North Carolina's Forest Resources Assessment

A statewide analysis of the past, current and projected future conditions of North Carolina's forest resources

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June 18, 2010

Dear friends and colleagues,

Periodic reviews of our forest resources are needed to evaluate their ever-changing status and to assess the ability of our programs to meet the conservation and sustainability directives of the North Carolina Division of Forest Resources. These directives are to lead the people of our state to develop, protect and manage these resources to ensure that they will be conserved now and sustained for future generations. This is a daunting task and we must work together as partners to be successful. The document attached to this letter is our completed statewide forest resources assessment that evaluates and analyzes the past and current conditions and projects the future conditions of these resources. In addition, the document includes goals and objectives that describe what we need to do to address key findings of the assessment. The document also outlines strategies on how we plan to achieve these goals and objectives. And finally, it contains priority maps to help tell the story of our forest resources and to help build partnerships. This compilation of assessment, goals, objectives, strategies and priority maps will guide us in the next five years in planning for the conservation of these resources and the associated economic, ecological and public benefits these resources provide.

North Carolina is blessed to have rich and diverse forest resources. From our seashores to the peaks of the Appalachian and Blue Ridge Mountains, our forest resources enrich the lives of all North Carolinians. Forests provide us with clean water and air, wildlife, recreation and forest products. They provide jobs and income, as well as, a place to escape from our jobs. They support the number one manufacturing industry in North Carolina. Our forest resources entice people to come to North Carolina and they make our state great.

All North Carolinians are stewards of our forest resources and we must work together as partners to be successful. Throughout the past 18 months we have invited the help of partners to make this document and strategic plan useful and pertinent. If you have been a partner in this project, I want to thank you for your help. If you are new to this document, I encourage you to join us as a partner. At this time of rampant change, it is critical that we work together to develop, protect and manage the multiple resources of North Carolina's forests through professional stewardship, enhancing the quality of life for our citizens while ensuring the continuity of these vital resources.

We respectfully submit this assessment, strategies and priority maps for your consideration.

Wib Owen
North Carolina State Forester

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Executive Summary

The following forest resource assessment and accompanying strategic plan and priority maps constitute a coordinated plan for moving North Carolina forests into the future. Driven by the need to efficiently target efforts to address state and national priorities, this document constitutes a broad vision for protecting and enhancing North Carolina forest values and benefits. While the mandate for this document and critical assessment originated in the 2008 Farm Bill under the Cooperative Forestry Assistance Act, its origins are deeply seated in a public that is demanding increased impact, accountability and innovation from its agencies. With that challenge as our goal, a committed group of staff, partners and sister agency personnel met over the past 18 months to make this publication a reality. The scope of this immense effort was only surpassed by the dedication and commitment of partners and staff who labored enthusiastically to complete this publication on time and on budget.

The arrangement of chapters mirrors the evolution of this effort from the Introduction (the process), Chapters 2-4 (reflect the national themes of Conserving Working Forests, Protecting Forests from Harm and Enhancing the Public Benefits from Forest. Within each of those chapters are comprehensive reviews of the condition of our forests and the impending threats and opportunities that exist to make them healthier, productive and yielding increased public benefits like clean air, water and precious wildlife habitat in urban and rural communities. The concluding Chapter 5 (Goals and Strategies is the logical follow-up to the assessment effort and constitutes a comprehensive a “strategic plan” for the next five years. The plan is organized by global goals that narrow to specific strategies that can be implemented at county and landowner level. Individual strategies specify the priority area, partners involved, resources required and connection to state assessment and national goals. The seven goals identified for North Carolina are listed below:

- Goal 1: Increase the sustainable management and conservation of forest lands in NC.
- Goal 2: Reduce negative impacts from forest threats.
- Goal 3: Increase the restoration, maintenance, and management of fire adapted species and ecosystems.)
- Goal 4: Maintain or increase the viability and sustainability of existing and emerging markets.
- Goal 5: Increase and enhance fish and wildlife habitat on North Carolina’s forests
- Goal 6: Manage, conserve, restore, and enhance forestlands important to current and future supplies of clean water for economic, social, and ecological uses.
- Goal 7: Enhance the benefits and sustainable management of urban forests.

The priority landscape and program maps complete the document by illustrating areas within the state that will best be served by the strategic efforts detailed in the plan. The maps reflect the conservation, protection and enhancement themes that permeate the assessment document and federal directives. The priority landscape and program maps were developed to educate and inform constituent and to focus implementation and ultimately deploy resources. Priority areas will likely be used for USDA Forest Service accomplishment reporting by the Division of Forest Resources and for multi-state partnerships funding pursuits. Priority areas will not restrict program delivery nor interfere with equitable provision of assistance nor services. Certain functions, such as firefighting and insect / disease outbreak response, imminent threats to life and property will always take precedent. The intent from the onset was to use the assessment and planning process to become a more efficient agency in the delivery and deployment resources to protect, enhance and conserve our state forest resources. We welcome your assistance and support in making our intentions your reality!

Acknowledgements

The following individuals and the organizations they represent contributed countless hours to the development and completion of this document. The coordinators express our sincere gratitude to all who played a role in this effort.

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Maintaining Viable Urban Forests

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Outreach Committee

Chris Carlson, Brian Haines, Alton Perry, Tom James and Les Hunter, NC Division of Forest Resources.

Partners and Stakeholders

Representatives from the following federal state and local government agencies, non-profit organizations, associations, partnerships and private interests contributed to this effort in numerous ways. Individuals representing the numerous partners and stakeholders listed below served on various working groups during the assessment phase, participated in one or more of the three partner/stakeholder meetings, provided comments and suggestions during the review process, assisted in development of GIS map products and were involved in the development of

goals, objectives and strategies. Engagement of and collaboration with these same partners and stakeholders is crucial as the focus turns to implementation of the strategies identified in this assessment.

Albemarle-Pamlico National Estuary Program
Camp Lejeune Forestry
City of Wilmington
The Conservation Fund
The Conservation Trust for North Carolina
Duke University
Environmental Defense Fund
The Nature Conservancy
NC Association of Consulting Foresters
NC Association of Professional Loggers
NC Cooperative Extension Service
NC Department of Agriculture
NC Department of Environment and Natural Resources
NC Division of Forest Resources
NC Division of Parks & Recreation
NC Division of Water Resources
NC Division- Society of American Foresters
NC Farm Bureau
NC Forestry Association
NC Green Builders Association
NC Natural Heritage Program
NC Prescribed Fire Council
NC State University College of Natural Resources
NC State University Department of Forestry and Environmental Resources
NC Tree Farm Program
NC Urban Forestry Council
NC Wildlife Federation
NC Wildlife Resource Commission
NC Woodlands
Resource Management Service, LLC
Southern Appalachian Multiple-Use Council
Southern Environmental Law Center
State Climate Office of North Carolina
Triangle Land Conservancy
US Environmental Protection Agency
US Fish and Wildlife Service
USDA Forest Service
USDA Farm Service Agency
USDA Natural Resources Conservation Service
Weyerhaeuser

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Chapter 1. Assessment Process and Outcomes

1.a.
Background and Approach

The USDA Forest Service and state forestry agencies have enjoyed an effective and unique partnership of assistance and outreach to private landowners, communities, tribes, and other partners for several decades under the State and Private Forestry (S&PF) organization. A component of this partnership involves financial support from the USDA Forest Service to support state programs and efforts in sustainable forest management, urban and community forestry, wildland fire management, forest health protection, and conservation education. The Food, Conservation, and Energy Act of 2008, also known as the 2008 Farm Bill, directed the USDA Forest Service to implement a “Redesigned” State and Private Forestry organization. The purpose of this new approach to S&PF is to shape and influence forestland use on a scale, and in a way, that optimizes public benefits from trees and forests for both current and future generations. The Redesign approach involves (1) an examination of current conditions and trends affecting forestland and (2) a review of S&PF programs to see if technical, financial, and other resources are being most effectively applied. The goal of this approach is to proactively address forestry challenges by developing and delivering an up-to-date set of programs, skills, and opportunities.

As part of the Redesign effort, each state must complete a statewide assessment of forest resources and a strategy for their management to receive federal funding. Each assessment is to provide a comprehensive analysis of forest-related conditions, trends, threats, and opportunities within a state. The resource strategies developed along with the assessment define long-term plans for investing state, federal, and other resources where they can most effectively stimulate or leverage desired action and engage multiple partners.

Federal Redesign guidance directs states to develop statewide forest resource assessments that do the following:

- Provide an analysis of present and future forest conditions, trends, and threats on all ownerships in the state using publicly available information.
- Identify forest-related threats, benefits, and services consistent with the S&PF Redesign national themes.
- Delineate priority rural and urban forest landscape areas to be addressed by the state resource strategy. States can also identify linkages between terrestrial and aquatic habitat, as appropriate.
- Work with neighboring states and governments to identify any multistate areas that are a regional priority.
- Incorporate existing statewide plans, including wildlife action plans and community wildfire protection plans. Address existing S&PF program planning requirements. States can also draw upon relevant national and regional assessments as appropriate.

Building on the findings in the statewide forest resource assessments, federal Redesign guidance directs the development of statewide forest resource strategies. The guidance requires each state to outline long-term strategies for addressing (1) priority landscapes identified in the state forest resource assessment and (2) the following national themes and associated management objectives:

- Conserve working forestlands: Conserve and manage working forest landscapes for multiple values and uses.
- Protect forests from harm: Protect forests from threats, including catastrophic storms.
- Enhance public benefits from trees and forests: Conserve and enhance air and water quality, soil, biological diversity, carbon storage, forest products, forestry-related jobs, production of renewable energy, and wildlife habitat.
- Describe how the state proposes to invest federal funding, along with other resources, to address state, regional, and national forest management priorities.
- Include a long-term timeline for project and program implementation.
- Identify partner and stakeholder involvement.
- Identify strategies for monitoring outcomes within priority forest landscape areas and how action will be revised when needed.
- Describe how the state's proposed activities will accomplish national S&PF objectives and respond to specified performance measures and indicators.
- Describe how S&PF programs will be used to address priority landscape and management objectives.
- Incorporate existing statewide plans, including wildlife action plans and community wildfire protection plans, and address existing S&PF program planning requirements.

Developing North Carolina's Statewide Forest Resource Assessment and Strategy

Issue Identification and Formulation

During the fall of 2008, the NC Division of Forest Resources (NCDFR) formed a task force to guide the development of the statewide forest resource assessment and strategy. Task force members first reviewed current and previously conducted assessments and plans. This review helped us to identify key focus points for our assessment efforts. Although numerous resources were reviewed and contributed to the issues addressed by the working groups, six documents stand out as primary references. These documents and others used to identify critical issues can be found in Appendix A.

The *North Carolina Wildlife Action Plan*, completed in 2005, is a comprehensive management tool developed by the NC Wildlife Resources Commission to help conserve and enhance the state's fish and wildlife and their habitats. A masterwork of state leaders in research, conservation, and education, the *NC Wildlife Action Plan* identifies diverse management strategies, research studies, and conservation efforts to ensure that all of our wildlife resources have healthy habitats where they can thrive. The forest sustainability work group drew heavily upon this resource in documenting (1) forests with high conservation value and (2) other prime wildlife habitat on which to focus appropriate conservation strategies. http://www.ncwildlife.org/Plan/WSC_WAP_Downloads.htm

The *Southern Forest Resource Assessment* (SFRA) *Summary Report* was published in 2002 to address concerns raised by natural resource managers, the science community, and the public regarding the status and likely future of forests in the South. Specifically of interest were changes to the region's forests brought about by rapid urbanization, increasing timber demand, increasing numbers of satellite chip mills, forest pests, and changing air quality. In response to these issues, leaders of three of the region's federal natural resource agencies (USDA Forest Service, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service) and the Tennessee Valley Authority worked together to assess the overall condition and changes of southern forests. More than 25 scientists and analysts from the above agencies as well as southern universities compiled the *SFRA Summary Report*. More than 100 scientists from universities, state and federal agencies, industry, and conservation organizations peer-reviewed the report for accuracy and completeness.
http://www.srs.fs.usda.gov/sustain/

The Southern Forest Futures Project (SFFP) is a multiyear effort by the USDA Forest Service, Southern Research Station and Southern Region, in partnership with the Southern Group of State Foresters. The SFFP builds directly on the Southern Forest Resource Assessment to examine how the forces of change identified in the SFRA, along with other emerging factors, could reshape forests over the next half century and beyond. Meta-issues identified during two public scoping sessions held in Raleigh and Asheville, NC, during 2008 helped further synthesize the key issues (topically and geographically) addressed here in *North Carolina's Forest Resource Assessment*. An active project as of June 2010, a draft SFFP report is expected to be completed by the end of 2010.
http://www.srs.fs.usda.gov/futures/

North Carolina's Forests, 2002, a publication by the USDA Forest Service, Southern Research Station (SRS), released in 2006, describes the principal findings of the seventh inventory of North Carolina's forest resources. Data from this publication helped us to identify current status and key trends associated with North Carolina's forest resources.
http://www.srs.fs.usda.gov/pubs/26000

Forest Statistics for North Carolina, 2002, another publication by the USDA Forest Service SRS, likewise helped us to identify current status and key trends. Although fieldwork for the eighth inventory of North Carolina's forest resources was completed in late 2008, the updated data were not available as we developed most of the current assessment. Therefore, we used predominantly 2002 data. The exception occurs in Chapter 2.a., "North Carolina's Forests, 2007," which does incorporate data from the eighth inventory released in February 2010.
http://www.srs.fs.usda.gov/pubs/6274

Report of the Governor's Task Force on Forest Sustainability, 1996, identified 79 recommendations supporting sustainability of North Carolina's forest resources and the economic viability of its forest-based economy. Most of the recommendations have since been implemented.
http://www.ncforestassessment.com/pdf/Report%20of%20the%20Governor's%20Task%20Force%20on%20Forest%20Sustainability_June%201996.pdf

Working Groups

During the issue identification process, we established six “assessment themes.” The themes helped us to identify threats to NC forests and the benefits and opportunities the forests provide: Socioeconomic Threats to Working Forests, Ecosystem Services, Forest Sustainability, Threats to Forest Health, Protecting Forests and Communities from Wildfire Risk, and Maintaining Viable Urban Forests. Based on these themes, the task force organized six working groups.

The working groups shared a common vision: to combine the collective wisdom of their members as they identified priority areas for focusing programs and future efforts. Each working group consisted of 10 to 20 members, including interested partners, stakeholders, and agency personnel, with subject matter expertise and a commitment to seeing the assessment through to completion. Each working group established a structure that included a leader or co-leader. Non-NCDFR partners led two working groups: Forest Sustainability and Threats to Forest Health. Each working group designated one or more NCDFR liaisons, one or more GIS coordinators, and a scribe. Based on each group’s assessment theme, working group members analyzed the forest resource trends and conditions and assigned priority rural and urban landscape areas. Each group also helped to develop appropriate strategies for dealing with the threats and opportunities that its members unveiled. These strategies helped form the basis for recommended program efforts in the coming 5 years.

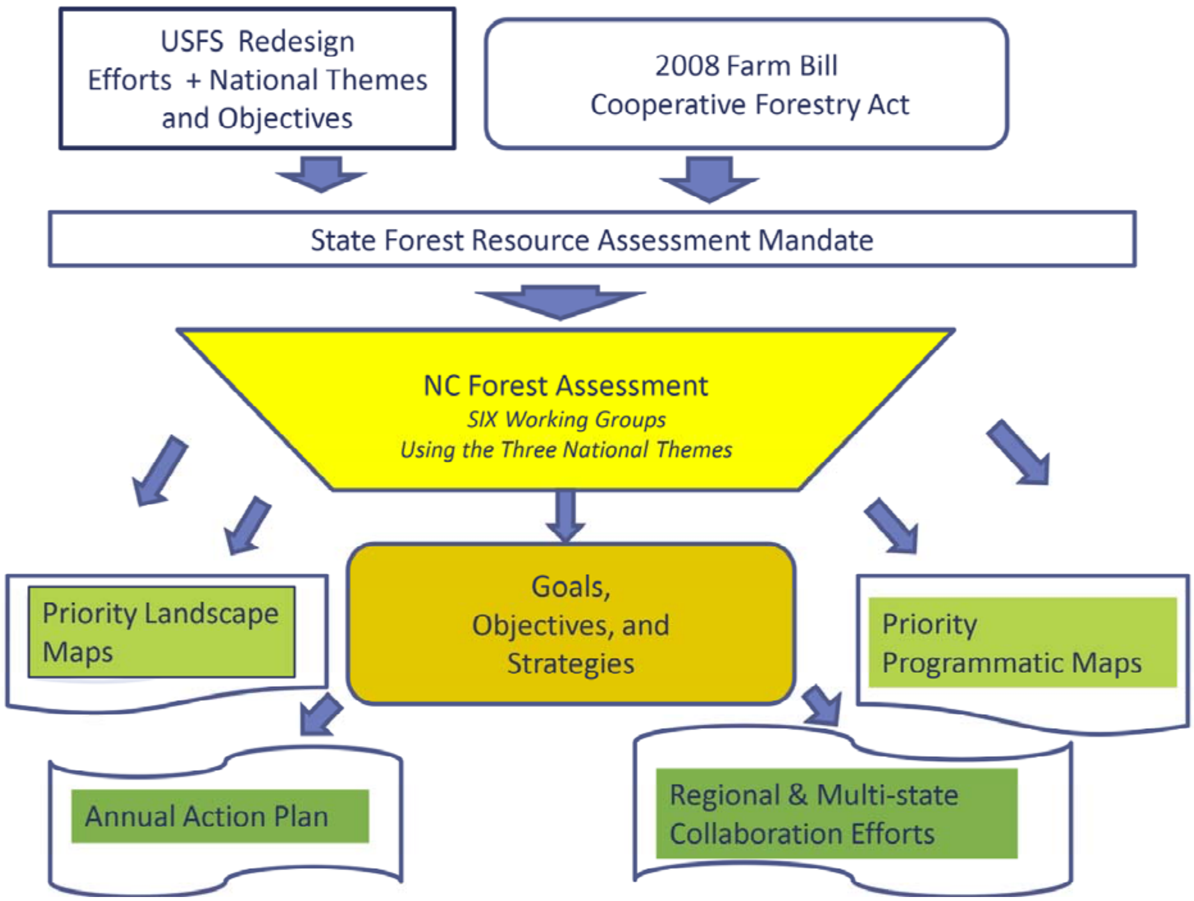
Partner and Stakeholder Involvement

The NC Division of Forest Resources worked collaboratively with more than 40 key partners and hundreds of stakeholders to develop this statewide forest resource assessment. Partners helped to ensure that federal and state resources focus management and outcomes on important priority landscapes. This statewide assessment represents a comprehensive analysis of the forest conditions, trends, threats, and opportunities within North Carolina. We give special thanks to professionals from the NC Wildlife Resources Commission (NCWRC) and the U. S. Fish and Wildlife Service for their unwavering assistance and editorial comments and for their critical roles on various working groups. Members of the State Stewardship Committee and NRCS State Technical Committee, who were briefed on the process, progress, and review of drafts of the assessment and strategies during the development process, received frequent updates and suggestions. The USDA Forest Service and USDI Fish and Wildlife Service are the two primary federal land management agencies involved in both assessment and strategy development. A complete list of partners and stakeholders is included in the Acknowledgements section of this assessment.

Partner Meetings and Review Periods

A central tenet of North Carolina’s approach has been the involvement of partners in designing and implementing the statewide forest resource assessment and strategy. This began early in the process when partners were asked to critique a design and implementation strategy in late 2008 (FIGURE 1*a*-1). At that meeting, partners asked for a detailed strategy and a website through which to track progress. The first formal meeting of partners was used to break stakeholders into separate working groups to draft the assessment. The final meeting’s purpose was to conclude the assessment portion and move into the strategy portion of the project. A formal review process was then implemented, and much of the interaction took place via email and Web postings. Two separate review periods were initiated, and comments were

FIGURE 1*a*-1. Relationship and process flow of the statewide forest resource assessment, the goals/objectives/strategies, and the priority maps.



received automatically by e-mail. Corrections and edits were made, and then final drafts were sent to an outside reviewer for style and usage changes. Those final edits were reflected in the final document submitted for approval by the USDA Secretary in June of 2010.

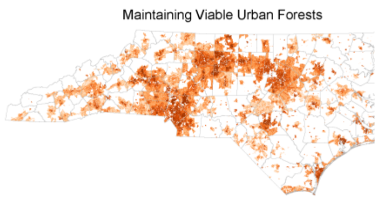
An initial meeting of key partners and stakeholders was held November 28, 2008, at the NC Wildlife Resources Commission headquarters in Raleigh. This meeting served to introduce the partners and stakeholders to the purpose of the statewide forest resource assessment and strategy, to introduce a draft plan of work, and to solicit feedback and support.

A second meeting of key partners and stakeholders was held February 26, 2009, at the Wake County Agricultural Center Commons in Raleigh. This was a participatory planning session designed to provide an update on progress since the October 2008 meeting and to recruit partner and stakeholder participation in six working groups. Breakout sessions were held to further synthesize key issues to be addressed within the six broad working group themes during the assessment phase.

A third meeting of key partners and stakeholders was held December 9, 2009, at the NCSU McKimmon Center in Raleigh. The purpose was to release draft findings of the six working groups from the Assessment phase and solicit input and support for a plan to transition to the strategy development phase.

Assessment Website

The assessment website was a communication tool that captured input and detailed the progress and effort of NCDFR staff and partners in completing the project. Everything from reference materials, federal guidance, presentations, and meeting minutes were captured and shared there. A calendar of events documented all activities that took place within the public settings and efforts for the process. The website was a crucial link among agencies, partners, and the public in the implementation of this nearly 2-year process: http://www.ncforestassessment.com



1.b.
Priority Map Development

Mapping Rationale

The identification of urban and rural priority areas is a requirement of all statewide assessments of forest resources, as specified in the S&PF Redesign guidance developed by the USDA Forest Service:

"State forest resource assessments will identify, describe, and spatially define forest landscape areas where forestry program outreach and activity will be emphasized and coordinated. Establishment of these priority areas is intended to (1) enable the efficient, strategic, and focused use of limited program resources; (2) address current state and national resource management priorities; and (3) produce the most benefit in terms of critical forest resource values and public benefits. This component of a state's assessment should be geospatially based."

Mapped priority areas provide a method for focusing on areas where federal investment can most effectively stimulate or leverage desired action and engage multiple partners. Mapping must enable the discovery of multistate areas in which collaboration can lead to stronger outcomes. Accomplishments using federal funds may be evaluated against priority areas to determine the effectiveness of S&PF program implementation.

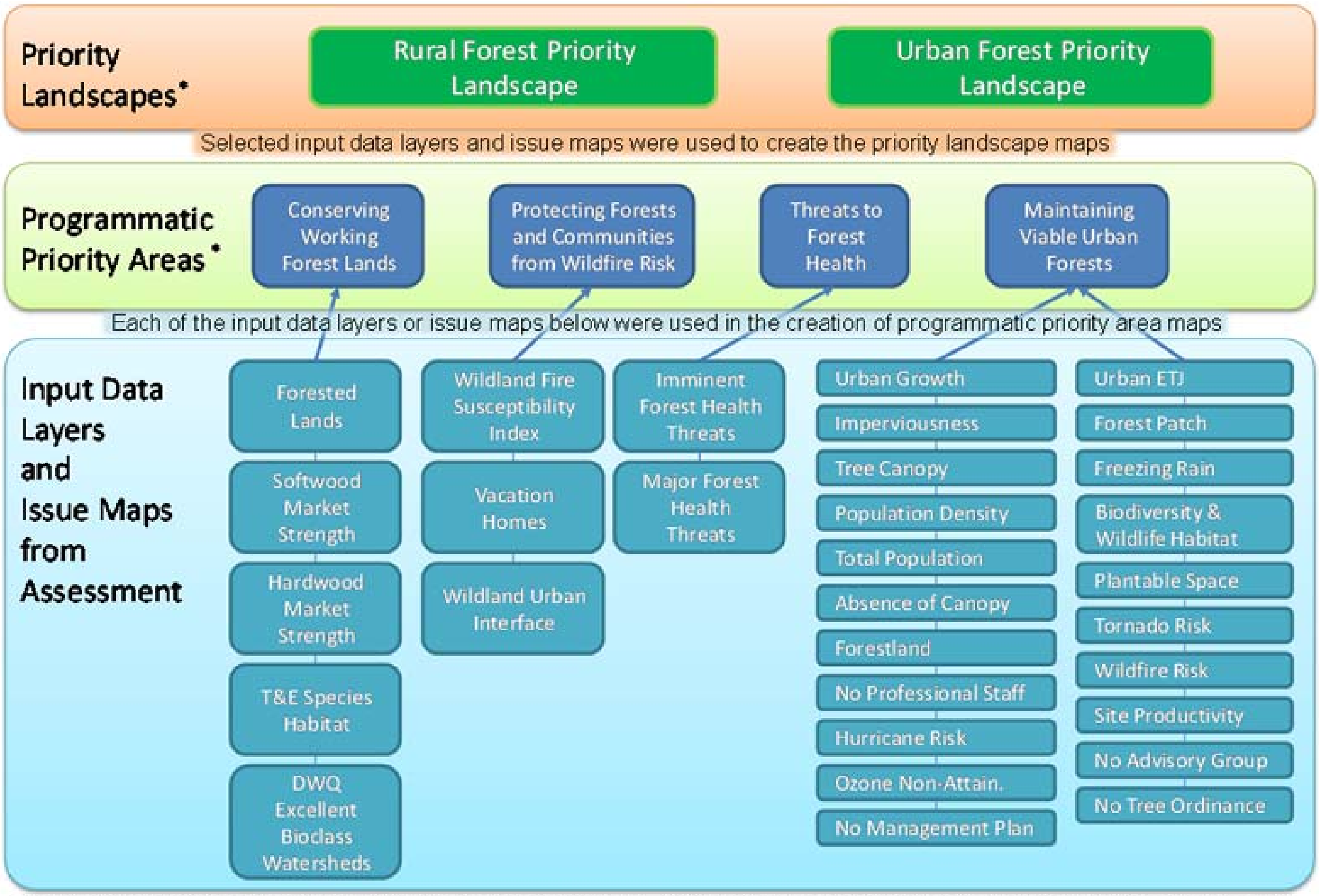
Mapping Approach

Two sets of priority maps were developed for North Carolina. The first set (1) shows areas of specific emphasis in North Carolina according to themes identified during the assessment process and (2) aligns with programmatic funding available from USDA Forest Service S&PF. These maps show areas of emphasis for these assessment themes: Conserving Working Forestlands, Protecting Forests and Communities from Wildfire Risk, Threats to Forest Health, and Maintaining Viable Urban Forests. The second set of maps shows overall urban and rural forest priority landscapes.

Each map is the result of overlay analysis, which is achieved by adding data layers with particular relevance to the map topic. Wherever possible, the input layers were straightforward datasets rather than complex models; this results in maps that are easier to interpret. Input layers were chosen based on their importance in the assessment and their ability to clearly represent a component of interest. The rural and urban landscape priority maps are not simple stacks of the thematic priority maps, but are the result of a separate consideration of layers relevant to urban and rural forested landscapes. FIGURE 1*b*-1 shows the relationships between each priority map and the data layers that were used for creating the map. Layer weights, if used, are noted in the bottom right corner of the layer's box.

Wherever possible, existing datasets were used, including datasets developed for the Forest Stewardship Spatial Analysis Project, Forest Legacy Assessment of Need, and *NC Wildlife Action Plan*. North Carolina has several statewide datasets surpassing anything available at a national level that were incorporated as part of the mapping process, including the NCDENR One NC Naturally project and NC Natural Heritage

FIGURE 1*b*-1. Relationship between the *Statewide Forest Resource Assessment*, the goals/objectives/strategies, and the priority maps.



* For details on input layers and weighting (if any), see the individual maps. Further details can also be found in the mapping and GIS analysis appendix.

Program database. Certain other environmental and social factors, such as cultural resources, demographic data, poverty, public health, recreation, and air quality were included as needed. Certainly, there are datasets that could benefit from improvement, and there are datasets that do not exist at the extent and scale necessary for use in a comprehensive assessment. Where these data gaps were encountered, they were documented to help focus future data development work at the state, regional, and national level.

Programmatic Maps

Conserving Working Forest Lands

(FIGURE 1*b*-2)

The Conserving Working Forest Lands map shows areas of North Carolina that should be targeted to prevent the loss of working forestlands from development and conversion to other nonforestry uses. These lands have high values for connectivity with other forestlands, water quality protection in existing high-quality waters, habitat for wildlife, and strong markets for hardwood and softwood products. The final component in the map is development risk. With active and informed forest management, these lands can provide economic and ecosystem benefits; in the absence of involved and informed management, they are at higher risk of succumbing to development pressure.

Protecting Forests and Communities from Wildfire Risk (FIGURE 1*b*-3)

The Protecting Forests and Communities from Wildfire Risk map shows areas of North Carolina where wildfire mitigation and preparedness efforts can reduce loss of life and property, and prevent degradation of the forest resource due to intense fires typical of southern forests. These lands rank high for wildfire susceptibility in the Southern Wildfire Risk Assessment System (ArcGIS software). Many of these areas are considered to be within the wildland-urban interface, and many are owned by individuals who may be unfamiliar with the role of fire in southern forests and firewise building principles.

Threats to Forest Health (FIGURE 1*b*-4)

The Forest Health Priority map shows areas of North Carolina currently at a moderate to high risk of damage from insects and diseases, both native and/or established and imminent invasive threats. The specific pests used to develop this map are as follows: southern pine beetle, littleleaf disease, annosus root rot, fusiform rust, hemlock woolly adelgid, balsam woolly adelgid, beech bark disease, redbay ambrosia beetle–laurel wilt, emerald ash borer, Asian longhorned beetle, and sirex woodwasp. As the map shows, both rural and urban landscapes across the state will likely see negative impacts from these pests. Although climate change is an important factor in modeling future impacts to forest health, much of the data is very coarse and was consequently left out of this analysis.

Maintaining Viable Urban Forests (FIGURE 1*b*-5)

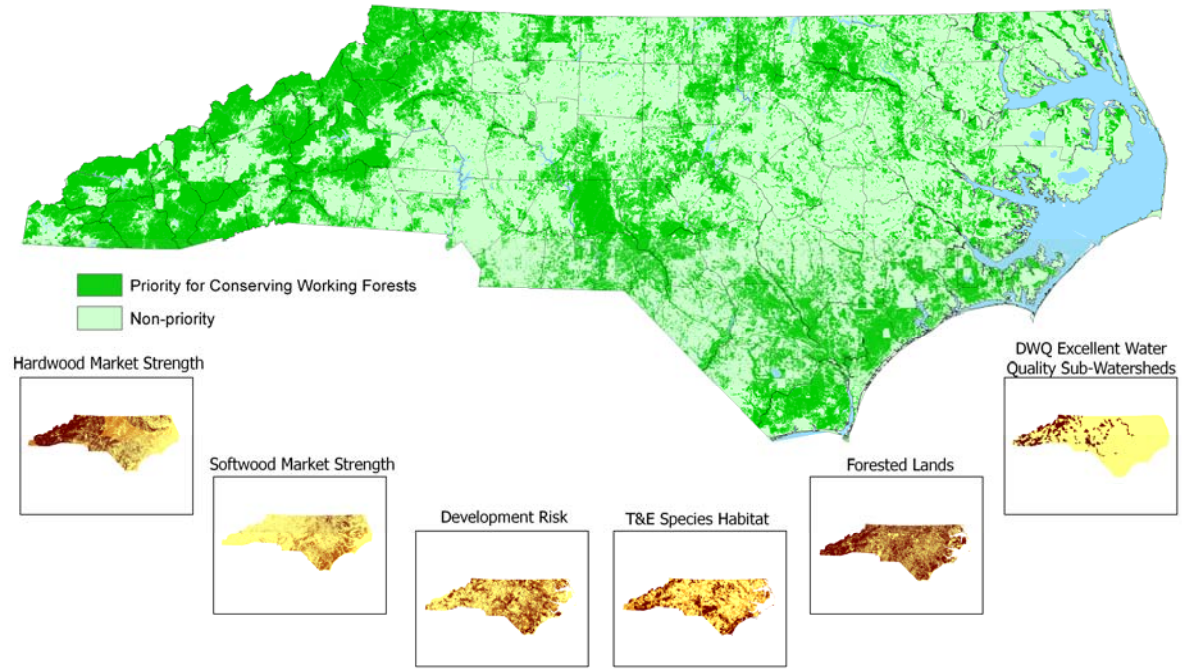
The Maintaining Viable Urban Forests map shows areas of North Carolina that are essential for restoring, conserving, and maintaining healthy urban trees and forests. These lands are experiencing rapid urbanization, increased amounts of impervious surface, and a higher number of catastrophic storm events, while also having tree canopy potential to offset the negative impacts of land-use change. These urban forestlands also have high values for energy conservation and improved air quality. Many municipalities within the priority areas manage their urban forests with limited resources and lack one or more of the components necessary for a sustained community forestry program. Coordinated planning and management of urban forests across jurisdictional boundaries will require new partnerships and initiatives at municipal, county, and statewide levels.

Landscape Maps

Rural Forest Priority Landscapes (FIGURE 1*b*-6)

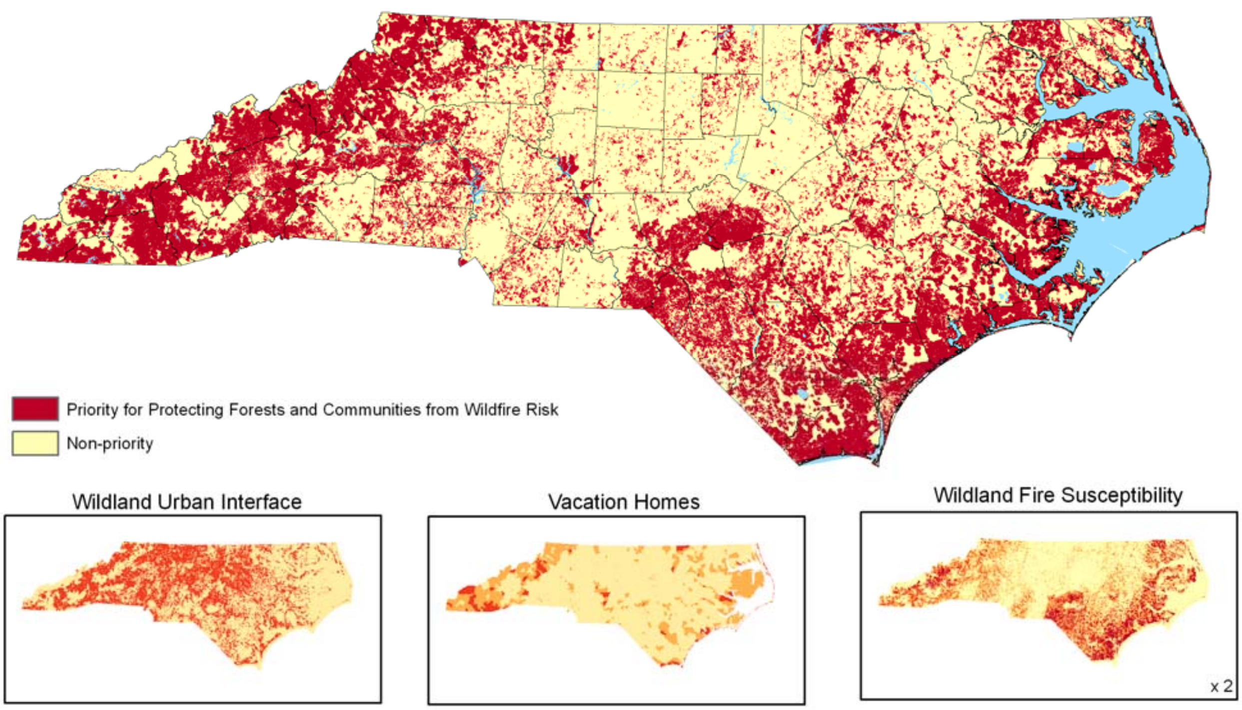
The “Rural Forest Priority Landscapes” map shows areas of North Carolina where forestry is an especially significant part of the rural landscape. Forestlands in these areas provide valuable benefits, such as the protection of critical water quality resources, wildlife habitat for threatened and endangered species, and viable economic options for landowners. Threats to forest health and productivity through insect and disease pests and wildfire are especially significant in these areas. Threats here have the potential to disrupt ecological systems depended upon by all NC inhabitants. Much of the priority rural forest acreage is in the NC coastal plain and mountains, though significant priority area exists in the Uwharrie Mountains, sandhills, and “northern tier” areas of the piedmont.

FIGURE 1*b*-2. Conserving Working Forestlands map.



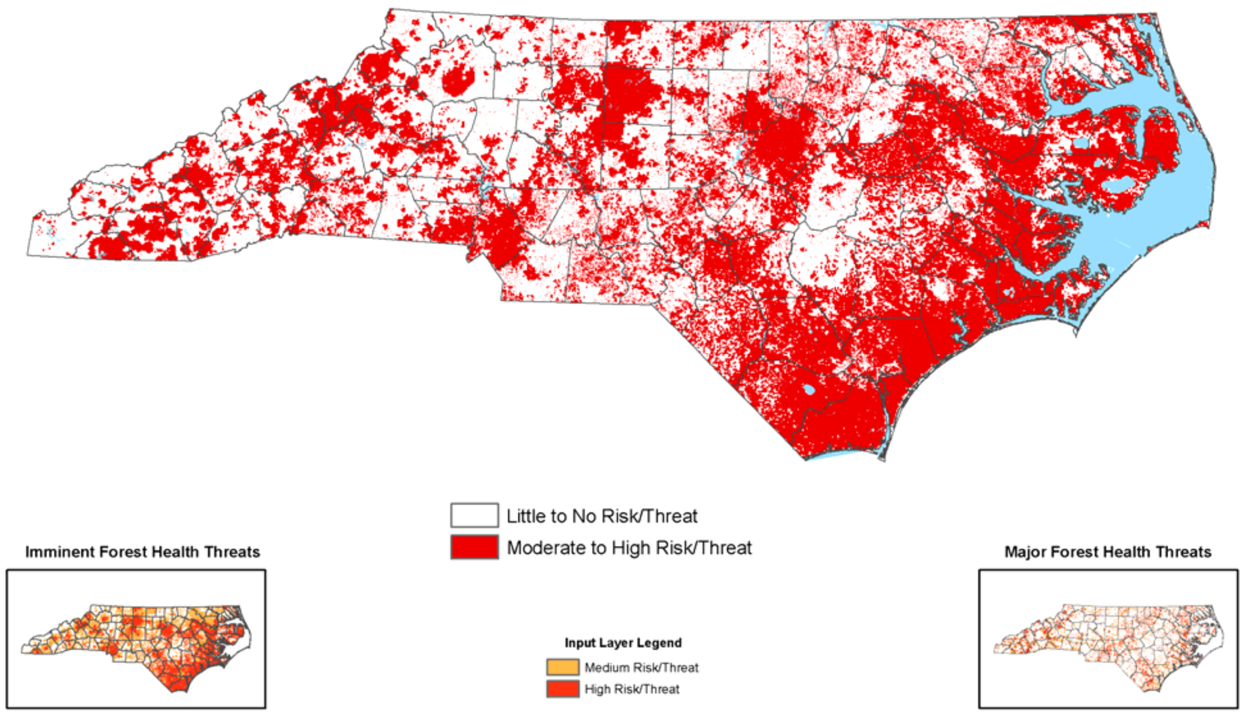
Created by: A. Bailey, NC DFR, 2010

FIGURE 1*b*-3. Protecting Forests and Communities from Wildfire Risk map.



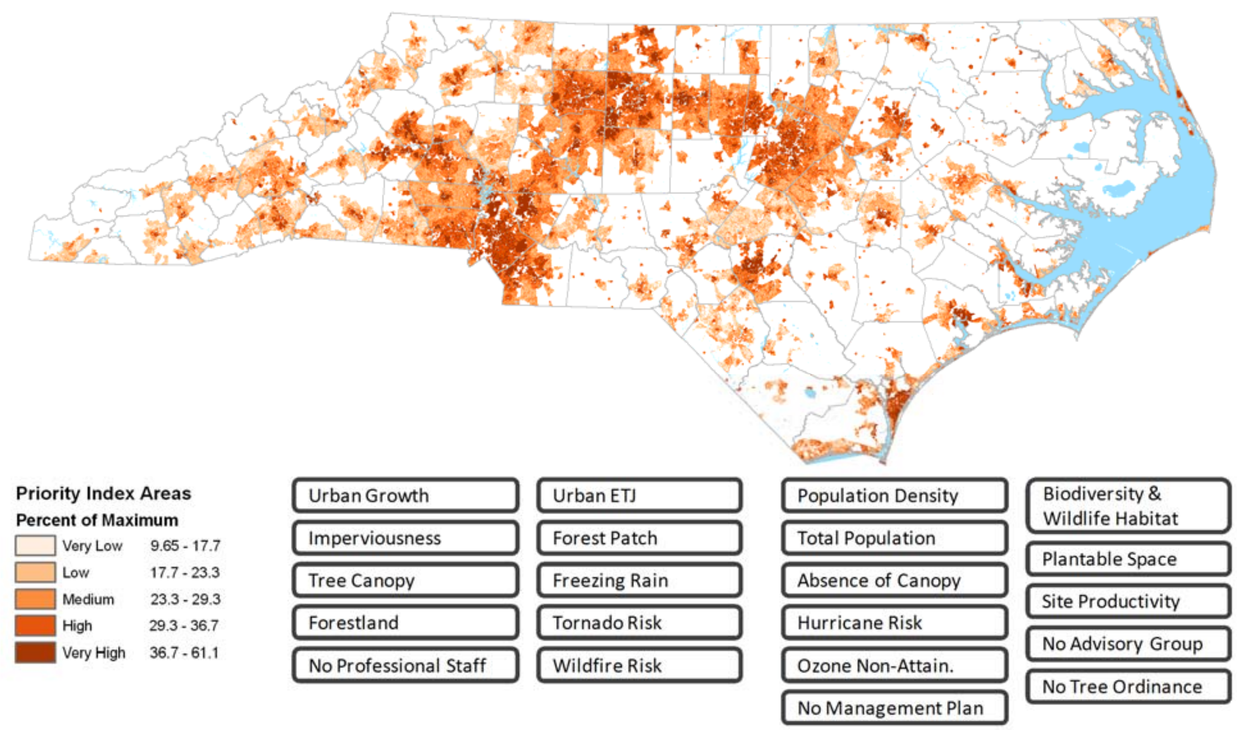
Created by: A. Bailey, NC DFR, 2010

FIGURE 1*b*-4. Forest Health Priority map.



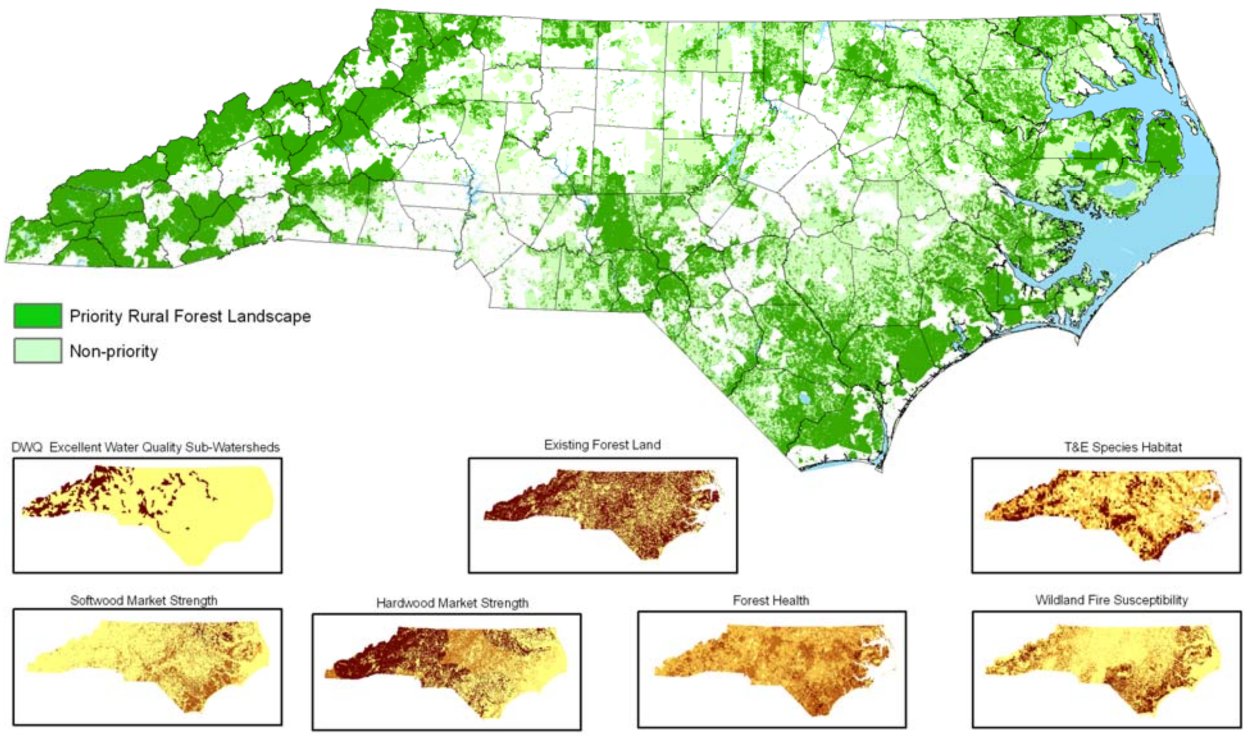
Created by: J Moan, NC DFR, 2010

FIGURE 1*b*-5. Maintaining Viable Urban Forests map.



Created by: A. Bailey, NC DFR, 2010

FIGURE 1*b*-6. Rural Forest Priority Landscapes map.



Created by: A. Bailey, NC DFR, 2010

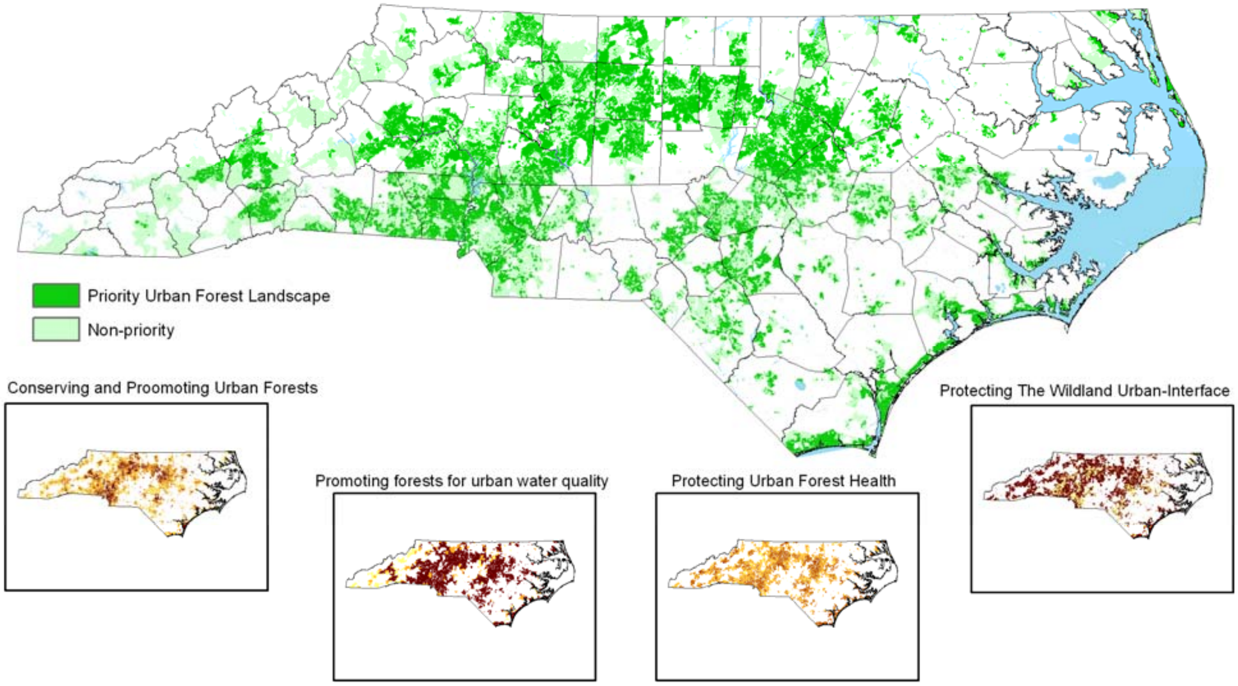
Urban Forest Landscape Priority (FIGURE 1*b*-7)

The Urban Forest Landscape Priority map complements the Maintaining Viable Urban Forests map (FIGURE 1*b*-5) by adding layers from these maps that have an urban component: Conserving Working Forestlands (FIGURE 1*b*-2), Protecting Forests and Communities from Wildfire Risk (FIGURE 1*b*-3), and Forest Health Priority (FIGURE 1*b*-4). Wildland-urban interface areas have inherent urban components, and many of these areas need intervention to reduce wildfire risk. Improving water quality is a commonly cited reason for maintaining urban tree canopy. Forest insects and diseases spread regardless of what is urban forest and what is rural; indeed, many invasive pests become established first in urban areas due to the easy movement afforded by dense transportation networks. Much of the forestland delineated as priority in this map are tracts of less than 14 acres. Parcelization and fragmentation are issues that must be addressed to effectively manage these forests.

How Priority Maps Can Be Used

These maps were developed to meet the needs of the NC statewide assessment of forest resources, to facilitate the effective implementation of the USDA Forest Service S&PF programs, and to provide a foundation for interagency partnerships. Priority areas are expected to be used for accomplishment reporting between the NC Division of Forest Resources and the USDA Forest Service, as well as for the formation of multistate partnerships to pursue funding. Priority areas provide a way to tell the story of forests in North Carolina, to educate and

FIGURE 1*b*-7. Urban Forest Priority Landscapes map.



Created by: A. Bailey, NC DFR, 2010

inform, and to build constituencies to effect positive change. Priority areas are not intended to restrict the delivery of certain programs or to exclude citizens from state-provided services. Certain functions, such as firefighting and response to insect and disease outbreaks, do not lend themselves to prioritization—imminent threats to life and property will always take precedent. The delivery of forestry programs and services will ideally strike a balance between activities conducted in priority areas and maintaining program access to all citizens of the state.

Wherever possible, existing datasets were used, including datasets developed for the Forest Stewardship Spatial Analysis Project, Forest Legacy Assessment of Need, and *NC Wildlife Action Plan*. North Carolina has several statewide datasets surpassing anything available at a national level that were incorporated as part of the mapping process, including the NC DENR One NC Naturally project and NC Natural Heritage Program database. Certain other environmental and social factors, such as cultural resources, demographic data, poverty, public health, recreation, and air quality were included as needed. Certainly, there are datasets that could benefit from improvement, and there are datasets that do not exist at the extent and scale necessary for use in a comprehensive assessment. Where these data gaps were encountered, they were documented to help focus future data development work at the state, regional, and national levels. Further explanation of the GIS process and data sources used in development of the maps can be found in the Appendix B.

1.c.

Multistate and USFS Redesign Efforts

The USDA Forest Service Redesign effort seeks to focus State and Private Forestry resources and funding on high-priority areas at a multistate landscape level. The purpose of the Redesign is to encourage collaboration among states to identify common forestry issues for maximum impact. Current Redesign projects address significant geographic issues at the landscape level. All of the projects are guided by three broad national themes (TABLE 1*c*-1). The Redesign's guiding principles emphasize landscape-scale projects that feature collaborative planning and implementation; prioritization of outcomes; and innovative use of technology, multistate involvement, and collaboration.

A number of forestry issues identified in North Carolina's statewide assessment are common to other states within the Southeast. For some of these issues, projects are already underway with multistate collaboration. Outcomes from NCDFR projects may provide information or program ideas that other states can apply. Many issues will need to be addressed with future projects, many of which will cross state borders.

Future Multistate and Regional Collaboration Opportunities

Forest resource issues, threats, and opportunities that cross state boundaries or that address regional priorities provide opportunities for multistate collaboration. In some instances these opportunities may be tied to a specific S&PF program area or a well-defined issue or need common to one or more states. In other cases, collaborative opportunities may be best identified and addressed geospatially, where watersheds, ecoregions, commodity markets, population centers, or other factors converge.

We anticipate that future planning and communication efforts will occur at the regional level to more fully explore collaborative opportunities regionally and among the states. One avenue to beginning these discussions is within the existing committee and task force structure of the Southern Group of State Foresters (SGSF). An early attempt to identify multistate collaborative needs occurred at the SGSF Summer Meeting held in Wilmington, NC, in June 2009. Now that states have completed their state forest resource assessments and strategies, it is time to revisit these opportunities and collectively plan strategies to effect positive change. Listed below is only a sample of the many priority opportunities for multistate or regional collaboration identified during the development of North Carolina's statewide forest resource assessment and strategy.

- Forest resource market changes. Changes in traditional markets and emergence of new markets, such as carbon trading, bioenergy, and ecosystem services, may change supply and demand and our management of forests.
- Climate change impacts. This meta-issue influences many other issues

c. Multi-State and USFS Redesign Efforts

TABLE 1*c*-1.—Current USFS Redesign Grant projects managed by the NC Division of Forest Resources

Funding Years	Project Name	Project Description	States Involved	NC Assessment Objectives Addressed
2008/ 2009	Enhancement of NCDFR's Fire Environment Program	Expands NC Remote Automated Weather System: Adds new RAWS stations, updates data collection and continues training of personnel.	NC	2.1, 3.1, 3.2, 3.3
2008	Landowner's Link to Virtual Forest Management Phase 1	Creates a "Link to Virtual Forest Management" website that enables landowners to develop their own forest management plans.	NC	1.2, 1.3, 5.2,
2008	North Carolina Firewise-Urban Intermix Community Grant Program	A directed effort to prevent wildfires and improve urban forest health by combining firewise and urban forest management concepts.	NC	2.1, 3.1, 3.2, 7.1
2008	North Carolina's Longleaf Pine Initiative and Action Plan	Sustains and promotes the restoration of longleaf pine in North Carolina via new stand establishment, conserving existing stands, and promoting total resource management.	NC	3.1, 3.2, 3.3, 5.2, 5.3
2008	Woodland Owner Short Course (WOSC), Regional Expansion	Expands the current curriculum of innovative forest management concepts to small landowners in the NC piedmont and coastal plain.	NC	1.2, 1.3, 3.1, 3.2, 3.3, 4.4, 5.2, 5.3, 5.4, 6.4, 7.1
2008	Student Intern Assessment SCA Crews	Employs Student Conservation Association (SCA) crews to complete community wildfire protection plans, urban forest assessments, forest pest and disease assessments and other valuable forest management data.	NC	2.1, 2.2, 2.3, 7.2
2008	Forest Health Information, Education, and Outreach	Funds brochures, posters and webpages to address hemlock woolly adelgid, gypsy moth, bark beetles, oak decline, storm damage to timber, storm damage to urban trees, defoliators, urban pests, and emerging issues.	NC	2.2, 7.3
2008	Digital Aerial Sketch-Mapping Technology	Funds acquisition of mapping technology and training in forest health, forest management, water quality, fire control, emergency management, and law enforcement.	NC	1.1, 2.1, 2.2, 3.3, 5.2, 5.3, 6.1, 6.2, 7.2
2008	Landowner Survey	Funds a survey of landowners to determine advice and services they need from natural resource professionals.	NC	1.2, 3.3
2009	Strategic Planning Tool to Assess Wood Energy Demands on Timber Market	Funds the development of a regional tool to assess the potential impact of demand for wood as an energy feedstock on product inventories, markets, and traditional wood-based industries.	NC, AL, GA, MS	1.2, 4.1, 4.2
2010	Shortleaf Pine Initiative	Sustains and promotes the restoration of shortleaf pine across the region through collaborative research and information and education efforts.	OK AR, NC, TX	3.1, 3.2, 5.2, 5.3

Funding Years	Project Name	Project Description	States Involved	NC Assessment Objectives Addressed
2010	Fire Activity and Emissions Tracking System (FAETS)	Develops a computer-based tracking system to enhance and collaborate with other resource databases.	NC, SC, VA, GA, LA, TN, OH, PA	2.1, 3.1, 3.2, 3.3

and strategies as well as program deliveries by all states.

- Threatened species and longleaf pine restoration. Loss of specific species across landscapes will require strategies and efforts that include all interested stakeholders.
- Invasive species. Aggressive action and cooperation will be needed to control and manage the continuing spread of numerous invasive species.
- Fire-smoke modeling and emissions. Pooling resources and databases will help to develop modeling tools and standards for smoke data collection and management.
- Forests and water quality. Identification of priority watersheds for forest conservation and coordination of strategies and management to improve conditions could produce regional effects.
- Urban and WUI. Canopy cover monitoring, land-use change predictive models, and storm damage rapid assessment are several potential areas for multistate cooperation.
- Forest health, Insects and diseases that threaten rural and urban forests spread regardless of state or national boundaries. Coordinated strategies are critical in areas of prevention, monitoring, control, data management, education, and enforcement.
- Outreach, information, and education. Collaboration and sharing of ideas, products, and resources to reach common audiences can be efficient and effective uses of limited resources.
- Research and technology transfer. Investigation, discovery, and the sharing and transfer of science-based knowledge to those who can use it is a classic example of activities well-suited to coordinated efforts.
- Data collection, management, analysis. Opportunities exist in all program areas to more effectively collect, manage, share, and analyze data.

1.d.

Implementation and Next Steps

Annual Action Plans and Investment of Financial and Other Resources

The S&FP Redesign effort directs states to develop an annual action plan that will identify specific strategies to be addressed in the coming year. This action plan is to include a component describing how federal funding, along with other resources, will be invested. States are also directed to describe the capabilities and limitations within the state for addressing the threats and opportunities identified in the strategy plan, including capacity (such as legal, financial, staffing, and partner resources).

The inclusion of matrices for each strategy (see Chapter 5, "Goals, Objectives, and Strategies") was a deliberate proactive attempt to capture the critical components that will be needed to develop annual action plans and partner/stakeholder collaboration, and to implement strategies. In the near term, a series of additional relational matrices will be developed to more clearly identify strategic associations by priority area, NCDFR program, and partners/stakeholders who will aid in developing annual action plans and facilitate strategy implementation and service delivery on the ground.

Integration with the *North Carolina Wildlife Action Plan*

Although numerous opportunities exist for integration of *North Carolina's Forest Resources Assessment* and the *North Carolina Wildlife Action Plan* (WAP), integration of common objectives and strategies is most readily apparent in the four statewide conservation strategies of the WAP listed below, along with the forest resource assessment objectives that most closely correlate.

1. WAP Urban Wildlife Management Strategies correlate to SFRAS Objectives 1.4, 5.4, 7.1, 7.2, 7.3, and 7.4.
2. WAP Private Lands Habitat Management Strategies correlate to SFRAS Objectives 1.2, 1.3, 3.1, 3.2, 4.1, 5.2, and 6.1.
3. WAP Land Conservation Strategies correlate to SFRAS Objectives 1.1, 3.3, 5.1, 5.3, and 6.2.
4. WAP Education, Outreach and Recreation Strategies correlate to SFRAS Objectives 3.1, 5.4, and 6.3.

Federally funded Programs Already Using Assessments and "Priority Maps"

A number of federally funded forestry programs already use information derived from forestry assessments. Most notably, this includes the use of priority maps that highlight areas of North Carolina where resources (such as funding and man-hours) can deliver the greatest benefits. Primary examples include the Forest Stewardship Program and the Forest Legacy Program.

The Forest Stewardship Program

Distinct as our forests are, they have one common denominator—they are extremely valuable to the citizens of North Carolina. Forests provide habitat for birds, deer, bears, and other animals. The headwaters of most of the state's rivers and streams are in forests, and forests thus ensure a steady supply of clean water. They offer solitude and aesthetic experiences for NC residents and for tourists. They provide raw materials for the state's manufacturing industry, which produces lumber, plywood, particleboard, paper, furniture, and hundreds of other products made from wood. They furnish an abundance of other miscellaneous forest products—such as Christmas trees, ornamental shrubbery, longleaf pine needles for mulch, mosses, herbs, and floral and edible plants—that contribute millions of dollars to the state's economy. They give landowners opportunities for additional income through leasing lands for hunting.

North Carolina's forests are diverse, insofar as both the benefits derived from them and the many private landowners who own them. These details will be examined and discussed throughout this document. Many of these landowners have different values, different levels of knowledge about forests, and different goals for using their forestlands. Public lands are being pressured to provide recreation, aesthetics, wildlife and fisheries, as well as timber products. Because these public lands are limited, the only way to meet this ever-increasing demand is to provide opportunities for some of these activities on private lands. The Forest Stewardship Program is a way to provide the technical assistance needed by landowners to meet personal objectives, and to improve all aspects of the forest environment for the state's citizens. This is applicable whether landowners seek to generate income through timber harvesting; manage for wildlife or fish habitat; maintain the soils and waters; or provide recreation or aesthetic opportunities for themselves, their families, or visitors to their land.

The Forest Stewardship Program helps to coordinate the various publicly supported assistance programs for forestland owners. It has been developed as a partnership among representatives of the following agencies or institutions: NC Division of Forest Resources; NC Wildlife Resources Commission; USDA Forest Service, Natural Resources Conservation Service, and Farm Service Agency; U.S. Fish and Wildlife Service; Cooperative State Research, Education and Extension Service; Duke University; and North Carolina State University. Many members of the above-mentioned organizations functioned as working group participants and chapter authors for this document. In general, the collaboration and oversight of this State Stewardship Committee, coupled with on-the-ground management plan assistance to landowners, has helped to increase the effectiveness and efficiency of other federal and state forestry programs. The cooperative planning by wildlife, soils, forestry, recreation, and other natural resource professionals has also served to keep landowners informed of regulatory requirements that must be met as well as best management practices that may be utilized on their lands.

The Forest Stewardship Program reports its annual accomplishments to the USDA Forest Service (TABLE 1*d*-1). Since 2008, the Southern Group of State Forester's Southern Forest Land Assessment (SFLA) GIS project has been used by the Forest Stewardship Program as a way of reporting how many stewardship plans were being carried out in "Important Forest Resource Areas." Future Forest Stewardship Program accomplishments will likely use this document's Conserving Working Forest

Lands priority map (FIGURE 1*b*-1) rather than that SFLA priority map. The Conserving Working Forest Lands map is an example of a visual and spatial tool that can be used by management and field personnel to plan their efforts and assess their accomplishments.

TABLE 1*d*-1.—NC Forest Stewardship Program accomplishments

Measure	Accomplishment
Number of stewardship plans and acres addressed (1990 – 2009)	21,928 plans, 645,311 acres
Number of tracts and acres certified under the stewardship program (1990 – 2009)	720 tracts, 132,069 acres
Number of trained stewardship plan writers, external to NCDFR (1990 – 2009)	64 writers
Percentage of stewardship plan acres that were located in spatially defined "Important Forest Resource Areas*" (1999 – 2009) *As defined by the Southern Forest Land Assessment GIS Project	48% (213,445 acres out of a total of 446,154 acres covered by stewardship plans)
Percentage of stewardship plans where the plan recommendations were being implemented by landowners (Based on 2008 –2009 Monitoring Results)	70%

The Forest Legacy Program

The Forest Legacy Program, authorized in the 1990 Farm Bill—Section 2103c, authorizes the USDA Forest Service or state governments to purchase permanent conservation easements on private forestlands. The program acquires certain land-use rights that both promote effective forestland management and protect the land from conversion to nonforest uses.

Threatened forestlands receive priority that (1) contain important scenic, cultural, and recreation resources; fish and wildlife habitats; water resources; and other ecological values; and (2) will support continuation of traditional forest uses. To be considered for the program, an NC landowner must have a Forest Stewardship Plan that addresses the multiple resource management of their property. Activities consistent with the Forest Stewardship Plan—including timber harvesting and recreational activities, such as hunting, fishing, and hiking—are allowed under the program and encouraged. The federal government may fund up to 75 percent of program costs, with at least 25 percent coming from private, state, or local sources. In addition to gains associated with the sale or donation of property rights, many landowners may also benefit from reduced taxes associated with limits placed on land use.

Former Governor James Hunt designated the NC Division of Forest Resources as the lead agency to oversee and implement the Forest Legacy Program. Participation in the Forest Legacy Program is entirely voluntary from both state and landowner perspectives. Titles to lands or interests in lands (conservation easements) acquired are held by the state of North Carolina. Tracts enrolled in the NC Forest Legacy Program between 2000 and 2009 are summarized in TABLE 1*d*-2.

Private forestland owners are eligible to participate in the Forest Legacy Program if their property is located within the program's designated area of eligibility. These areas of eligibility were reassessed and revised in 2008 using GIS technology. Many of the GIS layers used to identify the Forest Legacy eligibility areas were later used to help create other priority maps in

TABLE 1*d*-2.—NC Forest Legacy Tracts (enrolled from 2000 – 2009)

FY	Project	Acres	FLP Funding	Appraised Value
2000	Town Creek Phase I: Davis Farm (Brunswick County)	1,082	$1,400,000	$2,288,000
2001	Town Creek Phase II: Boise & Duckhead (Brunswick County)	1,508	$2,694,060	$2,650,000
2002	Blue Ridge Parkway Buffer: TCF (Haywood County)	328	$1,500,000	$550,000
	Blue Ridge Parkway Buffer: Roy Taylor (Jackson County)	864		$2,420,000
	Blue Ridge Parkway Buffer: TCF	222		$1,000,00
2003	RPM (Carteret County)	841	$1,490,000	$4,711,000
2004	Cool Springs (Craven County)	1,670	$1,481,209	$2,668,000
2007	Whitehurst Forest (Craven County)	181	$1,000,000	$2,047,500
2008	Clarendon Plantation (Brunswick County)	741	$1,485,000	$4,681,000
2009	Alliene LLC (Landowner = Fred Taylor)	812	$0.00 (Donation)	Not Appraised
TOTAL=		8,249	$11,050,269.00	$22,016,500.00

this document. This is particularly true of the Conserving Working Forestlands (FIGURE 1*b*-2) and Rural Forest Priority Landscape (FIGURE 1*b*-6) maps. The Forest Legacy Program's "Assessment of Need" (AON) document extensively outlines additional details of the program. A copy of the AON document, which was revised in 2010, can be found in Appendix C.

The Assessment's Impact on Future Forestry Programs

A tremendous amount of effort has gone into creating *North Carolina's Forest Resources Assessment*. The resulting information will help to shape the future of many forestry and natural resource management programs. Priority maps and the Goals/Objectives/Strategies matrix (see Chapter 5) will be used as both planning tools and assessment measures. These sources of information will help guide the decisions made by upper management personnel, and they will need to be presented to and used by field personnel if true on-the-ground impacts are to be achieved. A working example of how this could be accomplished involves an NCDFR district forester and county ranger. These two positions meet at least annually to discuss and set goals for forest management activities that are to be accomplished in a certain county. The district forester could very easily reference the Goals/Objectives/Strategies matrix, then review applicable priority maps for a county. A goal would then be set that incorporated this information. An example goal for that county might be either of the following:

- Write eight Forest Stewardship Plans this year, with at least four occurring in priority areas as designated by the Conserving Working Forest Lands priority map.

- Deliver six community wildfire protection plans, with three of them occurring in priority areas as designated by the Protecting Forests and Communities from Wildfire Risk priority map

These types of field-level goals could be established, implemented, and assessed with many forestry programs (such as Forest Health, Urban and Community Forestry, Forest Legacy), as well as with organizations beyond NCDFR. Priority maps could also be used for ranking or weighting purposes in terms of setting cost-share program rates, determining strength of applications, and other such goals.

Chapter 2. Conserving Working Forest

2.a.

North Carolina's Forests in 2007

Key Findings

- In 2007, North Carolina had 18 million acres of timberland—a gain of 362,000 acres since 2002. The gain reverses a declining timberland trend.
- Hardwood management types on timberland decreased by 489,000 acres, while softwood management types increased by 733,000 acres between 2002 and 2007. The biggest changes were in planted pine, which gained 573,000 acres, and the oak–pine management type, which lost 719,000 acres. Lowland hardwoods and natural pine also gained acreage.
- Ownership of North Carolina's timberland has shifted. Individual private ownership decreased 353,000 acres between 2002 and 2007, while private corporate ownership increased by 249,000 acres. Overall, the nonindustrial private forest (NIPF) class of ownership increased 250,000 acres and accounted for 78 percent of timberland ownership as of 2007. Forest industry ownership decreased 110,000 acres, accounting for 8 percent of timberland ownership. Public ownership of timberland increased 222,000 acres, 14 percent of timberland ownership. The National Forest System manages 46 percent of the publicly owned timberland.
- The volume of live softwood trees increased by nearly 1 billion cubic feet from 2002 to 2007. In 2007 loblolly pine accounted for 62 percent of the softwood volume and remained the predominant softwood species.
- The volume of live hardwood trees increased by nearly 2 billion cubic feet during the period from 2002 to 2007 and accounted for 66 percent of North Carolina's total wood volume. Yellow poplar was the predominant hardwood species, second only to loblolly pine in volume of all species for North Carolina.
- From 2002 to 2007, the average annual growth of softwoods exceeded annual removals by 96 million cubic feet per year. Softwood growth averaged 703 million cubic feet per year, a 13 percent increase over the period from 1990 to 2001. Planted softwoods made up 50 percent of the net annual growth, an increase of 47 percent from the 1990 to 2001 period. Softwood removals declined to 608 million cubic feet per year during 2002 to 2007. Planted softwoods accounted for 43 percent of the removals, an increase from the 1990 to 2001 period.
- From 2002 to 2007, the average annual growth of hardwoods exceeded annual removals by 218 million cubic feet per year. Hardwood growth averaged 748 million cubic feet per year, a 24 percent increase over the period from 1990 to 2001. Hardwood removals increased to 530 million cubic feet per year during 2002 to 2007.

Introduction

Information in this chapter draws heavily on the publication *North Carolina's Forests, 2002* by Brown, New, Oswalt, Johnson, and Rudis. Many of the figures were borrowed from a presentation given by Mark J. Brown at the North Carolina Forestry Association Annual Meeting, October 8, 2009 in Myrtle Beach, SC. All facts and figures for 2007 were derived from the USDA Forest Service EVALIDatorPC Version 4.0. Survey data for North Carolina was downloaded February 3, 2010 and consisted of the 370701 data set for 2003, 2004, 2005, 2006 and 2007.

Overview

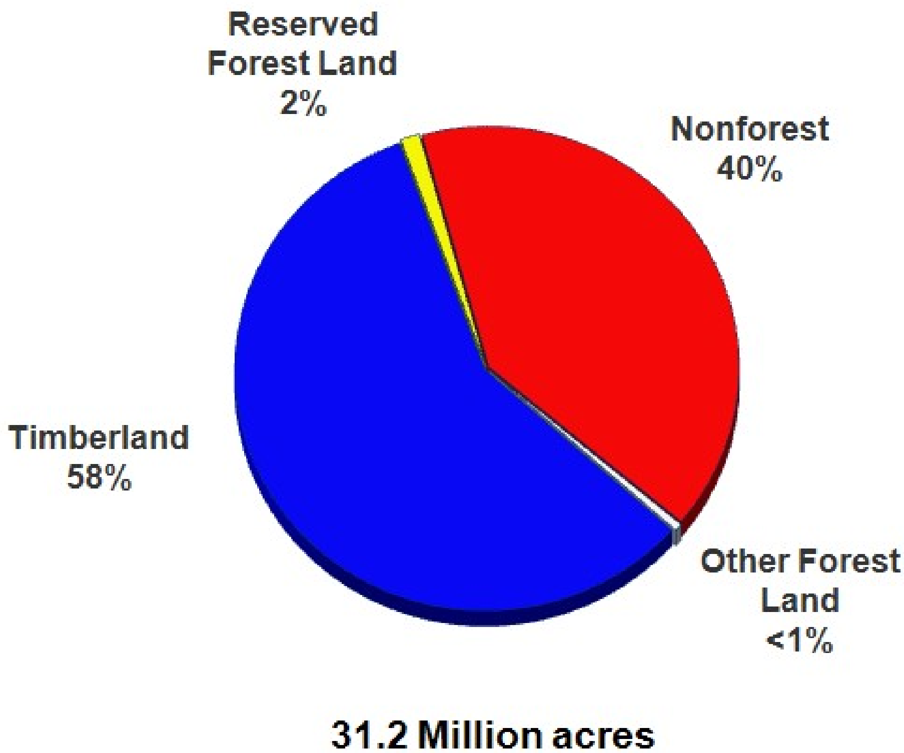
North Carolina has 31.2 million acres of land (FIGURE 2*a*-1). The 2007 forest survey found 18.6 million acres, or 60 percent of the land, to be forested. The remaining 12.6 million nonforested acres consisted of urban and industrial developments, farmland, and inland water.

Two percent of the 18.6 million forest acres were classified as reserved forestland. The 384,500 acres in this reserved status were located mostly in the Great Smoky Mountains National Park, national forest wilderness areas, and state parks. Another 156,000 forest acres were classed as unproductive because of adverse site conditions, such as rock outcrops, cliffs, or deep water.

After deduction of the reserved and other forestland acres, 18 million acres of North Carolina’s forests (97 percent) are classified as timberland. Timberland is forestland capable of growing 20 cubic feet of wood per acre per year and not reserved from cutting.

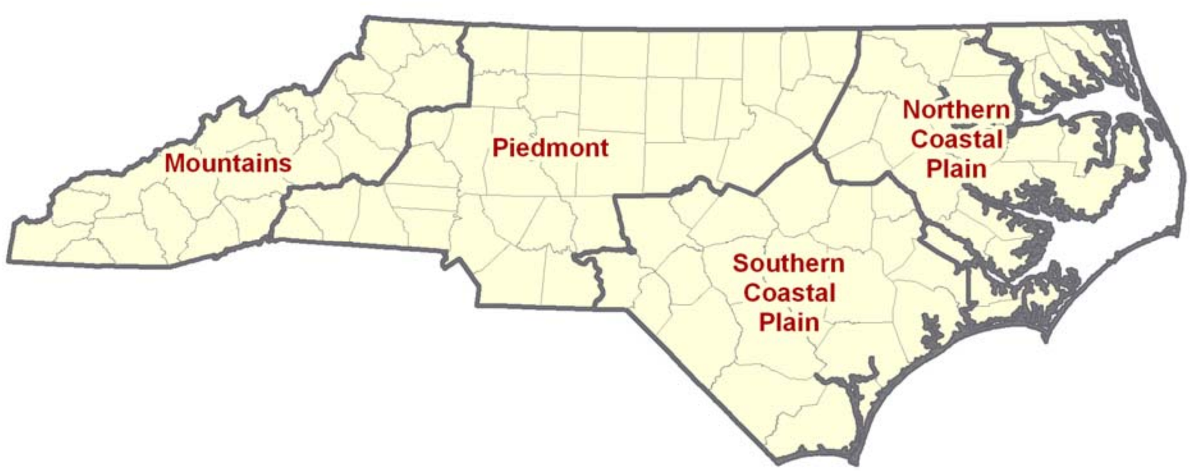
North Carolina is one of the most physiographically diverse states in the Eastern United States. Elevations range from sea level to 6,684 feet, the highest point east of the Rocky Mountains. North Carolina has more peaks over 6,000 feet than any state east of the Mississippi River. In contrast, it also has the most extensive system of barrier islands in the United States. Not far inland are pocosins and Carolina Bays, more concentrated here than in any other State. Areas of deep swamps are common in the eastern third of the state as well. North Carolina is located in three distinct physiographic provinces recognized by the U.S. Geological Survey as the Coastal Plain, the Piedmont, and the Blue Ridge. For this report, we use the designations developed by the USDA Forest Service Forest Inventory and Analysis Program (FIA) to describe North Carolina’s physiographic regions: northern and southern coastal plain, piedmont, and mountains (FIGURE 2*a*-2).

FIGURE 2*a*-1. Classification of land area in North Carolina, 2007.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

FIGURE 2*a*-2. Physiographic regions of North Carolina based upon survey unit (county) boundaries (data collected in the coastal plain units is cumulative throughout this section).



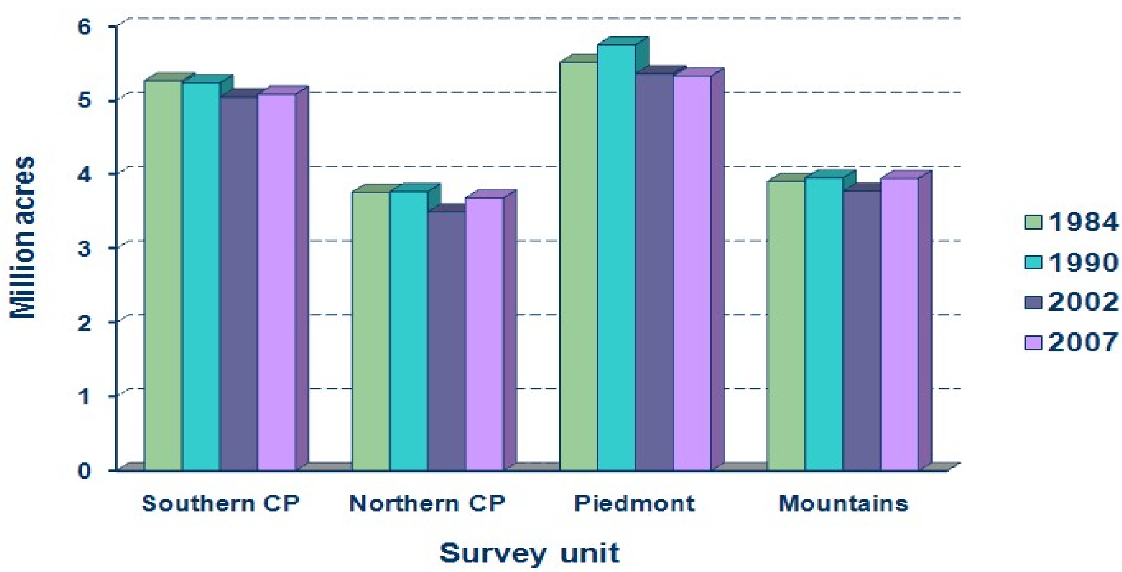
Created by: A. Bailey, NC DFR, 2010

Not only are there topographic differences among these regions, but also varying are land use, ownership, demographics, and tree species occurrence. Primary forest management issues differ among the regions as well. In the coastal plain, loss of longleaf pine is a concern. In the piedmont, the loss of shortleaf pine is a concern. In the mountains, oak regeneration and retention is a concern, along with the amount of older, overly mature stands.

The coastal plain is 59 percent forested and contains almost 49 percent of the state’s timberland (FIGURE 2*a*-3) (TABLE 2*a*-1). In addition, sizable areas exist in agricultural production. Metropolitan areas are widely dispersed. Most of the state’s softwood forest types, 72 percent, are found in this region as well. The coastal plain accounts for 80 percent of the state’s pine plantations. In fact, the majority of forest industry holdings in the state, 87 percent, are found in this region. Because the coastal plain contains the state’s lowest elevations as well as the smallest gradients in elevation, it contains most of North Carolina’s swamps and pocosins. Riverine systems are slower, more meandering, and typically of blackwater type if originating within the region. As a result of these features, most of the state’s bottomland hardwoods and cypress (a combined 84 percent) are found in the coastal plain. Loblolly pine is the most prevalent softwood type in the region, and nearly all of the state’s longleaf pine and pond pine are found there. Unique to this region of the state, Atlantic white cedar once covered large expanses but is now confined to small areas.

The piedmont has the least proportion of forest, 51 percent. Only 30 percent of the state’s timberland is found here. The piedmont contains the state’s largest metropolitan areas and the highest concentrations of people and nonforested areas (FIGURE 2*a*-4). Nonindustrial private forest (NIPF) landowners control a higher proportion of the timberland, 92 percent, than in the coastal plain and mountains. The terrain in the piedmont is much more varied than that of the coastal plain and includes a wide range of tree species. Hardwoods predominate, but mixed stands are common, with loblolly pine the most abundant

FIGURE 2*a*-3. Trends in timberland area in North Carolina by survey unit.



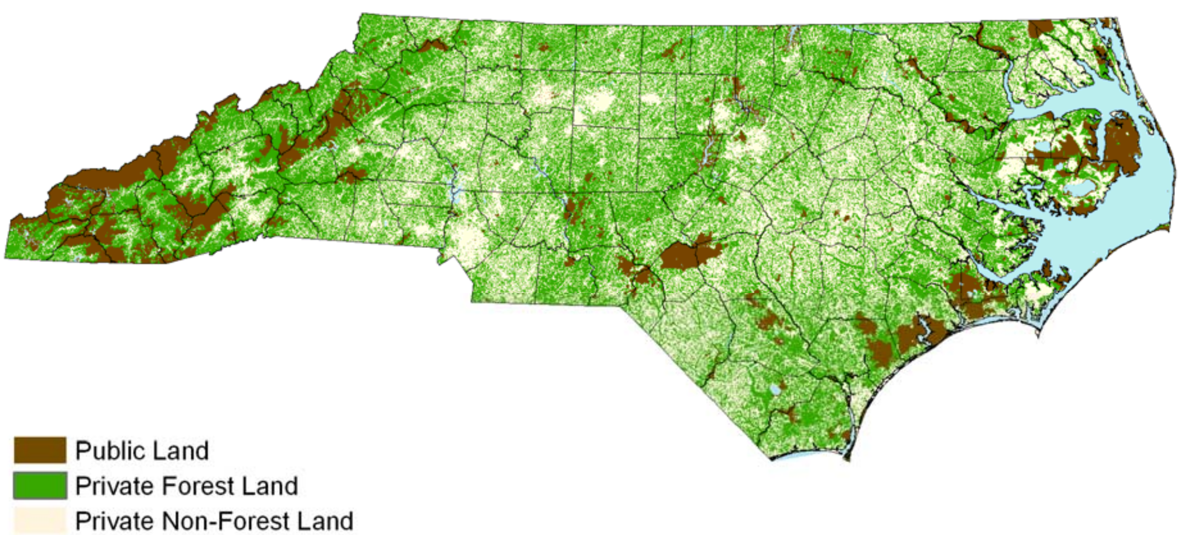
Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

TABLE 2*a*-1.—Timberland area by major species groups, forest type groups and survey unit, 2007

	Coastal Plain (Acres)	Piedmont (Acres)	Mountains (Acres)	North Carolina (Acres)
Hardwoods	**4,556,284**	**3,957,960**	**3,673,809**	**12,188,053**
Aspen / birch group	0	0	1,508	1,508
Elm / ash / cottonwood group	253,448	250,686	12,164	516,298
Exotic hardwoods group	3,775	0	2,948	6,723
Maple / beech / birch group	0	0	56,895	56,895
Oak / gum / cypress group	1,763,321	123,951	0	1,887,272
Oak / hickory group	1,388,073	2,790,366	3,110,179	7,288,618
Oak / pine group	1,141,857	792,957	380,836	2,315,650
Other hardwoods group	5,810	0	109,279	115,089
Softwoods	**4,098,975**	**1,333,748**	**263,373**	**5,696,096**
Loblolly / shortleaf pine group	3,807,672	1,305,697	115,707	5,229,076
Longleaf / slash pine group	289,850	257	0	290,107
Other eastern softwoods group	1,453	26,769	1,518	29,740
Spruce / fir group	0	0	12,063	12,063
White / red / jack pine group	0	1,025	134,085	135,110
Nonstocked	**111,287**	**35,978**	**11,644**	**158,909**
TOTAL	**8,766,546**	**5,327,686**	**3,948,826**	**18,043,058**

Source: USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

FIGURE 2*a*-4. Public land, private forest land, and private non-forest land in North Carolina, 2006.



Created by: A. Bailey, NC DFR, 2010

softwood type and Virginia pine second. The most common hardwood types are the white oak–red oak–hickory forest type followed closely by the yellow poplar–oak and the *sweetgum–yellow poplar* forest types. Riverine systems encounter more gradient; and because of the less organic soils, they are of red river bottom type.

The mountains are 76 percent forested—the highest percentage of forestland among all of North Carolina's regions. The region contains most of the state's reserved timberland, primarily in the Great Smoky Mountains National Park. The mountains have the highest proportion of publicly owned timberland in the state, mainly because this region includes the Pisgah and Nantahala National Forests. The mountains have fewer large cities and urban development than the state's other regions. The mountains contain the state's highest elevations and most rugged terrain. Because of the topography, the mountains are where the headwaters of many streams occur. Waters here are often whitewater in nature, and most are classed as freestone streams—those formed from rainfall and snowmelt. The mountains are dominated by upland hardwoods, which account for 80 percent of the region's timberland. Chestnut oak–black oak–scarlet oak forest-type stands dominate, followed by white oak–red oak–hickory forest types and then the yellow poplar–white oak–northern red oak forest type in terms of abundance. The highest elevations of the mountains also contain tree species typically occurring at more northern latitudes, such as spruce, fir, and yellow birch. White pine is the most common softwood type in the mountains, whereas the Virginia pine type is the most common yellow pine type present.

Historical Trends

The 2007 inventory was the eighth forest survey of North Carolina. The first one was completed in 1938 (Cruikshank, 1944). Forest surveys were repeated in 1956 (Larson, 1957), 1964 (Knight and McClure, 1966), 1974 (Knight and McClure, 1975), 1984 (Sheffield and Knight, 1986), 1990 (Brown, 1993) and 2002 (Brown, 2004). The 1938 survey recorded 18.1 million acres of timberland (FIGURE 2*a*-5). The late 1930s was a time of widespread family farms and part of the Great Depression era. Most of the agricultural land was in subsistence farming.

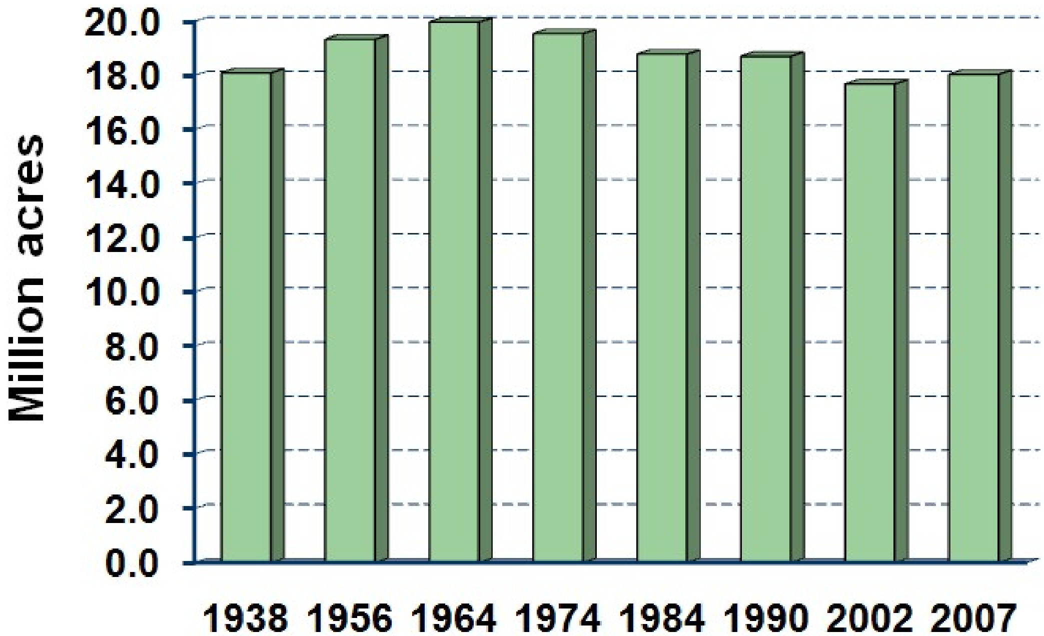
The 1956 survey recorded 19.3 million acres of timberland. The 1.2-million-acre increase since 1938 largely occurred from the reversion of many old fields to forestland as a result of industrial expansion after World War II. During this time, much of America's population left farming for work in factories, for which many relocated to urban areas (Healy, 1985).

The trend of old fields reverting to forestland continued into the 1964 survey, when timberland totaled nearly 20 million acres. This was the largest area of timberland recorded in any of the state's seven surveys. The 700,000-acre increase since the previous survey was also augmented by government programs and incentives for the planting of pines on many of the old fields instigated by the U.S. Department of Agriculture (USDA) Soil Bank Act of 1956.

By 1974, however, the increases in timberland measured by the forest survey had ended. The 1974 survey recorded 19.5 million acres of timberland in the state. Increased agricultural activity and the beginning of corporate farming largely drove the nearly 500,000-acre decline. Much of this activity occurred in the state's coastal plain because of its flat terrain and soils high in organic matter.

By the 1984 survey, another 800,000 acres of timberland were removed from the state's forests, leaving 18.8 million acres in timberland. In this decade, about half of the loss went to agriculture and half to urban development. Most of the loss to urban development took place in the piedmont, where populations and cities were beginning to grow at higher rates than elsewhere in North Carolina.

FIGURE 2*a*-5. Trends in area of timberland in North Carolina for surveys completed in 1938, 1956, 1964, 1974, 1984, 1990, 2002, and 2007.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

In the 1990 survey, timberland totaled 18.7 million acres, a decline of less than 100,000 acres. This was the shortest interval, however, between all seven surveys to date. Again, half the loss resulted from urban development and half from agricultural uses.

In 2002, the area of timberland had fallen to 17.7 million acres, the smallest amount in North Carolina since the surveys began in 1938. This was the fourth consecutive survey to record a decrease in timberland area. The decline was 1 million acres, a 5 percent decrease from the 1990 survey. Timberland accounted for 97 percent of North Carolina's forests in 2002.

In 2007, the area of timberland increased by nearly 360,000 acres to 18 million acres, a 2 percent increase from the 2002 survey. Timberland still accounts for 97 percent of North Carolina's forests in 2007.

Between 1990 and 2002, urban and other related land uses accounted for most of the diversions of timberland. Agricultural uses, a major cause of such forest diversions in past decades, were a distant second in losses in the 1990 – 2002 survey period. Population increases, primarily resulting from immigration to the state, were responsible for most of the increase in urbanization. The associated increases in urban infrastructure (such as transportation and power line rights-of-way, offices and industrial parks, shopping centers and malls, schools, and subdivisions) cumulatively consumed sizable areas formerly classed as timberland. Although timberland declined in all the state's physiographic regions from 1990 to 2002, the piedmont suffered the highest percentage loss, despite already being the least forested region. Timberland declined 7 percent in the piedmont, 5 percent across the coastal plain, and 4 percent in the mountains. This is understandable because the piedmont contains more miles of interstate and more cities with populations greater than 100,000 than the other regions. Altogether, between 1990 and 2002 in North Carolina, diversions totaled 1.6 million acres and outpaced total additions of 0.6 million acres for a net loss of 1 million acres. Urban and related uses accounted for 63 percent of these diversions. Agricultural uses accounted for 35 percent of the diverted acreage. New water impoundments accounted for 1 percent, and timberland transferred to a reserved status made up the final 1 percent.

From 2002 to 2007, North Carolina's timberlands increased in all the state's physiographic regions except the piedmont. The mountains showed the greatest increase, gaining nearly 5 percent, followed by the coastal plain with a gain of nearly 3 percent. The piedmont lost 0.6 percent. Overall, the net change in North Carolina's timberland increased by nearly 362 thousand acres. Additions to timberland from nonforestland were about 966 thousand acres while approximately 667 thousand acres of timberland were diverted to non-timberland uses. Urbanization and agriculture accounted for 92 percent of the diversions. Losses to urbanization were more than double the losses to agriculture. Timberland transferred to a reserved status accounted for 7 percent and new water impoundments accounted for the remaining 1 percent.

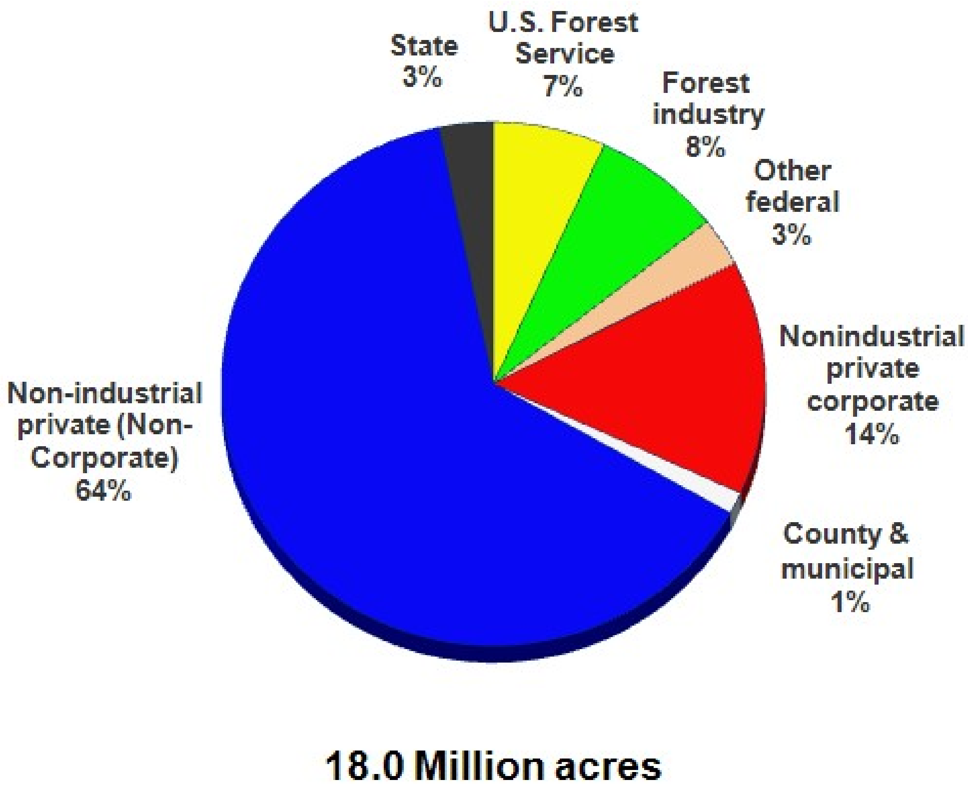
Ownership

In 2007, timberland owned by noncorporate, nonindustrial private landowners totaled 11.5 million acres and accounted for 64 percent of all timberland in the state (FIGURE 2*a*-6). Timberland owned by private nonindustrial corporations totaled 2.6 million acres and accounted for 14 percent of all timberland. Together, these individual and corporate timberlands comprise the NIPF landowner category. NIPF timberland totaled 14.1 million acres, or about 78 percent of the state's timberland.

Overall, the NIPF category increased by 250,000 acres, representing an increase of 2 percent since 2002. In 2007, private individual ownership totaled 11.5 million acres, the same area reported in the 2002 survey (FIGURE 2*a*-7). Although private ownership has remained nearly flat since the 2002 survey, the overall trend has been declining for several decades. In contrast, the 2.6 million acres in the private corporate group increased by 11 percent since 2002 and has been increasing for decades. This signifies either a real change in ownership from private individuals to entities like timber investment management organizations (TIMOs), or a trend toward incorporation by private landowners, or both.

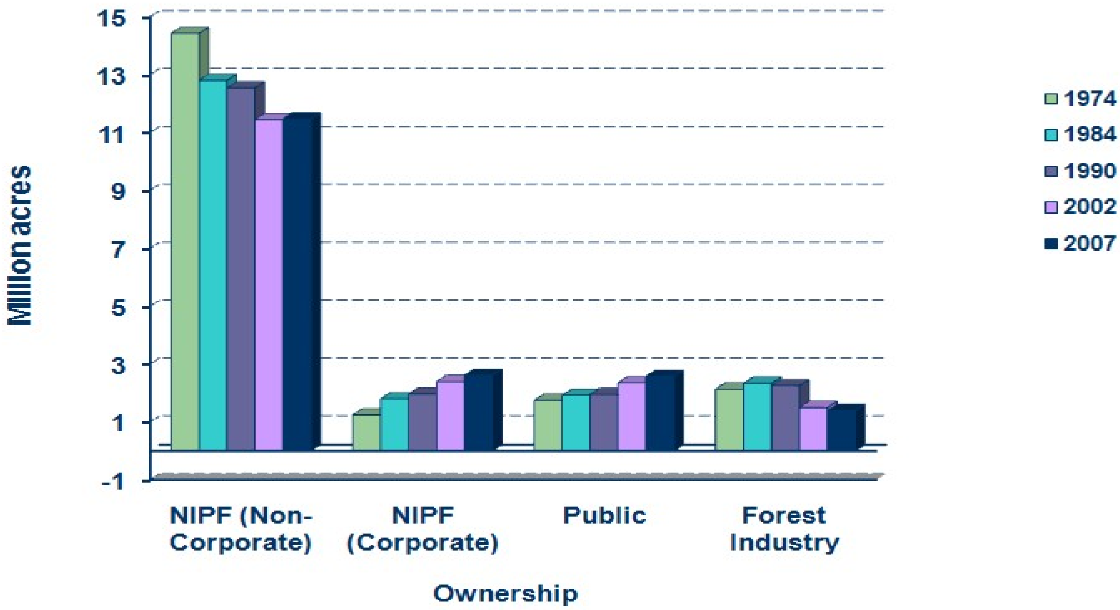
NIPF ownership varied among the state's regions. The proportion of a region's timberland under NIPF ownership was highest in the piedmont: NIPF landowners

FIGURE 2*a*-6. Area of timberland by ownership in North Carolina for the 2007 survey.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

FIGURE 2*a*-7: Ownership trends for timberland in North Carolina.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

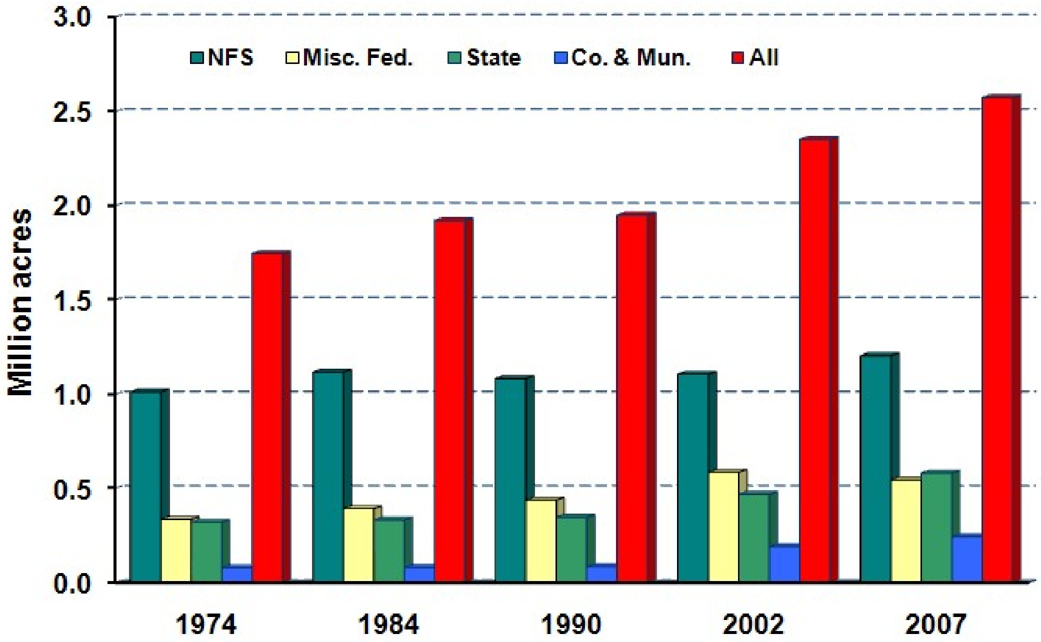
controlled 91 percent of the timberland in that region. The proportion under NIPF ownership was 74 percent across the coastal plain and 70 percent in the mountains.

Timberland owned by the forest industry totaled 1.4 million acres and accounted for 8 percent of all timberland in the state. From 2002 to 2007, forest industry holdings in the state have decreased by 7 percent, a continuation of the declining trend North Carolina has been witnessing since the 1980s, when industry holdings peaked at 2.3 million acres. In 2007, forest industry ownership was concentrated in the coastal plain. Forest industry ownership accounted for 14 percent of coastal plain timberland. Forest industry owned only 3 percent of piedmont timberland and just 1 percent of the timberland in the mountains.

Timberland owned by all public agencies totaled nearly 2.6 million acres and accounted for 14 percent of all timberland in the state. Public ownership of timberland has continued to increase by about 10 percent since 2002.

National forest system (NFS) lands comprised almost a half (47 percent) of the state's publicly owned timberland (FIGURE 2*a*-8) with 1.2 million acres. Miscellaneous federal lands, accounted for 545,000 acres, slightly more than a fifth of the total public timberland. State ownership of timberland accounted for 581,000 acres or about 23 percent of all public timberland. Local governments made up the remaining 243,000 acres of public timberland. The area of NFS lands has remained somewhat stable for decades, but did show a 9 percent increase in timberland from 2002 to 2007. Most NFS lands (85 percent) are located in the mountains. Publicly owned timberland was not equally distributed among the regions. Public ownership was highest in the mountains—29 percent of the timberland—largely due to NFS holdings. Public ownership accounted for 12 percent of coastal plain timberland, largely a combination of military, national forest, and state forest holdings. The lowest proportion and the fewest acres were found in the piedmont, where just 7 percent of the timberland was under public ownership.

FIGURE 2*a*-8: Ownership trends for public agencies in North Carolina.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

Public Land Ownership

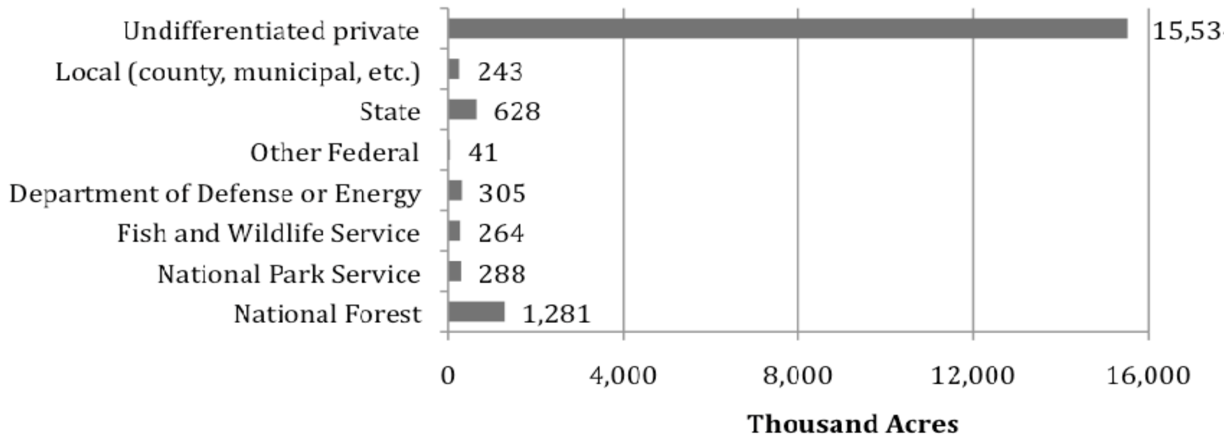
The state of North Carolina is fortunate to have many land management agencies that provide a diversity of public and social benefits to its citizens. Of the total forestland in NC, approximately 83 percent of is privately owned and 17 percent is publically owned (FIGURE 2*a*-4). State and local governments own approximately 29 percent of the public land and 71 percent is owned and managed by Federal agencies (FIGURE 2*a*-9).

The NC Division of Forest Resources (NCDFR) has a long history of collaborative efforts with public land management agencies on projects regarding forest management, forest health, fire suppression, prescribed burning, endangered species management, and forest fuel mitigation. NCDFR works with partners to provide technical assistance, training workshops and emergency response resources.

Over the years, NCDFR has collaborated on many ecological and silvicultural research studies for both pine and hardwood silviculture on several National Forests and state owned land. These research partnerships help to transfer new technology and management techniques to private landowners regarding forest management in North Carolina. NCDFR works very closely with the NC Wildlife Resources Commission with management activities beneficial to wildlife habitat or to ensure public access is available for hunting, nature enjoyment, and recreation.

NCDFR along other public land management agencies has been very active in promoting and providing assistance for prescribed burning. The NCDFR actively conducts prescribed burning on state owned land to manage for Red-cockaded Woodpecker (RCW) habitat and provides assistance on National Forests and Department of Defense land that is actively managed for RCW. The Fire Environment

FIGURE 2a-9. Acres of forestland by ownership class in North Carolina.



Source: USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

Branch of NCDFR has partnered with the Nature Conservancy and USDA Forest Service (USFS) to study the smoldering combustion limits of organic soils in NC. One factor limiting the use and acceptance of prescribed fire in these wetland communities is a lack of knowledge about conditions leading to sustained organic soil consumption. The USFWS is an active partner participating in prescribed burning activities and cooperative research that will be ongoing and applied to more sites for operational burning.

The NCDFR is involved in Community Protection Plans (CPP's). The USFS Community Protection Grant Program (also known as the Steven's Amendment Grant Program) provides funding to states through the National Fire Plan to proactively prevent and mitigate wildland fire hazards that have the potential to threaten communities surrounding national forests. The program emphasizes collaborative planning to maximize mitigation and prevention efficiency.

Under this program NCDFR, USFS, local communities and other cooperators have been working together to develop a mitigation and prevention plan for each national forest in North Carolina (TABLE 2*a*-2). These plans serve as a guide for the public to identify and mitigate wildland fire hazards that threaten the communities and privately owned land surrounding National Forests.

TABLE 2*a*-2.—Summary of NC CPP Activity by Fiscal Year and National Forestland

North Carolina CPP Activity Report	FY 2007-08	FY 2008-09
Total Acres Treated	1891	2873
Acres Treated by National Forest Location		
Uwharrie NF	1891	1924
Croatan NF		348
Nantahala NF		420
Pisgah NF		181

Source: NCDFR CPP Accomplishment Data 2009

Work is currently being performed in districts where national forestland is located and includes NCDFR districts 1, 2, 3, 4, 9, and 10. The criteria for areas to be included in the plan and receive grant funding are; 1) the area must be within three miles of a national forest boundary and 2) be considered a community at risk from wildfire. As long as the area meets these conditions, work can be performed on both private and public lands. The overall goal of the Community Protection Grant Program is to maximize acreage treated in the wildland-urban interface (WUI) that share boundaries with national forestland. Sites within WUI areas receive top funding priority for potential grant projects.

The Department Defense has a strong presence in North Carolina with bases and facilities operated by the US Army, US Marine Corp, US Air Force, and NC National Guard. The major installations of Fort Bragg (Army), Camp Lejeune (Marines), Pope Air Force Base, MCAS Cherry Point (Marines), Dare County Range (Air Force), and Camp Butner (NC National Guard) own and manage large areas of forestland used primarily for training purposes (TABLE 2*a*-3). The military's forestlands contain significant natural areas as well as threatened and endangered species. NCDFR provides technical assistance for forest management as requested and has cooperative agreements with the military services for wildfire suppression response.

TABLE 2*a*-3.—Acres of land owned by major military installations in NC

Major Military Installation	Acres owned (includes non-forestland)
Pope AFB	1,947
Seymour Johnson AFB	4,107
Fort Bragg	160,700
Camp Lejeune	114,801
MCAS Cherry Point	13,190
Dare County Range	46,595
Camp Butner	4,800

Source: DoD Base Structure Report FY 2008

Development encroachment adjacent to military lands and operational areas threatens our military's ability to train. Farming, ranching, and forestry are compatible with military land use. North Carolina has established the NC Working Lands Group as a collaborative means to protect farm, forest and ranch lands around military installations while resulting in net agricultural, environmental, natural resource, and economic and military readiness benefits.

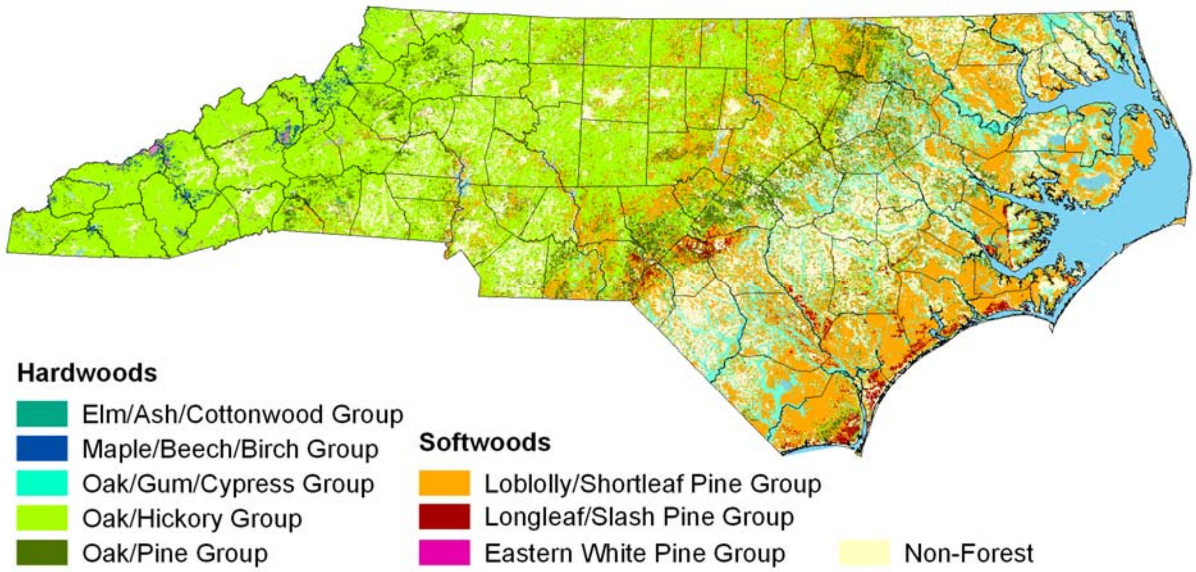
The Southeast Regional Partnership for Planning and Sustainability (SERPPAS) is multistate collaborative partnership between the Department of Defense, other federal agencies, and state environmental and natural resource agencies. SERPPAS works to prevent encroachment around military lands, to encourage compatible resource-use decisions, and to improve coordination among regions, states, communities, and military services. The region covered by SERPPAS includes the states of North Carolina, South Carolina, Georgia, Alabama, and Florida. NCDFR supports SERPASS objectives and participates in its Longleaf program.

The NCDFR is actively involved in many other collaborative projects and activities with public land management agencies within the state. The NCDFR Urban and Community Forestry Program cooperates with municipal and county governments on open space and green infrastructure planning. NCDFR also assists local governments with forest and water quality management on public water supply watersheds.

Forest-Type Groups

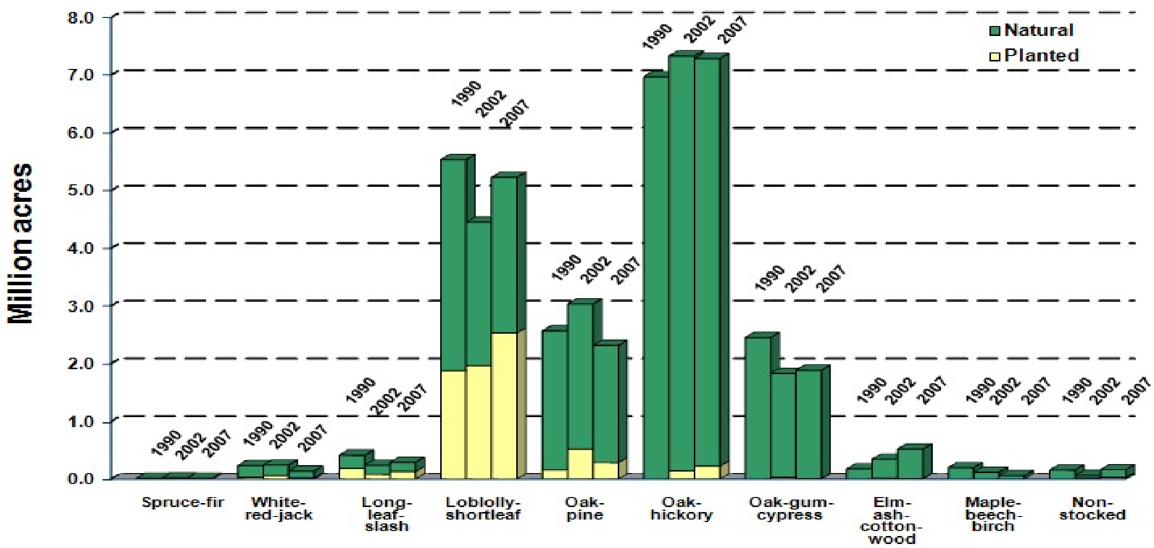
Due to the numerous and diverse forest types across North Carolina, groupings were used to portray the composition of forests (FIGURE 2*a*-10) and the recent trends in their area (FIGURE 2*a*-11). Oak–hickory types were clearly the state's predominant forest-type group, covering some 7.3 million acres. The oak–hickory type group decreased in area by less than 1 percent

FIGURE 2*a*-10. Forest-type groups of North Carolina.



Created by: A. Bailey, NC DFR, 2010

FIGURE 2*a*-11. Trends in area of timberland by forest-type groups and stand origin for North Carolina.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

since 2002 and accounted for 40 percent of the state's timberland in 2007.

The loblolly–shortleaf pine type group was second in abundance and covered 5.2 million acres. This group included Virginia-pine and pond pine types as well. The loblolly–shortleaf group increased in area by 17 percent during 2002 to 2007 and accounted for 29 percent of all timberland in 2007. Planted stands accounted for 49 percent of the loblolly–shortleaf group (fig. 10), or nearly 2.5 million acres. The increase in planted pine in the loblolly–shortleaf group accounted for 73 percent of the group's total increase.

The total area of the oak–pine type group decreased 24 percent to 2.3 million acres in 2007. The area of planted oak–pine decreased 45 percent below the 2002 level; and in the 2007 survey, 12 percent of the oak–pine stands had evidence of planting. Planted oak–pine stands have usually resulted from significant hardwood competition and stocking ratios that precluded classification as a pine type. Many of these stands originated as pine plantations. Over time and due to natural succession, hardwoods invaded and thrived, and the distribution of species changed to a mixed stand. Planting without site preparation or lack of other stand treatments would expedite the change in type.

The area of the oak–gum–cypress type group increased 3 percent to 1.9 million acres in 2007, following a 25 percent decrease from 1990 to 2002. The reasons for the large decrease from 2002 to 1990 are unclear. Possibly reclassification to oak–hickory or oak–pine types captured some of these acres. Slight changes in stocking, particularly for samples located in transition zones, can alter type classification. Another possible explanation may reside in the change of sample designs between surveys.

After nearly two decades of decreases in planting for the longleaf–slash pine forest-type group, the period from 2002 to 2007 saw a 55 percent increase. Natural stands experienced a 5 percent increase during the same period. Total acreage increased by 52,000 acres to 290,000 acres (FIGURE 2*a*-12).

All regions were dominated by hardwood types (TABLE 2*a*-1). However, their dominance differed by region. Hardwood types accounted for 93 percent of the mountains timberland, 74 percent of the piedmont, and 52 percent of the coastal plain. As one might expect, hardwood types were mostly upland in the mountains and lowland in the coastal plain.

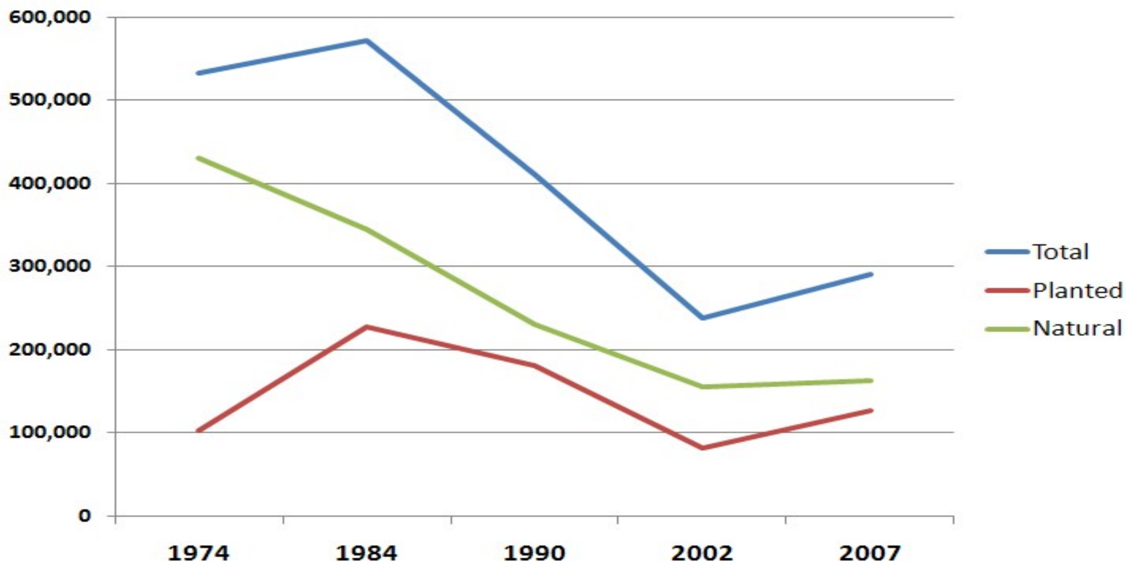
Forest-Management Types

Timberland in the preceding forest-type groups was consolidated into fewer categories, namely six forest-management types, based on a combination of stocking and stand origin. The six management types are pine plantation, natural pine, oak–pine, upland hardwood, lowland hardwood, and nonstocked. This consolidation was made to simplify portrayal of the state's timber resources.

Statewide, the area classified as pine plantation increased by 27 percent, from 2.1 to 2.7 million acres between 2002 and 2007 (FIGURE 2*a*-13), and accounted for 15 percent of the state's timberland. However, this timberland was not evenly distributed across the state. Pine plantations decreased in the mountains by 41,000 acres (TABLES 2*a*-4 and 2*a*-5). The piedmont gained 30,000 acres of pine plantations, and the coastal plain gained 583,000 acres. Eighty percent of all pine plantations in the state occurred in the coastal plain, where 24 percent of the timberland was in pine plantations. Pine plantations made up 9 percent of the piedmont timberland and less than 1 percent of the mountains timberland.

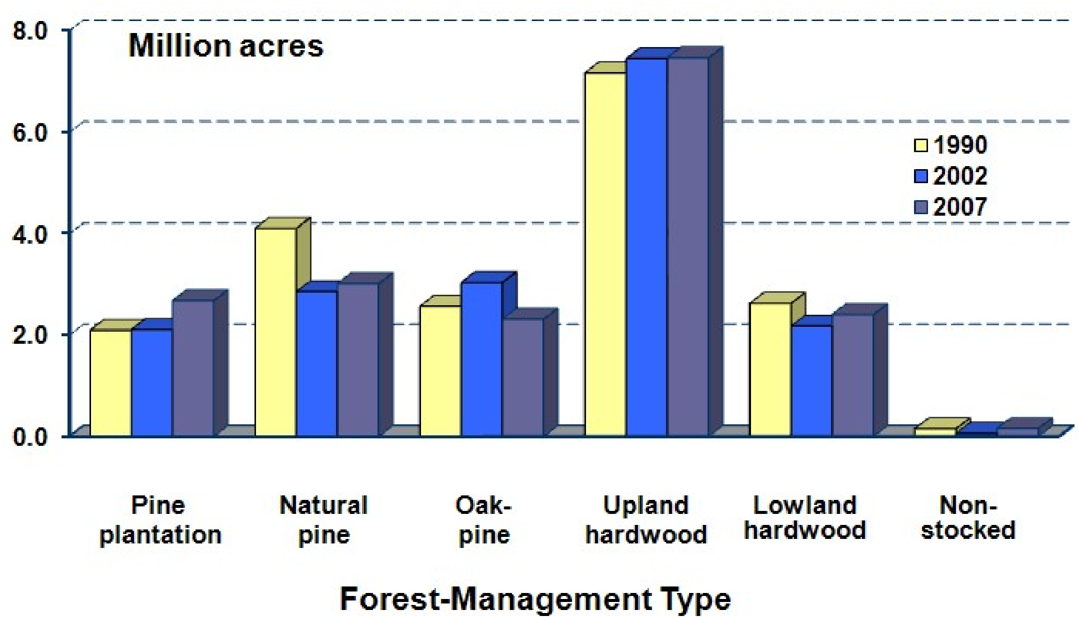
Between 2002 and 2007, the area of natural pine stands decreased by 7 percent in the piedmont and 24 percent in the mountains. The decrease was offset by a 293,000-acre increase in the coastal plain, resulting in an overall increase for North Carolina of 6 percent. Natural pine stands made up 17 percent of all timberland in 2007, compared with 16 percent in 2002 and 22 percent in 1990. Timberland classified as oak–pine forest-management type decreased by 719,000 acres in 2007, an overall decrease of 24 percent. The overall percentage of timberland represented by the oak–pine

FIGURE 2*a*-12: Timberland trends for the longleaf–slash pine type group.



Source: USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

FIGURE 2*a*-13. Area of timberland by forest-management type.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

TABLE 2a-4.—Timberland acres by survey unit and forest management type for survey years 2002 and 2007.

Timberland Acres	Coastal Plain	Piedmont	Mountains	Total
2002	**8,270,029**	**5,492,040**	**4,036,702**	**17,798,771**
Lowland Hardwoods	1,922,677	247,801	2,789	2,173,267
Natural Pine	1,663,746	891,763	300,751	2,856,260
Nonstocked	111,287	35,978	11,644	158,909
Oak-Pine	1,615,413	1,053,210	365,878	3,034,501
Planted Pine	1,559,248	472,922	74,831	2,107,001
Upland Hardwoods	1,397,658	2,790,366	3,280,809	7,468,833
2007	**8,766,545**	**5,327,687**	**3,948,826**	**18,043,058**
Lowland Hardwoods	2,016,769	374,637	12,164	2,403,570
Natural Pine	1,956,414	830,384	229,487	3,016,285
Nonstocked	111,287	35,978	11,644	158,909
Oak-Pine	1,141,857	792,957	380,836	2,315,650
Planted Pine	2,142,560	503,365	33,886	2,679,811
Upland Hardwoods	1,397,658	2,790,366	3,280,809	7,468,833

Source: USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

TABLE 2*a*-5.—Change and percent change in timberland acres by survey unit and forest management type for survey years 2002 and 2007.

Change in Timberland Acres	Coastal Plain	Piedmont	Mountains	Total
2002 to 2007	**496,516**	**-164,353**	**-87,876**	**244,287**
Lowland Hardwoods	94,092	126,836	9,375	230,303
Natural Pine	292,668	-61,379	-71,264	160,025
Nonstocked	0	0	0	0
Oak-Pine	-473,556	-260,253	14,958	-718,851
Planted Pine	583,312	30,443	-40,945	572,810
Upland Hardwoods	0	0	0	0

Percent Change in Timberland Acres	Coastal Plain	Piedmont	Mountains	Total
2002 to 2007	**6.0%**	**-3.0%**	**-2.2%**	**1.4%**
Lowland Hardwoods	4.9%	51.2%	336.1%	10.6%
Natural Pine	17.6%	-6.9%	-23.7%	5.6%
Nonstocked	0.0%	0.0%	0.0%	0.0%
Oak-Pine	-29.3%	-24.7%	4.1%	-23.7%
Planted Pine	37.4%	6.4%	-54.7%	27.2%
Upland Hardwoods	0.0%	0.0%	0.0%	0.0%

Source: USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

group dropped from 17 percent to 13 percent. Losses of 474,000 acres in the coastal plain and 260,000 acres in the piedmont were largely responsible for the overall decrease. The mountains gained 15,000 acres in the oak-pine forest management type between 2002 and 2007. Part of the overall decrease in the oak–pine forest-management type can be explained by increases in the pine component. Stands in which the pine component constituted a plurality of the stocking would have caused the reclassification of oak–pine type to either the pine plantation or natural pine management type.

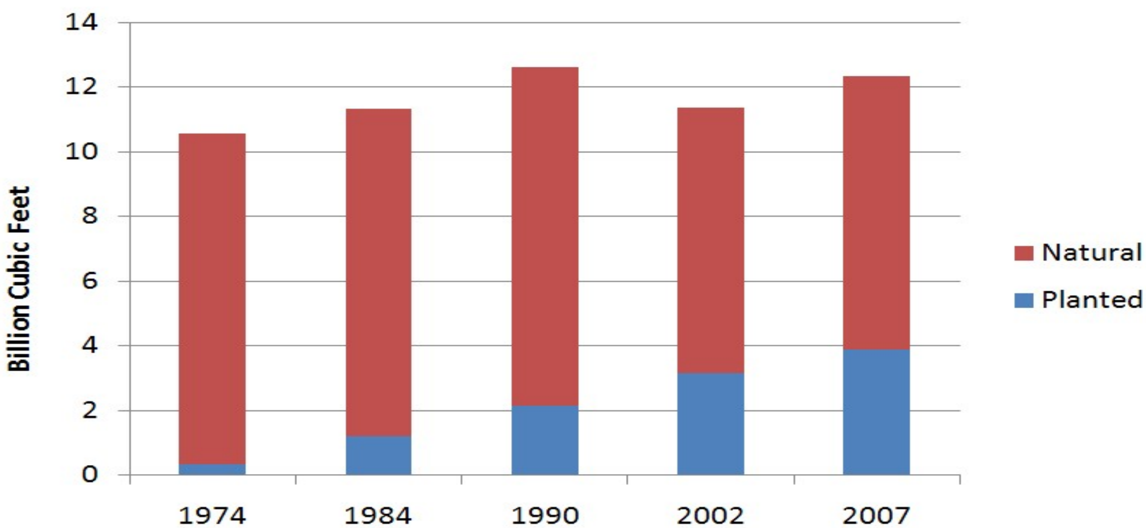
According to the 2007 survey, the area classified as upland hardwood type did not change from 2002 and remains at 7.5 million acres. Upland hardwood stands accounted for 41 percent of the state's timberland in 2007. The area classified as lowland-hardwood forest-management type increased 11 percent to 2.4 million acres. Lowland hardwood stands comprised 13 percent of the timberland in the state. Notable was a 336 percent increase in lowland hardwoods in the mountain region, bringing the total area from 2,789 acres to 12,164 acres. Lowland hardwoods in the piedmont were also significant with a 51 percent increase to 375,000 acres.

Volume

Softwood Volume

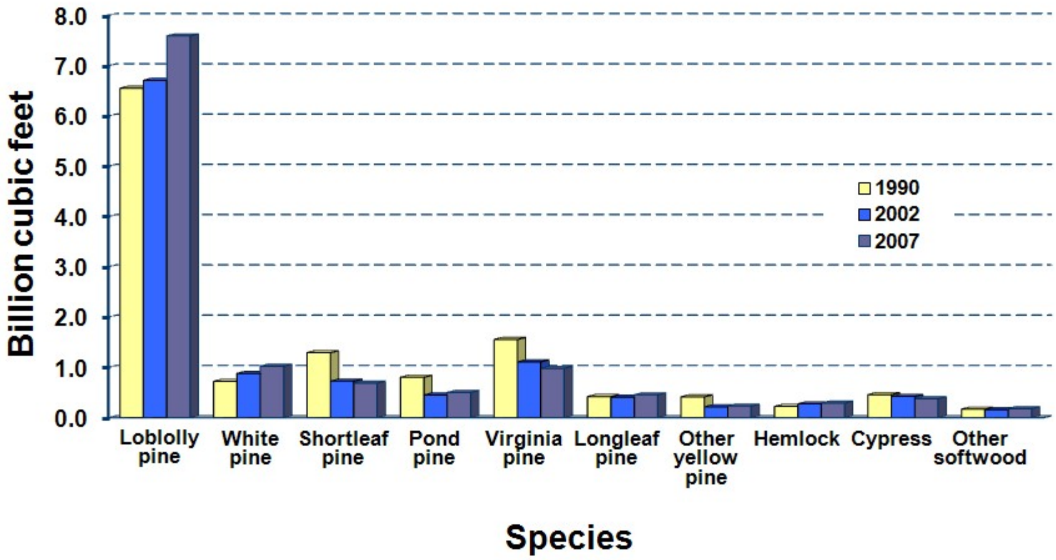
Softwood species made up 34 percent of the state's wood volume in 2007. The volume of softwood trees increased 9 percent since 2002 to 12.3 billion cubic feet (FIGURE 2*a*-14). Planted softwoods accounted for 32 percent or 3.9 billion cubic feet of the total softwood volume. This was a 23 percent increase from the 3.2 billion cubic feet of planted softwoods accounted for in 2002. Loblolly pine remains the predominant softwood species (FIGURE 2*a*-15). In addition, loblolly pine also accounted for the most volume of any single species in North Carolina, whether softwood or hardwood—7.6 billion cubic feet or 62 percent of all softwood volume. Loblolly, longleaf, pond, and slash pine all increased in volume. Shortleaf and Virginia pine continued to decrease in volume. White pine volume increased, as did hemlock. Most softwood volume was in the 8-, 10-, and 12-inch diameter classes (FIGURE 2*a*-16). Softwood volume increased in every diameter class during 2002 to 2007 and peaked in the 10-inch diameter class.

FIGURE 2*a*-14. Volume of live softwood trees on timberland by stand origin and survey year.



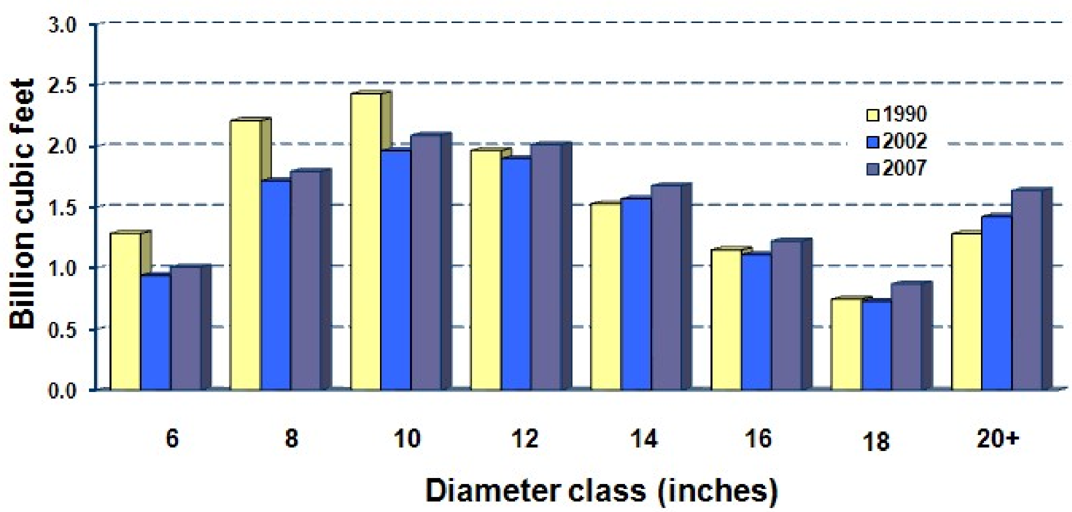
Source: USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

FIGURE 2*a*-15. Volume of live trees on timberland by species and survey year.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

FIGURE 2*a*-16. Volume of live softwood trees on timberland by diameter class.



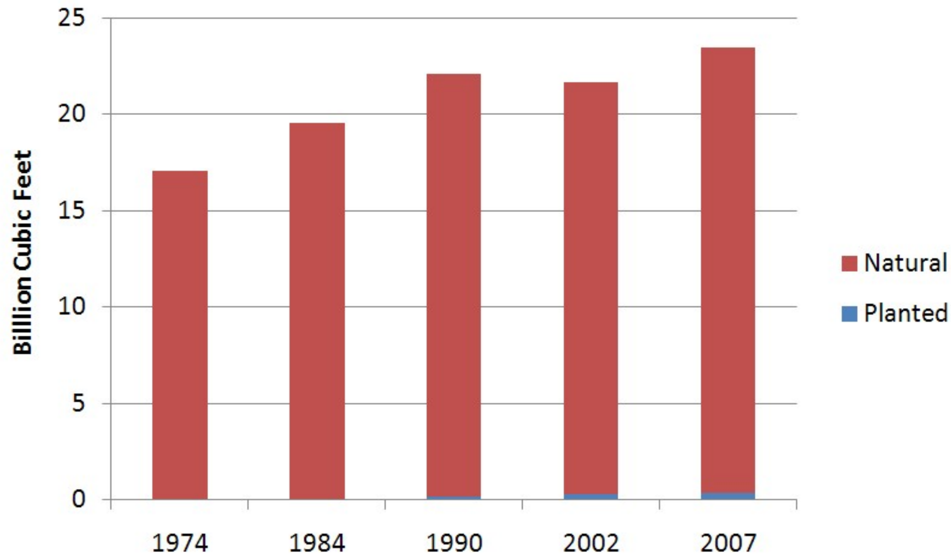
Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

Hardwood Volume

Hardwood species made up 66 percent of the state's wood volume in 2007: no change since 2002. This occurred despite an 8 percent increase in volume to 23.5 billion cubic feet (FIGURE 2*a*-17). As expected, only 1 percent of hardwood volume came from planted stands; about the same as in 2002. Yellow poplar was the predominant hardwood species, second only to loblolly pine in volume of all species in the state. Yellow poplar volume increased by 14 percent, to 4.7 billion cubic feet (FIGURE 2*a*-18). Soft maple and sweetgum were second and third in hardwood species volume. Soft maple increased in volume by 10 percent to 2.7 billion cubic feet in 2007, while sweetgum increased almost 5 percent to 2.2

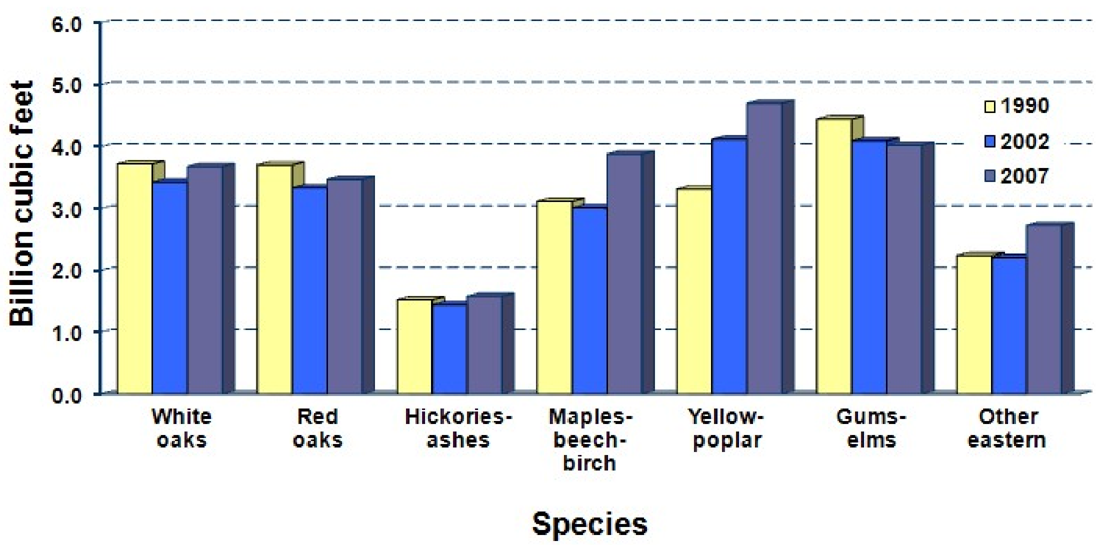
billion cubic feet. Collectively, the white oaks and the red oaks increased in volume, led by increases in chestnut oak, northern red oak, scarlet oak, and white oak. Southern red oak decreased in volume. By diameter class, hardwood volume was fairly evenly distributed compared with that of softwoods (FIGURE 2*a*-19). Hardwood volume was highest in the14-inch diameter class. Hardwood volume increased in all diameter classes between the 2002 and 2007 surveys.

FIGURE 2*a*-17. Volume of live hardwood trees on timberland by stand origin and survey year.



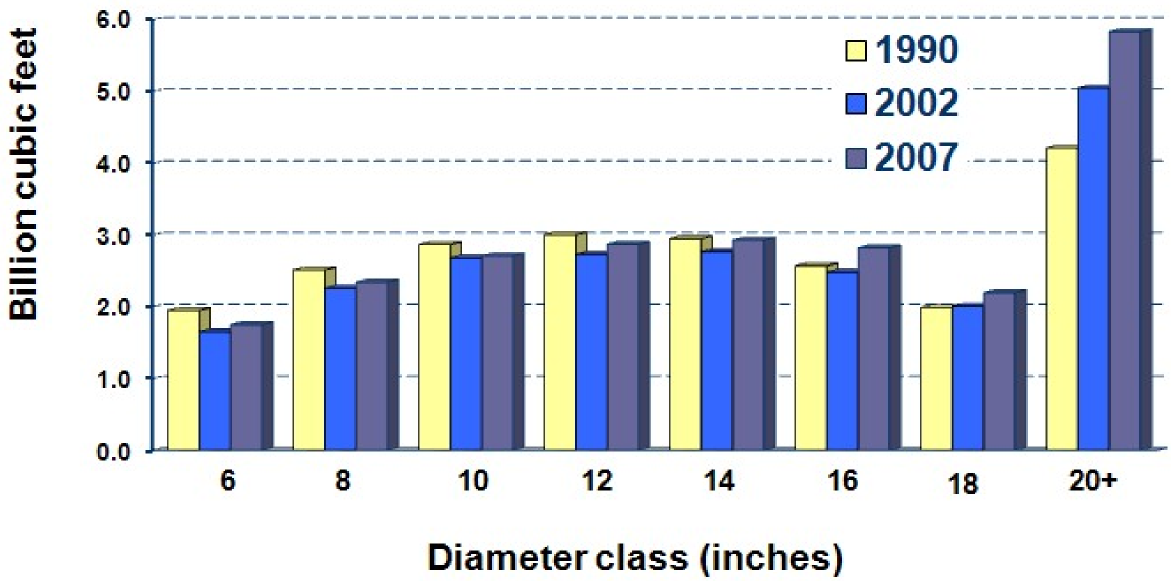
Source: USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

FIGURE 2*a*-18. Volume of live trees on timberland by species and survey year.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

FIGURE 2*a*-19. Volume of live hardwood trees on timberland by diameter class.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

Growth, Removals, and Change

The following two sections involve components of change surrounding the state's softwood and hardwood resources. Each section begins with a computed average total for growth during the remeasurement period referred to as *gross growth*. Gross growth includes growth on trees that survived since the previous survey, ingrowth, growth on new ingrowth, growth on mortality trees up until the time they died during the period, and growth on removal trees up until the time they were removed. It should be noted here that removals for FIA purposes include not only harvested trees but trees removed from timberland for other reasons, such as land clearing, conversion to urban uses, and transfer to reserved status. In addition to gross growth, the other components of change are mortality and removals. Mortality reduces gross growth to determine net annual growth, and removals reduce net annual growth to determine net change.

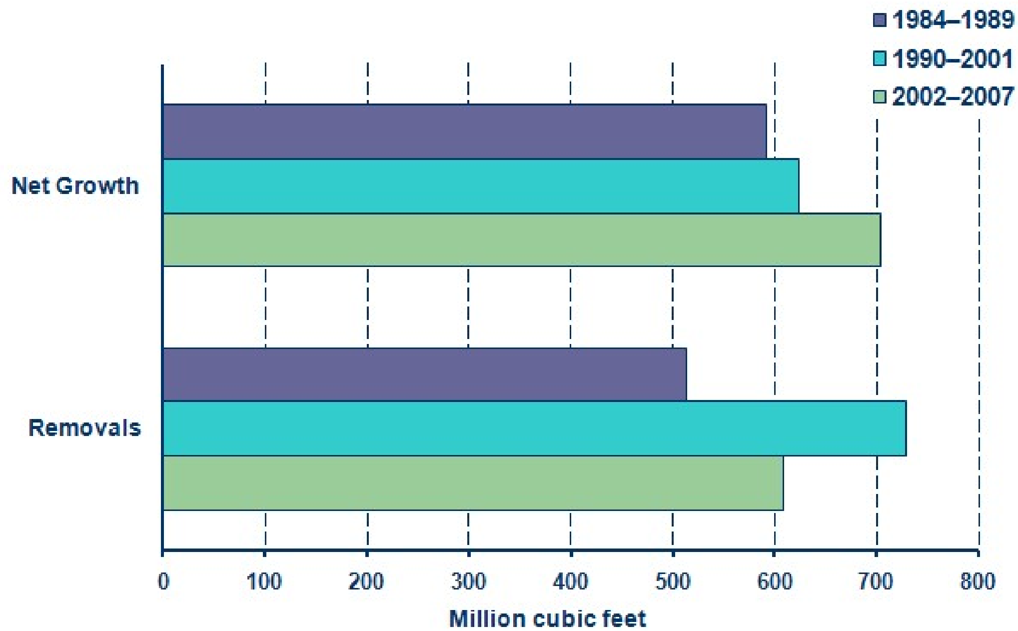
Softwood Growth, Removals, and Change

Softwoods provided 48 percent of the state's total net annual growth in tree resources. From 2002 to 2007, softwood growth averaged 703 million cubic feet annually (FIGURE 2*a*-20), an increase of 13 percent. Planted softwoods made up 50 percent or 353 million cubic feet of the softwood net annual growth during the 2002 to 2007 period. This was an increase from 47 percent or 296 million cubic feet from the 1990 to 2001 period.

Softwoods made up 53 percent of the state's total annual removals. During the 2002 to 2007 period, softwood removals averaged 608 million cubic feet annually (FIGURE 2*a*-20), a decline of 17 percent from the removals in the 1990 to 2001 period.

Planted softwoods provided 43 percent or 262 million cubic feet of the state's average annual softwood removals during 2002 to 2007. This is an increase from the removals in the 1990 to 2001 period, when planted

FIGURE 2*a*-20. Average net annual growth and removals of softwood live trees by survey period.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

softwoods accounted for 31 percent or 223 million cubic feet of total softwood removals.

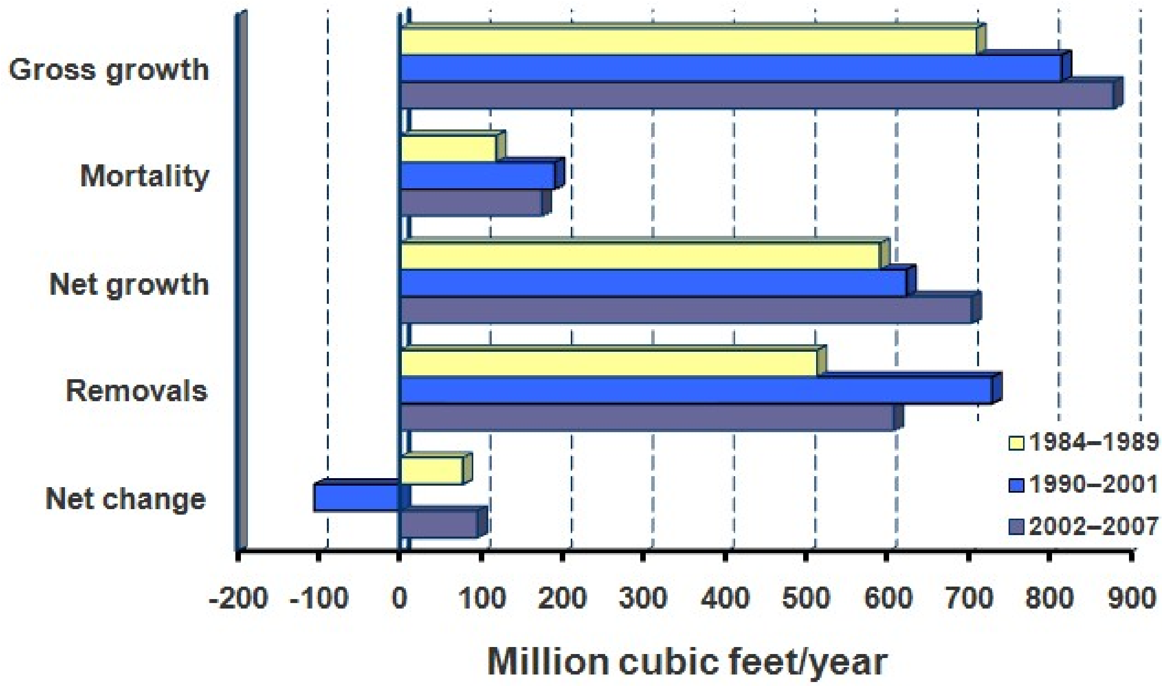
Between 2002 and 2007, annual softwood net growth exceeded net annual softwood removals by 16 percent or 96 million cubic feet. The growth and removals figures above reflect the changes that took place in the softwood resource from 2002 to 2007. A more complete look leading to net change observations in the softwood resource includes the impact of varying mortality rates and the ratio of growth to removals. FIGURE 2*a*-21 portrays how gross growth is reduced by mortality to yield net growth. Then net growth is reduced by removals to yield net change.

The impact of mortality on net change is often overlooked. Mortality is virtually uncontrollable in most cases, and largely unpredictable. The most significant mortality resulted from weather (drought, flooding, ice storms, tornados, and hurricanes), fires, and insect outbreaks. Mortality can even be species specific. From 2002 to 2007, the state's softwood resource accumulated 878 million cubic feet of gross growth per year. However, softwood mortality averaged 175 million cubic feet annually during the same timeframe. Thus, mortality reduced gross growth to 703 million cubic feet of net growth. Then the net growth was reduced by removals of 608 million cubic feet, which yielded an average net change in the softwood resource of 96 million cubic feet per year. This change reversed the negative net change of 105 million cubic feet per year experienced from 1990 to 2001.

Hardwood Growth, Removals, and Change

Hardwoods contributed 52 percent of the state's total net annual growth in tree resources. From 2002 to 2007, hardwood growth averaged 748 million cubic feet

FIGURE 2*a*-21. Components of change for softwoods by survey period.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

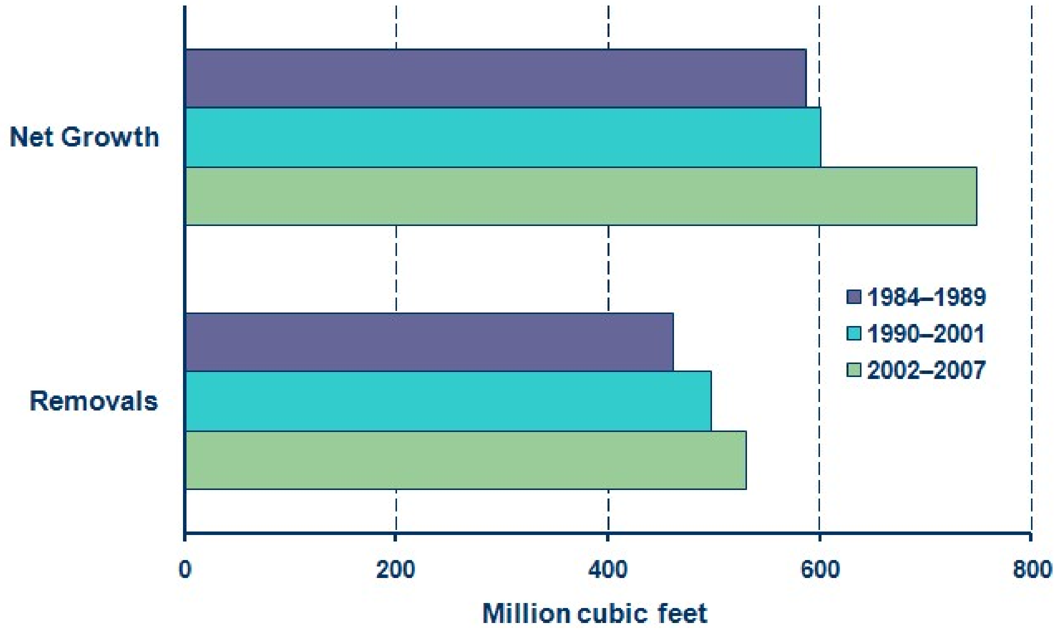
annually (FIGURE 2*a*-22) and increased 24 percent over that in the 1990 to 2001 period. Planted stands provided 4 percent of hardwood growth during the 2002 to 2007 period, an increase from that in the 1990 to 2001 period. Hardwoods made up 47 percent of the state's total annual removals. During the 2002 to 2007 period, hardwood removals averaged 530 million cubic feet annually (FIGURE 2*a*-22), a 6 percent increase from removals in the 1990 to 2001 period. Planted sources contributed 13 percent of hardwood removals during the 2002 to 2007 period.

From 2002 to 2007, net annual hardwood growth exceeded annual hardwood removals by 41 percent or 218 million cubic feet. Gross growth of hardwoods averaged 976 million cubic feet annually (FIGURE 2*a*-23). Average annual hardwood mortality of 228 million cubic feet reduced hardwood gross growth to 748 million cubic feet of net annual growth. Because hardwood removals of 530 million cubic annually were less than the net annual growth, a positive change of 218 million cubic feet annually occurred in the hardwood resource. This change follows another positive change in hardwoods recorded in the 1990 to 2001 period as well.

Summary

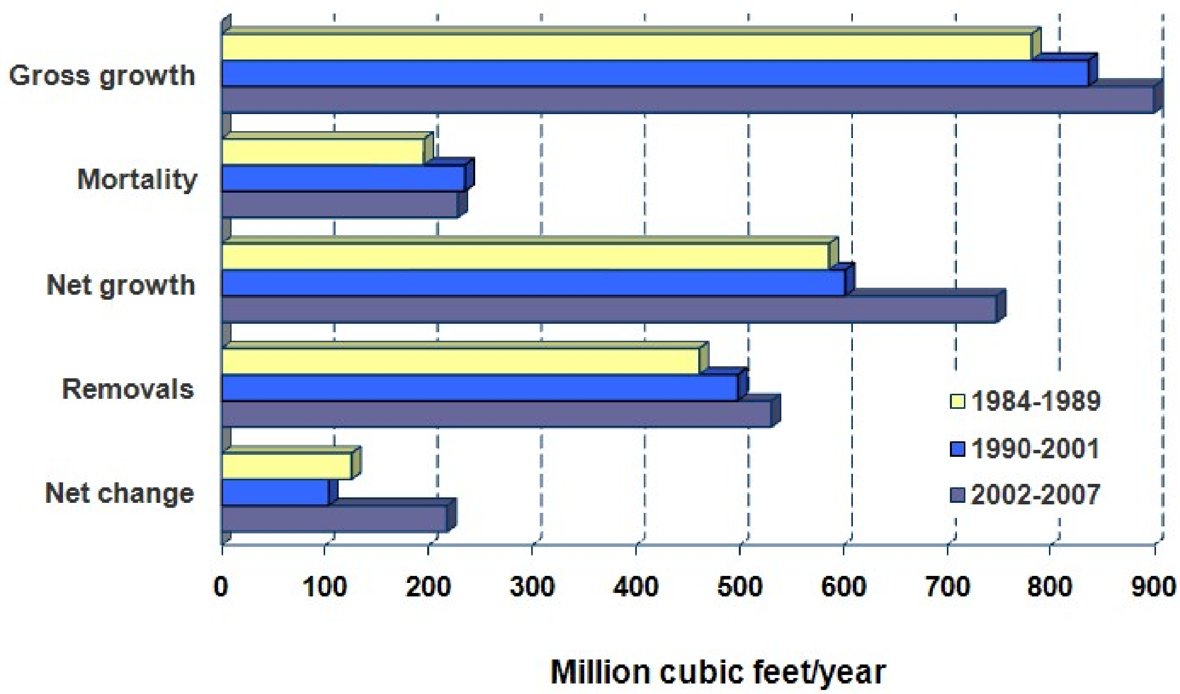
In 2007, forests covered 18.6 million acres in North Carolina, of which 18 million acres were classified as timberland. Hardwood forest types prevailed on 68 percent of timberland and planted pine stands occupied 15 percent. Nonindustrial private forest landowners controlled 78 percent of timberland, forest industry holdings declined in acreage but held at 8 percent, and publicly owned timberland totaled 14 percent. The volume of all live trees on timberland

FIGURE 2*a*-22. Average net annual growth and removals of hardwood live trees by survey period.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

FIGURE 2*a*-23. Components of change for hardwoods by survey period.



Source: Brown, M. J., 2009 and USDA Forest Service, Forest Inventory and Analysis (FIA), 2010

totaled 36 billion cubic feet, 66 percent of which consisted of hardwood. Planted pines made up 3.9 billion cubic feet of the total. Loblolly pine was the dominant individual species with 7.6 billion cubic feet. Net annual growth of all live trees averaged 1.4 billion cubic feet, and annual removals averaged 1.1 billion cubic feet. Softwoods made up 48 percent of the growth and 53 percent of the removals. Softwood growth exceeded softwood removals by 96 million cubic feet. Hardwood growth exceeded hardwood removals by 218 million cubic feet.

Map Data Sources

FIGURE 2a-2: USDA Forest Service

FIGURE 2a-4: National Land Cover Dataset 2001, NC DENR Managed Areas dataset

FIGURE 2a-10: USDA Forest Service FIA, Reufenacht et al 2008.

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Glossary

average annual mortality. Average annual volume of trees 5.0 inches diameter at breast height (d.b.h.) and larger that died from natural causes during the intersurvey period.

average annual removals. Average annual volume of trees 5.0 inches d.b.h. and larger removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use during the intersurvey period.

average net annual growth. Average annual net change in volume of trees 5.0 inches d.b.h. and larger in the absence of cutting (gross growth minus mortality) during the intersurvey period.

census water. Streams, sloughs, estuaries, canals, and other moving bodies of water 200 feet wide and greater, and lakes, reservoirs, ponds, and other permanent bodies of water 4.5 acres in area and greater.

diameter class. A classification of trees based on tree d.b.h. Two-inch diameter classes are commonly used by USDA Forest Service FIA, with the even inch as the approximate midpoint for a class. For example, the 6-inch class includes trees 5 through 6.9 inches d.b.h.

d.o.b. (diameter outside bark). Stem diameter including bark.

forestland. Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. The minimum area considered for classification is 1 acre. Forested strips must be at least 120 feet wide. Forest land includes three sub-categories: timberland, reserved forestland, and other forest land.

forest-management type. A classification of timberland based on forest type and stand origin:

Pine plantation. Stands that (1) have been artificially regenerated by planting or direct seeding, (2) are classed as a pine or other softwood forest type, and (3) have at least 10 percent stocking.

Natural pine. Stands that (1) have not been artificially regenerated, (2) are classed as a pine or other softwood forest type, and (3) have at least 10 percent stocking.

Oak–pine. Stands that have at least 10 percent stocking and classed as a forest type of oak-pine.

Upland hardwood. Stands that have at least 10 percent stocking and classed as an oak–hickory or maple–beech–birch forest type.

Lowland hardwood. Stands that have at least 10 percent stocking with a forest type of oak–gum–cypress, elm–ash–cottonwood, palm, or other tropical.

Nonstocked stands. Stands that are less than 10 percent stocked with live trees.

forest type. A classification of forestland based on the species forming a plurality of live-tree stocking. Major eastern forest-type groups are as follows:

white–red jack pine. Forests in which eastern white pine, red pine, or jack pine, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, birch, and maple.)

spruce–fir. Forests in which spruce or true firs, singly or in combination, constitute a plurality of the stocking. (Common associates include maple, birch, and hemlock.)

longleaf–slash pine. Forests in which longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

loblolly–shortleaf pine. Forests in which loblolly pine, shortleaf pine, or other southern yellow pines, except longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

oak–pine. Forests in which hardwoods (usually upland oaks) constitute a plurality of the stocking but in which pines account for 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow poplar.)

oak–hickory. Forests in which upland oaks or hickory, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent, in which case the stand would be classified oak-pine. (Common associates include yellow poplar, elm, maple, and black walnut.)

oak–gum–cypress. Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent, in which case the stand would be classified as oak–pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)

elm–ash–cottonwood. Forests in which elm, ash, or cottonwood, singly or in combination, constitute a plurality of the stocking. (Common associates include willow, sycamore, beech, and maple.)

maple–beech–birch. Forests in which maple, beech, or yellow birch, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, elm, basswood, and white pine.)

Nonstocked stands. Stands less than 10 percent stocked with live trees.

gross growth. Annual increase in volume of trees 5.0 inches d.b.h. and larger in the absence of cutting and mortality. (Gross growth includes survivor growth, ingrowth, growth on ingrowth, growth on removals before removal, and growth on mortality before death.)

hardwoods. Dicotyledonous trees, usually broadleaf and deciduous.

Soft hardwoods. Hardwood species with an average specific gravity of 0.50 or less, such as gums, yellow-poplar, cottonwoods, red maple, basswoods, and willows.

Hard hardwoods. Hardwood species with an average specific gravity greater than 0.50, such as oaks, hard maples, hickories, and beech.

ingrowth. The net volume or number of trees that grow large enough during a specified year to qualify as saplings, poletimber, or sawtimber.

land area. The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river floodplains (omitting tidal flats below mean high tide), streams, sloughs, estuaries, and canals < 200 feet wide, and lakes, reservoirs, and ponds < 4.5 acres in area.

net annual change. Increase or decrease in volume of live trees at least 5.0 inches d.b.h. Net annual change is equal to net annual growth minus average annual removals.

nonforestland. Land that has never supported forests and land formerly forested where timber production is precluded by development for other uses.

nonstocked stands. Stands less than 10 percent stocked with live trees.

other forestland. Forestland other than timberland and productive reserved forestland. It includes available and reserved forestland that is incapable of producing annually 20 cubic feet per acre of industrial wood under natural conditions, because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness.

other removals. The growing-stock volume of trees removed from the inventory by cultural operations, such as timber stand improvement, land clearing, and other changes in land use, resulting in the removal of the trees from timberland.

ownership. The property owned by one ownership unit, including all parcels of land in the United States.

national forestland. Federal land that has been legally designated as national forests or purchase units, and other land under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III land.

forest industry land. Land owned by companies or individuals operating primary wood-using plants.

nonindustrial private forest (NIPF) land. Privately owned land excluding forest industry land.

<u>Corporate</u>. Owned by corporations, including incorporated farm ownerships.

<u>Individual</u>. All lands owned by individuals, including farm operators.

other public. An ownership class that includes all public lands except national forests.

<u>Miscellaneous federal land</u>. Federal land other than national forests.

<u>State, county, and municipal land</u>. Land owned by states, counties, and local public agencies or municipalities or land leased to these governmental units for 50 years or more.

reserved forestland. Land permanently reserved from wood products utilization through statute or administrative designation.

softwoods. Coniferous trees, usually evergreen, having leaves that are needles or scalelike.

yellow pines. Loblolly, longleaf, slash, pond, shortleaf, pitch, Virginia, sand, spruce, and Table Mountain pines.

other softwoods. Cypress, eastern red cedar, white cedar, eastern white pine, eastern hemlock, spruce, and fir.

stand age. The average age of dominant and co-dominant trees in the stand.

stand origin. A classification of forest stands describing their means of origin.

Planted. Planted or artificially seeded.

Natural. No evidence of artificial regeneration.

timberland. Forestland capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization.

tree. A woody plant having one erect perennial stem or trunk at least 3 inches d.b.h., a more or less definitely formed crown of foliage, and a height of at least 13 feet (at maturity).

2.b.
Declining Forest Types

Key Findings

- The volume and extent of longleaf pine, Atlantic white cedar, and shortleaf pine, species with ecological and economic importance, has significantly declined in North Carolina.

Introduction

The mission of the North Carolina Division of Forest Resources (NCDFR) is "to develop, manage, and protect the multiple resources of North Carolina's forests." Many of North Carolina's tree species are declining because of a multitude of pressures. NCDFR recognizes the need to initiate efforts to maintain and restore declining forest types. One of the major goals for the Forest Management Section states

> "NCDFR will maintain a leadership role in promoting the restoration and enhancement of declining forest tree species and forest ecosystems."

In the face of the many threats to our state's forest resources, a need to direct more efforts towards these species and ecosystems becomes even more important.

NCDFR efforts have focused on three conifers; longleaf pine, Atlantic white cedar, and shortleaf pine. Many other species are in decline or threatened, including spruce–fir types, Table Mountain pine, hemlock, and bottomland hardwoods. Resource professionals across the state have an obligation to conserve these communities when an opportunity arises. Conditions and threats for many threatened natural communities are discussed in detail in the *North Carolina Wildlife Action Plan* and in Chapter 4, section f, of this assessment.

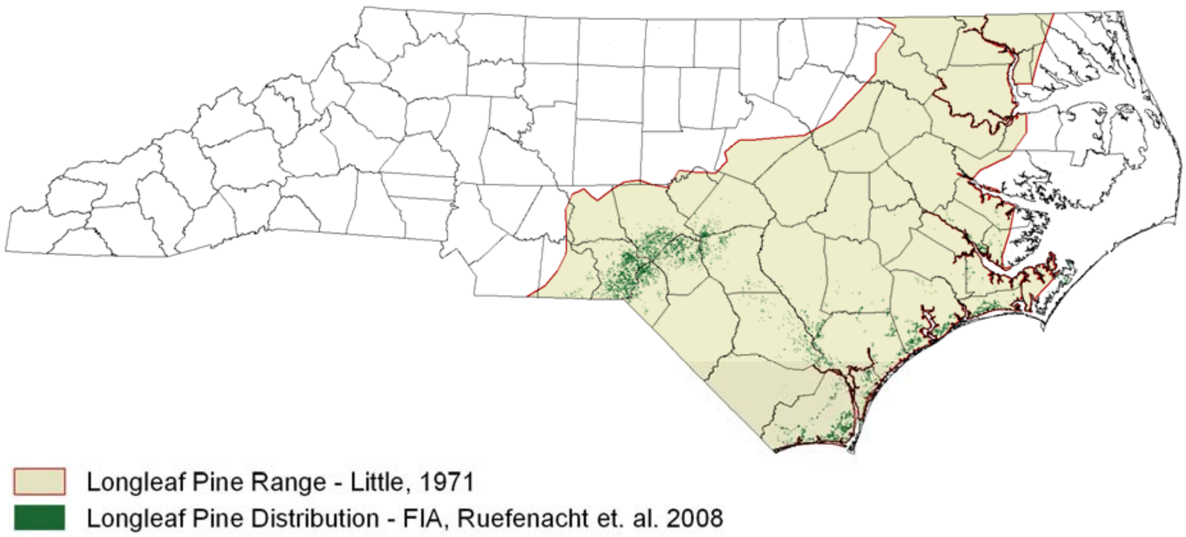
Longleaf Pine Forests

Historic Extent

Prior to European settlement, longleaf pine forests dominated the landscape of North Carolina's coastal plain and lower piedmont. Today longleaf occurs on less than 3 percent of its original range (FIGURE 2*b*-1). Longleaf pine forest is one of the most endangered ecosystems in the country. The decline of longleaf pine forests is attributed to a variety of factors, including a lack of planned management for regeneration, urbanization, harvesting, livestock grazing, and fire exclusion. USDA Forest Service FIA data reveal that North Carolina lost about 73,000 acres of longleaf pine forests between 1990 and 2007 with the majority of the loss occurring between 1990 and 2002 in the longleaf forest type and between 2002 and 2007 in the longleaf–scrub oak type (TABLE 2*b*-1).

Longleaf pine is a valuable timber species for sawtimber and pole markets. Its long needles generate a profitable landscaping mulch market. Longleaf pine is also valued for its rich and diverse ecosystem. Many rare and endangered species, including the red-cockaded woodpecker, are associated with the longleaf pine community. Longleaf ecosystems are recognized as one of the most diverse in the world. The *NC Wildlife Action Plan* provides a thorough assessment of the condition and threats to the natural

FIGURE 2*b*-1. North Carolina longleaf pine forest distribution in 2008 versus historic range.



Created by: D. Jones and A. Bailey, NC DFR, 2010

TABLE 2*b*-1.—Total area (acre) for longleaf pine type (141) and longleaf–scrub oak type (403) and ownership of combined forest types, 1990 – 2007

Survey Year	Longleaf Forest Type	Longleaf–Scrub Oak Type	Combined Total	Ownership of Combined Total			
				Public (acre, %)		Private (acre, %)	
1990	255,304	109,997	365,301	167,119	46%	198,182	54%
2002	177,461	114,605	292,066	136,046	47%	156,020	53%
2007	231,433	62,244	293,676	122,219	42%	171,457	58%

Source: USDA Forest Service, FIA

plant communities where longleaf pine is a key component (NC Wildlife Resources Commission, 2005). More efforts are needed to restore this valuable species to the landscape of North Carolina.

North Carolina Longleaf Forests Today

Based on the 2007 forest inventory of North Carolina (USDA 2010 data), the number of acres where longleaf pine is more than 50 percent of the stand stocking has increased since the 2002 survey (Brown et al., 2006). Currently, about 231,000 acres occur of the longleaf forest type. An additional 62,000 acres occur of the longleaf –scrub oak type (where longleaf pine comprises between 25 and 49 percent of the stocking, with scrub oaks, primarily turkey, blackjack, and dwarf post oaks, occupying 50 percent or more of the stand) (TABLE 2*b*-1). These two forest types combined account for about 293,000 acres of longleaf pine in North Carolina as of 2007. Fifty-eight percent of these forest types are privately owned, and 42 percent are in public ownership.

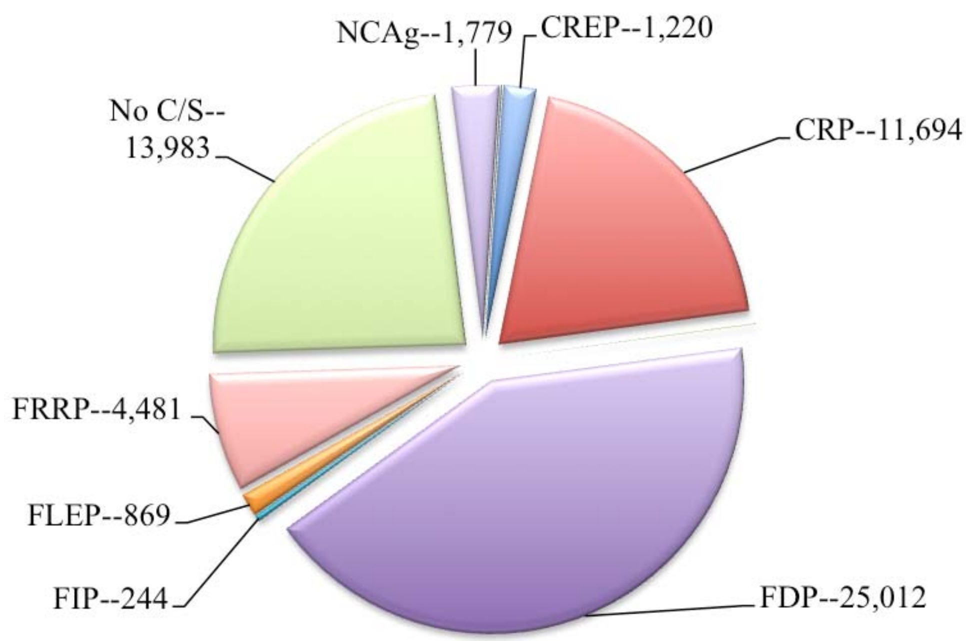
Fire exclusion has contributed to the decline in longleaf forest acreage. Of the 352 longleaf pine remnants examined by Frost (1993), only 91 stands (26 percent) were being maintained by fire. Typically, when fire is excluded from longleaf forests, these stands transition to other forest types. The best examples of remaining natural longleaf communities in North Carolina occur on Fort Bragg, the Croatan National Forest, and Sandhills Game Lands, and are maintained with regular prescribed burns.

Longleaf Restoration Efforts

According to NCDFR reports, an average of 5,642 acres of longleaf seedlings were planted between 2005 to 2009, a modest increase from an average of 5,200 acres per year from 1993 to 2004 (NCDFR, 2009). A number of cost-share assistance programs support longleaf pine establishment on private lands. North Carolina's Forest Development Program (FDP) is the primary state-administered financial assistance program supporting longleaf pine establishment. NCDFR foresters and rangers provide technical expertise and write management plans for these programs. The FDP provides an extra incentive to landowners who plant longleaf pine seedlings by reimbursing up to 60 percent of the establishment costs, a higher premium over the 40 percent cost-share rate for loblolly pine. More than 59,000 acres of longleaf pine have been established with NCDFR involvement since 1997. Of the total forestland established using cost-share funding between 1997 and 2007 (with NCDFR involvement), federal programs combined accounted for 24 percent, FDP accounted for 42 percent, and 24 percent was established with no cost-share funding (FIGURE 2*b*-2).

Recognizing the declining numbers for longleaf forests, the NCDFR implemented a Longleaf Pine Restoration Initiative in 1993. The initiative focused on artificial regeneration as the primary means to restore longleaf pine to sites where it was

FIGURE 2b-2. Acres of longleaf establishment by federal and state cost-share programs, 1997 – 2007.



Source: NCDFR 4220 database, 2010

historically found and adapted to, especially in the lower piedmont and coastal plain. A goal to double the annual number of acres planted to longleaf was proposed. Generally, the goals of the 1993 Longleaf Pine Restoration Initiative were met.

Beginning in 2006, NCDFR revised and expanded the objectives of the original initiative giving it new direction. The overall objective of the 2006 – 2010 NCDFR Longleaf Pine Restoration Initiative is to "Sustain and promote restoration of longleaf forests in North Carolina through efforts to establish new stands, conserve existing stands, and promote total resource management" (NCDFR, 2006). Specific objectives support actions in reforestation, outreach and education, research, restoration management, conservation, and collaboration.

The Longleaf Alliance (LLA) was established in 1995 with the express purpose of coordinating a partnership between private landowners, forest industries, state and federal agencies, conservation groups, researchers, and other enthusiasts interested in managing and restoring longleaf pine forests for ecological and economic benefits. North Carolina land managers and owners benefit from the LLA outreach and research efforts. NCDFR is a member of the LLA. A range-wide restoration initiative, Americas Longleaf, has recently completed a Longleaf Range-wide Conservation Plan with a goal to increase longleaf from 3.1 to 8 million acres. Another regional effort, the Southeastern Regional Partnership for Planning and Sustainability (SERPPAS), a partnership of state and federal environmental agencies and the U.S. Department of Defense, has pledged support for longleaf restoration. Numerous conservation partnerships are active in North Carolina with an interest in longleaf restoration, including Onslow Bight Conservation Forum, Cape Fear Arch, Greater Uwharrie Conservation Partnership, NC Prescribed Fire Council, Chatham Conservation Partnership**,** and Sandhills Conservation Partnership.

Recently, numerous restoration projects were funded by grants secured from the USDA Forest Service State and Private Forestry Redesign Program. In 2009 additional support was provided by the American Reinvestment and Recovery Act (ARRA). Funds from ARRA are targeted to increase longleaf seedling production, restore longleaf ecosystems, promote an education and outreach effort, and assist in the formation of a North Carolina Longleaf Coalition.

Atlantic White Cedar Forests

Historic Extent

Once a common forest type in NC coastal wetlands and waterways, the area of Atlantic white cedar has decreased to less than 10 percent of its original range. Exploitive logging, natural regeneration failure, absence of artificial regeneration, drainage impacts, fire exclusion, and lack of competition control are cited as reasons behind the decline. NCDFR has identified Atlantic white cedar as a species of concern. NCDFR supports and participates in an Atlantic White Cedar Alliance formed in 1995 by a group of researchers and land managers, including universities, state and federal government, forest industry, environmental and forest consultants, and private landowners. This informal cooperative research effort advocates for the conservation, restoration, management, and use of Atlantic white cedar across its range.

Atlantic White Cedar in North Carolina

Because of large sampling errors, attributed to the small population and limited distribution of the species, USDA Forest Service FIA data provides only an estimation of forest area of Atlantic white cedar. It does point to a continuing decline in area occupied by this species in North Carolina from 1990 to 2007 (Table 2*b*-2).

In 1997 an extensive inventory of remnant Atlantic white cedar stands was commissioned by the U.S. Air Force (Davis and Daniels, 1997). No plantations and only natural stands whose diameter at breast height (4.5 feet above ground line) exceeds six inches were inventoried. Of the 10,583 acres of mature Atlantic white cedar stands identified, 77 percent were publicly owned and 23 percent privately owned. A vast majority (88 percent) of the acres occur in the northern counties of the coastal plain: Dare, Tyrrell, Camden, Hyde, and Washington. The U.S. Fish and Wildlife Service (USFWS) Alligator River National Wildlife Refuge holds the largest stand at 4,152 acres, with the U.S. Air Force Dare County Bombing Range holding the second largest at 2,242 acres. Other populations of note are found in the Great Dismal Swamp, Sandhills, Green Swamp, and Bladen County. Hurricane Isabel and two wildfires have damaged or destroyed a significant portion of the Atlantic white cedar stands in the Great Dismal Swamp.

Shortleaf Pine Forests

Shortleaf pine, valued commercially for superior sawtimber and ecologically for its habitat diversity and integrity, has declined since European settlement. Historically periodic fire maintained shortleaf pine forests throughout North Carolina. Agricultural land clearing prior to the Civil War destroyed many shortleaf forests in the coastal plain and piedmont. When the fields were abandoned in the early 1900s, loblolly pine trees (left along waterways and poorly drained soils) replaced what was once occupied by shortleaf. In the piedmont, the removal of the valued shortleaf pine allowed hardwoods to dominate in what were formerly mixed shortleaf–hardwood stands.

Today, shortleaf pine is most prevalent in two forest types, shortleaf and shortleaf–oak, and is associated with many other hardwood and pine stands. According to the last several forest inventories, the forested area of shortleaf pine and the number of shortleaf trees occupying each acre has sharply dropped in North Carolina (Brown 2004, USDA 2010). Reasons for this decline include urbanization, especially in the piedmont, lack of management for regeneration, fire exclusion, forest conversion, and harvesting. Interest in restoration efforts is growing among state and federal agencies across the Southeast.

Table 2*b*-2.—Area (acres) of Atlantic white cedar forestland, 1990 – 2007

		Stand-age			
Survey Year	Total Acres*	0 - 20 yrs	21 - 40 yrs	41 - 60 yrs	61 - 80 yrs
1990	33,615 (28)	5,693	7,922	14,084	5,915
2002	15,215 (56)	11,603	3,613		-
2007	10,341 (72)	-	5,937	4,403	-

**value in parenthesis = percent sampling error*

Source: USDA Forest Service, FIA data, 1990 – 2007

Shortleaf Pine in North Carolina

Based on USDA Forest Service FIA data, the combined area of shortleaf pine and shortleaf pine–oak forest types has declined by 59 percent since 1990 (USDA 2010). The shortleaf pine forest type had the sharpest decline, losing almost 70 percent of its area. In 1990 the shortleaf pine forest type accounted for almost 60 percent of the total shortleaf pine area; by 2007 it dropped to 44 percent (FIGURE 2*b*-5). The basal area of the shortleaf pine stems across all forest types declined by 47 percent during that same period (Hopkins, 2006). Moser et al. (2007) found that the amount of shortleaf pine regeneration in most states was in decline, along with the overstory basal areas containing shortleaf pine. The smaller proportion of shortleaf regeneration versus overstory basal area point to a potential absence of shortleaf pine in future forests (Moser, 2007). Three-fourths of the shortleaf stands are found in the piedmont region (FIGURE 2*b*-3). In the mountains, all of the 51,458 acres with shortleaf pines were a mixed shortleaf pine–oak type suggesting pure shortleaf stands are rare there. A vast majority of the shortleaf forest type (94%) and shortleaf pine–oak forest type (79 percent) is privately owned. The bulk of the shortleaf growing stock is found in large-diameter trees. Since 1990 the age class distribution has shifted towards a predominance of older aged stands (FIGURE 2*b*-6). This decline in area of young stands reflects an overall lack of regeneration. Declining area, decreasing basal area, and lack of regeneration have discouraging implications for the future of shortleaf pine.

Shortleaf Pine Restoration Efforts

For a variety of reasons, including slow growth, susceptibility to littleleaf disease, and lack of regeneration success, artificial regeneration of shortleaf pine has lagged behind other species. According to NCDFR, an average of 110 acres of shortleaf were planted each year between 2005 and 2009 on NIPF land (NCDFR, 2009). A number of cost-share assistance programs support shortleaf pine establishment on private lands. North Carolina's FDP is the primary state-administered financial assistance program supporting shortleaf establishment, although the federally funded Environmental Quality Incentives Program (EQIP), a program of the USDA Natural Resources Conservation Service, will also fund the planting of shortleaf pine. NCDFR foresters and rangers develop management plans and provide technical expertise for these programs. The FDP provides additional incentives by reimbursing landowners for up to 60 percent of establishment costs to plant shortleaf pine seedlings compared to the standard cost-share rate of 40 percent for loblolly pine.

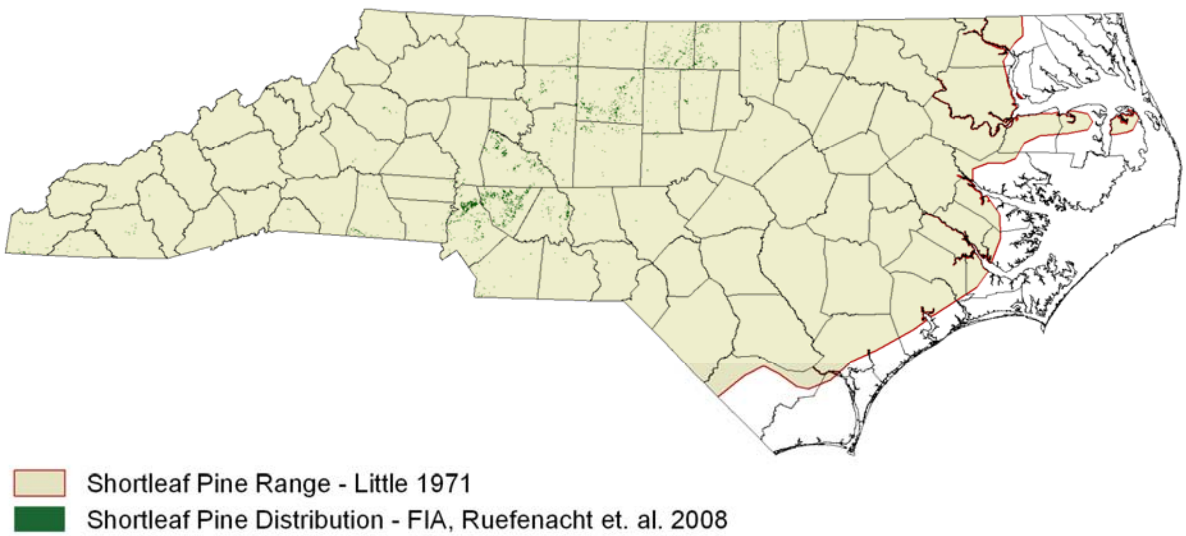
Summary

NCDFR recognizes the need to initiate efforts that maintain and restore declining forest types. In the face of the many threats to North Carolina's forest resources, the need to spotlight these species and ecosystems becomes even more important. NCDFR efforts have focused on three conifers: longleaf pine, Atlantic white cedar, and shortleaf pine.

Longleaf pine once covered a vast area of North Carolina's piedmont and coastal plain. At this writing in 2010, only a small portion of those forests remain. Numerous state agencies, federal agencies, nongovernmental organizations, resource professionals, and owners of forestland support restoration efforts and practice longleaf forest management in NC. Thanks to their efforts, the decline in longleaf pine acreage has begun to slow down and longleaf pine acreage increased between 2002 and 2007.

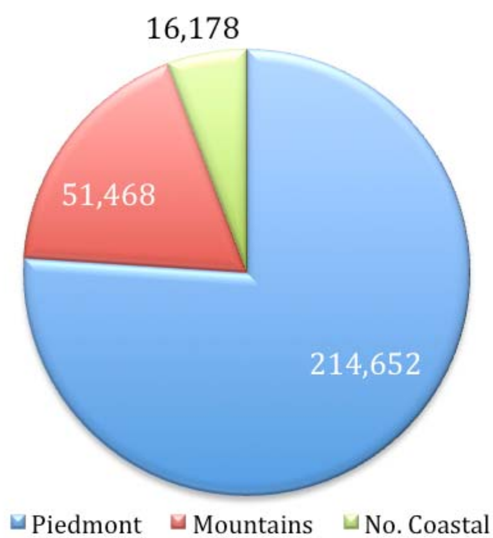
b. Declining Forest Types

FIGURE 2*b*-3. North Carolina shortleaf pine forest distribution in 2008 versus historic range.



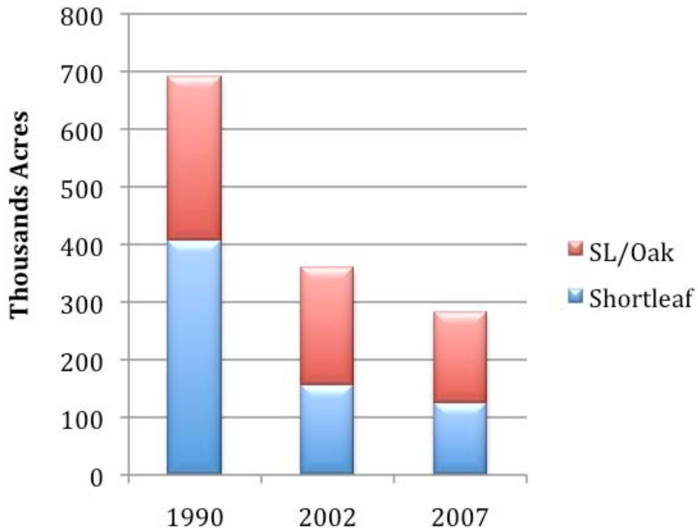
Created by: D. Jones and A. Bailey, NC DFR, 2010

FIGURE 2*b*-4. Area of shortleaf pine in acres for geographical regions of North Carolina from analysis of the 2007 forest inventory data.



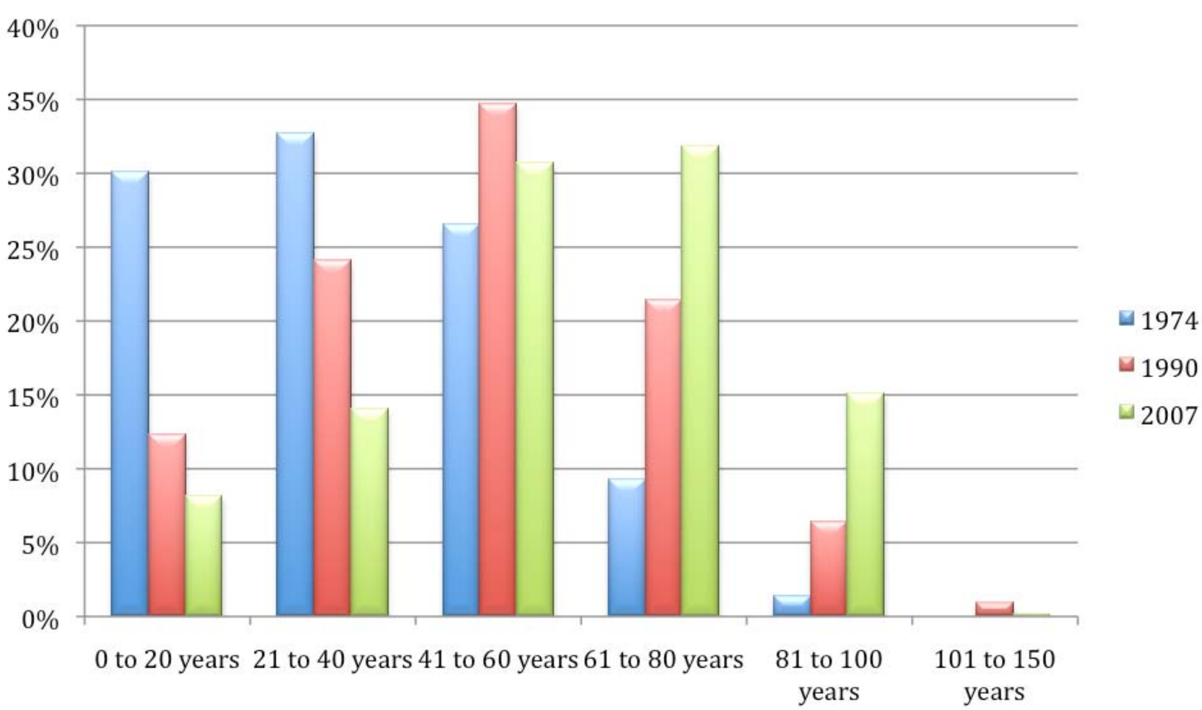
Source: USDA Forest Service, FIA data, 1990 – 2007

FIGURE 2*b*-5. Area of shortleaf pine from 1990, 2002, 2007 forest inventory data for the shortleaf pine and shortleaf pine–oak forest types.



Source: USDA Forest Service, FIA data, 1990 – 2007

FIGURE 2*b*-6. Percentage of total shortleaf pine area that shifted to older stands from analysis of the 2007 Forest Inventory Analysis data for North Carolina.



Source: USDA Forest Service, FIA data, 1974 – 2007.

b. Declining Forest Types

Atlantic white cedar, an economically and ecologically valued tree, once occupied a significant portion of North Carolina’s inner coastal plain. Today it is found on a small portion of its historic range. According to FIA data, Atlantic white cedar acreage A growing number of conservation partnerships have formed to bring longleaf pine forests back to North Carolina’s landscape. continues to decline. Because of its small distribution, an accurate assessment of Atlantic white cedar status and trends is not available. More than 75 percent of the remaining stands are publically owned. An informal group—consisting of researchers, land managers, and private landowners—advocates for the conservation, restoration, management, and use of Atlantic white cedar across its range.

Shortleaf pine was once found across most of North Carolina. It has not received the same focus commercially as loblolly pine or ecologically as longleaf pine, and has significantly diminished. According to FIA data, acreage of the two forest types most commonly associated with the species, shortleaf pine and shortleaf pine–oak forest types, declined by 60 percent from 1990 to 2007. Shortleaf pine forest acreage has dropped by almost 70 percent. The data show that North Carolina’s growing stock is getting older and is not being replaced by artificial or natural regeneration.

Many tree species and forest types have declined from their historic distribution. For some, the decline continues. Efforts are needed to quantify the extent of the loss, evaluate the health of the remnants, improve management, increase awareness, and instigate restoration action. New threats continue to pressure our state’s forests. We are obligated to constantly monitor their numbers and assess their condition and health so we don’t lose these valuable species.

Map Data Sources

FIGURE 2b-1: Little 1971, USDA Forest Service FIA, Reufenacht et al 2008.

FIGURE 2b-3: Little 1971, USDA Forest Service FIA, Reufenacht et al 2008.

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2.c.

Family and Minority Forests Ownership

Key Findings

- A 2006 survey of North Carolina landowners identified the following as the top reasons for owning forestland: passing land on to heirs, land investment, beauty or scenery, part of farm or ranch, and nature protection. Owning forestland for commercial timber production is typically not a primary reason for owning forestland.
- The majority of family forests and farms are small. Almost 90 percent of family forests are less than 50 acres with the majority less than 10 acres. Nearly seven of 10 family farms are less than 100 acres, while most are less than 50 acres.
- The size of forest and family farm holdings in North Carolina will continue to decrease from development, land use change, and generational transfer of property. This may lead to a decrease in traditional resource management activities.

Introduction

Family forests accounted for 11.19 million acres or almost 61 percent of the 18.4 million acres of North Carolina's forestland in 2006 (Butler, 2008) (TABLE 2*c*-1). About 469,000 family forest owners control family forests. More than half of family forest ownerships are small in size (less than 10 acres). Nearly 9 in 10 family forest owners have tracts that are less than 50 acres in size, yet in sum total these small-acreage owners control about 38.3 percent or 4.38 million forested acres. The proportion of timberland that is privately owned is greatest in the piedmont at 93 percent, compared to 72 percent in the coastal plain and 71 percent in the mountains.

Diverse Landowner Objectives

The recent National Woodland Owner Survey indicates that family forest owners have many different management objectives, values, and reasons for ownership (Butler, 2008). The top reasons for owning family forestland in North Carolina include the following:

- Pass land on to heirs
- Land investment
- Enjoy beauty or scenery
- Part of farm or ranch
- Protect nature and biologic diversity

These reasons were more commonly expressed by owners of smaller properties (less than 50 acres) than owners of larger properties. Owners of larger properties are more likely to own land for monetary reasons, such as investment or the

TABLE 2c-1.—Area of family-owned, private, and public forests in North Carolina, 2006

Ownership Category	Area (acres)
Family	11,194,000
Other Private	4,303,000
Total Private	15,497,000
Federal	2,090,000
State	601,000
Local	258,000

Total Public	2,949,000

Source: North Carolina's Forests, 2002 (Brown et al., 2006)

production of timber products. Given the historic decrease in size of forest holdings and the socioeconomic status of new owners (higher income, highly educated), social amenities will likely take precedence over management objectives that emphasize timber production.

Natural resources professionals who educate and serve these new forest owners will need to apply different approaches to meet the changing resource management needs of family forest landowners. Ongoing social marketing efforts, and addressing needs by type have been proposed as new approaches to addressing the needs of current and future owners with their diverse management and ownership objectives (Hermansen-Baez, 2008; Butler et al., 2007).

The Link Between Family Forests and Farms

North Carolina working forests include land that is primarily forested but may include a significant component of pasture and cropland. These working forests have the potential to produce economic benefits to the landowners. When actively managed in a sustainable manner, working forests can provide social and environmental benefits to the public.

Many farm properties are forested to some degree; thus, the fate of rural forests is directly linked to that of farms. The conservation of working forests in North Carolina will become increasingly more important for the long-term sustainability of open space, forest productivity and health, and wildlife habitat. The most obvious landscape effects of human activities from our state's increased urbanization are the reduction of open space (forestland and cropland) and the fragmentation of our remaining working forests and farms into smaller, isolated parcels.

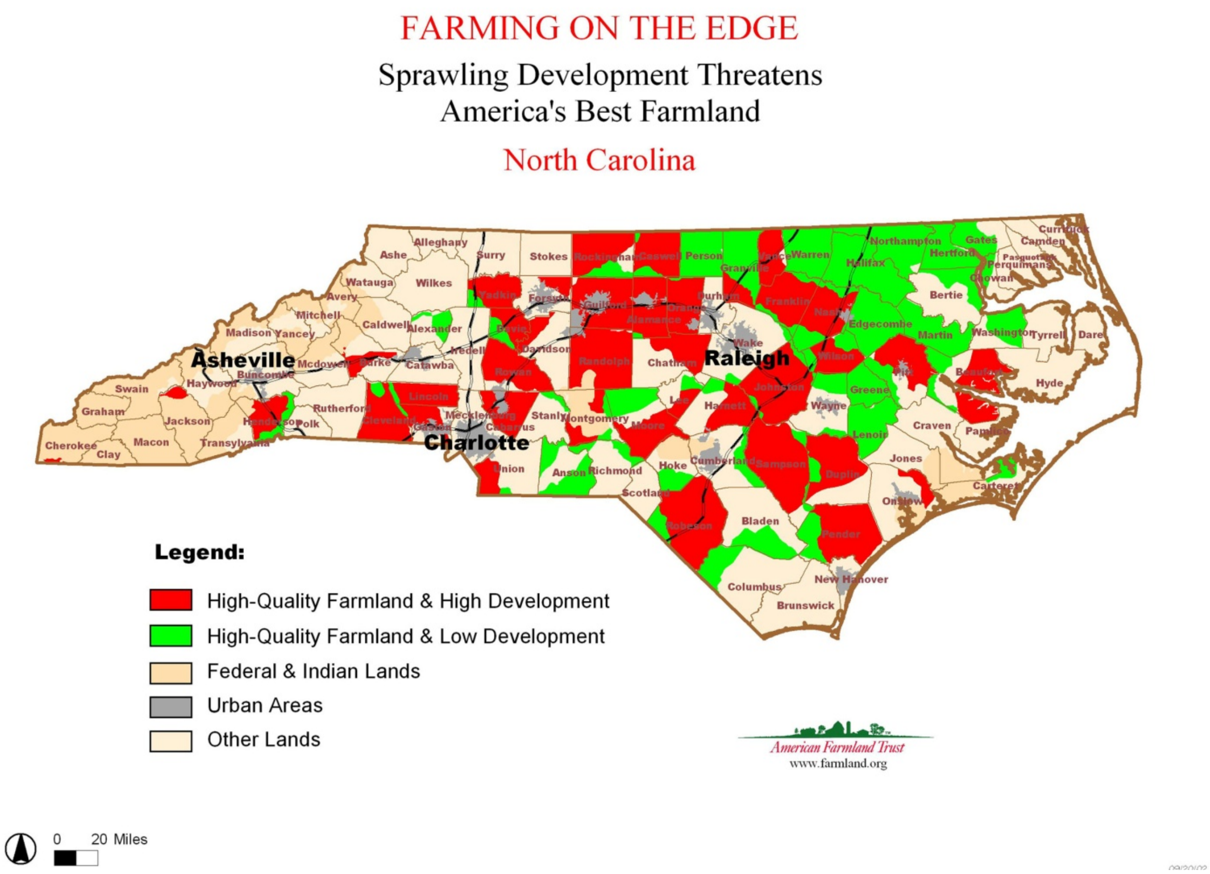
Between 1987 and 2007, North Carolina lost a total of 1,270,100 acres or 20 percent of its cropland, while losing a total of 1,104,200 acres or 7 percent of its forestland. Over this same 20-year period, a greater percentage loss of cropland acres occurred in the mountains compared to the piedmont, even though more total acres were lost in the piedmont (Ouzts 2007).

Open space losses in the coastal plain are projected to be below the statewide averages. The mountains will experience similar rates of open space losses when compared to the statewide projections, except for projected losses in cropland acres. Based on projections by Ouzts (2007), the mountains could lose about 69,100 cropland acres (31 percent of total cropland acreage) during 2007 to 2027, while some rural mountain counties could lose about 45,500 cropland acres (45 percent). Across all three regions, the loss of open space will likely continue, with the greatest loss occurring in cropland acres (Ouzts, 2007). This cropland and open space is very important for providing the early successional habitat that benefits many wildlife species.

In a report by the American Farmland Trust, sprawling development has the potential to threaten North Carolina's best farmland (FIGURE 2*c*-1). Between 1992 and 1997, North Carolina ranked fourth among the 20 states losing the most prime farmland. High-quality farmland areas have relatively large amounts of prime or unique farmland at risk to development. Future conservation and management efforts should be prioritized and directed to landowners who have working forests and family farms that are most at risk of potential conversion and fragmentation from development.

Heavy land-use pressures will likely continue and increase most rapidly in the

FIGURE 2*c*-1. North Carolina farmland at risk of development.



Source: American Farmland Trust, 2002

piedmont's urban and exurban areas. Piedmont counties near metropolitan areas will see the greatest losses in forestland, but most notable is the rate of cropland loss. Future conservation measures should include increased funding for land and water conservation measures, increased partnerships and collaborative projects with land trusts, and financial incentives for local land conservation.

Family Farms

The *2007 Census of Agriculture* (USDA, 2009) estimates the majority of family farms in North Carolina are small, with seven of 10 farms comprising less than 100 acres. With small farm size comes poor economies of scale; this is especially true considering that nearly half of farms comprise less than 50 acres. The percent of total farmland in cropland is now 57.8 percent, while 6.9 percent is in pasture.

There were an estimated 52,913 farm entitites in 2007; about 9 in 10 were owned through individuals, families, or sole proprietorships. The average age of the farm operator was 57.3 years, mirroring the aging of most forest landowners. The majority of the total number of farms are owned by persons of White or Causasian (95.4 percent) ethnic background, while 2.8 percent of farms are owned by African Americans (TABLE 2*c*-2).

TABLE 2c-2.—North Carolina Farm Demographic Summary, 2007

Race	Total Number of Farms	Percent Total
White or Caucasian	50,503	95.4%
African American	1,491	2.8%
American Indian and Alaska Native	603	1.1%
Asian	122	0.2%
Spanish, Hispanic or Latino origin	478	0.9%
More than one race	185	0.3%

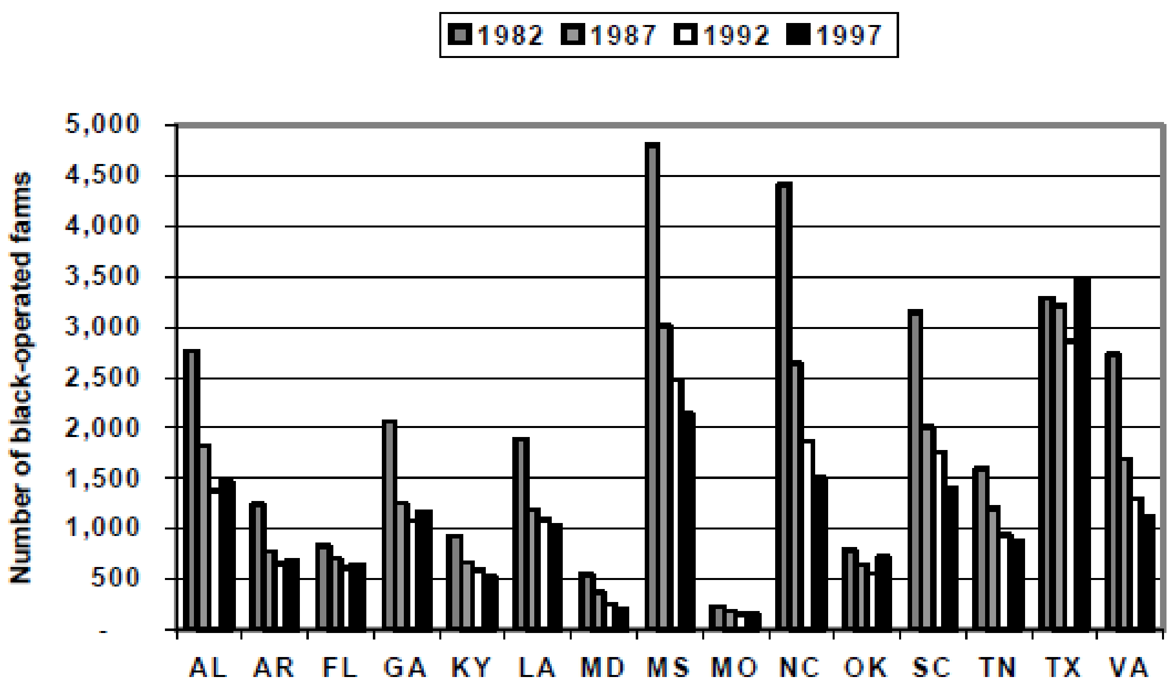
Source: *U.S. Census of Agriculture 2007* (USDA, 2009)

In the 10-year period from 1997 to 2007, total farmland acres decreased from 9,444,867 to 8,474,671 acres, while cropland acres decreased from 5,701,023 to 4,895,204. In 2005, the state lost 1,000 farms; and between the period from 2002 to 2005, North Carolina lost roughly 6,000 farms and more than 300,000 acres of farmland (Wilson, 2007).

Since 1982 and earlier, the number of African American owned farms among rural populations has been declining in North Carolina and across the South (FIGURE 2*c*-2). The number of African Americans owning or operating farms in the U.S. has declined by 98 percent, compared to a 66 percent drop among all other farm operators since farm ownership peaked in 1920 (USDA, 1997). In 1920, there were 926,000 African American farmers in the United States. In the 2002 Census, African Americans operated only 29,000 farms.

In 1950, African American farmers in North Carolina owned about 500,000 acres and by 1982, the total acreage was 40,000. This was a 92 percent reduction over this period.

FIGURE 2c-2. Minority landholders and working forests in the South.



Source: Warren, Williamson, and Sills (2003).

Reaching the Limited-Resource Audience

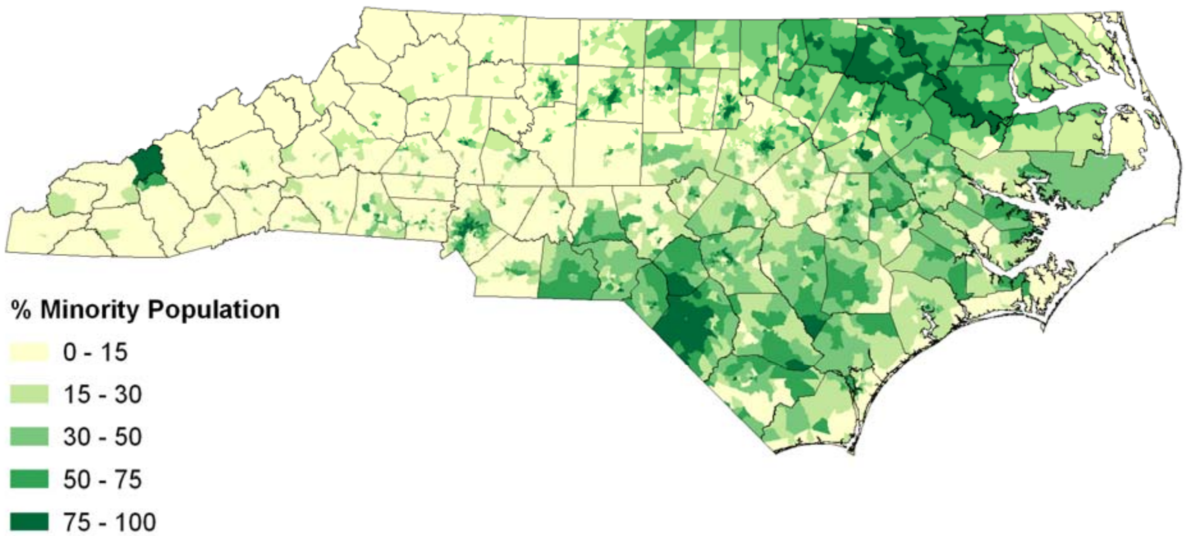
Many African American farmers and forest landholders can also be categorized as "limited resource" (Warren, Williamson, and Sills, 2003). African American farms are typically small acreage and located on poor soils in economically depressed areas. Within the coastal plain, there are higher rural populations of minority or limited-resource landowners than in the mountains or piedmont. These farmers own land at risk to potential fragmentation and parcelization from economic constraints and heir property transfer events (FIGURE 2*c*-3).

There has been a systematic failure to provide education and technical assistance to minority owners regarding estate planning to secure their property for future generations. The lack of detailed wills has resulted in generations of divided ownership and fractured heir transfer that can contribute to highly fragmented land ownership and uncertainty about long-term decision-making. This geographical and decision-making constraint may further compound management difficulties, especially for absentee landowners.

Minority and other limited-resource landholders often have small farm and forest acreages; they typically have limited access to capital and lower education, lower literacy levels, and lower annual incomes than other farmers. Increased financial incentives along with new outreach efforts are needed to provide targeted technical assistance to minority and underserved landowners to assist them in the conservation and management of these smaller working forests.

Family farms and ownerships will continue to change as a result of intergenerational transfer and sales. Nationally, a fourth of these family forestland owners intend to sell or transfer their land soon, owing largely to the fact that a fifth of those owners are 75 years or older (Butler, 2008).

FIGURE 2*c*-3. Minority population density in North Carolina by Census block group.



Created by: B. Vaughn, Conservation Fund, 2009

Summary

Family forest owners account for almost 61 percent of the total forestland in North Carolina. More than half of these family forest and farm ownerships are small (less than 50 acres). Family forest landowners have diverse management objectives for owning land that include aesthetics, social amenities, investment, and leaving a family legacy. Natural resource professionals who educate and serve these forest owners will need to apply different management approaches to meet these changing resource management needs.

Forest and farms are becoming more fragmented for a variety of reasons. The conservation of working forests will become increasingly more important for the long-term sustainability of open space, forest productivity and health, and wildlife habitat. Future conservation and management efforts should be prioritized and directed to landowners who have working forests and family farms that are most at risk of fragmentation and potential conversion from development within both rural and urban priority landscapes.

Limited-resource landowners are often not aware of available programs and services to assist them with managing their farms or forestland. Family forest ownership will continue to change as a result of intergenerational transfer or property sales because of tax constraints. Family forest and minority landowners will need increased outreach efforts, financial incentives, help with conservation measures, and other technical assistance to conserve working forests for future benefits.

Map Data Sources

FIGURE 2c-1: Map is from the publication: American Farmland Trust. 2002. Farming on the Edge: Sprawling Development Threatens America's Best Farmland.

c. Family and Minority Forests Ownership

FIGURE 2c-3: US Census Bureau

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Glossary

limited-resource landowners. Traditionally under-served landholders. This group includes those who have smaller-than-average land holdings with no or limited access to substantial amounts of capital or off-farm income. This group may include beginning farmers; farmers producing for emerging or alternative markets; and certain individuals or groups, such as minority farmers who are traditionally under-served by credit and other farm service institutions (SARE, 2000).

2.d.

Population Growth and Land-Use Change Impacts

Key Findings

- North Carolina is one of the fastest growing regions in the Southern United States with approximately 70 percent of the state's population classified as urban.
- By 2030, North Carolina's population is expected to increase by more than 50 percent since 2000, adding approximately 4 million people.
- Developed land in the state has grown by 1.86 million acres in the two decades following 1987. The majority of land-use change occurred in the piedmont (77 percent) compared to the coastal plain (52 percent) and the mountains (44 percent).
- 1.1 million acres of North Carolina forest was lost to land-use change between 1987 and 2007.
- If current population growth, development, and land-use trends continue, North Carolina may lose approximately 0.9 million acres of forestland and 1.1 million acres of cropland by 2027.

Population Changes

North Carolina is one of the fastest growing regions in the Southern United States in terms of population growth, economic activity, land-use changes from development, and wildland urban interface pressures. From the period of 1990 to 2000, North Carolina was among the fastest growing states in the country, with the sixth highest numeric population change—adding more than 1.4 million people.

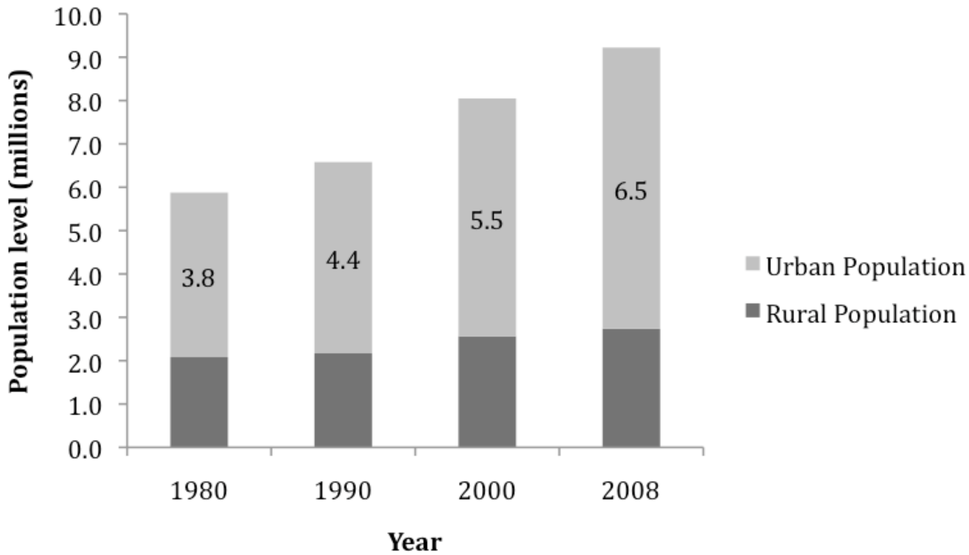
In 2008, North Carolina ranked as the 10th most populated state in the country with a population of approximately 9.2 million people, of which 70 percent were classified as urban (FIGURE 2*d*-1).

From April 1, 2000 to July 1, 2008, the state has experienced a population growth rate of 14.6 percent compared to 8 percent for the entire United States. By 2030, North Carolina's population is expected to increase by more than 50 percent from the 2000 census, adding approximately 4 million people to reach more than 12 million (FIGURE 2*d*-2) (Stuart 2006). Over 60 percent of this population growth is projected to come from new migration into the state.

North Carolina's current population is comprised primarily of 67.2 percent White persons not Hispanic, 21.6 percent African American persons, 7.4 percent Hispanic or Latino origin, 1.9 percent Asian persons, and 1.3 percent American Indian or Native persons. Our state population has almost double the national average of African American persons, who comprise a significant ethnic component of both our rural and urban populations.

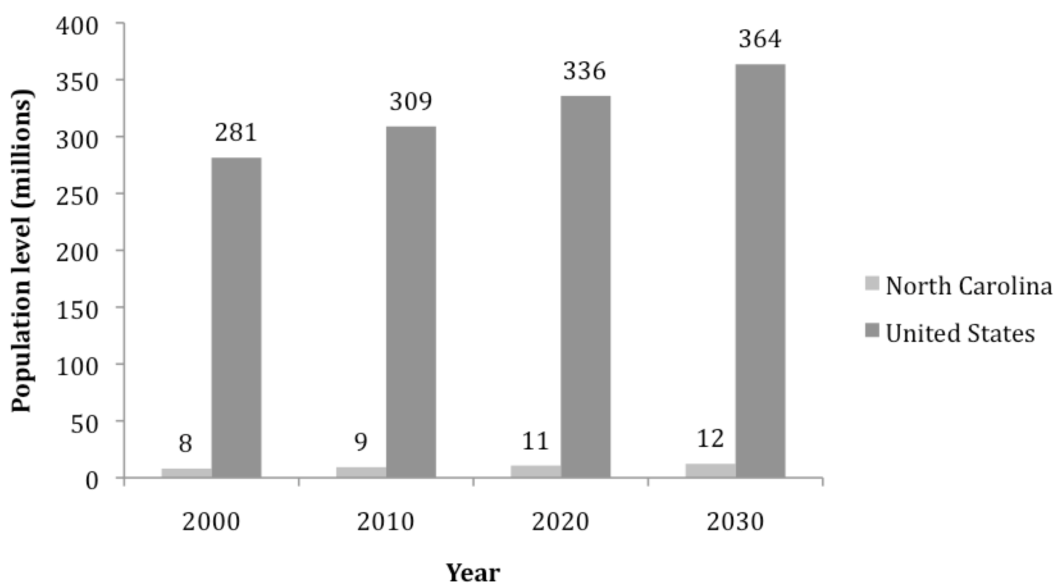
North Carolina's economic transformation is ongoing and has brought many benefits, including new jobs and opportunities, international recognition as a business location, and rapid population growth and development across many regions of the state.

FIGURE 2*d*-1. North Carolina population level for urban and rural populations from 1980 to 2008.



Source: U.S. Census Bureau data, 2008

FIGURE 2*d*-2. Population projections by 10-year period for North Carolina and the United States from April 2000 to July 2030.



Source: U.S. Census Bureau, Population Division, Interim State Population Projections, 2005

Our state is beginning to experience significant losses from development due to housing and associated infrastructure (roads, schools, business offices, commercial retail businesses, and industrial construction) that support a robust economy and an increasing population (TABLE 2*d*-1). A USDA Forest Service report, *Forests on the Edge*, indicates that private forests, particularly in the Eastern United States where most private forests occur, are likely to see dramatic increases in housing development in the next three decades, with consequent impacts on ecological, economic, and social services (Stein, et al., 2005).

The 2000 Census estimated that 36 out of 100 counties in North Carolina had population densities greater than 150 per square mile (FIGURE 2*d*-3). In 2000, North Carolina had 165.2 people per square mile and 3,132,013 households with 2.49 people per household. Based on the 2008 population estimate, North Carolina now has 189.3 people per square mile.

In 2000 there were approximately 72.3 housing units per square mile compared to 32.8 units per square mile for the United States. For the period of 2010 to 2030, a gain of 1,050,365 housing units is expected with an average gain of 525,182 units projected for each decade. This increased projection results in a 25 percent gain over 20 years (TABLE 2*d*-1).

If current population and development patterns continue to 2030, roughly half the state will be settled at a density equivalent to being urban, suburban, or sprawling exurban (Wilson, 2007) (FIGURE 2*d*-4, 2*d*-5, 2*d*-6). Population density increases in North Carolina's urban-rural interface will present new challenges to many landowners wanting to conduct traditional forest management. A study conducted in the Virginia piedmont concluded that the probability of conducting traditional forest management for timber production approaches zero at population densities of 150 people per square mile (Wear et al., 1999).

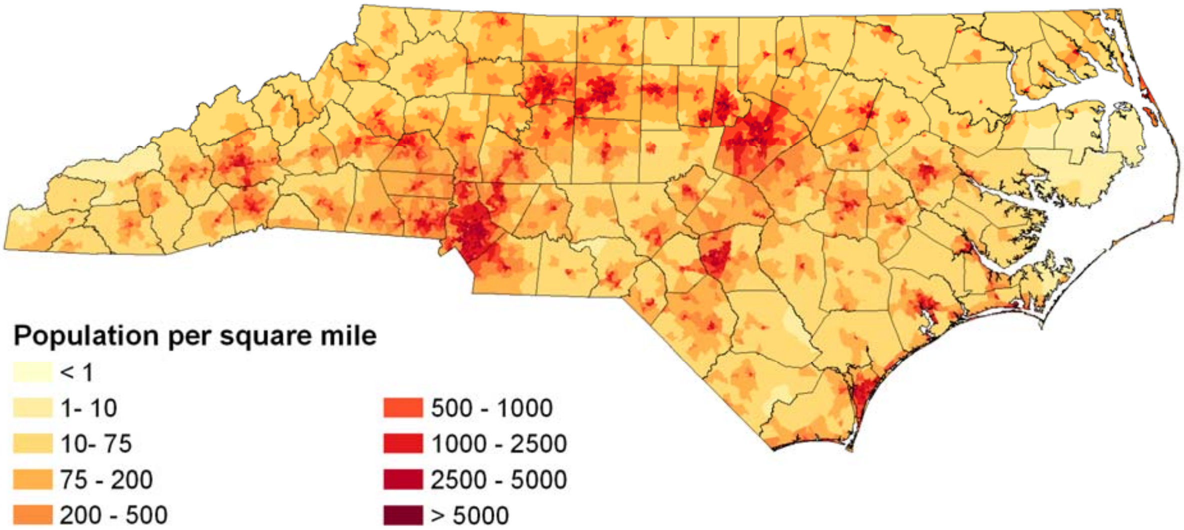
Increasing urbanization in fast growing rural areas has the potential to negatively impact water quality from the loss of forestland or conversion of open space to development. Research by the USDA Forest Service (Stein et al., 2005) has identified watersheds across the nation that would be impacted most by increased housing density during the next two decades (by 2030). Two of those projected watersheds occur in North Carolina, the Deep River and the Pee Dee River (including South Carolina).

TABLE 2*d*-1.—Growth in number of housing units in North Carolina

Year	No. Housing Units Statewide	Numeric Gain	Percentage Gain
1980	2,274,196	632,181	38.50%
1990	2,818,193	543,997	23.92%
2000	3,523,944	705,751	25.04%
2010	4,152,147	628,203	17.83%
2020	4,716,944	564,797	13.60%
2030	5,202,512	485,568	10.29%

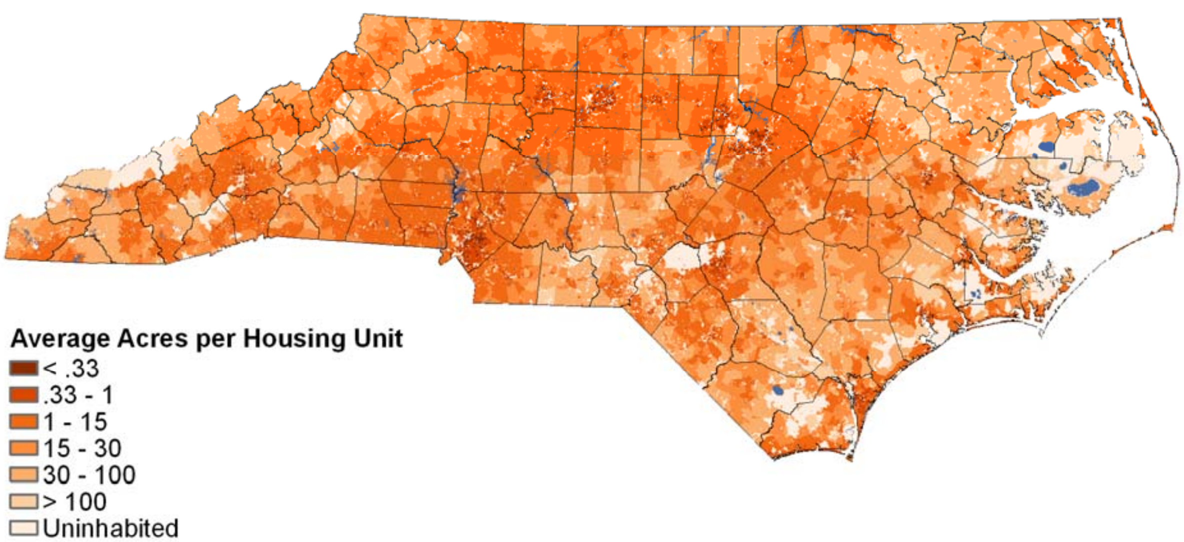
Source: Wilson, R. 2007.

FIGURE 2*d*-3. Population by census tract (square mile) in North Carolina.



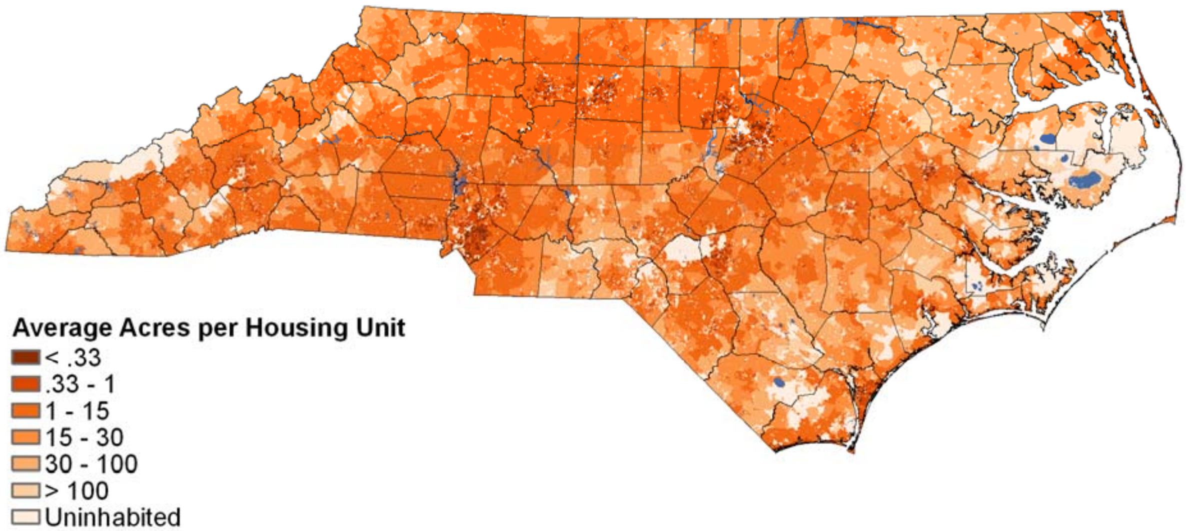
Created by: A. Bailey, NC DFR, 2010

FIGURE 2*d*-4. Average number of acres per housing units in North Carolina in 2010.



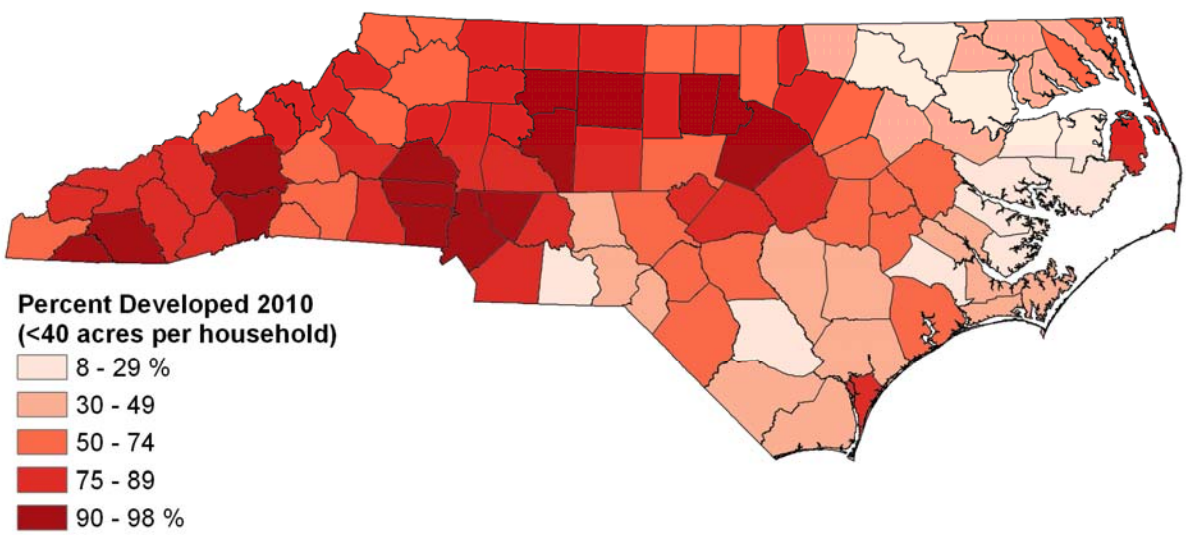
Created by: A. Bailey, NCDFR, 2010.

FIGURE 2*d*-5. Average number of acres per housing units in North Carolina in 2030.



Created by: A. Bailey, NCDFR, 2010.

FIGURE 2*d*-6. Percent of land developed in North Carolina, 2010.



Created by: A. Bailey, NCDFR, 2010.

Land-use Changes

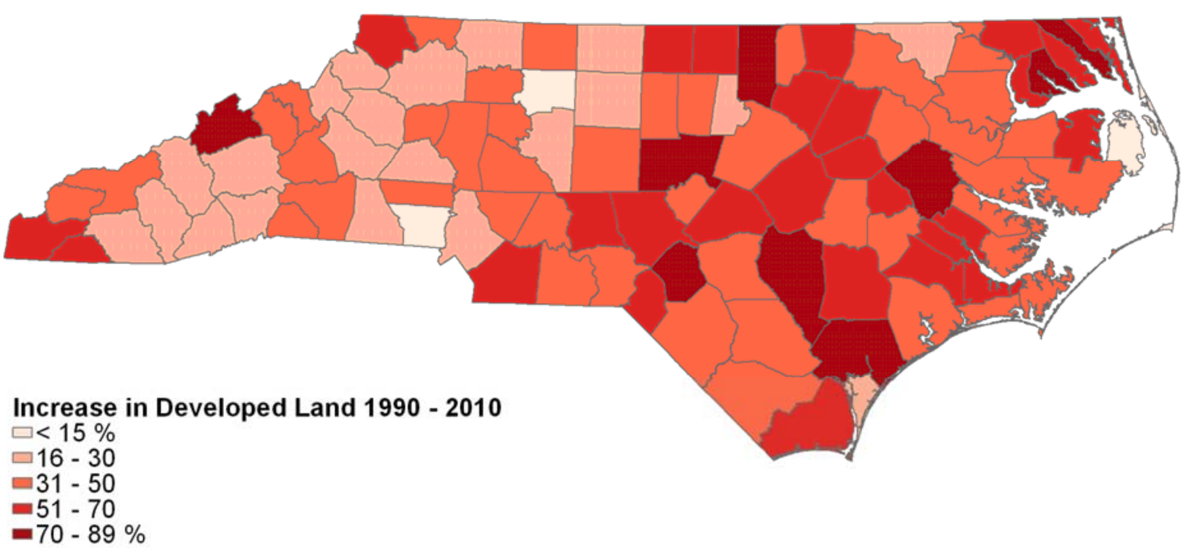
Housing development, along with its accompanying infrastructure, commercial, and industrial development, has been recognized as a primary cause of anthropogenic landscape change (Hammer et al., 2004). In North Carolina land-use change is occurring at unprecedented rates (FIGURE 2*d*-7 and 2*d*-8, TABLE 2*d*-2 and 2*d*-3). The rate of increase in developed acres is even higher than the state's population growth. Over a 20-year period, from 1987 to 2007, the state's population grew by 40 percent, but the number of developed acres increased by 65 percent (Ouzts, 2007).

Developed land in the state has grown by 1.86 million acres, with the majority of land-use change occurring in the piedmont (TABLE 2*d*-2). During the last 20 years, the piedmont has lost 638,000 acres of forestland, a decrease of 8 percent (Ouzts 2007). During this same period, the piedmont developed 1.38 million acres of land, a 77 percent increase in developed land area (TABLE 2*d*-2).

In an overall national ranking of the most sprawling metropolitan regions in the United States, the Triad (Greensboro, Winston-Salem, High Point) was ranked second, while the Triangle (Raleigh, Durham, Chapel Hill) was ranked third. The counties that comprise these metropolitan areas contain approximately 59 percent of the state's population. It is estimated that 70 percent of the state's new residents that migrated to North Carolina from 1987 to 2007 are living in the counties surrounding the piedmont's major cities (Ouzts 2007).

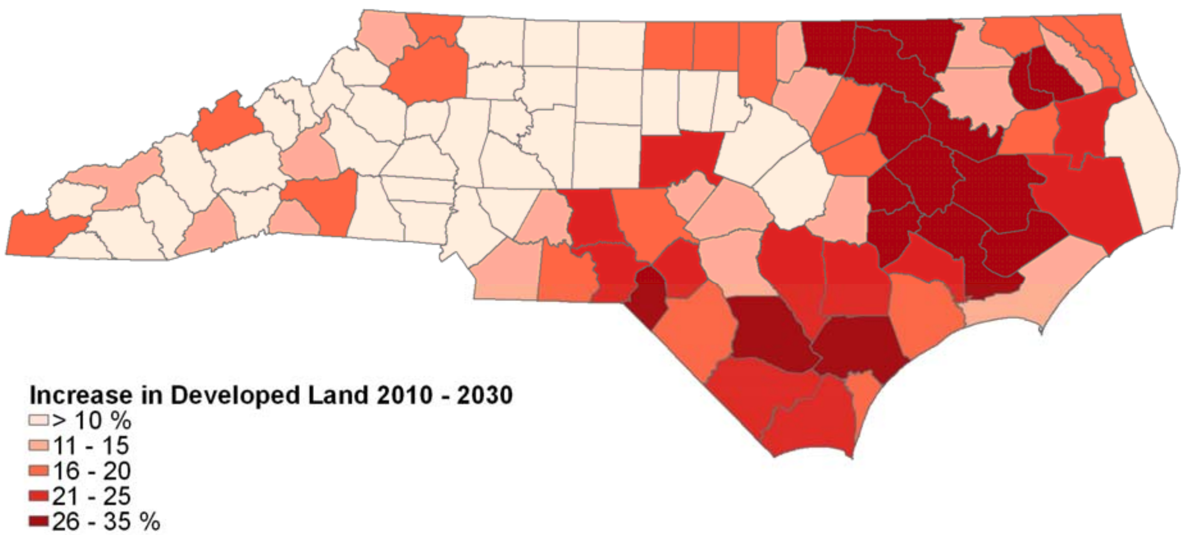
Between 1987 and 2007, the coastal counties of North Carolina lost more than 262,000 acres of forestland. During this same period, coastal counties also experienced a 52 percent increase in developed land or 248,000 acres of development. The Wilmington-Jacksonville metropolitan area counties added 109,000

FIGURE 2*d*-7. Development changes in North Carolina, 1990 – 2010.



Created by: A. Bailey, NCDFR, 2010.

FIGURE 2*d*-8. Estimated changes in development in North Carolina, 2010 to 2030.



Created by: A. Bailey, NCDFR, 2010.

TABLE 2d-2. National Resources Inventory (NRI) data for change in developed area by geographical region, 1987-2007

	1987 Developed Land Area	2007 Developed Land Area	Total Acres Developed 1987-2007	Percent Change in Developed Area
Piedmont Total	1,784,800	3,161,900	1,377,100	77%
Charlotte	364,900	685,400	320,500	88%
Fayetteville	154,400	236,300	81,900	53%
Rocky Mt.-Greenville	94,200	169,700	75,500	80%
Triangle	320,600	647,100	326,500	102%
Triad	364,600	583,800	219,200	60%
Piedmont Rural	486,100	808,500	322,400	66%
Coastal Total	478,700	726,700	248,000	52%
Wilmington-Jacksonville	185,300	294,600	109,300	59%
Coastal Rural	293,400	428,700	135,300	46%
Mountains Total	591,100	851,500	260,400	44%
Asheville	106,900	166,600	59,700	56%
Hickory-Morganton	180,700	248,600	67,900	38%
Mountains Rural	303,500	433,800	130,300	43%
Rural Total	1,083,000	1,671,000	588,000	54%
Urban Total	1,771,600	3,045,800	1,274,200	72%
State Total	2,854,600	4,716,800	1,862,200	65%

Source: Losing Our Heritage: Development and Open Space Loss in North Carolina (Ouzts, 2007)

TABLE 2d-3. Development projections by county groupings, 2007-2027

Region	Projected Increase in Developed Acres	Percent Change
Piedmont Total	1,400,700	44%
Coastal Total	207,000	28%
Mountains Total	184,800	22%
Rural	461,600	28%
Urban	1,272,200	42%
Total	1,733,900	38%

Source: Ouzts, 2007

acres of developed land, a 59 percent increase since 1987, while the rural coastal counties added 136,000 during this same time period—a 46 percent increase (Ouzts, 2007).

Development in the mountains occurred at an almost equal rate in both urban and rural counties, with development increasing 43 percent in rural areas and 45 percent in mountain urban counties near the Asheville and Hickory-Morganton metro areas (Ouzts, 2007).

In the next 20 years, development will continue to increase very rapidly in North Carolina, particularly around urban areas in the piedmont (TABLE 2*d*-3). The Triangle area is projected to be developed the most rapidly, with its developed land increasing by 58 percent, followed by the Charlotte area at 48 percent, the Rocky Mount-Greenville area at 35 percent, and other piedmont rural counties at 35 percent (TABLE 2*d*-3).

The state's mountains and coastal plain will also experience increased land-use pressures from new residents and retirees moving into these parts of the state. The western mountain region is projected to have a development rate of 22 percent, while the coastal plain is projected to develop at a slightly higher rate of 28 percent from 2007 to 2027.

In the mid 1980s, land was developed at a rate of 1.13 acres for each new person entering the state; five years later it was 1.0 acre per new resident; and by the mid 1990s, that rate had fallen to 0.65 of an acre per new resident. If the U.S. Census projections for the next 20-year period from 2007 to 2027 predict an increase of 30 percent, or 2.7 million people, North Carolina could potentially lose another 1.75 million acres to development using the same rate of 0.65 acres per new resident.

Several metropolitan areas within the piedmont will likely experience development rates that have the potential to influence the management of rural working forests located in close proximity of these rapidly developing areas. Often times these new residents do not have the same connection to the land, their management objectives are not based on generating revenue from traditional agricultural or forest management practices, and they have other conservation objectives for ownership.

Impact on Forest Resources

The increase in population density and land-use change will have an important influence on the conservation and management of working forests and on the future benefits they provide (Wear and Greis, 2002; Stein et al., 2005). Consequential changes to forests could result in the following:

- Changes in traditional uses of forests
- Decreases in the production of timber and other forest products
- Continued increase in forest fragmentation and parcelization in specific regions of the state
- Forest health changes
- Loss of opportunities for outdoor recreation
- Declines in native fish and wildlife and their habitats

- Water quality declines and altered hydrology

Urbanization combined with emerging environmental policies is predicted to result in as much as a 32 percent decrease in available timber supply with accessible commercial timber acres (NC Office of the Governor, 1996). The 2003 release of the Southern Forest Resources Assessment (SFRA) identified urbanization as a critical threat to forest sustainability in the Southeast (Wear and Greis, 2002). This report indicated that North Carolina led the nation in loss of commercial forest to urban uses from 1982 to 1997, losing over 1 million acres, 5.9 percent of the state's total forest area. Several recommendations to ensure forest sustainability in North Carolina were previously outlined in the report of the governor's Task Force on Forest Sustainability (1996).

Impact on Urban Forests

Rapid urbanization and associated land-use change is putting increasing pressure on the sustainability of trees and forests in NC communities. For an in-depth discussion of these impacts, refer to Chapter 4, Section k, of this document, "Maintaining Viable Urban Forests."

Local land-use planning processes often do not integrate strategies to conserve a connected green infrastructure alongside new growth. The loss of connectivity between urban green spaces leads to a loss of biodiversity and reduced ecosystem function in North Carolina's urban forest.

Traditional development patterns will continue to result in habitat fragmentation, loss of biodiversity across the landscape, decreased air and water quality, and loss of connection between people and the natural surroundings. Continued fragmentation of North Carolina's urban forests may result in decline in habitat for some priority species in the *NC Wildlife Action Plan* (2005) and a reduction in wildlife corridors.

Community planners, local governments, land trust organizations, and resource management agencies will need to work together to plan for future projects that can accommodate new development while minimizing the impacts to both urban and rural priority landscapes.

Summary

North Carolina has undergone changes taking it from a predominately rural state in the 1950s to an urban one. Almost 70 percent of the state's population can be classified as urban. It is expected that North Carolina will continue this trend of increasing population and development, especially around metropolitan areas in several regions of the state.

Increasing population densities in the state are contributing to increase housing densities and detrimental land-use impacts to our natural resources. Within the state, there are regional differences in how this increased development is affecting both forestland and cropland. Population density increases within the urban-rural interface will present new challenges to many landowners wanting to conduct traditional forest management. Increasing urbanization in fast growing rural areas has the potential to negatively impact water quality from the loss of forestland or conversion of open space to development.

Changes at the urban-rural interface will likely have an increasingly important influence on the conservation and management of working forests, the future supply of timber in North Carolina, and the multiple benefits that forests may be able to provide in the future.

Map Data Sources

FIGURE 2d-4: US Census Bureau

FIGURE 2d-4: Hammer et al. 2004

FIGURE 2d-5: Hammer et al. 2004

FIGURE 2d-6: Forests on the Edge: David Theobald

FIGURE 2d-7: Forests on the Edge: David Theobald

FIGURE 2d-8: Forests on the Edge: David Theobald

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Glossary

exurban. Private forest lands with 16 to 64 housing units per square mile. Lands with these higher housing densities can still support many wildlife species and other ecological functions, although perhaps at a reduced level. However, management for commercial timber may be less likely.

open space. An area of land that is valued for natural processes and wildlife, for agricultural and sylvan production, for active and passive recreation, for providing other public benefits, or for any combination of these uses. Open space may be either open, forested, cropland, or pastureland that has not been converted or used to support development.

private forest. For this project, private forest includes tribal, forest industry, and nonindustrial private ownerships; it excludes public lands and private lands protected through conservation easements.

rural. Private forest lands with 16 or fewer housing units per square mile. Forest lands with this housing density can generally support a diversity of economic and ecological functions commonly associated with private forests, such as management for timber, most wildlife species, and water quality.

sustainable development. Development that integrates environmental protection, economic development, and social equity.

sustainable forestry. The practice of meeting the forest resource needs and values of the present without compromising the ability of future generations to meet their own needs.

urban. Private forestland with 64 or more housing units per square mile. Such lands are less likely to be used for timber production or to contribute to wildlife habitat and water quality because of increased road density, infrastructure, and human population levels. Such forest patches, however, are often highly valued for their aesthetics, noise abatement properties, and positive effect on property values.

2.e.

Management Practices for Forestry and Wildlife

Key Findings

- Very few NC family forest landowners have a written management plan, or have received professional assistance or financial incentives, to actively manage their forestland.
- Pine plantations account for 12 percent of the total forestland in North Carolina, with 9 percent of nonindustrial private forestlands classified as pine plantations.
- Continued support and funding for state and federal cost-share programs and initiatives are needed to provide financial and management incentives to NC landowners.
- Intensive forest management practices have the potential to enhance productivity in managed forests on fewer acres. Actively managed forests may reduce pressure to harvest natural forests while sustaining a long-term timber supply.
- Forest management practices in planted pine forests have intensified in North Carolina over the last few decades. This trend is expected to increase for forest industry owners, real estate investment trusts (REITs), and TIMOs, but not for NIPF landowners As forested parcels get smaller they typically become more difficult, both operationally and economically, to mange intensively.
- A state forest nursery and tree improvement program is important to provide a diverse and stable supply of forest seedlings that meet current and future needs for reforestation, ecological restoration, wildlife habitat, and urban tree plantings
- Forest management practices and activities are effective methods to enhance forest wildlife habitat conditions for both game and nongame species.
- Prescribed fire is an effective management activity to enhance and maintain many NC forest habitat types and fire-dependent ecosystems.
- Between 2004 and 2009, approximately 95 to 97 percent of the forestry sites inspected statewide were documented to be in compliance with the NC Forest Practices Guidelines Related to Water Quality (FPGs).
- Forestry research support and funding is decreasing for traditional growth and productivity topics in favor of social and environmental issues, sustainability topics, and ecosystem services. This trend is expected to continue.

Introduction

Forest management in North Carolina is practiced by several ownership classes and agencies across many diverse forest types and geographic regions. The NC Division of Forest Resources (NCDFR) supports and helps landowners and other natural resource professionals implement a wide variety of resource management practices that contribute to forest management, forest protection, forest health, and conservation programs. This section's assessment is not a complete analysis or summary of forest management accomplishments in North Carolina, but presents an overview of accomplishments by NIPFs, who own 78 percent of North Carolina's forestland. Forest Inventory Analysis (FIA) data found in "Forest Statistics for North Carolina, 2002" (Brown 2004) was used to assess the current status of forest management practices in this chapter. Trends were identified by comparing the change in status between the 2002 FIA survey and the 1990 FIA survey for North Carolina (Johnson 1991, Brown 2004). Promoting sustainable forest management practices to the NIPF ownership class, will be important to enhance public benefits from trees, protect forests from threats, and conserve working forests for the future.

Family Forests Owners' Attitudes Toward Management

Family forest landowners in North Carolina have varying reasons for owning their land and differing levels of engagement with it. The numbers of NC landowners enrolled in forest certification programs, conservation easements, and cost-share programs, and who have a written management or stewardship plan, are very low.

Only 4 percent of family forest owners in North Carolina currently have a management plan for their forestland (Butler, 2008). NC family forest owners' future plans (next 5 years) for their forestland included either "leave it as is—no activity" (32 percent), "minimal activity to maintain forestland" (14 percent), or "have no current plans" (10 percent). Harvesting timber for sawlogs, pulpwood, or firewood was listed as a planned activity by less than 10 percent of family forest landowners. Only 6 percent of family forest owners in North Carolina have participated in cost-share programs in the past 5 years (Butler, 2008).

This low participation in active forest management may reflect the desires and attitudes of forest owners. It may also be caused, however, by other factors, such as economy of scale on smaller parcels, lack of information on the benefits or associated costs from various management practices, and less than optimal outreach efforts by conservation program administrators (GfK NOP, 2006).

Just 15 percent of NC family forest owners who responded to the *2006 National Woodland Owner Survey* indicated that they had received technical advice about the management of their property. The majority of family forest owners who responded indicated that their primary sources for obtaining forestry advice included state forestry agencies (55 percent), private forestry consultants (14 percent), university extension agencies (8 percent), loggers (7 percent), other landowners (6 percent), and federal agencies (5 percent). Forest management activities implemented in the last 5 years by family forest owners by resource activity have included planting trees (18 percent), fire hazard reduction (15 percent), wildlife habitat improvement (10 percent), herbicide application (9 percent), and site preparation (10 percent) (Butler, 2008; GfK NOP, 2006).

Status and Trends of Forest Management Practices in North Carolina

USDA Forest Service FIA data and analysis (Brown 2004) and other reports (Moffat 1998, Snider 1999, Siry 2002) indicate that while forest industry managers of forestland apply intensive forest management to a majority of their land, only a small portion of NIPF landowners are actively managing their forestlands. Pine plantations account for 12 percent of the total forestland in North Carolina with a majority located in the coastal plain.

Pine plantations represent 51 percent of the land managed by forest industry and TIMOs. Pine plantations are typically managed more intensively than other forest types (Siry and Cubbage, 2001a). In contrast, only 9 percent of the NIPF in North Carolina consists of pine plantations. The amount of land managed by TIMOs is expected to increase, and the intensity of management is projected to increase for both industry-owned and TIMO forestlands (Siry and Cubbage, 2001a). Forests owned by industry are managed more intensively for fiber production than NIPFs, although there is growing interest from NIPF landowners within the piedmont and coastal plain in better managing pine forests for future income potential.

FIA survey data indicates that a final harvest occurred on an average of 246,400 acres per year in North Carolina from 1990 to 2002. The number of acres of NC forests harvested by a clear-cut method has decreased by 20 percent across all ownership types during 1990 to 2002. Partial cutting or harvests increased 33 percent between the 1990 and 2002 survey periods and occurred on 79,000 acres per year.

The number of acres artificially regenerated annually for all forest types decreased slightly from 1990 to 2002 by about 3,200 acres or 3 percent. A total of 100,000 acres were artificially regenerated annually, with 63 percent of this artificial regeneration conducted by NIPF landowners and 33 percent by forest industry landowners (TABLE 2*e*-1). Pine plantations represent 62 percent of the artificially regenerated acres. The total number of acres of natural regeneration also experienced a decrease of 19 percent during this same period. This decrease was reported across all forest types, but was more significant for upland hardwoods (13.5 percent) and oak–pine forest types (23.4 percent) than for pines (Brown 2004).

NC Division of Forest Resources Accomplishments

The NC Division of Forest Resources (NCDFR) compiles a Total Accomplishment Report (TAR) annually for statewide and individual county activities, projects, and associated accomplishments that have NCDFR involvement and participation. The NCDFR also works closely with other partnering resource management agencies and professionals to record accomplishments, provide technical assistance, and recommend services to NIPF landowners. The TAR shows the diversity of activities and projects that NCDFR is able to provide to NC landowners, natural resource management agencies, municipalities, and local communities. These reports are not a complete summary of all forest management that occurs in North Carolina, and further work would be needed to compile additional information from various agencies and companies.

In North Carolina there are approximately 469,000 family forest landowners and another 56,000 “other private ownership” entities in the state. Family forest landowners own about 11.2 million acres or 61 percent of the total area of forestland (Butler 2008). NCDFR is responsible for assisting NC forest landowners interested in managing their forestland for urban benefits, water quality, forest protection, forest improvement, non-timber resource improvement, and traditional forest management.

TABLE 2e-1.—Status and trend of NC forest management practices by ownership group, 1990 – 2002, in annual acres treated and percent change over survey period

Forest Management Practice	Public	Forest Industry	Nonindustrial private	Total	% Change Between 1990 and 2002 FIA Surveys
	thousand acres per year				percent
Final Harvest	6.6	40.3	199.5	246.4	-19.7
Partial Cut	2.9	4.7	71.1	78.8	32.9
Thinning	3.8	26.7	20.8	51.3	0.4
Timber Stand Improvement	1.9	3.0	9.9	14.8	23.6
Site Preparation	3.4	29.6	45.0	78.0	-24.1
Other Treatment	4.7	4.7	43.2	52.6	-51.1
Artificial Regeneration	4.6	32.9	63.0	100.5	-2.8
Natural Regeneration	8.7	10.8	193.9	213.5	-18.6

Between 2004-2009, the NCDFR, consulting foresters, and other natural resource professionals have developed 35,932 management plans for NIPF landowners impacting 1,799,634 acres (TABLE 2*e*-2). This total, when combined with the acres impacted from urban forest management assistance, represents that management direction or assistance occurs on 17 percent of family forests in North Carolina. From 2004 to 2009 an average of 7,186 management plans impacting 359,926 acres were written each year. This total also includes the assistance and accomplishments of NIPF landowners who use the professional services of a consulting forester and other resource professionals. As of 2009 there were approximately 239 active consulting foresters providing management services within North Carolina.

There has been a decrease in the number of urban plans and assists from 5 years ago because of a recent shift in program delivery to the municipal and community level versus individual urban homeowners. During this same time, there was a change in the federal funding allocation formula to support urban forestry programs that can have the biggest impacts on more people living within urban areas. Going forward, there is increased opportunity for urban forestry programs to partner with the NCDFR Forest Stewardship Program to reach more landowners and accomplish more activities for aesthetic or scenic benefits within the urban-rural interface.

Reforestation and Cost Share

The 1977 North Carolina General Assembly passed the Forest Development Act (NCGS 113A-176), which established a voluntary cost-sharing program to "provide financial assistance to eligible landowners to increase the productivity of the privately-owned forests of the State." The Forest Development Program (FDP) is designed to encourage NIPF landowners to reforest their land after harvest, and to put idle or unproductive land into forests.

The Primary Forest Product Assessment Act (NCGS 113-189) of 1977 prompted the evaluation of the primary forest products processed by North Carolina sawmills and other timber industries. This assessment (typically $2 million per year) along with legislative appropriations (often $589,500 per year), provides funding for reforestation and forest stand improvement work cost shared under the FDP. This partnership successfully leverages state money with

TABLE 2*e*-2.—5-year summary of urban and forest management plans developed and acres impacted by management or assistance

State Fiscal Year	Management Plans Developed [1]		Urban Forest Management Assistance [2]	
	No. of Plans	Acres Impacted	No. of Plans/Assists	Acres Impacted
2004 – 05	7,982	396,360	876	23,726
2005 – 06	6,791	358,342	670	37,938
2006 – 07	7,357	350,177	479	17,620
2007 – 08	6,723	332,534	494	14,633
2008 – 09	7,079	362,221	387	11,463
Totals	35,932	1,799,634	2,906	105,380
Average	7,186	359,926	581	21,076

Source: Data retrieved from NCDFR's 4220 Forest Management & Urban Forestry Accomplishment Records Program

[1]Includes Forest Management, Practice, Pre-Harvest, Regeneration, Rehabilitation, Replant and Stewardship plans written by NCDFR foresters and rangers as well as others (typically private consulting foresters or wildlife biologists).

[2]Includes Municipal Area Assists, Shade Tree Assists, Urban Assists, Urban Plan,s and Urban Tree Planting by Landowners.

funds from private citizens and timber industry. Landowners usually pay 60 percent of expenses, and FDP funds typically reimburse the other 40 percent, up to a prevailing rate. Of that 40 percent, 71 percent has historically come from assessments paid by the timber industry, 25 percent from appropriations, and 4 percent from earned interest on the account (Brogan 2009). The actual assessment rate being paid by the primary processors (timber industry) has not changed since the original rate was established in 1977.

State and federal cost-share programs are important resources to provide financial incentives and assistance to family forest landowners to conduct a variety of management practices in North Carolina. Records of North Carolina's statewide reforestation accomplishments from 1999 to 2008 indicate that 75,000 to 100,000 acres are typically planted each year. The state's cost share program, the FDP, has accounted for the planting of approximately 50,000 of those acres annually. The number of acres planted using state financial incentives represents about 50 to 75 percent of the total reforestation being carried out by NIPF (Brogan 2009).

On average, FDP has provided direct financial assistance to over 1,500 forest owners each year (Brogan 2009). NIPF landowners have planted nearly 1.2 million acres of forestland under the FDP since 1978. The majority was planted to loblolly pine, but this figure also includes 3,057 acres of hardwood species and 44,601 acres of longleaf pine. A review of NC longleaf planting accomplished under various cost-share programs from 1997 to 2006 revealed that 25,000 acres of the 60,000 total longleaf pine acres planted were funded and accomplished using the state FDP cost-share program. TABLE *D*-1 in Appendix D provides a detailed summary of total acres reforested annually by state and federal cost-share programs in North Carolina since 1970.

FIGURE 2*e*-1 summarizes the cumulative number of acres established under the various cost-share programs available in North Carolina from 1970 to 2008 (Brogan 2009). The largest total number of acres planted was funded under the state's FDP program. Funding levels and support for some of the federal cost-share programs since 1970 have varied considerably, and only six viable forestry cost-share programs are available today.

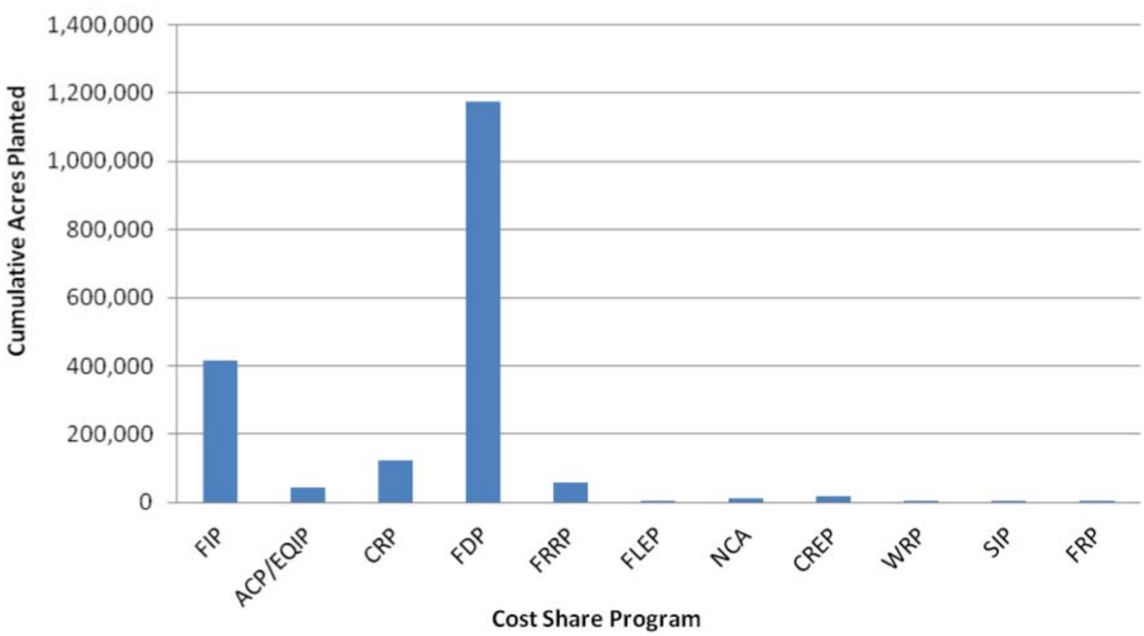
Each year the FDP program provides financial assistance for about 23,247 acres of site preparation, 51,048 acres of reforestation, and 2,021 acres of forest stand improvement (TABLE 2*e*-3). It has been called a "gateway" program that allows field personnel to interface with more landowners and potentially provide value-added services in addition to assisting them with financial incentives.

Site Preparation Practices

Approximately 78,000 acres were site prepared in North Carolina annually from 1990 to 2002, indicating a decline of 24 percent across all ownerships compared with the previous FIA survey period of 1984-1990 (Johnson 1991, Brown 2004). About two-thirds of these acres were site prepared for planting pine. The trend shows an increase in site preparation for planted pine, but decreases for natural pine, oak–pine, and both lowland and upland hardwoods. Forest industry and NIPF landowners account for 40 percent and 57 percent of the total acres that were site prepared, respectively.

Site preparation conducted by NIPF landowners with FDP cost share funding averaged 23,247 acres annually from 1999 to 2008. This represents about 52 percent of the average acres that were annually site prepared during 1990 to 2002. A survey conducted by the NC Division of Forest Resources found that 65 percent of landowners planting pine in 1998 did not prepare the site (Pickens, 2002). Some

FIGURE 2*e*-1. Acres reforested in North Carolina by cost-share programs (1970 – 2008).



Source: S. Brogan, NCDFR, 2009

NOTE: FIP = Forestry Incentives Program; ACP/EQIP = Agricultural Conservation Program/Environmental Quality Incentives Program; CRP = Conservation Reserve Program; FDP = Forest Development Program; FRRP = Fran Reforestation and Rehabilitation Program; FLEP = Forest Land Enhancement Program; NCA = NC Agricultural Cost-share Program: CREP = Conservation Reserve Enhancement Program; WRP = Wetland Reserves Program; SIP = Stewardship Incentives Program; FRP = Forest Recovery Program

TABLE 2*e*-3.—Summary of FDP acres accomplished by management practice (1999 – 2008)

Fiscal Year	Site Preparation	Reforestation	Forest Stand Improvement
1999 – 2000	23,753	46,972	2,449
2000 – 2001	31,908	58,595	1,905
2001 – 2002	38,157	61,286	2,914
2002 – 2003	24,473	54,445	850
2003 – 2004	20,633	52,826	1,553
2004 – 2005	17,703	50,272	2,322
2005 – 2006	20,371	44,597	2,029
2006 – 2007	15,745	47,563	2,665
2007 – 2008	16,476	42,877	1,500
Totals	209,219	459,433	18,187
Average Acres	23,247	51,048	2,021

Source: NC Division of Forest Resources, Forest Development Program

common factors that have resulted in NIPF landowners not conducting site preparation include high initial costs of practices, lack of professional advice, and increased use during harvest operation. Genetically improved pine seedlings have now become the standard in many pine planting projects and do not always represent an intensive management objective by the landowner but rather a decision to plant the best genetic material that is currently available.

Specific data for North Carolina on fertilizer application during site preparation is not always readily available or shared by various forest ownerships. However, reports by the NC State University (NCSU) Forest Nutrition Cooperative (FNC) showed fertilized acres by forest industry and TIMOS increased from about 200,000 acres in 1990 to about 1.2 million acres in 2004(Albaugh, 2007). Fertilizer use among FNC members at tree establishment averaged about 200,000 acres per year since 1995, while mid-rotation fertilization fluctuated between 1 million and 1.3 million acres per year for the same period. Applications were largely on loblolly pine plantations (91 percent). New research information along with market fluctuations in fertilizer prices will likely influence fertilizer application rates and acres applied in the future.

Forest Stand Improvement Practices

The 2005 NC Legislature authorized new forest stand improvement practices for the FDP program to “improve tree growth and overall forest health.” These new practices were specified and approved in Administrative Code in November 2006. As of July 1, 2007, NIPF landowners could apply for FDP cost-share assistance for forest stand improvement practices such as prescribed burning, density release treatments, fertilization, crop-tree crown release, and cull-tree removal.

In recent years the overall number of forested acres thinned in North Carolina has remained relatively constant at about 50,000 acres per year. A majority of the thinning occurred on pine stands with forest industry accounting for 52 percent and NIPFs for 41 percent of the acres. Timber stand improvement is practiced on about 14,800 acres annually. TSI practices increased 24 percent between the 1990 and 2002 FIA surveys. This occurred primarily on NIPF lands, which account for 67 percent of the total.

In the past, most of the TSI practices were focused on pine management, primarily for improved timber production. Recently, the *term timber stand improvement* has been replaced with *forest stand improvement* to reflect an increased effort to manage and improve forest stands for multiple benefits. Family forest landowners are interested in conducting management practices with less intensive objectives and greater ecological benefits, such as biodiversity, water quality protection, recreation, and forest habitat enhancement.

Future opportunity exists to provide more forest stand improvement practices to natural stands, especially hardwood stands that may be overstocked, or have less than ideal stocking levels of desirable species, for improved productivity and forest health benefits. Hardwood stands that have been mismanaged in the past may need some type of intermediate treatment to improve the stand productivity for both timber and wildlife habitat benefits.

Many landowners that live within the urban-rural interface landscape no longer prefer typical silviculture and harvesting methods associated with traditional forest management. To assist more forest landowners, resource professionals will need to apply adaptive management strategies and be willing to provide and implement silviculture practices that are tree-oriented rather than acre-oriented and focus on the production of quality rather than quantity. Forest stand improvement practices can be used to accomplish scenic and aesthetic benefits along with forest wildlife habitat improvement.

Between 2004-2009, 2,793 forest stand improvement practices have been implemented on 132,957 acres of NIPF (TABLE 2*e*-4). On average, about 559 projects are conducted on 26,591 acres annually. The majority of the forest stand improvement practices are conducted for the purposes of pre-commercial thinning, prescribed burning for silviculture benefits, and herbicide or mechanical release treatments.

An opportunity exists to increase forest stand improvement practices on more acres for improved forest habitat in overstocked forest stands, improved forest health and productivity in natural or degraded hardwood stands, and increased scenic amenities. A continuation review and legislative report on the Forest Development Program (FDP) concluded that funding levels are not adequate to meet the current and future FDP demands by NC landowners seeking financial assistance (Brogan, 2009). The FDP maintains a waiting list of fully qualified but unfunded landowners each year due to a lack of full funding for the cost-share program. The work on this waiting list averages over $2.2 million annually and represents another 25,000-plus acres per year that could be reforested. Future increases in FDP funding and support are necessary to address the current and future demands for financial incentives.

Within the last few years, an increased number of federal and state cost-share practices have become available to NC landowners for ecosystem restoration, wildlife habitat enhancement, forest stand improvement, riparian and wetland restoration, and conservation benefits. The long-term acceptance, application, and sustainability of these practices will depend on future funding commitment levels, collaborative administration and record keeping by cooperating agencies, and increased outreach efforts by resource professionals to forest landowners.

TABLE 2*e*-4.—5-year summary of forest stand improvement accomplishments [1] by NIPF

Fiscal Year	No. of Projects/ Activities	Acres Treated
2004 – 2005	486	26,691
2005 – 2006	507	25,614
2006 – 2007	582	31,420
2007 – 2008	533	20,812
2008 – 2009	685	28,420
Totals	2,793	132,957
5-year Average	559	26,591

[1] *Forest stand improvement practices recorded include prescribed burning for silviculture purposes, precommercial thinning, release treatments, fertilization, crop-tree release treatments, and other.Future Cost-share Support and Capacity*

Forest Management Practices for Enhancing Forest Productivity

Over the past several decades, the Southeast has become a major source of timber products. Increased growth and yield from planting of genetically improved seedlings, controlling competitive vegetation, applying fertilizer, and other intensive management techniques have the potential to increase the available timber supply to meet an increasing demand. As the demand increases for ecosystem services and the amount of available forestland for timber production decreases, the importance of producing more volume on less land will continue to become increasingly critical.

Substantial productivity gains from pine plantations have occurred due to a broader acceptance of intensive management practices including genetic tree improvement, site preparation, herbicide application, thinning and fertilization. From 1952 to 2007, wood volumes harvested from planted pine plantations have doubled and rotation lengths have decreased by 50 percent (Fox et al., 2007a).

Although hardwood forests occur on 72 percent of the forestland in North Carolina, few landowners practice intensive forest management on hardwood forests since significant volume increases are difficult to achieve for many hardwood species and few hardwood plantations exist in the state. Hardwood forests are often managed by landowners for objectives other than financial gain.

Potential Productivity Gains

Productivity projections in this section refer to intensive forest management in pine plantations, generally in the coastal plain or piedmont. To quantify the impact of intensive management practices on productivity, Professor Jacek P. Siry, with the Warnell School of Forestry and Natural Resources, University of Georgia (Siry 2001b) developed five management intensity levels, ranging from traditional planted pine practices (site preparation and planting) to increasingly more intensive practices that use genetically improved seedlings, vegetative control, and fertilization. He used the TAUYIELD growth and yield model (Amateis et al., 1995) to project volume gains for each management intensity level in TABLE 2*e*-5.

Increased productivity gains can be realized with each increase in management intensity. By applying the most intensive management regime, a 70 percent volume increase is predicted (Siry, 2001b). Although up-front investment costs are high for these practices, published literature has documented improved net present value (NPV) and internal rate return (IRR) across many sites.

Herbicide and Fertilizer Use

The use of silvicultural herbicides is an important tool to increase forest productivity and enhance wildlife habitat in the South (Wagner et al., 2004). Herbicides have been found to be beneficial for improving forest wildlife habitat and biodiversity in Southern

TABLE 2*e*-5.—Projected growth and yield data for unthinned pine management intensities levels

	Stand Age			
Management Intensity Level[1]	15	20	25	30
	cubic feet of growth per acre			
SP	1121	2004	2716	3158
SP + G	1353	2355	3135	3605
SP + G + F	1353	2637	3433	3912
SP + G + F + H	1670	3139	4033	4502
SP + G + F + H(x2)	2170	3645	4587	5057

[1] SP = Site Preparation, G = Genetics, F = Fertilization, H = Herbicide
[2]TAUYIELD assumes a Site Index 60 at base age 25 and planting density of 600 trees per acre.

Source: Siry, 2001b

U.S. forests via manipulation of forest structure, creation of snags, and control of invasive plant species (Miller and Miller, 2004). The use of herbicides by NIPF owners in North Carolina has shown a slow but steady increase in application since 1996, averaging 14,625 acres per year from 2000 to 2006 (FIGURE 2*e*-2).

A similar trend is believed to apply to forest industry lands, although comprehensive data on herbicide application and use by forestry industry and other resource management agencies is difficult to compile. Increased herbicide use is likely due to a shift away from more costly mechanical methods, price reductions, and scientific studies showing greater effectiveness of herbicides for increasing early pine productivity rates and survival.

Herbicide use for site preparation is the most common objective (68 percent), followed by vegetative release (30 percent) (Pickens 2007). Control of undesirable hardwoods and herbaceous competition in pine plantations can significantly increase early pine seedling growth. First-year weed control has shown to increase the site quality index by 4 feet at age 25 (Siry, 2001b). Mid-rotation vegetative control, often applied after a thinning, has shown volume increases of 300 cubic feet per acre (Siry, 2002).

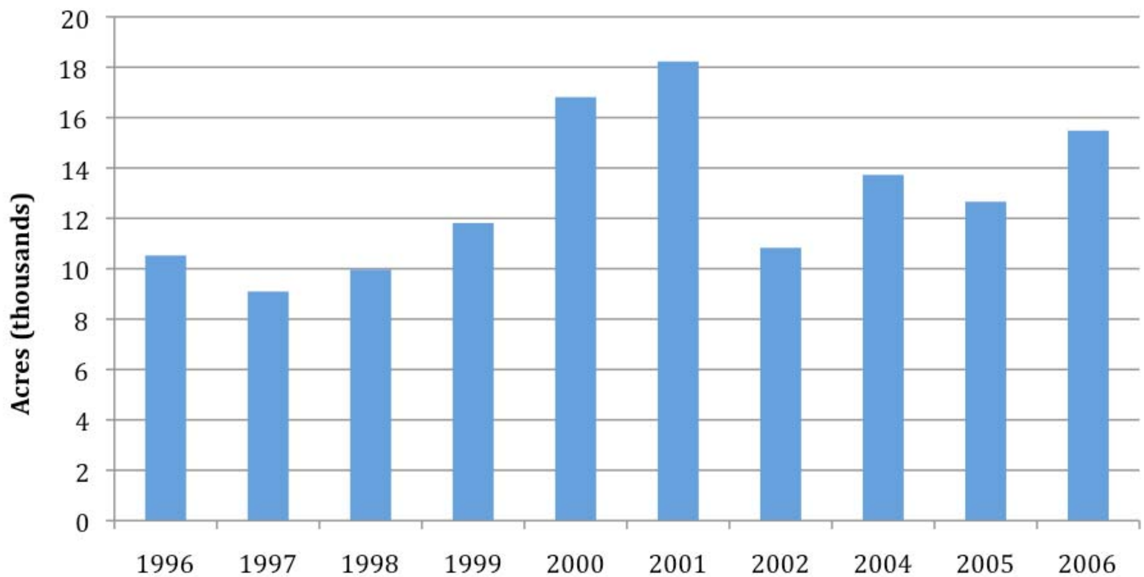
In the Southeastern United States, it is estimated that herbicides are applied annually on 1 percent of the forestland, primarily in pine plantations (Michael, 2000). Among NIPF landowners whose ownership was less than 500 acres, herbicides, pesticides, and fertilizers were applied on less than 5 percent of their property. Landowners with more than 500 acres applied herbicides, pesticides, or fertilizers on 32 percent of their forestland (USDA Forest Service, 2008).

Fertilization is becoming increasingly popular on forest industry lands as knowledge of sites that consistently respond to fertilization increases. Dramatic and significant gains are possible on nutrient deficient soils. Fertilizer applied at planting on phosphorous-deficient soils increases volume growth by 40 cubic feet per year throughout the rotation (Fox et al, 2007a) and a one-time application of 200 pounds of nitrogen and 25 pounds of phosphorous at mid-rotation increases growth by an average of 400 cubic feet per acre over an 8-year period (Fox et. al, 2007a).

Forest Tree Improvement and Genetics

For more than 50 years, tree improvement programs in the south have focused on

FIGURE 2*e*-2. Total number of acres treated with herbicides for forestry purposes involving NCDFR, 1996 – 2006.



[1]Source: B. Pickens, NCDFR, 2007. No data were reported for 2003.

improving several traits important for southern pine plantation forestry. Among these traits are height and volume growth, stem form, wood quality, and disease resistance. Nearly all of the loblolly pine plantations that have been established in recent years were planted using genetically improved seedlings (McKeand, 2006). Currently, the major forest tree seedling nurseries in North Carolina are producing second- and third-generation improved loblolly pine. Improvement of other southern pine species, such as longleaf, shortleaf, pond, and Virginia pines, has not been developed beyond rogued first-generation populations.

Across the south, second-generation loblolly pine seedlings can produce volume growth estimated to be greater, on average, than unimproved seed by 17 percent for coastal plain sources and 21 percent for piedmont sources (McKeand, 2006). These mixed-seed orchard seedlots have been mostly replaced by single-family seed collections. Plantations established from the best single-family parents can produce gains of about 26 to 50 percent over unimproved seed, with volume gains as much as 400 cubic feet per acre. In North Carolina, these expected gains are even greater due to the highly rated families selected for placement in improved seed and breeding orchards, and the planting of any of the top single families from these orchards (Roeder, 2010).

Third-generation and mass control pollinated (MCP) breeding in North Carolina is starting to produce commercial quantities of seed. Until seed supplies increase further, third-generation and MCP seedlings will be available only on a limited basis to North Carolina landowners. Wood volumes produced by these genetically improved third-generation families are estimated to surpass unimproved families by 40 to 60 percent or more. Volume improvement by MCP breeding will be even greater (Roeder, 2010). Improvement in stem quality and rust resistance results in higher yields per acre of higher quality trees. Some high production clones are also available across the south, but are more expensive.

Since 1957, the NC State University Cooperative Tree Improvement Program (NCSUCTIP) has provided technical guidance, direction, and technical outreach to genetically improve loblolly pine. NCDFR is an active member of this program. Other members include five state forestry organizations and several different classes of private members. Members share breeding and testing efforts. Initially, the NCSUCTIP developed selected populations of all the southern pines and some other species. NCDFR is one of the few members that has maintained the selected germplasm of these other species and continues to work with them. All loblolly pine germplasm and data analyses developed by the cooperative are available to members. Seedlings grown from this germplasm are available to the nonindustrial private landowner.

Many landowners are currently not aware of the genetic differences and options available for planting seedlings from improved loblolly pine families. Planting contractors are frequently the individuals who make purchase decisions for landowners regarding nursery source and genetic family. More effort is needed to educate forest landowners regarding species, genetics, and appropriate management practices to enhance productivity. To help in this effort, the NCSUCTIP has developed a rating system that allows seedling consumers to evaluate the genetic potential of improved loblolly pine seedlings that they are about to obtain. The *Loblolly Pine Productivity Rating System* (PRS) is available for use by all cooperative members. NCDFR is the only producer of loblolly pine seedlings for planting in North Carolina that actively makes these PRS ratings available to their seedling customers.

The NCDFR genetic tree improvement program remains active with longleaf pine, shortleaf pine, Virginia pine, Atlantic white cedar, eastern white pine, and Fraser fir. Hardwood species under improvement include sweetgum, yellow poplar, sycamore, and white oak. Cooperative work is also being conducted by NCDFR, other state forest services, and the USDA Forest Service. In general, most hardwood species available from NCDFR's nurseries are unimproved and have undergone little or no genetic improvement. Seed production areas of these unimproved species are being established for seed collection purposes. There has also been an increased interest in the genetics improvement of American chestnut and butternut for disease resistance.

Forest Nursery and Seedling Capacity

North Carolina currently has only 2 major nurseries selling forest seedlings to the general public. These include NCDFR nursery in Goldsboro, North Carolina and the Weyerhaeuser Company nursery in Washington, North Carolina. In addition, there are two additional private forest seedling nurseries in the state.

Over 40 species of tree seedlings are produced and sold in North Carolina for reforestation, afforestation, wetland and stream mitigation projects, wildlife plantings and urban tree planting. The majority of nursery production is bare-root loblolly pine seedlings for reforestation purposes. In the 2008-2009 planting season over 62 million seedlings were produced in North Carolina. Of this total, the forest industry nursery sold about 49 million seedlings while the state forestry nursery sold 13 million seedlings. Total seedling production in the state declined by 9% from 2005 to 2009 while total seedling production across the South declined 4 percent. The NCDFR state forestry nursery is the only large producer of bare-root hardwood seedlings in North Carolina.

Weyerhaeuser Company, NCDFR, and at least one private nursery have the capacity to produce containerized longleaf pine seedlings. For the past several years, public demand has exceeded the available supply of longleaf pine containerized seedlings. North Carolina has ranked 7th in the South in seedling production for each year from 2005 to 2009. An adequate supply of longleaf seedlings is critical to meet the restoration goals proposed in North Carolina's and America's Longleaf initiatives.

The NCDFR has been producing tree seedlings for sale to North Carolina landowners since about 1925. Nursery production is authorized by NC General Statute 113-35, which allowed the Department to "establish and operate forest tree nurseries and forest tree seed orchards". The law assures that an adequate supply of forest tree seedlings, of the highest quality, is available so the State will continue to maintain a strong forest-based economy.

State forestry nurseries are important to maintain a reliable and stable supply of forest seedlings to meet current and new demands to increase productivity, improve wildlife habitat, restore wetlands and streams, supply biomass or carbon markets, and establish tree species of concern. In 1996 a special commission of consulting foresters, representatives from forest industry, forestry associations, landowners and private citizens was formed to study the effects of privatization of the nursery program in the state of Georgia. This commission study concluded that the private sector could not procure all the state's seedling needs alone. They recommended the state continue to operate a nursery program to insure a stable and adequate supply of quality seedlings. In 1996 the Southern Group of State Foresters agreed that maintaining viable state nursery programs was in the best interest of sustainable forestry in the South.

In 1978 the Southern Forest Nursery Management Coop (SFNMC) was founded to research and develop effective weed and disease control technologies for nursery production, and to transfer this knowledge to members. The SFNMC represents the forest tree nursery community on issues where the Environmental Protection Agency (EPA) and the U.S. Department of Agriculture are involved (USDA). The NCDFR and Weyerhaeuser Company nurseries are members of the SFNMC along with seven other southern state forestry agencies, seven private firms, and the U.S. Forest Service (USFS).

Proposed changes by the EPA regarding the use of soil fumigants could drastically affect future nursery operations for forest seedling nurseries. If the proposed regulations are implemented, nurseries will have to make significant modifications that will impact production and seedling costs shift toward growing more containerized stock vs. bare-root stock, or close operations. A reduction in the production of bare-root seedlings in favor of containerized seedlings is one option being considered by many nurseries. A shift toward more containerized seedlings would require a significant investment in added infrastructure.

Forest Management Practices to Enhance Forest Habitat and Ecosystems

Active forest management can be used to replicate the disturbance regimes from natural forces and create forest habitat needed by many wildlife species. To meet the needs of a variety of wildlife species and habitat, land managers will need to create a mosaic of plant communities and forest habitat in various age groups across the landscape. Forest practices such as harvesting methods, prescribed burning, thinning, forest stand improvement practices, and herbicides can be applied to alter forest structure and composition to meet the habitat needs of many game and non-game wildlife species.

Prescribed Burning

Based on data compiled from NCDFR Total Accomplishments Reports, the statewide average annual acres prescribed burned for hazard reduction, wildlife, or silviculture objectives was 118,779 acres during 2000-05. About two -thirds of the prescribed burning was for hazard reduction burning, mostly by federal, state, and non-government entities. Prescribed burning for wildlife habitat and silvicultural purpose averaged 32,492 and 7,422 respectively. Seventy percent of the prescribed burning is conducted in the Coastal Plain region (Table 2*e*-6). No clear trends are noted from the data, with the exception of a decrease in prescribed burning carried out by forest industry ownerships.

Yearly fluctuations in accomplishments do occur because opportunities to conduct prescribed burning are greatly influenced by variations in weather, and other barriers. Other barriers attributed to the ability to conduct more prescribed burning include the reduced capacity of fully trained or qualified personnel, reduced capacity of fire control equipment and smoke management limitations and public attitudes toward prescribed fire.

The North Carolina Prescribed Burn Act was passed in 1999 to help mitigate and overcome some of the barriers to prescribed burning. The NC Prescribed Burn Act limits the prescribed burner's liability for damage or injury resulting from impacts of smoke due to prescribed burning. This act also acknowledges the benefits of prescribe burning and establishes burning requirements.

North Carolina is experiencing an increased level of interest in prescribed burning by a wide variety of groups. This increased interest resulted in the formation of the NC Prescribed Fire Council (NCPFC) in 2003. The mission of the NCPFC is to foster cooperation among all partners in North Carolina with an interested in prescribed fire. Currently the NCPFC has 188 members representing approximately 35 entities. Another effort to promote prescribed burning is the Governor's proclamation that the second week in February be declared Prescribed Fire Awareness Week for North Carolina.

TABLE 2*e*-6.—Summary of prescribed burning acres in North Carolina by region and purpose, 2000 – 2005

	HRB by LO[1]	HRB by Other [2]	HRB by Industry	Silviculture Burn [3]	Wildlife Burn [4]
Coastal Plain	6,136	47,680	8,282	3,311	17,258
Piedmont	8,307	7,404	537	3,809	14,871
Mountain	62	468	0	292	362
Statewide Average	14,505	55,552	8,819	7,411	32,492

[1] HRB = Hazard reduction prescribed burn where the primary objective is to reduce fuel loads to reduce the threat from wildfire.
[2] HRB by Other = Hazard reduction prescribed burn conducted by all other state, federal, local government agencies or nongovernment organization.
[3] Silviculture Burn = Acres of post-establishment, in-stand burning where silvicultural or ecosystem restoration objectives are primary over HRB objectives.
[4] Wildlife Burn = Acres of post-establishment, in-stand burning where wildlife habitat enhancement objectives are primary over HRB objectives.

Fire Exclusion and Fire Dependent Ecosystems

Changes in land use and fire exclusion have the potential to alter the structure and composition of our current forests and associated wildlife communities. Many forests and natural communities have evolved from disturbance events such as fire ignited by lightning, severe storm events, and landscape manipulation. Many plants and animals depend on fire to flourish. Examples include animals such as bobwhite quail, red-cocked woodpecker, fox squirrel, pine snake and many birds and plants such as wiregrass, Venus flytrap, pitcher plant, and other rare or threatened species. Prescribed burning helps to reduce vegetation competition, releases seeds, promotes flowering or fruiting, and creates enhanced cover for these species.

Fire exclusion threatens the health and existence of many native plant communities and the wildlife they support. The use of prescribed fire in North Carolina is an important wildlife and forest management tool to maintain fire-dependent ecosystems. The use of prescribed fire and herbicides in mid-rotation plantations can also be used to develop pine savanna vegetation typical of older, natural fire-maintained pine stands (Miller and Miller, 2004). These two silvicultural prescriptions are especially important tools in the management and sustainability of both longleaf pine and shortleaf pine ecosystems.

Non-Timber Resource Protection and Enhancement

Many landowners in North Carolina are interested in managing their forestland to protect water quality, improve recreation, protect important archaeological sites, or enhance wildlife habitat. The Forest Stewardship Program (FSP) coordinates various public and private technical assistance programs available to forest landowners to help develop and implement a multi-resource management plan. From 2001 – 2007 an average of 43,000 acres per year were enrolled in the Forest Stewardship Program in North Carolina.

The NCDFR provides technical assistance to assist landowners with activities and projects that provide non-timber benefits (TABLE 2*e*-7). Over the last 5 years, approximately 151,442 thousand acres were managed for non-timber values, with an average of 30,288 acres treated annually. The majority of these projects and activities were for wildlife enhancement.

Soil and Water Quality Protection Measures to Benefit Forests

In North Carolina, forestry related site-disturbing activities must comply with the performance standards described in the state regulation entitled the Forest Practices Guidelines Related to Water Quality (FPGs). The statewide FPGs are incorporated as part of the state's Sedimentation Pollution Control Act, and cover the full spectrum of forestry activities; refer to the NCDFR's Website for citations of the FPGs. The NCDFR is delegated the authority to inspect forestry sites for compliance with the FPGs. FPG inspection results from 2004 through 2009 are presented in Table 2E-8.

In addition to the FPGs, the state has a comprehensive set of forestry Best Management Practices (BMPs) that often are the primary means to promote compliance with the FPGs and other water quality regulations. While the implementation of forestry BMPs is voluntary in North Carolina, the NCDFR conducts periodic site survey assessments to determine the degree of BMP implementation. More information about these BMP surveys can be found in the

TABLE 2*e*-7: 5-year Summary of Non-Timber Resource Protection and Enhancement[1] projects conducted by NIPF owners involving NCDFR personnel or programs

	Soil & Water Protection[2]		Recreation Enhancement[3]		Wildlife Enhancement[4]	
Fiscal Year	No. Projects/ Activities	Acres Treated	No. Projects/ Activities	Acres Treated	No. Projects/ Activities	Acres Treated
2004-05	223	7434	13	118	372	26,577
2005-06	170	5070	21	505	384	33,146
2006-07	212	4938	14	928	428	31,438
2007-08	112	1638	27	690	266	12,259
2008-09	86	3100	30	606	325	22,995
Totals	803	22,180	105	2,847	1,775	126,415
Average	161	4,436	21	569	355	25,283

[1] Non-Timber Resource Protection and Enhancement projects are for benefits other than wood production, including wildlife and fisheries, recreational and archeological, and soil and water projects.
[2] Soil & Water Protection projects and activities may include stabilization or re-vegetation to prevent erosion, bridges, culverts, or rock fords.
[3] Recreation Enhancement also includes archeological projects and activities that may include trails construction, vista clearings, understory clearing, and recreational area development and structures.
[4] Wildlife Enhancement projects and activities include prescribed burning, food plots, mast tree plantings, wildlife habitat practices, and nest boxes.

Water Quality Section of the NCDFR website.

Ongoing efforts of education, training, and on-site technical assistance are employed to reach landowners, loggers, and others who may need to understand FPG's, BMP's and the multitude of water quality regulations that affect forestry operations in North Carolina.

From 2004 to 2009, approximately 18,346 forestry sites were inspected for FPG compliance. Between 95 to 97 percent of the forestry sites inspected were documented to be in compliance over this same period (TABLE 2*e*-8). Forestry BMP implementation continues to be very high in North Carolina. Three-year BMP implementation results from 2000 to 2003 are summarized in a *Final Report for the NC Forestry BMP Implementation Survey* (Raval, 2005). In North Carolina the average statewide BMP implementation over this 3-year survey period was 82 percent. The level of BMP implementation varied regionally, and the level of BMP implementation was based on the review of more than 5,000 individual practices indentified on 565 sample harvest sites. From 1997 to 2007, 25 statewide BMP implementation monitoring surveys were conducted throughout the South. Combining all BMP categories in all states, and using only the most recent survey data, the average BMP implementation for the South was 87 percent. The range of overall implementation reported by individual states for all surveys during this same period was from 68 percent to 99 percent (SGSF, 2008).

All inspections of any forestry operation are documented at the local level and summarized in a statewide database. More detailed information on forestry sites not in compliance with FPGs is maintained in a violation tracking database. This database can provide summary information to forest industry to review quarterly compliance reports and utilize this information for Sustainable Forstry Initiative (SFI) purposes. Many of the forestry sites not in compliance are brought back into

TABLE 2*e*-8.—Summary of forestry site inspections[1] for *NC Forest Practices Guidelines* (FPG) related to water quality

	Forestry Sites			
Fiscal Year	Inspected[2]	In Compliance	Not in Compliance	In Compliance (%)
2004-05	4241	4012	229	95
2005-06	3903	3722	181	95
2006-07	3914	3747	167	96
2007-08	3070	2952	118	96
2008-09	3218	3115	103	97
Totals	18,346	17,548	798	96

[1]This is the total number of forestry sites inspected for FPG compliance, not including re-inspections.
[2] Sites include active and inactive harvest operations, reforestation activities, precommercial thinning, release treatments, and forest road construction not associated with a harvest.

compliance through recommendations and technical assistance provided by NCDFR personnel. Only a small number of sites are referred to other agencies for further assistance (TABLE 2*e*-9). Referrals are violations that will involve additional follow-up action or expertise or may be violations that fall outside of NCDFR jurisdictional responsibility.

Streamside Management Zones

In North Carolina forestry activities must establish and maintain a streamside management zone (SMZ) alongside certain types of streams and bodies of water. Forested buffers are an effective measure to protect water quality during harvesting, road construction, herbicide or fertilizer applications, and site preparation activities.

The width of SMZ's vary according to site specific factors such as soils, slope, type of water body,overall site disturbance, and landowner objectives. The forestry BMP Manual contains recommendations for establishing SMZ's. While the primary objective of establishing a SMZ is for water quality protection, a well-managed SMZ can provide multiple benefits, including wildlife cover and habitat; recreation; aesthetic visual screens; and windbreaks. Generally, harvesting is allowed within a SMZ, but should occur in a low-impact manner that maintains the integrity of the soil and water resources.

Forest Certification in North Carolina

Forest certification is a relatively new development since the 1990's, and deals not with the final product, but the practice of forestry, growth of the product, harvesting of the product, and ecological impacts associated with the harvesting of the product (Klingberg 2003). Forest certification is gaining widespread attention by a variety of stakeholders including state agencies, forest industry, environmental organizations, professional foresters, loggers, government policy makers, social activists, and the general public (Viana et al. 1996; Mater 1999).

Forest certification has been promoted as a tool for broader public acceptance of forest management and for achieving environmental, social, and economic benefits on certified forests (Moore and Cubbage, 2008). The concept of forest certification has emerged as a management tool to attain sustainable forestry using a voluntary market approach rather than a regulatory approach. Four major certification systems are active in North Carolina. These organizations are Sustainable Forestry Initiative (SFI), Forest Stewardship Council (FSC), Green Tag, and American Tree Farm System (ATFS). Of the four, SFI and ATFS fall under the Program for the Endorsement of Forest Certification (PEFC), the world's largest forest

TABLE 2*e*-9.—Summary of NC forest practices guidelines (FPG) referrals[1]

	Fiscal Year				
Agency	2004 – 05	2005 – 06	2006 – 07	2007 – 08	2008 – 09
DFR—LE	1	2	2	0	2
DLR	7	4	3	2	2
DWQ	6	4	4	1	0
DACS	0	0	0	0	0
Totals	14	10	9	3	4

[1] Agencies include NC Division of Forest Resources-Law Enforcement(DFR—LE), NC Division of Land Resources (DLR), NC Division of Water Quality (DWQ), and NC Department of Agriculture and Consumer Services (DACS).
[2]Total is the actual number of tracts referred. Some tracts may have been referred to more than one agency.

certification umbrella organization endorsing national and/or regional forest certification standards that meet its rigorous sustainable forest management criteria.

Very few family forest landowners are aware of forest certification programs. In the U.S., only 12 percent of the family forest owners, who own 24 percent of the family forest land, have heard of forest certification with very few family forest landowners (<1 percent by ownership) currently enrolled in a forest certification program (Butler 2008). By comparison, less than 5 percent of NC family forest landowners who responded to a 2006 NWO survey were familiar with forest certification programs or have land currently enrolled (Butler 2008).

Forest Stewardship Council (FSC) certified forestlands currently amount to about 12,000 acres in NC, all of which are privately owned. Comparatively, the Sustainable Forestry Initiative (SFI) and American Tree Farm System (ATFS) certify about 352,000 and 1.1 million acres respectively. Over 65 percent of the forestland enrolled under the ATFS is owned by NIPF landowners making the ATFS the most accessible forestland certification system for this ownership group in NC. Recently, the ATFS has modernized its standards and guidelines in order to reach PEFC sustainability benchmarks. In 2009, ATFS was audited at the National level and received third party certification from PEFC.

Forest industry forestlands are certified by both the SFI and the ATFS, with SFI accounting for nearly 90 percent of the certifications. North Carolina has a very active statewide SFI implementation committee. The primary certification alternatives at the present time work best for larger NIPF's, but are currently difficult and costly for the average NIPF landowner to implement (Mercker 2006).

Other studies conducted in SE states have found that very few landowners are familiar with certification requirements and were reluctant to outlay cash for direct or indirect costs associated with certification expenses (Vlosky 2000, Newsome et al. 2003). Mercker (2006) found that NIPF landowners most likely to consider forest certification were typically well educated, professionals that were new at forest land ownership, had received advice or information about their forestland, and desired to stay up-to-date with new forestry practices and programs.

Newsome et al (2003) results showed that there was a positive relationship between landowner's awareness of certification and the following:

- Landowner's who have participated in government programs in the past,
- Landowner's who receive a higher proportion of their income from forestry

- Landowner's who interact more frequently with professional foresters or county extension agents
- Landowner's who belong to associations

North Carolina NIPF landowners share many of the common socio-demographics of the prospective landowners that would indicate a willingness to consider forest certification if given the appropriate information and technical assistance. Educational focus should be with those landowners having the characteristics most favorable toward considering certification. Five sociodemographic variables were identified by Mercker (2007) as significantly related to landowner's willingness to certify, including landowners who: 1) were well educated, 2) were new at land ownership, 3) were professionals, 4) have received forestry advice or information, and 5) desired to stay up to date with new forestry practices and programs.

Increased enrollment in forest certification systems by North Carolina NIPF landowners will require future efforts to assess their awareness and acceptance of current programs available to them and target educational programs to landowners with characteristics favorable toward certification. Additional training on the process and benefits of forest certification will be needed for natural resource professionals that can assist NIPF landowners willing to consider certification for their forests as well as third party assessment opportunities.

Having a good knowledge of forest certification is a precondition for NIPF landowner participation. Lindstrom (1999) found that without adequate knowledge of forest certification, private forest landowners are not likely to participate, no matter how good the certification system. Mercker (2006) found that the top reasons landowners chose for certifying their forests were if certification 1) made their forest healthy, 2) improved wildlife habitat, or 3) saved money by reducing the likelihood of future regulation. Future opportunities may also exist to expand forest certification systems that incorporate emerging markets in ecosystems services and demand for export timber products. Group certification opportunities through third party organizations may also develop in the future.

Regardless of the reasons for NC landowners to enroll in forest certification systems, increased future efforts will be needed in education, outreach, training, and a collaborative effort between resource management agencies, forest industry, NGO's, and natural resource professionals to promote forest certification in North Carolina.

Forest Certification may become a more important tool to many forest landowners in NC to demonstrate a commitment to forest sustainability and a long-term dedication to proper management and stewardship of our forest resources.

Building Research Capacity

Currently, North Carolina has a variety of forestry research organizations or centers that are capable of addressing a broad range of forestry issues (TABLE 2*e*-10). For the purposes of this assessment, a narrow definition of forestry research is used and those institutions engaged in broader natural resource management research are not included. These forestry research centers tend to be clustered in the center of the state. Universities are the focus for forestry research and provide a consortium of information for the other research centers both in and out of state. Several of the research centers have research forests associated with them.

TABLE 2*e*-10.—Primary organizations conducting forestry research in North Carolina

Research Institutions	Location	Type of work
NC State University Department of Forestry and Environmental Resources	Raleigh	Full spectrum research, undergraduate and graduate programs
Duke University Nicholas School of the Environment	Durham	Full spectrum research, graduate programs
US Forest Service—Southern Research Station	Asheville	Full spectrum
NC Division of Forest Resources	Raleigh	Urban forestry, water quality; applied forest management
Weyerhaeuser	New Bern	Pine silviculture
National Council for Air and Stream Improvements (NCASI)	Research Triangle Park	Forestry and pulp and paper

Both public and privately operated forestry-related cooperatives exist in North Carolina (TABLE 2*e*-11). The proprietary nature of their research limits the dissemination of their findings to their members only. However, the existence of multiple such organizations in the state underscores the investment in research and development in the forest products sector in North Carolina.

Forestry research cooperatives are important to investigate and assess future research areas, such as forest management and sustainability, forest tree improvement and productivity, and forest modeling. These cooperatives are the joint efforts of the USDA Forest Service, state forestry agencies, forestry programs at southern universities, and forest industry. In recent years funding for these cooperatives has declined due to consolidation in forest industry and declining research budgets from other agencies.

A major concern associated with the transition in forestland ownership in the South has been the decreasing support of forestry research. Both internal proprietary research and external cooperative research programs have declined substantially or have been eliminated by forest industry (Clutter et al., 2005). Consequently, several of the research cooperatives in the South have been terminated in the last 10 years, and the support for some of the remaining programs has declined to the point where their long-term survival is questionable (SIFRC, 2000; Clutter et al., 2005).

Emerging areas that are gaining increased research interest and subsequent funding includes declining ecosystems and species restoration, climate change mitigation, biofuels for energy, carbon management and sequestration, and invasive species.

TABLE 2*e*-11.—Forestry-related cooperatives in North Carolina

Name	Location	Type of work
Forest Nutrition Cooperative	Raleigh NC State/VA Tech	Forest productivity
NC State Cooperative Tree Improvement Program	Raleigh NC State University	Tree Improvement
Southern Forest Resources Assessment Consortium	Raleigh NC State University	Modeling of forest biological, economic, and social information
Southern Center For Sustainable Forests	Duke/NC State/NCDFR	Forestry Certification, Chip Mill Study

Summary

Few family forest landowners in North Carolina have a written forest management plan or received professional advice or financial assistance to actively manage their property. Nearly 30 percent of forest landowners list "leave as is" as their plan for management activities in the next five years. Harvesting timber is listed as a planned activity by less than 10 percent of forest landowners. Of the forest landowners that do seek management advice, the majority of them indicate that the state forestry service is one of their primary sources of information.

Demand for timber products is increasing, while available forestland is decreasing through conversion to other uses (Wear, 2002). Intensive forest management practices have the potential to increase productivity in managed forests on fewer acres. Actively managed forests may reduce pressure to harvest natural stands while sustaining a long-term timber supply. The area of pine plantations in North Carolina, currently accounting for 12 percent of the total forested area, is expected to double in the next 30 years (Prestemon and Abt, 2002). Most of these plantations will be established using practices such as the planting of genetically improved seedlings and application of herbicides, which should improve productivity. Productivity gains will range from 10 to 70 percent over traditional plantations with the highest quality sites exhibiting the best response. Forest industry owners, REITs, and TIMOs will practice even more intensive management.

Few NIPF landowners, even those who own large tracts, practice intensive forestry. An increase in the number of small NIPF tracts (which are difficult operationally and economically to manage intensively) is predicted.

Forest nurseries in North Carolina produce a sufficient supply of forest seedlings to meet the reforestation needs of the state. The NCDFR nursery program produces 45 different species of native forest seedlings for timber, wildlife habitat, wetland mitigation, and ecosystem restoration. A state nursery and tree improvement program is important to provide a diverse and stable supply of forest seedlings. Volume gains realized from genetically improved seedlings benefit landowners economically and help meet the demand for wood products on fewer acres.

North Carolina has funded a strong cost share program, the FDP, to improve productivity for nonindustrial private landowners. The FDP provides funding for about half to three-fourths of all the acres artificially reforested each year. A higher funding rate is available for the planting of longleaf pine, shortleaf pine, Atlantic white cedar, and hardwood species. Other federal cost-share programs and initiatives are available for establishing forests to benefit wildlife habitat, threatened and endangered species, and water quality. Continued support and funding for state and federal cost-share programs and initiatives are important to provide financial and management incentives to family forest landowners.

Changes in land use and fire exclusion have altered the structure and composition of our forests and associated wildlife communities. Forest management practices and activities—such as prescribed burning, thinning, timberstand improvement, and herbicide use—are effectively used to enhance forest habitat for game and nongame wildlife species. The use of prescribed fire in North Carolina is an important wildlife and forest management tool to maintain fire-dependent ecosystems and as an effective technique for reducing the risk from wildfire.

Soil and water quality protection measures will continue to be important to monitor and implement during any forestry operation to prevent nonpoint source pollution and to maintain favorable public opinion about forestry practices in the future. The trend in forestry research appears to be away from traditional growth and productivity topics towards more sustainability topics, such as ecosystem services.

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Glossary

clone. A vegetatively propagated organism, or a group of such organisms consisting of an ortet and its ramets.

family forest owners. Families, individuals, trusts, estates, family partnerships, and other unincorporated groups of individuals that own forest land. This group is a subset of nonindustrial private forest owners.

forest certification. The stewardship and use of forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality, and potential to fulfill, now and in the future relevant ecological, economic, and social functions at local, national, and global levels, and that does not cause damage to other ecosystems"

germplasm. (1) Within an individual or group, the collective hereditary materials that are the physical basis for inheritance; the hereditary stream. (2) The genotype, with particular reference to its transmission to the next generation.

mass controlled pollinations (MCP). A method of tree breeding where large numbers of pollen parentage are completely controlled, eliminating pollen contamination and allowing for positive assortative mating among seed orchard parents to maximize genetic gains or specific genetic traits.

roguing. A systematic removal of individuals not desired for the perpetuation of a population, e.g., from a seed stand, nursery, or genetic test.

Sustainable Forestry Initiative (SFI). A voluntary, third-party organization that develops standards of good forest management and certifies that forests are well-managed as defined by a particular standard ensuring that certain wood and paper products come from responsibly managed forests.

timber investment management organization (TIMO). A management group that aids institutional investors in managing their timberland investments. A TIMO acts as a broker for institutional clients.

timber stand improvement. An intermediate treatment made to improve the composition, structure, condition, health, and growth of evenly or unevenly aged forest stands.

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urban-rural interface. The area or zone where infrastructure and other associated development from human populations meet or intermingle with rural forests and farms.

2.f.

Emerging Markets in Ecosystem Services

Key Findings

- Ecosystem markets are available to landowners in North Carolina, but are primarily on a case-by-case basis, with the majority of markets focusing on mitigating impacts upon water quality.
- Best estimates are that approximately 19 stream and/or wetland compensatory mitigation banks exist in North Carolina, indicating that landowners in this state may be in an advanced position, relative to other southern states, to capitalize on the projected needs for future water-resource ecosystem markets.
- Based upon anecdotal evaluation of the components that could drive the creation and implementation of forestry-based strategies to offset carbon dioxide (CO_2), it would appear that managing forests for CO_2 could be successful in North Carolina, thus offering a potential source of continued support for working forests.

Introduction

Ecosystem services are the benefits people obtain from ecosystems. Examples of the type of services include: provisioning (food, water, timber, and fiber); regulating (climate, floods, disease, wastes, and water quality); cultural (recreational, aesthetic, and spiritual); and supporting (soil formation, photosynthesis, and nutrient cycling). While the intrinsic values of the ecosystem services provided by forests have long been recognized, only recently have there been efforts to monetize ecosystem services in a manner that could benefit private landowners.

Status and Examples of Ecosystem Markets

Current markets for ecosystem services range from nonexistent to highly developed and vary by geographic location. The most well-known markets are those for provisioning services, which include timber, fiber, food, and water. In North Carolina there may be opportunities for landowners to benefit from several nontraditional ecosystem markets:

1. Wetland and stream compensatory mitigation banking
2. Nutrient offset banking and credit trading
3. Riparian buffer mitigation banking
4. Endangered species conservation banking
5. Carbon credit trading

The information outlined in this document for each ecosystem market is simply a brief overview and not a full description of eligibility, benefits, risks, or regulatory requirements needed to participate in these markets. A landowner needs to obtain the professional services of an environmental consultant who can describe the extensive regulations that govern these ecosystem markets and assess their respective market opportunities for the landowner.

Overview of Mitigation Banking

The term *mitigation banking* refers to the restoration, enhancement, preservation, or creation of wetlands, streams, riparian buffers, or endangered species habitat conservation areas that off set expected adverse impacts to these ecosystems from land development, roadway construction, and related disturbance activities. Mitigation banks are highly regulated by numerous federal and state agencies. Once a mitigation bank has been approved by the appropriate regulatory agencies, the credits from the mitigation services conducted on the mitigation bank are available for sale to an entity that is proposing impacts to wetlands, streams, or endangered species habitats. Recent changes in federal and state laws give a preference to private-sector mitigation banks for offsetting impacts from development projects. This new guidance may prove to be an opportunity for private landowners to realize revenue from mitigation banking activities.

Wetland and Stream Compensatory Mitigation Banking

Impacts to wetlands and streams are mitigated by any of three methods (in order of preference): avoiding; minimizing; and then as a last resort, compensating for the impacts. Compensatory mitigation can, in turn, be achieved through one or more of the following: restoration, enhancement, preservation, and creation. From 1995, when the federal mitigation policy was established, until 2008, when new federal and state laws revised how mitigation should be conducted, approximately 19 wetland or stream mitigation banks existed in North Carolina. Since the 2008 revisions, at least 5 mitigation bank proposals in North Carolina have been submitted to the U.S. Army Corps of Engineers, with 3 having been approved. The rapid increase in mitigation banking proposals since April 2008 indicates that this ecosystem market is growing and opportunities may exist for forestland owners across the state. Extensive information about the rules, policies, and requirements for compensatory wetland and stream mitigation are available on these Web sites:

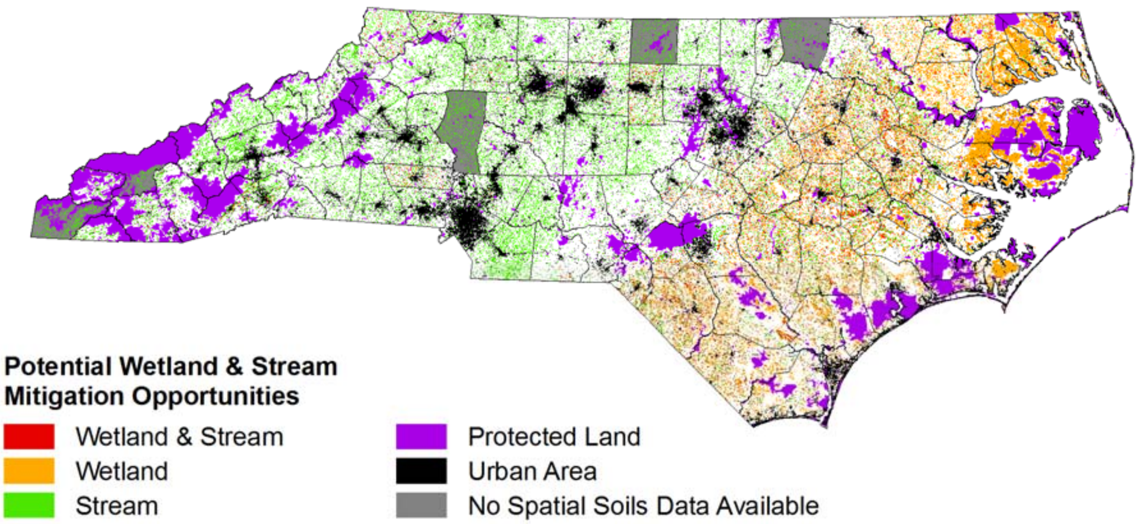
- U.S. Army Corps of Engineers: www.saw.usace.army.mil/WETLANDS/Mitigation/index.html
- NC Ecosystem Enhancement Program: www.nceep.net
- U.S. Environmental Protection Agency: www.epa.gov/wetlandsmitigation

FIGURE 2*f*-1 depicts approximate locations of potential wetland and stream mitigation site opportunities for private landowner participation.

Nutrient Offset Banking and Credit Trading

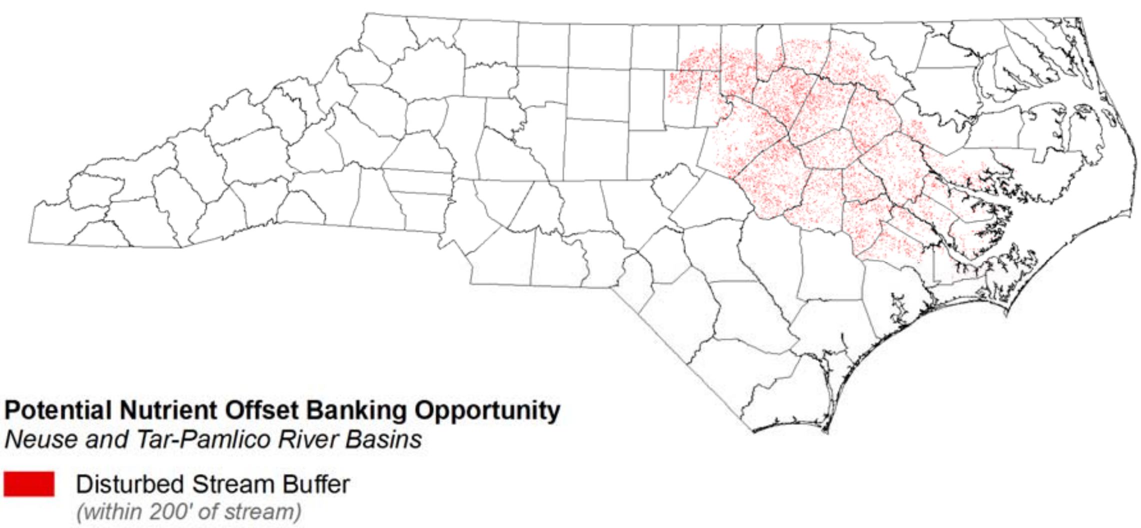
The NC Nutrient Offset Program was developed in 2001 to assist wastewater dischargers and land developers in the Neuse River basin and Tar-Pamlico River basin with compliance of strategies to manage these nutrient-sensitive waters. Developers in these river basins must work with local municipalities to reduce the nutrient contributions associated with their land development activities. If developers are unable to meet the requirements associated with the nutrient rules, they must develop strategies to offset their nutrient contribution, one of which is to pay into the NC Riparian Buffer Restoration Fund. Land that has been converted from forestland to agriculture, pasture, and other disturbed land use may qualify for providing nutrient offsets through forest restoration and enhancement activities in the Neuse River or Tar-Pamlico River basins. Forestland owners within these basins that have degraded and/or unbuffered streams and/or wetlands on their property could be eligible to provide nutrient offset credits and be compensated for planting trees or otherwise enhancing a 200-foot buffer adjacent to streams and wetlands. This Web site has more information about this offset opportunity: www.nceep.net/services/stratplan/Nutrient_Offset_Program.htm. FIGURE 2*f*-2 depicts approximate locations for nutrient offset bank establishment opportunities.

FIGURE 2*f*-1. Approximate wetland and stream mitigation site opportunities for private landowners.



Created by: D. Jones, NCDFR, 2010

FIGURE 2*f*-2. Approximate nutrient offset bank opportunities for private land owners.



Created by: D. Jones, NCDFR, 2010

Riparian Buffer Mitigation Banking

Certain watersheds and river basins in North Carolina are required to implement state rules that are intended to manage and control nutrients in the streams, wetlands, and bodies of water that exist within these watersheds or basins. These areas include the Catawba River basin, Goose Creek watershed (Union and Mecklenburg counties), Jordan Lake watershed, Neuse River basin, Tar-Pamlico River basin, and Randleman Lake watershed. One of the primary ways to regulate excessive nutrients is by protecting and maintaining vegetated riparian buffers alongside designated streams and bodies of water. A landowner may be able to benefit from the creation of a new forested riparian buffer within these designated watersheds if another landowner or developer in the same drainage area wishes to encroach upon an existing riparian buffer elsewhere. This mitigation of a riparian buffer would then be one alternative allowed under the state's rules. As in all cases, a landowner should employ the services of an environmental consultant who can determine the eligibility and requirements of riparian buffer mitigation or other mitigation-related activities. To learn more about riparian buffers, contact the NC Division of Water Quality: http://h2o.enr.state.nc.us.

Endangered Species Conservation Banking

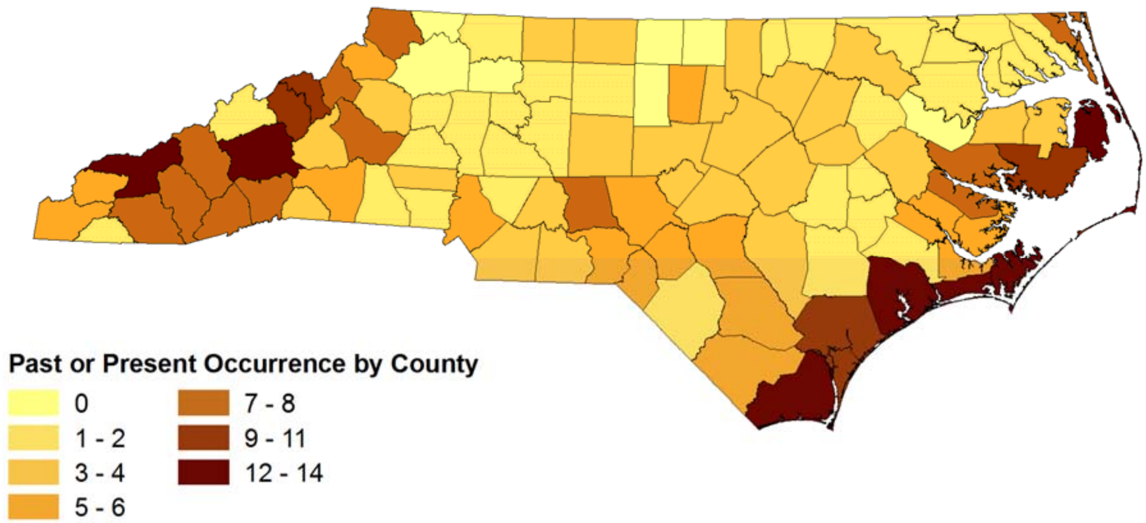
Endangered species conservation banking is a growing strategy for managing adverse impacts to endangered species populations and habitats in the United States (Fox and Nino-Murcia, 2005). Similar to the mitigation policies associated with wetland and stream compensatory mitigation, endangered species conservation banking includes the restoration, enhancement, preservation, and/or creation of habitat for species listed under the Endangered Species Act (ESA) or for those species under consideration for listing. For unavoidable impacts to ESA listed species, conservation banks may be considered on a case-by-case basis by the U.S. Fish and Wildlife Service (USFWS) as a flexible alternative for "meeting a variety of conservation needs of a listed species" (USFWS, 2003).

In 2003, the USFWS prepared a memorandum to be used by USFWS staff when evaluating conservation banking proposals: "Guidance for the Establishment, Use, and Operation of Conservation Banks". The document outlines the goals, objectives, strategy, eligibility, site selection, service area, and other governing characteristics that a proposed conservation bank must consider. This memo is available through USFWS at: http://www.fws.gov/Endangered/pdfs/MemosLetters/conservation-banking.pdf

In North Carolina, there are 13 mammals, seven birds, eight reptiles and amphibians, 19 fish, and 26 plants listed on the endangered species list (USFWS, 2010). Although no private conservation banks exist in North Carolina, at least eight private conservation banks exist across the Southeast, from South Carolina to Texas (EM, 2010). Conservation banking may become a more commonly used strategy as urban land-use development continues to place a strain on species and natural habitats.

FIGURE 2*f*-3 depicts the number of federally listed species that are known to occur (past or present) in each county of North Carolina. When supporting ecosystem habitat exists and/or habitat restoration is undertaken in collaboration with USFWS and in accordance with conservation bank guidelines, the future establishment of conservation banks is more likely to occur in

FIGURE 2*f*-3. Federally-listed species occurrences in North Carolina.



Created by: D. Jones, NCDFR, 2010

counties with listed species occurrences. For more information about specific species listed in North Carolina, refer to the USFWS Web site: www.fws.gov/raleigh/es_tes.html

Carbon / CO_2 Markets

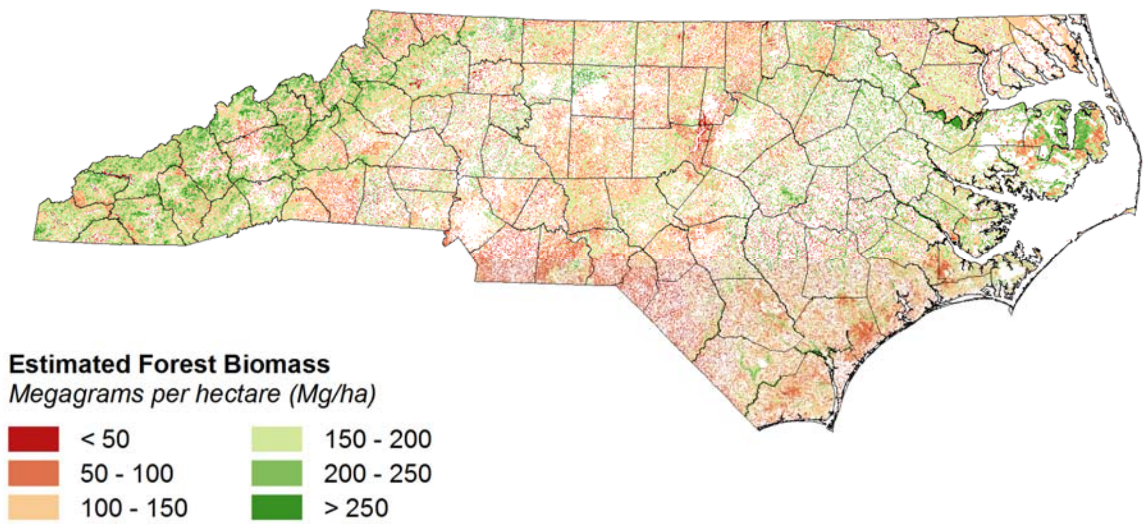
There is a growing recognition that forests, silvicultural practices, forestland management, and increased utilization of wood-based products can contribute to mitigating, offsetting, or reducing the level of carbon dioxide (CO_2) in our atmosphere. Ongoing research is attempting to quantify the existing carbon stock of aboveground vegetation and within the soil; this work is a vital first step in understanding the role forestry plays in CO_2 management. FIGURE 2*f*-4 illustrates the current state of knowledge regarding forest carbon biomass quantities in North Carolina. Carbon retention and carbon sequestration have emerged as the two approaches to CO_2 management.

Carbon retention includes the conservation and/or preservation of existing forestlands, thus preventing them from conversion to nonforest land use. Retention is also accomplished by the conversion of trees into renewable wood-based products, which effectively retain carbon for the duration of the product's life cycle. The forestland that produced the timber is then reforested to continue the carbon management cycle.

Carbon sequestration includes the process of accruing or capturing an incremental amount of CO_2 from the atmosphere, and is generally understood to focus on the establishment of new trees.

The potential markets for forestry-based CO_2 offsets are still developing. While the Chicago Carbon Exchange (CCX) has been trading for a few years as the most well-known market in the United States, the deployment (or reward) of capital to or from forest landowners for the purposes of marketing carbon credits remains a financial under-performer when compared with markets for traditional forest products.

FIGURE 2*f*-4. Estimated forest carbon biomass (above- and below-ground) in North Carolina.



Created by: D. Jones, NC DFR, 2010

Several attributes appear to collectively create a more favorable scenario for the successful implementation of forestry-based strategies for CO_2 management. Each of the following six attributes shows promise in North Carolina:

- Carbon-rich, naturally productive soils
- Diverse forest species composition
- Abundant, privately-owned "working" forestlands
- Proximity to forest product processing facilities and consumer markets
- Proximity to large-volume, identifiable CO_2 emissions
- Access to investment capital, financial markets, and funding to support forestry activities

Soils

Soils are a vast repository of carbon. Ideally, to manage for CO_2 offsets, carbon-rich soils should remain in a relatively stable and undisturbed condition. The relatively long-term growth and harvest cycles of forests are suitable to sustain a stable soil-based carbon bank. In particular, North Carolina's organic (peat) soils in the lower coastal plain should be examined as to how forestry-related management measures can enhance carbon storage and/or reduce the potential of carbon loss from these soils.

Species Composition

According to the literature, forests of diverse species yield greater potential to sequester carbon. North Carolina's tremendous diversity of forest species should prove valuable in the development of CO_2 offset measures.

Private Forestlands

Private forestlands in North Carolina will play an important role in carbon retention. The majority of working forests in which an actively managed CO_2 offset process can be sustained are those in private ownership. Nearly 80 percent of North Carolina's 18-

million acres of forestland is privately owned (Brown et al., 2006).

Forest Products

Retention of CO_2 by processing wood into usable products requires that a substantial network of forest product processing facilities be located near the raw material, and relatively close to the end user. The overall CO_2 management cycle can be implemented more efficiently and with a lower overall carbon footprint when supply is close to demand. North Carolina, despite numerous recent closings of manufacturing facilities during the ongoing economic recession, still retains a high number of wood-based processing facilities throughout the state.

When assessing the potential demand for wood-based products, North Carolina is consistently cited as one of the fastest growing population centers of the U.S., and this trend is expected to continue (U.S. Census Bureau, 1996). Increased populations will produce a commensurate increase in the consumption of forest-based products for construction and other purposes.

CO_2 Emissions

Although there are multiple sources of CO_2 emissions, the most readily identifiable man-made source of emissions is fossil-fueled electricity generation. On the presumption that, as noted above, the supply must meet the demand for an effective CO_2 offset market (or any market) to succeed, North Carolina is well positioned with an estimated 25 fossil-fuel electricity generating units across the state.

Access to Capital

Within the last decade, we have seen significant increases in awareness and action from financial investors and market makers to participate in owning and managing forestland as a component of an investment portfolio. North Carolina is in a unique position among states of the Southeast because several of the well-known timber investment organizations have operations, management offices, and/or timberland properties across the state. This existing base of forest investment knowledge could readily expand into the world of CO_2 offset markets if the opportunity and financial viability improve. In addition, North Carolina is often considered the banking and financial operating center of the South, allowing us to presume that capital may be more readily available for the development and execution of markets for CO_2 management. The financial investment community's proximity to and familiarity with North Carolina's forests and markets could create conditions in which CO_2 offset markets, or other ecosystem markets, would be more readily established and accepted in this state.

In addition to private financial capital, North Carolina has a long history of cooperation with the federal government regarding the stability and sustained operations of several strategic military installations and facilities. In recent years, a renewed focus by state and federal officials has led to new partnerships and efforts to assess how forestry, agriculture, and traditional 'working lands' can serve as operational buffers around military facilities to bolster national security and mitigate potential quality-of-life concerns for surrounding residents and businesses.

The gains North Carolina is poised to realize through the federal Base Realignment and Closure (BRAC) Program, and the state's commitment to cooperation with its federal military partners, may provide additional future funding sources for the conservation of existing privately owned forestlands or the establishment of new forestland in areas buffering military facilities. The presumption here, as in the paragraph above, is that an increased availability of capital investment in forestland would entice forest owners to participate in a future CO_2 offset management market, in addition to traditional forest product markets.

Summary

Ecosystem services markets vary in their stages of development and potential for sustainable economic opportunity. Markets related to water resources are already established, but so far remain limited in availability to the average forestland owner. North Carolina forestland owners show interest in participating in existing nontraditional markets. It can be presumed that once a stable, verifiable market for carbon credits and offsets from forests is developed, forestland owners (and forests) will also benefit from it.

Map Data Sources

FIGURE 2f-1: National Land Cover Dataset 2001, NRCS SSURGO soils, National Hydrography Dataset (Plus)

FIGURE 2f-2: National Hydrography Dataset (Plus), National Land Cover Dataset 2001

FIGURE 2f-3: N.C. Natural Heritage Program 2010

FIGURE 2f-4: USDA Forest Service – Forest Biomass across the Lower 48 States and Alaska

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Chapter 3. Threats to Forest Health

3.a.

Insects, Diseases, and Non-native Invasive Plants: Threats to Forest Health

Key Findings

- Major forest pests and non-native invasive (NNI) plants significantly damage the ecological and economic vitality of North Carolina's forests.
- Risks to the ecological and economic vitality of North Carolina's forests will intensify as new forest pests and NNI plants are introduced. The challenges of protecting forests from threats will increase and become more complex.
- Pathways for the introduction of new pest species vary greatly, ranging from intentional introductions with unintended results to accidental introductions. Movement of very diverse items—such as timber, firewood, outdoor household articles, and ornamental plants—add to the complexity of monitoring and managing threats to forest health.

Introduction

Insect, disease, and non-native invasive (NNI) plant species have long threatened the health and productivity of North Carolina's forest resources. Presently native, naturalized, and recently introduced forest insects, diseases, and NNI plant species directly threaten North Carolina's forests. Native and naturalized insect and disease threats are responsible for mortality, loss of tree growth, tree deformity, and reduced tree quality. In addition, non-native insect and disease pests may also contribute to loss of forest tree species and alter forest composition. NNI plants can crowd out native plants, decreasing species diversity, simplifying natural systems, and even creating monocultures, all of which make these areas less resilient. Invasive weeds can also limit production of native wildlife food and habitat.

Current threats include major and locally significant forest pests and NNI plants already found in the state. Major forest pests can eliminate species, significantly alter forest compositions, or cause mortality and loss of growth. Locally significant pests can cause considerable damage, but impacts are normally confined to localized areas or limited by the host species range.

In addition to pests and NNI plants currently found in the state, North Carolina's forests may be vulnerable in the future to other biological threats that have been brought from other countries into the United States. These potential or imminent threats are not currently found in North Carolina, but are spreading in other parts of the country. When these species reach the state, they could cause significant damage to our forest resources.

The movement of firewood and other wood products that can harbor various insects and diseases facilitates the spread of some of these forest pests; as such, these pests will be treated as a separate threat at the close of this section.

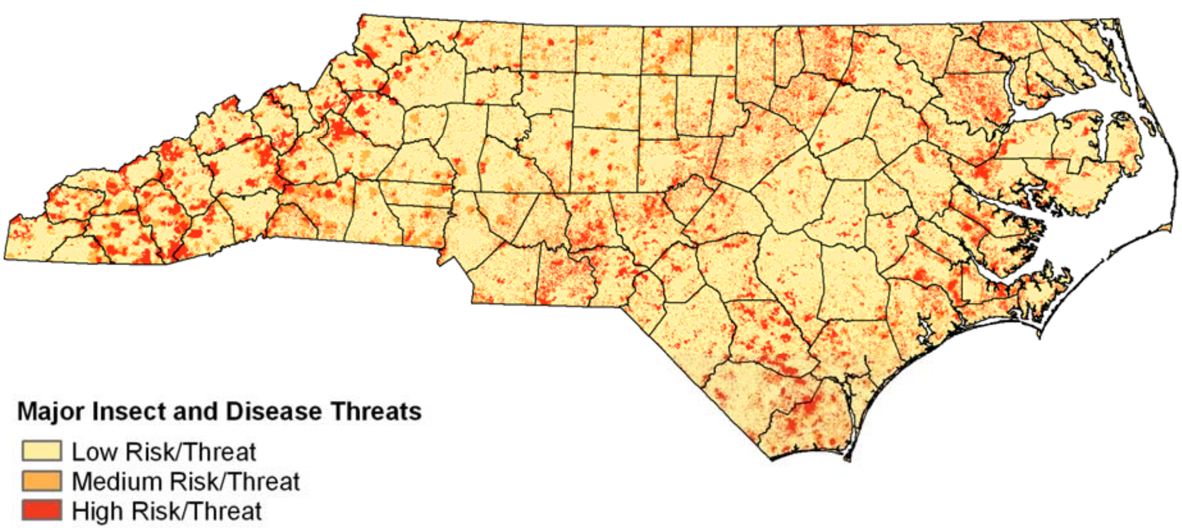
Current Major Forest Health Threats

Background

Major forest pests can cause significant ecological and economic damage to North Carolina's forest resources. Major forest health threats consist of native and non-native species of insects, diseases, and invasive plants. Losses from native forest insects and diseases are typically cyclical as native forest tree and pest species have coexisted for many years. The intensity and duration of cyclical outbreaks can be aggravated by anthropogenic land use and lack of proper management. Non-native insects and diseases provide unique challenges to forest health because native forest trees have not evolved with these pests and therefore never developed adequate natural defenses. In addition, major NNI plants crowd out native species; their impacts minimize diversity, simplify natural systems, limit production of native wildlife food, and foster monocultures. Many non-native species continue to spread and may not have reached their full biological impact, so the full economic and ecological losses have yet to be realized.

A major insect and disease threat map was developed from several data layers (FIGURE 3*a*-1). These layers included (1) the USDA Forest Service, Forest Health Technology Enterprise Team (FHTET), southern pine beetle hazard map; (2) the "forest health" layer from the Southern Forest Land Assessment (including annosus root rot, fusiform rust, southern pine beetle, balsam woolly adelgid, gypsy moth, and beech bark disease); and (3) hazard maps related to littleleaf disease, balsam woolly adelgid, and hemlock woolly adelgid. These layers were combined to show areas of medium or high risk for forest mortality based on geographical analysis. This analysis is not necessarily based on a specific time frame.

FIGURE 3*a*-1. Map of North Carolina's major insect and disease threats by risk level.



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Current Major Forest Pests

Major Diseases

Annosum root disease or root rot is caused by the native fungus *Heterobasidion annosum.* This disease can be a serious problem in thinned pine stands. Loblolly (*Pinus taeda*), slash (*P. elliottii*), and white (*P. strobus*) pines are the most affected species, but shortleaf (*P. echinata*) and longleaf (*P. palustris*) pines and red cedar (*Juniperus virginiana*) are also commonly infected. The airborne fungal pathogen enters stands by infecting freshly cut stumps or wounded roots, causing root rot. Once gaining access to a stand, the fungus can spread to adjacent healthy trees through root contacts and grafts. Advanced infection increases the risk of windthrow and can result in growth loss and mortality, either from the direct effects of root disease or from bark beetle attacks on the stressed trees.

Since 2005, between 25,000 and 30,000 acres per year of pine timber in North Carolina on nonindustrial private forest lands have been commercially thinned with the twin goals of improving forest health and increasing wood production (NCDFR, 2009). An increased risk of *H. annosum* infection may be likely where thinning is conducted on high risk sites. Increased damage may occur in thinned pine stands where the disease is already present.

Fusiform rust is caused by the native fungus *Cronartium quercuum* f. sp. *fusiforme* and is most abundant in young, rapidly growing pine plantations of loblolly and slash pines in high-rust hazard areas. Fusiform rust stem infections in young trees normally cause tree death. Later infections result in quality loss at harvest or in stem weakness and breakage at the canker. Trees not killed or structurally weakened may suffer a loss of growth. This disease can severely limit the productivity of pine forests in the South, and rust-infected trees may succumb to other pest problems.

Littleleaf disease is caused by *Phytophthora cinnamomi*, a non-native fungus-like microorganism, in combination with other factors. This disease is most commonly found in North Carolina’s piedmont, where shortleaf pine is the most seriously damaged host. This pathogen damages tree roots, sapping vigor, reducing tree growth, and often leading to tree mortality. Littleleaf disease is caused by a complex of factors, which includes the presence of the pathogen, heavy clay soil, and soil that is low in nitrogen. Shortleaf and loblolly pine stands growing on sites at high risk for littleleaf disease are also at high risk for southern pine beetle infestations.

On poor sites, trees may survive up to 6 years after initial infection. On better sites, trees may persist 15 to 20 years. Concerns over the potential for loss of pine stands to littleleaf disease have caused a decline in planting shortleaf pine in much of North Carolina’s central piedmont. Acreage of shortleaf pine has been declining in the state since the early 1980s.

Oak decline is due to abiotic and biotic influences and tends to be most damaging among members of the red oak group: northern red (*Quercus rubra*), scarlet (*Q. coccinea*), pin (*Q. palustris*), and black oaks (*Q. velutina*). Members of the white oak group, white oak (*Q. alba*) and chestnut (*Q. prinus*), are not immune but are less prone to decline-associated mortality. Decline diseases, such as oak decline, are not caused by a single insect or pathogen but are instead the product of interactions among physiologically mature trees, environmental stresses, and forest pests. Oak decline can be problematic in both urban and rural areas. Trees predisposed by drought stress become weakened and more susceptible to the effects of spring defoliating insects or frost. Insects and pathogens of opportunity combine to cause tree death. Oak decline generally takes several years to kill susceptible trees.

Predisposing factors for oak decline include older stands with a large proportion of oaks and less productive sites characterized by shallow or clay soils. Inciting factors, such as prolonged drought, repeated insect defoliation, or late-season frosts, then trigger decline events. Finally, contributing factors, such as diseases and insects, combine with inciting factors to further weaken and kill stressed oaks. Management of oaks to create more complex age and species mixtures on the landscape, reduce competition for moisture and nutrients, and promote healthy hardwoods is the best defense against oak decline but is lacking in many areas.

Major Insects

Southern pine beetle (SPB), *Dendroctonus frontalis,* is a native insect and the most destructive insect pest of pine in the South. Preferred hosts in North Carolina include loblolly, shortleaf, pond *(Pinus serotina)*, and Virginia pines *(Pinus virginiana).* SPB colonizes and feeds on the inner bark of pine trees and introduces fatal blue-stain fungi. Weakened, stressed stands are most susceptible.

During periodic outbreaks, SPB populations can rise, attack, and quickly kill acres of trees. During epidemics, SPB can attack and kill even healthy pines. Abundance of dead trees, both standing and down, following an outbreak can lead to large amounts of fuel loading and create hazardous conditions for forest firefighting. The last outbreak in North Carolina was in the mountains between 1998 and 2002. During that time, 2.7 million acres of forest were affected and a total of $6.4 million worth of timber was destroyed.

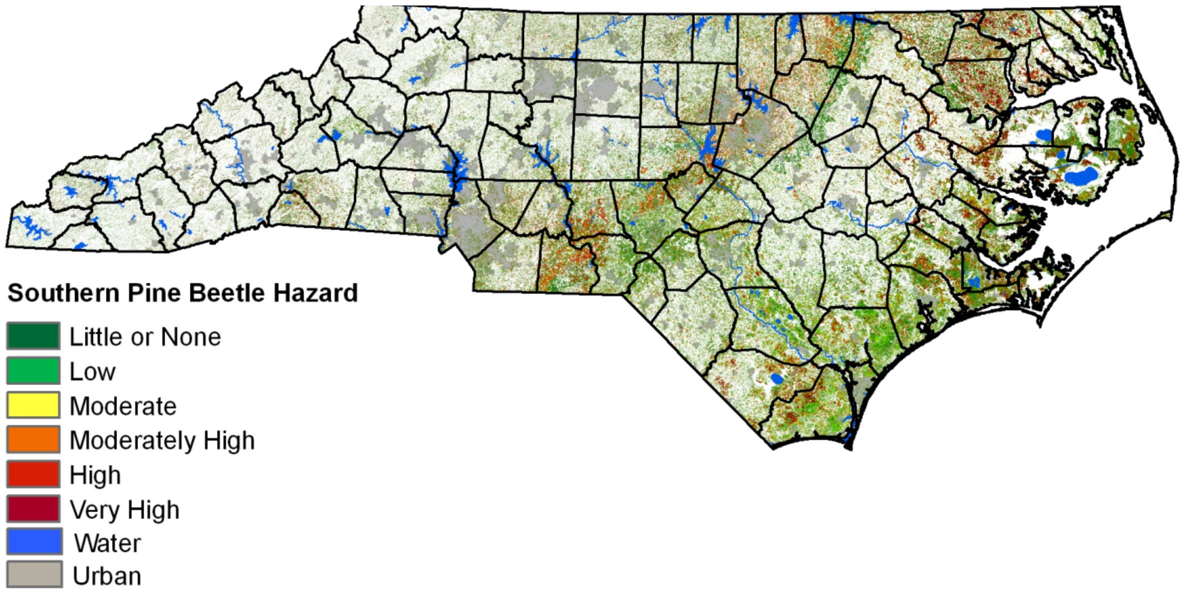
Practicing good silviculture before outbreaks, which reduces basal area and encourages healthy radial growth, can prevent the spread of SPB in stands. The NCDFR administers a cost-share program to help forest landowners thin young stands to help prevent southern pine beetle susceptibility. This Southern Pine Beetle Prevention Program is funded by a federal grant from the USDA Forest Service, Forest Health Protection. Planting less susceptible species (longleaf pine) and planting pines at low stocking (less than 500 trees per acre) are also acceptable prevention practices.

Control of outbreaks is usually limited to salvaging affected stands or felling and leaving affected trees and a small buffer to prevent spread. In urban forests, control can become contentious due to infestations crossing multiple ownerships.

A southern pine beetle hazard map was developed through modeling by the USDA Forest Service FHTET (FIGURE 3a-2). The FHTET hazard modeling aims to predict areas that will lose 25 percent or more of the total basal area in stems more than 1 inch (2.54 cm) in diameter due to southern pine beetles within the next 15 years. FHTET has developed SPB hazard designations for North Carolina using both remotely derived data and forest inventory data. The FHTET hazard modeling framework uses many datasets to predict where susceptible forest types occur, including those derived from land cover, topography, soil types, elevation, climate, and previous forest inventories.

Gypsy moth, *Lymantria dispar*, is a non-native pest. Oaks (*Quercus spp*.) are the preferred host species for feeding caterpillars, but a variety of other hardwoods serve as hosts as well. Older larvae will also feed on several conifer species. Since being introduced from Europe into the United States (Massachusetts) around 1869, the gypsy moth has infested 19 states. Current

FIGURE 3*a*-2. Southern pine beetle hazard map.



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quarantined areas include two counties in North Carolina and all Virginia counties along the state line from the Atlantic Ocean to Martinsville, Virginia (FIGURE 3*a*-3). Occasional populations of this defoliator are found in North Carolina and are quickly controlled by the NC Department of Agriculture and Consumer Services (NCDA&CS) in cooperation with the USDA Slow the Spread (STS) Program. The goal of STS is to slow the spread of the gypsy moth by using integrated pest management strategies. Despite these efforts, it is likely that the gypsy moth will expand its range to include all of North Carolina over the next 25 years.

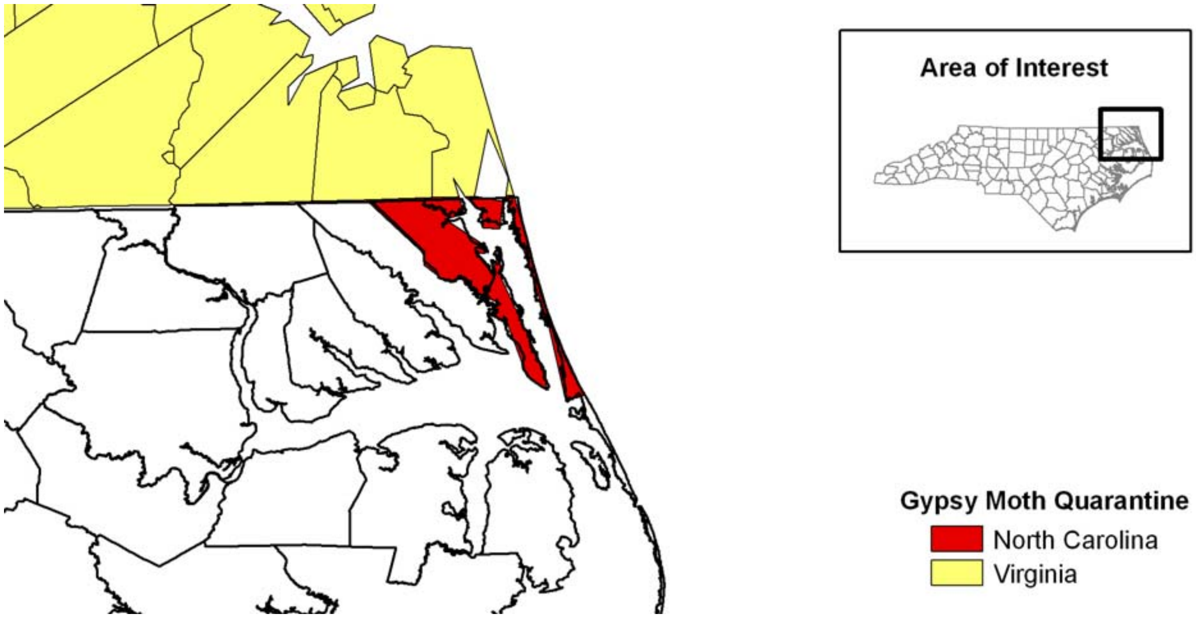
Without intervention, the gypsy moth spreads about 13 miles per year. Artificial movement dramatically hastens the moth's spread because it 'hitchhikes' on items that are moved long distances, such as nursery stock, firewood, vehicles, forest products, and outdoor household articles.

Because the gypsy moth has infested only a small area in North Carolina, it can be treated in this assessment as both a current threat to that area and an imminent threat to forests in the rest of the state.

Hemlock woolly adelgid (HWA), *Adelges tsugae, is* native to Asia. It is a small, aphid-like insect that threatens the health and sustainability of eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*Tsuga caroliniana*). HWA was first reported in the eastern United States in 1951 and has since been established in 16 states. The tiny sucking insect now infests most of the range of native hemlocks in North Carolina. Mortality is very apparent in infested stands—primarily in forested stands where control is difficult and cost-prohibitive. Heavy infestations can kill trees in as little as 4 years, yet some trees have survived infestations for more than 10 years.

Hemlocks are an important habitat component for deer, small mammals, and almost 90 species of birds. Hemlocks also provide shade for favorable brook trout habitat and supply important riparian ecology benefits. Because of the hemlock's important role in riparian ecology, its loss

FIGURE 3*a*-3. European gypsy moth quarantine map, 2008.



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could have a devastating impact on these ecosystems.

Most control measures are confined to application of systemic insecticides on urban landscape trees and on easy-to-access forest trees of high ecologic, aesthetic, historic, and sentimental value. However, the impact of the adelgid continues to outpace efforts to control the pest. The USDA Forest Service and several universities, including NC State University, are conducting research into releasing predatory beetles to control HWA. Unfortunately, most of our hemlocks will be lost from North Carolina's mountains before adequate control can be developed.

Balsam woolly adelgid (BWA), *Adelges picea*, is a non-native insect that infests the Fraser fir (*Abies fraseri)* in North Carolina's mountains. This tiny sucking insect was introduced into North America from Europe around 1900 and appeared in North Carolina in the 1950s. BWA has altered the age and species composition of Fraser fir, resulting in its listing as a "Federal Species of Concern." Currently, there is no reliable long-term control of BWA in forest settings. Research investigating releases of predator beetles has shown promise, yet control is limited to chemical applications on Christmas tree farms and in urban landscapes.

Major Non-Native Invasive Plants

Bradford pear, *Pyrus calleryana*, is a tree cultivar from China that was thought to produce sterile seeds. Bradford pear has been planted as an ornamental tree for many years. More recently it has been found to be an invasive species in the NC piedmont and coastal plain. These aggressive pears invade roadsides, utility rights of ways, forest edges, and cutover areas by forming dense, thorny thickets. Starlings and other fruit-eating birds spread nonsterile seeds. Early chemical control is not difficult; however, the entire root system must be killed or removed to prevent resprouting.

Garlic mustard, *Alliaria petiolata*, is a perennial herb native to Europe that invades moist, shaded understories, trails and roadsides, forest openings, and floodplains. Once established, this plant increases in density and replaces native vegetation, leading to decreases in native plant richness and diversity. Mostly a problem in the North Carolina mountains and piedmont, garlic mustard also has implications for wildlife management as the weed is not used by wildlife. Presence of garlic mustard also interferes with reproduction of a rare species of butterfly and can kill emergent larvae.

Control by hand removal of entire root systems may be practical for light infestations, but stems need to be disposed of properly to prevent seed dissemination. Fire can control garlic mustard, but fire also stimulates germination. Five-year monitoring is necessary for full eradication.

Japanese knotweed, *Polygonum cuspidatum,* is a shrub-like perennial herb found along water sources and low lying areas, spoil and gravel pits, driveways, utility rights of way, and old home sites. It spreads quickly and forms dense thickets in open areas. This weed tolerates high salinity, extreme drought, high temperatures, full shade, and periodic flooding. Knotweed aggressively competes with and displaces native species, ultimately forming a monoculture groundcover. Japanese knotweed can affect forest management following harvest, thinning, or wildlife food plot openings.

Meadowsweet refers to two shrub species: *Spirea japonica and S. thunbergii.* These escaped ornamental shrubs can dominate disturbed areas along streams and riparian areas, roadsides, meadows, forest openings, and other sites. *Spirea japonica* is most notably a problem in the Sandhills, while *S. thunbergii* is more problematic in the mountains. The shrubs rapidly form dense infestations of entangled stems, branches, and abundant foliage that choke out native species. Seeds are prolific and can survive for many years in the soil, making control extremely difficult. Repeated mowing or cutting can control but not eradicate the shrub. More than one chemical application may be necessary with large populations.

Miscanthus, *Miscanthus sinensis,* is a tall clump grass native to tropical Asia that infests many sites, particularly after fire: disturbed sites; forest margins; roadsides; and shores of reservoirs, lakes, and streams. Miscanthus can be found statewide, but is particularly aggressive in the mountains. It tolerates shade and thrives in moist, well-drained soil. Miscanthus is extremely flammable and increases the risk of wildfire. Herbicide treatment generally is the only effective method of control.

Oriental bittersweet, *Celastrus orbiculatus,* is an ornamental woody vine that is capable of climbing native vegetation and ultimately strangling or smothering its hosts, or breaking their stems with weight loads. Oriental bittersweet is primarily found in the mountains and piedmont along forest edges, hedgerows, roadsides, fields, and disturbed woodlands. This Oriental species hybridizes with native bittersweet (*Celastrus scandens),* causing the native species to lose its genetic identity. Oriental bittersweet is classified as a "Class C State Noxious Weed" and is quarantined in 18 mountain counties in North Carolina. Movement of this noxious weed from quarantine areas is prohibited except under certificate or permit from the NCDA&CS Plant Industry Division, Plant Protection Section. Control options include manual, mechanical, and chemical techniques, which work best in combination.

Paulownia, *Paulownia tomentosa,* was introduced as an ornamental tree and has become naturalized in the mountains and piedmont. Paulownia grows fast and sprouts prolifically. Its seed is disseminated long distances by wind and water. Paulownia trees often invade forest edges, roadsides, disturbed forest openings, and streamsides, where the trees displace native species and can outcompete rare plants in marginal habitats. Control options include manual, mechanical, and chemical means, most successfully in combination.

Chinese privet and Japanese privet, *Ligustrum sinense* and *L. japonicum,* are ornamental shrubs that have invaded forest edges and fence rows statewide, primarily in bottomlands. Although they both prefer full sun, Japanese privet tolerates more shade than Chinese privet. Both shrubs create dense thickets that replace native plant species and fundamentally alter forest edge composition and structure. Seeds are dispersed across the landscape by birds. A number of manual, mechanical, and chemical control options exist; however, combinations or repeated efforts are required because of the prolific seed supply and sprouting stems and roots.

Stilt grass, Japanese stilt grass, or Nepalese browntop grass, *Microstegium vimineum,* is an aggressive grass that tolerates shade and adapts to a variety of soil conditions. This bamboo-like grass is a threat to many native plants in open woods, floodplain forests, wetlands, uplands, fields, paths, clearings, roadsides, ditches, utility corridors, yards, and gardens statewide. Dense patches displace native groundcover and shade young tree seedlings. Stilt grass can quickly take over an area and can adversely affect afforestation and reforestation efforts. Once established, stilt grass is very difficult to control. Small patches can be removed by hand. Effective herbicides do not offer complete control as seeds can remain viable in the ground for many years.

Tree of heaven, *Ailanthus altissima,* is an invasive Chinese tree found across the state; it is most aggressive in the mountains and piedmont. This tree is somewhat shade-tolerant and grows quickly after invading any type of disturbance. In urban areas, *A. altissima* will take over unmaintained sidewalks, alleys, and abandoned properties. In rural areas, it invades forest edges and openings, fields, and fence rows and can adversely affect afforestation and reforestation efforts.

Tree of heaven thrives on high quality sites and will outcompete and displace even a fast-growing native tulip poplar (*Liriodendron tulipifera*). Eliminating *A. altissima* is difficult due to its abundant viable seeds and prolific root and stem sprouting. Persistent monitoring and control using biological, manual, mechanical, or chemical techniques is needed.

Locally Significant Forest Threats

The major pests and NNI plants listed above are by no means the only threats to forests and trees in North Carolina. Locally significant pests and NNI plants also have the ability to cause significant damage and impact diversity in local areas. Some of these threats are confined to a small geographic area and pose little risk of spreading into unaffected areas. NNI plants in this category also have the ability to crowd out native species, alter natural systems, limit production of native wildlife food, and create monocultures. Non-native species of this category usually spread into uninfected ranges more slowly. Table 3a-1, 3a-2, and 3a-3 provides lists of significant localized threats.

Certain localized threats, such as dogwood anthracnose, kudzu, and bamboo, easily could have been included as major threats. These forest pests and NNI plants could not be ignored; their presence in an area causes major problems. The threats in the major threats assessment were deemed to be those that will have the *most* impact on forest health, productivity, afforestation and reforestation, and diversity over the next 30

a. Insects, Diseases, and Non-native Invasive Plants

TABLE 3*a*-1.—Locally significant diseases

Diseases
Beech Bark Disease, *Neonectria coccinea var. faginata* – Exotic fungal disease that is of major concern in high elevation forests in Western North Carolina. No real control known in forested areas at this time.
Brown Spot Needle Blight, *Scirrhia acicola* – Needle blight fungus causing defoliation of longleaf pines in the sandhills and coastal plain. Can be controlled by prescribed burning.
Butternut Canker, *Sirococcus clavigigenti-juglandacearum* – Exotic fungal disease has all but wiped out butternut trees in the mountains and piedmont. Few residual trees are heavily cankered. No known control.
Dogwood Anthracnose, *Discula destructive* – Exotic fungal tree disease that has killed more than 60% of the native dogwoods in the mountain region. No real control known in forested areas.
Oak Wilt, *Ceratocystis fagacearum* - Potentially a destructive disease (origin debated) confined to and causing little damage to oaks in five mountain counties. Removing affected trees can control spread.
Pitch Canker, *Fusarium circinatum* – Native tree disease causes bleeding cankers, dieback, and mortality of loblolly and longleaf pines statewide.
White Pine Decline/Loblolly Pine Decline, *Leptographium procerum, Phytophthora spp., Pissoides spp.* – Complex of environmental, insect and disease factors that cause decline and mortality of white and loblolly pines. Primarily a problem with older pines and pines planted off-site.

TABLE 3*a*-2.—Locally significant Insects

Insects
Black Twig Borer, *Xylosandrus compactus* – Non-native tip boring insect found primarily in the coastal plain. Causes twig dieback and flagging of branches in a variety of hardwoods including bays, magnolias and dogwoods. Mortality is rare as only smaller branches are affected. Damage often confused with the more serious redbay ambrosia beetle.
Fall Cankerworm, *Alsophila pometeria* - Native defoliator of oaks, this caterpillar is usually kept under control under normal forest conditions by natural predators. Populations periodically build up to damaging levels in Charlotte/Mecklenberg County and require chemical control to limit nuisance and tree mortality.
Fall Webworm, *Hyphantria cunea* and **Eastern Tent Caterpillar,** *Malacosoma americanum* and **Forest Tent Caterpillar,** *Malacosoma disstria*- Native defoliators of hardwoods found statewide. Except during extreme outbreaks, these pests primarily cause only aesthetic damage and are rarely controlled. They are often nuisances in urban areas. Forest tent caterpillars experience periodic outbreaks, defoliating tupelo gum and other bottomland hardwoods along the Roanoke River basin.
Locust Leafminer, *Odontata dorsalis* – Native late season defoliator of black locusts. Rarely a tree killer, the pest mostly causes aesthetic damage over the range of locusts in the state. Creates numerous citizen calls in late summer. Usually not controlled.
Nantucket Pine Tip Moth, *Rhyacionia frustrana* – Native tip boring insect that attacks all pine species in North Carolina. Larvae feeding on buds and branch tips can lead to mortality in seedlings and young pines, but usually causes tip dieback, and deformities and forked stems.
Pales Weevil, *Hylobius pales* and **Reproduction Weevils,** *Pachylobius picivorous* – Native weevils found statewide cause mortality of seedlings by feeding on stem bark. Can be controlled by timing of harvest/reforestation and by chemically treating seedlings.
Pine Bark Adelgid, *Pineus strobe* – Native sap sucking aphid like insect found throughout the range of white pines. Causes loss of vigor that can lead to decline and mortality.
Pine Engraver Beetle, *Ips spp.* And **Black Turpentine Beetle,** *Dendroctonus terebrans* – Opportunistic native bark beetles that can kill pines stressed by drought, lightning, root or stem damage, fire, or wind/ice events. Practices to reduce stress can prevent attacks and large infestations can be controlled by salvage harvests.
Redheaded Pine Sawflies, *Neodiprion lecontei* – Native defoliator of loblolly and longleaf pines. Repeated defoliations can potentially lead to mortality. Natural predators usually keep populations under control though there can be periodic localized outbreaks.

TABLE 3a-3.—Locally significant Non-native Invasive Plants

Non-native Invasive Plants
Chinaberry, *Melia azedarach* - Tree that invades disturbed areas, roadsides and forest edges throughout the state. It has the potential to grow in dense thickets, restricting the growth of native vegetation. Control usually requires a combination of chemical and mechanical practices.
Common Reed, *Phragmites australis* - Herbaceous or grasslike weed that invades wet areas in the coastal plain. Can hamper forestation efforts by shading out young trees. Requires a combination of burning and chemicals to control.
English Ivy, *Hedera helix* - Weedy vine sometimes used as ornamental groundcover statewide. On the ground, vines create a dense covering that crowds out other vegetation. As a climbing vine, it engulfs and kills branches, either by blocking sunlight or by weight making trees susceptible to breakage or windthrow during storms. Provides hiding habitat for defoliating gypsy moth caterpillars and harbors the bacterial leaf scorch pathogen.
Japanese Honeysuckle, *Lonicera japonica* - Weedy vine thrives in a variety of habitats including fields, forests, wetlands, barrens, and all types of disturbed lands. Fast growing and spread easily by birds, this weed can quickly outcompete native vegetation. Vines have the ability to twist tightly around trunks and branches of host trees and effectively 'choke' their hosts. Several chemical and non-chemical controls exist, but control requires persistence.
Kudzu, *Pueraria montana* - Weedy vine that invades roadsides, old fields, forest edges and disturbed areas statewide. While difficult to control, its rate of spread to new areas is slow. Control requires a commitment and is rarely, if ever, effective with one treatment.
Mimosa, *Albizia julibrissin* - Tree that is a strong competitor to native trees and shrubs in open areas or forest edges. Often spreads easily from nearby landscape trees. Control is possible with a combination of chemical and mechanical practices.
Multiflora Rose, *Rosa multiflora* - Woody shrub creates dense thickets in a variety of light, soil and moisture conditions statewide. Can be controlled with a variety of mechanical and chemical treatments.
Periwinkle, *Vinca minor* - Weedy vine that invades open to shady forests often around former plantings at old homesites statewide. This species forms dense and extensive mats along forest floors that exclude native vegetation. Easily controlled mechanically or in combination with chemicals.
Sericea, Korean or Chinese Lespedeza, *Lespedeza cuneata* - Herbaceous weed which invades fields, meadows, marshes, pond borders, open woodlands and roadsides statewide. Difficult to control, this plant can hamper forestation efforts by crowding and shading young trees, thus requiring additional chemical site preparation.
Wisteria, Chinese, *Wisteria sinensis* and **Japanese**, *Wisteria floribunda* - Found statewide, vines impair and overtake native shrubs and trees through strangling or shading. Both species are hardy and aggressive, capable of forming dense thickets where little else grows. Can be controlled with a variety of mechanical and

years. The categorization of threats described in this section as "locally significant" does not diminish the need to monitor and control outbreaks and spread.

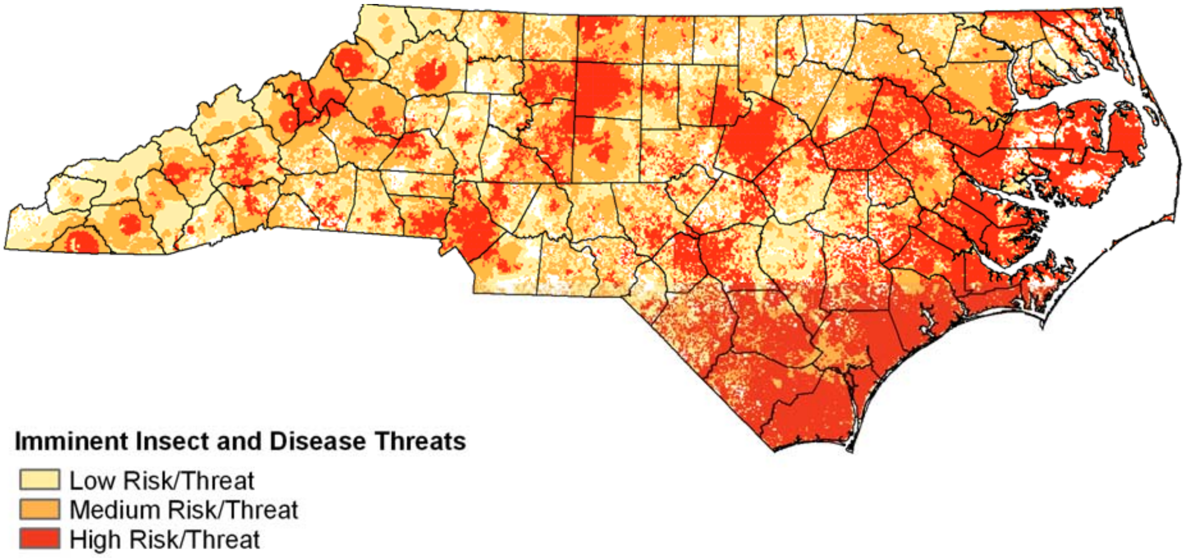
Imminent Forest Health Threats

Background

Imminent forest health threats are threats not yet in North Carolina, but these pests and NNI plants are in adjacent states or have the capability to move large distances, either naturally or artificially. Such species have the potential to invade North Carolina within the next few years. Short descriptions of each of these threats follow.

An imminent insect and disease threat map (FIGURE 3*a*-4) was developed in much the same way as the major insect and disease map. The layers included in the analysis were the FHTET emerald ash borer risk map, the FHTET sirex woodwasp risk map, the FHTET Asian longhorned beetle risk map, and a redbay ambrosia beetle–laurel wilt risk map developed by Koch and Smith (2008). The three layers created by FHTET all address invasive pests that are likely to be introduced into North Carolina via

FIGURE 3*a*-4. Imminent forest health threats map; includes emerald ash borer, Asian longhorned beetle, redbay ambrosia beetle, and sirex woodwasp.



Created by: J. Moan, NC DFR 2010

firewood and thus show the highest risks in urban and suburban areas and transportation corridors. The redbay ambrosia beetle–laurel wilt hazard map was derived from forest inventory data, current rate of spread, and climate data to predict where the insect and pathogen would make the largest impact in North Carolina. This map shows areas determined to be low, medium, or high risk based on geographical analysis and is not necessarily based on a specific time frame.

Imminent Forest Pathogen Threats

Sudden Oak Death (SOD), *Phytophthora ramorum*, is mostly confined to the West Coast of the United States. Sudden oak death is a recently discovered disease caused by a fungus-like microorganism. While the destruction from this disease is far away, the pathogen causing ramorum leaf blight and sudden oak death was first introduced into North Carolina in 2004 in plant nursery shipments from California. Affected plants were quickly eradicated.

The host list for this disease is broad, continues to expand, and includes a good number of forest and landscape trees species found throughout North Carolina, including native oaks. While *P. ramorum* can kill oaks, it does not usually kill susceptible nonoak hosts. Instead, depending on the plant, it may cause symptoms such as leaf spots, defoliation, twig and branch dieback, or blighting. Yet, nonoak hosts (most notably rhododendron and mountain laurel) can spread innoculum (spores) and subsequently infect and kill susceptible oaks.

Forests in all areas of the state may be vulnerable to this disease, but suitable hosts and cool moist weather conditions make forests in the mountains and foothills especially at risk. Because the most likely introduction of *P. ramorum* into the state would be through movement of infected ornamental plants, trees in urban forests could be susceptible sites for early infections.

Eradication is easiest to achieve in nursery settings where regulatory controls have reduced the risk of spread into the state. The NCDA&CS Plant Industry Division inspects plant nurseries on a regular basis and puts a high priority on detecting and eradicating any new introductions on nursery stock. In addition, the NCDFR conducts annual surveys of areas outside of suspected nurseries to detect the presence of any pathogen that may have escaped into the environment. These annual surveys are conducted as a part of a cooperative national project coordinated and funded by the USDA Forest Service Forest Health Protection Program. To date, surveys in North Carolina have not detected the presence of the pathogen outside of nurseries receiving infected plants. If detected in the forest environment, control is extremely difficult.

Imminent Forest Insect Threats

Emerald ash borer (EAB), *Agrilus planipennis,* is a tiny wood-boring insect that most likely arrived in the United States around the Great Lakes area in solid wood packing material from Asia. This borer has killed millions of ash trees in Michigan, Ohio, Illinois, Indiana, Pennsylvania, West Virginia, Maryland, Missouri, Wisconsin, Minnesota, Kentucky, and Ontario and Quebec, Canada, through July 2009. Massive eradication efforts where it has been detected involve removal of affected trees and healthy tree buffers, with varying degrees of success. Quarantines on the movement of non-heat-treated wood materials, including firewood, have been placed around areas of known infestations.

All North Carolina species of ash (*Fraxinus* spp.) are susceptible to attack by this insect. Though ash is a minor component of forests statewide, green ash is a common riparian tree in the piedmont and on the largest coastal plain rivers. Rapid mortality of green ash could have significant water quality implications. In addition, green ash is a popular street tree, and its loss is a major concern to urban dwellers and professionals alike. Surveys so far have not detected the presence of the EAB in North Carolina. Currently, there is no reliable control method to stop the local spread of this insect.

Asian longhorn beetle (ALB), *Anoplophora glabripennis,* entered the United States inside solid wood packing material from China. The Asian longhorn beetle was discovered in 1996 in New York, with recent urban outbreaks in Illinois, New Jersey, and Massachusetts, and Toronto, Canada. Massive eradication efforts remove affected trees and healthy tree buffers, with varying degrees of success. Quarantines on the movement of non-heat-treated wood materials, including firewood, have been placed around areas of known infestations.

The beetle prefers maples (*Acer* spp.), buckeyes (*Aesculus* spp.), elms (*Ulmus* spp.), birches (*Betula* spp.), and willows (*Salix* spp.), but will also attack a variety of other hardwood species. Introduction of this pest in North Carolina could lead to a major change in forest species composition. Host species are found throughout the state, especially along riparian corridors, wetland areas, and mountain cove sites that are rich in plant species and diversity. Surveys so far have not detected the presence of the ALB in North Carolina.

Sirex woodwasp, *Sirex noctilio,* is native to Europe, Asia, and northern Africa, but now has been introduced onto every continent. Introduced into the United States, most likely on solid wood packing material, *S. noctilio* was first detected in New York and has since been detected in Pennsylvania and Ontario, Canada. In North Carolina, it has the potential to attack and kill even healthy southern yellow and white pine species. Sirex woodwasps have caused up to 80 percent tree mortality in yellow pine plantations in the Southern Hemisphere where outbreaks were detected (Haugen and Hoebeke, 2005). North Carolina's timber industry, especially in the piedmont and coastal plain, could also be at risk or severely impacted by any potential losses inflicted by the discovery or presence of sirex woodwasp. Efforts to control the spread of sirex woodwasp include surveys, trapping, biocontrol research, and quarantines. The NCDA&CS has enacted an external quarantine regulating the movement of unprocessed pine materials into the state. Surveys, to date, have not detected the presence of the sirex woodwasp in North Carolina.

Imminent Insect-and-disease Complex Threat

Redbay ambrosia beetle (RAB), *Xyledborus glabratus,* and **laurel wilt**, caused by the fungus *Raffaelea lauricola,* together constitute an insect-and-disease threat. The redbay ambrosia beetle serves as an insect vector for the fungus causing laurel wilt, a destructive disease of redbay (*Persea borbonia*) and other trees in the laurel family, including swampbay (*Persea palustris*), sassafras (*Sassafras albidium*), spicebush (*Lindera* spp.), and pondspice (*Litsea aestivalis*). *Lindera melissifolia* is a federally listed endangered plant, and *Litsea aestivalis* is listed as a threatened plant in multiple states.

The non-native redbay ambrosia beetle was first detected in Georgia in 2002; the associated pathogen, a highly virulent, invasive, wilt-inducing fungus, is believed to have arrived in the United States along with the beetle. Investigators believe that RAB was introduced into the United States in wooden crating material from Southeast Asia. Both RAB and laurel wilt have been observed as far north as Myrtle Beach, South Carolina. Mortality has been documented to spread about 20 miles per year on average. Neither threat has been detected in North Carolina, but its arrival in North Carolina is imminent within the next few years.

Redbay and swampbay are prominent species in North Carolina’s coastal plain. In addition, pondspice and spicebush are found in the coastal plain and sassafras is found throughout the state. Laurel wilt has the potential to extirpate (cause local extinction) of any of these species in the Lauraceae family from much of the coastal plain. As the insect and pathogen go through an area, all affected plants eventually wilt and die. Dead foliage persisting on plants in areas with high densities of bay species will create fire hazards due to dead, dry aerial fuels. Because redbay trees resemble young live oaks, they are popular choices for retention during development in urban areas along the coast.

Various species of wildlife would also be impacted by the reduction or elimination of laurel wilt host species. Songbirds, bobwhite quail, and turkeys often feed on the fruit, while deer and bears frequently feed on foliage and fruits of redbay and sassafras. Several rare species of swallowtail butterflies rely heavily on redbay, sassafras, and spicebush for completion of their life cycle. At this time, no reliable controls exist for either the *Raffaelea lauricola* fungus or the *Xyleborus glabratus* insect vector.

Imminent Weed Threats

Cogongrass, *Imperata cylindrical*, is a 2- to 4-foot-tall perennial Southeast Asian grass infamously ranked as one of the 10 worst weeds of the world (Holm et al., 1977). Cogongrass is currently found in Alabama, Florida, Georgia, Mississippi, South Carolina, and Tennessee. The grass is headed toward North Carolina, mainly from the south.

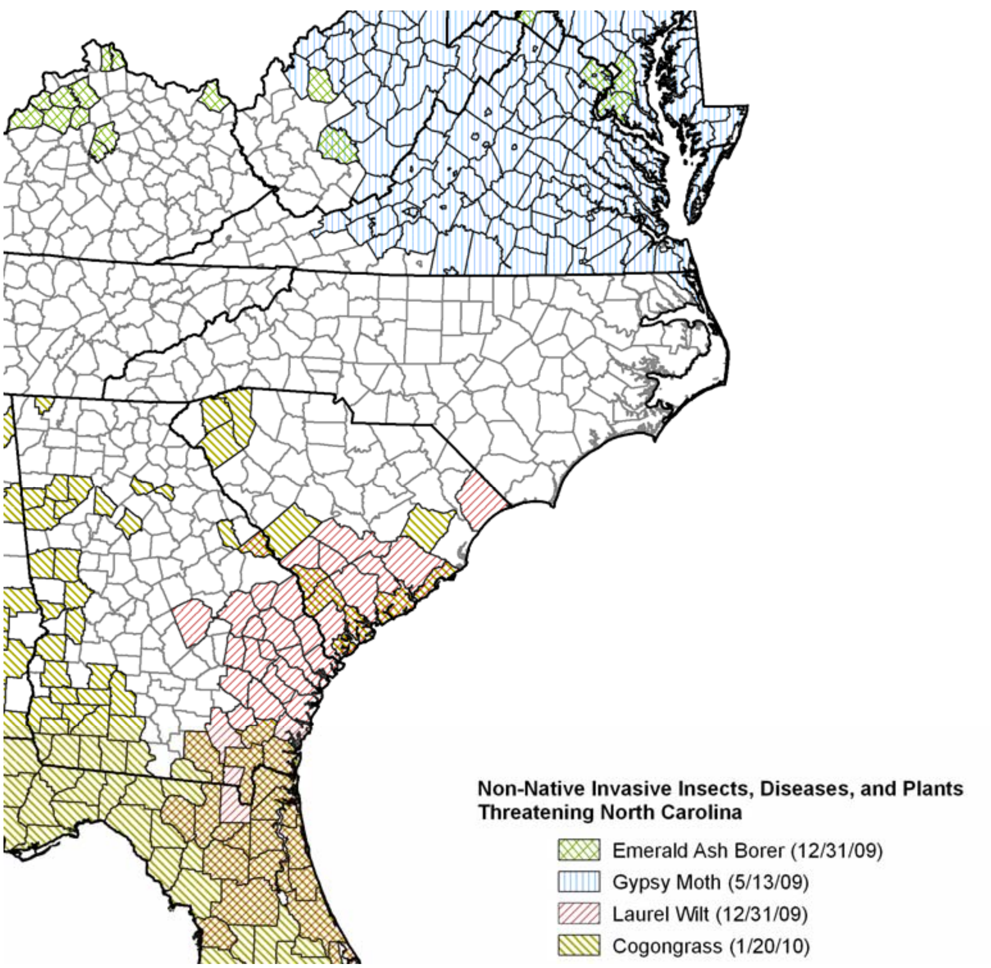
Disturbed roadsides, forests, and open fields can be invaded and overtaken by cogon grass. It forms dense thatch and leaf mats that make it virtually impossible for other plants to compete or coexist. In addition, cogongrass is cold hardy and tolerates shade, high soil salinity, and drought. It has even been found growing on sand dunes and up to the edges of ponds and lakes. Large infestations of cogon grass can alter the normal fire regime of a fire-driven ecosystem by causing more frequent and intense fires that injure or destroy native plants. Cogongrass displaces a large variety of native plant species used by native animals as forage, host plants, and shelter.

Cogongrass is easiest to control when colonies are very small. Once established, it is nearly impossible to eradicate and very difficult to effectively control without persistent chemical and mechanical (tilling) practices.

Major Non-native Invasive Imminent Threats

Although all of the imminent threats described above have the potential to spread into the state, emerald ash borer, redbay ambrosia beetle–laurel wilt, and cogongrass have been detected in adjacent states and have the greatest potential to spread into North Carolina (FIGURE 3*a*-5). In addition, gypsy moth—described as a current threat due to its presence in Currituck and Dare counties—is considered an imminent threat to the remainder of the hardwood forest resources statewide.

FIGURE 3*a*-5. Major non-native invasive imminent threats.



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Additional threats to North Carolina's forests that are not currently known to exist in the United States may also be looming. Though regulations are in place to intercept the movement of non-native invasive insects, pathogens, and plants at ports and borders, increases in global trade also increase the risk of these threats making their way into the country. On average, a new non-native invasive species arrives in the United States every 2 years. Each provides unique challenges to protecting threatened resources.

Forest Health Threats Related to the Movement of Firewood

Insects and diseases that are transported via commercial, residential, or recreational firewood affect many species of forest trees. Many damaging non-native invasive forest pests are directly traceable to interstate and intrastate movement of firewood (TABLE 3*a*-4). Natural movement of invasive pests may be limited to a few hundred feet or up to 20 miles per year. However, movement of pests in firewood can be 300 to 600 miles per day. A national campaign is underway to limit the movement of firewood due to the potential for transporting pests, primarily non-native invasive insects and diseases, from one geographic area to another.

A survey of firewood for sale in Virginia by the VA Department of Agriculture found that about two-thirds of the firewood came from outside state borders, including 13 states (western states among them) and three countries (Canada, Honduras, and Estonia) (Asaro, 2008). Even though North Carolina has not completed a similar survey similar results could be expected. Firewood that has not been heat treated (disinfected) and/or thoroughly inspected for pests has the potential to be a transportation vector for the pests in TABLE 3*a*-4.

TABLE 3*a*-4.—Forest threat organisms found in transported firewood

Present in North Carolina	
Insects	**Disease Pathogens**
Balsam woolly adelgid *	Beech bark disease
Gypsy moth	Butternut canker*
Hemlock woolly adelgid *	Dogwood anthracnose
Pine bark adelgid *	Oak wilt *
Not Present in North Carolina, but can be introduced	
Insects	**Diseases/Pathogens**
Asian longhorn beetle	Laurel wilt
Emerald ash borer	
Redbay ambrosia beetle	
Sirex woodwasp *	

* Movement of this pest in firewood is not likely but possible.

Source: NC Forest Health Working Group, 2009

Resource Capability and Availability

Native and naturalized insects and diseases have long been monitored on state and private lands in North Carolina by the NCDFR. On federal lands, the USDA Forest Service, the federal agency owning the property, or both, monitors these pests. Though research, monitoring, management methods, information and educational materials, and extension and outreach capabilities continue to evolve, these pests have been around for long enough that knowledge and standard procedures are generally in place to deal with them. Resource capabilities at the local and NCDFR Pest Control Branch level are usually adequate to handle normal threats except during certain epidemics, when additional resources are requested of other state and federal partners.

Recent and imminent invasions by aggressive non-native species provide other unique challenges to protecting the health and vitality of North Carolina's forests. Many new pests entering the country require extensive research into biology, host preferences, host responses, monitoring techniques, and safe management methods because they are often not considered pests, or are easily overlooked, in their native countries. In addition, NNI plants are increasingly being recognized as threats to forest diversity, wildlife habitat, and forest establishment and management.

No single agency or organization alone can handle these new and diverse threats to the health of North Carolina's forests. It will take a concerted and collaborative effort by many natural resource agencies and organizations in the state to address these threats and their potential impacts. Few state and private resources specialize in forest entomology and pathology in North Carolina. For weedy plant species, some individuals in state agencies, nongovernmental organizations, and private companies specialize in identification and/or control of NNI plants. However, most who deal with invasive plant issues as related to forestry usually concentrate in other areas of forestry or agriculture, and invasive plant issues are collateral duties. Adequate training for natural resource professionals and information for landowners will need to be an ongoing priority.

Summary

Many insects, diseases, and NNI plants have been identified as significant forest health threats to North Carolina's forests. The identification of current and imminent threat exposure offers an opportunity to prioritize risks and responses as these threats materialize. Appropriate strategies to combat these present threats are generally adequate, but multi-partner strategies to deal with complex issues concerning non-native invasive pests and plants are clearly needed.

Map Data Sources

FIGURE 3a-1: USDA Forest Service - Forest Health Technology Enterprise Team, Southern Forest Land Assessment

FIGURE 3a-2: USDA Forest Service - Forest Health Technology Enterprise Team

FIGURE 3a-3: USDA Animal & Plant Health Inspection Service

FIGURE 3a-4: USDA Forest Service - Forest Health Technology Enterprise Team (FHTET), Koch and Smith 2008

FIGURE 3a-5: USDA Forest Service - Forest Health Monitoring and FHTET

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Holm, L. G.; Plucknett, D. L.; Pancho, J. V.; and Herberger, J. P. 1977. *The World's Worst Weeds: Distribution and Biology*. Honolulu, HI: University Press of Hawaii.

a. Insects, Diseases, and Non-native Invasive Plants

Koch, F. H. and Smith, W. D. 2008. Spatio-temporal analysis of *Xyleborus glabratus* (Coleoptera: Circulionidae: Scolytinae) invasion in Eastern U.S. forests. *Environmental Entomology 37*(2): 442-452.

Glossary

current forest health threats. Insects, diseases, and non-native invasive weeds currently found in North Carolina that threaten trees and forest ecosystems. Insects and diseases may be native or non-native.

extirpate. To cause extinction in a localized area.

imminent forest health threats. Forest health threats that are not currently found in North Carolina but are in adjacent states or have the capability to invade North Carolina within the next few years.

locally significant forest health threats. Current forest health threats that can cause significant damage and impact diversity in local areas. These pests may be confined to a small geographic area, spread more slowly, or pose little ability to spread into unaffected areas.

major forest health threats. Current forest health threats that can cause significant ecological and economic damage to North Carolina's forest resources.

non-native invasive pest Insects or diseases that are not indigenous to North Carolina and when introduced aggressively infest or infect forest trees and plants.

non-native invasive plant. Plants that are not indigenous to North Carolina and when introduced aggressively outcompete or otherwise impact native vegetation.

3.b.

Fire and Fire Exclusion in North Carolina's Forests

Key Findings

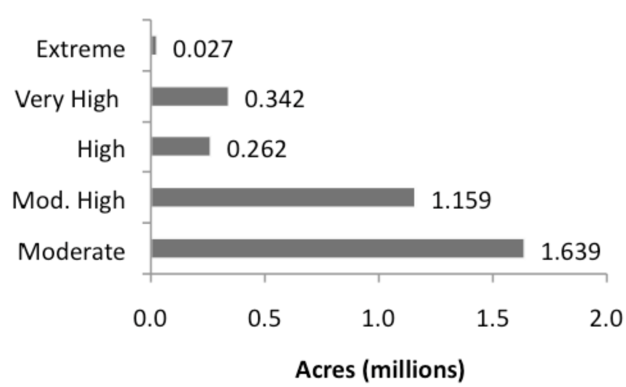
- Fire exclusion contributes to the decline or loss of fire-dependent ecosystems and species, and creates fuel conditions that produce destructive wildfires.
- Population increases in North Carolina's wildland-urban interface areas create significant challenges for firefighters and residents.
- Firefighting capacity to rapidly and effectively control wildfires has decreased over the past decade across North Carolina.
- The public lacks awareness of wildfire hazards and "Firewise" concepts.
- Smoke-sensitive areas occur in much of North Carolina. These areas and air quality regulations restrict controlled burning and necessitate coordinated planning at state, regional, and national levels.

Introduction

North Carolina has more than 3.4 million acres at moderate to extreme risk of wildfire (FIGURE 3*b*-1). Protecting citizens, communities, forest resources, and other natural resources from the negative effects of wildfires occurring on the lands of North Carolina is crucial.

Over the past 10 years, North Carolina has experienced an average of 5,500 fires a year that have burned an average of 38,200 acres annually. Wildfires occur throughout the state and are not limited to one geographical

FIGURE 3*b*-1. North Carolina acreage at moderate to extreme risk of wildfire by risk level.



Source: Southern Wildfire Risk Assessment, 2008 area (FIGURE 3*b*-2). It is crucial that cooperating and assisting agencies form partnerships to (1) identify and mitigate the hazards, risks, and effects from wildfire; (2) educate the public to ensure their safety and emergency responder safety; and (3) continue protecting and enhancing our forest resources. Current and projected issues that fire service agencies and cooperators face relating to wildland fire can be addressed via four focus areas: forest health, population demographics and growth, the wildland-urban interface, and resource capability and availability.

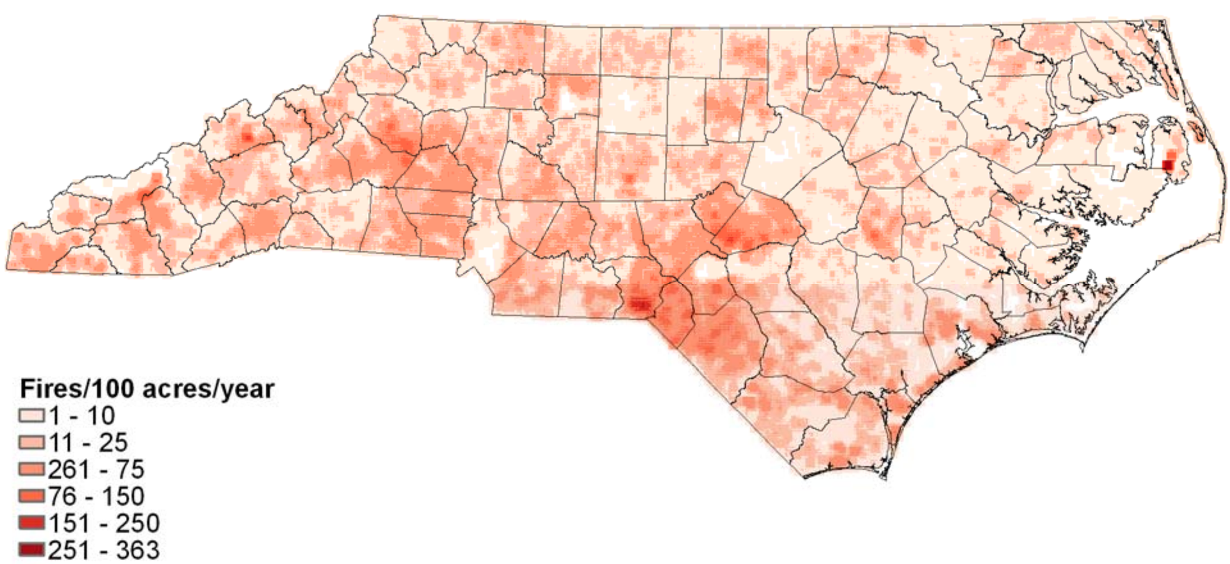
Forest Health

Increased fuel loading in North Carolina forests has greatly influenced the intensity and size of fires. Lack of controlled burning is a primary cause of this increased fuel loading. Pest insects and diseases, natural disasters, and invasive species also have increased fuel loads.

Historically, many of North Carolina's forests burned on a regular basis (FIGURE 3*b*-3). Fuels and vegetation responded accordingly with lower fuel loadings and flashier, quicker burning fuels that resulted in lower intensity wildfires.

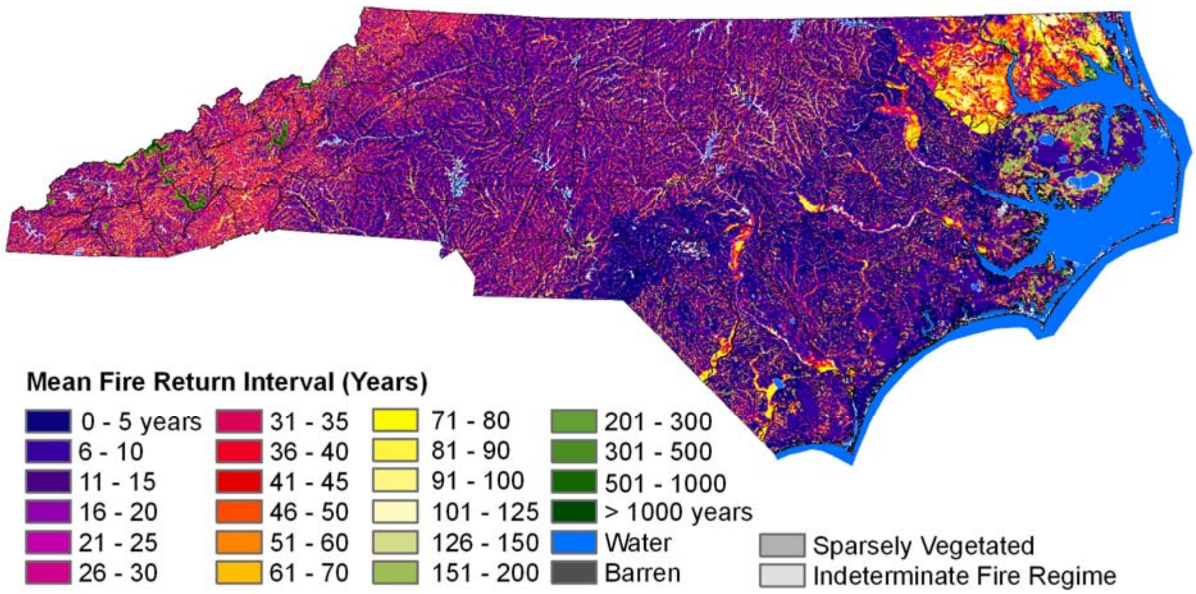
Fire contributes to the diversity of plant communities supporting fire-dependent and fire-adapted ecosystems in North Carolina. Over the last two decades, increased population and the corresponding infrastructure have produced smoke-sensitive areas across much of the state (FIGURE 3*b*-4). These smoke-sensitive areas make burning difficult or impractical where forestland would often benefit the most from a controlled burn. In addition, North Carolina's prescribed fire and smoke management programs must comply with new federal Clean Air Act requirements that include regional haze regulations, revisions to the National Ambient Air Quality Standards (NAAQS) for particulate matter and ozone, and the Exceptional Event Rule.

FIGURE 3*b*-2. Fire occurrences in North Carolina, 2000 – 2008.



Created by: J. Shedd, NCSU, & A. Bailey, NCDFR, 2010

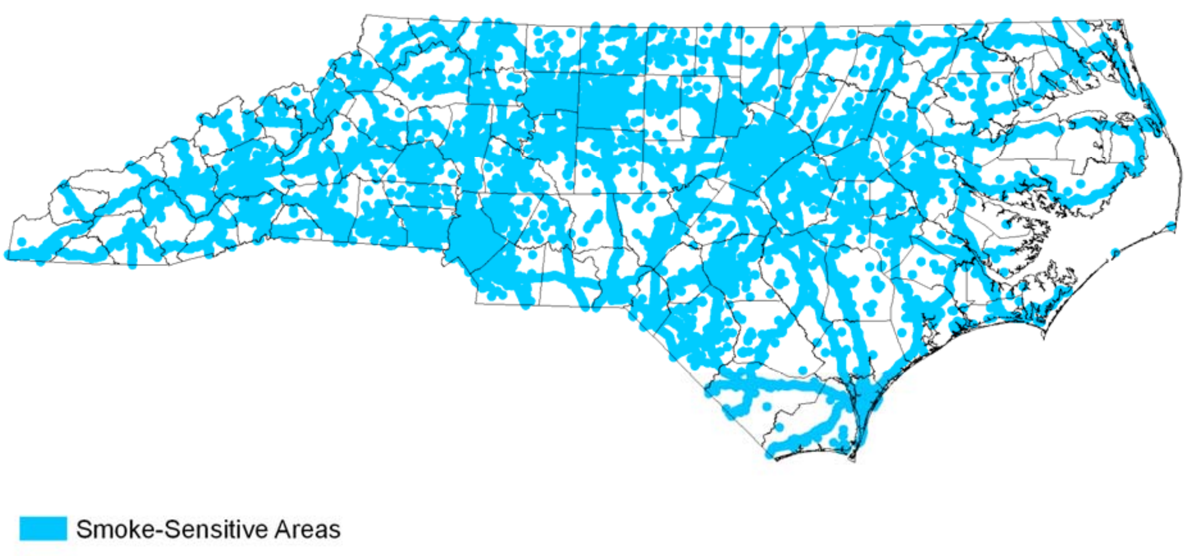
FIGURE 3*b*-3. Presumed mean interval (years) between fire return in NC under a presumed historical regime.



***Northeastern NC data subject to change.**

Created by: J. Shedd, NCSU, & A. Bailey, NCDFR, 2010

FIGURE 3*b*-4. Smoke-sensitive areas in North Carolina, 2009.



Created by: J. Rogers & A. Bailey, NCDFR, 2010

Smoke management is a high priority in fire planning and implementation. It will take working cooperatively with our strategic partners to address smoke management and facilitate the planned increased burning for all native fire-adapted ecosystems while complying with state and federal air quality laws. An average of 104,354 acres of controlled burning has been accomplished annually over the past 10 years, with the majority being performed on government-owned land or military reservations.

Forest insects or disease outbreaks have frequently affected fuel loading and fire behavior and will continue to do so. Fire intensity in damaged areas is elevated due to continual accumulation of dead fuels in all fuel size classes. Specific pests of significance from a fire control perspective are discussed in Chapter 3.a., "Insects, Diseases, and Non-native Plants."

Natural disasters, including hurricanes and ice storms, occur regularly in North Carolina. In affected areas, fire behavior and safety issues arise. Damage usually occurs over large areas, and the sudden increase in fuel loading significantly influences fire behavior and affects accessibility. The increased fire intensity and limited accessibility for equipment and personnel often require a change in tactics to a more indirect attack, which leads to larger fire acreage.

The spread and introduction of invasive plant species that burn rapidly and propagate fire has become an issue in certain areas. This trend is expected to increase. Fuel characteristics of invasive species of concern include volatile foliage and species that produce high volumes of fine fuels. Species of concern from a fire control perspective are discussed in detail in Chapter 3.a.

Population Demographics and Growth

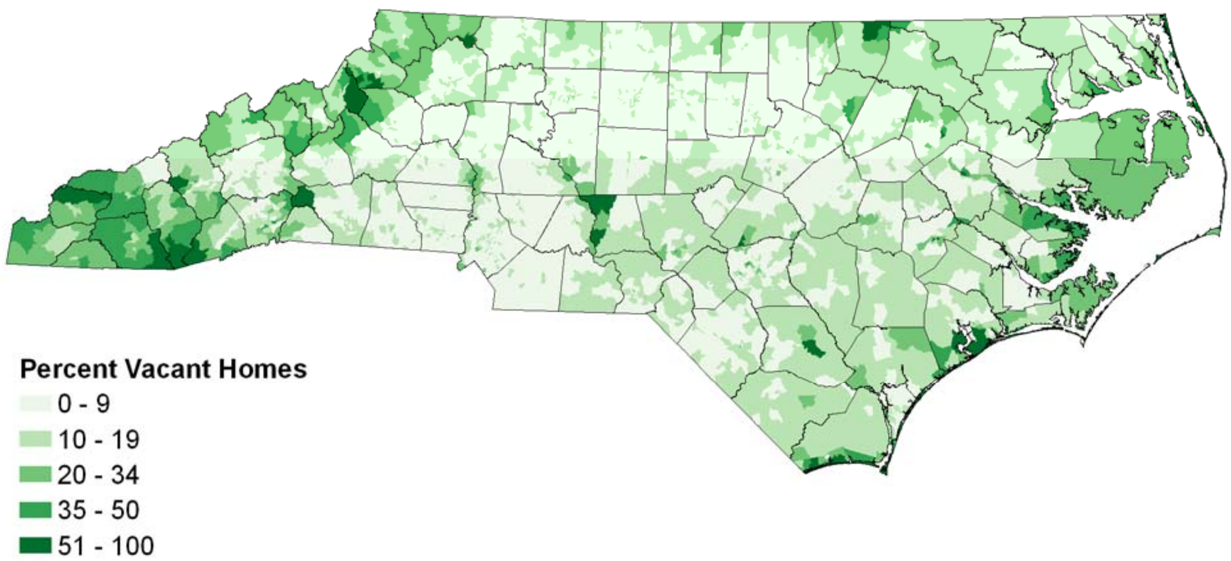
As North Carolina continues to transition from a rural and agricultural state to an urban and suburban one, people's perception of fire and their expectations of fire services have changed. Many people moving to forested areas are coming from metropolitan areas or states where forestland is not as fire-dependent and fire is not as frequent.

Historically, North Carolina's rural population understood the role of fire and its importance in wooded areas. Many residents who are new to living in forested areas are not aware of the benefits that prescribed fire has on an ecosystem. This lack of ecosystem and fire familiarity may also lead to a lack of awareness about wildfire hazards that threaten their homes and property. Many residents living in the wildland-urban interface (WUI) expect that the local fire service will be able to respond to a wildland fire threatening their property with engines and other resources. In reality, most subdivisions in the WUI contain more structures than local fire departments can protect.

North Carolina's population increased by 14.6 percent from 2000 to 2008; it is expected to increase another 16 percent by 2020 (U.S. Census Bureau, 2005). Fire records indicate that humans cause over 85 percent of the state's fires. As population increases, so will the number of structures located in the WUI and human interactions with forestland.

In addition to the increase in permanent residences, the number of vacation or secondary homes has also increased statewide. These homes are predominantly located in the mountains; along the coast; and around lakes, reservoirs, and rivers (FIGURE 3*b*-5). Without full-time residents,

FIGURE 3*b*-5. Percentage of NC homes vacant in 2000.



Created by: A. Bailey, NCDFR, 2010

many secondary or vacation homes have yards or exteriors that are not maintained regularly, which causes fuel buildup on and around the structures. As more residences are built, subdividing increases, turning large pine plantations and large blocks of forestland into subdivisions or minifarms. Often these developments are sited in forestland with minimal vegetation being removed for home construction to maintain a concealed, secluded, natural setting. This practice may create aesthetically pleasing developments, but it also places residents and property in areas of high fire danger.

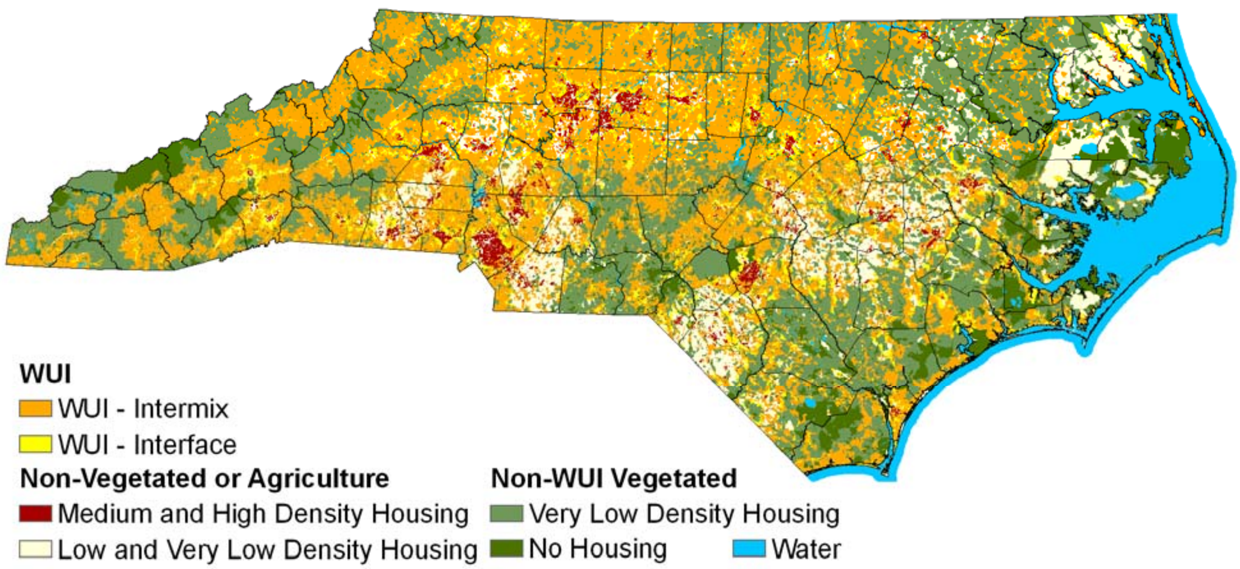
Wildland-Urban Interface (WUI)

As the population increases, more structures are being built in historically forested areas. A University of Wisconsin study in 2005 found that North Carolina had more than 5.5 million acres in the WUI (FIGURE 3*b*-6).

In 1998, 32 percent of all wildland fires occurring in North Carolina threatened residences. By 2008, that number had increased to 42 percent. During the drought year of 2007, 29 homes and 265 structures were destroyed by wildfire in the state.

Many new homes are constructed without any community wildfire planning (FIGURE 3*b*-7). This has created neighborhoods with limited accessibility plus flammable building construction and flammable landscaping with no defensible space incorporated. Currently, state building code and most county building codes and ordinances do not include Firewise practices and principles (as defined by Firewise Communities/USA). Lack of Firewise planning greatly increases the probability that if a wildland fire occurs in the community, more homes will be threatened and emergency response personnel will be at greater risk. In addition, the number of

FIGURE *3b*-6. Wildland-urban interface areas in North Carolina based on vegetation and housing density, 2000.



Created by: A. Bailey, NCDFR, 2010

communities with homeowner rules or covenants, codes, and restrictions has increased. Some stipulations are so restrictive that fuel mitigation projects on homeowners' property cannot be accomplished.

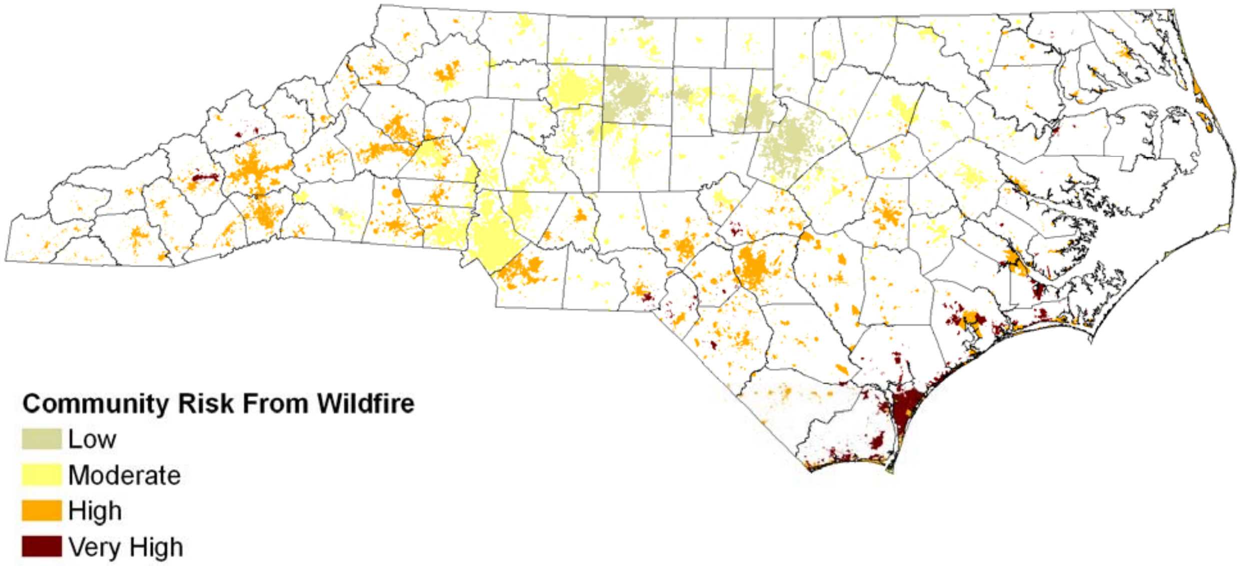
On-the-ground designation and recognition of the communities at risk is accomplished through the creation of Community Wildfire Protection Plans (CWPPs). North Carolina has implemented the CWPP process at the fire department district level. This level of implementation allows for data collection at the local level; provides an excellent tool for use by the local fire departments, fire managers, and emergency management officials; and captures the needs and details specific to a portion of a county. The communities at risk, which are determined and identified during the CWPP process, then become target communities for implementing the practices and principles of the Firewise Communities/USA program. As of January 1, 2010, 236 CWPPs are in various stages of completion statewide (FIGURE 3b-8). Completion of approximately 1,350 CWPPs to include all fire departments is projected by 2014.

Resource Capability and Availability

No single agency or organization alone can handle the wildland fire situation in North Carolina. It takes a concerted effort by all agencies to safely deal with wildland fire and its impact. Through reduction in workforces and retirements, wildland fire agencies have less firefighting experience than in years past. The many collateral duties of current employees also make it difficult for employees to attain the needed level of fireline qualifications.

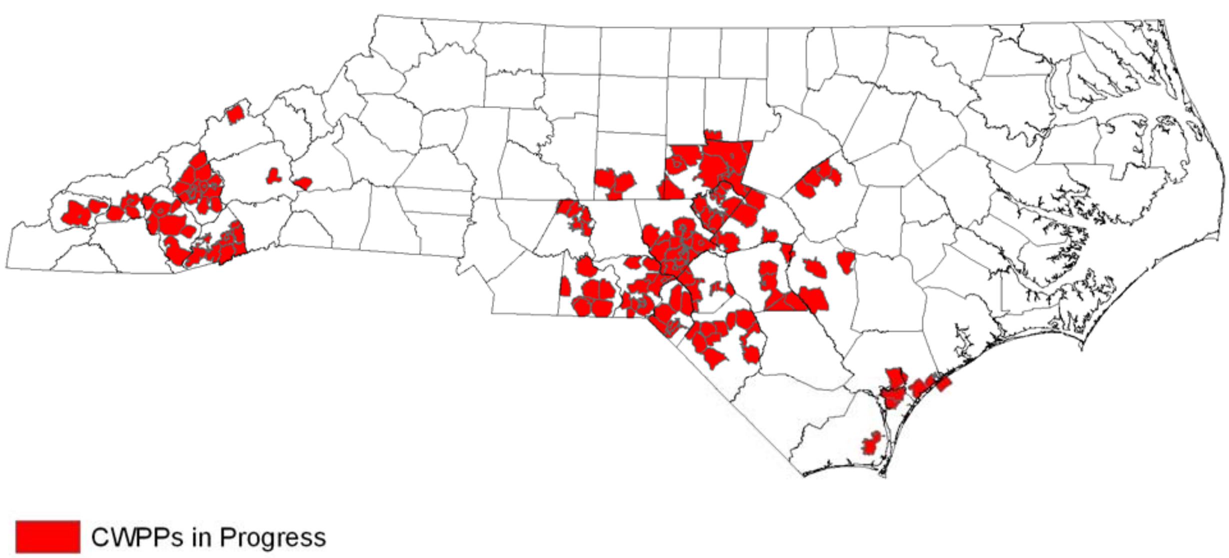
The first responders to the majority of wildland fires in North Carolina are community fire departments. These local departments rely on approximately 50,000 volunteer and paid firemen in the state, and

FIGURE 3*b*-7. NC communities at risk of wildfire, 2009.



Created by: J. Shedd, NCSU, & A. Bailey, NCDFR, 2010

FIGURE 3*b*-8. North Carolina CWPPs, 2009.



Created by: J. Rogers & A. Bailey, NCDFR, 2010 records indicate that only 20 to 30 percent have received any wildland fire training in the last 10 years. Due to limited funding, many fire departments are unable to purchase wildland personal protective equipment for all their members.

Another substantial reduction in wildland firefighting resources occurred as the timber industry companies went out of business or reorganized. Since 1985, 85 industry tractor-plow units with qualified operators have been lost, which is nearly half the number of tractor-plows that were available for wildfire response in the state before 1985. In addition to handling initial fires on their properties, timber companies also conducted thousands of acres of prescribed burning to protect their woodlands.

Summary

As North Carolina's population increases and home construction continues in the WUI, wildfire risk threatens not only forest habitats but the public as well. The increased fuel loading in forests and lack of controlled burning in fire-dependent ecosystems has added to the threat. It will take a unified effort by all wildland fire organizations to educate the public, address smoke issues, conduct fuel mitigation projects, and protect North Carolina citizens and forest resources from wildfire.

Map Data Sources

FIGURE 3b-2: NC Division of Forest Resources, USDA National Forest Service, USDI National Park Service, USDI Fish and Wildlife Service, USDI Bureau of Indian Affairs

FIGURE 3b-3: Wildland Fire Leadership Council: Landfire

FIGURE 3b-4: NC OneMap, NC Department of Transportation

FIGURE 3b-5: US Census Bureau

FIGURE 3b-6: Radeloff et al. 2005

FIGURE 3b-7: Southern Wildfire Risk Assessment

FIGURE 3b8: NC Division of Forest Resources

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Glossary

controlled burn. The use of fire under specific environmental conditions to achieve forest management objectives. Used to reduce hazardous fuel levels, control unwanted vegetation, favor desired vegetation, and improve visibility and wildlife habitat.

Firewise. An approach that emphasizes (1) community responsibility for wildfire planning via the design of a safe community; (2) effective emergency response; and (3) individual responsibility for safer home construction and design, landscaping, and maintenance,

smoke-sensitive area. An area in which smoke from outside sources is intolerable. North Carolina's smoke-sensitive areas are calculated as a 2-mile buffer surrounding medical facilities, major roads, schools, and universities.

wildfire. A rapidly spreading fire, often occurring in wildland areas, that is out of control.

wildland-urban interface. The area where people's homes and structures meet the natural environment of forests and wildlands.

3.c.

Climate, Atmosphere, and Natural Disasters

Key Findings

- Though not fully understood, climate change and atmospheric conditions may differentially impact North Carolina forests' composition and resilience.
- Natural disaster events will continue to threaten the health and productivity of North Carolina's forests. Forest and tree damage offer challenges and opportunities for forest management, forest use, and public safety.
- Sea level is predicted to rise by 1 to 2 feet or more by 2100, increasing the salinity of estuaries, coastal wetlands, and tidal rivers. This will likely alter coastal ecosystems and displace them farther inland.

Climate Change Concerns

Forested lands cover more than 50 percent of North Carolina and help clean and naturally regulate freshwater supply. North Carolina's climate is warm and wet, with mild winters and high humidity. The average annual temperature in the Southeast did not change significantly over the past century (NC Climate Office).

Since the 1970s, there has been a clear warming trend in North Carolina, however, local climate variability is so high in the state that significant trends are difficult to deduce at this point. (State Climate Office of North Carolina, 2010a). Local climate variability is high in the state, making it difficult to deduce significant trends. The number of freezing days has declined by four to seven days per year for most of the Southeast region since the mid-1970s. Average autumn precipitation has increased by 30 percent for the region since 1901. Heavy downpours have increased in many parts of the region, while the percentage of the region experiencing moderate to severe drought increased over the past three decades. The area of moderate to severe spring and summer drought has increased by 12 percent and 14 percent, respectively, since the mid-1970s. Even in the fall months, when precipitation tends to increase in most of the region, the extent of drought increased by 9 percent.

Climate models project continued warming in all seasons across the Southeast and an increase in the rate of warming through the end of this century. The projected rates of warming are more than double those experienced in the Southeast since 1975, with the greatest temperature increases projected to occur in the summer months. The number of very hot days is projected to rise at a greater rate than the average temperature. Under a lower emissions scenario, average temperatures in the region are projected to rise by about 4.5°F by the 2080s, while a higher emissions scenario yields about 9°F of average warming (with higher summer temperatures and higher heat indexes) by the 2080s. Rainfall from individual hurricanes will increase, but results for future precipitation for the Southeast are variable.

The frequency, duration, and intensity of droughts are likely to increase. Changes in precipitation patterns, longer growing seasons, and late freeze vulnerability will alter forests in unpredictable ways.

Increased Hurricane Intensity

The destructive potential of Atlantic hurricanes has increased since 1970, correlated with an increase in sea surface temperature. An increase in average summer wave heights along the U.S. Atlantic coastline since 1975 has been attributed to a progressive increase in hurricane power. The intensity of Atlantic hurricanes is likely to increase during this century, with higher peak wind speeds, rainfall intensity, and storm surge height and strength. Even with no increase in hurricane intensity, coastal inundation and shoreline retreat would increase as sea-level rise accelerates, which is one of the most certain and most costly consequences of a warming climate.

An increase in hurricane intensity will further affect low-lying coastal ecosystems and coastal communities along the South Atlantic coastal margin; these communities are already quite vulnerable. An increase in intensity is very likely to increase inland and coastal flooding, coastal erosion rates, wind damage to coastal forests, and wetland loss. (Karl et al., 2009)

Major hurricanes pose a severe risk to people, personal property, and public infrastructure in our state; and these risks are likely to be exacerbated. Hurricanes make their greatest impact at the coastal margin where they make landfall, causing storm surge, severe beach erosion, inland flooding, and wind-related casualties for both cultural and natural resources (Karl et al., 2009). Major hurricanes, such as Fran and Hugo, damaged rural forests inland and significantly harmed urban forests in the densely populated areas of Raleigh and Charlotte.

Heat-related Stress

The warming projected for the Southeast during the next 50 to 100 years will create heat-related stress for people, agricultural crops, livestock, trees, transportation and other infrastructure, fish, and wildlife. Maximum and minimum temperature increases will impact natural systems more than the projected average temperature change (Karl et al., 2009).

Examples of potential impacts on forest ecosystems include decline in forest growth due to the combined effects of thermal stress and declining soil moisture, as well as decline in dissolved oxygen in streams, lakes, and shallow aquatic habitats, leading to fish kills and loss of aquatic species diversity. Other effects of the projected increases in temperature include more frequent outbreaks of shellfish-borne diseases in coastal waters, altered distribution of native plants and animals, local loss of many threatened and endangered species, displacement of native species by invasive species, and more frequent and intense wildfires (Karl et al., 2009). Such catastrophic fires put communities at risk, can be devastating even to fire-adapted species such as longleaf pines, and can deplete soil nutrients if topsoil layers are actually burned. In 2007, drought-related fires burnt about 600,000 acres in Georgia and Florida, the largest fires in the history of either state (National Interagency Fire Center, 2007).

Decreased water availability due to increased temperature and lack of rainfall events, coupled with an increase in societal demand, will likely affect many sectors of North Carolina's economy. Climate change will also alter the amount and timing of water available to natural systems (Karl et al., 2009).

During droughts, recharge of groundwater will decline as the temperature and spacing between rainfall events increase. Increased groundwater pumping will further stress or deplete aquifers, placing increased strain on surface water resources. Increasing evaporation and plant water-loss rates alter the balance of runoff and groundwater recharge, which is likely to lead to saltwater intrusion into shallow aquifers in many parts of the Southeast (Karl et al., 2009).

Sea-level rise

An increase in average sea level of one to two feet or more by 2100 (FIGURE 3*c*-1) and the likelihood of increased hurricane intensity and associated storm surge (Karl et al., 2009) are likely to be among the most costly consequences of climate change for North Carolina. As sea level rises, coastal shorelines will retreat (FIGURE 3*c*-2). Wetlands will be inundated and eroded away, and low-lying areas, including some communities, will be flooded more frequently—some permanently—by the advancing sea. Catastrophic damage to existing buildings and infrastructure is expected, as these structures were not designed to withstand the intensity of the projected storm surge.

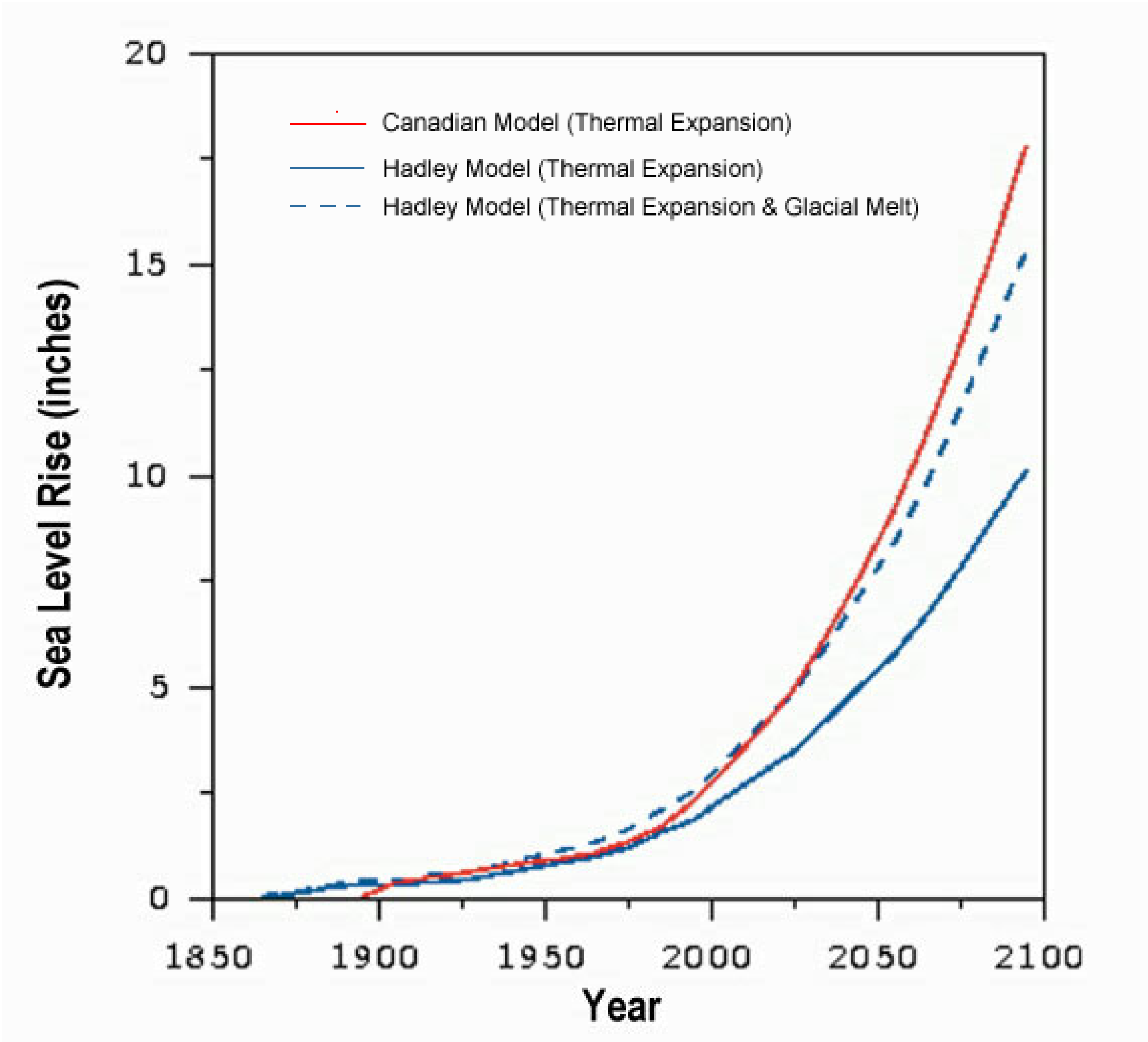
As temperatures increase and rainfall patterns change, soil moisture and runoff to the coast are likely to be more variable. The salinity of estuaries, coastal wetlands, and tidal rivers is likely to increase in North Carolina's coastal plain, thereby altering coastal ecosystems and displacing them farther inland, especially were no barriers exist. More frequent storm surge flooding and permanent inundation of coastal ecosystems and communities is likely in low-lying areas, particularly along the Outer Banks and Pamlico-Albemarle Peninsula where the land surface is sinking. Rapid acceleration in the rate of increase in sea-level rise could threaten a large portion of the coastal zone. The likelihood of a catastrophic increase in the rate of sea-level rise is dependent upon ice sheet response to warming, currently the subject of much scientific uncertainty. Such rapid rise in sea level is likely to result in the destruction of barrier islands and wetlands (Corbett et al., 2008).

Ecological Tipping Points

Ecological systems provide important services that have high economic and cultural value in the Southeast. Ecological effects cascade among living and physical systems, yet few are aware of the impacts to ecological systems until their livelihood or life style is affected. Below are examples of ecological disturbances that result in abrupt responses to warming, as opposed to gradual and proportional responses (Karl et al., 2009):

- The sudden loss of coastal landforms that serve as a storm surge barrier for natural resources and coastal communities (such as in a major hurricane).
- Saltwater intrusion into coastal forests and freshwater aquifers once sea level reaches a critical elevation.
- Intense wildfires in southeastern forests once lower soil moisture and higher temperatures reach critical levels.
- Intense droughts leading to the drying of lakes, ponds, and wetlands and the local or global extinction of riparian and aquatic species.
- A precipitous decline of wetland-dependent coastal fish and shellfish populations due to the rapid loss of coastal marsh.

FIGURE 3*c*-1. Historic and projected changes in sea level based on the Canadian and Hadley model simulations.



Source: U.S. Global Change Research Program, National Assessment Team, 2000

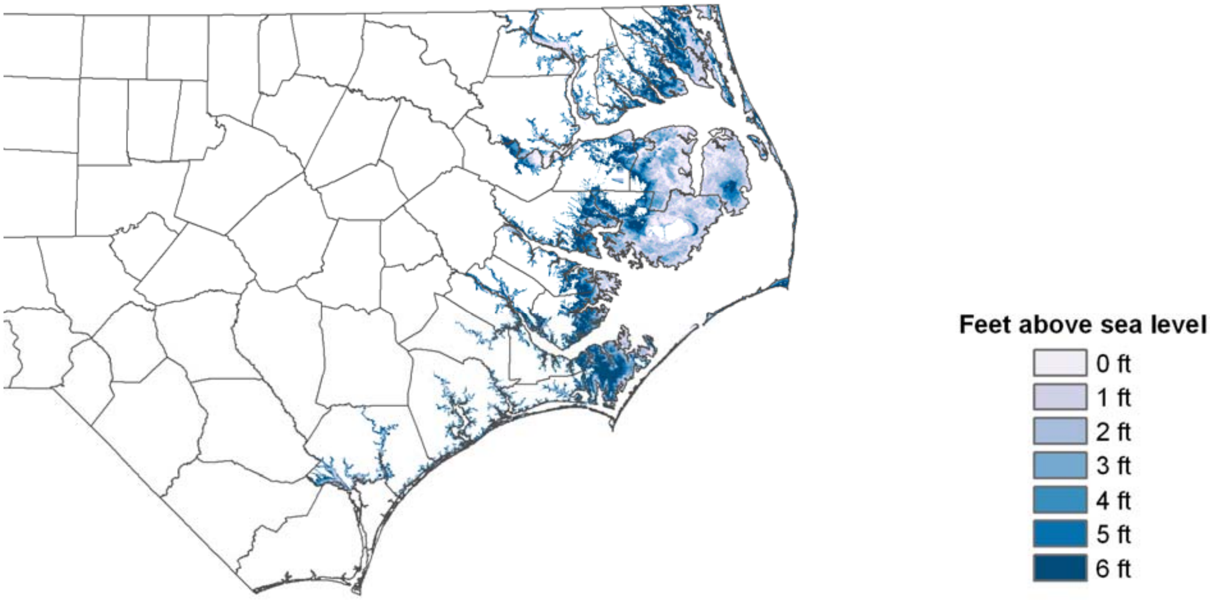
Note: The Canadian model projection includes only the effects of thermal expansion of warming ocean waters. The Hadley projection includes both thermal expansion and the additional sea-level rise projected due to melting of land-based glaciers. Neither model includes consideration of possible sea-level changes due to polar ice melting or accumulation of snow on Greenland and Antarctica.

Other abrupt impacts from climate change may include increased activity by damaging forest tree insects, pathogens, and non-native plant species.

Direct Effects on Trees and Forests

Except in areas directly affected by sea-level change, much needs to be learned about the direct impacts of climate change on individual tree species and populations. Affects depend on not only climate change variables, but also species tolerance to current and future conditions. Further research assessment needs to be made on species and populations occurrence, abundance, and genetics to prioritize those species and ecosystems at highest risk of negative impact and to develop long-term strategies to manage these impacts.

FIGURE 3*c*-2. NC coastal areas within 6 feet of sea level.



Created by: M. Fields, The Nature Conservancy of NC, 2009

Atmospheric Deposition

High elevation forests, coastal forests, and wetlands can be impacted by atmospheric deposition (Sullivan 2000). High elevation forests continue to be impacted because sulfur deposition is greatest, the depth of the soils are shallow, and the soils are cooler and have lower microbial activity. The most sensitive sites are strongly influenced by the parent geology, which influences the amount of base cations (calcium, magnesium, and potassium) present to neutralize acid anions (sulfates and nitrates) deposited from the atmosphere (Snyder et al. 2004, Sullivan et al. 2002a, Sullivan et al. 2002b, and Sullivan et al. 2007). Deposition of nitrogen compounds can lead to eutrophication of certain ecosystems and cause competitive imbalances between vegetative species (SAMAB 1996, and Sullivan 2000). Deposition of mercury in wetland ecosystems is a great concern when sulfur-loving bacteria can convert the mercury into biologically toxic forms (Sullivan 2000).

In severe cases of acidic deposition, the soil pH is lowered below 4.5 and aluminum is released, which can kill the fine roots. A reduction in the amount of fine roots is likely to reduce the amount of nutrient and water uptake by vegetation, and potentially increase susceptibility to disease and insect attack (Elliott et al. 2008, and Sullivan 2000). Decreases in the base cations supplies in the soil can also lead to aquatic impacts in sensitive watersheds by causing reductions in health and mortality of sensitive aquatic organisms, such as phytoplankton, zooplankton, aquatic insects, and fish species (Sullivan 2000, and Sullivan et al 2007). Too much nitrogen deposition can lead to an increase in the abundance of certain species that can adapt to the increased availability of nitrogen. Mercury can accumulate to toxic levels in biological organisms as it moves through the food web (Sullivan 2000).

High elevation soils are typically derived from soil low in base cations, making atmospheric deposition a threat. Historical sulfur deposition (since the 1860s) has been accelerating the loss of base cations from soils. A delayed recovery from sulfur dioxide reductions will occur, partly because the soils have been retaining a portion of the sulfur deposited historically in sensitive ecosystems (Sullivan et al. 2007).

Air Quality

Fine particles (especially sulfates) reduce a person's enjoyment of scenic views. High levels of fine particulates and ground-level ozone may impact the health of terrestrial organisms, and ground-level ozone may cause a physiological response or biomass reductions in sensitive vegetation (SAMAB 1996). Ground-level ozone concentrations are greater at the high elevations (where the National Ambient Air Quality Standards have been exceeded) then valley sites in western North Carolina.

Natural Disasters

Background

Forests in North Carolina have been shaped by cyclical weather events. Tropical storms, hurricanes, winter storms, and droughts are most notable among these. Forests and forest trees adapt to wind, ice loading, and droughts or are replaced by species that can withstand these threats. These events influence natural forests to a large degree, but have a significant impact on urban forests where placement and maintenance of trees can affect personal safety, property, utility infrastructure, and transportation corridors during natural disasters.

Storm damaged forests create challenges related to forest management and wood use. After storms, massive volumes of valuable timber, some still marketable, may be damaged—uprooted, windthrown, or stems broken above the ground. Assessment and salvage may be difficult after the storm due to infrastructure damage, panic, and flooded wood markets. Rehabilitating the forest and returning it to a productive state may also be difficult because of the shear mass of damaged timber.

Forests damaged by wind also create extreme fire hazards. Down and dead trees increase fire fuel loading, create hazards, and cause forest access problems for firefighters. In addition to forest trees, damage to and loss of urban trees causes immeasurable losses, injuries, and deaths. Falling limbs and trees can cause injury and loss of life, property damage, disruption of utility services, and road blockages. Trees weakened by storm damage and drought may be vulnerable to infestation or infection by opportunistic insects and diseases, demonstrated contributors to overall forest fire risk.

Tropical Storms and Hurricanes

North Carolina has a long and notorious history of destructive hurricanes (Figure 3*c*-3 and Table 3*c*-1). The coast of North Carolina can expect to receive a tropical storm or a hurricane once every 4 years. The state's protruding coastline makes it vulnerable to tropical cyclones that curve northward in the western Atlantic Ocean. Cape Fear and Cape Lookout are also favored areas for tropical cyclones to make landfall. Between 1886 and 1996, North Carolina experienced 28 direct landfalls from tropical cyclones, while a total of 82 tropical cyclones passed through the state (State Climate Office of North Carolina, 2010b).

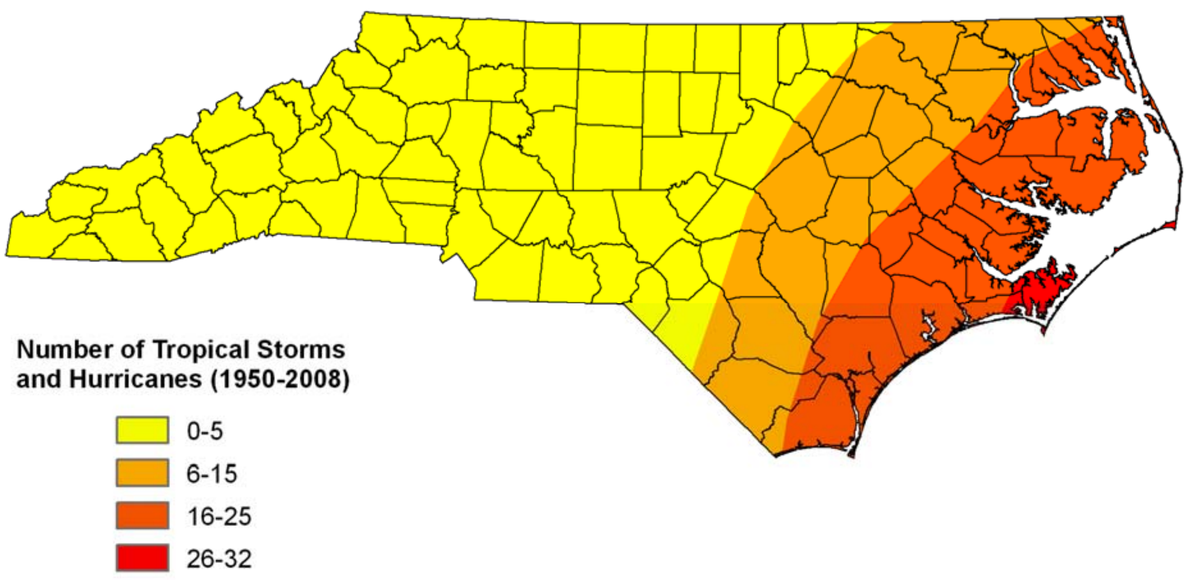
The most widespread type of wind damage to forests in North Carolina is caused by tropical storms and hurricanes; additional wind damage can be caused by tornadoes, downbursts, and severe thunderstorms. Trees normally can withstand prevailing wind conditions. Extreme wind conditions (force and duration) from unusual directions or accompanied by soaking rains can directly result in windthrow or damage. Damage may take the form of stem, branch, or root failure (breakage), wood shaking, crown twist, and direct mechanical damage from flying debris.

Ice Storms

Winter weather (snow, sleet, and freezing rain) occurs with the greatest frequency in the northern latitudes and higher altitudes (the Appalachian Mountains). However, such weather regularly affects the southeastern United States as far south as Georgia during each cold season.

Perhaps the most destructive form of precipitation is freezing rain (or ice loading). Freezing rain accumulation on trees and power lines can cause them to snap, resulting in power outages and damage to homes, automobiles, and ecosystems. The fact that each frozen precipitation type occurs with some regularity throughout the Southeast is due mainly to the topography of

FIGURE 3*c*-3. Tropical storms and hurricanes, 1950 – 2008. A storm was counted if its eye passed within 50 miles.



Created by: A. Bailey, NCDFR, 2010

TABLE 3*c*-1.—Acres damaged and value lost when timber was damaged by three recent major hurricanes

Hurricane Name, Year	Acres Damaged	Estimated Value of Losses
Isabel, 2003	833,192 acres of timber sustained some level of damage in the Northern Coastal Plain	Timber damage valued over $565 million
Fran, 1996	Damaged or destroyed 8.25 million acres of forest in 58 counties	Exceeded $1 billion
Hugo, 1989 (Hugo made landfall in South Carolina.)	More than 2.7 million acres of forests in twenty-six counties mainly in the Piedmont	Over $250 million

Source: NC forest damage appraisals of hurricanes (Doggett, 1989, 1996; Trickel, 2003)

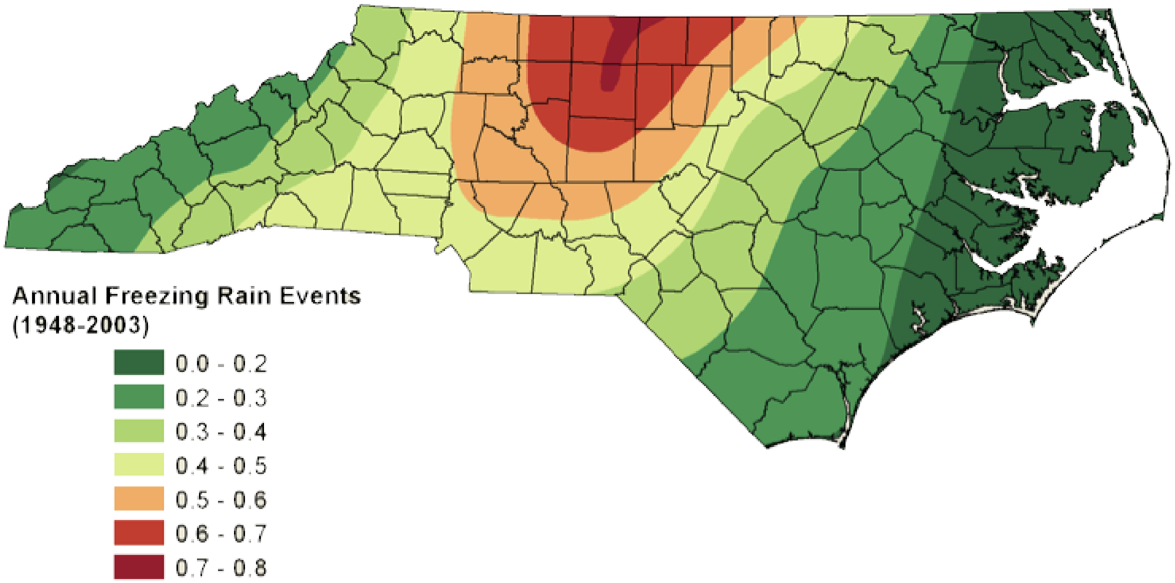
the region as well as its geography. Continental polar air masses from Canada typically supply the cold air necessary for snow, while cold, dry air from New England entering the region can become entrained against the east slopes of the Appalachian Mountains, forming a dome (or wedge) of near-surface cold air. The moisture necessary for precipitation is brought up from the Gulf of Mexico, where the thermal contrast between the cold land surface and the relatively warmer gulf waters provides a favorable environment for storm development and intensification. In these situations, if a cold dome is already in place east of the mountains, the warm frontal boundary and moisture associated with the developing storm may migrate northward over the cold dome, setting the stage for a mixed precipitation (freezing or frozen) event (State Climate Office of North Carolina, 2010c).

Ice storms are frequent in North Carolina, with the piedmont experiencing a freezing rain event once every 2 years (FIGURE 3*c*-4 and TABLE 3*c*-2). Ice damage to trees can be caused by episodes of freezing rain and to some degree by heavy, wet snowstorms. Heavy ice accumulation can cause trees to carry extreme loads. In addition, wet soil conditions and wind can magnify the effects of heavy loading, resulting in branch and stem failure (breakage), crown twisting, uprooting and bent stems. Most species of trees may be affected by ice, though some species are more tolerant than others. (Shortleaf is more tolerant of ice than loblolly pine.)

Drought

North Carolina experiences periodic drought episodes that put a great deal of stress on forest and landscape trees. Drought is defined by the State Climate Office of North Carolina as a deficit in normal precipitation for a region over a period of time sufficient to cause impacts. Dry weather alone does not constitute a drought; impacts define a drought. Drought from the forest impact

FIGURE 3*c*-4. Annual freezing rain event frequency, 1948 – 2003.



Created by: A. Bailey, NCDFR, 2010

TABLE 3*c*-2. Acres damaged and value lost during three recent major winter storms

Year	Acres Sustaining Some Level of Timber Damage	Estimated Value of Timber Damaged
Winter, 2000	578,000 acres in the Sandhills and southern piedmont.	> $264 million
Winter, 2002	2,008,805 acres in the northern coastal plain and piedmont, and parts of the mountains and Sandhills.	> $481 million
Winter, 2004	249,704 acres in the southern coastal plain.	> $97 million

Source: NC forest damage appraisals of winter storms– (Trickel, 2000, 2002, 2004)

perspective is often realized in the form of fire danger and moisture stress to trees.

Continued thermal stress and declining soil moisture will cause a decline in tree growth.

Lower soil moisture and higher temperatures may lead to the failure of newly established seedlings, intense wildfires, or pest outbreaks (such as the southern pine beetle) in southeastern forests. Intense droughts may cause the drying of lakes, ponds, and wetlands, and the local or global extinction of riparian and aquatic species.

Drought may kill weak trees outright, but more frequently drought predisposes trees to pests because of lower food reserves, poorer response to pest attack, and poorer adjustment to pest damage. Recent droughts have lead to increases in *Ips* spp. and black turpentine bark beetles, oak decline, procerum root rot, and other insect and disease activity. In addition, some pines and wetland hardwoods died directly because of drought stress. Although it is still too early to determine if the recent drought will lead to increased southern pine beetle activity, previous droughts were thought to have contributed to southern pine beetle outbreaks. “Unhealthy trees are more prone to drought—drought creates unhealthy trees” (Coder, 1999). Trees in urban landscapes are especially susceptible to stress from dry conditions. Often, dry compacted soils make acquiring sufficient moisture difficult; and the heat created and trapped in urban areas by automobiles, asphalt, and concrete creates a higher demand for water by urban trees.

Summary

Climate change, atmospheric change and pollution, and natural disasters have real and potential effects on forest and natural ecosystems. The most immediate impact of climate change is realized in rises in sea level. As sea levels continue to rise, coastal forests will be displaced as shorelines retreat. Impacts of temperature change to North Carolina’s forests are less apparent and in need of further research. Atmospheric deposition and air quality also have impacts on both forest health and enjoyment of our forests. Ice- and wind-storms cause millions of dollars worth of damage to North Carolina’s forests. Some climate models suggest that these storms may become more frequent, more intense, or both in the future.

Map Data Sources

FIGURE 3c-2: US Global Change Research Program 2000

FIGURE 3c-3: NOAA Coastal Services Center

FIGURE 3c-4: Fuhrmann and Konrad II 2010

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Glossary

atmospheric deposition. Occurs when pollutants are transferred from the air to the earth's surface.

cation. An ion or group of ions having a positive charge and characteristically moving toward the negative electrode in electrolysis.

eutrophication. An increase in the concentration of chemical nutrients in an ecosystem to an extent that increases the primary productivity of the ecosystem.

tropical cyclone. An intense low-pressure system typically associated with high winds, flooding due to storm surge, and intense rainfall, and thunderstorms. Tropical cyclones are broken into three categories based on sustained wind speeds: tropical depression, tropical storm, and hurricane.

Chapter 4. Enhancing the Benefits of North Carolina's Forests

4.a.

Forest Industry Employment

Key Findings

- North Carolina's forest products industry consists of more than 2,500 establishments with about 80,000 workers. The industry has a payroll exceeding $3 billion, contributes more than $6 billion to the state's gross product, and provides more than $28 billion in economic benefit. The industry typically ranks as one of the top two in the North Carolina manufacturing economy.
- Even as the number of manufacturing sector jobs increased and wage growth improved in North Carolina between 2000 and 2008, forest industry related jobs and wage growth declined.
- Employment declined in the Furniture and Related Product Manufacturing and Wood Products Manufacturing sectors between 1999 and 2008. These sectors are largely responsible for the overall decline in forest industry related jobs. Among the hardest hit were sawmills and veneer and plywood facilities.
- Between 1990 and 2008, employment increased for select subsectors that focus on millwork, cabinetry, and gathering of forest products.
- Forest industry related job growth is negative in every Economic Development region within North Carolina.
- Between 1990 and 2008, average growth in forestry industry related wages lags behind the growth of private industry wages overall. Since 2000, private industry wage growth has been positive while forest industry related wage growth has been declining.
- From 1999 to 2008, nearly 200 logging establishments were lost, a 33 percent decline from an average of 703 establishments in the decade from 1990 to 2000.
- More data is needed to fully understand North Carolina's logging industry.
- More data is needed to fully understand North Carolina's niche markets, such as pine straw raking, herbal and floral plant collection, and edible and culinary forest product collection and production.

Introduction

When calculating the impact of the forest products industry on the North Carolina economy, economists have traditionally aggregated four North American Industry Classification System (NAICS) sectors: Forestry and Logging, Wood Product Manufacturing, Paper Manufacturing, and Furniture and Related Product Manufacturing. North Carolina has 2,562 forest products industry manufacturing facilities employing 82,000 people. Total wages are $3.1 billion, and the value of shipments $18.3 billion. The total annual economic benefit of the forest products industry is estimated to be $28.5 billion (Ashcraft, 2009).

This assessment also includes a fifth NAICS sector: Support Activities for Agriculture and Forestry. The aggregate of all five sectors is referred to as "forest industry related."

Forest Industry Related Employment

Labor statistics for North Carolina are provided by the NC Employment Security Commission (NCESC). In 2008, about 77,000 people worked in forest industry related occupations (FIGURE 4*a*-1). The Furniture and Related Product Manufacturing sector is the largest employment sector with 40,000 jobs in 2008. Wood Product Manufacturing is the next largest with approximately 20,000 jobs. The Paper Manufacturing sector contributed another 12,000 jobs, and the Agriculture and Forestry Support Activities and Forestry and Logging sectors added an additional 5,000 jobs (FIGURE 4*a*-2).

Overall employment in forest industry related jobs is contracting faster than the average for all private industries in North Carolina (TABLE 4*a*-1). From 1990 to 2008, forest industry related employment declined at an average annual rate of 1.7 percent. During this same time period, all private industry in North Carolina increased at an average annual rate of 1.5 percent. From 1990 until 1999, forest industry related employment grew; however, this trend reversed during the period from 1999 to 2008, and jobs were lost at the average annual rate of 4.7 percent. Private industry jobs continued to grow during this same time period.

To fully appreciate the forest industry employment picture in North Carolina, the individual industry sectors must be examined. Of the five sectors comprising the related forest industries, employment changes in the Furniture and Related Product Manufacturing and the Wood Products Manufacturing sectors are largely responsible for the decline in overall employment (FIGURE 4*a*-2).

Furniture and Related Manufacturing

In 1990, the North Carolina furniture industry employed more than 80,000workers. By 2008, this number was reduced by half, an average annual decline of 3 percent. More recently, from 2000 to 2008, the rate of decline more than doubled to 7 percent annually.

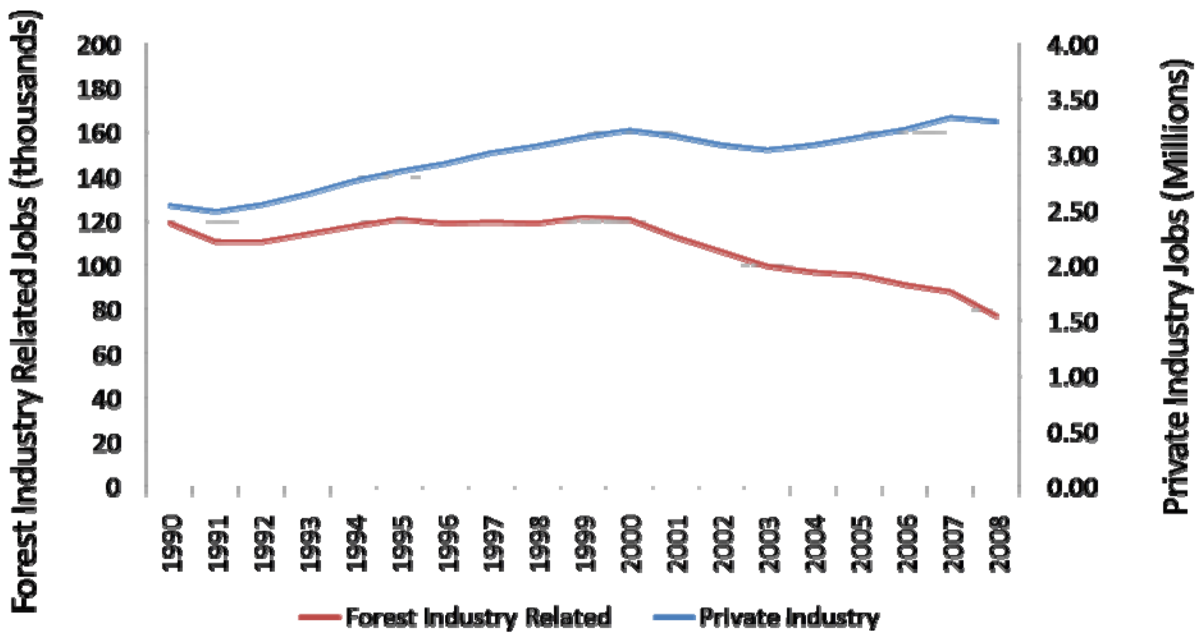
During the same period, growth in employment was enjoyed by the "custom architectural woodwork and millwork" subsector (5.6 percent annually) and the "wood kitchen cabinets and countertops" subsector (4.4 percent annually). Growth in these subsectors exceeded the average annual growth of all private industries, which had an average annual growth rate of 1.5 percent (TABLE 4*a*-1).

Wood Product Manufacturing

North Carolina's wood product manufacturing industry employed more than 30,000 workers at its peak in 1999. In 2008, the industry employed only 20,000, a 31 percent decline. Overall the Manufacturing industry employment declined slightly (0.5 percent annually) while wood products manufacturing employment declined 3.4 percent annually.

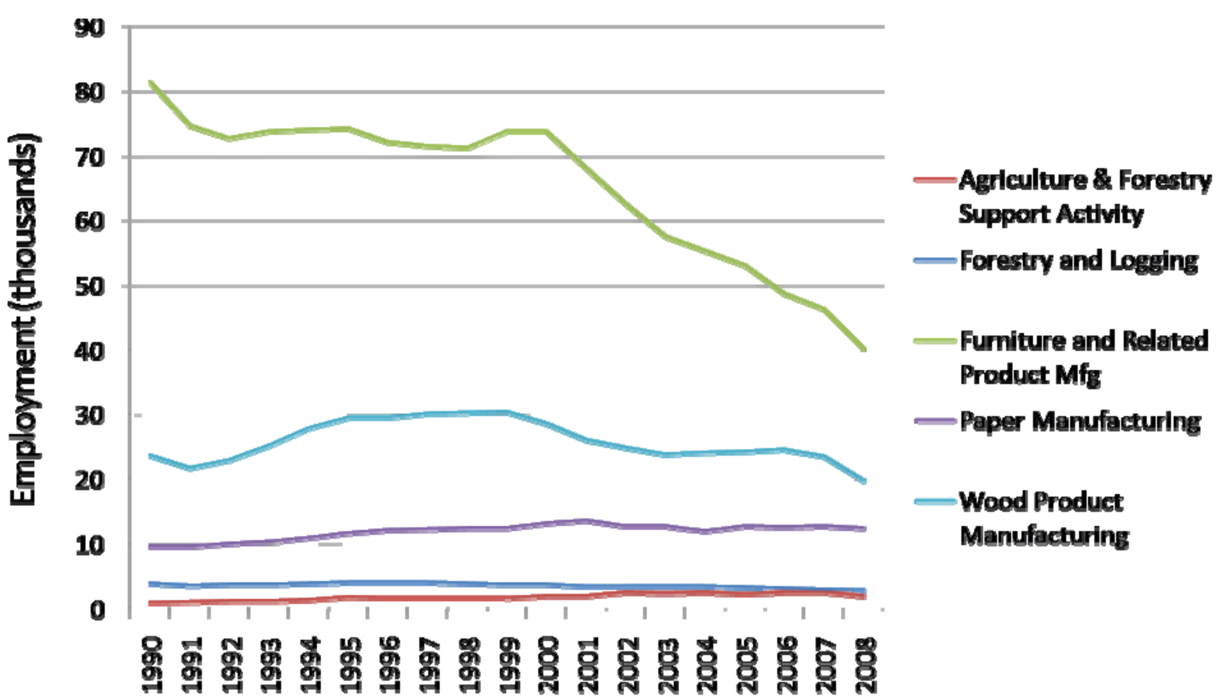
As shown in TABLE 4*a*-1, nearly every sub-sector within the Wood Product Manufacturing sector has declined in North Carolina from 1990 to 2008. The two exceptions are "engineered wood member manufacturing" and "other millwork (including flooring)." Sawmills are among the hardest hit subsectors.

FIGURE 4*a*-1. North Carolina forest industry related and private industry jobs, 1990 – 2008.



Source: NC Employment Security Employment Commission (NCESC), 1990 – 2008.

FIGURE 4*a*-2. Forest industry related employment trends by NAICS sector, 1990 – 2008.



Source: NCESC. 1990 – 2008

a. Forest Industry Employment

TABLE 4a-1.—NC forest industry related employment and wages average annual growth rate (%) by NAICS sector, 1990 – 2008

NAICS Code	Industry Sector and Subsectors	Average Annual Employment Growth (%)	Average Annual Wage Growth (%)
113	Forestry and Logging	-1.4%	2.5%
113310	Logging	-1.3%	2.2%
113110	Timber Tract Operations	0.2%	7.2%
113210	Forest Nursery/Gathering Forest Products	7.2%	10.1%
115	Agriculture & Forestry Support Activity	4.8%	12.9%
115310	Support Activities for Forestry	1.3%	5.9%
321	Wood Product Manufacturing	-0.5%	2.6%
321114	Wood Preservation	-3.3%	0.1%
321912	Cut Stock, Resawing Lumber, and Planing	-3.3%	-1.0%
321212	Softwood Veneer & Plywood Manufacturing	-2.3%	1.2%
321211	Hardwood Veneer & Plywood Manufacturing	-2.0%	1.0%
321113	Sawmills	-1.6%	1.7%
321999	Miscellaneous Wood Product Manufacturing	-1.0%	3.7%
321920	Wood Container and Pallet Manufacturing	-0.4%	1.8%
321219	Reconstituted Wood Product Manufacturing	-0.2%	3.0%
321213	Engineered Wood Member Manufacturing	0.6%	7.2%
321918	Other Millwork (including Flooring)	1.7%	5.7%
322	Paper Manufacturing	1.5%	5.1%
322110	Pulp Mills[1]	-9.5%	-5.5%
322213	Setup Paperboard Box Manufacturing	-7.6%	-4.3%
322121	Paper (except Newsprint) Mills	-4.2%	-2.2%
322214	Fiber Can, Tube and Drum Manufacturing	-3.4%	-0.2%
322130	Paperboard Mills	-1.9%	0.7%
322211	Corrugated/Solid Fiber Box Manufacturing	0.0%	3.0%
322212	Folding Paperboard Box Manufacturing	0.7%	3.3%
337	Furniture and Related Product Mfg	-3.0%	0.3%
337122	Nonupholstered Wood Household Furniture	-6.4%	-3.5%
337211	Wood Office Furniture Manufacturing	-5.9%	-2.3%
337121	Upholstered Household Furniture Mfg	-1.0%	1.6%
337110	Wood Kitchen Cabinets and Countertops	4.4%	8.9%
337212	Custom Architectural Woodwork & Millwork	5.6%	13.3%
Multiple	All Forestry Related Industries[2] (3 digit NAICS)	-1.7%	1.7%
Multiple	All Private Industries (3 Digit NAICS)	1.5%	5.5%

[1]Pulp Mill parameters are from 2001 to 2008. No data available from 1990 to 2000.
[2] "All Forestry Related Industries" includes NAICS Codes 113, 115, 321, 322, 337.

Source: NCSEC, 1990 – 2008

Paper Manufacturing

Employment in the Paper Manufacturing sector has been increasing since 1990 at an average annual rate of 1.5 percent. In 2008, about 12,000 people were employed, a 26 percent increase from 1990. From 1999 to 2008, among the Paper Manufacturing subsectors, positive employment growth occurred in the “folding paperboard box manufacturing” and “corrugated/solid fiber box manufacturing” subsectors. Negative employment growth is occurring in both “pulp mills” and “paper mills,” among other subsectors during the same period.

Forestry and Logging

Employment in the Forestry and Logging sector declined at an average annual rate of 1.4 percent from 1990 to 2008. However, between 1997 and 2008, the annual rate of decline accelerated to 2.9 percent. The logging subsector, with an average annual decline of 4.8 percent from 1998 to 2008, was largely responsible for the overall decline in employment in this sector.

Data fully describing North Carolina’s logging subsector is limited to data from the NC Employment Security Commission, which indicates that from 1990 to 1999, the total number of logging establishments increased. From 2000 to 2008, however, a significant decline occurred (33 percent), with nearly 200 lost from the previous decade’s average of 703 (FIGURE 4*a*-3).

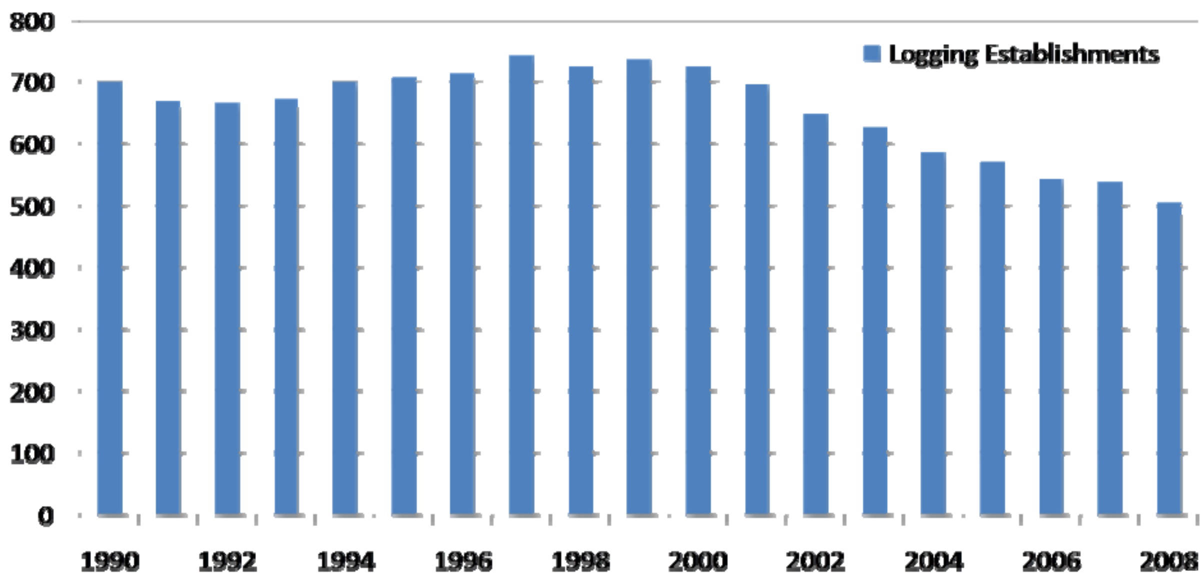
FIGURE 4*a*-4 shows the distribution of logging contractors who are currently registered as ProLoggers with the North Carolina Forestry Association (NCFA), a fair proxy for the distribution of logging contractors in the state.

In 2008, the combined wage amount for forest industry related occupations was $2.7 billion (FIGURE 4*a*-5). The Furniture and Related Product Manufacturing sector had the highest payroll at $1.3 billion. The Wood Product Manufacturing and Paper Manufacturing sectors ranked second and third respectively, with $668 million and $603 million. The Agriculture and Forestry Support Activity and Forestry and Logging sectors contributed an additional $144 million in payroll (FIGURE 4*a*-6).

Wage growth varied by the five sectors (TABLE 4*a*-1). In the Forestry and Logging sector, overall growth averaged 2.5 percent per year with the largest increase occurring in the “forest nursery/gathering forest products” subsector, which experienced an average annual increase of 10.1 percent from 1990 to 2008. The “timber tract operations” subsector had 7.2 percent average annual wage growth, while the “logging” subsector wage growth averaged 2.2 percent annually from 1990 to 2008. The 12.9 percent annual growth rate for wages in the Agriculture and Forestry Support Activity sector was carried primarily by nonforestry related agriculture activities. The “support activities for forestry” subsector did, however, experience a 5.9 percent average annual increase in wages, which exceeded the 5.5 percent average annual growth rate for all private industry during 1990 to 2008. Growth rates for wages in the Wood Product Manufacturing sector were positive for all subsectors except the “cut stock, resawing lumber, and planing” subsector. Only two subsectors experienced wage growth that exceeded the average for all private industry in North Carolina: the “engineered wood member manufacturing” subsector, with 7.2 percent average annual growth in wages, and the “other millwork (including flooring)” subsector, with 5.7 percent average annual growth. Overall, growth rates for wages in the Paper Manufacturing sector were positive at an average annual rate of 5.1 percent from 1990 to 2008. Positive growth was carried largely by nonprimary processing facilities, such as

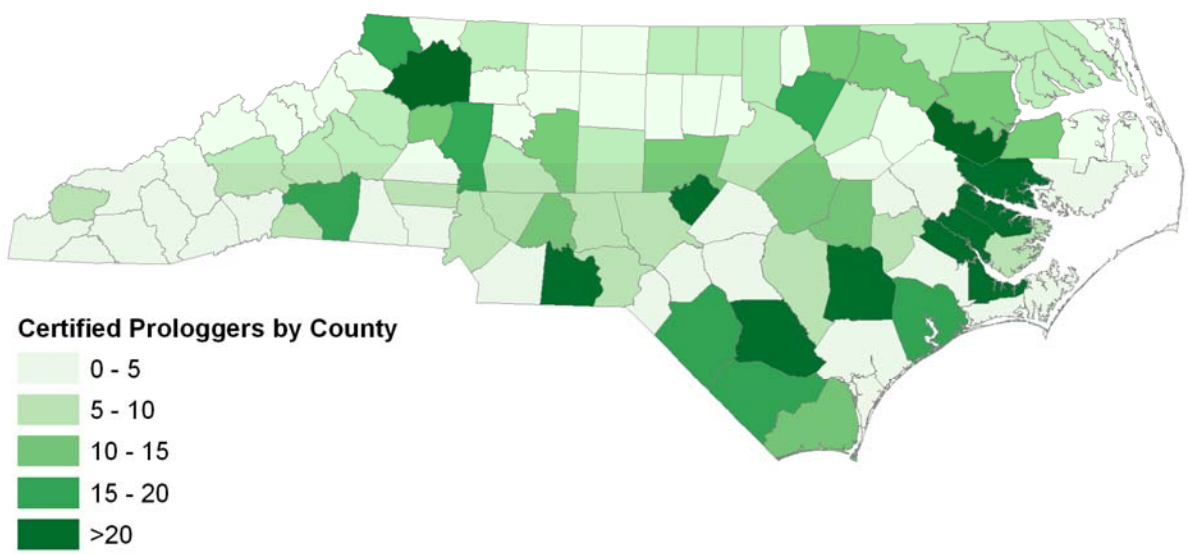
a. Forest Industry Employment

FIGURE 4a-3. Total number of logging establishments in North Carolina by year, 1990 – 2008.



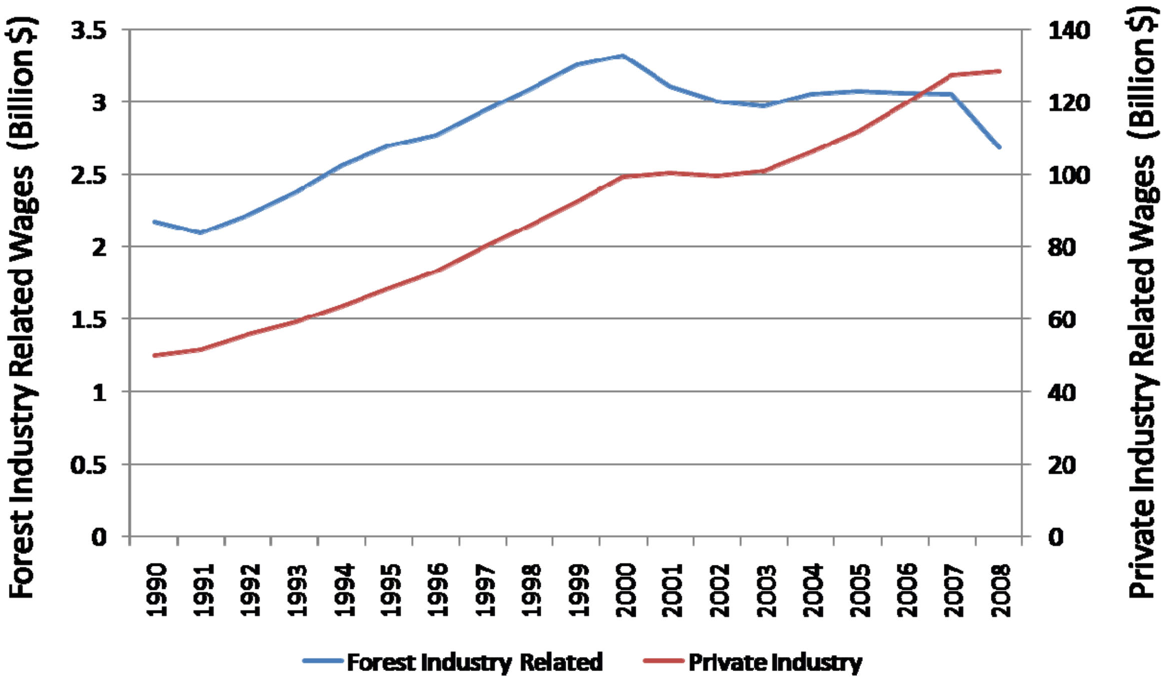
Source: NCESC

FIGURE 4*a*-4: North Carolina certified prologgers by county.



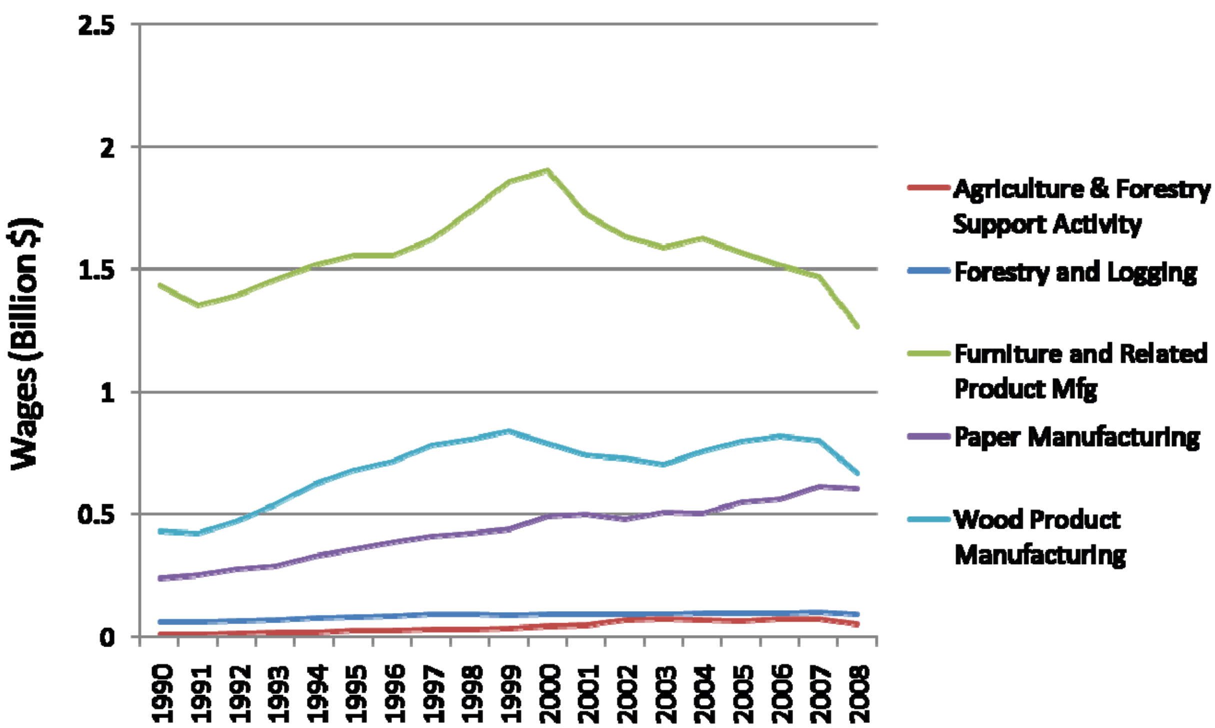
Created by: A. Bailey, NCDFR, 2010

FIGURE 4*a*-5. Forestry industry related and private industry wages in North Carolina by year, 1990 – 2008.



Source: NCESC, 1990 – 2008

FIGURE 4*a*-6. Forest industry related wage trends in North Carolina by NAICS sector and year, 1990-2008.



Source: NCESC, 1990 – 2008

the “corrugated/solid fiber box manufacturing” and “folding paperboard box manufacturing” subsectors. Annual declines in wage growth were experienced by primary processing facilities, such as pulp (minus 5.5 percent) and paper mills (minus -2.2 percent). Paperboard mills did experience positive growth as well. From 1990 to 2008, overall growth was positive at 0.3 percent annually. The largest gains were experienced by the “custom architectural woodwork and millwork” (13.3 percent average annual growth in wages) and “wood kitchen cabinets and countertops” (8.9 percent).

Summary

Both employment and wages in the forest industry related job sector are declining. The number of logging enterprises statewide also appears to be in decline. There are small sub-sectors with positive growth (such as kitchen cabinets and custom architectural millwork), but the available data indicate that the forest industry contribution to North Carolina’s economy, while still strong, is not what it once was.

Map Data Sources

FIGURE 4a-4: NC Forestry Association 2009

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Glossary

forest products industry. A term used commercially that encompasses the NAICS sectors and subsectors defined for forestry.

forest industry related. The term used in this report to encompass the NAICS sectors defined below.

NAICS. The North American Industry Classification System is used by government agencies and business to classify business establishments according to type of economic activity in the United States, Canada, and Mexico. The following NAICS sectors comprise what we refer to in this report as “forest industry related.”

NAICS Sector 113 – Forestry and Logging. Industries in the Forestry and Logging subsector grow and harvest timber on a long production cycle (i.e., of 10 years or more). Long production cycles use different production processes than short production cycles, which require more horticultural interventions prior to harvest, resulting in processes more similar to those found in the Crop Production subsector. Consequently, Christmas tree production and other production involving production cycles of less than 10 years are classified in the Crop Production subsector.

NAICS Sector – 115 Support Activities for Agriculture and Forestry. Industries in the Support Activities for Agriculture and Forestry subsector provide support services that are an essential part of agricultural and forestry production. These support activities may be performed by the agriculture or forestry producing establishment or conducted independently as an alternative source of inputs required for the production process for a given crop, animal, or forestry industry. Establishments that primarily perform these activities independent of the agriculture or forestry producing establishment are in this subsector.

NAICS Sector – 321 Wood Product Manufacturing. Industries in the Wood Product Manufacturing subsector manufacture wood products, such as lumber, plywood, veneers, wood containers, wood flooring, wood trusses, manufactured homes (i.e., mobile homes), and prefabricated wood buildings. The production processes of the Wood Product Manufacturing subsector include sawing, planing, shaping, laminating, and assembling of wood products starting from logs that are cut into bolts, or lumber that then may be further cut, or shaped by lathes or other shaping tools. The lumber or other transformed wood shapes may also be subsequently planed or smoothed, and assembled into finished products, such as wood containers. The Wood Product Manufacturing subsector includes establishments that make wood products from logs and bolts that are sawed and shaped, and establishments that purchase sawed lumber and make wood products. With the exception of sawmills and wood preservation establishments, the establishments are grouped into industries mainly based on the specific products manufactured.

NAICS Sector – 322 Paper Manufacturing. Industries in the Paper Manufacturing subsector make pulp, paper, or converted paper products. The manufacturing of these products is grouped together because they constitute a series of vertically connected processes. More than one is often carried out in a single establishment. There are essentially three activities. The manufacturing of pulp involves separating the cellulose fibers from other impurities in wood or used paper. The manufacturing of paper involves matting these fibers into a sheet. Converted paper products are made from paper and other materials by various cutting and shaping techniques and includes coating and laminating activities.

NAICS Sector – 337 Furniture and Related Product Manufacturing. Industries in the Furniture and Related Product Manufacturing subsector make furniture and related articles, such as mattresses, window blinds, cabinets, and fixtures. The processes used in the manufacture of furniture include the cutting, bending, molding, laminating, and assembly of such materials as wood, metal, glass, plastics, and rattan. However, the production process for furniture is not solely bending metal, cutting and shaping wood, or extruding and molding plastics. Design and fashion trends play an important part in the production of furniture. The integrated design of the article for both esthetic and functional qualities is also a major part of the process of manufacturing furniture. Design services may be performed by the furniture establishment's work force or may be purchased from industrial designers.

4.b.

Timberland Property Values

Key Findings

- Timberland values in the South increased steadily between 1996 and 2007, nearly doubling between 2003 and 2007. Factors contributing to this increase included land divestitures by integrated forest products companies, the corresponding purchase or transfer of these timberlands by TIMOs, REITs, and other investors, and a general increase in land prices.
- Former industry timberlands are now owned primarily by TIMOs and REITs, and not by vertically integrated forest product companies.
- A gap in knowledge exists that could be filled with a data based analysis of nonindustrial private forestland value trends in North Carolina.

Introduction

The information on timberland values reported here reflects prices for the entire South rather than values specific to North Carolina as many large timberland transactions include tracts of land in several states. Tract-specific price evaluations are most commonly conducted by land appraisers using comparable sales and are generally not available to the public. Despite the lack of available public data specific to North Carolina, timberland price trends throughout the South are representative.

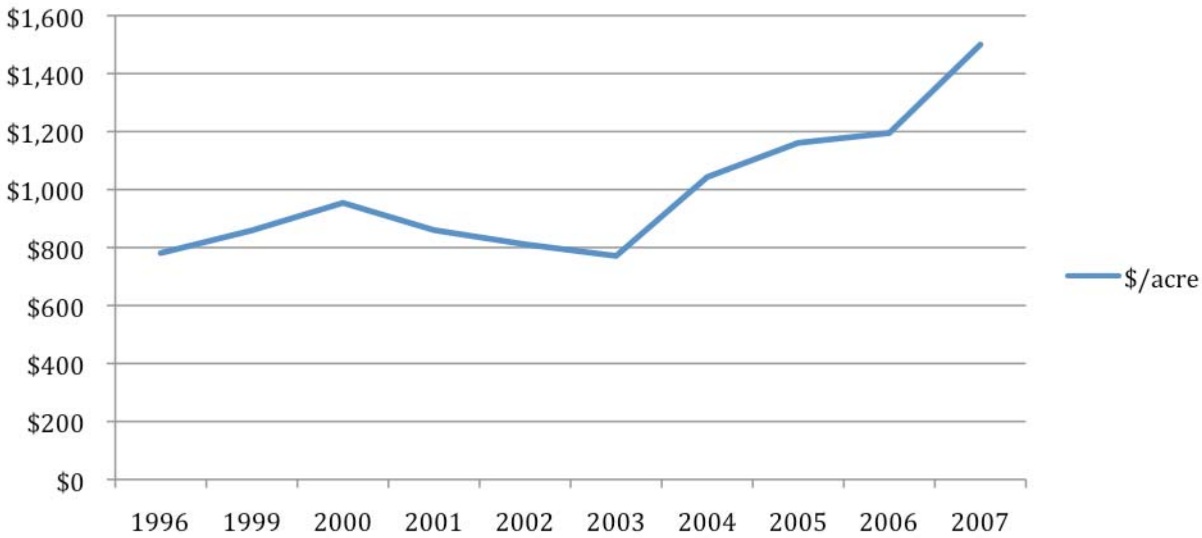
Timberland prices have risen fairly steadily since the mid-1990s, with the value of Southern U.S. timber properties approximately doubling over this time (FIGURE 4*b*-1). Two factors appear to be driving this increase: land divestitures by integrated forest products companies and a general increase in land prices.

Land Divestitures by Integrated Forest Products Companies

Since the 19th century, sawmills have often owned large tracts of timberlands to help secure their supply of raw materials. As the forest products industry grew in North Carolina, large, publicly held, vertically integrated forest products companies developed. These companies, such as Georgia-Pacific, International Paper, Union Camp, Federal Paper Board, Champion International, and Weyerhaeuser, owned hundreds of thousands of acres of timberland in North Carolina to support their various manufacturing facilities, often a combination of sawmills, pulp mills, or paper mills.

The 1990s saw considerable consolidation of these companies, and a shift in market pressures began to motivate these large companies to separate their timberland holdings from their manufacturing base. At the same time, timberlands became popular as an investment class for institutional investors, such as pension funds and insurance companies. Just since 2006, more than 8 million acres of timberland have changed hands across the South in transactions exceeding 100,000 acres each in size. The sellers in 2006 and early 2007 were almost exclusively traditional, integrated forest products firms. The buyers

FIGURE 4*b*-1. Southeastern timberland sales, weighted average price per acre, 1996 – 2007.



Source: Timber Mart—South

were timberland investment management organizations (TIMOs), real estate investment trusts (REITs), private investors and land buyers, and conservation groups such as The Nature Conservancy (James W. Sewall Company, 2008).

This trend has produced a fundamental shift in timberlands ownership, now dominated by organizations and owners focused on extracting value from their timber assets rather than consuming timber to manufacture lumber and produce paper. The implications of this trend for North Carolina are not yet completely clear.

Land Prices in General—The Nonindustrial Private Forestland Owner

In addition to a shift in the industrial timberlands base, the nonindustrial private forestland owner (NIPF) has seen an increase in timberland values as well. Incorporated in the price of land is the anticipated future use of the land and its resources. Timber management has historically been considered a residual land use (Wear and Newman, 2004). As the population centers of North Carolina expand, forestland is being converted to other uses of higher value than forestry, and the value of land is rising accordingly. Forestland is being sold into the residential and second home markets at per acre prices well above traditional timberland prices. With this increase in timberland prices, the likelihood of using land for long-term timber management decreases as NIPF owners see better economic returns by selling to developers.

North Carolina’s Forestry Present-Use Value (PUV) Program

“Qualified North Carolina owners of soundly managed commercial forestland have enjoyed property tax reductions since 1974 through the state’s forestry present-use property tax program. However, tax savings via this program vary widely across the state. First, tax rates differ from county to county. Second, in urban counties, there is often a wide difference between market value (which reflects the highest-priced and best use of property) and the use value of property on which a timber crop is growing. In rural areas, the difference between market value and use value is often slight. Therefore, forestland owners in urban counties may see the greatest savings.

Third, the program, detailed in N.C. General Statutes 105-277.2 through 105-277.7, is still evolving. Numerous legislative changes, court decisions, and property tax commission rulings have altered it over the years. (Hamilton and Bardon, 2007)”

The major provisions of the North Carolina Forestry PUV program and the steps that landowners must follow to qualify for the tax savings are outlined in a North Carolina Cooperative Extension Service “Woodland Owner Note” titled “North Carolina’s Forestry Present-Use Property Tax Program” (http://www.ces.ncsu.edu/nreos/forest/pdf/WON/won40.pdf).

The program has been widely utilized by forest landowners and has enabled many to retain their property in productive timberland rather than selling or converting it to another land-use. Based on the program’s requirement of a forest management plan, many landowners who would otherwise not come in contact with forestry professionals have been reached. North Carolina county tax offices have some latitude in implementing their forestry PUV program. According to the North Carolina Department of Revenue (NCDOR), key elements in a written plan for a sound forestland management program include:

- Management and landowner objective statement
- Location map and/or photo
- Forest stand(s) description/inventory and stand management recommendations
- Regeneration and harvest methods and dates
- Regeneration technique

The NCDOR website (http://www.dor.state.nc.us/downloads/property.html) maintains a “Present Use Value” section where landowners may access the following forms that are critical to understanding and participating in the forestry PUV program:

- Form AV-4 (“North Carolina General Statutes Pertaining to Present-Use Value Assessment and Taxation of Agricultural, Horticultural, and Forestlands”)
- Form AV-5 (“Application for Agriculture, Horticulture, and Forestry Present-Use Value Assessment”)

Summary

Until the recent economic downturn, undeveloped land prices in North Carolina, including forestland, were steadily rising on a per acre basis. This trend was very appealing to all types of forestland ownerships. There may be some leveling of the demand for development land with the current soft economy, which would bode well for maintaining land as forestland.

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4.c.

Timber Stumpage Values

Key Findings

- Pine sawtimber prices have been declining since 2000, largely due to declines in eastern North Carolina pine sawtimber stumpage values.
- Since 1993, the average statewide pine pulpwood stumpage price has been slowly declining, driven largely by the decline in western North Carolina pulpwood stumpage prices.
- Except for hardwood pulpwood, eastern North Carolina stumpage prices traditionally exceed western North Carolina stumpage prices for pine sawtimber, pine pulpwood, and mixed hardwood sawtimber.
- Except for pine sawtimber, eastern North Carolina stumpage prices are below the South’s regional average for pine pulpwood, mixed hardwood sawtimber, and hardwood pulpwood, while western North Carolina stumpage prices are all below statewide averages.
- Pine pulpwood stumpage prices have traditionally been significantly higher than hardwood pulpwood prices. In eastern North Carolina, that trend continues with the gap between pine and hardwood prices averaging around $7 per cord. In western North Carolina, hardwood stumpage prices caught up with pine stumpage prices around 2002, and frequently were higher than pine pulpwood prices from 2002 to 2008.
- Data is needed to assess stumpage value trends for higher grade hardwood sawtimber, by species.
- Total stumpage value averaged over an 8-year period from 2001 to 2008 tended to be greater in the eastern counties of North Carolina. This difference in values between east and west can be related to various factors, including markets, species, urbanization, and infrastructure.

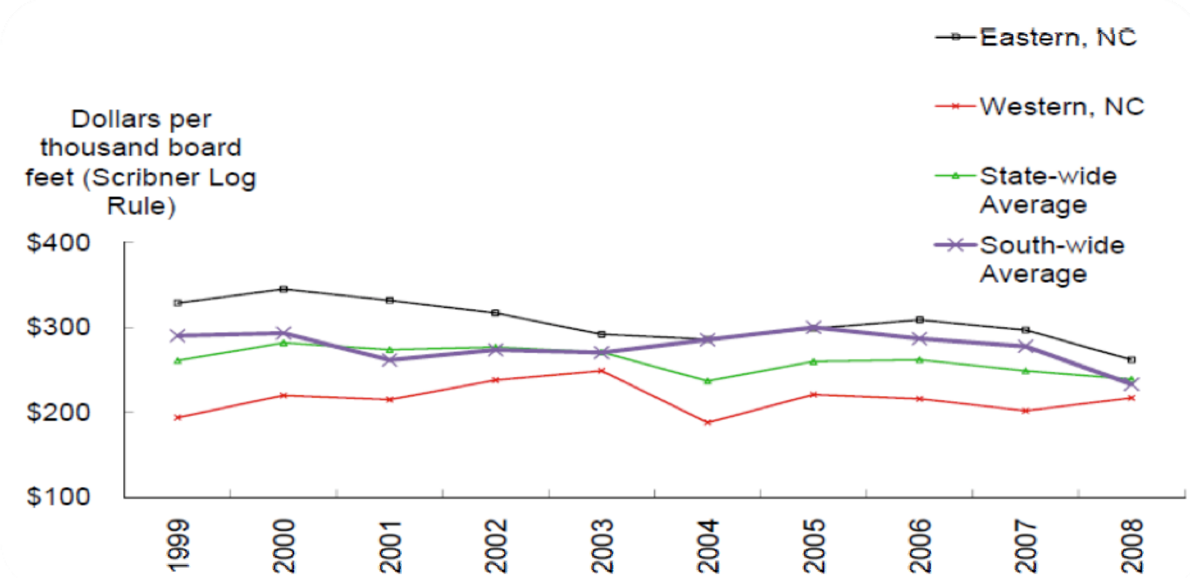
Pine Sawtimber

An analysis of the pine sawtimber stumpage price trends from 1999 to 2008 indicates that since their peak in 2000, average statewide stumpage prices have been declining at about 1.2 percent annually while South-wide stumpage prices have declined at 0.8 percent annually (FIGURE 4*c*-1). Regionally, eastern North Carolina pine sawtimber stumpage prices have traditionally been higher than western North Carolina stumpage prices. Eastern North Carolina stumpage prices for pine sawtimber are generally higher than South-wide averages, while western North Carolina stumpage prices for pine sawtimber are generally lower. From 1976 to 2000, pine sawtimber stumpage prices in North Carolina have increased (FIGURE 4*c*-2).

Pine Pulpwood

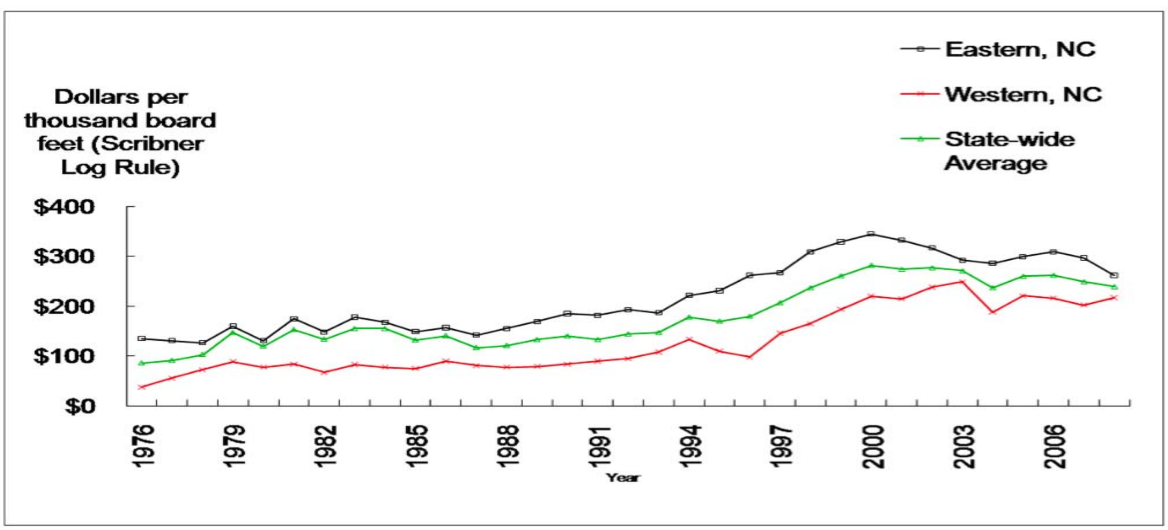
The overall trend in pine pulpwood stumpage from 1976 to 2008 was an increase in prices. Between 1976 and 1993, the prices increased sharply, particularly in the western counties of North Carolina, which saw an average annual increase of 8.6 percent. Eastern prices increased during this same period, but at the lower rate of 4.9

FIGURE 4c-1. Pine sawtimber stumpage price history, 1999 – 2008.



Source: Timber Mart–South, 2009

FIGURE 4c-2. Average pine sawtimber stumpage prices by NC region and statewide, 1976-2008.



Source: Timber Mart–South, 2009

percent (FIGURE 4*c*-3). However, there have been some periods of negative growth.

Since 1993, average statewide stumpage prices have been slightly declining, with eastern prices nearly flat at 0.9 percent annual growth, and western prices decreasing at 1.8 percent annually (FIGURE 4*c*-4). Beginning around 1999, eastern North Carolina prices have remained flat while western North Carolina stumpage prices halved their rate of decline to 0.9 percent. Both eastern and western pine pulpwood stumpage prices are lower than South-wide averages (FIGURE 4*c*-5).

Hardwood Pulpwood

Hardwood pulpwood stumpage prices have been increasing since 1976. Both eastern and western North Carolina stumpage prices have increased at an average annual rate of around 7 percent. The greatest rate of increase occurred between 1976 and 1993. During this period, eastern and western hardwood pulpwood stumpage values increased at an average annual rate of 10.1 and 11 percent respectively (FIGURE 4*c*-6).

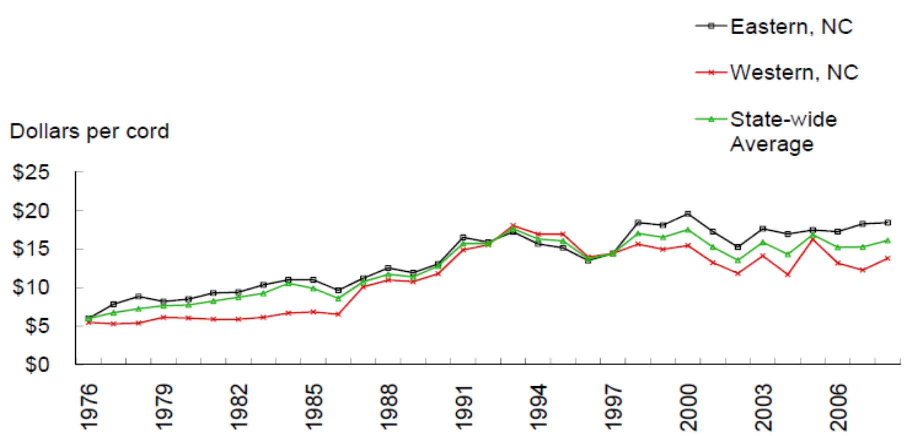
Since 1993, the rate of increase has slowed to around 1.7 percent annually for both regions of North Carolina (FIGURE 4*c*-7). Western stumpage values are historically higher than eastern North Carolina stumpage values, and both regions are below the South-wide average for hardwood pulpwood (FIGURE 4*c*-8). Since 1999, South-wide stumpage prices for hardwood have been increasing at an average annual rate of 5.3 percent, while North Carolina's average statewide stumpage prices have been increasing at an annual rate of only 3.4 percent.

Mixed Hardwood Sawtimber

North Carolina's stumpage prices for mixed hardwood sawtimber can be highly variable (FIGURE 4*c*-9). Prices have been increasing since 1976, but have leveled off since 2001.

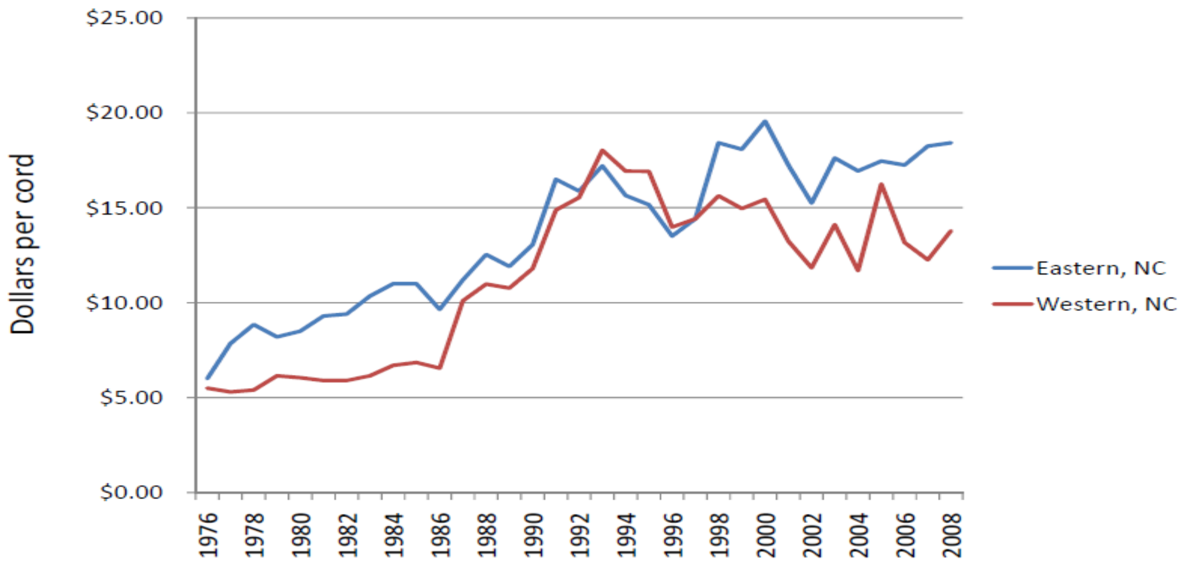
Since 1999, western North Carolina stumpage prices are increasing, but at only 0.3 percent annually (FIGURE 4*c*-10). Eastern North Carolina prices during this same time period have been increasing at an average rate of 1.25 percent annually, while South-wide prices were increasing at an average annual rate of 2.7 percent. From 1999 to 2006, stumpage prices for mixed hardwood have been generally higher than the South-wide average, but recently prices eroded (2007 and 2008) to below the South-wide average.

FIGURE 4*c*-3. Pine pulpwood stumpage price history, 1976 – 2008.



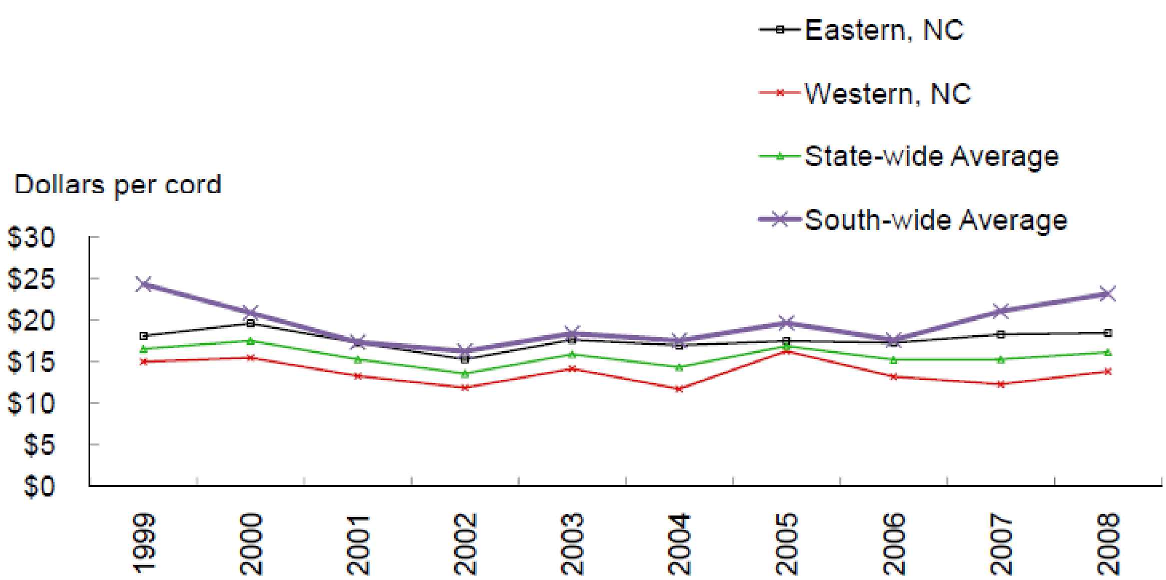
Source: Timber Mart–South, 2009

FIGURE 4c-4. Eastern versus western NC pine pulpwood prices.



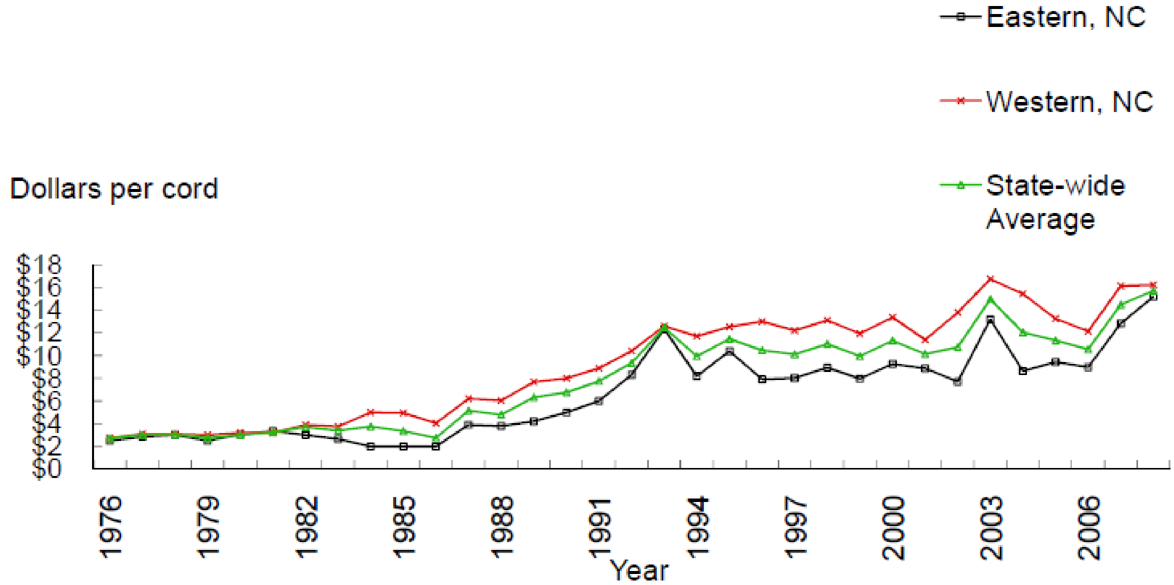
Source: Timber Mart–South, 2009

FIGURE 4c-5. Pine pulpwood stumpage price history, 1999 to 2008.



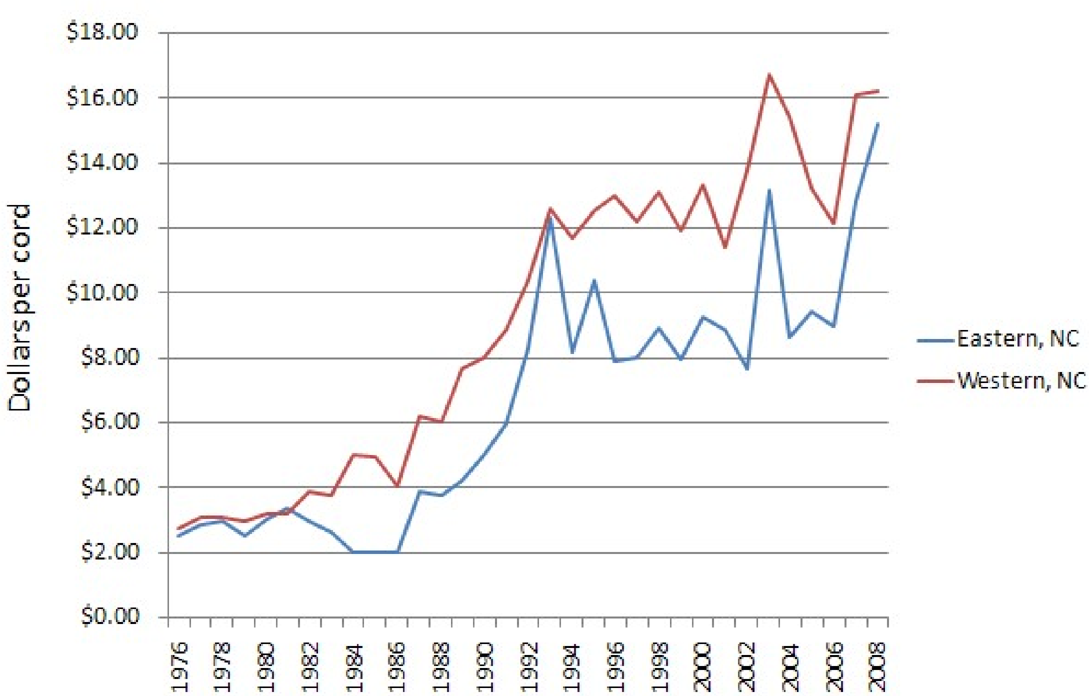
Source: Timber Mart–South, 2009

FIGURE 4*c*-6. Hardwood pulpwood stumpage prices history, 1976 to 2008.



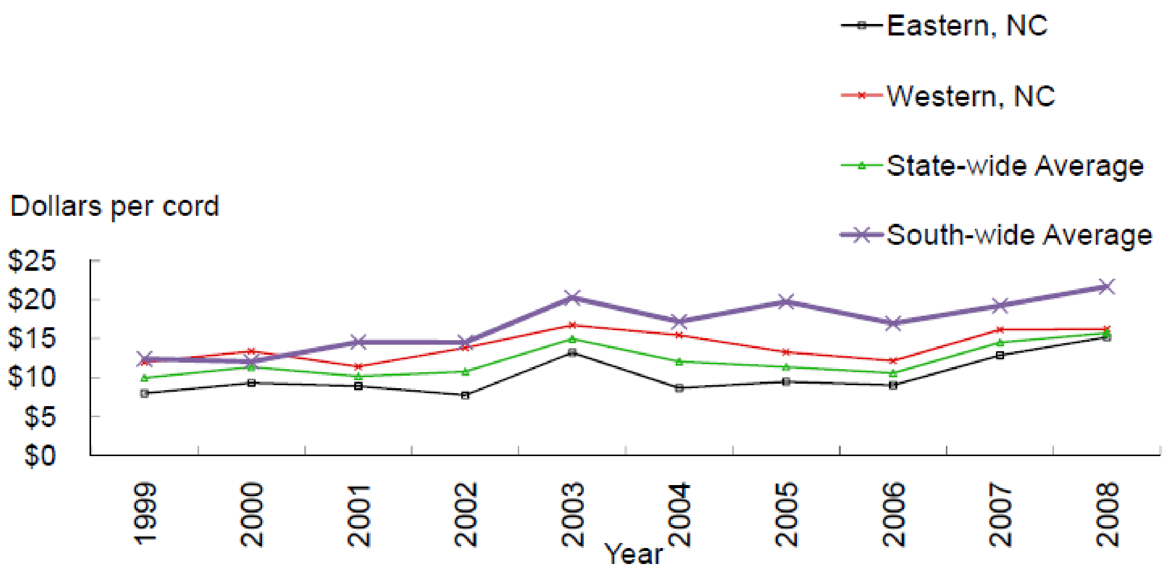
Source: Timber Mart–South, 2009

FIGURE 4*c*-7. Eastern versus western NC hardwood pulpwood prices.



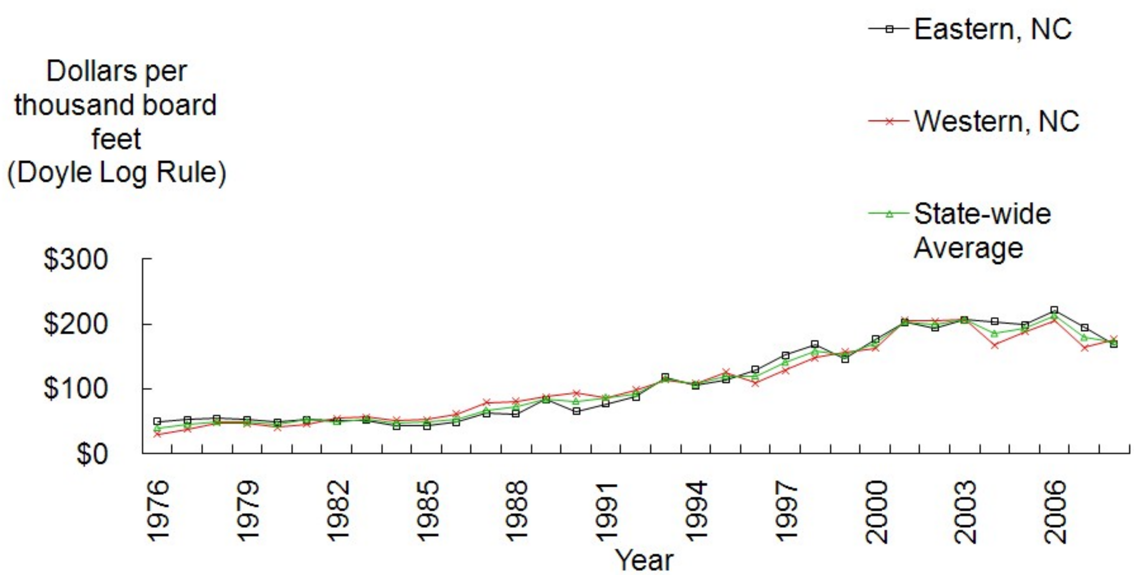
Source: Timber Mart–South, 2009

FIGURE 4*c*-8. Hardwood pulpwood stumpage price history, 1999 to 2008.



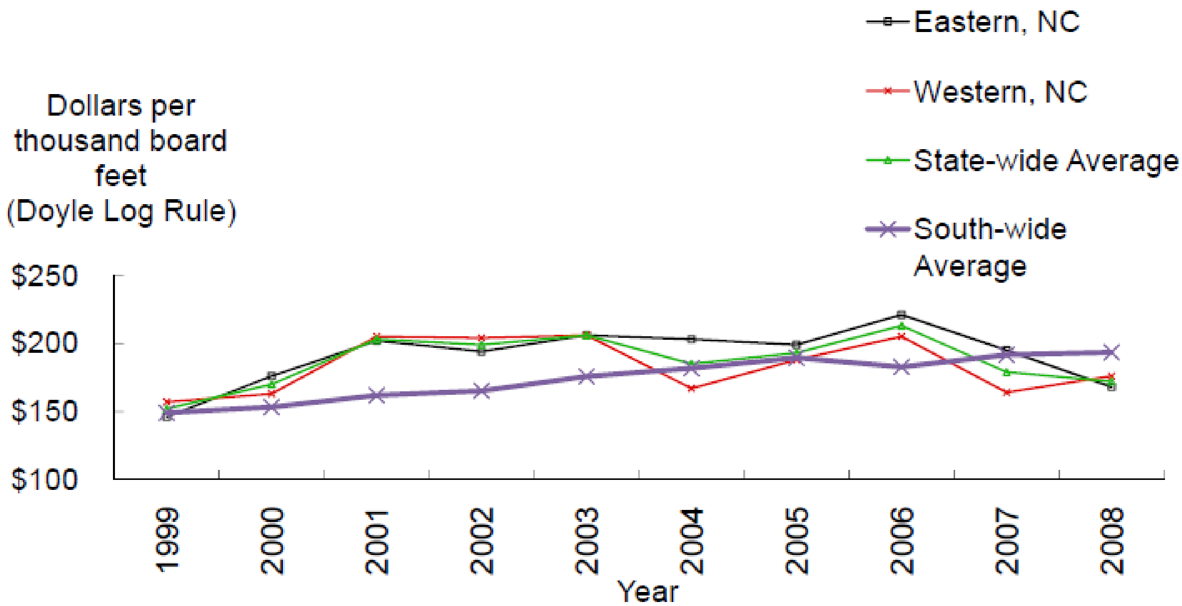
Source: Timber Mart–South, 2009

FIGURE 4*c*-9. Average mixed hardwood sawtimber stumpage prices by NC region and statewide, 1976-2008.



Source: Timber Mart–South, 2009

FIGURE 4c-10. Mixed hardwood sawtimber stumpage price history, 1999 to 2008.



Source: Timber Mart–South, 2009

Hardwood and Softwood Pulpwood Gap

Pine pulpwood stumpage prices have traditionally been significantly higher than hardwood pulpwood prices. In eastern North Carolina, that trend continues with the gap between pine and hardwood prices averaging around $7 per cord (FIGURE 4c-11).

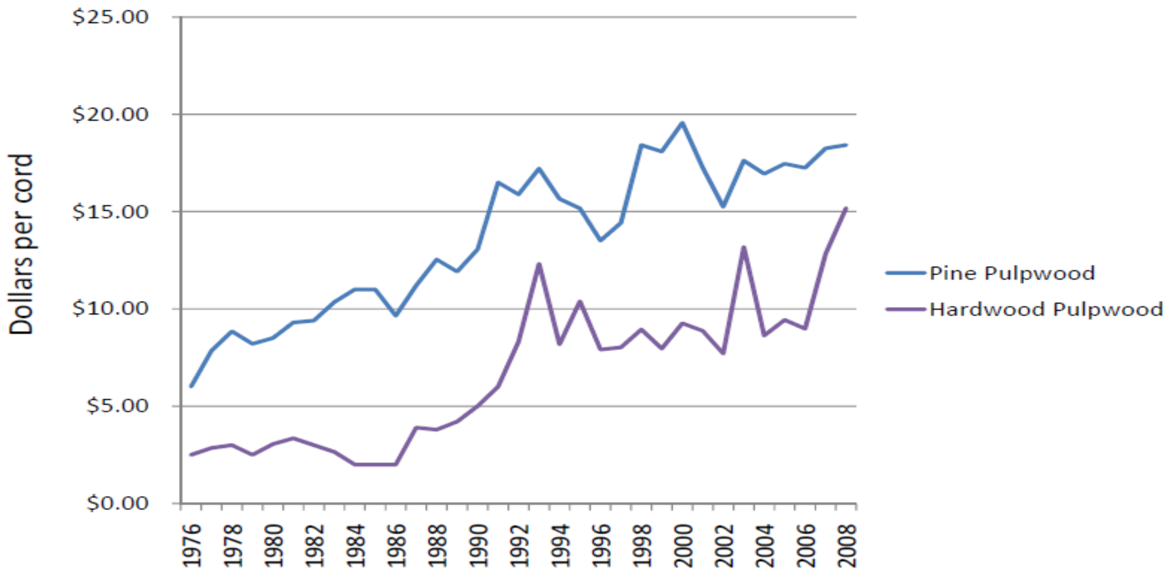
In western North Carolina, the situation is different. From 1976 to around 1993, pine pulpwood enjoyed a significant price differential over hardwood pulpwood. Beginning in 1993, the stumpage value of pine pulpwood began eroding at the average rate of 1.8 percent annually, while hardwood pulpwood increased at an average rate of 1.6 percent. As a result, hardwood stumpage prices caught up with pine stumpage prices around 2002, and have frequently been higher than pine pulpwood prices in the period since then (FIGURE 4c-12).

Economic Value of Timber Stumpage to North Carolina Landowners

The NC Cooperative Extension Service publishes an annual report that estimates the annual income from North Carolina timber harvested and delivered to mills. The data are calculated by combining county-level timber product output data provided by the Southern Research Station, USDA Forest Service, with timber stumpage and delivered prices from Timber Mart–South.

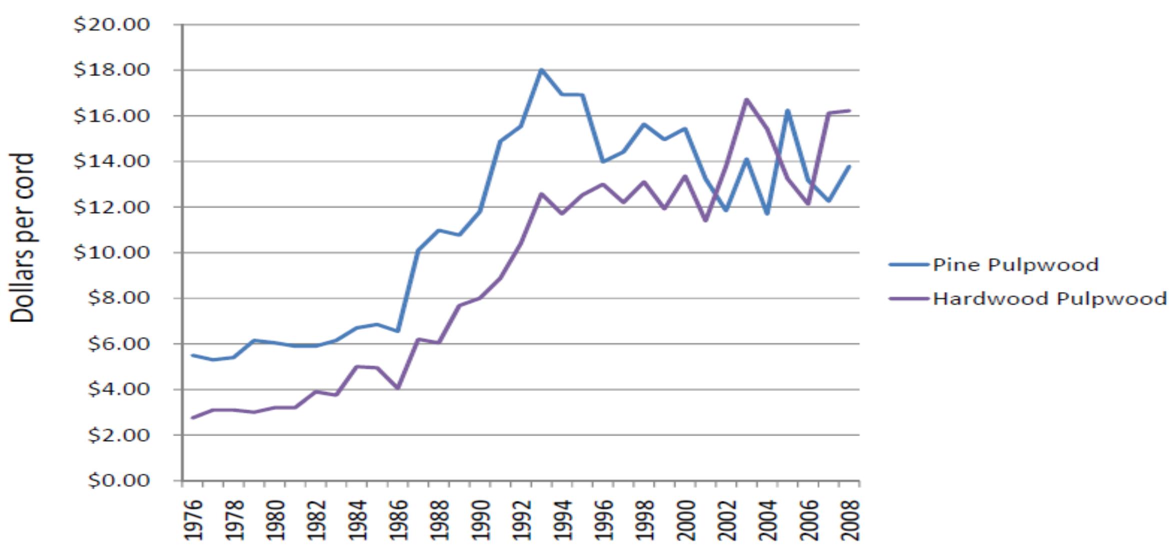
FIGURE 4c-13 depicts the 8-year average of county-level stumpage prices in North Carolina. Primary wood-using facilities are also displayed to help correlate stumpage values with the number and type of facilities in the drain area. Total stumpage value averaged over an 8-year period from 2001 to 2008 tended to be greater in the eastern counties of North Carolina. This difference in values between east and west can be related to various factors, including markets, species, urbanization, and infrastructure.

FIGURE 4c-11. Eastern NC pulpwood price comparison, pine versus hardwood, 1976 – 2008.



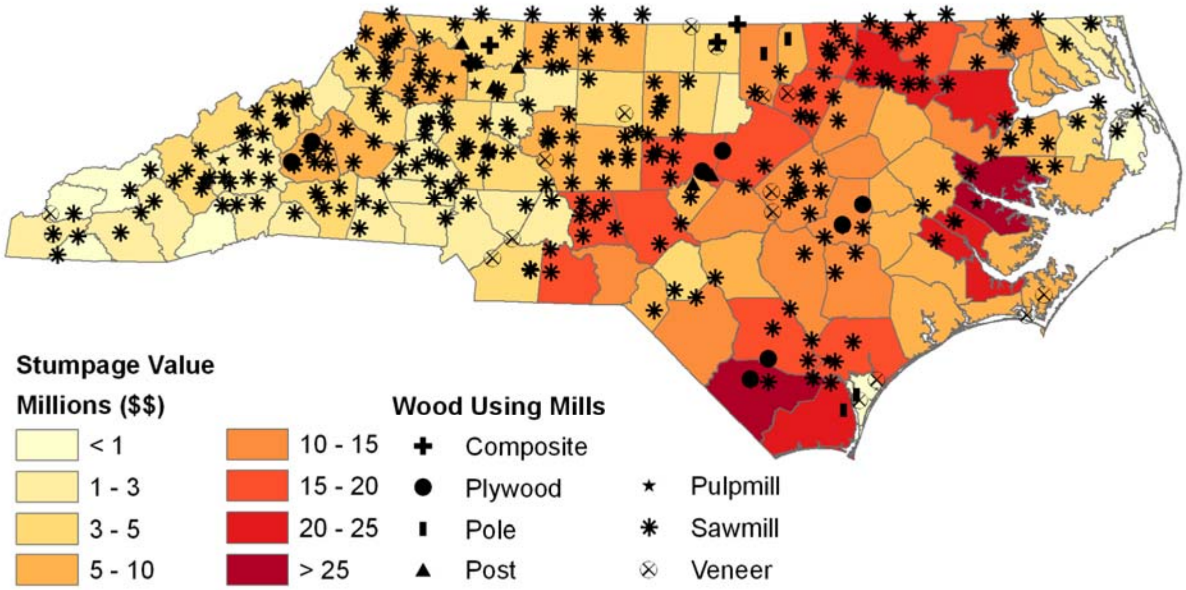
Source: Timber Mart–South, 2009

FIGURE 4c-12. Western NC pulpwood price comparison, pine versus hardwood, 1976 – 2008.



Source: Timber Mart–South

FIGURE 4*c*-13. NC 8-year average of total stumpage value by county and wood-using mills, 2001 – 2008.



Created by: A. Bailey, NCDFR, 2010

Summary

Stumpage prices in North Carolina have generally increased for all products since 1976, with the prices for pine sawtimber and mixed hardwood sawtimber leveling off since around 2000. Pine pulpwood prices began declining around 1993. Eastern North Carolina prices for pine sawtimber, pine pulpwood, and mixed hardwood sawtimber are usually higher than western North Carolina stumpage prices and generally higher than South-wide stumpage prices, except for pine pulpwood. Hardwood pulpwood prices in western North Carolina usually exceed eastern North Carolina hardwood pulpwood prices, but both are usually lower than the South-wide price. The gap between eastern North Carolina pine pulpwood prices and eastern North Carolina hardwood pulpwood prices is fairly consistent at around $7 per cord. In western North Carolina, the gap between pine pulpwood and hardwood pulpwood starts to close around 1993 until around 2002, when hardwood pulpwood prices frequently exceed pine pulpwood prices. Differences in stumpage values between eastern and western North Carolina can be attributed to various factors, including markets, species, urbanization, and infrastructure.

Map Data Sources

FIGURE 4c-13: USDA Forest Service

c. Timber Stumpage Values.

References and Sources Cited:

Timber Mart–South. 2009. Market news. Athens, GA: University of Georgia, Center for Forest Business. Online: http://www.tmart-south.com/tmart/index.html

4.d.

Primary Wood-Using Facilities

Key Findings

- By 2007 the number of primary processor wood-using facilities in North Carolina was less than one-half of the number of facilities in 1990. Despite the large number of mills that have closed, however, total production from roundwood for all products and species has remained relatively flat since 1990.
- Secondary manufacturing was not evaluated for the assessment.
- Exporting opportunities for the forest products industry were not examined for this resource assessment.

Introduction

The wood products industry is a major contributor to North Carolina's manufacturing economy. In 2008 the industry had about 2,562 companies employing 82,780 people, a payroll of $3.1 billion, and shipping products valued at $18.3 billion (Ashcraft, 2009). The majority of these companies are small, employing fewer than 100 people. The industry can be divided into primary and secondary processors. This section focuses on the primary processing facilities, which are surveyed on a biennial cycle by the NC Division of Forest Resources (NCDFR), in cooperation with the Southern Research Station of the USDA Forest Service. The surveys complement the Forest Inventory and Analysis periodic inventory of volume and removals from the state's timberlands. They are conducted to determine the amount and source of wood sales and annual timber product drain, by county, and to determine interstate and cross-regional movement of industrial roundwood.

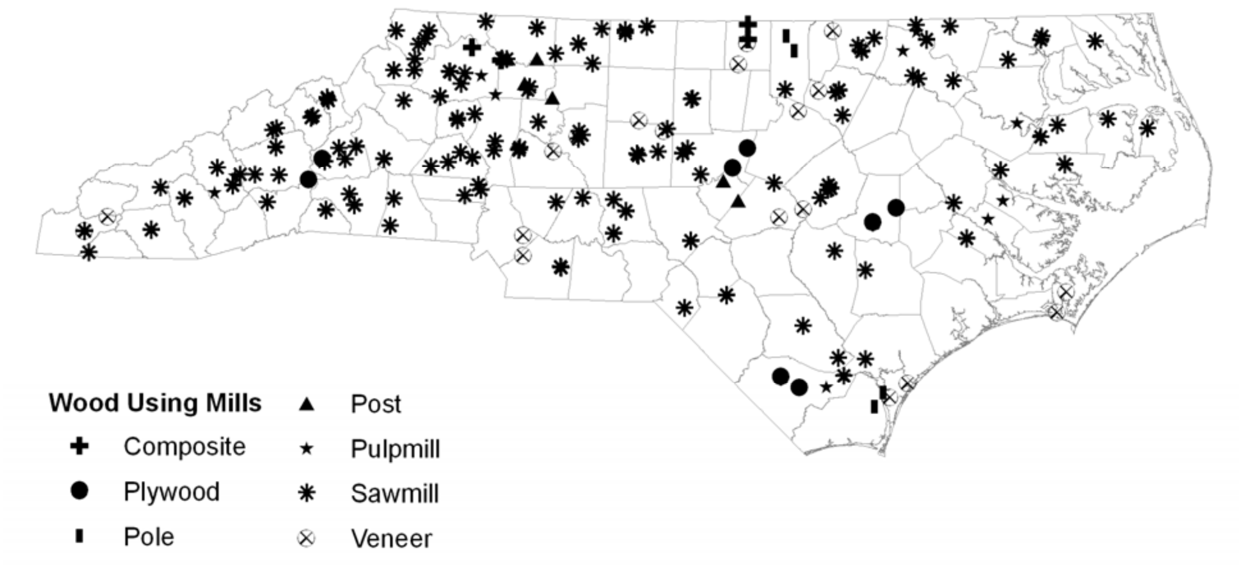
Primary Processing Facilities

Primary processing facilities are those wood processors that process roundwood in log or bolt form or as chipped roundwood. FIGURE 4*d*-1 shows the distribution of mills operating in 2007.

In 1990, North Carolina had a total of 366 primary processors. This included 308 sawmills, 32 veneer mills, eight pulp mills, five composite panel mills, and 13 other industrial mills, such as pole and piling and firewood producers. Since 1990, North Carolina has been steadily losing its primary processing manufacturing facilities, with an average annual decline of 4.7 percent for all mill types. By 2007, North Carolina had only 163 mills, a 55 percent decrease over 17 years. TABLE 4*d*-1 describes the decline in primary wood-using plants by type of mill from 1990 to 2007.

In 2007, North Carolina's primary processors received 714.1 million cubic feet of roundwood. The productive output for all primary processing facilities was 728.4

FIGURE 4*d*-1. NC primary wood-using mills, 2007.



Created by: A. Bailey, NCDFR, 2010

TABLE 4*d*-1.—Primary wood-using facilities in North Carolina by mill type and percent change, 1990 – 2007

Mill Type	1990	1992	1994	1995	1997	1999	2001	2003	2005	2007	Percent (%) Change 1990 to 2007	Annual percent (%) change
Sawmill	308	306	275	273	243	240	215	204	153	136	-78	-4.6
Veneer	32	29	27	27	23	24	20	18	14	14	-86	-5.1
Pulp	8	8	8	8	7	7	7	6	6	6	-35	-2.1
Composite panel	5	4	4	4	3	3	3	3	3	2	-71	-4.2
Other	13	10	8	8	4	4	4	4	4	5	-146	-8.6
All mills	366	357	322	320	280	278	249	235	180	163	-79	-4.7

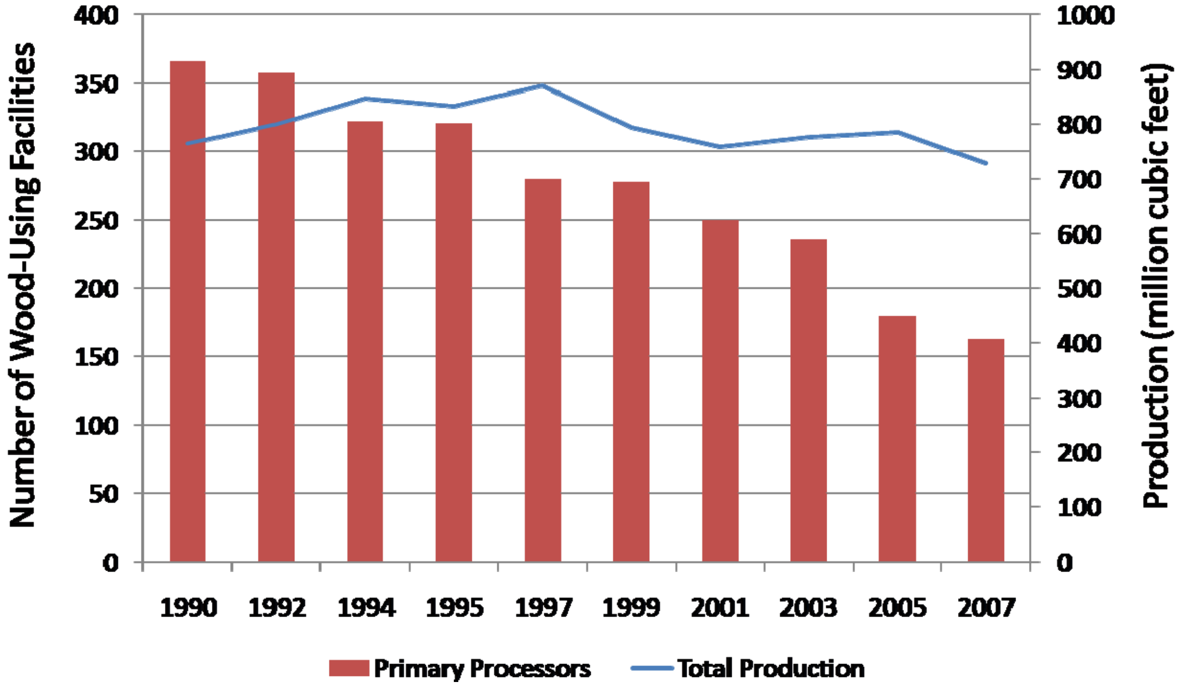
Source: Cooper, and Mann, 2009

million cubic feet, the lowest output since 1990. However, despite the large number of mills that have closed since 1990, total production from roundwood for all products and species has been relatively flat from 1990 to 2007 (FIGURE 4*d*-2). From 1990 to 1997, total production increased at the average annual rate of 1.8 percent; whereas from 1997 to 2007, total production of both hardwood and softwood declined at the average annual rate of 1.3 percent. Both softwood and hardwood production had positive annual growth from 1990 to 1997.

Sawmills

In 2007, North Carolina had 136 sawmills, a net loss of 17 mills since 2005 and only 44 percent of the number of sawmills operating

FIGURE 4*d*-2. Wood-using facilities and total roundwood production by year in North Carolina, 1990 – 2007.



Source: Cooper and Mann, 2009.

in 1990. On an annual basis, North Carolina is losing sawmills at an average rate of 4.6 percent (TABLE 4*d*-1). The piedmont has the most sawmills of any survey unit with 61, followed by the mountains with 40, the northern coastal plain with 19, and the southern coastal plain with 16. Twenty-four sawmills are classified as large, capable of producing more than 20 million board feet of product. Of the 24 large mills, 11 are located in the piedmont, six each in the northern and southern coastal plain, and one in the mountains. About 79 percent of the small and medium sized sawmills are located in either the mountains or the piedmont (TABLE 4*d*-2).

Small to medium mills outnumber the large mills, but the large sawmills produce considerably more output. Of the mills operating in 2007, 24 percent had receipts of less than 1 million board feet and 60 percent had receipts less than 10 million board feet. Fifty-five sawmills (40 percent) had receipts greater than 10 million board feet. However, those 55 sawmills accounted for 90 percent of saw log receipts.

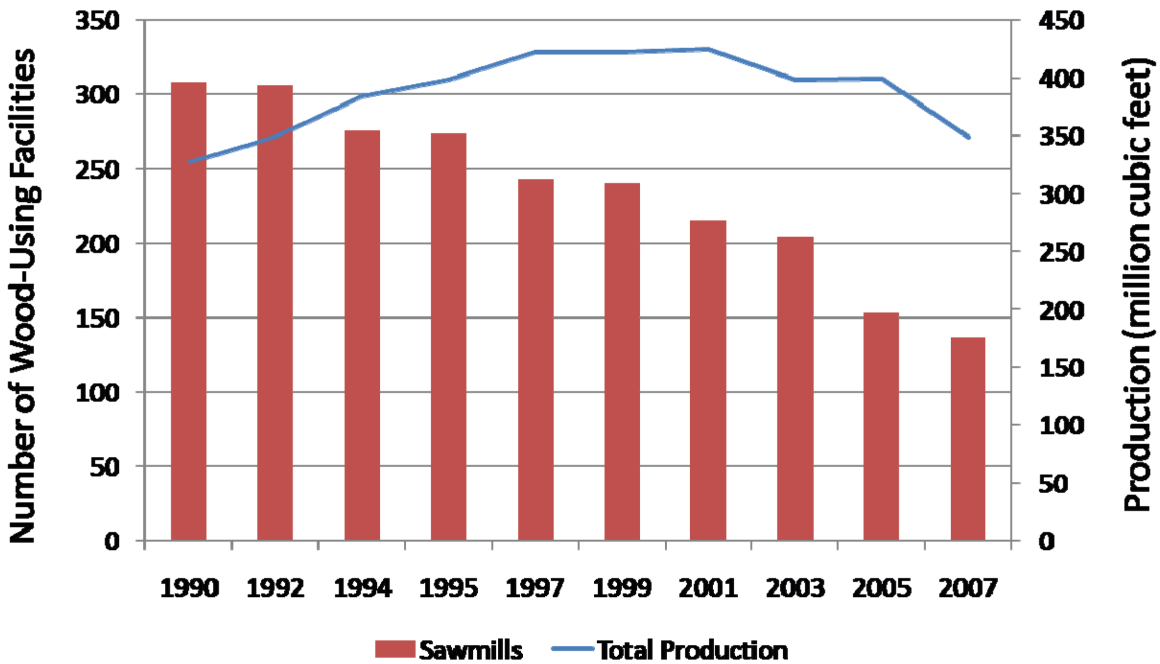
In 2007, total roundwood receipts at the 136 sawmills were 374.4 million cubic feet and accounted for 52 percent of North Carolina's total receipts for primary processors (FIGURE 4*d*-3). Softwood represented 71 percent of total roundwood receipts, while

TABLE 4*d*-2.—Number of sawmills by size and survey unit, 2007

Size of Sawmill	Mountains	Piedmont	Northern Coastal Plain	Southern Coastal Plain	Total
Small (0-5 mmbf)	24	28	6	7	65
Medium (5-20 mmbf)	15	22	7	3	47
Large (>20 mmbf)	1	11	6	6	24
All Plants	40	61	19	16	136

Source: Cooper and Mann, 2009

FIGURE 4*d*-3. Number of North Carolina wood-using facilities and total roundwood sawlog production by year, 1990 –2007.



Source: Cooper and Mann, 2009

hardwood comprised the remainder.

On the output side, saw logs accounted for 48 percent of the state's total roundwood output. In 2007, North Carolina sawmills produced 348.4 million cubic feet of wood products. Softwood output was 244.6 million cubic feet, while hardwood output was 103.7 million cubic feet. From 1990 to 2001, total saw log production increased at an average annual rate of 2.4 percent. However, from 2001 to 2007, total production declined at an average annual rate of 3.4 percent (FIGURE 4*d*-2). On a species basis, softwood output increased from 1990 to 2001 and then began to decline at an average annual rate of 3.4 percent. Hardwood production increased from 1990 to 1999 then began a slow decline of 2.2 percent annually.

In 2007, North Carolina retained 94 percent of its saw log production for in-state manufacturing. Saw log imports, at 46 million cubic feet, exceeded exports by 26 million feet in 2007, making North Carolina a net importer of saw logs.

Pulp Mills

Six pulp mill facilities were operating and receiving roundwood in 2007, two fewer than in 1990. Four of North Carolina’s six pulp mills are located in the coastal plain, three in the northern counties and one in the southern counties. The mountainous western part of the state has two pulp mills. No pulp mills are located in the North Carolina piedmont.

In 2007, total pulpwood receipts for the six mills were 245 million cubic feet, accounting for 34 percent of the total receipts for all primary processors in North Carolina. Softwood accounted for 63 percent, or 155 million cubic feet of receipts. Hardwood accounted for 37 percent, or 90 million cubic feet of receipts.

Total output was 280 million cubic feet, 38 percent of the total output for North Carolina. Softwood accounted for 151 million cubic feet of output, while hardwood accounted for 129 million cubic feet.

The loss of pulp mills has an immediate impact on the total receipts and output of the remaining facilities, unlike North Carolina's sawmill industry, which mitigates the loss of some sawmills by expanding, becoming more efficient, or both. With each loss, as in 1997 and 2003, the overall consumption and production of roundwood pulpwood suffers (FIGURE 4*d*-4).

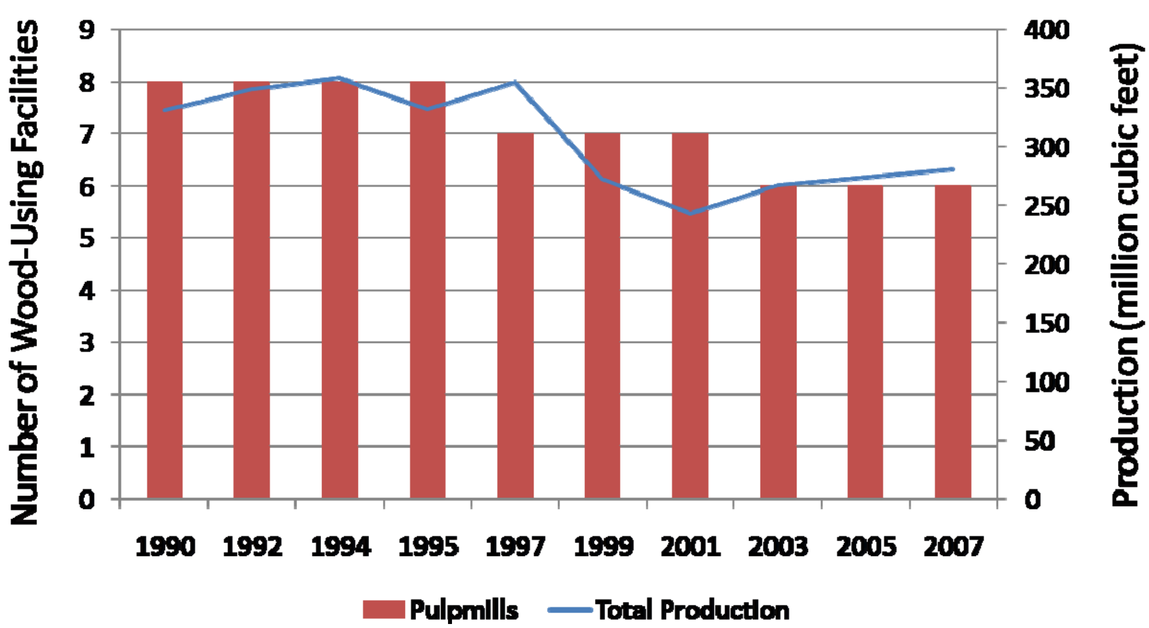
Seventy percent of the roundwood cut for pulpwood was retained for processing by NC pulp mills. Roundwood pulpwood exports amounted to 85 million cubic feet, while imports totaled 50 million cubic feet, making North Carolina a net exporter of roundwood pulpwood.

Composite Panel Mills

In 1990, North Carolina had five composite panel manufacturing facilities. In 2007, only two of these facilities remained. In 2007, the total roundwood receipts for the state's two composite facilities were 39 million cubic feet, or 5.5 percent of the total receipts in North Carolina by primary processors. Softwood accounts for 83 percent of the receipts, while hardwood accounts for 17 percent.

Total mill output in 2007 was 45.7 million cubic feet. From 1990 to 1997, total output remained flat at around 34 million cubic feet. Total output was about equal from both hardwood and softwood production. Beginning around 1994, hardwood production began declining, at the average

FIGURE 4*d*-4. Number of NC wood-using facilities and total roundwood pulpwood production by year, 1990 – 2007.



Source: Cooper and Mann, 2009

annual rate of 8.1 percent. In 1997, softwood production began increasing at an annual rate of 7.9 percent (FIGURE 4*d*-5).

Seventy-three percent of the composite panel production was retained for processing by NC mills. Exports amounted to 12.2 million cubic feet, while imports totaled 5.9 million cubic feet, making North Carolina a net exporter of roundwood used for composite panels.

Veneer and Plywood Mills

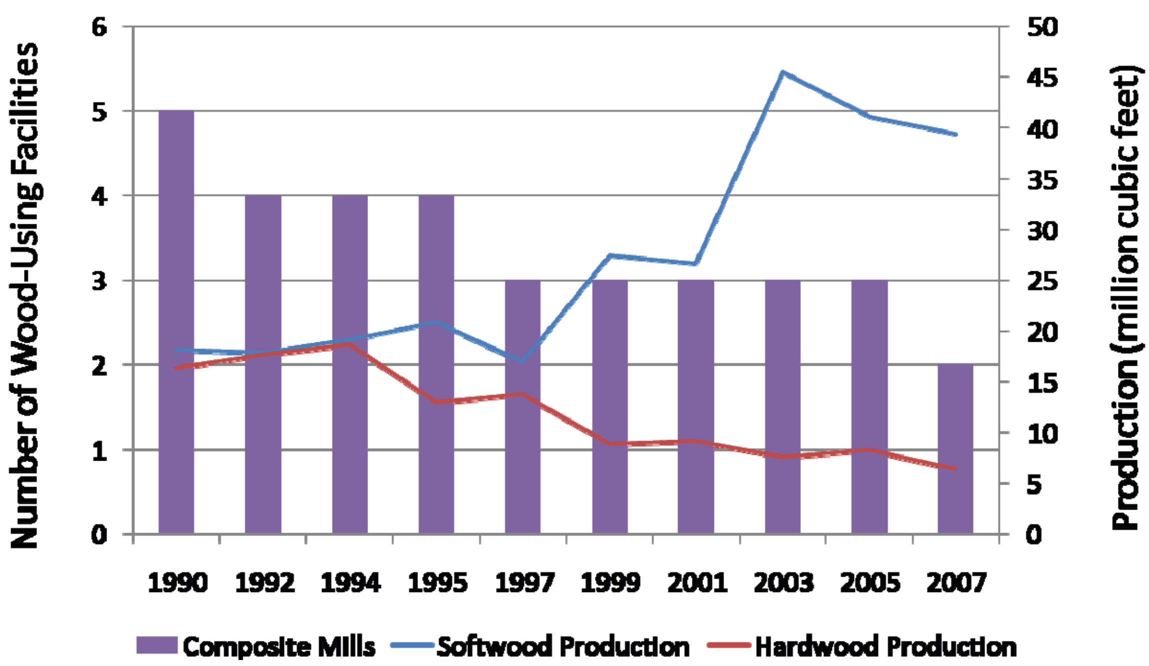
In 1990, more than 30 veneer or plywood mills were operating in North Carolina. By 2007, less than half of them remained in operation. The piedmont, with seven mills, has the most facilities, followed by the southern coastal plain with four facilities, the mountains with two, and the northern coastal plain with one facility (FIGURE 4*d*-6).

Total roundwood receipts in 2007 were 53.8 million cubic feet, or seven percent of the total receipts in North Carolina by primary processors. Softwood accounts for 60 percent of the receipts and hardwood 40 percent.

Total mill output in 2007 was 50.4 million cubic feet. Total output declined at an average annual rate of 1.5 percent from 1990 to 2007 (FIGURE 4*d*-6). Overall, hardwood production has declined the most, at an average annual rate of 2.8 percent from 1990 to 2007. Softwood production also declined, but at a slower rate of 0.9 percent annually.

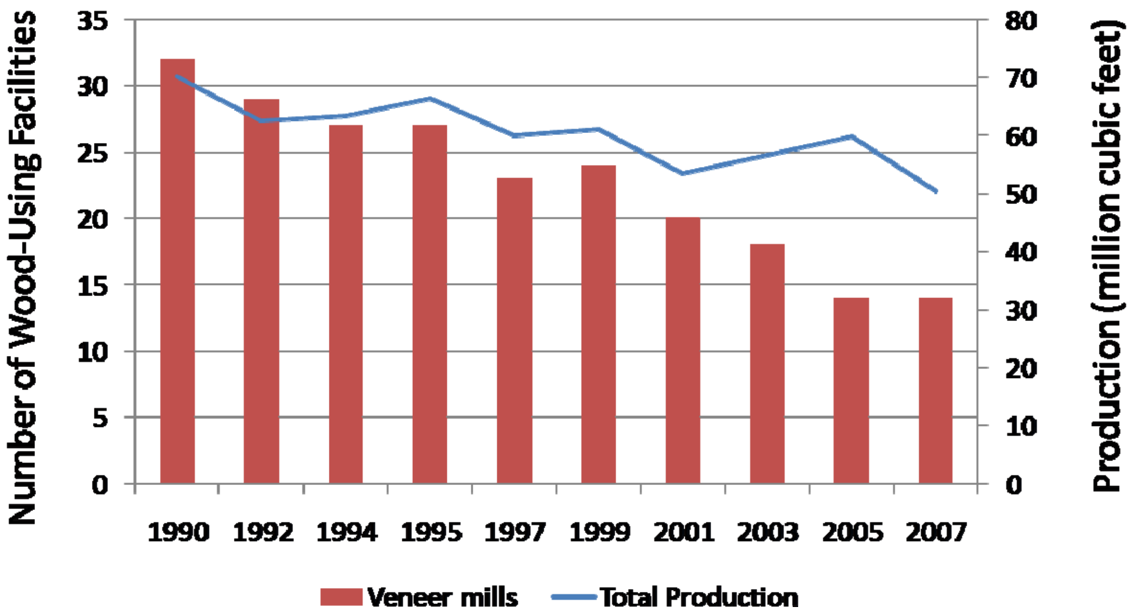
North Carolina retained 85 percent of its veneer log production for processing at veneer mills within the state. Imports amounted to 10.7 million cubic feet, while exports totaled 7.3 million cubic feet, making North Carolina a net importer of roundwood veneer logs.

FIGURE 4*d*-5. Number of NC wood-using facilities and total roundwood composite panel productions by species and year, 1990 – 2007.



Source: Cooper and Mann, 2009

FIGURE 4*d*-6: Number of NC wood-using facilities and total roundwood veneer log production by year, 1990 – 2007.



Source: Cooper and Mann, 2009

Other Mills

Roundwood harvested for other industrial uses (poles, posts, mulch, firewood, logs for log homes, and all other industrial products) were processed by five primary processing facilities. Four facilities are located in the North Carolina piedmont with one located in the southern coastal plain. Total receipts at these five facilities were 1.3 million cubic feet in 2007, less than one-quarter of 1 percent of the total roundwood receipts for North Carolina.

Roundwood output was 3.4 million cubic feet. Softwood accounted for 70 percent of the output, and hardwood accounted for 30 percent. North Carolina was a net exporter of roundwood used for other industrial products.

Summary

The number of total roundwood production facilities in North Carolina has declined steadily since 1990, although total roundwood production has remained flat. The state is a net exporter of roundwood for pulp, panels, and other industrial uses, while it is a net importer of veneer and sawlogs. It is unclear what impact an increased demand for pulpwood by bioenergy companies will have on North Carolina’s primary processing facilities.

Map Data Sources

FIGURE 4d-1: USDA Forest Service

References and Sources Cited

Ashcraft, D. 2009. Personal communication. Raleigh: NC State University, College of Natural Resources, Office of the Executive Director of Development and College Relations.

Cooper, J. A. and Mann, M. C. 2009. North Carolina's timber industry—An assessment of timber product output and use. *2007. Resour. Bull.* SRS-156. Asheville, NC: USDA Forest Service, Southern Research Station.

Glossary

composite panels. Roundwood products manufactured into chips, wafers, strands, flakes, shavings, or sawdust and then reconstituted into a variety of panel and engineered lumber products.

consumption. The quantity of a commodity, such as pulpwood, utilized by a particular mill or group of mills.

primary processor. *See* **primary wood-using plant**.

primary wood-using plants. Industries receiving roundwood or chips from roundwood for the manufacture of products, such as veneer, pulp, and lumber.

production. The total volume of known roundwood harvested from land within a State, regardless of where it is consumed. Production is the sum of timber harvested and used within a State, and all roundwood exported to other States.

pulpwood. A roundwood product that will be reduced to individual wood fibers by chemical or mechanical means. The fibers are used to make a broad generic group of pulp products that includes paper products, as well as fiberboard, insulating board, and paperboard.

receipts. The quantity or volume of industrial roundwood received at a mill or by a group of mills in a State, regardless of the geographic source. Volume of roundwood receipts is equal to the volume of roundwood retained in a State plus roundwood imported from other States.

roundwood (roundwood logs). Logs, bolts, or other round sections cut from trees for industrial or consumer uses.

roundwood products. Any primary product, such as lumber, poles, pilings, pulp, or fuelwood, produced from roundwood.

timber products. Roundwood products and byproducts.

timber products output. The total volume of roundwood products from all sources plus the volumes of byproducts recovered from mill residues (equals roundwood product drain).

veneer log. A roundwood product either rotary cut, sliced, stamped, or sawn into a variety of veneer products, such as plywood, finished panels, veneer sheets, or sheathing.

4.e.

Non-timber Forest Products

Key Findings

- Assessing the financial impact and benefits of managing forestland for non-timber products is difficult, due largely to the diversity in products and the markets that may or may not exist.
- Non-timber forest products are becoming an emerging forest market segment as landowners recognize the potential financial gain these products can offer.
- In North Carolina, pine straw is the most widely known commercially valuable non-timber forest product.
- Additional investigation is warranted on the financial viability and environmental sustainability of managing forests for non-timber products.

Introduction

Many commercial plant-based non-timber products come from North Carolina forests. These non-timber forest products (NTFPs) can be aggregated into four general categories: edible and culinary, specialty woody products, floral and decorative, and medicinal and dietary supplements, each described below. With a few exceptions, mainly pine straw and some medicinal plants, markets for NTFPs may not be readily known or accessible, requiring the initiative of the forest landowner to seek them out. Innovative and motivated forestland owners in North Carolina can improve their forest-based revenue by researching, managing, harvesting, and marketing these products. Recent interest in some of these non-timber products, particularly plants grown for medicinal and dietary supplements, is raising new concerns about overharvesting and the sustainability of managing for non-timber products in some areas of the state.

Edible and Culinary

Mushrooms, berries, nuts, sap and resins, ferns, wild tubers, and bulbs are among the edible forest products with viable markets in North Carolina. The ramp, or leek, is probably the most recognizable member of this category as it is widely gathered and sold in local markets in the mountains. Recently, interest in wild mushroom gathering and cultivation has grown dramatically, particularly in the mountains. Many restaurants across the state feature locally gathered wild and cultivated mushrooms, and a state growers' association has emerged promoting their use and cultivation.

Specialty Woody Products

These products are created from woody vines, saplings, or parts of trees other than sawn wood, such as burls, branches, cypress knees, and bark. Handicrafts, carvings, utensils, containers, musical instruments, and furniture made from unsawn tree parts and vines are included in this category. Poplar bark has also made a comeback as natural decorative siding material for residential and commercial buildings.

Floral and Decorative Products

Many plant species are used in landscaping and floral arrangements, including pine straw, fresh and dried flowers, aromatic oils, greenery, basket filler, wreaths, roping, and mosses. Pine straw mulch, a product of longleaf pine (*Pinus palustris)* forests centered in the Sandhills region of eastern North Carolina, may be the most economically important NTFP in the state. Galax (*Galax urceolata*) and woods moss are important in the North Carolina mountains, while Spanish moss (*Tillandsia usneoides*) is gathered in the coastal plain.

Medicinal and Dietary Supplements

These products are concentrated in the mountains and represent a highly valued category of NTFPs in North Carolina. A recent surge of interest in organic remedies and diet supplements has spawned renewed interest in collection, research, and improved cultivation methods. The NC Cooperative Extension Service has a research branch dedicated to medicinal herbs and non-timber forest products located in the Mountain Horticulture Crops Research and Extension Center in Fletcher, North Carolina. Dr. Jeanine Davis heads the effort and works with other researchers and practitioners through the NC Consortium on Natural Medicines: www.naturalmedicinesofnc.org/. Among the more than 50 products in this category, three plant species gathered in our North Carolina forests lead in importance: ginseng (*Panax quniquefolium*), black cohosh (*Actaea racemosa)*, and bloodroot (*Sanguinaria canadenseis)*.

Economic Value

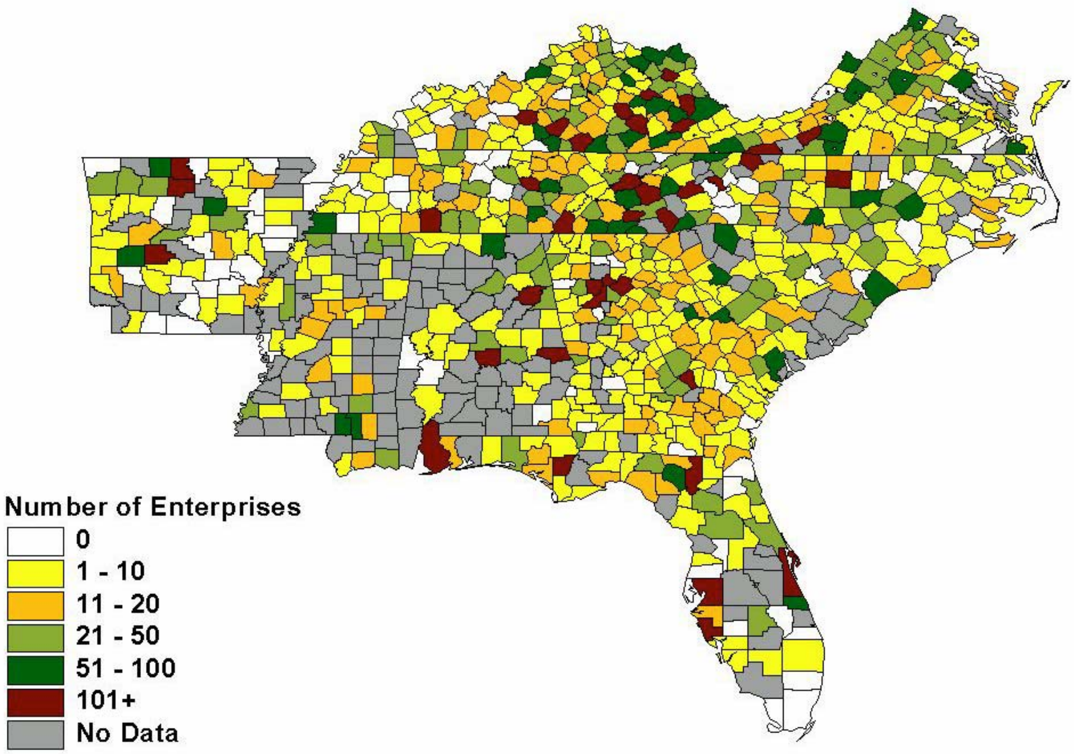
It is difficult to assess the annual impacts or economic value for most of the NTFPs because of the generally small, niche-type operations and localized markets developed around the growing, collecting, and harvesting of the forest resources that make up these products. The NC Pine Needle Producers Association is an exception and works openly to improve the economics, sustainability, and quality of pine straw harvesting and production. NTFPs have contributed and will continue to contribute to forestland owners' income across the state.

A survey of Cooperative Extension agents throughout the Southeast asked agents to estimate the number of NTFP enterprises in their operating areas (Chamberlain and Predny, 2003). These enterprises could be individuals, family farms, small businesses, or formal corporations that were using or marketing flora- or fungi-based products gathered from forests. FIGURE 4*e*-1 shows the results of this survey for North Carolina. Predictably, the survey revealed a strong concentration of these enterprises in the southern Appalachian hardwood forests of western North Carolina and eastern Tennessee, as well as a concentration in the NC Sandhills.

Estimates of the economic impact of NTFPs in North Carolina indicate that longleaf pine straw raking generates more than $25 million annually for landowners and is the highest revenue producing NTFP (Blevins et al., 1996).

Ginseng is probably the next most economically important NTFP in North Carolina. Ginseng is collected in the mountains. No formal economic data is reported or collected on ginseng in North Carolina. One estimate, based on 2001 prices, suggests that the average wholesale

FIGURE 4*e*-1: Perceived distribution of non-timber forest products enterprises in the Southeast, 2003.



Source: Chamberlain and Predny, 2003.

value of forest-collected ginseng in a four-state area, including North Carolina, exceeds \$18.5 million (Chamberlain and Predny, 2003). The market value of ginseng in the same year was estimated at \$12.1 million for North Carolina (Greenfield and Davis, 2003). Wild ginseng roots are much more valuable than forest or field-cultivated roots. Annual pricing for wild ginseng is quite volatile and can range from \$175 to \$1,000 per dried pound, depending on the demand from the Far East, where the root is prized for its perceived medicinal values. Experts expect the value to escalate as supplies of wild ginseng decline.

Other estimates of important NTFPs to North Carolina based on 2001 pricing (Chamberlain and Predny 2003) include galax (\$10 million in North Carolina), black cohosh (\$2.25 million in the Southeast with no state estimate for North Carolina), and bloodroot (\$1.9 million in the Southeast with no estimate for North Carolina).

Management and Sustainability of NTFPs

With the current lack of reliable harvest and collection documentation and research efforts for most NTFPs, it is difficult to address sustainability issues. However, some natural resource professionals are raising concerns about the overharvesting of some medicinal plants and the impacts harvesting may have on the associated plant communities.

Concerns about the impacts of pine straw raking on forest productivity were the focus of much research in the 1990s. Generally, research showed that a single raking was not likely to affect productivity, but repeated raking could result in significant nutrient losses, thus producing less wood and pine straw (Blevins et al., 1996). Commercial fertilizer application is recommended to replenish nutrients to pine stands actively managed for pine straw production.. Although this will physically and economically replace the nutrient removals, other impacts on the ecosystem may remain. These include impacts on soil moisture, temperature, and microbial populations, as well as a potential decrease in vegetative species diversity. An association of pine straw suppliers has been formed to promote sustainable harvesting practices and production of high quality pine straw: http://www.ncpineneedleproducers.com/

Due to sustainability concerns for some NTFPs on National Forests in western North Carolina, the USDA Forest Service has recently focused on enforcing plant collection and gathering laws through a permitting process and increased federal law enforcement patrolling. Of particular interest on federal lands is the gathering of ginseng, galax, and ramps. The Great Smoky Mountains National Park has banned the harvesting of ramps and focused on poaching of medicinal plants within the park. The federal government has even used high-tech identification devices in ginseng roots to collar illegal gathering of this plant, with some success.

At this time we find little evidence, with the exception of pine straw, that management of NFTPs is incorporated in forest management plans, or that NFTPs are negatively affecting traditional forest product management activities.

Summary

With the exception of pine straw, assessing the status of NFTPs in North Carolina is difficult, given the unresearched nature of cultivation, collecting and harvesting, and marketing most of these products. There is evidence, however, that pine straw and medicinal plants are having a positive economic impact in their respective regions. Forestland owners could potentially supplement their forest-based incomes with NFTP revenue new initiatives, proper planning, technical management assistance, and market development.. As interest in many of these products increases, the economic impact on North Carolina will increase as well. We expect that more attention will then be given to researching, managing, and tracking NFTPs, both ecologically and economically, across the state.

Map Data Sources

FIGURE 4e-1: Chamberlain and Prednv 2003

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4.f.

Water Quality and Quantity

Key Findings

- North Carolina's surface water supply watersheds are 60 percent forested, while the state's groundwater wellhead protection areas are 36 percent forested. Forests and forest management practices play a vital role in sustaining clean, abundant, and affordable supplies of drinking water in North Carolina.
- Approximately two-thirds of the subwatersheds in North Carolina have less than 70 percent forest or natural land cover. Evidence has indicated that when a watershed's land cover falls below this threshold percentage, a significant drop can be expected in the overall quality of the water delivered from that watershed.
- Based upon the relatively rapid expansion of urbanizing areas, an emerging opportunity exists to re-evaluate and transform the role that forest management can serve in those subwatersheds that are located across urban, suburban, and rural transition areas.

Introduction

Forests are among the most efficient land uses for enhancing the quality of our water, protecting the sources of our water, and providing vital ecosystem services related to water resources. Examples of these ecosystem services include the following:

- Absorbing rainfall and snow melt, which helps to recharge groundwater;
- Minimizing flooding by dissipating the energy of storm flows;
- Slowing surface runoff, which reduces soil erosion;
- Buffering and filtering pollutants from surface waters; and
- Providing aquatic habitat that supports biodiversity and recreation.

Approximately 53 percent of our nation's freshwater supply originates on forestland with more than 180 million people in the United States receiving drinking water from these ecosystems (Brown et al., 2008; USDA–USFS, 2007). In a study conducted in 2002 by the Trust for Public Land and the American Water Works Association, researchers found that for every 10 percent increase in forest cover in a water supply source area, treatment and chemical costs decreased approximately 20 percent, up to about 60 percent forest cover (TPL and AWWA, 2002). In North Carolina, the state's surface water supply watersheds are 60 percent forested, while the groundwater wellhead protection areas are 36 percent forested (Homer et al., 2004; NCDEH, 2009; NCDWQ, 2009a). Therefore, forests and forestry practices are vital for the long-term sustainability of clean and affordable municipal drinking water in the state.

North Carolina's Waters

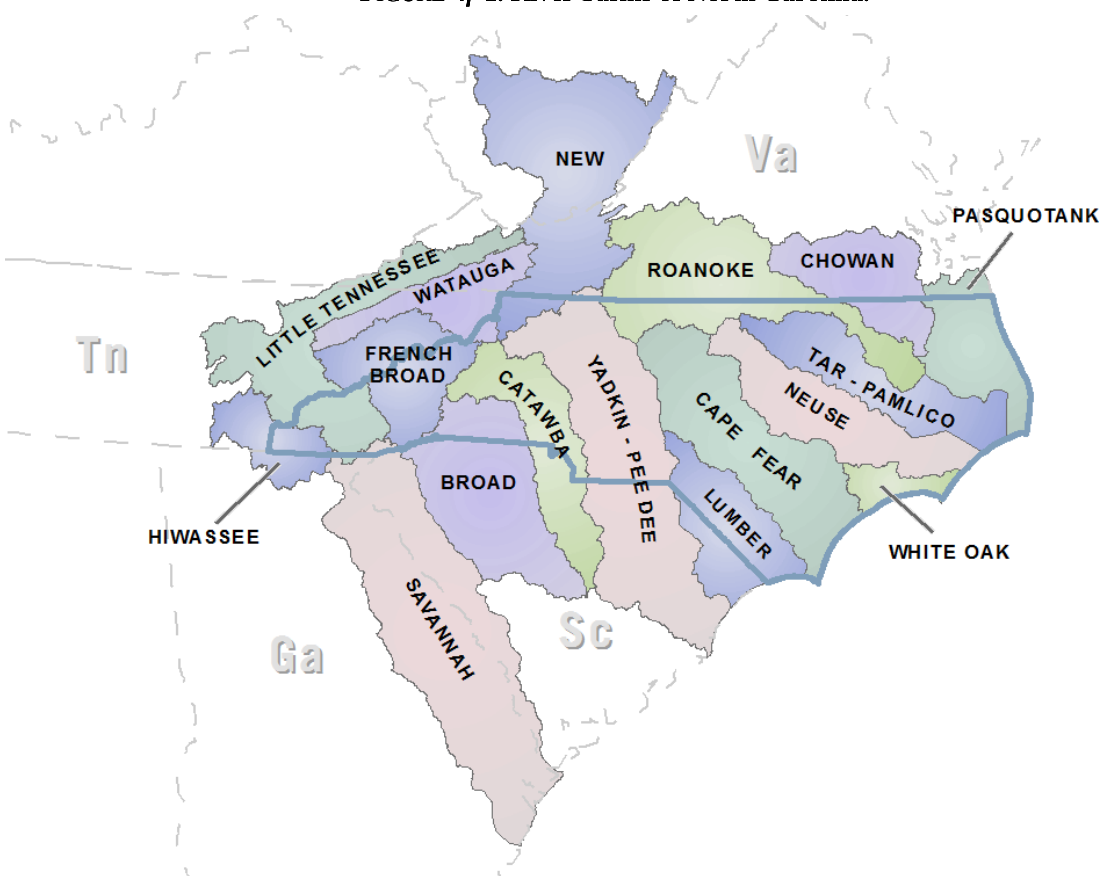
Because of North Carolina's rapid population growth over the past decade, water resources are critically important for supporting socioeconomic development as well as biodiversity, recreation, and other uses. Within the state's boundary, there are

17 major river basins with approximately 39,633 miles of river and stream; 235,843 acres of lake and reservoir; 2,123,121 acres of estuary; and eight principal aquifers. (NCDWQ, 2009b; NCDWR, 2009) (FIGURE 4*f*-1).

Across the state, North Carolina annually receives an average of 48 inches of precipitation (FIGURE 4*f* -2), with surface waters draining, on average, approximately 18 inches (FIGURE 4*f*-3).

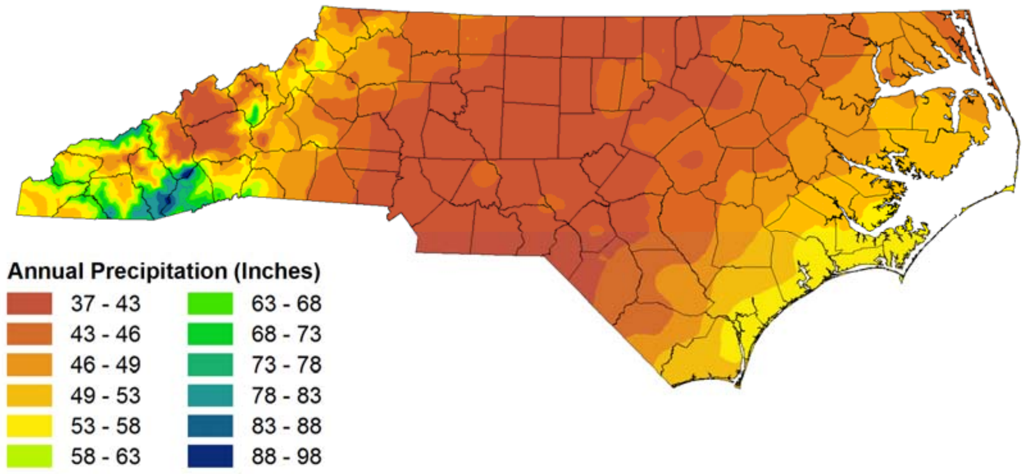
While North Carolina is fortunate historically to have abundant surface and subsurface water resources, significant population increases and land-use conversions coupled with droughts have led to decreasing water quality and quantity in some areas. One of the primary stressors on water quality and quantity is the conversion of forestland (and other land uses) to urban land (NRC, 2008). Significant amounts of forestland are being converted on an annual basis as population growth leads to increasing urbanization.

FIGURE 4*f*-1. River basins of North Carolina.



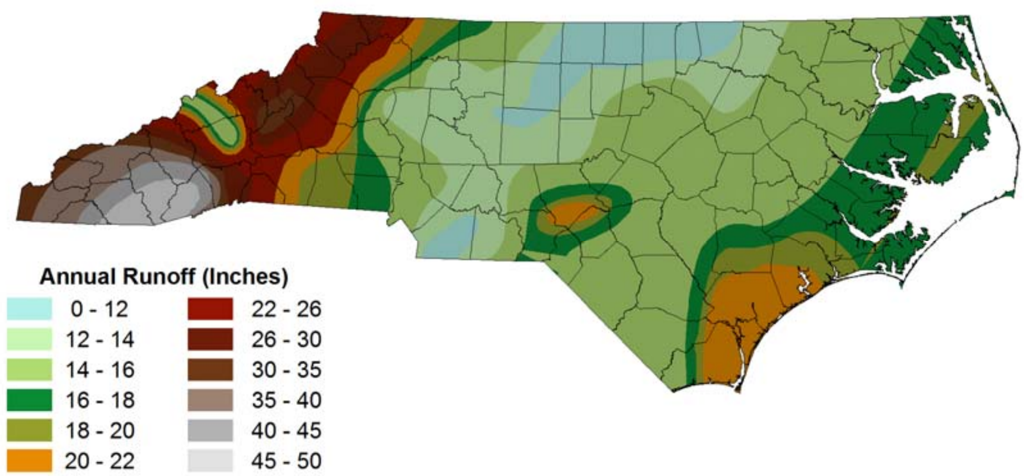
Source: NC Wildlife Resources Commission, 1999

FIGURE 4*f*-2. North Carolina annual precipitation.



Created by: D. Jones, NCDFR, 2010

FIGURE 4*f*-3. North Carolina annual runoff.



Created by: D. Jones, NCDFR, 2010

Water Quality

Qualitative Indicators of Water Quality

The U.S. Environmental Protection Agency describes "impaired waters" as those not clean enough to meet the standards of their best intended use (such as swimming, aquatic life support, and water supply). Of the 23 percent of the state's waters assessed in the *North Carolina Integrated Report Categories 4 and 5 Impaired Waters List 2010311* prepared by the NC Division of Water Quality (NCDWQ, 2008), approximately 24 percent of assessed freshwater stream miles, 31 percent of assessed lake acres, 29 percent of assessed bay and estuarine acres were *not* supporting their designated uses. Although the approximate cumulative percentages of impaired waters in North Carolina are lower than the national average, these values may not reflect the extent of water quality impairments due to the limited scale of the assessment.

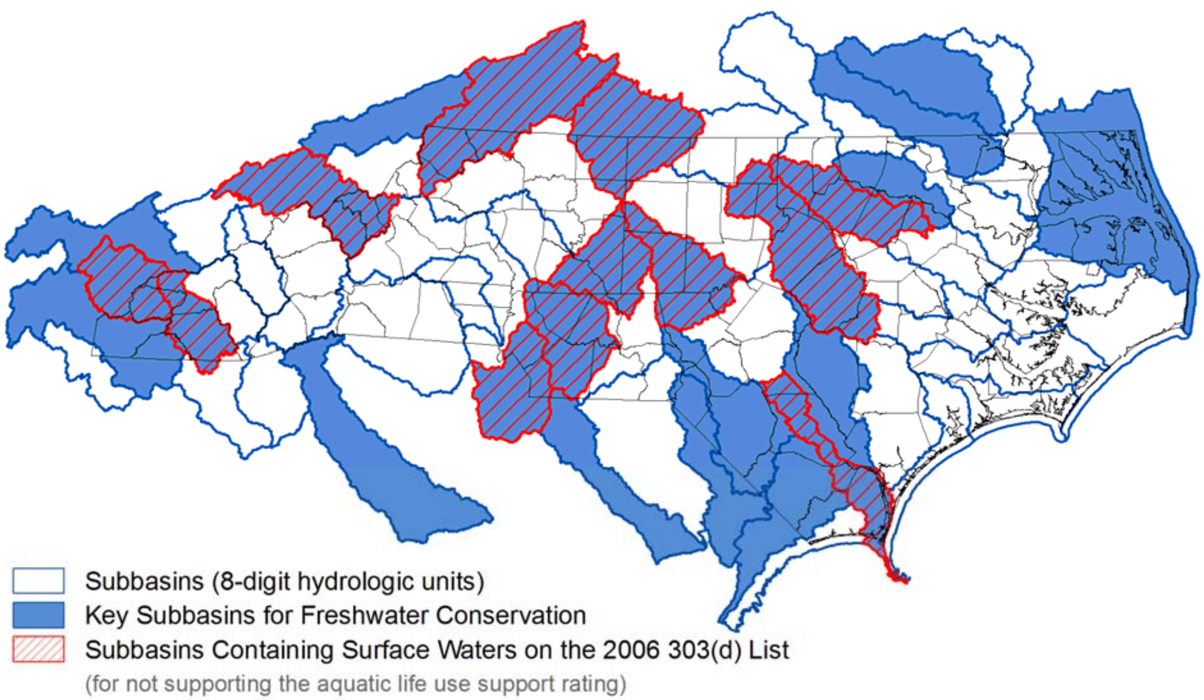
In addition, as discussed in the *NC Wildlife Action Plan*, The Nature Conservancy (TNC) identified 25 subbasins (8-digit hydrologic units) as aquatic conservation priorities for the protection of freshwater biodiversity in North Carolina (Master et al., 1998). Twelve of the 25 subbasins identified in the TNC assessment contain surface waters that are listed on the 2006 303(d) list for not meeting the aquatic life use support rating (FIGURE 4*f* -4).

Quantitative Indicators of Water Quality

At least two general indicators of watershed water quality are directly related to land use and land cover (LULC): (1) percent of forest and natural cover within a watershed and (2) percent of impervious cover (surface) within a watershed. Studies have demonstrated that watershed water quality conditions commonly begin to deteriorate when the forest and/or natural cover percentage drops below 70 percent (Black and Munn, 2004; NCDWQ, 2009c). In 1992, nearly 47 percent (829 out of 1,775) of the subwatersheds (12-digit hydrologic units) within the state were less than 70 percent forest and/or natural cover (Vogelmann et al., 2001: USDA–NRCS et al., 2008). From 1992 to 2001, due largely to the conversion and loss of forestland, an additional 361 subwatersheds dropped below the 70 percent threshold (Homer et al., 2004; USDA–NRCS et al., 2008), resulting in two-thirds of all subwatersheds in the state having less than 70 percent forest and/or natural cover.

Other studies have identified impervious cover as a key indicator of water quality.

FIGURE 4*f*-4. Key subbasins for freshwater conservation: Subbasins impaired for aquatic life use support.



Created by: D. Jones, NCDFR, 2010

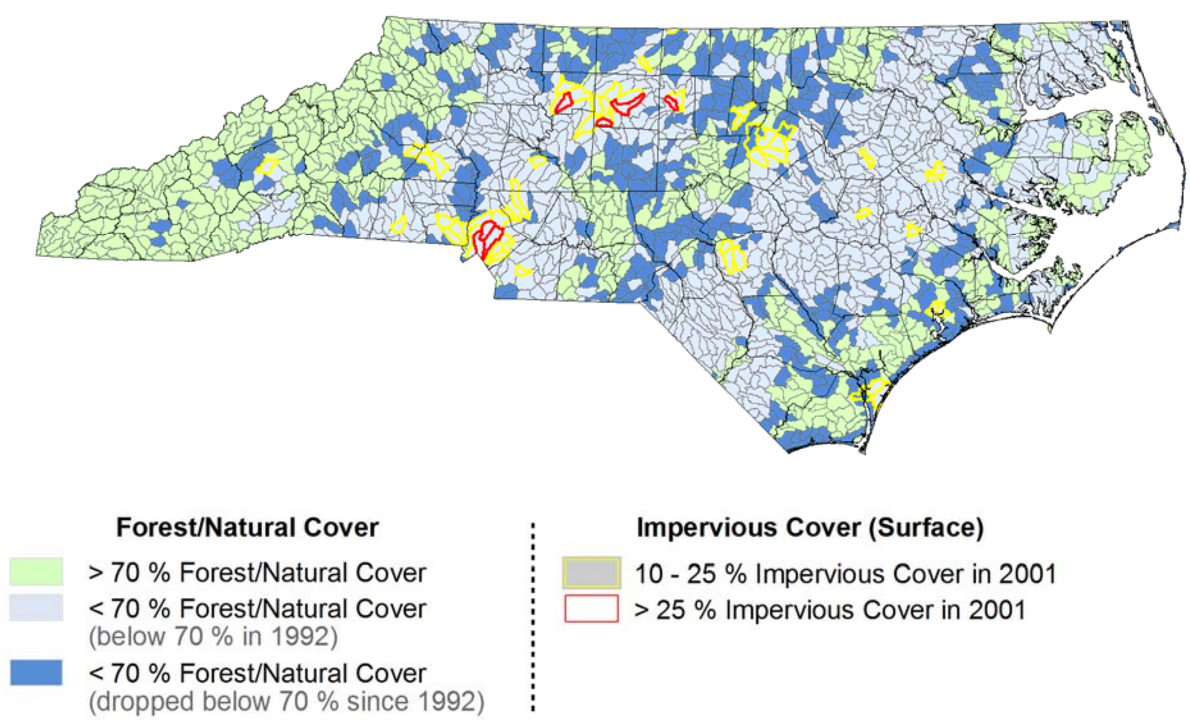
The Center for Watershed Protection (CWP) summarized the findings of several studies on water quality and watershed impervious cover (Schueler,1994), and integrated the findings into a general watershed planning model, known as the impervious cover model (ICM). The ICM predicts that most stream quality indicators decline when watershed impervious cover (IC) exceeds 10 percent, with severe degradation expected beyond 25 percent IC (CWP, 2003). According to the 2001 National Land Cover Database (NLCD) Impervious Cover Dataset (Homer et al., 2004), 63 subwatersheds within the state are more than 10 percent impervious. By 2030, this number is expected to double (Exum et al., 2005). The trend in the loss of forest and/or natural cover when compared with impervious cover in subwatersheds of North Carolina is illustrated in FIGURE 4*f*-5.

Water Quantity and Supply

Water supply shortages are becoming more prevalent in the Southeast as the growing population places more demand on the resource. In addition to a rapidly increasing population, several studies predict that the South will experience increases in air temperature and variability in precipitation associated with global warming in the 21st century (Kittel et al., 1997; Karl et al., 2009). These conditions make it difficult to predict the fate of water supply conditions in the Southeast.

North Carolina is beginning to experience water supply shortages despite a relatively high average rainfall, significant surface water reservoirs, and productive regional aquifers in the coastal plain. The "headwaters of Piedmont river basins, where

FIGURE 4*f*-5. Forest and/or natural cover trends in relation to impervious cover.



Created by: D. Jones, NCDFR, 2010

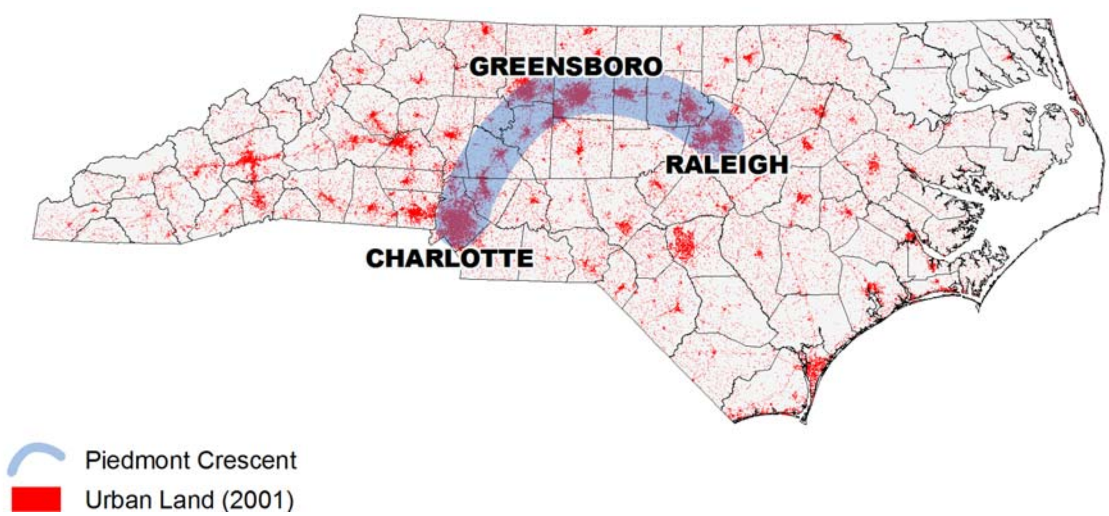
stream flows are greatly reduced during dry weather; the Cretaceous aquifers of the Coastal Plain, which have relatively slow recharge rates; and areas along the coast and on the Outer Banks, where the natural availability of freshwater is limited" (NCDWR, 2001) are customarily the areas that encounter water supply shortages. However, frequent localized seasonal droughts in the last 20 years, as well as record-setting statewide droughts in 2002 and 2007, have exacerbated water shortages and expanded water supply concerns to areas that typically have had ample water quantities.

The NC Rural Economic Development Center (NCREDC) reports in their Water 2030 Initiative that although water demand over the next 25 years is expected to remain relatively constant for many industries, consumption by the state's growing population is expected to increase approximately 37 percent, from 244.5 billion gallons annually to 335 billion gallons in 2030, if consumption continues at its current rate (NCREDC, 2006).

Future water supply is of particular concern in many parts of North Carolina's "Piedmont Crescent" (roughly the I-40 and I-85 corridors, FIGURE 4*f* -6). In areas of the piedmont, natural geologic formations prevent access to underlying groundwater supplies. Also, headwater streams that supply surface drinking water in this region are commonly shallow; subject to precipitation-driven fluctuations; and due to their proximity to urban areas, are more susceptible to pollution, such as urban runoff.

Water supply in eastern North Carolina along the coastal plain relies heavily on groundwater aquifers. Expanding development in this region may lead to water supply shortages if aquifers are depleted beyond their recharge rates. In addition, drawdown of these aquifers (without recharge) could lead to saltwater intrusion and a reduction in the availability of potable ground water supplies (NCREDC, 2006).

FIGURE 4*f*-6. Piedmont Crescent.



Created by: D. Jones, NCDFR, 2010

In the mountainous western region of North Carolina, a mix of surface reservoirs and shallow groundwater sources supplies water. Although water quantity in the mountains has customarily been sufficient to meet municipal needs, rapidly growing population centers could begin to see shortages as water supply planning and infrastructure improvements struggle to keep pace with the increasing establishment of retirement and vacation homes.

In an effort to identify the areas of greatest need for additional water supply planning in the state, NCREDC made forecasts of water demand growth from 2005 to 2030. These estimates, currently being updated by the NCREDC, are illustrated in FIGURE 4*f* -7.

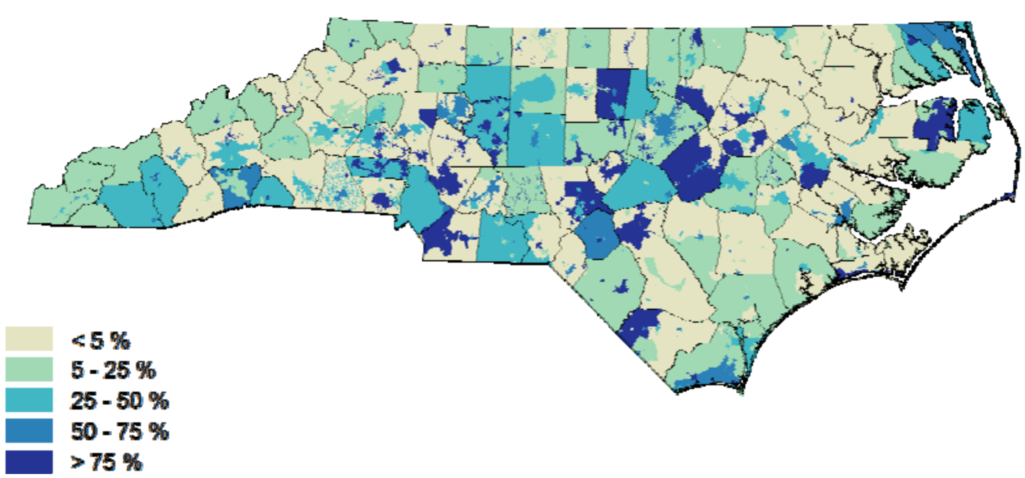
Priority Forest Watershed Assessment

Priority forest watersheds in North Carolina are those in which "continued forest conservation and management is important to the future supply of clean municipal drinking water, or where restoration or protection activities will improve or restore a critical water source" (USDA–USFS and NASF, 2008). The spatial analysis conducted to develop this priority assessment used five existing datasets (data layers) that are listed below, ranked in order of their weighting:

1. NC Conservation Planning Tool – Water Services Assessment
2. NCREDC – Forecasted Water Demand Growth
3. Southern Forest Lands Assessment (SFLA) – forestland layer
4. NC Source Water Assessment and Protection Areas
5. Southern Forest Lands Assessment (SFLA) – development layer

The maps in FIGURE 4*f* -8a and 4*f*-8b illustrate the priority forest watersheds with the darker shading representing the higher priority watersheds.

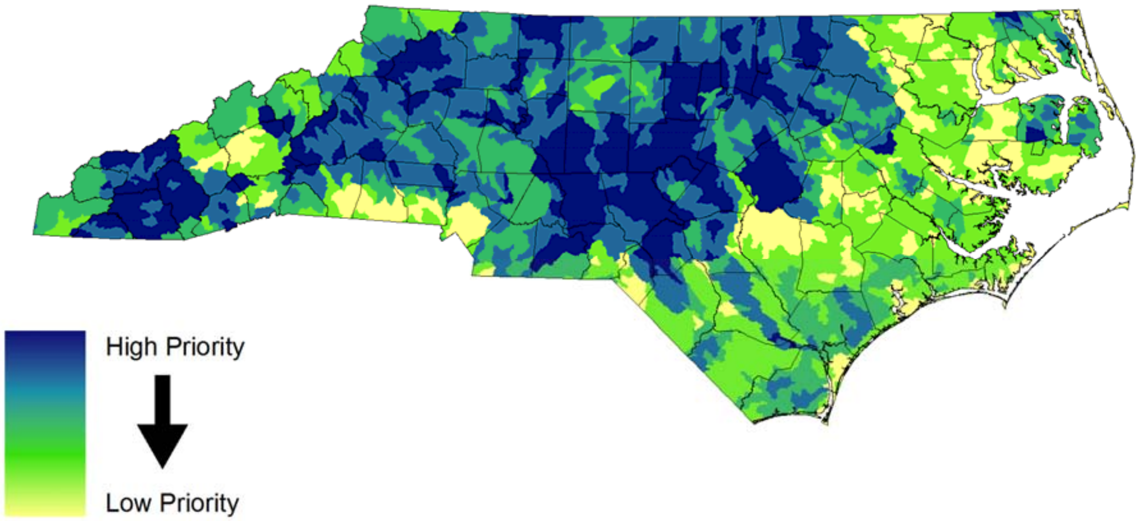
FIGURE 4*f*-7. Forecast of water demand growth 2005 – 2030 (all sectors included).



Created by: D. Jones, NCDFR, 2010

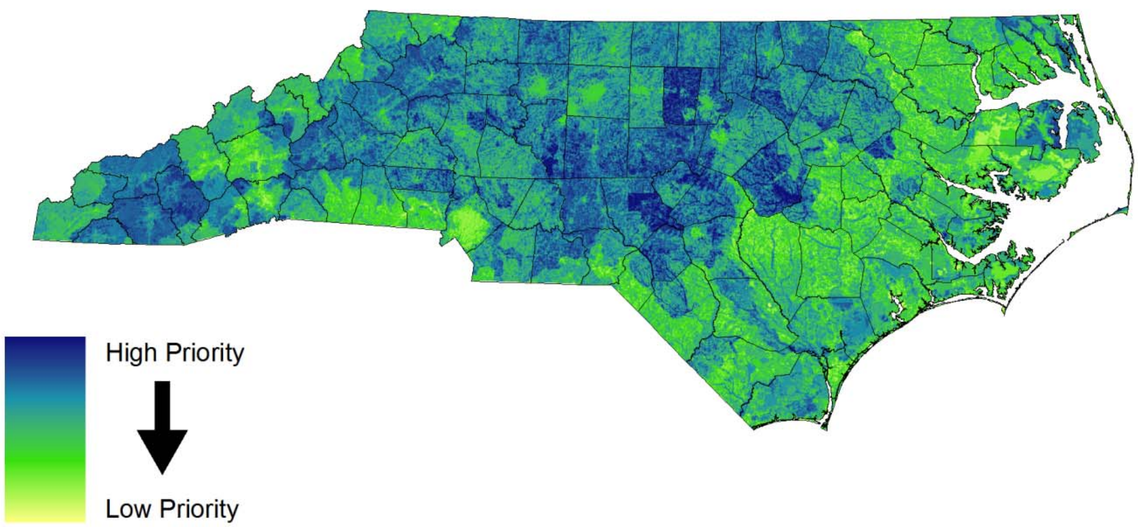
f. Water Quality and Quantity

FIGURE 4*f* -8a. Priority forest watersheds in North Carolina for water quality and quantity illustrating a subwatershed relative value.



Created by: D. Jones, NCDFR, 2010

FIGURE 4*f*-8b. Priority forest watersheds in North Carolina for water quality and quantity illustrating a 30-meter pixel display.



Created by: D. Jones, NCDFR, 2010

Summary

Based upon the priority forest watersheds, there are numerous areas in North Carolina where forestland and associated forestry practices can support the continued delivery of high quality sources of water supply. In particular, areas that support the water supplies of major population centers in the state could benefit from a focused emphasis on achieving a high level (70 percent or higher) of forest and/or natural cover. Watershed-specific scenarios of how forests could support water resources are outlined below, based upon the impact of impervious surfaces illustrated in FIGURE 4*f* -5 and the priority forest watersheds illustrated in FIGURE 4*f* -8a and 4*f*-8b:

- Forest cover is 70 percent or greater; impervious surface is less than 10 percent.
- Forest cover is 70 percent or greater; impervious surface is more than 10 percent.
- Forest cover is less than 70 percent; impervious surface is less than 10 percent.
- Forest cover is less than 70 percent; impervious surface is between 10 percent and 25 percent.
- Forest cover is less than 70 percent; impervious surface is more than 25 percent.

Each of these scenarios would require different strategies to incorporate forests or forestry practices in a manner that would support water quality and water supply.

Map Data Sourcess

FIGURE 4f-1: NC Wildlife Resources Commission

FIGURE 4f-2: Terziotti et al. 2001

FIGURE 4f-3: Gerbert et al., 1987

FIGURE 4f-4: US EPA

FIGURE 4f-5: National Land Cover Dataset 2001, National Landcover Dataset 1992

FIGURE 4f-6: National Land Cover Dataset 2001

FIGURE 4f-7: NC Rural Economic Development Center

FIGURE 4f-8a: NC Conservation Planning Tool, NC Rural Economic Development Center, Southern Forest Lands Assessment, NC Source Water Assessment

FIGURE 4f-8b: NC Conservation Planning Tool, NC Rural Economic Development Center, Southern Forest Lands Assessment, NC Source Water Assessment

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4.g.

Forest Wildlife Habitat

Key Findings

- North Carolina has many different forested ecological communities (25 identified in the *NC Wildlife Action Plan*, NCWRC, 2005), some of which are considered globally endangered (such as the southern Appalachian spruce–fir forest and maritime deciduous forest) because of their rarity and decline. Each of these ecological communities provides uniquely suited habitat for wildlife species.
- North Carolina has a large diversity of wildlife species, many of which are in decline because the forest ecosystems upon which they depend are in decline.
- There is a wealth of scientific knowledge about North Carolina forest ecosystems—their locations, conditions, and threats—as well as the wildlife species of our state.
- Many forest types, and thus the wildlife that depend upon them, continue to suffer from common threats, including development (homes, roads, recreational); conversion to monocultures or nonhistoric forest types; fragmentation; fire exclusion; pests, nonnative pathogens, and exotic species; logging (shorter rotations, high grading, poor practices); lack of management; and altered hydrology.
- Conditions of our forests directly affect nonforested ecosystems that are critical for wildlife, such as aquatic species.
- Extensive knowledge of forests and wildlife species, and their threats, puts North Carolina in a position to actively address the decline of forest ecosystems and the wildlife species that depend on them.

Introduction

This section draws heavily upon the *NC Wildlife Action Plan* (NCWRC, 2005) and its focus on nongame species. The ecoregion map of North Carolina used in the *Action Plan* (FIGURE 4*g*-1) is referred to frequently in this section.

This section condenses the description, conditions, and threats to rare and declining communities across a broad statewide framework. It includes the following:

- Description of forest landscape types by North Carolina region
- Current conditions and trends
- Threats to forests and impacts on wildlife and habitats

TABLE 4*g*-1 provides a broad overview of North Carolina's forest landscape types and the regions in which they occur. Detailed descriptions follow by North Carolina region and forest type. For information on game species and priority species in the forest landscape types by North Carolina region and river basins see Appendix E.

Mountain Terrestrial Habitats

The mountainous western portion of North Carolina makes up the majority of the Southern Blue Ridge physiographic section, which is referred to in the *NC Wildlife Action Plan* (NCWRC, 2005) as an ecoregion. Elevations reach 6,684 feet (Mt. Mitchell), and habitats range from high peak spruce–fir forests to low floodplain valleys. Because this region escaped glaciation, a diverse floral and faunal assemblage (more than 400 endemic species) can be found here. The southern Appalachian region is the world's center for plethodontid salamander diversity (Ricketts et al., 1999). Many of the factors that impact species conservation in this region can be traced to wider 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). Other habitat loss issues include succession of high elevation heath and grass balds, homogeneous maturity of forested stands (resulting in a lack of understory 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.

Spruce–Fir Forest (SFF)

Description. Spruce–fir forests occur on high mountaintops in western North Carolina, generally above 4,500 feet. Many plant and animal species found in this community are more common further north and have either (1) evolved here in isolation from their northern cousins or (2) remain in small areas where elevation provides similar conditions to more northern latitudes. These forests provide critical breeding habitat for many landbirds of conservation concern, such as brown creeper, northern saw-whet owl, and black-capped chickadee, which are likely endemic to these high peaks (Pashley et al., 2000; Rich et al., 2004; Johns, 2004).

FIGURE 4*g*-1. Ecoregions of North Carolina.

Created by: A. Bailey, NCDFR, 2010

TABLE 4*g*-1. Primary forest habitat types in North Carolina by type and region

Forest Type	NC Region	Status	Significance	Threats
Bogs and associated wetlands	Mountains	Rare and limited in distribution. Only 500 acres remain, some on agricultural lands.	Significant habitat for rare plants and animals, including endangered plant and animal species.	Development, fire suppression, agricultural practices, water diversion and disturbance
Caves and mines	Mountains	Scattered across the mountains on public and private land. Some occur in the piedmont.	Some mines can function as caves do for wildlife. Habitat for bats.	Recreational activities
Cove forest	Mountains	Most occur in the Pisgah and Nantalahala National Forests.	One of the most diverse ecosystems outside of tropical zones. Critical habitat for endemic salamanders.	Development, non-native insects and plants, timber harvest, conversion to other land uses
Dry coniferous woodlands	Coastal plain (Loblolly–slash pine forest)	Occur throughout the region. Forest industry own more than 1 million acres.	Habitat for early successional wildlife and pine specialist species.	Fire suppression, habitat fragmentation, roads, lack of diversity, lack of gap management, overstocking
	Mountains	Occur mostly in the foothills and far western counties.	Includes pines that can reproduce only in a fire-maintained system. Habitat for birds.	Lack of regular fire development, pine beetle outbreaks
	Piedmont	Relatively stable now. Include acidic cliff and heath communities.	Tremendous variation in plant composition.	Development, fire suppression, erosion and soil movement from human activities, pests and diseases
Dry longleaf pine forest	Coastal plain	Reduced to 3 percent of its previous range. Endangered habitat that occurs mostly on military bases and game lands.	Small mammals and birds rely on the grass-dominant understory and open pine ecosystem.	Development, agriculture, fire suppression, pine straw raking, fire ants
Floodplain forest	Coastal plain	Reduced condition overall. Can be found in various conditions throughout the coastal plain.	Intermittent flooding supports aquatic animals and plants. Habitat for furbearers, breeding amphibians, overwintering birds, and migrant birds.	Dams, development, draining, logging, runoff, exotic species, sediment load
	Mountains	Restricted to large streams and rivers.	Critical habitat for salamanders and frogs.	Agriculture, development, hydro-electric facilities, habitat fragmentation
	Piedmont	Occur along most piedmont streams and rivers. True bottomland forests are rare.	Movement corridors for wildlife. Pools offer breeding sites for salamanders. Remnants of canebrake provide habitat for migratory birds.	Agriculture, commercial logging, altered hydrogeology, nutrient inputs that affect water quality, sediment, exotic plants, commercial turtle collection,

Forest Type	NC Region	Status	Significance	Threats
High and low elevation rock outcrops	Mountains	Scarce.	Includes many distinct natural communities that support plants and animals found only in rocky habitat.	Recreation development, intrusion of woody plants from other habitats
Maritime Forest and Shrub	Coastal plain	Endangered. Extremely poor condition and often disturbed. Occurs along barrier islands and mainland NC coast.	Dynamic environments support migratory birds and snake species for which little information is available.	Coastal development, clearing, lack of fire, feral animals
Mesic forest: Coastal	Coastal plain	Relatively scarce and in poor condition.	Habitat for birds, small mammals, and reptiles.	Logging, development, fire suppression, exotic invasive plants
Mesic forest: Piedmont	Piedmont	Quite common but intact natural sites have been reduced.	Habitat for forest interior birds.	Agriculture, development, conversion to pine plantation monoculture, shorter rotation logging, exotic plants
Northern hardwoods	Mountains	Acreage is greater now than in the past due to expansion into areas once occupied by spruce-fir forests.	Habitat for wildlife species that also rely on spruce-fir forests.	Lack of disturbance, non-native insects and pathogens, development
Oak forest and mixed hardwood–pine	Coastal plain	Scattered throughout the region in small patches. Once widespread but now replaced by agriculture and pine plantations.	Habitat for birds and amphibians.	Forest conversion to agriculture and pine, development, roads
	Mountains	Most widespread forest type. Complex mix of hardwoods, pines, and a diverse shrub layer.	Trees produce mast critical to wildlife. Habitat for wildlife, including salamanders and birds.	Development, agriculture, fire suppression, insects, and disease
	Piedmont	Found across the piedmont, but total acreage is declining. Includes oak–hickory stands and pine plantations.	Logging resource. Provides habitat for wildlife, including quail if managed.	Development, diseases, intensive forest management for logging, fire suppression, non-native insects
Pocosin	Coastal plain	Reduced condition due to fire suppression. Extensive examples on public lands. Includes various peatland communities	Wintering birds rely on the soft mast and habitat. More information needed on species use.	Fire suppression, conversion to agriculture and forestry, development, sedimentation, habitat fragmentation
Small wetland communities	Coastal plain	Greatly reduced by development and drainage. Includes various ephemeral pool communities.	Habitat for birds, amphibians, reptiles and aquatic species. Breeding sites for amphibians, crayfish, and other aquatic species.	Development, roads, drainage for agriculture, stormwater runoff, introduction of frogs and predatory species, all-terrain vehicles

Forest Type	NC Region	Status	Significance	Threats
	Piedmont	Upland pools are rare. Upland depression swamp forests and low elevation seeps are scattered throughout the piedmont. Greatly reduced by development and human impacts.	Important breeding sites for salamanders.	Roads, storm water runoff and pollution, drainage for agriculture or development, altered hydrology, introduced fish, bullfrogs, and other predators, timber harvest, all-terrain vehicles
Spruce–fir forest	Mountains	Endangered. Remaining stands exist mostly on public land. Wildlife species have declined.	Critical breeding habitat for many landbirds of conservation concern.	Development, non-native insects (balsam woolly adelgid), pollution, isolation, climate change
Tidal swamp forest and wetlands	Coastal plain	Relatively good condition. Primarily occurs in the northern coastal plain	Nesting sites for bald eagles. Habitat for marsh birds.	Fire suppression, drainage for mosquito control, development
Wet pine savanna	Coastal plain	Reduced condition due to fire suppression. Exists mostly on public lands.	Very diverse herbaceous plant communities where fire occurs that support reptiles, amphibians, and woodpeckers.	Fire suppression, pine plantations, development, fireline construction, loss of transition zone

Condition. 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. These forests have been threatened and remain so due to human activities, non-native species, and natural factors. 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 to 95 percent in conservation ownership in the Southern Blue Ridge physiographic province including North Carolina, Tennessee, and Virginia (Hunter, et al. 1999; SAMAB, 1996).

Threats. Spruce-fir habitat in North Carolina and throughout the southern Appalachians has been significantly altered due to residential and recreational development; historic land use for logging and grazing; fire; non-native insects; air pollution; and natural factors, such as insects, isolation, and climate. Recently, 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 firs of the high elevation forests. The wildlife species associated with spruce-fir haves declined (such as red crossbill, brown creeper, pine siskin, black-capped chickadee, northern saw-whet owl, and northern flying squirrel).

Northern Hardwoods (NHW)

Description. Northern hardwood forests are found on high elevation sites (generally above 4,000 feet, but more often above 4,500 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. 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). Northern hardwood forests provide habitat for numerous wildlife species that also rely heavily on spruce–fir forests. Yellow birch, beech, sugar maple, and buckeye often provide more abundant natural cavities and decaying wood than spruce or fir for species that rely on spruce–fir forests (such as northern flying squirrels, yellow-bellied sapsuckers, black-capped chickadees, and northern saw-whet owls) and other wildlife.

Condition. Northern hardwood forests in western North Carolina are more widespread throughout the region, owing to their respectively lower elevation. Most of the available northern hardwood forest in North Carolina can be found on federally owned lands. 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.

Threats. Lack of disturbance has reduced available habitat for disturbance-dependent species, such as golden-winged warbler and yellow-bellied sapsucker (Hunter et al., 2001). The closed canopy conditions decrease habitat for bird species that rely on diverse understory development, such as Canada warbler. 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 insects and pathogens (including hemlock woolly adlegid, balsam woolly adelgid, gypsy moth, and beech scale) are potential problems for several tree species in this ecosystem. The isolated nature of several wildlife populations, such as northern flying squirrel, northern saw-whet owl, blackcapped chickadee and Weller's salamander, is likely detrimental to the genetic flow and overall long-range health of the species.

Cove Forest (CFT)

Description. Montane cove forest occurs in low to mid-elevation sites in moist, protected areas. Coves are generally stable, unevenly aged climax forests, characterized by a dense tree canopy. 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. Rich coves have a relatively open mid-story with a dense herbaceous layer of ferns and other plants; acidic coves have a dense mid-story (often 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). 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.

Condition. Cove hardwood habitat is well represented in the North Carolina mountains (Hunter et al. 1999). The Southern Blue Ridge physiographic section (mostly North Carolina, with portions of Tennessee, Georgia, and South Carolina) contributed approximately 1 million acres of cove hardwoods in the 1999 survey by Hunter et al. Most cove hardwood forest in western North Carolina is in mid- to late successional stages (SAMAB, 1996; Hunter et al., 1999), representing more than 80 percent of the cove hardwood forest on the Pisgah and Nantahala National Forests (USDAFS, 2001).

Threats. The most significant threat to cove hardwood habitat is its conversion to other uses, primarily residential development. The reduction in habitat quality by virtue of being bisected by roads and driveways can certainly have a significant impact upon wildlife species (Rosenberg et al., 2003). Several exotic pest species (including the hemlock wooly adelgid, gypsy moth, and beech scale) and non-native plants could have a potential significant impact upon the health of the cove hardwood forest. Timber harvesting and conversion to other forest types (white pine) or other uses on private lands in certain areas could also decrease the future of this habitat. Some bird species that require a diverse understory may be affected by the aging of stands, which can result in decreased plant diversity until the stand ages enough to produce canopy gaps (Hunter et al., 2001).

Dry Coniferous Woodlands (DCW)

Description. This habitat type occurs on dry 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. Canopy species may include Table Mountain pine, pitch pine, Virginia pine, chestnut oak, Carolina hemlock, or white pine. In addition, a 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 that have experienced recurring fires, support diverse understories of a wide variety of Vaccinium spp. and other ericaceous shrubs and herbs (NCNHP, 2001). Table mountain pine and table mountain/pitch pine stands can only reproduce in a fire maintained system due to their serotinous cones and shade intolerance.

Condition. Dry coniferous woodlands are widespread in the southern Appalachians and in the Valley and Ridge and Cumberland Plateau physiographic regions. Most of the dry coniferous woodland habitat occurs in the foothills region, or in the far western counties (such as Cherokee and Clay counties). 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).

Threats. The most significant problem affecting dry coniferous forests in North Carolina is the lack of regular fire to maintain and reproduce this habitat. Pine beetle outbreaks can have significant impacts, killing the dominant pine overstory. For species such as prairie warblers, woodpeckers, and nuthatches, an additional problem is the lack of early successional habitat of this type or conversion of this habitat to other pine habitat (mainly white pine). Lack of stand management decreases the quality of habitat for woodland hawks by decreasing prey abundance and limiting their ability to hunt in dense understory growth. Limited use of fire as a management tool, due to the proximity of residential or other development, hinders management.

Oak Forest (and Mixed Hardwood–Pine) (OPF)

Description: Oak dominated forest is the most widespread and heterogeneous type within the Southern Blue Ridge on relatively dry slopes and ridges. This habitat is a complex mix of 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). 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 communities of this habitat, contain a mixture of oak species (often white oak dominates). Hickories may be present, and the understory's shrub layer is often quite diverse, supporting species such as flowering dogwoods, flame azaleas, and huckleberries. Red oak forests may dominate at medium to high elevations (this is the most common community on high mountains) and on ridgetops where spruce–fir and northern hardwoods are absent or adjacent (NCNHP, 2001).

The production of mast, such as oak acorns, hickory nuts, and a wide variety of soft mast, make this forest type one of the most important habitats of the region, benefitting a variety of wildlife species.

Condition. This habitat has been subjected to many natural and anthropogenic stresses that have shaped its current distribution and condition. The loss of American chestnut in the landscape, development patterns, historic demands for timber products, fire suppression and a variety of other impacts have affected oak forests. Hunter et al. (1999) indicate that over half of the available oak forest habitat is currently in mid- to late successional stage.

Threats. Three distinct problems affect habitat loss in the oak forest type: habitat loss, insects and disease pests, and inappropriate management. These include the following specific historic and ongoing problems:

- Loss or conversion of habitats due to human activities, such as development and agriculture, leading to greater degrees of habitat fragmentation.
- Loss of ephemeral pool habitats for amphibian species.
- Chestnut blight, oak decline, gypsy moths, and other diseases and pests may significantly affect the composition and diversity of hardwood stands throughout the southern Appalachians.
- Fire suppression affects species diversity and richness and the composition, structure, and diversity of hardwood stands.
- Homogeneity of stand age has resulted in lack of understory development, decreasing habitat for bird species that rely on a diverse understory.

Many species (such as cerulean warbler, black-capped chickadee, green salamander, seepage salamander, crevice salamander, Wehrle's salamander, northern pine snake) are affected by these threats. Likewise, neotropical migrant birds may be experiencing winter range habitat loss.

High and Low Elevation Rock Outcrops (HER)

Description. Rock outcrops are quite limited across the North Carolina landscape and include many distinct natural communities defined by Schafale and Weakley (1990), including boulderfield, rocky summit, granitic dome, acidic cliff and mafic cliff, rocky outcrops, and talus slopes. Low elevation rock outcrops include low elevation granitic domes and rocky summits, acidic cliffs, mafic cliffs, and some boulder fields. In general, rock outcrops are found on ridgetops, peaks, and upper steep or rocky slopes where soils are thin and rock dominates the surface. Species of interest include rock vole, long-tailed shrew, Allegheny woodrat, several rare plant species, and other species found only in low elevation cliffs and rock outcrop habitat (such as southern Appalachian woodrat, spotted skunk, crevice and Southern zigzag salamanders). Rocky 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.

Condition. 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.

Threats. High and low elevation rock outcrop habitats can be affected by numerous activities and situations, including these:

- Recreational activities (climbing and trampling) can have significant impacts upon the physical characteristics of the site and disrupt behavior patterns of particular wildlife species.
- Development causes direct habitat loss and makes indirect impacts upon wildlife species.
- Intrusion by alder, rhododendron and other woody plants affect rock outcrop plant communities.

Many unknown problems remain that can and will impact high and low elevation rock outcrop communities and their fauna. The scarcity of low elevation rock outcrop habitat across the landscape of North Carolina lends greater significance to the need to identify and manage these habitats appropriately to conserve wildlife.

Floodplain Forest (FPF)

Description. Floodplain forests within the North Carolina mountains are generally restricted to larger streams and rivers. The most common ecological communities associated with floodplain forest in the mountains are montane alluvial forest and piedmont–low mountain alluvial forest. Floodplain forests of the mountains often contain small or isolated patches of swamp forest, swamp forest-bog, floodplain pools, and semipermanent impoundments (Schafale and Weakley, 1990). 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 part of the year are important for breeding amphibians.

Condition. Floodplain forests occur on floodplains or immediately adjacent to waterways. Historic development patterns and land uses have impacted much of the floodplain forestland in the North Carolina mountains. Flat land is most amenable to agriculture, residential development, and transportation. A few examples of functional floodplain forest remain along major rivers in the mountains.

Threats. Development makes the biggest negative impact upon floodplain forest habitat. These forests have historically supported agricultural activities, transportation development, hydroelectric facility development, commerce, and urban development. Direct impacts to habitat include direct loss, habit fragmentation, and altered hydrology and plant composition.

Floodplain pools within floodplain forests have been directly impacted by conversion to other land uses, and by hydroelectric facilities that have reduced the frequency, duration, and magnitude of flood events. This is a significant threat to floodplain forests because they are particularly important habitats for breeding amphibians in the region, mainly due to the inclusion of floodplain pools and semipermanent impoundments (beaver ponds). Temporarily flooded areas are critical breeding habitat for salamanders (such as marbled, mole, four-toed, and spotted salamanders) and other amphibians, such as chorus frogs and wood frogs.

Another consequence of some land management strategies is the altering of floodplain forests, leading to homogeneity in structure and composition. Historic land use and land clearing, the absence of water quality protection, and diminution of flood regimes are the primary causes of this threat.

Other problems affecting particular species that use floodplain forests include geographic and genetic isolation (mole and four-toed salamanders, bog turtles) and small ranges of particular species, such as Junaluska and longtail salamanders and mountain chorus frogs.

Unique Habitats: Caves and Mines (CAM)

Description. Caves are found scattered across the Southern Blue Ridge and across the state. Cave types include solution caves, fissure caves, and rock shelter–boulder caves. These types vary largely by the manner in which they formed. Solution caves are created by the action of water, which dissolves the underlying rock to form tunnels. Fissure caves are formed by movement of the earth's surface, which results in cracks of the rock layers. Rock shelter–boulder caves are formed by erosive forces, weather events, earth surface movements, and other factors, which essentially leave spaces underneath and/or behind surface rock. The vast majority of caves in North Carolina are rock shelter–boulder caves. In addition to natural formations, an extensive mining history in North Carolina has left us with excavations that mimic environmental conditions of natural caves

Condition. The NC Cave Survey has documented more than 1,300 caves in the state (Cato Holler, pers. comm.). Some mines do function like caves in providing the range of microhabitat conditions needed by cave obligate species. Usually, the larger the mine excavations and the air volume within are important correlates of use by cave dwelling animals*;* in general, the bigger the mine, the greater the potential for wildlife use (particularly by bats of various species).

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). Certain wildlife groups (mostly bats) have been surveyed in some caves on an irregular schedule over the past couple of decades.

Threats. Recreation is the greatest threat to cave and species conservation (TNC and SAFC, 2000). Many wildlife species that use caves, if not the caves themselves, have been and continue to be affected by human activities, including both direct impacts (such as repeated disturbance during bat hibernation), as well as indirect impacts (habitat changes that make microhabitat conditions inside the cave or mine unsuitable).

Bogs and Associated Wetlands (BAW)

Description. Bogs and wetlands are natural communities found throughout western North Carolina. Mountain bogs, though very limited in their distribution and availability across the landscape, are one of the most significant habitats of the state for rare plants and animals (TNC and SAFC, 2000. Bog habitat types include swamp forestbog complex, southern Appalachian bog, southern Appalachian fen, hillside seepage bog, high elevation seep, and meadow bog. In addition, these wetlands can be contained in landscapes of montane and 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.

Mountain bogs form in poorly drained depressions or on gentle, flat valley bottoms that are not subject to flooding. Unlike northern bogs of glacial origin, Bogs are often small (less than 2 acres), dispersed, and have varied hydrologic regimes, typically seepage or springs fed bogs. However, beaver activity and impoundment can provide the ideal conditions for bog creation under the right circumstances. Small remnant bog communities can be found in the headwater areas of some artificial impoundments. Generally, bogs are underlain by wet organic or mucky mineral soils; while most are very acidic, a few bogs can be relatively basic (NCNHP, 2001).

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 vegetation is dependent upon hydrology, soils, geographic location, disturbance history, current land-use activities, and other factors. Human activities, such as livestock grazing, play a major role in the current vegetation makeup of 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 plants federally listed as endangered are associated with mountain bogs. State-listed or rare species are also associated with mountain bogs, including the bog turtle, mole salamander, four-toed salamander, and alder flycatcher.

Condition. Mountain bogs are among the rarest communities in North Carolina. The US Fish & Wildlife Service (2002) estimates that only 500 acres still exist of the original 5,000 acres of bogs in North Carolina. The condition of mountain bogs is quite variable, owing to conversion to other uses, primarily through draining, filling, or impoundment. Some bogs support a mix of open and closed canopy vegetation, maintained by hydrology, elevation, and other natural factors. Other bogs may be open canopied (dominated by herbaceous vegetation) due to active management of vegetation or other land uses (grazing).

Threats. Numerous bogs have been destroyed to make way for industrial, commercial, and residential development and 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. Agricultural practices can be helpful tools in managing mountain bog habitats in some situations.

A significant problem for some mountain bog forest types is secondary succession of the plant communities at particular sites. 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). Salamanders, (mole, four-toed, marbled, three-lined, and spotted salamanders) require pools of water for breeding. Factors responsible for allowing succession to proceed (fire suppression, hydrologic diversion, or other disturbance factors) have enabled bogs that formerly provided open or mixed open–shrub habitat to become closed canopy swamps.

Piedmont Terrestrial Habitats

The North Carolina piedmont, referred to in the *NC Wildlife Action Plan* (NCWRC, 2005) as the Piedmont Ecoregion, includes mid-elevation forest and bogs at the Blue Ridge escarpment to low floodplain valleys towards the east. Species diversity for some animal groups is relatively high. 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 state's mountains and coastal plain. Remaining hot spots of biodiversity include high quality stream, floodplain, and wetland habitats, in addition to well-managed farms and forestland.

Many of the factors affecting species conservation in this region can be traced to larger habitat-level issues. Species diversity and conservation in the piedmont is heavily affected by rapid development and growth throughout the region. Patterns of growth in the piedmont have favored sprawling subdivisions outside of city cores, putting even greater pressures on wildlife habitats and diminishing the quality of life for many urban residents. The USDA Forest Service has documented a sharp loss in forestland cover in counties surrounding the piedmont's large 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 in the piedmont are also threatened by habitat degradation and fragmentation. Habitat fragmentation limits area-sensitive species and isolates other species, making them more vulnerable to disturbance, disease, and depredation. Road and transportation development projects have affected populations in ecologically sensitive areas. Increased human development also brings an increased risk of introducing exotic species.

Dry Coniferous Woodlands (DCW)

Description. Dry coniferous woodlands occur 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 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). Amongst the species that may grow in these areas are Virginia pine, shortleaf pine, as well as hemlocks and rhododendron on sites that are more sheltered. 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 mountains, but piedmont examples occur on high ridges and monadnocks in the western counties of the North Carolina 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. The natural fire regime needed to maintain these areas, however, is not clearly understood.

Condition. Dry coniferous woodlands along ridgetops and steep slopes are relatively rare in the piedmont, occurring mostly in counties that border the mountains. The overall condition of this habitat, however, is comparatively stable but this will change unless fire is used to manage these areas.

Piedmont acidic cliff communities occur throughout the North Carolina piedmont and generally border floodplain forests or stream channels. Tremendous variation in plant composition occurs among these sites based on elevation, aspect, and geographic location and in the amount and quality of the conifers present.

Threats: Four specific threats affect this forest type:

- *Fire suppression*. 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 mass wasting.
- *Tree pests and diseases*. Numerous native and exotic pests can affect coniferous trees in this habitat (such as southern pine beetle, tip moths, pine webworm, Schweinitzii root and bud disease, and red heart of pine disease).
- *Development, habitat loss, and fragmentation.* Development projects are affecting dry coniferous woodlands in the North Carolina piedmont.

Oak Forest (and Mixed Hardwoods–Pine) (OPF)

Description: Oak forests are found across the piedmont on a variety of natural communities that have an oak-hickory or mixed hardwood–pine component.

Dry mesic oak–hickory forests and dry oak–hickory are the most common 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. A variety of oak and hickory tree species dominate these communities, but pines may also be an important component. Shrub layers vary in density in these areas, though herbs are usually sparse (Schafale and Weakley, 1990). Both of these forest types are naturally unevenly 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). The basic oak–hickory forest type is also found scattered throughout the piedmont on slopes, ridges, and uplands with basic soils (Schafale and Weakley, 1990).

In addition to these natural communities, pine plantations occur in the piedmont, primarily of loblolly pine (Brown and Sheffield, 2003), and their acreage is increasing. Although significant variation can occur in the structure and composition of these pine plantations, particularly in the mid-story, the vast majority are evenly aged stands with only loblolly pine in the canopy.

Condition. 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 seven percent, or by about 400,000 acres, between 1990 and 2002, primarily due to urban development and 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 these tracts varies widely across the piedmont by the extent and age composition of canopy trees, management history, and tract size (Godfrey 1997). Some tracts are too small to support viable populations of area-sensitive species or species with large home ranges or dispersal movements. Land-use conversions in the piedmont (primarily to suburban and exurban development) contribute significantly to the reduced condition of some tracts. Fire suppression and conversion to pine plantations are two management activities that have most extensively affected 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 sweet gum, depending on the degree of canopy opening and disturbance history. Disturbances of many types, exotic plants, and fire suppression have undoubtedly changed the species composition and structure of the oak dominated forests.

Threats. Many of the problems affecting oak and mixed hardwood–pine forests, including fire suppression and evenly aged forest management, result in a loss of both habitat complexity and associated wildlife niches (Hunter et al., 2001).

- *Development*. Development causes direct loss of forest habitat and fragmentation of the remaining forested patches. Fragmentation by roads and development can be particularly problematic for reptiles (timber rattlesnake and box turtle), amphibians, and small mammals that suffer 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.
- *Intensive forest management*. Pine dominated forestry limits late successional habitat, canopy gaps, hollow trees, large diameter snags, and woody debris. Some native forest stands are being replaced by evenly aged pine plantations, resulting in decreased habitat value for such forest species as Kentucky warbler and wood thrush. Pine plantations do provide increased opportunities to properly manage habitat for brown-headed nuthatch and bobwhite quail.
- *Fire suppression leading to reduced or altered understory community and shifting tree species composition*. Historical data suggest that oak communities benefited from periodic fires (Abrams, 1992; Close, 1996), and many oak species tolerate fire. Lack of fire has also allowed some fire-intolerant mesophytic plant species, including American beech, to become quite common in oak dominated communities (Franklin and Kupfer, 2004).
- *Exotics*. Many potential and realized impacts occur from imported gypsy moths (Lymantria dispar) and other

non-native insects, kudzu and other non-native plants, and non-native pathogens 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.

Piedmont Mesic Forest (PMF)

Description. Piedmont mesic forests occur on moist portions of upland habitat, steep north-facing slopes, and lower slopes; along ravines; and on stream bottoms and high sections of outer floodplains. 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.

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).

Condition. Mesic habitats in the piedmont have experienced less direct habitat degradation and fragmentation. 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.

Threats.

- *Development*. As with all piedmont forest habitats, fragmentation of mesic forests into smaller or narrower contiguous blocks is a concern for forest interior birds (including 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.
- *Conversion to pine plantation monoculture.* After logging, some mesic forest habitats are replanted to evenly aged loblolly pine plantations, reducing species and structural diversity until oaks can return to the forest through natural succession.
- *Shorter rotation logging*. Increasing land costs have necessitated timber harvests as soon trees reach economic viability, limiting late successional habitat characteristics, such as canopy gaps and standing and fallen snags. A lack of canopy gaps threatens avifauna, including the eastern wood-pewee, red-headed woodpecker, northern flicker, hooded warbler, and Kentucky warbler. The reduction in standing snags negatively affects 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.

Floodplain Forest (FPF)

Description. Piedmont floodplain contains a 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 sweet gum.

Historically, many floodplains were maintained in switch cane (Arundinaria gigantea) and herbaceous plants through fire and other periodic disturbances. 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 that are flooded for part 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 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 migration periods. We need to develop more accurate and usable protocols for sampling many floodplain species, including amphibians, to better understand status, distribution, and life histories (Taylor and Jones, 2002).

Condition. Floodplain forests exist along most rivers and streams in the piedmont. They vary in width, 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. Small remnants of "canebrake" communities still exist throughout the piedmont, but management strategies to maintain this feature are almost nonexistent.

Alterations by human activities have affected much of the piedmont's riverine and floodplain habitats. Logging and clearing land for agriculture, development, recreational use, and reservoir construction all cause direct loss and alteration of floodplain forests. Land-clearing activities conducted adjacent to, upstream, and downstream of floodplain forests can cause indirect impacts to the floodplains. These impacts particularly affect hydrology. Flooding events may occur with greater frequency due to increased upstream impervious surfaces and clearing of vegetation near buffers.

Managed river flows have affected the timing and intensity of overbank flow into the floodplain, altering hydrology and sediment deposition. The input of nutrients from flood events makes levee sites along streams and rivers very fertile, and overbank flow helps to recharge vernal pools in the wetland. Changes in flow regimes may eventually lead to changes in 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 sediment pollution. Beaver activity and 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—frequently invade 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, which has led to few bottomlands of any large size remaining. 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.

Threats.

- *Direct habitat loss.* Riparian forests have become scarce in the piedmont because many of these areas are now used for food and fiber production and location of sewer lines.
- *Altered hydrology*. The most significant source of habitat alteration is altered hydrology. Controlled flows downstream of dams and the construction of levees can reduce overbank flood events that are important for recharging ephemeral wetlands and spreading nutrients in the floodplain. Dams can alter the timing and duration of flood events.
- *Habitat fragmentation*. The reduced size of remaining forest patches may affect 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 late successional habitat*. Older floodplain forests contain large-diameter trees and snags, dead wood, and canopy gaps that support dense undergrowth. Lack of snags and den trees is often a limiting factor for several species of wildlife, especially secondary cavity users (McComb et al., 1986). "High grade" logging operations remove the larger trees that provide important habitat 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 other factors) can have a strong impact on amphibians, turtles, and other animals associated with floodplain forests.
- *Exotic plants*. Japanese grass (Microstegium vimineum), Chinese privet, and Japanese honeysuckle can suppress the growth of other plants and alter habitat structure, and these plants have little wildlife value.
- *Loss of canebrake communities*. Cane communities are maintained through fire or other periodic disturbance. 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.
- *Commercial collecting of bog and spotted turtles*. The extent of commercial collecting for the pet trade, and its impact on local populations is unknown but potentially a problem.

Small Wetland Communities (SWC)

Description. Small wetlands include vernal pools, seeps, small depression ponds, ephemeral wetlands, and beaver ponds. Some depressions may hold water for much of the year; others may be saturated for only a few months. All piedmont wetland habitats are important 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 section entitled "Linking Terrestrial and Aquatic Systems"). Wading birds, waterfowl, and songbirds, too, may also use small wetland communities for nesting and feeding.

Upland pools are a rare habitat type in the piedmont. Wetland shrubs and herbs and small depressions dominate this habitat where water is impounded by an impermeable substrate. Tree species along the edges of these habitats may include black gum, water oak, red maple, and sweet gum. Shrubs may include buttonbush, blueberries, and swamp dog hobble. 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 (such as willow oak, red maple, and sweet gum) with a sparse shrub layer, including 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).

Beaver ponds make up a natural community, but these ponds result from modification of other community types. Dead trees in beaver ponds are important foraging and nesting habitat for woodpeckers, such as the red-headed woodpecker, and for wood duck nesting.

Condition. Piedmont wetland habitats are heavily affected 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. A reduction of beaver ponds will place more importance on man-made ponds as the primary habitat for many lentic aquatic species.

Threats. Threats to North Carolina piedmont wetlands tend to fall into the category of human impacts leading to unintended consequences.

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 during nonbreeding portions of amphibian and reptile life cycles.

Water quality. Increases in impervious surfaces cause excess stormwater runoff and pollution from point and nonpoint sources, which degrade 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. The loss of ephemeral wetland habitats greatly affects 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 efforts of amphibians in small wetlands.

Timber harvest. Clear-cutting near ephemeral wetlands increases solar radiation and the 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).

Coastal Plain Terrestrial Habitats

The North Carolina coastal plain is a largely flat low-elevation inland that extends eastward from the piedmont fall line. Referred to as the Mid-Atlantic Coastal Plain ecoregion in the *NC Wildlife Action Plan* (NCWRC, 2005), 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; it represents the northern extent for many southeastern breeding species and the southern range for many northeastern breeding species.

Habitat loss is one of the most obvious threats affecting species conservation. Habitat fragmentation due to land conversion (including agriculture, development, and roads) and fire suppression also affects habitats in the coastal plain. 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, including many reptiles and amphibians.

Water quality concerns stemming from local development, agriculture, livestock, and sources originating in upstream piedmont cities, are affecting aquatic vertebrate and invertebrate species in the coastal plain. Direct impacts on aquatic fauna can indirectly affect terrestrial vertebrates (such as insectivorous small mammals) that rely on aquatic species as their primary food source.

Oak Forest (and Mixed Hardwoods–Pine) (OPF)

Description. Oak forests include the oak–hickory forest type, and may 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. The dry oak–hickory forest is uncommon in the coastal plain, yet it was clearly widespread before European settlement and land clearing (Schafale and Weakley, 1990). Dry mesic oak–hickory forest was historically found throughout the state's eastern counties, but much of this forest type is now in agriculture or pine plantations (Schafale and Weakley, 1990).

Condition. Oak-dominated forest communities are located throughout the coastal plain and now exist only in small patches. Most of these forests have been logged or cleared within the past 300 years, many multiple times. The quality of remaining coastal plain tracts varies widely by age of the canopy trees, management history, and degree of fragmentation. 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 logging stands, compromised understory, and crowded mid-story.

Disturbed areas in oak forests have varying amounts of pines, red maple, tulip poplar, and sweet gum depending on the degree of canopy opening and disturbance history. Heavily logged areas or high graded logging sites have a mixture of pines and hardwoods. Usually these forests are unevenly aged, with old trees occasionally present. Disturbance of many types, exotic plants, and fire suppression have undoubtedly changed the species composition and structure of coastal plain forests naturally dominated by oaks. In turn, due to less frequent fires, many areas once dominated by longleaf pine have been invaded by oaks, hickories, and other hardwoods. Many of these former longleaf areas, if disturbed frequently, have a high percentage of the total habitat dominated by patches of weedy hardwood species, such as sweet gum, tulip poplar, and red maple.

Threats. Forest conversions, microhabitat loss, lack of woody debris, and roads have affected amphibians, reptiles, and small mammals in oak–mixed hardwood stands in the NC coastal plain. Conversion to intensively managed loblolly pine stands is a threat. A lack of canopy gaps affects bird species that rely on those gaps for foraging areas (including, nightjars, eastern wood-pewee, northern flicker, red-headed woodpecker). Development and roads have caused habitat fragmentation, especially for amphibian species found within the matrix habitat of oak–mixed hardwoods.

Coastal Mesic Forest (CMF)

Description. 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. Coastal mesic forest 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, sweet gum, 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 North Carolina coastal plain) and basic mesic forest, scattered and found primarily in an 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 unevenly 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 sweet gum, as well as exotics, including Japanese honeysuckle (Schafale and Weakley, 1990).

Condition. 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. Examples of the *upland* *flat variant* are found in Perquimans and Bertie counties. *Marl outcrop* and *terrace slope variants* are rare because the basic substrates they exist upon are rare within the North Carolina coastal plain (Schafale and Weakley, 1990).

The condition of coastal plain mesic forest overall is relatively poor due to almost complete fire suppression (infrequent fires helped control the extent of mesic vegetation), high grading of stands for logging, exotic species, and habitat fragmentation.

Due to the region's relatively flat topography, coastal plain mesic forests are scarce compared to piedmont mesic forests. Most coastal plain mesic 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.

Threats. Development has fragmented the habitat, and high grading for logging has changed the forest condition and composition. Although fires would have naturally swept through these sites relatively infrequently, these would have been suppressed, which affects community composition related to mesic plant species and probably exotics. Logging has depleted the amount of dead and downed material as well as other old growth characteristics, including tree cavities, hollow trees, and vine tangles. 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 reduced the numbers of some avifauna, including 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 affected bird species, such as the Swainson's warbler, Kentucky warbler, hooded warbler, and wood thrush, as well as many small mammals and reptiles.

Dry Coniferous Woodlands (Loblolly–Slash pine Forest) (DCW)

Description. Nonlongleaf 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 densely growing pocosin shrubs (including wax myrtle), and hardwood tree species, such as oaks, hickories, sweet gum, and 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 each stand's history.

Condition. Industrial timber companies own more than 1 million acres of pine plantations (mainly loblolly pine) in the North Carolina coastal plain. These plantation stands include a variety of age classes and stand conditions. Most pine plantation habitat is found in the upper coastal plain because drainage is better there, but it can be found throughout. Most stands are harvested between 18 and 33 years of age, but some exceptions occur. Generally the harvest strategies provide exceptional habitat on a landscape scale for a variety of early successional wildlife species, pine specialists species, and even forest species for some periods of time over the life of many stands and adjacent areas. Silvicultural strategies (including thinning, herbicide treatments, fertilization, pruning, and prescribed fire) determine the species composition and structure of the midstory and understory. Areas that were most likely dominated by longleaf but have evolved to a loblolly component due to lack of fire are scattered throughout the North Carolina coastal plain and are generally in poor structural condition with a dense midstory and sparse to moderate understory.

Threats. 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 and changed their structure as well as the vegetative species in both the understory and overstory. Acquisition can be a problem in these upland habitats because 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. Pine plantation characteristics likewise complicate 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.

Dry Longleaf Pine Forest (LLP)

Description. 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 grassy and/or herbaceous 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 fire during the growing season 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 North Carolina coastal plain. They have an open to sparse canopy of longleaf pine, scattered scrub oaks, abundant lichens and bare sand, and naturally experienced frequent low-intensity fire, except in areas with too 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 (nonwetland) sites, range throughout the North Carolina coastal plain and the 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 and 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, including turkey oak, blackjack oak, and bluejack oak. These communities naturally experienced frequent low-intensity surface fires. 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 North Carolina Sandhills.

Xeric sandhill scrub sites occur on deep sand ridges and swale systems. Relict aeolian sand deposits, Carolina Bay rims, and sandy uplands occur mainly in the Sandhills region and southern counties of the North Carolina coastal plain (Schafale and Weakley, 1990). Longleaf pine dominates the open canopy with an 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). Without fire, the scrub oaks become denser and larger, and in turn reduce the herb layer and possibility of surface fires.

Condition. Longleaf pine communities, once the most abundant Coastal Plain province habitat, now exist in just 3 percent 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 percent) were being maintained by fire, while the rest (74 percent) were fire-suppressed and in transition to other forests types." Longleaf pine forests presently occur in 19 North Carolina counties (TABLE 4g-2).

TABLE 4g-2. NC longleaf pine acreage by county, 2005

County	Acreage
Moore	30,200
Hoke	28,300
Richmond	25,800
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
Lenoir	400

Source: NCWRC, 2005.

The best remaining examples of the dry longleaf pine habitat in the North Carolina coastal plain are on the military bases of Fort Bragg, Camp Lejeune, Sunny Point, and Cherry Point, the Croatan National Forest, Holly Shelter Game Land, and Sandhills Game Land. Most of the acreage 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.

Threats. Most loss of this habitat type has occurred 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 to feel comfortable making recommendations about planting 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 the use of only cool-season fires) has caused the deterioration of many additional sites, particularly on private lands and around urban areas where smoke management creates problems for managers and landowners. Without fire, scrub oaks (or mesic trees) become larger and denser and form closed canopies that reduce understory vigor. The loss of understory grass and the presence of oak leaf litter (less flammability) reduce the likelihood and effectiveness of future surface fires (Schafale and Weakley, 1990). Designated “Wilderness Areas” are good examples 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 finely textured soils that are moderately to excessively drained, making them ideal sites for residential and commercial development. In addition, the scenic quality of longleaf pines and the white sands in the North Carolina Sandhills make the region an ideal site for golf courses and associated development. Many thousands of acres have been developed, particularly around Southern Pines and Pinehurst, North Carolina.

Pine straw raking has tremendously affected understory habitat by removing understory grasses and forbs, preventing their growth, and sometimes 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, affecting both primary (woodpeckers) and secondary (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 areas with large woody debris, have been lost, affecting reptiles and small mammals (Loeb 1999). Fire ant impacts are also a growing threat.

Pocosin (POC)

Description: Peatland communities of the North Carolina 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 North Carolina 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 within 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. An extremely dense shrub layer characterizes higher, drier sites.*

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 persistently low stature (less than 1.5 meter 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 to 3 meters high, and trees still tend to be scattered and small in stature. *Pond pine woodlands* occur on parts of domed peatlands within poorly drained interstream flats, peat-filled Carolina Bays, and shallow swales and are found throughout the North Carolina coastal plain (Schafale and Weakley, 1990). Some stands occupy many thousands of acres, such as those in Croatan National Forest, Holly Shelter Game Land, and Green Swamp. Pond pine woodlands 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* sp.). 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*. Forests dominated by Atlantic white cedar are found throughout the coastal plain but are most common in the outer counties of the coastal plain and usually exist 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 evenly 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 and by 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 that naturally supported them (Schafale and Weakley, 1990).

Streamhead pocosin communities resemble peatland pocosins, but they are found in very different physical settings such as ravines in permanently saturated seeps in the North Carolina Sandhills. 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. A higher shrub and tree diversity occurs in 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 persist through much of the winter. Pocosin habitats are important for a variety of birds that require shrub and scrub for habitat, though we lack status and distribution data, as well as detailed information, about the bird communities that use pocosins (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 pocosins (Mitchell, 1994).

Condition. Pocosin habitats are found throughout the outer counties of the North Carolina 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 North Carolina pocosin habitats tends to be on small acreages (less than 100 acres).

Extensive examples of pond pine woodlands exist in the Green Swamp, at Alligator River National Wildlife Refuge, Pocosin Lakes National Wildlife Refuge, 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). Communities dominated by Atlantic white cedar still exist at Alligator River and

Pocosin Lakes National Wildlife Refuge, 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. Under natural conditions, pond pine woodlands and high pocosin habitats would normally contain many trees more than 100 years old. Although much of the pond pine dominated sites are still very old, fire suppression is causing a large buildup 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.

Threats. 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, fire lines 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 because 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).

Wet Pine Savanna (WPS)

Description. 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 composed 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 North Carolina 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 North Carolina 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, 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). Many rare plants are 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 without 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.

Condition. The condition of wet pine savanna communities in the North Carolina 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 that reduces light to the forest floor, once again inhibiting plant diversity. The additional overstory somewhat dries the site through transpiration as well. 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 Wildlife Resources Commission (Holly Shelter Game Lands, Sandhills Game Land), and the USDA Forest Service (Croatan National Forest). 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 1950s, a small (117-acre) but significant extension to the site called “Pelham Savanna” has been purchased by the NC 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.

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 because they typically have a sparse overstory and open midstory that is preferred by the woodpeckers.

Threats. 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 nonindustrial forestlands, have many severely rutted or highly graded areas.

Fire suppression and a lack of prescribed burning during the growing season has caused a thick shrubby understory to develop that 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. Micro habitats and ecotones have been lost due to fireline construction, and the lack of woody debris particularly affects 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 (including red-cockaded woodpecker, Bachmans’s sparrow, Henslow’s sparrow, brown-headed nuthatch, American kestrel, and prairie warbler) (Hunter et al., 2001; Johns, 2004).

Floodplain Forest (FPF)

Description: The North Carolina 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 in the piedmont or mountains and flowing into the coastal plain).

Sand and mud bar communities are found throughout the North Carolina coastal plain and are usually in and adjacent to streams and rivers. 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 NC coastal plain (Schafale and Weakley, 1990). Sand and mud bars 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 North Carolina coastal plain (Schafale and Weakley, 1990). Oxbow lakes are abandoned river channel meanders with permanent still water that are 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, sweet gum, 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, a highly variable flow regime occurs with floods of short duration and periods of very low flow (Schafale and Weakley, 1990). The shrub layer ranges from sparse to dense, and the herb layer is usually well-developed. These areas are greatly affected by riverine forces 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, sweet gum, 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 as levees are. 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, box elder, water hickory and sweet gum, 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 North Carolina coastal plain, and typical trees include swamp chestnut oak, cherrybark oak, laurel oak, water oak, willow oak, Shumard’s oak, sweet gum, 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).

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).

Because cypress–gum swamps flood for long periods of time, their vegetation diversity is usually low. But they can 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. These trees have been 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, but the trees are close enough to interact. If a floodplain contains levees and ridges large enough to support distinctive communities that are 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).

Condition. The floodplain forest systems of the Coastal Plain province in the Southeast are now only small fragments and sections of the original millions of acres present before European settlement. These floodplain forests have been lost or altered by development, drainage, agriculture, and logging (Weller and Stegman, 1977). Several species of wildlife that once called large floodplain systems home are gone or greatly reduced in numbers. Throughout the North Carolina coastal plain, floodplain forest communities in various conditions and sizes can be found. The conditions of 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 affect 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, high-grading of stands for logging, 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 North Carolina coastal plain, and even many blackwater systems now have high sediment loads (Schafale and Weakley, 1990).

Floodplain forests along the Roanoke River may be the finest example remaining in the state, yet even their flow regime has been greatly affected by dams. Other large floodplain forests are associated with the Cape Fear River, Neuse River, Tar-Pamlico River, and Chowan River. Nonpoint source and point source pollution from a variety of human activities has greatly increased in many river basins due to growing human population. Untreated stormwater runoff from large cities and towns is a major problem that affects both the aquatic and terrestrial wildlife associated with floodplain forests.

Threats. Alteration of hydrology due to dam creation and the draining of wetlands is 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 affected the availability of quality bat and chimney swift roosting and breeding sites and nesting productivity for such species as wood duck and hooded merganser. Lack of downed woody debris also has affected 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. Bottomland hardwood birds that are sensitive to breeding area have likely been affected 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 for logging has changed plant species diversity and stand vegetative structure. Forestry activities (including logging) have reduced colonial waterbird and eagle nesting areas. Increases in populations of non-native plants (including privet, Japanese grass, Japanese honeysuckle) and the overall loss of large cane breaks 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. Sewer lines have been constructed along many floodplain corridors, especially in the upper counties of the North Carolina 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.

Small Wetland Communities (SWC)

Description. 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 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 section entitled “Linking Terrestrial and Aquatic Systems”).

Vernal pools are small sites that flood seasonally and occur throughout the NC 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 counties of the NC coastal plain over limestone formations. Scattered trees (pond cypress and swamp black gum) may be present in both deep and shallow water zones, and a dense shrub layer surrounds most ponds.

These shrubby zones provide breeding habitat for birds that nest in shrub and scrub (Hunter et al., 2001; Johns, 2004), and these sites are used by wading birds for foraging and nesting. The main value of these sites, however, is that they provide critical habitat for reptiles and breeding amphibians.

Cypress savannas are rare sites 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 NC 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 because they rarely contain fish.

Beaver ponds make up a natural community but result from modification of other community types, and thus the potential exists for human action to mimic them effectively. Dead trees in beaver ponds are important foraging and nesting habitat for woodpeckers (such as the red-headed woodpecker) and for wood duck nesting.

Condition. 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 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.

Threats. Development and fragmentation has reduced the availability of small wetland communities, affecting 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 nonbreeding portions of amphibian and reptile life cycles.

Many of these habitats are inherently small and are easily affected by nearby development or drainage. Cutting ditches through wetlands can alter their hydrology and habitat quality. Many coastal plain depressions have been drained, 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 storm water runoff into adjacent seasonal wetlands. Long-term drought and possibly excessive pumping of groundwater has lowered water tables and pond levels in some areas.

Ephemeral and isolated wetlands are very valuable to amphibians because these wetlands 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 efforts 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.

Tidal Swamp Forest and Wetlands (TSF)

Description. These habitats occur along rivers or sounds in areas where flooding is influenced by lunar tides, wind tides, or both. 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, and freshwater marshes containing giant cordgrass, saw grass, cattails, American three square, black needle rush, spike sedges, southern wild rice, 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., 2001; Johns, 2004; Rich et al., 2004), including rails and bitterns. Invasive *Phragmites* spp. form 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 and a dense to open shrub layer. These areas are influenced by lunar or wind tides (or both) with little or no salinity in the water (Schafale and Weakley, 1990). Saltwater intrusion during major storm events can cause major disturbances to this community.

Condition. This habitat can be found primarily in the northern counties of the NC 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 because it is not suitable for development, although few 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 variants occur in Currituck, Camden, Chowan, and Dare counties.

Threats. 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 marsh habitat. An increase in the amounts of Phragmites species 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 number of nest sites for bald eagles, but marsh sites are still important for a variety of birds that use herb-dominated marsh sites.

Maritime Forest and Shrub (MFS)

Description. Maritime communities occur along barrier islands and the mainland NC coast on stabilized upper dunes and flats protected from saltwater flooding and the most extreme salt spray. All of the barrier island maritime forest and 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). Successional shrub communities have become more common on former grass-dominated sites due to artificial building of dunes (Schafale and Weakley, 1990).

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). The rare *maritime deciduous forest* is dominated by beech, American holly, loblolly pine, and hickory. Shrubs and vines can be dense, and a moderate herb layer can be present. These deciduous forests 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).

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., 2001; Johns, 2004). These communities are also important for some snake species for which we have little status, distribution, or demographic information.

Condition. The condition of maritime forests is extremely poor. Maritime forests are endangered habitat types in North Carolina, primarily due to coastal development. In many places where some assemblage of the habitat remains, houses and other structures are spread throughout.

Threats. Residential and commercial coastal development is the single most important factor leading to the loss of maritime forest habitat. Clearings for houses and the resulting fragmentation 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. Burning is almost impossible to conduct in areas surrounded by homes. Feral animal impacts (horses, goats, cows, cats) occur on some of the barrier islands. 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 from people who inhabit the area.

Linking Terrestrial and Aquatic Systems

Aquatic and terrestrial systems are highly connected and interdependent. For example, upland land clearing activities can erode and send sedimentation into adjacent lowland and riparian habitats. North Carolina can make great strides if it adopts a comprehensive management strategy that links the conservation of aquatic and terrestrial resources. As the following overview of the state's aquatic habitats indicates, the threats to aquatic habitats mirror many of the threats that alter and fragment forest habitats: increased development and urbanization, crop and animal agriculture, point and nonpoint source pollution, and hydrologic alteration.

Aquatic Habitats

The richness of North Carolina's aquatic fauna and habitat diversity is related to the geomorphology of the state and its unique river drainages (FIGURE 4g-2). The headwaters of 11 rivers 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 (Hiwassee, Little Tennessee, French Broad, Watauga, and New). The other 12 basins are part of the Atlantic Slope and flow to the Atlantic Ocean. Distinct aquatic communities are found on each side of the Eastern Continental Divide with relatively few native species in common. Each river basin drains diverse terrain, and a wide variety of aquatic habitats exist among NC basins. North Carolina ranked third highest in overall diversity of stream-types (Warren et al., 1997). Generally, streams in the Blue Ridge Mountains dominate the western half of the state and are relatively high gradient and cool with boulder and cobble-gravel bottoms and low to moderate fertility. The larger western streams and rivers have historically supported exceptionally diverse warm-water communities. The NC 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 White Oak, Chowan, and Pasquotank rivers are entirely

FIGURE 4*g*-2. River Basins of North Carolina.

HR	-	Hiwassee
LT	-	Little Tennessee
FB	-	French Broad
WT	-	Watauga
NW	-	New
SH	-	Savannah
BR	-	Broad
CT	-	Catawba
YP	-	Yadkin - Pee Dee
RO	-	Roanoke
CF	-	Cape Fear
NE	-	Neuse
TP	-	Tar - Pamlico
CH	-	Chowan
PQ	-	Pasquotank
LP	-	Lumber
WO	-	White Oak

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within the NC coastal plain. They are characterized by low gradient, warm water, sand and mud bottom, and high fertility. Natural lakes and extensive wetlands are important aquatic habitats found only in the NC coastal plain.

The Southeast 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 percent of the U.S. fauna, and nearly 50 percent of the North American fish fauna (Burr and Mayden, 1992). Mollusk diversity in the region is “globally unparalleled,” with 91 percent of all U.S. 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 percent of the total aquatic 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.

Threats to Aquatic Habitat

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 percent increase in 20 years (Warren et al., 2000). North Carolina ranks third among southeastern states in number (21) and percentage (11.5 percent) 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 percent of all U.S. mussel species and 8 percent of southeastern snails) are presumed extinct (Neves et al., 1997). By state, between 34 percent and 71 percent (mean = 58 percent) of mussel species, or populations of species, are imperiled in the Southeast, which represents 98 percent of all rare mussel species in the United States (Neves et al., 1997). In North Carolina, 59 percent of freshwater mussel species are imperiled (Neves et al., 1997). Assessments of NC mussel populations in the 1990s reported 62 of 147 known populations (42 percent) to be “in poor or very poor condition” (Rader 1994), and only 51 populations (35 percent) are likely to maintain viable over the next 30 years (Alderman et al., 1992). Among crustaceans listed as endangered or threatened in the United States, 54 percent are from the Southeast (Schuster 1997). Twelve species (26 percent) of NC crayfish are listed as species of concern or rare in the state (Clamp et al., 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 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 (impoundments) is the primary cause of population declines for 72 percent of southeastern fishes considered imperiled (Etnier, 1997). Nonpoint source pollution and the effects of impoundments are 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 perturbations (Adams et al., 1990; Bogan, 1993; Neves et al., 1997). The small habitat range of crayfish make them extremely vulnerable to habitat loss and competition (Clamp et al., 1999; Taylor et al., 1996). Nearly all aquatic species are threatened by pollution and impoundment, and competition from nonindigenous species (Taylor et al., 1996).

North Carolina aquatic species threats stem from point and nonpoint source pollution, hydrologic alteration, physical habitat manipulation, and biological pollution. Recent water quality improvements from point source pollution aside, overall habitat degradation continues to threaten the health of aquatic communities. Increased development and urbanization, poorly managed crop and animal agriculture, and mining affect aquatic systems. Impoundments on major NC rivers and tributaries alter the hydrologic regime of many waterways resulting in habitat fragmentation, blockage of fish migration routes, and physical habitat alterations.

Map Data Sourcess

FIGURE 4g-1: Keys et al. 1995

FIGURE 4g-2: NC Office of Environmental Education and NC Wildlife Resources Commission

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Glossary

coastal plain. A term used in this document with or without “North Carolina” (NC), to refer to the sections of the Coastal Plain province encompassed by North Carolina’s boundaries (see **physiograpic region** in this glossary).

ecoregion. An area defined by environmental conditions and natural features; a region defined by its ecology. Ecoregions span state borders but share similar environmental conditions and natural features. This term has been used to describe regions of the United States for the USDA Forest Service (Bailey, 1995) and in the *NC Wildlife Action Plan* (NCWRC, 2005). Ecoregions correspond to U.S. Geological physiographic regions to some extent. *See* **physiographic region** in this glossary.

Blue Ridge Ecoregion refers to areas in North Carolina and other states that are part of the Southern section of the Blue Ridge province.

Mid-Atlantic Coastal Plain Ecoregion refers to areas in North Carolina and other states that are part of the Coastal Plain province.

Piedmont Ecoregion refers to areas in North Carolina and other states that are part of the Piedmont province.

exotic species. A species that occurs outside of its native 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 that exists in a given area due to human action or activity that has led to its dispersal across natural geographic barriers and/or produced conditions favorable to its growth and spread.

invasive species. A species occurring outside of its native range that is likely to cause harm to or threaten the survival of native species.

mountains. A term used in this document with or without "North Carolina" (NC) to refer to the sections of the Blue Ridge province encompassed by North Carolina's boundaries (see **physiograpic region** in this glossary).

physiographic region. Physiographic regions are based on terrain texture, rock type, and geologic structure and history. The U.S. Geological Survey classification system has three tiers: *divisions*, which are broken into *provinces*; some provinces break further into *sections*. North Carolina crosses three provinces that encompass other states:

The *Blue Ridge province* is part of the *Appalachian Highlands division*. The Blue Ridge province encompasses mountainous lands in the Southeast, including areas of Virginia, North Carolina, and Tennessee. North Carolina's mountainous areas occur in the *Southern section* of the Blue Ridge province.

The *Coastal Plain province* is part of the *Atlantic Plain division*. The Coastal Plain province includes coastal lands in the East and Southeast from New Jersey to southern Texas.

The *Piedmont* province is part of the *Appalachian Highlands division*. The Piedmont province encompasses inland areas and foothills in the East and Southeast from Pennsylvania south to Alabama.

piedmont. A term used in this document with or without "North Carolina" (NC) to refer to areas of the Piedmont province encompassed by North Carolina's boundaries (see **physiograpic region** in this glossary).

riparian. Pertaining to a river or other natural course of water and the corridor adjoining it, including the banks and floodplain of a river.

riverine. Relating to, formed by, or resembling a river; living or situated on the banks of a river.

serotinous. a pinecone or other seed case that requires heat from a fire to open and release the seed.

southern Appalachian region. This term is used to describe southern parts of the Appalachian Highlands division. The area this term describes corresponds roughly to the Blue Ridge province and its Southern section.

4.h.

Bioenergy in North Carolina

Key Findings

- North Carolina consumed an estimated 2,633.8 trillion British Thermal Units (BTUs) of energy to produce electricity in 2002; only 4 percent of that energy was generated from biomass resources. Existing renewable feedstocks within North Carolina have the potential to replace another 10 percent of its energy needs. Almost 60 percent of this additional feedstock would come from North Carolina's enormous forest resource.
- Studies suggest approximately 4.7 million tons per year of biomass may be available strictly from the residues of softwood and hardwood conventional harvests, with another 3.6 million tons per year available from harvesting of residual saplings and thinning residues.
- North Carolina's Renewable Energy Portfolio Standard is poised to increase demand for woody biomass as a renewable feedstock for electricity generation.
- Research and synthesis regarding the sustainability and impacts of woody biomass are warranted.

Introduction

North Carolina has a vast and sustainable woody biomass resource that could be used to offset much of the fuel imported into our state (Jeuck, 2008). Although North Carolina already produces 4 percent of its energy using biomass, it has the potential to produce another 10 percent with its existing biomass resources. Almost 60 percent of this additional biomass would come from North Carolina’s enormous forest resource, and the rest would be derived from agricultural and “waste” resources, such as animal renderings, animal waste, and other discarded materials (Rich, 2007).

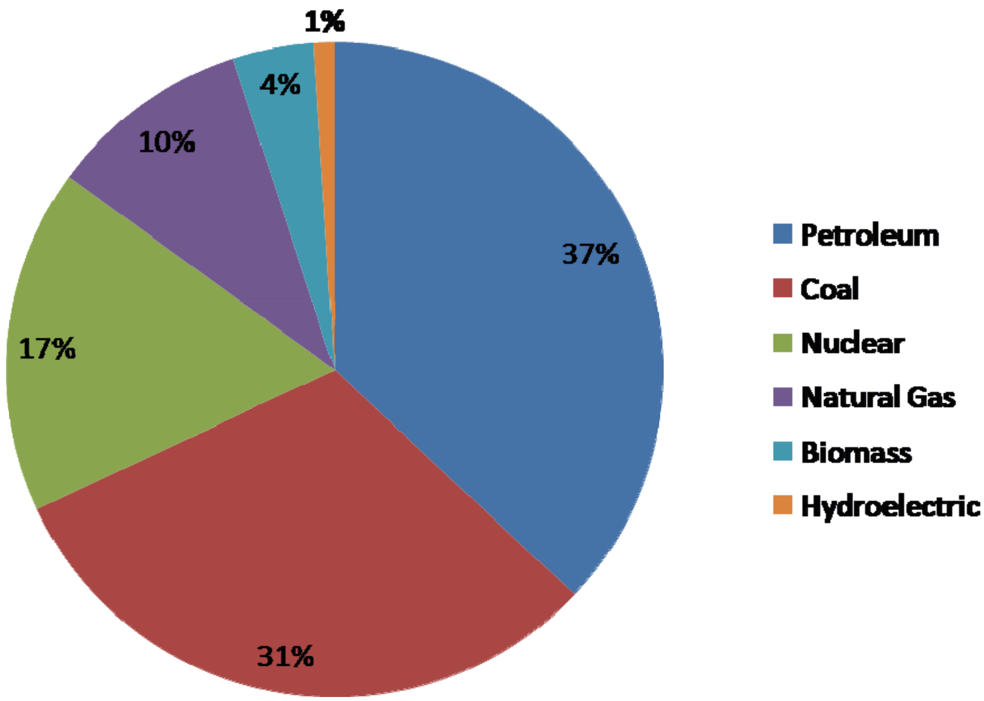
Bioenergy

North Carolina is ranked eighth nationwide in biomass utilization, consuming an estimated 2,633.8 trillion British Thermal Units (BTUs) of energy (Rich, 2007); only 4 percent of that energy was generated from biomass resources (FIGURE 4*h*-1). The bulk of biomass energy results from wood-fired boilers and landfill gas-to-energy projects.

North Carolina’s Renewable Energy Portfolio Standard

Interest in renewable energy is being fueled by the combined effects of declining fossil fuel availability, rising costs of extraction and transportation, and growing worldwide demand from industrializing countries (Hazel and Hobbs, 2008). In August 2007, the NC General Assembly adopted a Renewable (energy) Portfolio Standard (RPS) through passage of Senate Bill 3-2007. The legislation requires all NC investor-owned utilities to displace 12.5 percent of 2020 retail electricity sales. A minimum of 7.5 percent of total electricity

FIGURE 4*h*-1. NC energy consumption, 2002.



Source: Rich, 2007

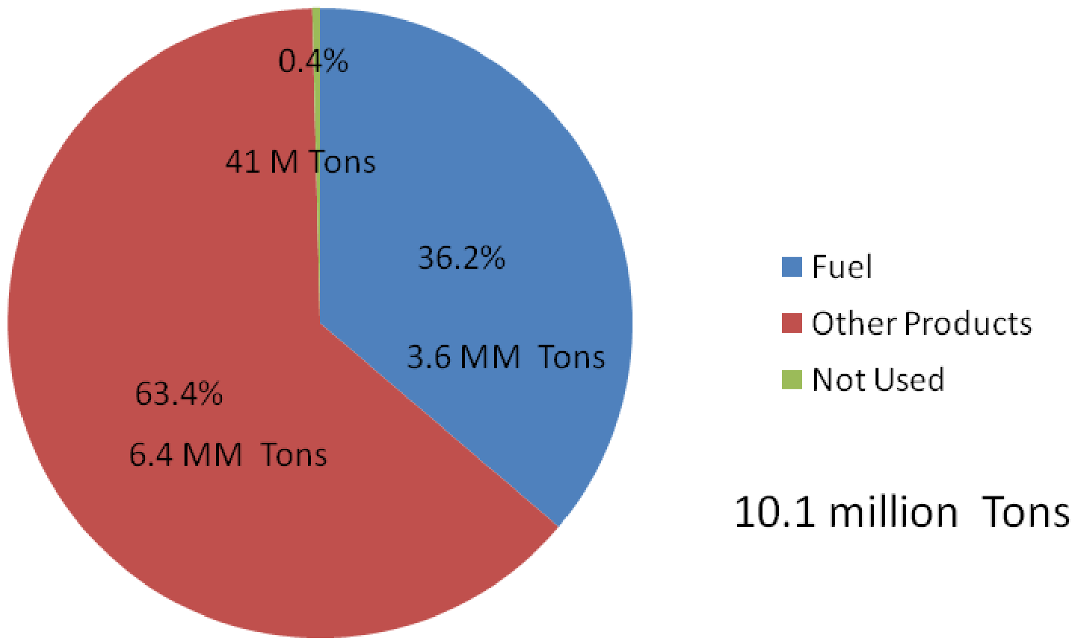
must come from in-state renewable energy sources, and 5 percent can be credited to energy efficiency measures. Municipal utilities and electric cooperatives must meet a target of 10 percent renewable energy use and energy efficiency by 2018 under slightly different rules. Eligible renewable energy resources for the NC RPS include solar electric (photovoltaic), solar thermal, wind, hydropower, ocean current or wave energy, landfill gas, waste heat from renewable, hydrogen derived from renewable, and biomass from farms and forests. The NC RPS provides for improved net metering and interconnection standards, and values the use of combined heat and power (CHP) technology.

Existing Use of Biomass

Wood processing and manufacturing facilities already utilize most of the sawdust, bark, and shavings waste for energy and other products, such as particle board and paper (Hazel and Hobbs, 2008). The NC Division of Air Quality (NCDAQ) data on facilities with wood-fired boilers and USDA Forest Service Timber Product Output data for 2005 were used to estimate the throughput of biomass feed stocks for nearly 200 industries and primary processing facilities. NCDAQ data indicated that about 1.5 million tons of biomass feed stocks are used annually by the nonprimary processors. The primary processing facilities used approximately 3.6 million tons annually (FIGURE 4*h*-2). The production of electricity in North Carolina consumed 5.1 million tons of biomass feedstock in 2005.

The northern counties of the coastal plain are the largest consumers of biomass for energy production in North Carolina, followed by the piedmont, southern counties of the coastal plain, and the mountains.

FIGURE 4*h*-2. NC Forest industry residues by product class.



Source: Johnson and Mann, 2007

Future Biomass Resources

New woody biomass-based energy under the RPS will come directly from forest thinning, restoration cuts, and logging residues (slash, unused tops, limbs, and nonmerchantable stems). In cases where pulpwood markets are nonexistent or a minor market component, wood normally harvested as pulpwood may be used. The majority of the biomass resource is located in North Carolina's poorest and most rural areas, which will focus economic development where it is most needed. Experts claim that biomass utilization could be a multibillion dollar industry for North Carolina (Hazel and Hobbs, 2008).

Analysis of North Carolina's biomass availability (TABLE 4*h*-1) suggests a sustainable supply of some 4.7 million tons of biomass strictly from the residues of softwood and hardwood conventional harvests. Another 3 to 3.6 million tons a year may be available from the harvest of residual saplings or thinning operations. The unused woody biomass reserves nearly equal the available pulpwood that supplies the existing pulp and paper industry within North Carolina and its bordering states (Megalos, 2008a).

TABLE 4*h*-1.—NC woody biomass availability (tons/year)

	Logging Residues	Residual Saplings	Post-Thinning Residues	Total Residual Biomass	Pulpwood Yields (for comparison)
Softwood	1,557,979	462,109	392,358	2,412,446	3,831,581
Hardwood	3,142,710	2,587,764	216,247	5,946,722	4,850,434
Total	4,700,689	3,049,874	608,605	8,359,168	8,682,015

Source: Megalos (2008a)

North Carolina appears to have ample distributed woody biomass resources. A study completed for the U.S. Environmental Protection Agency (EPA) OSWER Center for Program Analysis (FIGURE 4*h*-3) indicates that North Carolina is well suited for several biopower facilities, especially throughout the piedmont and the coastal plain and in select counties in the mountains.

Concerns about Using Biomass

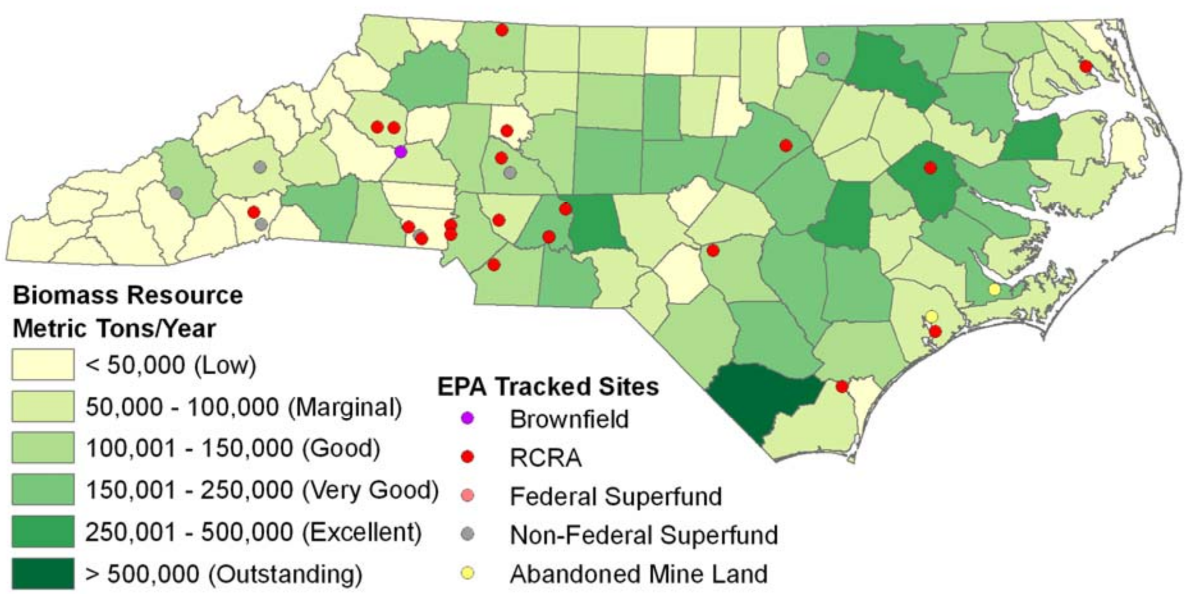
High energy costs, concerns over fossil fuel emissions, and legislation to favor renewable energy will likely contribute to new and expanded woody biomass markets. The expansion of a wood-based energy industry, however, has prompted concerns about intensified forest biomass removal and its impact on water, wildlife, biodiversity, and site nutrients (Megalos, 2008b).

Harvests that utilize biomass for energy and other value-added products are likely to be unsustainable where the following conditions occur:

- Markets do not exist in close proximity to the resource (transportation is cost prohibitive).
- Small diameter material is on the verge of becoming a higher-valued product and thus can generate a greater price than biomass by growing it for additional years.
- Biomass removal will jeopardize or degrade the multiple forest resources already in place.

The ultimate fate of successful woody biomass operations depends upon viable forest products markets, harvesting and transportation costs, price points, and a sustainable supply. Biomass harvests can help sustain the state forest resources where a shift to greater productivity is wanted and when these conditions occur:

FIGURE 4*h*-3. U. S. Environmental Protection Agency tracked sites in North Carolina with biorefinery facility site potential.



Created by: A. Bailey, NCDFR, 2010

- Stands are degraded or understocked and in need of regeneration or restoration.
- Low-quality material or a poor species mix exists or predominates.
- Stands are dense, and current markets preclude the commercial sale of overstocked biomass.
- Biomass removals results in improved wildlife habitat, access, or enhanced protection from fire, insect damage, and disease.

Summary

North Carolina currently produces about 4 percent of its energy needs using woody biomass but could provide an additional 10 percent from its forest resources. In August of 2007, the NC General Assembly adopted a Renewable (energy) Portfolio Standard (RPS) through passage of Senate Bill 3-2007. The legislation sets several targets through 2018 to promote the use of renewable energy feedstocks. Concerns about the impacts on water, wildlife, biodiversity, and site nutrients must be addressed as North Carolina seeks to increase its use of renewable feedstocks for energy production.

Map Data Sourcess

FIGURE 4h-3: US EPA 2009

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Glossary

primary processors. Industries receiving roundwood or chips from roundwood for the manufacture of products, such as veneer, pulp, and lumber.

4.i.

Recreation Resources

Key Findings

- Forest-based recreation and tourism are driving forces for protection and management of public and private lands.
- Nature-based tourism and lease arrangements can offset recreation management costs on private and public forests.
- Recreational demand is expanding and outpacing the ability of public funds to protect public forestlands.
- A strong network of environmental education centers, state educational forests, outdoor education programs, and camps are helping to inform the next generation of state leaders and voters who are committed to sustaining North Carolina’s forest resources.

Introduction

In 2007 businesses that supported fishing, rafting, and camping contributed more than $7.5 billion to North Carolina’s economy (Outdoor Industry Association, 2007). Nature-based recreation in North Carolina depends on the diverse natural resources that cover the state. Recreation on state- and nationally-owned forests and parks, wildlife refuges, and gamelands encompasses many recreational uses, such as walking, hunting, fishing, hiking, and environmental education. These uses also involve private businesses located near recreational areas and stimulate local economies, which in turn bolster the demand for recreational land use.

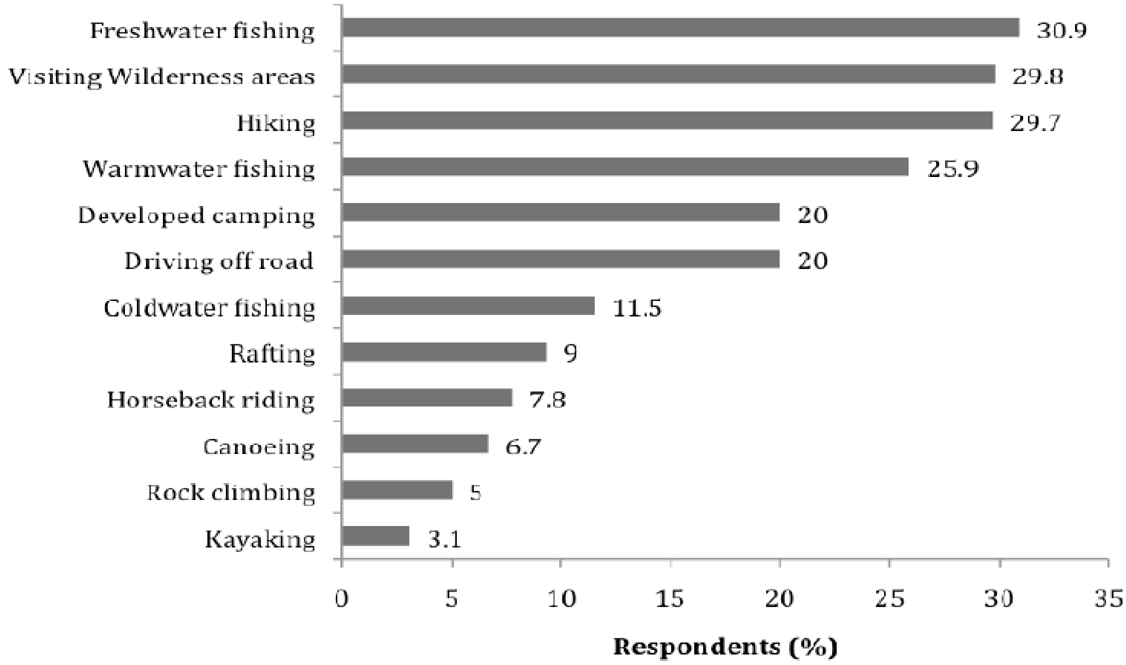
Demand for Forest-Based Recreation

Public lands are an important recreational resource for North Carolina’s burgeoning population. Federal agency landholdings increased slightly (40,000 acres) between 1999 and 2007, while state, local, and private nonprofit conservation organizations conserved almost 500,000 acres. As North Carolina’s population continues to increase, greater demands will be placed on the state’s forest resources (Joint Legislative Commission on Land and Water Conservation, 2007).

The National Survey on Recreation and the Environment (NSRE) found that over 97 percent of Americans age 16 and over participated in at least one of the 80 outdoor recreation activities surveyed during the year prior to survey interviews. Based on results from the NSRE 2006 survey, visiting wilderness areas is the most popular nature-based land activity (29.8 percent) and freshwater fishing (30.9 percent) is the most popular water-based activity in North Carolina (FIGURE 4*i*-1).

A recent survey identified 2.8 million wildlife recreation participants in North Carolina in 2005 (USDI, 2006). Those participants spent $2.8 million that year,

FIGURE 4*i*-1. Popularity of recreational activities in North Carolina in 2006 based on percent of respondents.



Source: *2000 – 2002 National Survey on Recreation and the Environment* (Interagency National Survey Consortium, 2006)

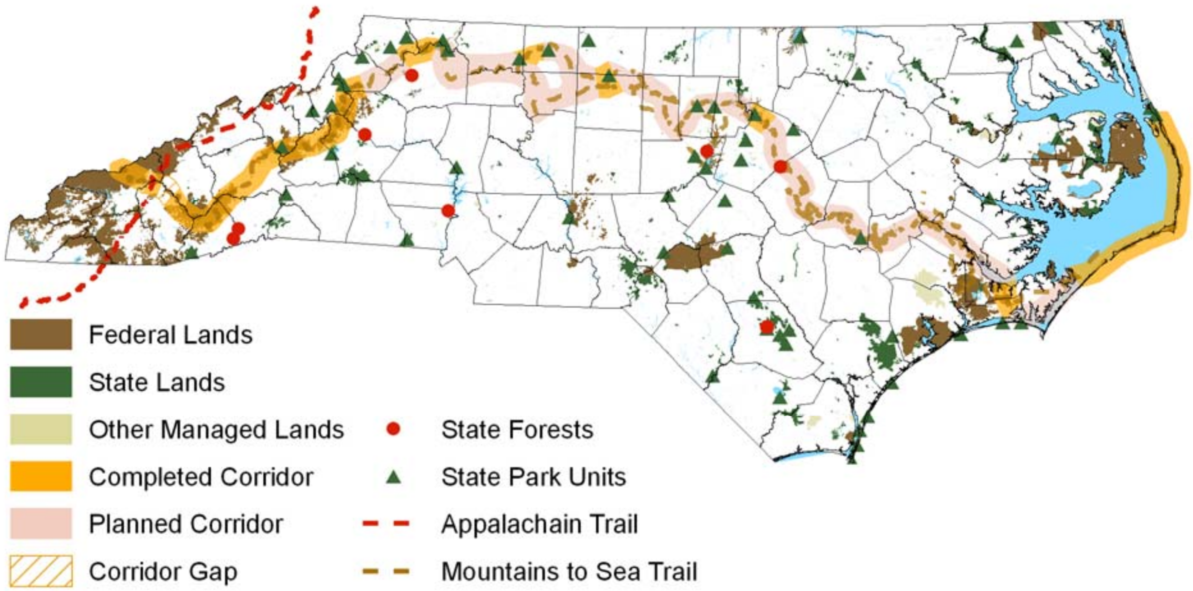
with more than one-third of that total on trip-related expenses. Those involved in fishing and hunting accounted for $1.8 million of that total and spent almost $900,000 for equipment. At least 2.8 million participants were involved in some type of wildlife or outdoor-related activity in 2005; and of that total, almost 2 million were between 6 and 15 years old.

Recreation Resources

Outdoor recreation activities can be divided into those that use a facility and those that depend primarily on a natural resource. Any land or water resource used to produce satisfying leisure is considered a recreation resource. Federal conservation agency lands provide a large amount of the undeveloped land and water or "green infrastructure" used for outdoor recreation in North Carolina. State-owned outdoor recreation lands are generally less developed than those found in most southeastern states (NC Division of Parks and Recreation, 2008).

Some data are available (FIGURE 4*i*-2) on protected lands in North Carolina. It can be assumed that most protected lands are available for a limited array of recreation or nonconsumptive public uses. Protected lands account for 10 percent of the total area of North Carolina (McKerrow, Williams, and Collazo, 2006). The largest areas of protected land are located in the eastern and western portions of the state, where accessibility and economic use is often limited by wet or mountainous terrain. In the NC coastal plain, protected areas are mostly U.S. Fish and Wildlife Service National Wildlife Refuges, U.S. Department of Defense military installations, and the Croatan National Forest. Protected areas in the western mountains of North Carolina include the Cherokee, Nantahala, and Pisgah National Forests, the Great Smoky Mountains National Park, and ever-expanding NC Wildlife Resources Commission game lands. The relatively few large protected areas in the NC piedmont are upland lands owned by the U. S. Army

FIGURE 4*i*-2. North Carolina open space and conservation land.



Created by: A. Bailey, NCDFR, 2010

Corps of Engineers surrounding man-made reservoirs and the highly fragmented Uwharrie National Forest (McKerrow, Williams, and Collazo, 2006).

Recreation, tourism activities, and nonconsumptive uses of forests occur on public lands usually at no or low cost to the participant. Nearby private sector and economic development revenues provide benefits to forest-dependent communities where public lands predominate. In western North Carolina, such places as the Nantahala River, the Nantahala National Forest, the Great Smoky Mountains National Park, and the Blue Ridge Parkway are protected lands that support numerous river- and forest-based outfitters and private tourism-related businesses (such as restaurants, gas stations, and tour guide services). These public places make direct impacts on local economies. For example, forest-based recreation contributes directly to over 80 percent of Swain County's economy.

In the NC piedmont, the U.S. National Whitewater Center has blended man-made improvements — "the world's largest recirculating river" and rock climbing towers—with the Catawba River and 300-plus acres of forest cover that include 14 miles of hiking, biking, and running trails. Central Park NC is a regional nonprofit that is connecting small business owners with natural-resource-based and sustainable economic development opportunities in and around the Uwharrie Forest and North Carolina Zoo in attempts to make these resources premier tourist destinations.

In northeastern North Carolina, a regional nonprofit organization, Roanoke River Partners, has created a network of 14-plus canoe camping platforms that attracts boaters, fishing enthusiasts, birdwatchers, and other outdoor travelers for multiday visits to the five-county Lower Roanoke River area. North Carolina has partnered with another regional nonprofit organization, Partnership for the Sounds, to promote a regional economic development strategy focused on ecotourism development and environmental education. In southeastern North Carolina, Turnbull Creek

Educational State Forest is one of six forests (www.ncesf.org) managed by the NC Division of Forest Resources to provide hands-on environmental education experiences that are helping teachers meet state science curriculum requirements.

Regional trails provide opportunities for some of the most popular recreation activities in North Carolina as well as corridors for nonmotorized transportation, wildlife, and interconnecting larger open areas. The city of Raleigh's greenway system, the American Tobacco Trail, the Carolina Thread Trail, and the Mountains-to-the-Sea Trail are all corridors that provide recreation, and link forested areas, open spaces, developed recreation facilities, and communities across the state. The NC Birding Trail, Charles Kuralt Trail, NC Paddle Trails, Homegrown Handmade Trail, Historic Albemarle Trail, NC Scenic Byways, NC Civil War Trails, and other trails provide access to bird-watching, historic and cultural tourism, agritourism, and other recreational and tourism activities against a backdrop of forestlands.

The southern portion of the Blue Ridge Parkway, a nationally significant Scenic Byway, provides a transportation corridor winding through public and private forests, small towns, and tourism destinations. The Scenic Byway also provides an important demonstration of viewshed protection to support non-timber-related recreational and economic development opportunities for many mountain counties.

The 2008 edition of the *Guide to Environmental Education Centers in North Carolina* lists 185 environmental education (EE) centers across the state, including the six educational state forests operated by the NC Division of Forest Resources (NC Office of Environmental Education and NC Association of Environmental Education Centers, 2008). According the Guide, these facilities

> "…provide quality environmental education for the public, including exhibits, programs and outdoor experiences. …EE centers serve as valuable community assets by conserving our state's essential ecosystems and providing places for our citizens and visitors to experience and appreciate the natural world."

In addition to providing land for activities, many of these facilities feature educational programming that focuses on the diverse landscape, communities, and surrounding forests throughout the state.

Forest-based Recreation Supply Challenges

As noted in the *NC Outdoor Recreation Plan* (NC Division of Parks and Recreation, 2008), communities across North Carolina are experiencing very different challenges in the 21st century. Piedmont metropolitan areas are growing rapidly as more people move into the area, drawn by the good jobs, good schools and colleges, mild climate, and an abundance of recreational opportunities. This increased growth is threatening open space and causing land prices to escalate. Conversely, other regions in the state have suffered job losses as traditional industries close. Slowing economies, tighter local budgets, and fewer resources are left to meet the needs of residents.

Municipal and county recreation departments have identified a $230 million backlog for capital improvement and land acquisition of more than 22,000 acres (Tucker, 2007). The NC Division of Parks and Recreation has identified a need of $335 million for new construction and the renovation of existing state parks facilities (excluding needs for new state parks).

State conservation trust funds provide funding for acquisition of green infrastructure for forest-based recreation facilities and activities. The bulk of recreation funding is available through local government bond referenda. Between 2004 through 2008, 23 counties and municipalities passed $721.23 million in bond referenda for recreational facilities and parkland, largely in the urbanized piedmont.

Summary

North Carolina’s natural resources support a myriad of recreational opportunities, ranging from wildlife viewing to hunting and fishing, and are the basis for a multibillion dollar outdoor recreation industry. As the population in North Carolina increases, the demand for recreational opportunities and resources will continue to increase. This increase in recreational demand will require a balance between protection and use.

Map Data Sourcess

FIGURE 4i-2: NCDENR, NC One Naturally, 2009

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4.j.

Heritage Resources

Key Findings

- North Carolina is richly endowed with centuries-old archaeological sites that preserve the human experience across its diverse natural and cultural landscape. Currently 27 sites are designated as "State Historic Sites."
- North Carolina's heritage and archaeological history is closely intertwined with the utilization and conservation of the state's forests.
- North Carolina has more than 192 environmental education centers, which includes 7 educational state forests and 3 dedicated forest history sites.
- There is a lack of forestry outreach program evaluation, impact data, and needs assessment.

Introduction

North Carolina's heritage, or cultural resources, includes the physical remains, archaeological sites, historic structures, archival records, oral traditions, and human-modified landscapes that serve as records of past human activities. North Carolina is richly endowed with centuries-old archaeological sites that preserve the human experience across its diverse natural and cultural landscape.

Historic Sites

The NC Department of Cultural Resources preserves places and properties that played a key role in the state's formation and history. Currently 27 sites are designated as "State Historic Sites." These sites showcase buildings and grounds for education, awareness, and appreciation by visitors and the citizenry (FIGURE 4*j*-1). Homesteads and living historic farms also seek to illustrate long-gone agrarian lifestyles that shaped the landscapes of today with subsistence farming and exploitive natural resource use.

Archaeological Sites

Archaeological sites capture a prehistory of more than 12,000 years of human habitation prior to European settlement in what was to become the state of North Carolina. Knowledge and use of forest resources among prehistoric people were undoubtedly quite high. People throughout prehistory exploited wood and bark for tools and shelters, medicinal plants, and natural plant food sources (such as nuts, shoots, and root crops). Archaeological study is the chief means for understanding this prehistoric period. During the 1540s, Spanish explorers under the leadership of Hernando De Soto encountered several Carolina Indian groups who were occupying the entire mid-Atlantic coastal area, linked by a commonly shared language and culture called Algonkian.

The Native Americans whom De Soto met included Siouan, Iroquoian, and Muskogean

FIGURE 4*j*-1. Location map of current NC "State Historic Sites."

Created by: NC Department of Cultural Resources, 2010

speakers, commonly referred to today as the historic ancestors of the Catawba, Cherokee, and Creek tribes (Claggett, 1996). Points and artifacts provide the only material to describe, interpret, and marvel at ingenuity of prehistoric people (FIGURE 4*j*-2). The identification and study of archaeological resources increase our knowledge of land management by our earliest ancestors and their daily activities.

Religious Sites

Early settlement groups, often driven by the pursuit of religious freedom, left their mark on the North Carolina landscape in the form of settlements and church buildings that range from grand urban edifices to simple rural meeting houses. Examples of Episcopal, Quaker, Methodist, Baptist, Presbyterian, Lutheran, Reformed, Moravian, and some Catholic and Jewish denominations exist as historically registered places of worship across North Carolina. The preservation of cemeteries and churches of early African-American postemancipation congregations are also of great historic significance and public pride.

Heritage Landscapes

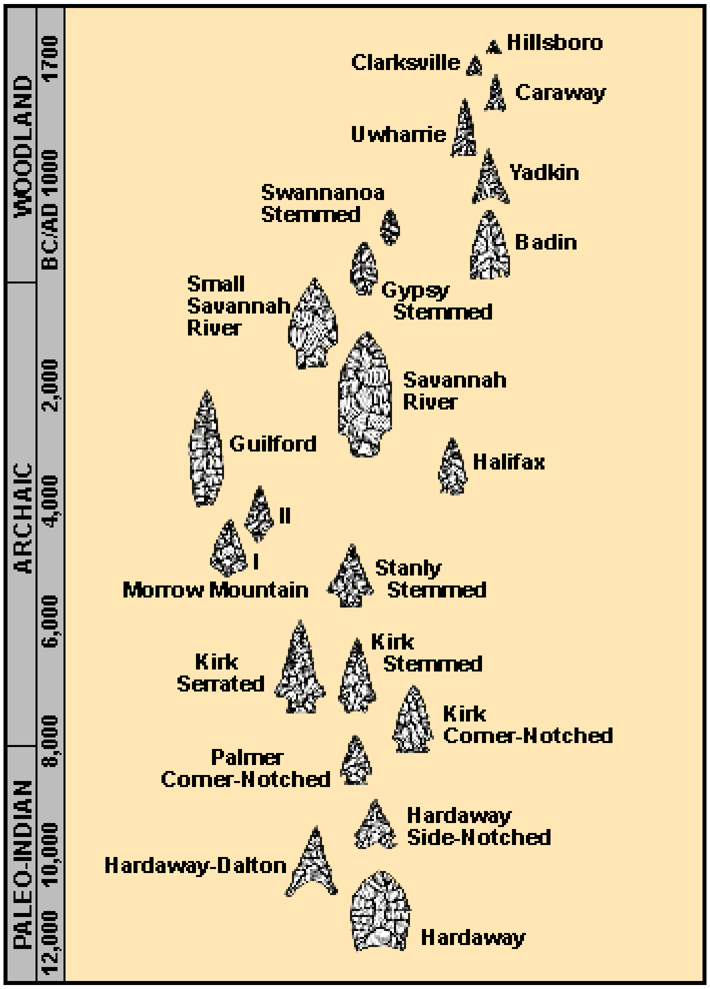
Forest Landscapes

Today, visitors to the North Carolina mountains can learn more about the unique aspect of the region's agricultural and early forest heritage at the Cradle of Forestry, a 6,500-acre State Historic Site within the Pisgah National Forest, near Brevard, that was established by Congress to commemorate the beginning of forestry conservation in the United States.

Blue Ridge National Heritage Area

North Carolina's mountains and foothills have become the geographic center of handmade crafts in the United States. Today more than 4,000 craftspeople live and work in western North Carolina. Congressional designation of the Blue Ridge National Heritage Area in 2003 officially recognized the heritage importance of 25 western counties and the Cherokee Qualla (Reservation) Boundary. Appreciation of the region's past includes the interpretation, preservation, and celebration of crafts, music, agricultural traditions, and a rich natural and Cherokee heritage.

FIGURE 4*j*-2: Projectile points of the NC piedmont.



Source: Ward, H. T., 1983

The NC Department of Cultural Resources contains specific offices relating to preservation of heritage resources. The Office of State Archaeology (OSA) protects endangered archaeological sites on private or public lands through enforcement of the NC Archaeological Resources Protection Act (G.S. 70, article 2) among other laws. The OSA also maintains a statewide, computer-based inventory of archaeological sites, along with maps, photographs, and artifact collections. This inventory includes such significant sites as Indian villages, shipwrecks, and colonial plantations listed in the National Register of Historic Places.

Services of the OSA that can be useful to forest managers or landowners include the following:

- Performing map checks for recorded archaeological sites
- Performing site assessments for archaeological resources
- Performing site visits
- Reviewing scope of work for archaeological survey
- Reviewing project plans for potential effects on archaeological resources

The State Historic Preservation Office can also provide the following:

- Access to statewide architectural files, maps, and National Register nominations for sites, buildings, structures, and historic districts.
- Technical assistance to landowners in the maintenance and restoration of historic properties.
- General preservation advice and referrals to other preservation organizations, such as the nongovernmental organization Preservation North Carolina.

Map Data Sourcess

FIGURE 4j-1:NC Historic Sites 2010

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4.k.

Maintaining Viable Urban Forests

Key Findings

- Urban areas within the Piedmont Crescent are high-priority areas for tree conservation and planting efforts to improve local air quality.
- Communities of all sizes and in all regions of North Carolina could reduce energy consumption with strategic tree planting efforts; the more densely populated areas are higher priority areas.
- North Carolina municipalities are predicted to lose approximately 6 percent of their current forestland between 2010 and 2030. A higher number of mountain communities will lose forestland; the greatest amount of change will occur in the piedmont.
- Natural disasters have the greatest impact on urban forests within the northern counties of the North Carolina piedmont and the southern counties of the North Carolina coastal plain.
- Only one out of every three communities has at least one of the four performance measures that lead to an active urban forestry management program.

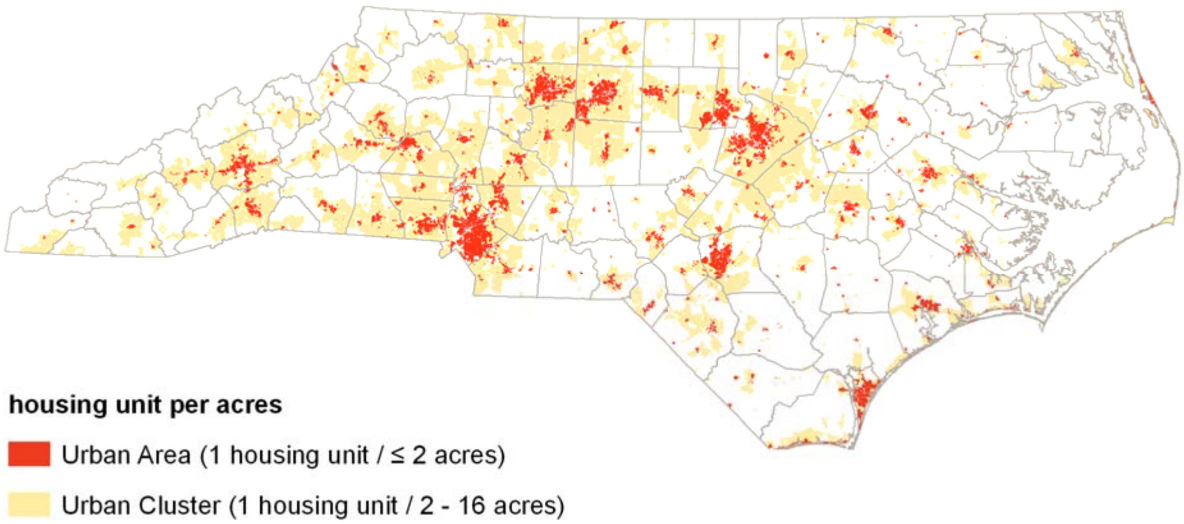
Introduction

Rapid urbanization is a growing threat to the sustainability of the trees and forests in North Carolina’s communities. Urban forests are the natural backyards for many communities, serving as society's connection to nature and improving our quality of life. Proactive management, strategic green infrastructure planning, and proper policy development will be necessary to restore, conserve, and connect the trees in our communities.

The primary goal of this assessment is to identify priority areas where forest loss would have the greatest potential to make a negative impact on urban and community forests. This assessment (1) describes urban forest conditions across the state, (2) identifies benefits and services associated with the urban forest canopy, (3) highlights trends and issues of concern within the urban areas, and (4) outlines strategies for addressing the critical urban forest issues and priority urban forest areas.

For this report, we define an urban forest as the system of trees, and associated natural resources within city jurisdictional limits, as well as the surrounding area where the urban fringe is expanding into the rural landscape. The assessment will focus on the urban areas and urban clusters described by Hammer et al. (2004) (FIGURE 4*k*-1 and TABLE 4*k*-1). *Urban areas* have a housing density of at least one house per 2 acres. *Urban clusters* are defined as areas with a housing density of one house every 2 to 16 acres. *Urban clusters* are associated with the edge of urban areas, and also capture rural communities that are experiencing growth in population and development.

FIGURE 4*k*-1. North Carolina urban housing density in 2000 and designation of urban areas and urban clusters, representing land area included within the analysis.



Created by: A. Moore, NCDFR, 2010

TABLE 4*k*-1.—Area within each urban designation by forested and nonforested land use

	Forested Acres	Nonforested Acres	Total Acres
Urban Area	285,174	1,187,228	1,472,402
Urban Cluster	3,927,110	3,684,091	7,611,201
Total Acres	4,212,284	4,871,320	9,083,603

Created by: A. Moore, NCDFR, 2009

There are 655 census-designated places (communities and towns) across North Carolina (U. S. Census Bureau, 2002). Most of the municipalities across North Carolina are small communities, with populations of less than 10,000 (TABLE 4*k*-2). Trends in urban forest conditions often are based on community size and location, in terms of planning needs and resources available.

A healthy urban forest has been defined as an urban forest with the ability to provide sustained goods and services, such as clean air and water, energy conservation, storm water mitigation, sense of place and high biodiversity (McPherson, 1993). The North Carolina Urban and Community Forestry Program (U&CF) uses this broad definition as the building block of a healthy urban forest. A healthy urban forest is one that is actively managed for long-term benefits, is structurally diverse enough to withstand environmental change and periodic catastrophic events, and consists of an interconnected network of green space that conserves the natural ecosystem values and function. The result is an urban forest in which the environmental goods and services provided far outweigh the cost associated with managing and maintaining the resource.

Spatial Analysis Methodology

To assess direct conservation of viable urban forests in North Carolina, we identified five prominent issues that negatively impact urban forest management; (1) changing land use patterns and increasing urbanization are

TABLE 4*k*-2.—Size classification of North Carolina communities based on population

Community Size	Population	Number in North Carolina
Small	< 10,000	590
Medium	10,000 – 60,000	52
Large	> 60,000	13

Source: U. S. Census Bureau, 2002

threatening the health and viability of urban forests, (2) natural catastrophic events can threaten the health, value, and ecological integrity of urban forests, (3) rise in atmospheric concentration of greenhouse gases has and will continue to have an impact on climate, air quality, and quality of life, (4) urban tree canopy is underutilized as a tool in energy conservation efforts, and (5) urban forestry information and education is not reaching the citizens to generate support and advocacy at the local level needed to develop proactive urban forest management programs. Water quality, stormwater management, and urban pests and disease were determined to have significant impact on urban forest health; however they are discussed in their entirety in other chapters of this assessment. Analysis for each issue was limited to the urban area and urban cluster regions (FIGURE 4*k*-1). To pinpoint the aforementioned priority areas, available GIS data layers that best represent the components of each issue were identified. The data layer used for each issue was given a relative importance value, included in the priority index, to reflect each issue's importance relative to the other layers in the analysis. The working group using their professional experience and knowledge decided upon importance values. Data layers were combined through a weighted overlay analysis using the relative importance value. The weighted overlay process gives each 30-m^2 pixel a value expressed as a percentage of the total possible score. The resulting output produced a pixel-value map referred to as the "Priority Areas" map. The determination of *very low* through *very high priority* is a relative designation based on natural breaks within the data.

From each Priority Areas map, the average score of all the pixels within the boundaries of the U.S. Census named places in North Carolina was determined. The resulting map is referred to as the "Priority Places" map, which shows the cities and towns with the highest priority for U&CF programs and initiatives to solve the problems identified within each issue.

Issue 1. Changing land use patterns and increasing urbanization are threatening the health and viability of urban forests.

North Carolina is currently the sixth fastest growing state in the nation by population (U. S. Census Bureau, 2000). In general, metropolitan areas across the United States grew faster (14 percent) than nonmetropolitan areas (10 percent). This rapid population growth is fueling development patterns that (1) lead to fragmentation of forest lands and (2) threaten the long-term health and viability of our urban forests. Research has documented that urban forests provide specific environmental, social, and economic benefits, including clean air and water, cooler ambient air temperatures, storm water runoff mitigation, wildlife habitat, and recreational opportunities. As the urban tree canopy and associated green space is removed, the amount of natural resources that provide the benefits noted is diminished and fragmented, thereby reducing the benefits an urban forest can provide.

Local land-use planning processes often do not integrate strategies to conserve a connected green infrastructure alongside new growth. The loss of connectivity among urban green spaces leads to loss of biodiversity and reduced ecosystem function. Moreover, traditional development patterns often result in habitat fragmentation, loss of biodiversity across the landscape, decreased air and water quality, and disconnection between people and their natural surroundings. Habitat loss and conversion are considered two of the most critical threats to fish and wildlife resources in North Carolina. According to the *NC Wildlife Action Plan*, open spaces (such as fields, forests, and river corridors) within the urban and suburban environment are crucial for conserving populations of development-sensitive wildlife species.

Five data layers were used to identify patterns of changing land use, especially where urbanization threatens the health and viability of urban forests (TABLE 4*k*-3). The *Urban Extraterritorial Jurisdiction* (ETJ) data layer captured the primary locations of urban forests. The *Urban Growth Score* data layer shows the areas that are projected to change from a housing density of no more than one unit per 16 acres to a housing density of at least one unit per 2 acres between the years 2000 and 2030, identifying rapidly changing landscapes across the state. The *Forest Patches* and *Forest Land* data layers from the Southern Forest Land Assessment (SFLA) were used to capture important urban places where forest resources are available. The *Forest Patches* layer emphasizes forest tracts larger than 500 acres and indicates where an urban area development is most likely to fragment the landscape. *Forest Land* is based on land-cover classification and identifies areas that are 25 to 100 percent forestland or shrubland. The *Biodiversity and Wildlife Habitat* layer from the *One NC Naturally* "Conservation Planning Tool" was included to give priority to areas that contribute to overall landscape function and connectivity (such as protect water quality and sensitive natural areas).

North Carolina legislation states that, depending on population size, cities can extend their jurisdiction up to 3 miles from the city limits (Owens, 2006). Municipal boundaries were given a 1-, 2-, or 3-mile buffer, depending on population size, to capture the maximum ETJ as well as the urban-rural interface area where new development and growth may be focused in future years.

Very high and high priority areas appear to be contained within the urban cluster area, around the larger communities (FIGURE 4*k*-2), where there is rapid urbanization and higher amounts of forestland. This supports the need for urban forestry efforts for areas in the urban interface zone across the state.

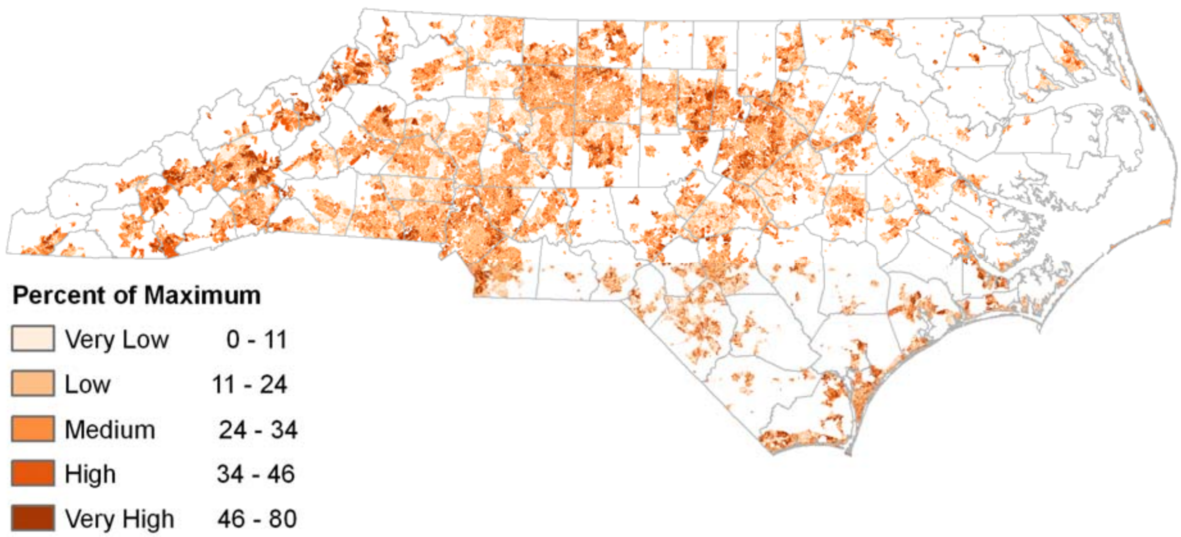
TABLE 4*k*-3.—Layer weights for Issue 1 (Changing land use patterns and increasing urbanization are threatening the health and viability of urban forests.)

Data Layers	Contribution to Priority Index
Urban Growth Score	40%
Urban ETJ	20%
Forest patches	20%
Forestland	10%
Biodiversity/Wildlife Habitat	10%

Created by: A. Moore, NCDFR, 2009

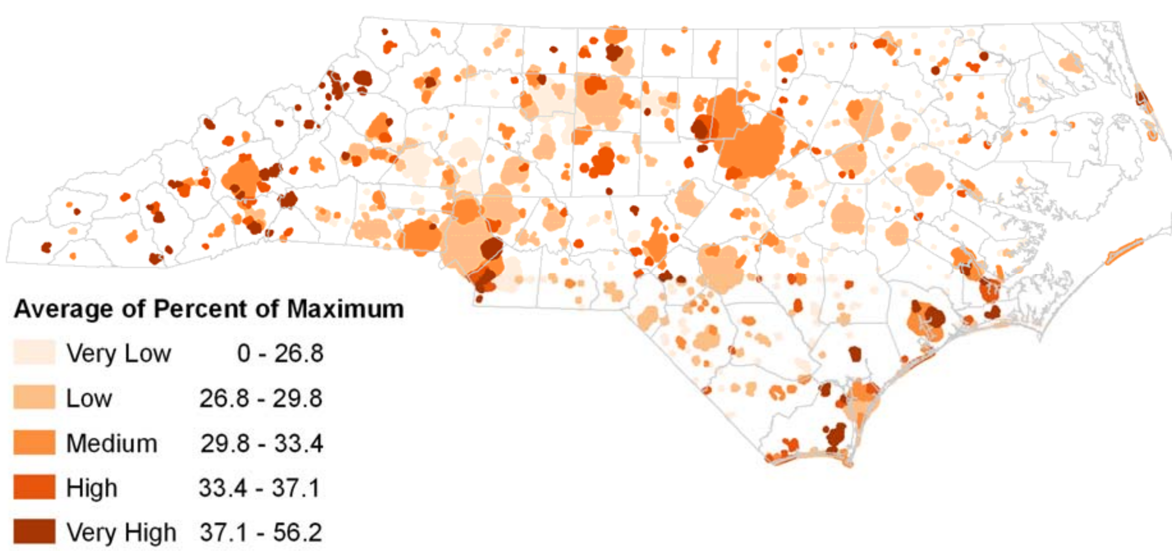
The very high and high priority ranked places are communities that have the greatest amounts of urban forest resources available to manage and where management activities could help reduce the impact of urbanization and land-use changes on the urban forest (FIGURE 4*k*-3). High priority communities varied in size and location across the state. However, the mountains contain 41 percent of the very high and high priority places, the coastal plain 32 percent, and the piedmont 27 percent. Between 2010 and 2030, North Carolina communities are

FIGURE 4*k*-2. Priority ranking of urban areas identifying areas that would increase urban forest health and viability.



Created by: A. Moore, NCDFR, 2010

FIGURE 4*k*-3. Priority ranking of named places plus associated ETJ, identifying municipalities experiencing rapid growth but currently forested.



Created by: A. Moore, NCDFR, 2010

predicted to lose approximately 6 percent (27,674 acres) of the forestland within their city limits, plus an additional 2 percent (58,301 acres) of forestland will be converted to urban uses within their ETJs (TABLE 4*k*-4).

Issue 2. Natural catastrophic events, including severe storms and floods, can threaten the health, value, and ecological integrity of urban forests.

Natural disasters that can occur in the United States include floods, hurricanes, tornados and other high-velocity windstorms, and ice storms. These events affect communities of all sizes and require a cooperative effort among municipal agencies, private arboricultural companies, utilities, and volunteers (Burban and Andresen, 1994). Natural disasters are a constant threat to the urban forests of North Carolina. Although hurricanes, tornados, ice storms, and wildfires regularly occur in North Carolina, parts of the state are more susceptible than others to these catastrophic events. Natural disasters can have immediate impacts on public safety and infrastructure, and can require a significant amount of time for recovery. Guidelines and methods for determining how to mitigate or minimize the impact of natural disasters are critical in determining the capability of communities to respond.

Nonnative invasive plants, animals, and diseases can devastate urban forests and alter the diversity of the urban tree canopy. The impacts of these threats are addressed in Chapter 3, Section a, "Insects, Diseases, and Non-native Invasive Plants: Threats to Forest Health."

Six data layers were used to analyze the potential of natural disasters to negatively impact urban forests (TABLE 4*k*-5). The *Tree Canopy* data layer showed the forest resource that may be affected by a natural disaster. Because an urban tree canopy data layer does not exist at the municipal level for the entire state, urban tree canopy was derived using the *Forest Land* layer from the SFLA, identifying any area about 1 acre in size exhibiting at least 20 percent canopy. Data layers for natural disasters, including hurricanes, ice storms, and tornadoes, represent the likelihood of an occurrence of each of those events in North Carolina. *Wildfire Risk* is a combination of the probability of a wildfire occurring and the values at risk in the event that a wildfire does occur. *Hurricane Risk* and *Freezing Rain Risk* were given higher weights because of their potential to affect multiple communities at the same time. Conversely, tornado and wildfire events tend to affect single communities and thus were given lower weights. Finally, *Population Density* signifies the human values at risk from a catastrophic event.

TABLE 4*k*-4.—Area within city boundaries and ETJ, by forest and nonforest acres, for 2010 and 2030

	2010		2030	
	Nonforest (acres)	Forest (acres)	Nonforest (acres)	Forest (acres)
City Limits	2,003,106	430,084	2,030,779	402,410
ETJ	3,306,976	2,741,178	3,365,277	2,682,877
Total	5,310,082	3,171,262	5,396,056	3,085,287

Created by A. Moore, NCDFR, 2009

TABLE 4*k*-5.—Layer weights for Issue 2 (Natural catastrophic events can threaten the health, value and ecological integrity of urban forests.)

Data Layer	Contribution to Priority Index
Tree Canopy	40%
Hurricane Risk	25%
Freezing Rain Risk	15%
Population Density	10%
Wildfire Risk	5%
Tornado Risk	5%

Created by: A. Moore, NCDFR, 2009

Communities with the higher average values are at a higher risk of negative impacts to their urban forests from catastrophic events and thus may benefit most from assistance. Priority areas with the highest potential for threats from catastrophic events were concentrated in the southern counties of the coastal plain and in the northern counties of the piedmont, due to the threats of hurricanes and ice storms, respectively (FIGURE 4*k*-4).

To have the greatest impact on the health and viability of the urban forest, efforts should be focused on the communities with very high risk to urban forests from catastrophes (FIGURE 4*k*-5). Communities in the northern piedmont and the southern coastal plain had higher risks than elsewhere in North Carolina.

Issue 3. The rise in atmospheric concentrations of greenhouse gases, especially carbon dioxide, as a result of the burning of fossil fuel and conversion of forest to other land uses, has and will continue to have an impact on climate, air quality, urban forest health, and quality of life.

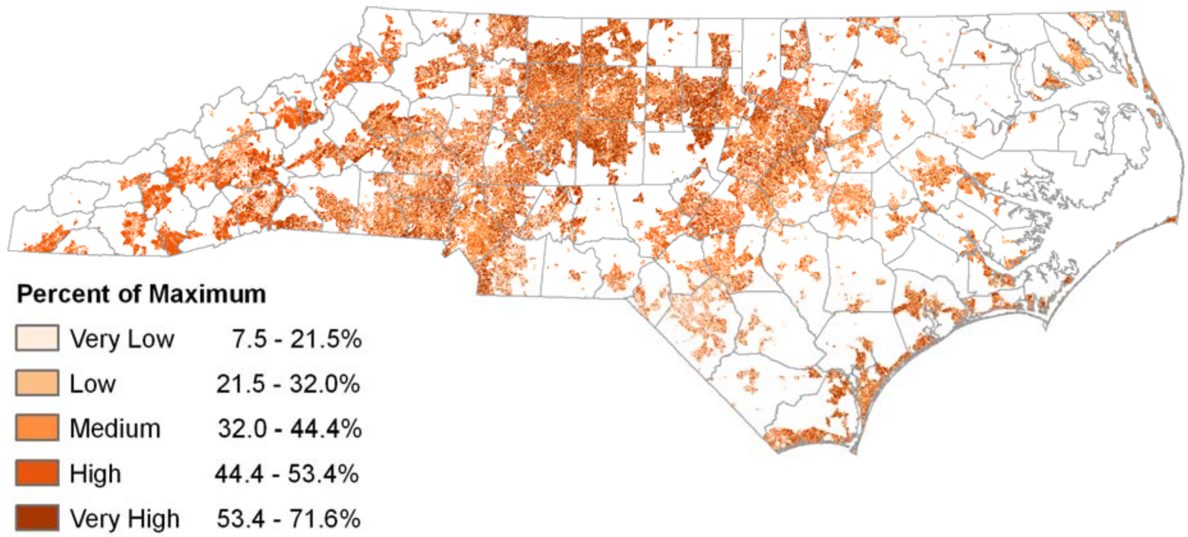
As impervious surfaces replace forest canopy and vegetation, urban “heat islands” develop. Urban heat islands are areas that become warmer than their rural surroundings, forming "islands" of higher temperatures in the landscape. On warm summer days, the air in a city can be 6 to 8°F hotter than in surrounding areas. This change in temperature can lead to disruption of rainfall cycles, more severe and unpredictable weather events, and elevated overall temperatures, which in turn leads to more energy and fossil fuel consumption. Heat islands can affect communities by decreasing water quality and increasing summertime peak energy demand, air conditioning costs, air pollution, greenhouse gas emissions, and heat-related illness and mortality (U.S. EPA, 2010).

Causes for temperature differences in urban areas have been linked to the absence of vegetation and the presence of more impervious surfaces, such as buildings and pavement, absorbing the sun's rays. Urban canopy trees provide shade to decrease daytime ground-level temperatures, sequester carbon in their leaves and woody biomass, and decrease the need to consume energy for cooling if strategically planted.

The U.S. Environmental Protection Agency (EPA) sets standards for the six principle pollutants (carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide) considered to be the main sources of poor air quality. In North Carolina, ozone is the most common air quality problem and the main component in urban smog (NC Division of Air Quality, 2008). Ozone levels generally are higher in urban areas, which contain more cars, industry, and other emissions sources. The energy demands, manufacturing byproducts, and transportation activities associated with urban areas have a direct, negative impact on air quality.

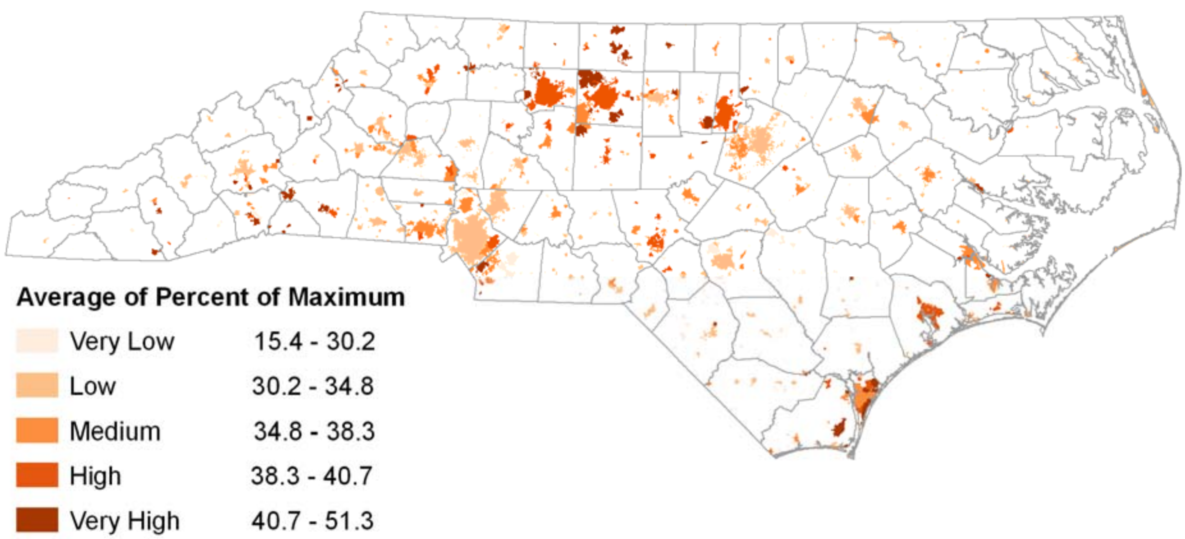
Urban and community forests provide important environmental and human health benefits, including carbon storage and sequestration, air pollution removal, surface

FIGURE 4k-4. Priority areas index identifying where urban forest areas and their associated values are most at risk from catastrophic events.



Created by: A. Moore, NCDFR, 2010

FIGURE 4*k*-5. Priority ranking of named places identifying municipalities where urban forests and their associated values are most at risk from catastrophic events.



Created by: A. Moore, NCDFR, 2010

air temperature reduction, improved water quality, reduced noise pollution, increased property value, improved human comfort, and improved aesthetics (Nowak and Dwyer, 2007). In North Carolina, tree cover in urban areas has been determined to sequester 1.3 million tons of carbon per year ($29 million value) and remove 36,590 metric tons of air pollutants from the air annually (Nowak and Greenfield, 2009).

To identify areas most at risk from air pollution, five data layers were used (TABLE 4*k*-6). Because tree canopy is associated with reduced heat island effect and greater carbon sequestration, *Absence of Tree Canopy* indicates areas of higher priority. Areas designated by the EPA as *Ozone Nonattainment Areas* were included in the analysis to represent areas of poor air quality. Next, the percentage of *Imperviousness* in an area was added to capture the potential for heat islands. *Population Density* was included to show the risk to humans from poor air quality and impacts of urban heat islands. Finally, *Urban Growth Score* was used as an indication of increased pollution and to express the probability of tree canopy loss in the future.

TABLE 4*k*-6.—Layer weights for Issue 3 (The rise in atmospheric concentrations of greenhouse gasses, especially carbon dioxide, as a result of the burning of fossil fuel and conversion of forest to other land uses has and will continue to have an impact on our climate, air quality, urban forest health, and quality of life.)

Data Layer	Contribution to Priority Index
Absence of Tree Canopy	35%
Ozone Nonattainment Area	25%
Imperviousness	20%
Population Density	10%
Urban Growth Score	10%

Created b: A. Moore, NCDFR, 2009

The Piedmont Crescent is located in the NC central piedmont and stretches northeast from Charlotte, through Greensboro and Winston-Salem, to Raleigh-Durham and the Research Triangle area. The Piedmont Crescent is identified as having great opportunity for tree conservation and planting efforts to combat poor air quality (FIGURE 4*k*-6).

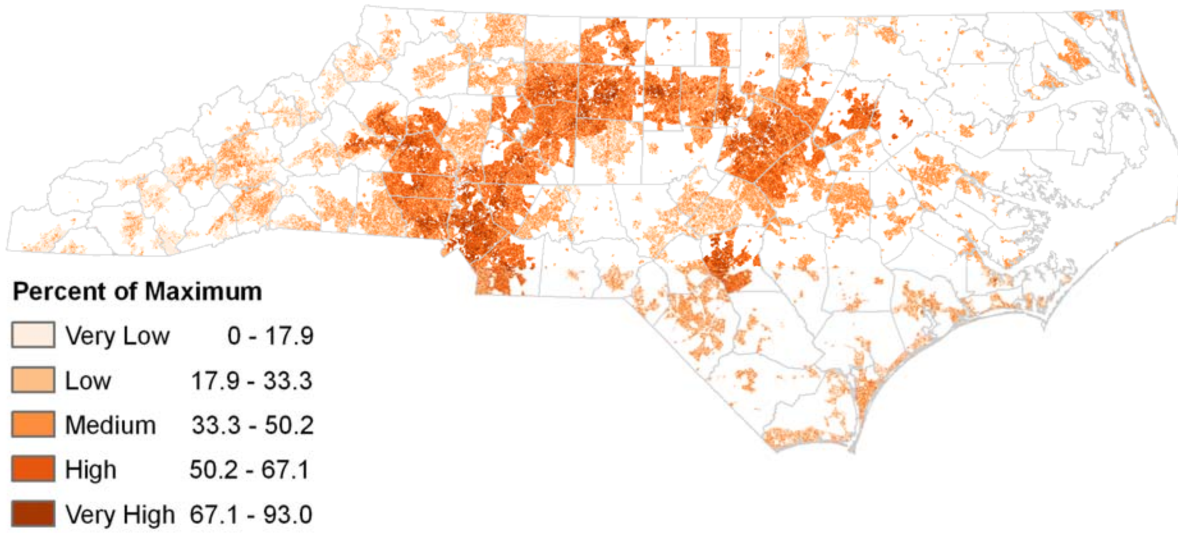
FIGURE 4*k*-7 identifies the communities where tree conservation efforts could be focused to provide the greatest impact on air quality. Most high priority municipalities are located in the NC piedmont, specifically along the I-40 and I-85 corridor. Nine of North Carolina’s 13 largest cities are classified as very high or high priority places for tree conservation efforts.

Issue 4. The urban tree canopy is underutilized as a tool in energy conservation efforts.

North Carolina’s energy consumption is among the highest in the nation (Energy Information Administration, 2010). North Carolina ranks 11th in population, 10th in per capita coal consumption, and 9th in per capita electricity consumption (Energy Information Administration, 2010). More than 50 percent of North Carolina households use electricity for heat, and approximately 42 percent of the electricity consumed in North Carolina is used in homes (FIGURE 4*k*-8).

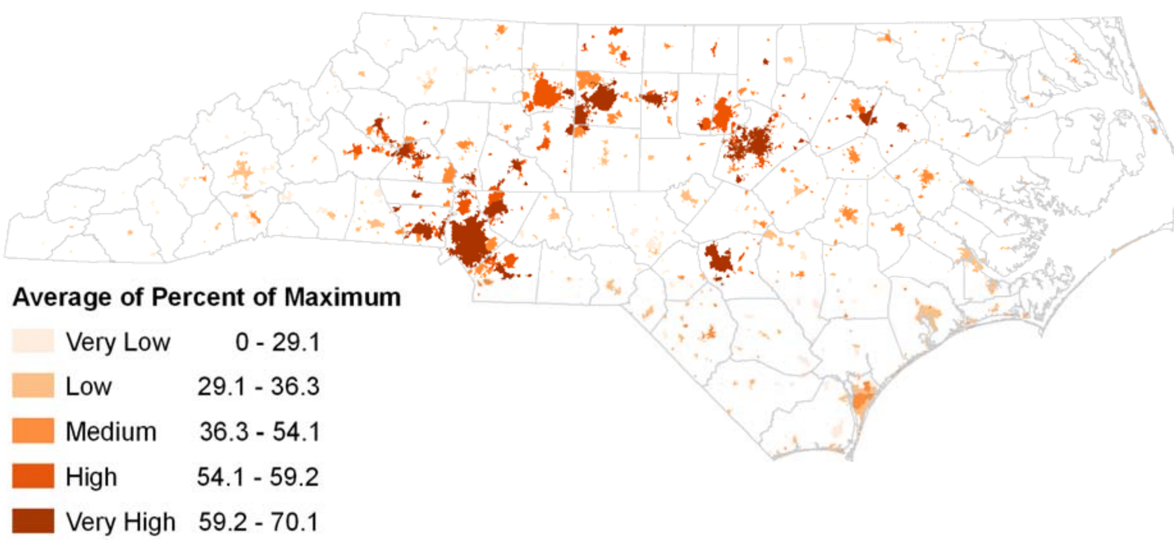
Urban trees are an underutilized tool in energy conservation efforts. A single large tree planted on the west side of a house can reduce annual cooling costs by 9 percent (Urban Forest Research, 2001.) Strategic planting of multiple trees around a building can reduce cooling costs by 15 to 35 percent, and a vegetative windbreak can reduce heating costs by 10 to 20 percent (Arbor Day Foundation, 2009).

FIGURE 4*k*-6. Priority areas index identifying areas with poor air quality, but with opportunities for tree conservation.



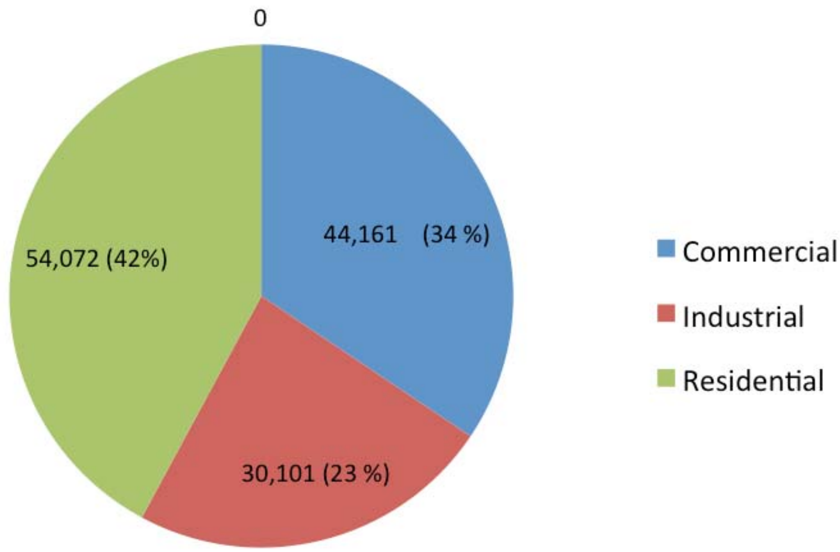
Created by: A. Moore, NCDFR, 2010

FIGURE 4*k*-7. Priority ranking of named places identifying municipalities with poor air quality, but with opportunities for tree conservation.



Created by: A. Moore, NCDFR, 2010

FIGURE 4*k*-8. North Carolina Electricity consumption by sector in million kWh.



Source: U.S. Department of Energy, 2005

The American Clean Energy and Security Act of 2009, HR 2454, encourages utility companies to partner with local nonprofit tree planting organizations to plant trees to reduce residential energy demand. The legislation recognizes that trees can assist homeowners and small businesses in lowering their electric bills by reducing the amount of energy required to heat and cool buildings, which also reduces the peak load demand on the utility company.

McPherson et.al. (2006a,b,c) analyzed the benefits of coniferous and small, medium, and large deciduous urban trees in both yard and public (park and street) settings for the first 40 years following planting. The costs accumulated over 40 years were subtracted from the benefits of 40 years to determine the "Net 40 Benefit" of the tree. Benefits evaluated included reduction in heating and cooling costs, net atmospheric CO_2 reduction, air pollution reduction, rainfall interception, and aesthetics. Costs included tree planting, tree and stump removal, pest and disease control, infrastructure repair, litter and storm cleanup, liability and legal costs, and administration and inspection. Costs and benefits of urban trees were evaluated for all regions of the United States. All three regions of North Carolina were captured in the national analysis (TABLE 4*k*-7).

Large maturing tree species provide more benefits throughout their life than small maturing tree species (McPherson et al., 2006a,b,c). Although these data indicate that the benefits associated with large mature tree species far outweigh the benefits of small trees, a "downsizing" of the urban forest continues. In misguided attempts to reduce maintenance costs, municipalities and homeowners use small maturing species to replace large maturing trees. This action compounds the issue of energy conservation because small maturing trees do not provide the same benefits of carbon storage, shade, and rain interception by their canopy.

To prioritize areas that can best use trees as

TABLE 4*k*-7.—Net benefits of an urban tree from time of planting to 40 years by NC region

Mature Tree Size	Net Benefit over 40 years (Net 40 Benefit)					
	Coastal Plain		Piedmont		Mountains	
	Yard Tree	Public Tree	Yard Tree	Public Tree	Yard Tree	Public Tree
Small	$280	$40	$720	$280	$600	$160
Medium	$1040	$760	$1400	$960	$1360	$640
Large	$4320	$3880	$3680	$3160	$3040	$2320
Conifer	$2040	$1640	$1760	$1120	NA	NA

Source: McPherson et al., 2006a,b,c

an energy conservation tool, six available data layers were selected (TABLE 4*k*-8). *Imperviousness* identifies areas that have the potential to form a heat island, thereby increasing energy consumption for cooling buildings. *Population Density* indicates areas where energy consumption may be the highest and would benefit most from efficiency programs utilizing trees. *Forestland* represents carbon storage that may deserve protection and can be a cooling source through evapotranspiration. *Urban Growth Score* indicates a potential increase in both housing density and associated population, resulting in a reduction of both tree canopy and plantable space and an increase in energy consumption. The *Plantable Space* data layer captures the land not currently in tree canopy or impervious surface and may offer opportunity for tree planting. Finally, *Site Productivity* indicates areas that are most suitable to tree planting and establishment.

TABLE 4*k*-8.—Layer weights for Issue 4 (The urban tree canopy is underutilized as a tool in energy conservation efforts.)

Data Layer	Contribution to Priority Index
Imperviousness	30%
Population Density	20%
Forestland	20%
Urban Growth Score	15%
Plantable Space	10%
Site Productivity	5%

Created by: A. Moore, NCDFR, 2009

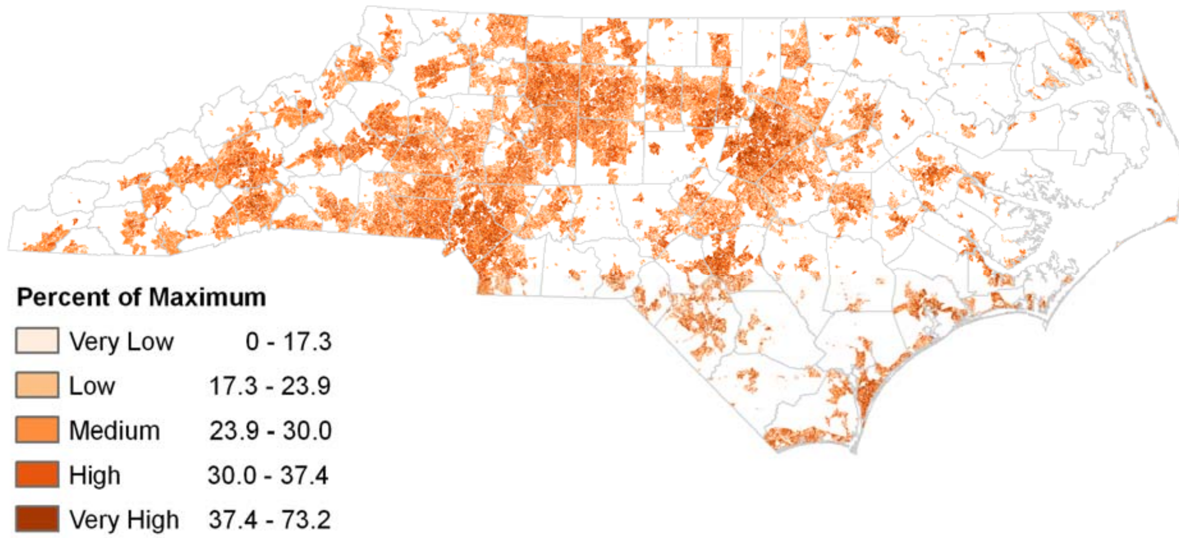
High priority areas are concentrated within and immediately adjacent to the medium and large municipalities across the state (FIGURE 4*k*-9). Communities identified on the map have the ability to reduce overall energy consumption by increasing the tree canopy, no matter what the community's priority ranking. Municipalities identified as high priority are those that have high energy demand (based on population levels) as well as opportunity for tree planting, and therefore have more opportunity to improve energy conservation by increasing urban tree canopy cover (FIGURE 4*k*-10).

Current U.S. urban tree planting efforts aimed at reducing energy consumption, such as Million Trees New York City and the Sacramento Tree Initiative, establish appropriate plantings on public and private property for the greatest benefit. To fully realize the energy conservation benefits of the urban tree canopy in North Carolina, available tree planting locations on both public and private properties will need to be used.

Issue 5. Urban forestry information and education is not reaching the citizen level to generate support and advocacy at the local/municipal level needed to develop proactive urban forest management programs.

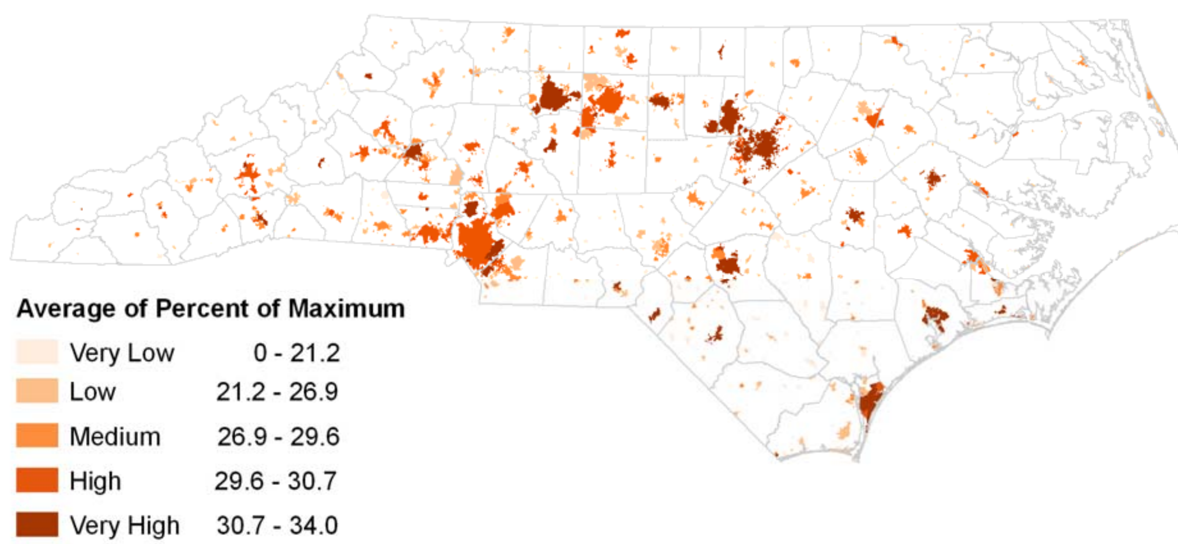
The NCDFR U&CF Program promotes the management of urban trees in North Carolina by providing technical, financial, and educational assistance to any group

FIGURE 4*k*-9. Priority areas index identifying areas where urban tree canopy has potential to reduce energy demands.



Created by: A. Moore, NCDFR, 2010

FIGURE 4*k*-10. Priority ranking of municipalities with the greatest potential to reduce energy demand by increasing urban tree canopy.



Created by: A. Moore, NCDFR, 2010

seeking to improve the environment and aesthetics of their community by managing their urban trees. In an effort to track progress and milestones, performance measures are captured within the Community Accomplishment Reporting System (CARS). The four performance measures (professional staffing, tree ordinances, management plans based on scientific inventories, and tree advocacy groups providing citizen support) indicate the level of management within a municipality. A municipality that achieves all four of the performance measures is considered to be actively managing its urban forest resource. The goal of the U&CF Program is to increase the number of communities with actively managing urban forestry programs. Places that are lacking in a single performance measure could be moved into the managing program status by fulfilling that measure.

Five data layers were used to identify the municipalities in North Carolina with the fewest of the four performance measures (TABLE 4*k*-9). Having a professional forester or arborist on staff is the best indicator of a community approaching managing program status. Large cities without such a position should receive priority attention. Similarly, municipalities not having a management plan, not having a tree management ordinance, and not having an advocacy group for support, all add a level of priority to each municipality. Total population was included to account for the number of people living within managing and developing programs.

The highest priority places indicate high population communities that are lacking one or more of the performance measures and would benefit from U&CF program assistance (FIGURE 4*k*-11). All of the medium-sized communities (population 10,000 to 60,000) across the state are ranked as the highest priority communities, while small communities are mostly ranked as high priority (FIGURE 4*k*-11).

TABLE 4*k*- 9.—Layer weights for Issue 5 (Urban forestry information and education is not reaching the citizen level to generate support and advocacy at the local/municipal level needed to develop proactive urban forest management programs.)

Data Layer	Contribution to Priority Index
Total Population	40%
No Professional Staff	30%
No Management Plan	20%
No Ordinance	5%
No Advocacy Group	5%

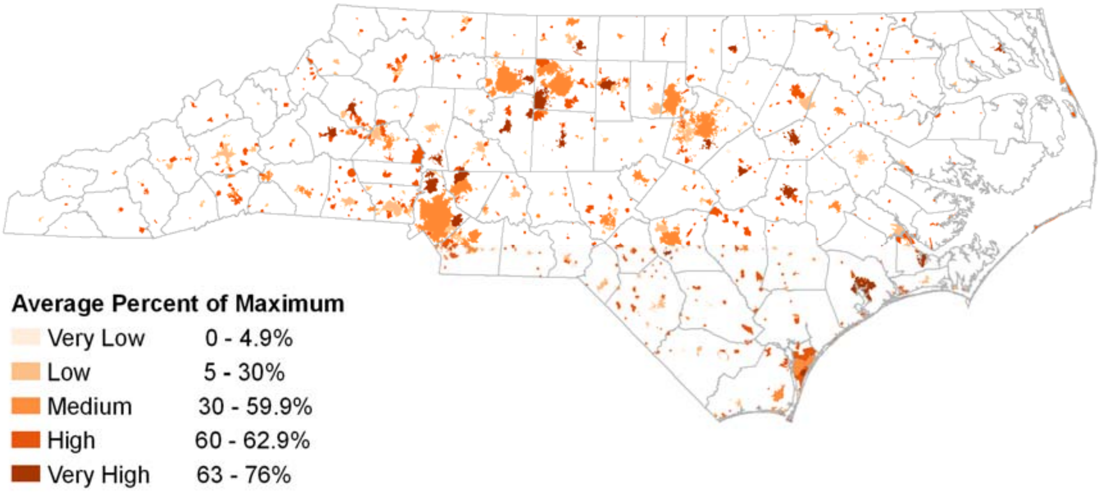
Created by: A. Moore, NCDFR, 2009

Combined Analysis: Overall Urban Forest Priority

To determine an overall priority rating for municipalities and urban areas of North Carolina, the data layers used to analyze the five urban forest issues were incorporated by adding their priority index contribution for each issue (layer weight) and dividing by 5 (TABLE 4*k*-10). The map of overall urban forest priority identifies urban areas that are essential for restoring, conserving, and maintaining the healthy trees and forests in North Carolina communities.

Municipalities within and surrounding the Piedmont Crescent are considered higher priority, which is indicative of higher population levels and higher rates of urban growth (FIGURE 4*k*-12). While all municipalities in North Carolina would benefit from additional support to maintain and improve urban forest health, medium and large municipalities generally show the greatest opportunity for impact on urban forest health (FIGURE 4*k*-13). Ten municipalities across North Carolina are ranked as very high priority for maintaining urban forest health; all of them are medium

FIGURE 4*k*-11. Priority ranking of named places identifying municipalities missing one or more of the components required to be classified as a managing urban forestry program.



Created by: A. Moore, NCDFR, 2010

TABLE 4*k*-10.—Layer weights for the “Overall Urban Forest Priority”

Data Layer Name	Contribution to Priority Index
Urban Growth Score	13%
Imperviousness	10%
Tree Canopy	8%
Population Density	8%
Total Population	8%
Absence of Canopy	7%
Forestland	6%
No Professional Staff	6%
Hurricane Risk	5%
Ozone Non-Attainment	5%
Forest Patch	4%
Urban ETJ	4%
No Management Plan	4%
Freezing Rain	3%
Biodiversity Wildlife Habitat	2%
Plantable Space	2%
Tornado Risk	1%
Wildfire Risk	1%
Site Productivity	1%
No Advisory Group	1%
No Tree Ordinance	1%

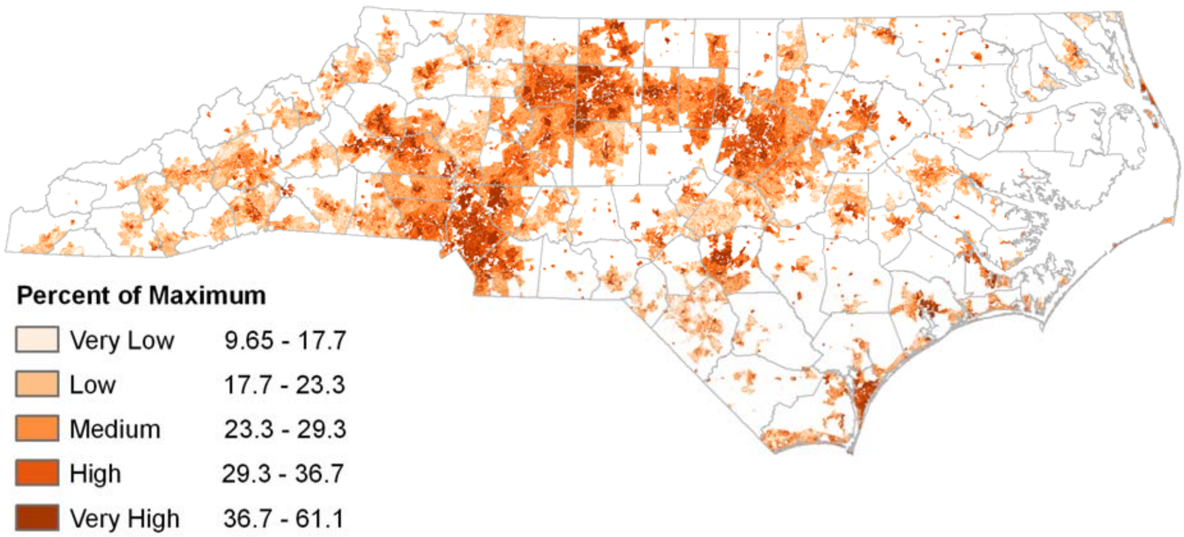
Created by: A. Moore, NCDFR, 2009

and small municipalities (TABLE 4*k*-11). Twelve of the 13 large municipalities are ranked as high priority, while 33 medium and 164 small municipalities are high priority for maintaining viable urban forests in North Carolina (TABLE 4*k*-12).

Summary

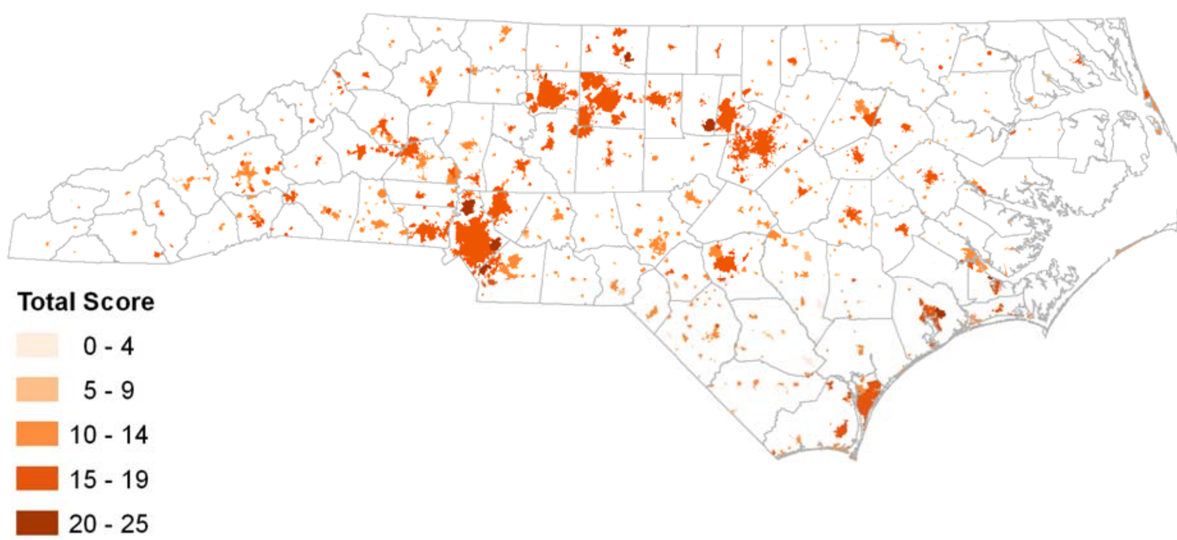
North Carolina is an urbanizing state, with a significant amount of growth expected to occur in the near future. Maintaining healthy and viable urban forests is a broad concept that brings together several key environmental and social goals and requires partnerships across jurisdictional boundaries. Population growth and land-use change will have a profound impact on the air, forests, and watersheds across the state. Both large and small communities will play a role in maintaining overall urban forest health and viability in North Carolina, but several key communities deserve immediate attention. In all communities, coordinated planning and management will help ensure the long-term sustainability of urban forests. Urban and community forestry program capacity at the municipal and county level will continue to be important to support regional and statewide efforts.

FIGURE 4*k*-12. Priority areas identifying areas with greatest potential to improve urban forest health and viability.



Created by: A. Moore, NCDFR, 2010

FIGURE 4*k*-13. Priority ranking of named places identifying municipalities with greatest potential to improve urban forest health and viability.



Created by: A. Moore, NCDFR, 2010

TABLE 4*k*-11.—Number of municipalities and population analysis within each priority class for the overall urban forest priority

Priority Ranking	Number of Municipalities	Total Population	Total Forest Land (Acres)	Percent of Population
Very High	10	142,159	31,483	3.00
High	209	3,194,644	384,367	73.00
Medium	338	934,156	209,779	21.00
Low	89	77,093	19,515	1.80
Very Low	9	210	11,187	0.04

Created by: A. Moore, NCDFR, 2009

TABLE 4*k*-12.—Top 20 communities, ranked by population, for overall priority for maintaining viable urban forests in North Carolina

Community Name	Population (2000)
Durham	187,035
Jacksonville	66,715
Chapel Hill	48,715
Huntersville	24,960
Asheboro	21,672
Lexington	19,953
Garner	17,757
Kernersville	17,126
Lenoir	16,793
Carrboro	16,782
Eden	15,908
Mint Hill	14,922
Reidsville	14,485
Masonboro	11,812
Piney Green	11,658
Roxboro	8,696
Weddington	6,696
Rural Hall	2,464
Neuse Forest	1,426
Spencer Mountain	51

Created by A. Moore, NCDFR, 2009

Map Data Sourcess

FIGURE 4k-1: Hammer et al. 2004

FIGURE 4k-2: US Census Bureau, NC DOT, One NC Naturally Conservation Planning Tool, Southern Forest Land Assessment

FIGURE 4k-3: US Census Bureau

FIGURE 4k-4: US Census Bureau, SFLA, Fuhrmann and Konrad, II, NOAA, FEMA 361 First Edition July 2000, Southern Wildfire Risk Assessment

FIGURE 4k-5: US Census Bureau

FIGURE 4k-6: US Census Bureau, NC DOT, National Land Cover Dataset 2001, NC DAQ

FIGURE 4k-7: US Census Bureau

FIGURE 4k-9: US Census Bureau, NC DOT, National Land Cover Dataset 2001, SFLA

FIGURE 4k-10: US Census Bureau

FIGURE 4k-11: US Census Bureau, USDA Forest Service Urban & Community Forestry (CARS)

FIGURE 4k-12: Hammer et al. 2004, US Census Bureau, NC DOT, One NC Naturally Conservation Planning Tool, Southern Forest Land Assessment, Fuhrmann and Konrad, II, NOAA, FEMA, Southern Wildfire Risk Assessment, NLCD 2001, NC Division of Air Quality, USDA Forest Service Urban and Community Forestry Program

FIGURE 4k-13: Hammer et al. 2004, US Census Bureau, NC DOT, One NC Naturally Conservation Planning Tool, Southern Forest Land Assessment, Fuhrmann and Konrad, II, NOAA, FEMA, Southern Wildfire Risk Assessment, NLCD 2001, NC Division of Air Quality, USDA Forest Service Urban and Community Forestry Program

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Glossary

census designated places. A type of place identified by the U.S. Census Bureau to delineate incorporated places, such as cities, towns and villages, as well as populated areas that lack separate municipal government but which otherwise physically resemble incorporated places.

Community Accomplishment Reporting System (CARS). The four performance measures used to ascertain a level of function for a municipal urban forest program, as determined by the USDA Forest Service: professional staffing, tree ordinances, management plans based on scientific inventories, and tree advocacy groups providing citizen support.

extraterritorial jurisdiction (ETJ). Legal ability of a government to exercise authority beyond its normal boundaries.

forest patch. A forest tract larger than 500 acres.

green space. Open, undeveloped land with natural vegetation.

healthy urban forest. A system of trees and associated resources in areas of increased human influences that is actively managed for long-term benefits, is structurally diverse enough to withstand environmental change and periodic catastrophic events, and consists of an interconnected network of green space that conserves the natural ecosystem values and function.

impervious surface. Surfaces that water cannot penetrate, such as buildings and pavement.

infrastructure. A basic framework or system of public works (including transportation, communication, sewage, water, and utility systems) needed to support human activity.

large community. A community with a population greater than 60,000 people.

medium community. A community with a population between 10,000 and 60,000 people.

net 40 benefit. A benefit calculated as the cost of a tree and its maintenance accumulated over 40 years subtracted from the tree's economic and environmental benefits over 40 years.

ozone non-attainment areas. Areas not meeting the ground-level ozone standards established by the U.S. Environmental Protection Agency in 1997 and 2008.

particulate matter. Tiny subdivisions of solid or liquid matter suspended in a gas or liquid.

Piedmont Crescent. A population term used to describe an area in North Carolina located in the central counties of the NC piedmont. The Piedmont Crescent stretches northeast from metropolitan Charlotte, through the Piedmont Triad cities of Greensboro and Winston-Salem at its center, to metropolitan Raleigh-Durham and the Research Triangle area at its eastern edge.

plantable space. Land not currently in tree canopy or impervious surface that may offer opportunities for tree planting.

priority places. Communities indicated as having a priority through data evaluation.

small community. A community with a population of less than 10,000 people.

urban areas. Areas with a housing density of at least one house per 2 acres.

urban clusters. Areas with a housing density of one house every 2 to 16 acres.

urban heat islands. Urban areas that become warmer than their rural surroundings, forming an "island" of higher temperatures in the landscape.

Chapter 5. Goals, Objectives, and Strategies

5.a.
Introduction

The Goals, Objectives, and Strategies (GOS) are based on issues and needs identified in the *Statewide Forest Resource Assessment's* key findings and priority maps. Seven broad goals have been identified, and each contains objectives that define what is to be accomplished. Strategies identify how to accomplish the objectives. The GOS document helps to provide a 5-year roadmap for NCDFR and its partners.

Each goal statement includes a narrative paragraph summarizing its intent. Each strategy includes a matrix that organizes the strategy into logical and consistent components. Each matrix summarizes key details as follows:

Objective statement—What will be accomplished to meet the associated goal. Included in the statement is a list of the *Statewide Forest Resource Assessment's* chapter sections where key findings are listed and addressed by the associated strategies. USDA Forest Service national objectives are also listed to indicate those that are supported by the associated strategies.

Strategy statement—How the objectives will be accomplished. Components needed to achieve the strategy are identified in columns as follows:

> **Priority Area(s)—**Identifies maps and priority areas that focus a strategy. The strategies will complement and be integrated into existing and newly created NCDFR and forestry stakeholder programs and responsibilities.
>
> **DFR Program Areas—**NCDFR programs and units that will be directly involved or provide support to accomplish the strategy.
>
> **Key Stakeholders and Partners—** Agencies, organizations, and groups from which leadership or collaboration will be needed to implement the strategy.
>
> **Resources Needed—**Programs and resources needed to implement the strategy.
>
> **Measures of Success—**Performance measures that could potentially be used to monitor strategy accomplishments.

An attempt was made to reduce unnecessary repetition within the GOS document. For example, a strategy or issue was not highlighted in one Goal if that strategy or issue was addressed in detail in another Goal. Specific activities to meet each strategy will be furthered developed in an annual action plan. NCDFR and its partners will incorporate the activities outlined in the annual action plan into existing or newly created programs. When appropriate, there will be an emphasis on the *Statewide Forest Resource Assessment's* priority areas.

The support and collaboration of partners and stakeholders is important to the successful implementation of the GOS. Therefore, partnership involvement and collaboration is integrated within most strategies. Funding, implementation and oversight of some strategies may be the responsibility of other organizations besides NCDFR. Examples of inter-organizational collaborative efforts (within North Carolina and also with other states) that already exist or are planned are included in the *Statewide Forest Resource Assessment*. The activities outlined in the annual action plan will require even more inter-organizational planning and cooperation by North Carolina’s forest and natural resource stakeholders.

It was realized early on that an education and outreach program is an integral part of many of the strategies. Information and education efforts, as well as research needs, have been integrated as a component within many strategies.

5.b.

Goals, Objectives, and Strategies Summary

5.c.
Abbreviations and Acronyms

Some of the acronyms used in the Goals, Objectives, and Strategies matrix differ from those used throughout the other sections of the *Statewide Forest Resources Assessment*. NC is omitted from state agency acronyms and other organizational acronyms to simplify the matrix.

Where confusion could occur between a state, local, federal, or national entity, NC is included in the acronym that applies to a state-level entity. NC is also included for certain commissions, foundations, and trusts.

NC Division of Forest Resources Programs, DENR

Air	Aviation Branch
BMP/NPS	Best Management Practices/Nonpoint Source Branch
BRIDGE	Young Offenders Conservation Program *Building, Rehabilitating, Instructing, Developing, Growing, Employing*
CWPP	Community Wildfire Protection Plan
ESF/SF	Educational State Forest/State Forest System
FCPB	Fire Control and Prevention Branch
FDP	Forest Development Program
FEB	Fire Environment Branch
FEPP	Federal Excess Personal Property Program
FFP	Firefighter Program
FHM	Forest Health Monitoring Program
FireWise	FireWise Program
FM	Forest Management Branch
FM&FD	Forest Management and Forest Development Section
Forest Protection	Forest Protection Section
Forest Stewardship	Forest Stewardship Program
FPG/WQ	Forest Practice Guidelines/Water Quality staff
FSPP	Forest Stewardship Plan Program
GSB	Geospatial Services Branch
I&E	Information and Education Branch
LE	Law Enforcement Branch
N&TI	Nursery and Tree Improvement Branch
Pest Control	Pest Control Branch
SP&A	Safety, Planning and Analysis Section
SPBPP	Southern Pine Beetle Prevention Program
TAR	Total Accomplishments Report
TD&P	Technical Development and Planning Branch

U&CF	Urban and Community Forestry Branch

Other Abbreviations and Acronyms

ADFPTF	N.C. Agricultural Development and Farmland Preservation Trust Fund
AF&PA	American Forest & Paper Association
APHIS	Animal and Plant Health Inspection Service, USDA
APNEP	Albemarle-Pamlico National Estuary Program, DENR
ARRA	American Recovery and Reinvestment Act
Assessment	*Statewide Forest Resources Assessment* document
BMP	Best Management Practice
CCAP	Community Conservation Assistance Program, DSWC
CCX	Chicago Climate Exchange
CGIA	NC Center for Geographic Information and Analysis
COG	Council of Government
CNR	NC State University College of Natural Resources
CPT	NC Conservation Planning Tool, DENR
CRP	Conservation Reserve Program, DSWC and NRCS
CREP	Conservation Reserve Enhancement Program, DSWC and NRCS
CWMTF	NC Clean Water Management Trust Fund
DACS	NC Department of Agriculture and Consumer Services
DAQ	NC Division of Air Quality, DENR
DCA	NC Division of Community Assistance, DOC
DCM	NC Division of Coastal Management, DENR
DEM	NC Division of Emergency Management, DENR
DENR	NC Department of Environment and Natural Resources
DFR	NC Division of Forest Resources, DENR
DLR	NC Division of Land Resources, DENR
DMF	NC Division of Marine Fisheries, DENR
DOC/CE	NC Department of Correction/Correction Enterprises
DOC	NC Department of Commerce
DOI	NC Department of Insurance
DOR	NC Department of Revenue
DOT	NC Department of Transportation
DPI	NC Department of Public Instruction
DPR	NC Division of Parks & Recreation/NC Parks, DENR
DSWC	NC Division of Soil & Water Conservation, DENR
DU	Ducks Unlimited
DWQ	NC Division of Water Quality, DENR
DWR	NC Division of Water Resources, DENR
EEP	NC Ecosystem Enhancement Program, DENR
EFETAC	Eastern Forest Environmental Threat Assessment Center, USFS
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program, NRCS
FEPP	Federal Excess Personal Property
FEOP	Forestry & Environmental Outreach Program, NC State University

FERC	Federal Energy Regulatory Commission
FFP	Forest Fire Protection
FHTET	Forest Health Technology Enterprise Team, USFS
FIA	Forest Inventory and Analysis Program, USFS and DFR
FPG	NC Forest Practices Guidelines Related to Water Quality
FSA	Farm Service Agency, USDA
FSC	Forest Stewardship Council
HOA	home owners association
ISA	International Society of Arboriculture
LID	low-impact development
LEED	Leadership in Energy and Environmental Design
LLA	The Longleaf Alliance
NASF	National Association of State Foresters
NCCC	NC Community College System
NCACC	NC Association of County Commissioners
NCACF	NC Chapter of the Association of Consulting Foresters
NCAFC	NC Association of Fire Chiefs
NCAPA	NC Chapter of the American Planning Association
NCAPL	NC Association of Professional Loggers
NCCES	NC Cooperative Extension Service
NCDT	NC Division of Tourism, DOC
NCFA	NC Forestry Association
NCCGIA	NC Center for Geographical Information and Analysis
NCHBA	NC Home Builders Association
NCLM	NC League of Municipalities
NCMNS	NC Museum of Natural Sciences, DENR
NCNLA	NC Nursery & Landscape Association
NCPFC	NC Prescribed Fire Council
NCSFA	NC State Firemen’s Association
NCSWCD	NC Soil & Water Conservation Districts
NCSU	NC State University
NCTFS	NC Tree Farm System (chapter of American Tree Farm System)
NCUFC	NC Urban Forest Council
NCWRC	NC Wildlife Resources Commission
NGO	nongovernmental organization
NHP	NC Natural Heritage Program, DENR
NHTF	NC Natural Heritage Trust Fund
NIPF(L)	non-industrial private forest (landowner)
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NPSP	nonpoint source pollution
NPV	net present value
NRCS	Natural Resources Conservation Service, USDA
NWCG	National Wildfire Coordinating Group
NWS	National Weather Service
NWTF	National Wild Turkey Federation

OEE	NC Office of Environmental Education, DENR
OSFM	NC Office of State Fire Marshal, DOI
PLT	Project Learning Tree
PPE	personal protective equipment
PSA	public service announcement
QU	Quail Unlimited
RC&D	Resource Conservation and Development District
R(E)PS	Renewable (Energy) Portfolio Standard for North Carolina
Riverkeepers	Various river basin and county foundations that focus on river conservation
SAF	Society of American Foresters
SCO-NC	State Climate Office of North Carolina
SFI	Sustainable Forestry Initiative
SGSF	Southern Group of State Foresters
SMA	Society of Municipal Arborists
SPB	southern pine beetle
STS	Slow the Spread of Gypsy Moth Program, USDA
SWAP	State Wildlife Action Plan (*NC Wildlife Action Plan* document)
SWRA	Southern Wildfire Risk Assessment
TCF	The Conservation Fund
TIMO	timberland investment management organization
TNC	The Nature Conservancy
UFORE	Urban Forest Effects Model
UNC	University of North Carolina
USACE	U.S. Army Corps of Engineers
USBIA	U.S. Bureau of Indian Affairs
USDA	U.S. Department of Agriculture
USDOD	U.S. Department of Defense
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Department of Agriculture–Forest Service
USFS-NF	U.S. Department of Agriculture–Forest Service, National Forests
USFS-SGCP	U.S. Department of Agriculture–Forest Service, Southern Global Change Program
USFS-SPF	U.S. Department of Agriculture–Forest Service, State and Private Forestry
USFS-SRS	U.S. Department of Agriculture–Forest Service, Southern Research Station
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USNPS	U.S. National Park Service
VAD	Voluntary Agriculture Districst
WRP	Wetlands Reserve Program
WUI	wildland-urban interface

5.d.
Goals, Objectives, and Strategies Matrix

Goal 1.—Increase the sustainable management and conservation of forests.

Effectively sustaining and conserving North Carolina's forestlands will require natural resource professionals and organizations to reach out to private landowners in new ways. Urban and urban-rural interface forests will continue to play an expanding role in delivering the many diverse benefits derived from woodlands. Inter-organizational cooperation will be needed to accomplish far-reaching tasks, such as identifying and conserving high-priority forestlands and reaching non-traditional and underserved landowners. Forestry organizations will need to adapt to an ever-urbanizing population in order to understand and help forestland owners and users meet their multi-dimensional management objectives. Simultaneously, these organizations must remain grounded in the science of silviculture and be able to provide guidance on actively managing forestlands in order to produce desired ecological, social and economic benefits.

Objective 1.1.—Conserve high-priority forest ecosystems and landscapes.
(Addresses key Assessment findings in sections 2b, 3a, 3b, 4g, 4j, and USDA Forest Service national objectives 1.1, 1.2, 2.2, 3.1, 3.2, 3.4, 3.5, 3.6, 3.7.)

Strategy1.1.1.—Collaborate with other natural resource organizations to identify high-priority forest ecosystems and landscapes.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Rural Forest Priority Landscape Map Conserving Working Forestlands Map Urban Forest Priority Landscape Map Forest Legacy “Areas of Need” Priority Ecosystems (State Wildlife Action Plan) Significant Natural Heritage Areas (Natural Heritage Program)	Forest Legacy Forest Stewardship FM GSB	DENR—NHP NCWRC NRCS Land trusts ADFPTF CWMTF NHT	Increased funding for GIS mapping capability Identification of lead individual and/or agency and formation of interagency team focusing on forestland conservation	Improved level of coordination among state agencies responsible for land acquisition and conservation Current and new partnerships that develop to assist with conservation efforts or to create new initiatives within high-priority ecosystems or landscapes Acres of forest permanently protected or conserved that are considered to be high-priority forest ecosystems or landscapes

Strategy 1.1.2.—Assist land management professionals with the delivery of programs and services that conserve high-priority forest ecosystems and landscapes.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map Priority Forest Watershed Map	FM Forest Legacy Forest Stewardship GSB BMP/NPS	NCWRC NRCS FSA DENR—DSWC, EEP CREP NCSWCD Land trusts NCCES USFWS	Increased funding for GIS mapping capability Training on conservation easements as well as forestry, wildlife, and conservation programs for financial and tax benefits Natural resource professional positions for technical assistance in priority areas	Acres of forest permanently protected or conserved in high-priority ecosystems and landscapes Current and new partnerships that develop to assist with the conservation efforts or to create new initiatives within the high-priority areas Number of technical assistance positions created or devoted to high-priority areas Forest conservation workshops delivered in high-priority areas

Objective 1.2.—Assist landowners with actively and sustainably managing forests for economic and social benefits. (Addresses key Assessment findings in sections 2b, 2d, 2e, 2f, 3a, 3b, 3c, 4a, 4e, 4f, 4g, 4h, 4i, 4k and USDA Forest Service national objectives 1.1, 1.2, 2.2, 3.1, 3.2, 3.4, 3.5, 3.6, 3.7)				
Strategy 1.2.1.—Provide increased technical and professional assistance to forest landowners that results in more active and sustainable management of their forestland.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map Priority Forest Watershed	FM Forest Stewardship U&CF TD&P BMP/NPS	NRCS FSA NCWRC NCACF USFS NCTFS	Funding for state and federal forest conservation cost-share programs Funding for state and federal initiatives and conservation programs Natural resource professionals to provide technical guidance, assistance, and implementation Funding to conduct research and transfer knowledge regarding forest management, wildlife, forest health, fire, and ecological issues Forestry, wildlife, and conservation programs for financial and tax benefits Funding to conduct social marketing and landowner outreach	Number of forest management, stewardship, wildlife habitat, and urban plans that benefits forests Number of acres where forestry management is accomplished or that are affected by management practices that benefit forests Number of technical assists to local communities and municipalities for forest management, forest health, and urban assistance

Strategy 1.2.2.—Increase support and funding for state and federal cost-share programs that result in more active and sustainable management of forestland.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Rural Forest Priority Landscape Map Conserving Working Forestlands Map	FM Field staff	DOR NC Legislature Forest product companies FSC NCFA USFS NRCS USFWS	Funding for state and federal forest conservation cost-share programs Outreach and education programs	Levels of legislative and federal funding Continued funding of the USDA Farm Bill components Educational programs directed at funding and supporting forest conservation cost-share programs

Strategy 1.2.3.—Strengthen and support forest nursery and tree improvement programs to ensure a stable supply of seedlings.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
North Carolina forest nurseries and tree improvement programs	N&TI Forestation Unit Field staff	USFS NCSU Cooperative Tree Improvement Program	Increased funding and support for nursery, tree improvement, and genetic work in North Carolina	Capacity to meet the current and future reforestation and afforestation needs (including species in decline) Establishment and distribution of genetically-improved planting stock Number of research and/or technical projects participated in by the N&TI program Acres planted with genetically-improved seedlings

Strategy 1.2.4.— Increase landowners' understanding of, and participation in, forest certification.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Rural Priority Landscape Map Urban Priority Landscape Map Conserving Working Forests Map Forest Legacy "Areas of Need"	FM TD&P BMP/NPS Forest Stewardship	NCFA NCTFS FSC AF&PA SFI Green Tag Southern Center of Sustainable Forestry NCCES SGSF Southern Forests Network	Landowner surveys Funding for DFR personnel dedicated to working on forest certification and forest sustainability issues Funding for training and outreach programs for professionals and landowners	Number of acres certified under a forest certification system Supply of certified forest products available for market demands Number of third-party assessment organizations to certify and audit certified forests Number of forest certification workshops, training sessions, and outreach events for landowners and natural resource professionals Increased awareness, understanding, and willingness of landowners to participate in forest certification programs

Objective 1.3.—Assess and redefine services provided to forestland owners to efficiently and effectively meet their diverse management objectives.

(Addresses key Assessment findings in sections 2b, 2c, 2d, 2e, 2f, 3a, 3b, 3c, 4a, 4b, 4d, 4e, 4f, 4g, 4h, 4i, 4j, 4k and USDA Forest Service national objectives 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7)

Strategy 1.3.1.—Assess, evaluate, and develop services to effectively reach nontraditional, underserved, and traditional forest landowners.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FM Forest Stewardship Forest Legacy U&CF TD&P FPG/WQ Forest Protection FEB Firewise I&E SP&A FIA	NRCS FSA NCWRC NCACF USFS FIA NCTFS NCCES Land trusts NCFA Landowners	Funding for landowner surveys Funding for state and federal initiatives and conservation programs Outreach and education programs for nontraditional and underserved forest landowners Natural resource professionals to provide technical services	Number of forest management, stewardship, wildlife habitat, and urban plans provided Number of nontraditional, underserved, and traditional forestland owners served Number of acres that have forest or wildlife management practices applied Number of technical assists to local communities and municipalities New initiatives and programs aimed at reaching an increased number of forestland owners

Strategy 1.3.2.—Strengthen and develop outside partnerships with public and private entities at federal, state, and local levels to improve and coordinate services and service delivery.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map Forest Legacy “Areas of Need”	FM Forest Stewardship Forest Legacy FPG/WQ BMP/NPS U&CF TD&P Forest Protection FEB Firewise CWPP I&E ESF/SF Field staff GSB	NCTFS NCACF NCFA NCCES FEOP NC Woodlands Land trusts NRCS FSA USFS SGSF NCWRC USFWS TNC USDOD DENR—DEM NCPFC NCDOR Local tax offices NCSWCD NGOs COG and municipal leaders County planning boards	Development and implementation of interorganizational MOUs Identification of lead individuals and organizations and formation of teams focusing on program services Funding to support leadership development and program understanding USFS funding (ex. redesign grants)	Improved level of coordination (ex updated MOUs, joint partnerships) among organizations that affect forests and forestland owners Current and new partnerships that develop to assist with forest conservation efforts Number of interorganizational outreach programs delivered Creation and implementation of landscape-level forest conservation efforts Improved level of coordination among local governments and the forestry community resulting in regional/county green infrastructure plans

Objective 1.4.—Strengthen and support an urban-focused initiative that meets ownership objectives for urban-rural interface landowners and communities.
(Addresses key Assessment findings in sections 2b, 2c, 2d, 2e, 2f, 3a, 3b, 3c, 4a, 4b, 4e, 4f, 4g, 4h, 4i, 4j, 4k and USDA Forest Service national objectives 1.2, 2.2, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6,)

Strategy 1.4.1.—Assess, evaluate and target services to effectively reach forestland owners in the urban-rural interface.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Wildland-urban interface map (Figure 3b-6) Protecting the Wildland-Urban Interface Map Conserving Working Forests Map	FM FSSP U&CF Forest Protection FEB Firewise FIA	USFS NRCS FSA NCSWCD NCCES Land trusts	Funding for surveys and research directed at targeted landowners and communities Funding for state and federal initiatives and conservation programs Outreach and education programs targeted at wildland-urban interface landowners and communities Natural resource professionals to provide technical services	Development of new programs or services to meet management objectives for landowners within the urban-rural interface Increased number of management plans and acres under management by landowners within the urban-rural interface Number of NC FireWise communities

Strategy 1.4.2.—Increase support and funding for measures that result in the conservation of working forests within the urban-rural interface.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Wildland-urban interface map (Figure 3b-6) Protecting the Wildland-Urban Interface Map Conserving Working Forests Map Forest Legacy "Areas of Need"	FM Forest Legacy Forest Stewardship U&CF	DENR NC Legislature Land trusts NRCS FSA USFS	Increased state and federal funding for land conservation measures within the urban-rural interface Funding for state and federal initiatives, cost-share programs, and conservation programs Natural resource professionals to provide technical services Favorable tax policies that benefit forestry, wildlife, and conservation programs	Number of landowners that implement conservation practices and measures in the urban-rural interface Number of landowners in the urban-rural interface that enroll their land in conservation easement programs Awareness level of landowners and communities regarding the benefits of working forests within the urban-rural interface Number of technical service providers focusing efforts in the urban-rural interface Number of landowners participating in tax incentive programs relating to forestry, wildlife, and conservation programs

Strategy 1.4.3.—Provide training to promote a better understanding and implementation of multidisciplinary management opportunities that are appropriate for urban-rural interface ownerships.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Wildland-urban interface map (Figure 3b-6) Protecting the Wildland-Urban Interface Map Conserving Working Forests Map	FM U&CF Forest Stewardship TD&P	NCCES USFS NRCS NCWRC NCTFS	Identification of lead individual and/or agency and formation of interagency team focusing on urban-rural interface management opportunities Funding for urban-rural interface professional training (ex. Changing Roles) Funding to deliver urban-rural landowner training (ex. Small Woodlot Management Program; FireWise)	Number of professionals who have completed the Changing Roles program Trainings on multi-disciplinary management techniques and opportunities (ex. Changing Roles) Development of new training programs to meet management objectives for landowners within the urban-rural interface (ex. Small Woodlot Management Program; FireWise) Increased number of management plans and acres under management by landowners within the urban-rural interface Number of NC FireWise communities

Strategy 1.4.4.—Assist land management professionals with the delivery of programs and services that target urban-rural interface ownerships.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Wildland-urban interface map (Figure 3b-6) Protecting the Wildland-Urban Interface Map Conserving Working Forests Map	FM Forest Legacy Forest Stewardship U&CF BMP/NPS Forest Protection FireWise FEB CWPP	DENR NCTFS NCACF NRCS FSA USFS Land trusts	Increased funding for GIS mapping capability Professional training on forestry, wildlife, and conservation programs that benefit the urban-rural interface Natural resource professional positions for technical assistance targeting the urban-rural interface	Number of landowners that implement conservation practices and measures Level of awareness of landowners regarding the benefits of working forests within the urban-rural interface Number of technical assists to local communities or landowners within the urban-rural interface Number of management plans and acres under management by landowners within the urban-rural interface Number of NC FireWise communities Number of technical assistance positions created or devoted to urban-rural interface areas Number of forest conservation programs delivered in urban-rural interface areas

Goal 2.—Reduce negative impacts from forest threats.

Fires, insects, diseases, invasive weeds, climate changes, and catastrophic events were identified in the *Statewide Forest Resource Assessment* as potential threats to forests, causing impacts such as mortality, loss of productivity and diversity, and declines in forest health.

Objectives and strategies under Goal 2 are designed to reduce the potential for overwhelming harm in priority areas identified as facing high risks from each of these threats. Protecting forests and trees from the negative effects of wildfire, pest insects, and diseases has long been an objective of natural resource management programs within the state. Protecting property and human resources has become increasingly complex because of human population growth into previously wooded areas, lack of prescribed burning, and the introduction of non-native pests and weeds into North Carolina. In addition, sea-level rise, air pollution, and potential increases in the frequency and intensity of weather events provide additional challenges to growing healthy forests.

Improved cooperation needs to occur among a diverse base of (1) local, state, and federal agencies and programs; (2) nongovernment organizations; and (3) landowners and homeowners. Cooperation will be a key component of any strategy designed to successfully manage for, prepare for, and respond to these forest threats. Emphasis on information and education, prevention, mitigation, monitoring, and control will be employed along with management to improve overall forest health, resilience, and resistance to threats.

Objective 2.1.—Minimize the impacts of wildfire on forests, citizens, and communities.
(Addresses key Assessment findings in sections 3a, 3b, 3c and USDA Forest Service national objectives 2.1, 2.2, 3.3)

Strategy 2.1.1.—Increase resources and capacity to respond to and manage wildland fires.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Protecting Forests and Communities from Wildfire Risk Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FCPB FEPP FFP Fire Department Assistance FEB I&E	OSFM NCAFC NCSFA USFS USFWS NPS USBIA USDOD DENR—DEM, DPR NCWRC	Funding for wildland fire agencies' equipment, such as PPEs, engines, tractor-plow units, aircraft, weather stations, smoke monitors, etc. Funding for fire department wildland fire equipment, such as PPEs, brush trucks, engines, Class A foam equipment, etc. Funding for training Funding for PPE and safety equipment for fire departments	Number of wildland fire emergency responders trained Number of fire department members trained Trained wildland firefighters and incident management teams FEPP/FFP equipment screened and distributed Quantities of agency firefighting equipment obtained. Quantity of wildland PPE, equipment, and foam purchased by fire departments

Strategy 2.1.2.—Educate the public, land management professionals, and government officials on wildland-urban interface fire risks, issues, and mitigation techniques.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Protecting Forests and Communities from Wildfire Risk Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FCPB FireWise Fire prevention and mitigation FEB CWPP U&CF FM I&E I&E SP&A	OSFM NCAFC NCFSA USFS USFWS USNPS/USBIA USDOD DENR—DEM NCCES UNC System NCCC NCPFC TNC	Funding for landowner and community surveys (ex. educational needs assessment) Funding to conduct public outreach, including materials (ex. billboards, television PSAs, workshops, and newspaper print ads) Funding for Fire Danger Adjective Rating signs	Number of FireWise communities Number of outreach efforts targeting wildland-urban interface landowners and communities (ex. number of attendees) Level of public awareness about the risks, issues, and mitigation techniques relating to wildland-urban interface fires Number of acres treated to reduce hazardous fuel loads

Strategy 2.1.3.— Encourage inter-organizational planning, policy-making, and collaboration that lead to the use of FireWise principles in construction and community planning.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Protecting Forests and Communities from Wildfire Risk Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FCPB FEB U&CF I&E FireWise Fire Prevention and Mitigation CWPP	OSFM NC Building Code Council NCAFC NCSFA NCHBA USFS USFWS USNPS BIA USDOD DENR—DEM NCCES UNC System NCACC DCA	Policy aimed at mitigating wildfire risk through state or local government regulations and policies (ex. building code changes) Development and implementation of interorganizational MOUs Identification of lead individuals and/or organization and formation of teams focusing on FireWise Funding to support leadership development and FireWise program understanding USFS funding (ex. redesign grants)	Reduced number of homes lost to wildfire Number of FireWise communities Changes to state and local government regulations or policies based on FireWise principles (ex. NC building code handbook) Improved level of coordination (ex. updated MOUs, joint partnerships) between organizations that leads to the use of FireWise principles in construction and community planning. Number of interorganizational outreach programs delivered

Strategy 2.1.4.—Increase decision support tools regarding fire danger, weather products, and fire response planning.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Protecting Forests and Communities from Wildfire Risk Map Urban Forest Priority Landscape Map Rural Forest Priority Landscape Map	FCPB FEB	NWS SCO–NC OSFM NCAFC NCFSA USFS USFWS USNPS BIA USDOD DENR—DEM	Funding for research and expansion of DFR FEB Funding for professional and landowner training on assessing burning conditions for wildfire protection or prescribed fire burning utilizing developed tools Funding to develop and support a NC Interagency Fire Environment Weather Observation network Funding for education and outreach Climatology research and data for planned and unplanned ignitions	Decision support tools developed Average acreage per wildland fire Improved wildfire control efficiency and effectiveness at field level Development of an NC Interagency Fire Danger Operating Plan and Weather Observation network Number of hazard reduction burned acres Number of structures threatened or destroyed Development of a Burn versus No-Burn Days Program Report on fire weather and fuel conditions that support large or extreme fire growth and successful planned ignitions

Strategy 2.1.5.—Encourage preparation and implementation of Community Wildfire Protection Plans.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Protecting Forests and Communities from Wildfire Risk Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FCPB FireWise Fire Prevention and Mitigation CWPP FEB U&CF FM I&E GSB	OSFM NCAFC NCFSA USFS USFWS USNPS BIA USDOD DENR—DEM NCCES UNC System	Funding for training professionals Funding for outreach program (ex. Fire Danger Adjective Rating materials) Increased funding for GIS capability	Number of completed CWPPs Acres of fuel mitigation accomplished Number of mitigation actions recommended in plans being implemented

Strategy 2.1.6.—Develop fire prevention and response plans, as well as training, for areas with increased fuel loading.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Protecting Forests and Communities from Wildfire Risk Map Urban Forest Priority Landscape Map Rural Forest Priority Landscape Map	FCPB FireWise Fire Prevention and Mitigation CWPP Pest Control U&CF FEB I&E FHM	OSFM NC Building Code Council NCAFC NCSFA NCHBA USFS USFWS USNPS BIA USDOD DENR—DEM NCCES UNC System NCACC DCA	Funding for fuels and fire weather workshops to assess burning conditions and areas of concern Funding for semipermanent Fire Environment weather observation stations Funding for Fire Environment monitoring equipment	Number of fire prevention and response plans written Number of acres under fire prevention and response plans Number of response trainings completed Number of Annual Fire Season Assessment Forecast reports delivered Number of deployments for Fire Environment monitoring to areas of elevated risk

Objective 2.2.—Minimize negative impacts to forest health caused by major, locally significant, or imminent insects, diseases, and nonnative invasive plants. (Addresses key Assessment findings in sections 3a, 4j and USDA Forest Service national objectives 1.1, 1.2, 2.1, 2.2, 3.4, 3.5, 3.6, 3.7)				
Strategy 2.2.1.—Train natural resource professionals to better identify, understand, report, and respond to forest health threats.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Forest Health Priority map Urban Forest Priority Landscape Map Rural Forest Priority Landscape Map	Pest Control U&CF FM Field staff	NCDA—Plant Industry Division USFS—FHP, U&CF, NFNC, SRS DENR—DPR, NHP, NCMNS NCWRC NCCES NCSU (Entomology and Pathology Depts.) NCFA NCTFS TNC NCACF Certified arborists	Funding for training program and materials for professionals	Number of trainings Number of training aids developed Number of resource professionals trained

Strategy 2.2.2.—Develop diverse information and education materials for the public to address identification and management of forest insect, disease, and non-native invasive threats.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Major forest insect and disease threats map (Figure 3a-1) Urban Forest Priority Landscape Map Rural Forest Priority Landscape Map	Pest Control I&E U&CF Field staff	DENR—DPR, NHP, NCMNS USFS—FHP, U&CF, NFNC, FHM, FHTET, STS, EFETAC USDI—USPS, USFWS NCFA NCTFS NCACF ISA City governments NCUFC NCSU (Plant and Disease Clinic) NCCES TNC Landowners Homeowners State forestry agencies —GA, SC, TN, VA	Funding for I&E materials Funding for Internet server space and enhanced Web presence	Number of products developed (ex. podcasts, webpages, news articles, posters, brochures, and other media) Number of users accessing materials through the Internet

Strategy 2.2.3.—Promote the use of local firewood to prevent the spread of invasive pests.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Forest Health Priority map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Pest Control I&E U&CF Field staff	DENR—DPR, NHP, NCMNS USFS—FHP, U&CF, NFNC, FHM, FHTET, STS, EFETAC Private organizations USDI—USNPS, USFWS NCFA TNC State forestry agencies —AL, AR, FL, GA, KY, LA, MS, OK, SC, TN, TX, VA	Funding for I&E materials Funding for Internet server space and enhanced Web presence	Number of products developed (ex. podcasts, webpages, news articles, posters, brochures and other media) Number of users accessing materials through the Internet Number of camping/park facilities utilizing the I&E materials

Strategy 2.2.4.—Survey and monitor outbreaks and spread of major and locally significant forest insect and disease threats.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Major forest insect and disease threats map (Figure 3a-1) Southern pine beetle hazard map (Figure 3a-2)	Pest Control U&CF Field staff FEB GSB	NCDA—Plant Industry Division (Gypsy Moth and other programs) USFS—FHP, U&CF, NFNC, FHM, FHTET, SRS DENR—DPR, NHP, NCMNS and others NCCES NCSU (Entomology and Pathology Depts., Plant and Disease Clinic)	Funding for monitoring and trapping supplies/ equipment (ex. data recorders, digital aerial sketch mappers) Funding for increased GIS, database, and server capability	Number of insect and disease surveys completed Number of pest occurrences detected Number of outbreak locations included in Annual Fire Season Assessment Report

Strategy 2.2.5.—Monitor the spread and movement (early detection) of imminent non-native invasive species.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Imminent forest health threats map (Figure 3a-4) Major non-native invasive imminent threats map (Figure 3a-5)	Pest Control U&CF Field staff GSB	NCDA—Plant Industry Division USFS—FHP, U&CF, NFNC, FHM, FHTET, STS, EFETAC USDA–APHIS DENR—DPR, NHP, NCMNS and others NCCES NCSU (Entomology and Pathology Depts., Plant and Disease Clinic) TNC NCUFC NC Invasive Species Advisory Committee Southern App. Coop. Weed Mgmt. Partnership NC Nursery and Landscape Association State forestry agencies —GA, SC, TN, VA	Funding for monitoring equipment (ex, data recorders, digital aerial sketch mappers) Funding for increased GIS, database, and server capability	Number of monitoring surveys completed Number of notices released to forestry stakeholders Number of partnerships developed to assist with monitoring

Strategy 2.2.6.—Promote interorganizational policy-making, collaboration, and planning, including rapid response planning, to address introduction and containment of forest health threats.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Imminent forest health threats map (Figure 3a-4) Forest Health Priority map Urban Forest Priority Landscape Map Rural Forest Priority Landscape Map	Pest Control U&CF FM Field staff	NC Legislature NCDA–Plant Industry Division USFS USDA–APHIS DENR NCCES NCSU (Entomology and Pathology Depts.) USNPS USFWS TNC Native plant societies NCUFC NCFA, NCTFS, NCACF N.C. Invasive Species Advisory Committee Southern App. Coop. Weed Mgmt. Partnership N.C. Nursery and Landscape Association State forestry agencies—GA, SC, TN, VA	Identification of lead individuals and/or organization and formation of teams focusing on policy-making, collaboration, and planning, including rapid response planning Development and implementation of interorganizational MOUs Funding for rapid response planning, personnel, and equipment Funding to support leadership development and program understanding USFS funding (ex. Redesign grants)	Identification of primary contacts for various phases of invasion Development of communications plan Development of targeted strategic plans Number of strategic plans implemented Number of partnerships developed Number of collaborative projects Number of MOUs developed Changes to state and local government regulations or policies to deal with current and imminent threats

Strategy 2.2.7.—Use sound silviculture practices and urban forest-management practices to mitigate forest health risks and minimize damage from threats.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Forest Health Priority map Southern pine beetle hazard map (Figure 3a-2) Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FM Pest Control U&CF Forest Stewardship Field staff SPBPP CWPP	NCFA NCTFS USFS—FHP, U&CF, NFNC, SRS NCCES NCUFC NCACF TNC Land trusts	Natural resource professionals to provide technical services Funding to implement Integrated Pest Management and conduct outreach Increased availability of silvicultural equipment and operators	Number of management plans addressing forest health risks Number of innovative approaches developed to minimize forest health risks Number of silviculture practices implemented to minimize forest health risks Number of acres managed to prevent southern pine beetle outbreaks Number of acres thinned utilizing SPBPP Cost-share Program

Objective 2.3.—Identify impacts and develop long-term approaches that minimize negative influences on forests caused by climate change, air quality, and weather events.

(Addresses key Assessment findings in sections 2c, 3c, 4d, 4j and USDA Forest Service national objectives 1.1, 1.2, 2.2, 3.2, 3.4, 3.5, 3.6, 3.7)

Strategy 2.3.1.—Promote research and knowledge sharing targeted towards better understanding of potential direct impacts to trees and forests from climate change and air quality.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FM&FD Stewardship U&CF Pest Control SP&A	DENR—DPR, NHP, NCMNS, Climate Change Work Group CNR UNC System USFS—EFETAC, FHTET, FHM, SRS TNC Native plant societies	Funding for increased GIS, database, and server capability Climatology research on impacts of climate change on NC forests, trees and ecosystems	Number of research projects Number of species/ecosystems identified by tolerance level to climate conditions Number of species/ecosystems identified as at-risk Number of collaborative efforts implemented to minimize impacts of climate change

Strategy 2.3.2.—Develop and promote forest-management practices specifically for areas most likely to be affected by sea-level change and saltwater intrusion.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
NC coastal areas within 6 feet of sea level map (Figure 3c-1)	FM&FD Stewardship U&CF Pest Control	DENR—DPR, NHP, NCMNS, Climate Change Work Group CNR UNC System USFS—EFETAC, FHTET, FHM, SRS TNC Native plant societies NCFA NCACF State forestry agencies — SC, VA	Research and modeling related to saltwater intrusion Funding for natural resource professional training Funding for increased GIS, database, and server capability	Identification of priority management zones Number of forest -management practices implemented Number of acres managed for transition to future conditions Number of training events Number of professionals trained

Strategy 2.3.3 Increase tree planting and use of silviculture practices to expand carbon storage capacities.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Rural Forest Priority Landscape Map Urban Forest Priority	U&CF FM&FD I&E Forest Stewardship	NCUFC NCFA/NCTFS Native plant societies ISA	Funding for state and federal forest conservation cost-share programs (ex. FDP) Funding for state and	Number of trees planted Number of acres planted Number of silviculture practices implemented Number of acres under silviculture treatment

Landscape Map	N&TI	NCCES NGO's (ex. TNC, LLA) USDOD Utilities NCACF Forest industry Carbon traders (ex. CCX) Green industry Forest nurseries	federal initiatives and conservation programs Forestry, wildlife, and conservation programs for financial and tax benefits Natural resource professionals to provide technical guidance, assistance, and implementation Funding to conduct research and outreach regarding carbon storage Funding to conduct social marketing and landowner outreach USFS funding (ex. Redesign grants, U&CF Grants)	Tons of carbon stored Number of landowners participating in carbon sequestration programs Number of acres under carbon sequestration programs

Strategy 2.3.4.— Promote interorganizational preplanning (to include response planning, policy-making, and collaboration) that leads to coordinated responses to manage forest resources affected by damaging weather events.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Tropical cyclone hazard areas map (Figure 3c-3) Ice storm hazard areas map (Figure 3c-4) Priority Urban Landscapes Priority Rural Landscapes	FM&FD U&CF I&E Pest Control BMP/NPS Field staff	NCFA NCUFC USFS—FHP, S&P DOT DENR—DEM Local governments NCTFS NCACF ISA State forestry agencies —GA, SC, TN, VA	Identification of lead individuals and/or organization and formation of teams focusing on policy-making, collaboration, and planning (ex. Storm Working Goup) Development and implementation of interorganizational MOUs Funding for personnel and equipment to develop strike teams Funding to conduct aerial survey Funding for storm-related I&E materials USFS funding (ex. Redesign grants)	Identification of primary contacts for various coordinated responses Changes to state and local government regulations or policies to deal with response to weather events and forest damage Number of prestorm organizational meetings Preparedness plans developed Number of Urban Storm Preparedness Kits developed and distributed Number of educational materials developed and distributed Number of strike teams trained, organized, and deployed Number of communities and landowners assisted Number of MOUs established Number of forest and urban tree storm damage assessments completed

Goal Statement 3.—Increase the restoration, maintenance, and management of fire-adapted species and ecosystems.

Many ecosystems in North Carolina were shaped by fire. Without regular burning, the health and numbers of fire-adapted plants and ecosystems have declined. Goal 3 is to restore and maintain fire-adapted ecosystems through the application of prescribed burning.

To meet this goal, we must increase our capacity to apply fire to the forest landscape as well as improve our understanding of the fire environment. Research in fire behavior, fuels, and air quality will allow the development of fire and ecological research tools, models, and techniques to better understand the fire environment. These tools, models, and techniques will allow more resource professionals to conduct safe and effective prescribed burns. We must also educate the public about the benefits of fire on forest ecosystems and forest health to promote greater public acceptance prescribed fire and increase its use.

Longleaf pine forests are of special interest for conservation and restoration efforts in North Carolina and across the Southeast. Many local partnerships have formed to promote the restoration of longleaf pine forests through the increased use of prescribed fire and reforestation incentives. The NC Division of Forest Resources is an important partner in leading these efforts and helping to develop conservation and management strategies. Similar efforts are needed to identify and assess the status and condition of other fire-adapted species, habitats, and ecosystems. Key components of the effort to restore fire-adapted ecosystems are (1) educating the public on the value of these ecosystems and (2) training natural resource professionals on how to better manage and conserve them.

Objective 3.1.—Promote a greater acceptance of prescribed fire and its increased use. **(Addresses key Assessment findings in sections 2e, 3a, 3b, 4g and USDA Forest Service national objectives 1.1, 1.2, 2.1, 2.2, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7)**				
Strategy 3.1.1.—Promote the application of prescribed fire as a management technique to benefit forest health, wildlife habitat, fuel reduction, and fire-adapted ecosystems.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
NC fire occurrences map (Figure 3b-2) NC communities at risk of wildfire map (Figure 3b-7) Wildland-urban interface map (Figure 3b-6) Protecting the Wildland-Urban Interface Map Priority Ecosystems (State Wildlife Action Plan) Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FM&FD Forest Stewardship Protection FEB FHM CWPP FireWise Educational and state forests BRIDGE Field staff GSB SP&A FDP FM	DENR—DAQ USFWS USFS USDOD NCWRC Natural Heritage TNC NCPFC USBIA USNPS SCO–NC NRCS	Development and implementation of inter-organizational MOUs Funding for state and federal cost-share programs (ex. FDP, EQIP, WHIP) Funding for state and federal initiatives and conservation programs Forestry, wildlife, and conservation programs for financial and tax benefits Merging of the fire danger and agriculture networks to create a Fire Environment Observation Network. Funding for increased GIS capability and development of a smoke management database	Completion of an interorganizational “Fire Danger Operating Plan” Number of acres where prescribed burning occurs for silviculture benefits, wildlife habitat enhancement, and fuel reduction. Number of acres of fire-dependent habitats restored Number of cooperative projects with DFR participation and technical assistance. Number of prescribed burning outreach and educational activities and programs. Number of weather observation stations Number of burning days available to conduct prescribed burning activities

Strategy 3.1.2.—Promote and conduct applied fire and ecological research to better understand and manage the fire environment.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
NC smoke sensitive areas map (Figure 3b-4) Wildland-urban interface map (Figure 3b-6) Protecting the Wildland-Urban Interface Map Protecting Forests and Communities from Wildfire Risk Map Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FEB Forest Protection FM TD&P CWPP Firewise Field staff GSB	DENR—DAQ USFWS USFS–Fire Research Labs and Model Consortium USDOD NCWRC Natural Heritage TNC NCPFC NWCG NOAA SCO–NC USEPA	Identification of lead individuals and/or organization and formation of teams focusing on fire environment research Funding and personnel for applied fire, and ecological research, field application, validation, and implementation of fire environment products, projects, and activities Funding for increased GIS capability and development of models Funding to conduct professional training	Development of applied fire and ecological research tools and techniques to promote increased use of prescribed fire (ex. social behavior/marketing survey) Development of new models and techniques for practitioners (ex. fire behavior; fuels—aerial, surface, and ground); estimating smoldering potential of organic soils, root mat, or deep duffs; smoke and air quality models) Number of cooperative applied fire research projects with DFR and/or fire environment efforts Number of new initiatives identified for future research and development Number of outreach activities to share research findings and information

Strategy 3.1.3.—Increase the resource capacity of trained and qualified personnel to conduct prescribed burning on private land.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Wildland-urban interface map (Figure 3b-6) Protecting the Wildland-Urban Interface Map Conserving Working Forestlands Map Rural Forest Priority Landscape Map	Forest Protection Training officer FEB FM Field staff GSB	NCPFC NCACF USFWS USFS USDOD NCWRC NCCES TNC	Funding for natural resource professional training and outreach materials Funding for prescribed burning equipment and specialized tools Funding for development of and training on fuel and advanced smoke modeling programs Funding for increased GIS capability (ex. Real-time mapping of all planned and unplanned fires)	Number of training workshops Number of burning crews, Certified Burners and private contractors Amount of equipment and specialized tools to conduct prescribed burning (air quality and smoke monitoring stations, estimated smoldering potential sensor arrays for organic soils or deep duffs)

Strategy 3.1.4.—Publicize the importance, value, and benefits of prescribed fire and educate the public about these aspects.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
NC fire occurrences map (Figure 3b-2) NC communities at risk of wildfire map (Figure 3b-7) Wildland-urban interface map (Figure 3b-6) Protecting the Wildland-Urban Interface Map Protecting Forests and Communities from Wildfire Risk Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FM Forest Protection I&E Unit Forest Stewardship ESF/SF	DENR USFS USFWS NCWRC NCCES NCPFC NWCG TNC USBIA USNPS USDOD	Funding for education and outreach efforts (ex. websites, workshops, media releases) Funding to conduct social marketing survey on the use of prescribe fire	Development of a website and information clearinghouse for the public Number of information and outreach materials developed and distributed Number of workshops and other training activities to promote prescribed fire Number of acres of forestland where prescribed burning occurred
Strategy 3.1.5.—Support the efforts of prescribed burners to acquire adequate and affordable liability insurance.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Wildland-urban interface map (Figure 3b-6) Protecting the Wildland-Urban Interface Map Protecting Forests and Communities from Wildfire Risk Map Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FEB Forest Protection FM Law Enforcement Field staff	DENR— DAQ DOI NC Legislature NCPFC NCFA NOAA SCO–NC USEPA	State policy addressing the acquisition of adequate and affordable liability insurance for prescribed burners Funding to conduct research on current status of liability issues and costs Funding to develop and maintain a certification system for prescribed burners Funding for outreach	Development of policy that appropriately limits liability for prescribed burners Number of prescribed burners and private contractors who can conduct controlled burns Number of acres where prescribed burning occurred Number of insurance underwriters for prescribed burners Development of certification system for prescribed burners Number of outreach activities and materials that promote insurance opportunities

Objective 3.2.—Restore and conserve fire-adapted species, habitats, and forest ecosystems. (Addresses key Assessment findings in sections 2b, 2e, 2f, 3b, 4g and USDA Forest Service national objectives 1.1, 1.2, 2.1, 2.2, 3.2, 3.3, 3.5, 3.6, 3.7)				
Strategy 3.2.1.—Identify, evaluate, and support management and conservation opportunities for fire-adapted species, habitats, and forest ecosystems.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
NC fire occurrences map (Figure 3b-2) Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map Priority Ecosystems (State Wildlife Action Plan)	FM Longleaf Initiative ARRA Longleaf Grant Forest Legacy TD&P Forest Stewardship GSB FIA	DENR—NHP USFWS USFS USDOD NCWRC NRCS FSA TNC NC Longleaf Coalition	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners Funding for increased GIS, inventory, and database of specific tree species and forest ecosystems and their distribution and abundance	Development of a regional or statewide strategic conservation plan that identifies key tree species, habitats, and ecosystems to conserve, manage, or restore Number of new initiatives developed Number of priority conservation areas for fire-adapted species and/or ecosystems identified Number of MOUs established
Strategy 3.2.2.—Promote and publicize restoration efforts and the ecological importance of restoring fire to fire-dependent ecosystems, and educate the public about fire restoration efforts and importance.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
NC fire occurrences map (Figure 3b-2) Protecting Forests and Communities from Wildfire Risk Map Conserving Working Forestlands Map Priority Ecosystems (State Wildlife Action Plan)	FM&FD Forest Stewardship Longleaf Initiative ARRA Longleaf Grant Forest Protection I&E ESF/SF GSB	DENR USFS USFWS NCWRC NCCES NCPFC TNC Longleaf Alliance America's Longleaf NC Longleaf Coalition	Promotional materials, such as demonstration areas, newsletter articles, e-mails, billboards, and radio/television PSAs. Funding for increased GIS analysis and support	Number of information and outreach materials developed Number of information and outreach programs, workshops, and conferences that raise public awareness aboutdeclining tree species and forest ecosystems

Strategy 3.2.3.—Promote the increased application of fire and ecological research and techniques to restore and manage fire-adapted species, habitats, and ecosystems.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
NC fire occurrences map (Figure 3b-2) NC smoke sensitive areas map (Figure 3b-4) Protecting Forests and Communities from Wildfire Risk Map Conserving Working Forestlands Map	FEB Forest Protection FM TD&P FIA Field staff GSB Forest Stewardship	DENR—DAQ USFWS USFS – Fire Research Labs & Model Consortium USDOD NCWRC Natural Heritage TNC NCPFC NWCG NOAA SCO–NC USEPA	Identification of lead individuals and/or organization for improved coordination and collaboration among various state agencies, key stakeholders, and cooperative partners Funding for applied fire and ecological research Funding and personnel for applied fire and ecological research, field application, validation, and implementation of fire environment products, projects, and activities Funding for increased GIS capability and development of models Increased resource capacity and funding to support research efforts. Funding for professional training	Development of applied fire and ecological research tools and techniques to promote increased use of prescribed fire Development of new modeling tools and techniques for practitioners in the areas of fuels, fire behavior, smoke management, and air quality Number of cooperative applied fire research projects with DFR participation Number of acres (mgmt. units) of fire-adapted species habitat and ecosystems that are restored, conserved, and managed Number of activities that support the restoration, conservation, and management efforts for fire-adapted species, habitats, and ecosystems Number of burning days available to conduct prescribed burning activities Number of new initiatives identified for future research and development Number of workshops, advanced training sessions, and technical transfers of research findings and information

Objective 3.3.—Restore and conserve longleaf pine forests.
(Addresses key Assessment findings in sections 2b, 2e, 2f, 4g and USDA Forest Service national objectives 1.1, 1.2, 2.1, 2.2, 3.1, 3.3, 3.5, 3.6, 3.7)

Strategy 3.3.1.—Identify, evaluate, and support management and conservation opportunities for longleaf pine forests in North Carolina.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
North Carolina longleaf pine forest distribution map (Figure 2b-1) Rural Forest Priority Landscape Map Priority Ecosystems (State Wildlife Action Plan)	FM Longleaf Initiative ARRA Longleaf Grant Forest Legacy TD&P Forest Stewardship GSB	DENR USFWS USFS USDOD NCWRC Natural Heritage NRCS FSA TNC Longleaf Alliance America's Longleaf NC Longleaf Coalition	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners Funding for increased GIS, inventory, and database of longleaf pine distribution and extent	Development of a regional or statewide strategic conservation plan Number of initiatives developed Number of collaborative projects developed Identification of priority conservation areas Number of MOUs established

Strategy 3.3.2.—Increase restoration of longleaf pine by afforestation, reforestation, and natural regeneration techniques.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
North Carolina longleaf pine forest distribution map (Figure 2b-1) Rural Forest Priority Landscape Map Conserving Working Forestlands Map	FM TD&P Longleaf Initiative ARRA Longleaf Grant Field staff N&TI Forestation FEB Forest Stewardship	NRCS FSA NCACF USFWS USFS USDOD NCWRC NCCES Research Cooperatives NGOs (ex. TNC, Longleaf Alliance, America's Longleaf, NC Longleaf Coalition)	Funding for state and federal cost-share programs (ex. FDP) Funding for state and federal initiatives and conservation programs Funding for training, education, and outreach for professionals Funding for developing economic analysis tools and growth and yield models for longleaf pine Funding for professionals to provide service	Number of management plans that promote longleaf pine establishment Number of acres of longleaf pine restored. Number of activities or acres affected by practices that promote longleaf pine restoration Number of longleaf pine seedlings produced (nursery capacity) Number of pounds of improved longleaf seed produced Development of economic analysis tools and growth and yield models for Longleaf pine Number of professionals providing services related to restoration of longleaf pine

Strategy 3.3.3.—Increase the use of prescribed fire as a management tool to restore longleaf pine ecosystems.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
NC fire occurrences map (Figure 3b-2) Protecting Forests and Communities from Wildfire Risk Map Conserving Working Forestlands Map Priority Ecosystems (State Wildlife Action Plan)	FM Longleaf Initiative ARRA Longleaf Grant Forest Protection FEB Field staff GSB Forest Stewardship	NCPFC NCACF USFWS USFS USDOD NCWRC NCCES NRCS DENR—DAQ NGOs (ex. TNC, Longleaf Alliance, America's Longleaf, NC Longleaf Coalition)	Funding for state and federal cost-share programs (ex. FDP) Funding for state and federal initiatives and conservation programs Funding for training, education, and outreach for professionals Funding for developing fuel and atmospheric dispersion (smoke) models Development of a real-time Web-based GIS mapping of all fires (planned and unplanned ignitions)	Number of acres burned to benefit the restoration and maintenance of longleaf pine forests Number of burning days available to conduct prescribed burning activities Development of new modeling tools and techniques for practitioners in the areas of fuels and fire behavior, smoke management, and air quality Number of burning crews, certified burners, and private contractors Number of workshops and advanced training sessions that focus on the technical transfer of research findings and information
Strategy 3.3.4.—Publicize the benefits of restoring longleaf pine and educate landowners, resource professionals, and the public about these benefits.				
Priority Landscape Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
North Carolina longleaf pine forest distribution map (Figure 2b-1) Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FM Longleaf Initiative ARRA Longleaf Grant Forest Protection I&E Forest Stewardship ESF/SF GSB	DENR USFS USFWS NCWRC NCCES NCPFC NGOs (ex. TNC, Longleaf Alliance, America's Longleaf, NC Longleaf Coalition)	Funding for education and outreach efforts (ex. website, workshops, media releases) Funding for developing GIS tools, economic analysis tools, and growth and yield models for longleaf pine	Number of products developed (ex. podcasts, webpages, news article, posters, brochures and other media) Number of users accessing materials through the Internet Development of economic analysis tools and growth and yield models for longleaf pine

Goal 4.—Maintain or increase the viability and sustainability of existing and emerging markets.

This goal will focus our resources on working with new and existing partners and agencies to help maintain or increase the viability and sustainability of existing and emerging markets. North Carolina's forest products industry has undergone dramatic changes since 1990. Declines have occurred in the number of establishments and the types of products that are being produced by traditional forest enterprises. We need to promote traditional markets, strengthen traditional markets that are at-risk, develop new products for traditional markets, and promote emerging markets for ecosystem services and nontraditional forest resources.

Biomass will be an increasingly important market-sector at the urban-rural landscape level due to increasing demand for biomass as a feedstock for biopower and biofuels. Ecosystem services markets can also help meet the expected increase in demand placed upon our forest resources and the constituent components of clean water, clean air, wildlife habitat, and recreation. Many rural and urban landscape areas (as described in the Urban Forest Priority Landscape Map) may be suitable for ecosystem services for carbon management or conservation benefits. Localized niche markets developed around the growing, collecting and harvesting of non-timber products currently exist in North Carolina and may be further developed as interest in these products increases.

Any effort to establish, promote, and monetize forest-based markets should directly benefit forestland owners and the forest products industry, while indirectly benefiting the public. Implementing these specific strategies will result in (1) a more robust and economically strong forest products industry and (2) an increased number of market opportunities for landowners to increase supplemental income from their forestland. Landowners could use this income to sustainably manage their forestland for multiple benefits while contributing to a healthy environment and economy.

Objective 4.1.—Advocate forest sustainability and market viability (current and future) for consumers and producers. (Addresses key Assessment findings in sections 2b, 2c, 2e, 2f, 3c, 4a, 4d, 4e, 4g, 4h, 4i, 4j, 4k and USDA Forest Service national objectives 1.1, 1.2, 2.2, 3.3, 3.4, 3.5, 3.6)

Strategy 4.1.1.—Advocate forest sustainability.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Softwood Market Strength Map Hardwood Market Strength Map Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Field staff ESF/SF FM Forest Legacy Forest Stewardship GSB I&E Outreach State Forests TD&P U&CF BMP/NPS FPG/WQ	USFS NCACF NCFA Forest Industry NCCES FEOP AF&PA FSC NCTFS NCWRC NC Woodlands NCAPL NGOs Forest landowners SGSF	Funding for I&E materials Funding for Internet server space and enhanced Web presence USFS funding (ex. Redesign grants) Funding for training, education, and outreach for professionals	Number of products developed (ec. podcasts, webpages, news articles, posters, brochures, and other media) Number of users accessing materials through the Internet Number of landowner cooperatives Number of acres under sound forest management Number of workshops or training opportunities provided Number of professionals trained

Strategy 4.1.2.—Educate forestland owners and partnering agencies about current and future forest-market opportunities.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Softwood Market Strength Map Hardwood Market Strength Map Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Field staff ESF/SF FM Forest Legacy Forest Stewardship Forest Protection GSB I&E TD&P U&CF BMP/NPS FPG/WQ FIA	USFS NCACF NCFA Forest Industry NCCES FEOP AF&PA FSC NCTFS NCWRC NC Woodlands NCAPL NGOs SGSF	Funding for I&E materials Funding for training, education, and outreach (ex. newsletter articles, e-mails, billboards and radio/television PSAs) USFS funding (ex. Redesign grants)	Number of products developed (ex. podcasts, webpages, news articles, posters, brochures, and other media) Number of users accessing materials through the Internet Number of workshops or training opportunities provided Number of landowners trained on forest markets

Strategy 4.1.3.— Provide technical assistance, information, and outreach to forest-based industries regarding forest sustainability and market viability.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Softwood Market Strength Map Hardwood Market Strength Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FM Forest Protection GSB I&E TD&P U&CF BMP/NPS FPG/WQ FIA	USFS NCACF NCFA NCCES FEOP UNC System NGOs NCDA – EXPORT NCAPL DOC SGSF	Identification of lead individuals and/or organization to develop partnerships among key partners and stakeholders focused on forest industry Funding for I&E materials Funding for Internet server space and enhanced Web presence Funding for training, education, and outreach (ex.newsletter articles, e-mails, billboards, and radio/television PSAs) Funding for developing GIS tools and market analysis USFS funding (ex. Redesign grants)	Number of products developed (ex. podcasts, webpages, news articles, posters, brochures, and other media) Number of users accessing materials through the Internet Number of workshops or training opportunities provided Number of people trained Number of MOUs established Number of clients served
Strategy 4.1.4.—Support and advocate for a favorable business environment for forest-based industries.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Softwood Market Strength Map Hardwood Market Strength Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	FM GSB I&E TD&P U&CF	Field offices ESF/SF FM Forest Legacy Forest Stewardship GSB I&E TD&P U&CF BMP/NPS FPG/WQ NCDA – EXPORT DOC Trade associations SGSF NCFA	Identification of lead individuals and/or organization and formation of partnerships focusing on business recruitment and retention Policies aimed at recruiting and retaining forest-based industries Development and implementation of inter-organizational MOUs Funding for training, education, and outreach (ex. newsletter articles, e-mails, billboards and radio/television PSAs) USFS funding (ex. Redesign grants)	Number of forest-based industries created Number of products manufactured by primary and secondary processors Number of jobs in forestry-related industries Amount of tax revenues from forestry-related industries Changes to state and local government regulations or policies that support and advocate for a favorable business environment for forest-based industries Number of products developed (ex. podcasts, webpages, news articles, posters, brochures, and other media) Number of users accessing materials through the Internet Number of workshops or training opportunities provided Number of people trained Number of MOUs established Number of clients served Number of grants awarded

Objective 4.2.—Advocate and promote domestic and export market opportunities for traditional forest products, including biomass and underutilized species. (Addresses key Assessment findings in sections 2e, 3c, 4e, 4h, 4k and USDA Forest Service national objectives 1.1, 1.2, 2.2, 3.3, 3.4, 3.5, 3.6)				
Strategy 4.2.1.—Identify and promote the retention and recruitment of domestic and export markets for biomass, underutilized species, and low-grade materials, and traditional forest products.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Softwood Market Strength Map Hardwood Market Strength Map Conserving Working Forestlands Map Protecting Forests and Communities from Wildfire Risk Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Field staff ESF/SF FM GSB I&E TD&P U&CF Forest Protection FIA	USFS NCACF NCFA Forest Industry NCCES FEOP AF&PA FSC NCTFS NCWRC NC Woodlands NCAPL NGOs NCCES DoC NCDA – EXPORT Trade associations APHIS	Policies aimed at retention and recruiting of domestic and export markets. Funding for I&E materials Funding for Internet server space and enhanced Web presence Funding for developing GIS tools and market analysis Identification of lead individuals and/or organization to develop partnerships among key partners and stakeholders related to market development, utilization, and education USFS funding (ex. Redesign grants)	Number of products manufactured by primary and secondary processors Number of jobs in forestry-related industries Amount of tax revenues from forestry-related industries Number of industries recruited or retained (ex. facilities capable of processing woody biomass, tree care businesses involved in urban biomass removal, utilities) Number of markets developed Number of market analyses completed Number of I&E products developed (ex. podcasts, webpages, news articles, posters, brochures, social media, and other media) Development of analytical GIS products for low-grade and underutilized forest products. Development of GIS database of buyers and sellers of forest products Number of tons of woody biomass materials diverted from local landfills Number of MOUs established Number of clients served Number of grants awarded Value added for low-grade materials

Objective 4.3.—Advocate and promote markets for forest-derived ecosystem services, non-timber products, and ecotourism. (Addresses key Assessment findings in sections 2a, 2b, 2c, 2d, 3b, 3c, 4a, 4d, 4e, 4f, 4g, 4h, 4i, 4j and USDA Forest Service national objectives 1.1, 1.2, 2.2, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7)

Strategy 4.3.1.—Identify and support entities involved in market retention, recruitment, and expansion of forest-derived ecosystem services, non-timber products, and ecotourism.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Wetland and stream mitigation site opportunities for private landowners Map (Figure 2f-1) Nutrient offset bank opportunities for private land owners (Figure 2f-2) Federally-listed species occurrences in North Carolina Map (Figure 2f-3) Forest carbon biomass in North Carolina Map (Figure 2f-4) Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Field staff ESF/SF FM Forest Legacy Forest Stewardship GSB I&E ESF/SF TD&P U&CF BMP/NPS FPG/WQ	NCDA – EXPORT Trade Associations NCDT DENR—EEP Mitigation banks Conservation groups Land trusts Landowners FSC SFI ATFS Greentag USFS NRCS USEPA DOT DOC USFWS USDOD NCFA NCACF NCCES SGSF	Identification of lead individuals and/or organization to develop partnerships among key partners and stakeholders related to market development, expansion, and education Policies aimed at retaining and recruiting markets. Funding for Internet server space and enhanced Web presence Funding for developing GIS tools and market analysis USFS funding (ex. Redesign grants) Funding for market and product development for non-timber products and ecotourism	Number of MOUs established Changes to state and local government regulations or policies that support and advocate for a favorable business environment Number of business entities involved in forest-derived ecosystem services, non-timber products, and ecotourism markets Number of acres available for ecosystem services, non-timber products, and ecotourism Number of permits issued for plant collection Creation of analytical GIS products for non-timber products and eco-tourism Database of forest-derived ecosystem services, non-timber products, and ecotourism opportunities Spatial database of buyers and sellers of forest products, including non-timber products and ecotourism. Number of market analyses completed (ex. market analysis report of water treatment costs correlated with source of water from forested watersheds) Number of credits established and utilized (ex. water quality trading, carbon credits, nutrients) Number of jobs created Number of aggregators and traders recruited or retained Number of clients served Number of grants awarded

Strategy 4.3.2.—Create and disseminate information that explains the concept of ecosystem services, non-timber products, and ecotourism.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Wetland and stream mitigation site opportunities for private landowners map (Figure 2f-1) Nutrient offset bank opportunities for private land owners (Figure 2f-2) Federally-listed species occurrences in North Carolina map (Figure 2f-3) Forest carbon biomass in North Carolina Map (Figure 2f-4) Conserving Working Forestlands Map Urban Forest Priority Landscape Map	Field staff ESF/SF FM Forest Legacy Forest Stewardship GSB I&E ESF/SF TD&P U&CF BMP/NPS FPG/WQ	Landowners USEPA USFS DENR—DSWC NRCS Conservation groups Land trusts NCFA ESF/SF FM Forest Legacy Forest Stewardship GSB I&E TD&P U&CF BMP/NPS FPG/WQ NCDA – EXPORT DOC Trade associations NCACF NCCES NCDT SGSF	Funding for state and federal Initiatives and Programs Policies aimed at retaining and recruiting markets (ex. tax incentives) Funding for education and outreach (ex. websites, newsletter articles, e-mails, billboards, and radio/television PSAs) Funding for developing GIS tools and market analyses (ex. quantifying ecosystem services and market viability) USFS funding (ex. Redesign grants) Funding for market and product development for non-timber products and ecotourism	Number of products developed (ex. podcasts, webpages, news articles, posters, brochures, demonstration sites, social media sites, and other media) Number of users accessing materials through the Internet Number of workshops or training opportunities provided Number of people attending educational workshops and training events

Strategy 4.3.3.—Educate forestland owners and partners about current and future market opportunities for forest-derived ecosystem services, non-timber products, and ecotourism.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Wetland and stream mitigation site opportunities for private landowners map (Figure 2f-1) Nutrient offset bank opportunities for private landowners (Figure 2f-2) Federally-listed species occurrences in North Carolina map (Figure 2f-3) Forest carbon biomass in North Carolina map (Figure 2f-4) Conserving Working Forestlands Map Urban Forest Priority Landscape Map	Field staff BMP/NPS U&CF Forest Stewardship N&TI TD&P I&E FEB FM ESF/SF Forest Legacy GSB FPG/WQ FIA	DENR—EEP, DSWC, DWQ, DAQ NRCS USACE DOT Mitigation banks Conservation groups Land trusts USFWS Landowners Forest certification programs NCFA NCACF NCCES NCDA – EXPORT DOC Trade associations NCDT SGSF	Identification of lead individuals and/or organization to develop partnerships among key partners and stakeholders focused on forest industries Funding for training natural resource professionals and landowners Funding for Internet server space and enhanced Web presence Funding for education and outreach (ex. newsletter articles, e-mails, billboards, and radio/television PSAs) Funding for developing GIS and databases (ex. partnership directory) USFS funding (ex. Redesign grants)	Number of products developed (ex. podcasts, webpages, news articles, posters, brochures, demonstration sites on ESF/SF, and other media) Number of users accessing materials through the Internet Number of workshops or training opportunities provided Number of landowners attending workshops and training events Number of landowners who participate in forest-derived ecosystem services, non-timber products, or ecotourism markets. Number of MOUs established Amount of funding for promotional materials Number of participants in collaborative projects and partnerships Creation of partnership directory and database Creation of analytical GIS products for non-timber products

Goal 5.—Increase and enhance forest fish and wildlife habitat.

The following objectives and strategies seek to increase and enhance fish and wildlife habitats across North Carolina's many diverse forests. With these objectives, we aim to conserve working forests as we seek to expand the public benefits that accrue from wildlife habitat sustainability. To prioritize this work, we look to forest ecosystems that are rare or declining, those that support rare and declining species, as well as those that support a diverse mix of wildlife species. Programs such as those available through the USDA Farm Bill are identified as tools currently available to increase fish and wildlife habitats. Funding resources to achieve management goals will come from various sources such as Farm Bill programs, competitive grants, Partners for Fish and Wildlife, and the Landowner Incentive Program, among others. Throughout North Carolina, various conservation partnerships exist with diverse members who focus on regionally important conservation targets. Conservation partnerships also bring together key partners in forestland conservation and are well-positioned to accomplish conservation objectives by combining and leveraging funds.

State and federal agency staff, land trusts personnel, and NGO biologists will provide technical assistance, individually and through partnerships. Tax incentives will be available through programs such as the Forest Legacy Program, NC Conservation Tax Credit, Forestry Present Use Valuation, and the Wildlife Conservation Land Program. An increase of private and public participation in wildlife conservation will develop—leading to forestland protection, habitat management, and environmental education. The result will be an increase in acres and enhancement of acres of protected and managed forestland benefitting wildlife. These objectives will be accomplished more specifically by such strategies as land acquisition, conservation easements, and conservation agreements, as well as by promoting forest-management plans and implementing forest-management practices that support natural forest ecosystems. The underlying key to success will come through education of landowners, citizens, and children.

Note: Several issues areas are not addressed within Goal 5 because they are addressed in other goals. For example, issues pertaining to the use of prescribed fire are addressed in Goal 3.

Objective 5.1.—Protect and conserve priority forest fish and wildlife habitat. (Addresses key Assessment findings in section 4g and USDA Forest Service national objectives 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 3.4, 3.5, 3.6, 3.7)				
Strategy 5.1.1.—Protect and conserve forestland with priority wildlife habitat through acquisition (fee simple) and conservation easements.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan) Forest Legacy "Areas of Need" Conserving Working Forestlands Map Rural Forest Priority Landscape Map	Forest Legacy Forest Stewardship Field staff FM	Landowners NRCS NCWRC USFWS USFS DENR—DPR, DSWC, NHP CWMTF TNC Land trusts USNPS NGO's Riverkeepers Various NC conservation partnerships CREP	Funding for state and federal initiatives and programs (ex. fully funded CREP, WRP, Forest Legacy) Competitive grants Funding for training and dedicated personnel to provide technical services on conservation easements opportunities Forestry, wildlife, and conservation programs for financial and tax benefits (ex. NC Conservation Tax Credit)	Number of acres protected and conserved through acquisition or conservation easements Number of properties brought into an easement program Number of stream miles protected Number of Natural Heritage Program acres conserved Number of priority ecosystem acres conserved as identified by the State Wildlife Action Plan Number of floodplain acres conserved
Strategy 5.1.2.—Enroll private forestland in long-term, nonpermanent conservation agreements using federal and state conservation programs.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan) Conserving Working Forestlands Map Rural Forest Priority Landscape Map	Forest Stewardship FSPP FM Field staff	NRCS NCWRC USFWS DENR—NHP FSA TNC NGOs Partners for Fish and Wildlife Wildlife Conservation Land Program Safe Harbor CREP CWMTF	Funding for state and federal initiatives and programs (ex. fully funded FSPP, CRP, CREP, EQIP, WHIP, Partners for Fish/Wildlife Program) Competitive Grants Funding for training and dedicated personnel to provide technical services on conservation agreement opportunities Forestry, wildlife, and conservation programs for financial and tax benefits (ex. NC Conservation Tax Credit) Funding for Wildlife Conservation Land Program	Number of acres under long-term conservation agreements Number of priority species' habitats protected Number of acres in Safe Harbor Number of acres enrolled in Farm Bill programs, such as CREP, annually Number of properties and acres listed in NC Registry of Natural Heritage Areas

Strategy 5.1.3.—Increase compliance with existing regulations that protect fish and wildlife habitat.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan)		NCWRC DENR—DWQ NRCS USFWS Land trusts Wildlife Conservation Land Program	Funding for wildlife enforcement officers Funding to maintain NCWRC Enforcement Communication Center (1-800-662-7137)	Number of acres patrolled or monitored Number of wildlife violations reported Number of educational programs offered to increase awareness Number of wildlife enforcement officers hired Number of calls to NCWRC Enforcement Communication Center (1-800-662-7137)

Strategy 5.1.4.—Provide technical assistance for the protection or mitigation of forest wildlife habitats affected by transportation and utility infrastructure.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan) Forest Legacy "Areas of Need" Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Forest Stewardship FSPP Forest Legacy U&CF BMP/NPS FM	NRCS NCWRC USFWS DENR—EEP, NHP DOT Land trusts USDOD FERC USEPA Utility companies	Funding for mitigation Funding to ensure an effective review and permitting process. Grants (ex. federal, foundation, state wildlife, NRCS Conservation Innovation grants) Full funding to carry out duties as designated in Section 7 of the Endangered Species Act and the Migratory Bird Treaty Act	Number of service calls provided by NCWRC Number of acres protected or mitigated (ex. wetlands) Number of stream miles protected or restored Number of impacts avoided Number of workshops held for DOT and utilities Number of collaborative projects and partnerships

Strategy 5.1.5.—Promote the sound management of riparian buffers with native species.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan) Wetland and stream mitigation site opportunities for private landowners map (Figure 2f-1) Conserving Working Forestlands Map Rural Forest Priority Landscape Map	FDP Pest Control Forest Stewardship FSPP NPS FM N&TI	DENR—NHP USFWS NCWRC NGOs SGSF Private nurseries CWMTF NCACF NCCES Riverkeepers	Identification of lead individuals and/or organization for improved coordination and collaboration between various state agencies, key stakeholders, and cooperative partners Development and implementation of inter-organizational MOUs Funding for training and dedicated personnel to provide technical services related to riparian buffer establishment and management Funding for education and outreach (ex. websites, newsletter articles, e-mails, billboards, and radio/television PSAs) Funding for state and federal cost-share programs (ex. FSPP, FDP, EQIP) Funding for state and federal initiatives and conservation programs (ex. non native invasive species control) Funding to support tree nurseries in the production of native riparian plant species Forestry, wildlife, and conservation programs for financial and tax benefits	Number of MOUs created Number of workshops held Number of professionals trained Number of miles or acres of riparian buffers established Number of participants in workshops Number of landowners implementing riparian management practices Number of seedlings produced for riparian buffer establishment Amount of cost-share funds available for landowners to implement management practices Number of ESF/FS annual visitors Number of NCWRC education center visitors

Objective 5.2.—Restore and actively manage forests to benefit priority fish and wildlife habitats.
(Addresses key Assessment findings in section 4g and USDA Forest Service national objectives 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7)

Strategy 5.2.1.—Use technical and financial assistance programs to identify and restore critical terrestrial and aquatic habitats at risk.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Priority Ecosystems (State Wildlife Action Plan) Forest Legacy "Areas of Need" Conserving Working Forestlands Map Rural Forest Priority Landscape Map	Forest Stewardship Forest Legacy FM FDP BMP/NPS Field staff FPG/WQ FSPP	Landowners NCWRC USFWS DENR—NHP NGOs NCTFS NC Woodlands NCACF Riverkeepers NCCES NRCS NCSWCD	Identification of lead individuals and/or organization for improved coordination and collaboration between various state agencies, key stakeholders, and cooperative partners Development and implementation of inter-organizational MOUs Funding for training and dedicated personnel to provide technical services related to identifying and restoring critical terrestrial and aquatic habitat at risk Funding for education and outreach (ex. websites, newsletter articles, e-mails, billboards, and radio/television PSAs) Funding for state and federal cost-share programs (ex. FSPP, FDP, CRP, EQIP, WHIP, CREP) Funding for state and federal initiatives and conservation programs (ex. non-native invasive species control) Forestry, wildlife, and conservation programs for financial and tax benefits	Number of MOUs created Number of workshops held Number of participants in workshops Number of professionals trained Amount of cost-share funds available for landowners to implement management practices Number of landowners assisted Number of landowners implementing management practices to restore critical terrestrial and aquatic habitat Number of miles or acres of critical terrestrial and aquatic habitat restored Number of stewardship or other forest-management plans written

Strategy 5.2.2.—Assist landowners with developing and implementing comprehensive forest-management plans that incorporate landowner wildlife management objectives and focus on utilizing silviculture practices that mimic natural ecosystem conditions beneficial to native wildlife species.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resource Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan) Forest Legacy "Areas of Need" Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Forest Stewardship Forest Legacy FM FEB SP&A U&CF FDP TD&P	Landowners NRCS NCWRC USFWS FSA NCCES NCACF USFS USGS DENR—DPR, NHP UNC System NCCES NCTFS NC Woodlands TNC Land trusts NCPFC NGOs (ex. The Wildlife Society, NC Longleaf Coalition) SAF	Funding for training and dedicated personnel to provide technical services to assist landowners with developing and implementing comprehensive forest-management plans Funding for education and outreach (ex. websites, newsletter articles, e-mails, billboards, and radio/television PSAs) Funding for state and federal cost-share programs (ex. FDP, CRP, EQIP, WHIP, CREP) Funding for state and federal initiatives and conservation programs Forestry, wildlife, and conservation programs (ex. Wildlife Conservation Land Program, Partners for Fish/Wildlife Program, NC Conservation Tax Credit)	Number of workshops held Number of participants in workshops Number of professionals trained Number of landowners assisted Number of stewardship or other forest-management plans written Number of acres enrolled in forest and wildlife conservation programs Amount of cost-share funds available for landowners to implement management practices Number of acres on which management practices (ex. reforestation, thinning, prescribed burning) were implemented Number of landowners implementing management practices (ex. reforestation, thinning, prescribed burning)

Strategy 5.2.3.—Conserve, restore, and connect ecologically functioning forests to decrease fragmentation and enhance wildlife habitats.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan) Forest Legacy "Areas of Need" Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Forest Legacy Forest Stewardship Field staff SP&A FM	CWMTF NRCS NCWRC USFWS USFS USGS FSA DENR—NHP UNC System TNC Land trusts NCPFC The Wildlife Society NGO's NC Longleaf Coalition SAF NCCES SGSF	Identification of lead individuals and/or organization for improved coordination and collaboration between various state agencies, key stakeholders, and cooperative partners Development and implementation of inter-organizational MOUs Funding for state and federal initiatives and conservation programs (ex. CWMTF) Forestry, wildlife, and conservation programs for financial and tax benefits Funding for training and dedicated personnel to provide technical services related to conserving, restoring, and connecting ecologically functioning forests Funding for education and outreach (ex. websites, newsletter articles, e-mails, billboards, and radio/television PSAs) Funding for state and federal cost-share programs (ex. FDP, CRP, EQIP, WHIP, CREP)	Number of MOUs created Number of wildlife corridors created Number of Forest Legacy tracts and acres Number of Natural Heritage Program acres conserved Number of SWAP defined acres conserved Number of floodplain acres conserved Number of workshops held Number of participants in workshops Number of professionals trained Number of landowners assisted Number of stewardship or other forest-management plans written Number of acres enrolled in forest and wildlife conservation programs Amount of cost-share funds available for landowners to implement management practices Number of acres in which management practices (ex. reforestation, thinning, prescribed burning) were implemented Number of landowners implementing management practices (ex. reforestation, thinning, prescribed burning) Number of specific wildlife species observed

Objective 5.3.—Promote the restoration and conservation of declining tree species and forest ecosystems.
(Addresses key Assessment findings in section 4g and USDA Forest Service national objectives 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7)

Strategy 5.3.1.—Assess, identify, and emphasize management and conservation strategies that prioritize declining tree species and forest ecosystems.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Priority Ecosystems (State Wildlife Action Plan) Forest Legacy "Areas of Need" Conserving Working Forestlands Map Rural Forest Priority Landscape Map	Forest Legacy Forest Stewardship FM FDP TD&P Pest Control SP&A GSB FIA	DENR—DPR, NHP USFWS USFS USDOD NCWRC NRCS FSA TNC UNC System NCCES NCPFC NGOs (ex., The Wildlife Society, QU, DU, NWTF, land trusts, NC Longleaf Coalition, America's Longleaf Conservation Plan, Atlantic White Cedar Alliance, American Chestnut Foundation)	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners Development and implementation of inter-organizational MOUs Funding for training and dedicated personnel to provide technical services related to management of declining tree species and forest ecosystems Funding for education and outreach (ex. websites, newsletter articles, e-mails, billboards, and radio/television PSAs) Funding for increased GIS, inventory, and database of specific tree species and forest ecosystems (distribution and abundance) Funding for state and federal cost-share programs (ex. FDP, CRP, EQIP, WHIP, CREP) Funding for state and federal initiatives and conservation programs (ex. CWMTF) Forestry, wildlife, and conservation programs (ex. Wildlife Conservation Land Program, Partners for Fish/Wildlife Program, NC Conservation Tax Credit)	Number of MOUs established Development of a regional or statewide strategic conservation plan that identifies key tree species and forest ecosystems in decline Number of new initiatives developed Number of priority conservation areas identified with declining tree species and forest ecosystems Participation and support of new partnerships and collaborative coalitions Number of acres of declining forest ecosystems restored or managed Number of new initiatives or action plan efforts developed for specific ecosystems and species in decline Number of workshops held Number of participants in workshops Number of professionals trained Number of products developed (ex. podcasts, webpages, news articles, posters, brochures, demonstration sites on ESF/SF, and other media) Number of ESF/FS annual visitors Number of NCWRC education center visitors

Strategy 5.3.2.—Educate the public on the benefits, ecological importance, and value of restoring and conserving declining tree species and forest ecosystems.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan) Forest Legacy “Areas of Need” Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Forest Legacy Forest Stewardship FM Forest Protection I&E ESF/SF TD&P U&CF	DENR—DPR, NHP USFS USFWS NCWRC NCCES NCPFC TNC NCTFS NC Woodlands SGSF NCACF NGOs (ex., Longleaf Alliance, America’s Longleaf Conservation Plan, Atlantic White Cedar Alliance, American Chestnut Foundation)	Funding for education and outreach (ex. newsletter articles, e-mails, billboards, and radio/television PSAs) Funding for Internet server space and enhanced Web presence USFS funding (ex. Redesign grants)	Number of information and outreach programs, workshops, and conferences to promote declining tree species and forest ecosystems Number of products developed (ex. podcasts, webpages, news articles, posters, brochures, demonstration sites, social media, and other media) Number of users accessing materials through the Internet Number of ESF/FS annual visitors Number of NCWRC education center visitors

Objective 5.4.—Educate natural resource professionals, the general public, landowners, and K-12 schoolchildren about forestland conservation, restoration, and management, and the value of forests for fish and wildlife habitat. (Addresses key Assessment findings in section 4g and USDA Forest Service national objectives 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7)				
Strategy 5.4.1.—Educate natural resource professionals on wildlife habitat management programs and initiatives.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan) Forest Legacy "Areas of Need" Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Forest Stewardship TD&P I&E FM FM&FD Field staff	NCWRC (including stewardship biologists) USFWS NCPFC SAF NCCES UNC System NCACF NRCS The Wildlife Society	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners Funding for education and outreach (ex. newsletters, training aids, websites) Funding for training and dedicated personnel to provide technical services (NCWRC and its stewardship biologists, NRCS) USFS funding (ex. Redesign grants)	Number of products developed (ex. podcasts, webpages, articles, brochures, and other media) Number of users accessing materials through the Internet Number of workshops held Number of professionals trained Number of stewardship or other management plans developed Number of landowners provided with technical services from trained professionals Number of landowners enrolled in wildlife conservation programs

Strategy 5.4.2.—Educate the general public, landowners, policy-makers, and K-12 schoolchildren about forestland conservation, restoration and management and the value of forests for wildlife habitat.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority Ecosystems (State Wildlife Action Plan) Forest Legacy “Areas of Need” Conserving Working Forestlands Map Rural Forest Priority Landscape Map Urban Forest Priority Landscape Map	Forest Stewardship Forest Legacy FM Field staff Forest Protection BMP/NPS SP&A I&E ESF/SF TD&P U&CF	NCCES UNC System School systems and home-school organizations DPI DENR—OEE, NHP, DPR, DSWC (Resource Conservation Workshop/Envirothon) NRCS NCWRC USFWS USFS TNC Land trusts NCPFC NCTFS NC Woodlands SGSF NCACF SAF NCFA NGOs (ex., The Wildlife Society, NC Longleaf Coalition)	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners Development and implementation of inter-organizational MOUs Funding for education and outreach (ex. newsletter articles, e-mails, displays for ESF/SF, billboards, and radio/television PSAs) Funding for training and dedicated personnel to provide technical services Funding for Internet server space and enhanced Web presence Full funding for programs (ex. Partners for Fish/Wildlife Program, Forest Stewardship Program, NC Environmental Education Programs, PLT, NC Wild) Funding to provide ESF/SF with adequate staff USFS funding (ex. Redesign grants)	Number of MOUs established Number of products developed (ex. podcasts, webpages, news articles, posters, brochures, demonstration sites on ESF/SF, and other media) Number of users accessing materials through the Internet Number of workshops held Number of participants in workshops Number of stewardship or other management plans developed Number of ESF/FS annual visitors Number of NCWRC education center visitors Number of school programs Number of youth attending environmental camps Number of PLT facilitators trained Number of school curriculum projects developed Number of schools using PLT or NC Wild in their curriculum

Goal 6.—Manage, conserve, restore, and enhance forestlands important to current and future supplies of clean water for economic, social, and ecological uses.

With this goal, we will continue efforts to address water resource issues, particularly those issues tied to best management practices (BMPs) for traditional, rural forestry. Continued emphasis is needed on traditional programs tied to BMP technical assistance. These programs support the substantial level of silvicultural management within the state's working forests. A unique opportunity has emerged, however, to bridge the gap between traditional BMP-program delivery and emerging nonpoint source pollution issues in rural-to-urban transitional forested watersheds. We can bridge this gap successfully only by diversifying the base of cooperators and stakeholders, many of whom historically have not been directly affiliated with forestry program delivery. This new approach will provide technical assistance to forestland owners, home owners, land developers, and local governments and describe for them opportunities to protect or enhance the health of their watershed(s) by integrating forestry-related practices. Sustainable funding sources and personnel are needed to support ongoing and future efforts to meet the objectives in this goal. National objectives related to water resources, working lands, and public benefits are addressed by this goal and the strategies that support it.

Objective 6.1.—Increase implementation of forestry BMPs and compliance with water-quality regulations.
(Addresses key Assessment findings in sections 2c, 4e, 4f, 4g, 4h and USDA Forest Service national objectives 1.1, 1.2, 2.2, 3.1, 3.5, 3.6)

Strategy 6.1.1.—Evaluate forestry operations for implementation of forestry BMPs and compliance with water-quality regulations.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Conserving Working Forestlands Map (emphasis on active sites, areas with historically-lower BMP implementation and FPG compliance rates, environmentally sensitive areas, and cases identified through public complaints) Priority forest watersheds in North Carolina maps (Figures 4f-8a and 4f-8b) Freshwater conservation watersheds map (Figure 4f-4) Urban Forest Priority Landscape Map	FPG/WQ Law Enforcement BMP/NPS FM FM&FD Field staff	NCAPL NCFA (Prologger) Forest Industry Landowners DENR—DLR, DWQ USACE USEPA 319/NPS Program	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners responsible for monitoring and enforcing regulations Development and implementation of inter-organizational MOUs Funding for DFR water quality foresters and associated technical support staff. Funding for and development of training for DFR staff related to site evaluations Funding for DFR BMP/NPS Program	Number of DFR water-quality foresters and associated technical support staff employed Number of MOUs established Number of sites inspected for compliance FPG compliance rate Number of BMP implementation surveys BMP implementation rate Monitoring of BMP effectiveness Number of training programs conducted Number of DFR personnel trained in site evaluation Amount of grant funding to support DFR BMP/NPS Program

Strategy 6.1.2.—Develop threshold criteria for determining when a noncompliant forestry operation directly contributes to a degradation or loss of in-stream aquatic habitat sufficient to warrant restoration or remediation of the affected water resource.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Conserving Working Forestlands Map (emphasis on active sites, areas with historically-lower BMP implementation and FPG compliance rates, and environmentally sensitive areas) Priority forest watersheds in North Carolina maps (Figures 4f-8a and 4f-8b) Freshwater conservation watersheds map (Figure 4f-4) Urban Forest Priority Landscape Map	FPG/WQ Law Enforcement BMP/NPS FM FM&FD Field staff I&E ESF/SF N&TI	DENR—DCM, DLR, DMF, DWQ, EEP USACE USEPA SGSF (Water Resources Committee) NCWRC USFWS NCAPL Private nurseries Silviculture Contractors	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners responsible for monitoring and enforcing regulations Development and implementation of inter-organizational MOUs Funding for DFR BMP/NPS Program Funding for research and analysis Funding for and development of training on threshold criteria	Number of MOUs established and interagency agreements executed Amount of grant funding to support DFR BMP/NPS Program and research Development of criteria Number of training programs conducted Number of personnel trained in threshold criteria Linear feet of impacted stream remediated or restored Volume of sediment removed from affected streams Number of trees planted along affected streams

Strategy 6.1.3.—Increase the use of portable temporary bridging for crossing streams or ditches during forestry operations.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Conserving Working Forestlands Map (emphasis on active sites, areas with historically-lower BMP implementation and FPG compliance rates, and environmentally sensitive areas) Priority forest watersheds in North Carolina maps (Figure 4f-8a and 4f-8b) Freshwater conservation watersheds map (Figure 4f-4) Urban Forest Priority Landscape Map	BMP/NPS FPG/WQ FM FM&FD ESF/SF Field staff	NCAPL NCFA (Prologger) Forest Industry Landowners USEPA 319/NPS Program DENR—APNEP, DLR, DWQ Conservation groups Bridgemat suppliers USFS SGSF	Funding for DFR BMP/NPS personnel and for the portable bridgemat program. Funding for training and outreach (ex. Prologger, demonstration areas) Funding for survey and analysis on mat use Development of and funding for cost-share program USFS funding (ex. Redesign grants)	Amount of grant funding to support DFR BMP/NPS Program and research Number of sites where bridgemats are used. Number of stream crossings or ditches protected by use of bridgemats. Number of loggers using bridgemats. Development of a cost-share program for loggers to purchase bridgemats

Objective 6.2.—Retain or increase the area of forestland within priority watersheds.
(Addresses key Assessment findings in sections 1b, 2b, 4e, 4f, 4h, 4i and USDA Forest Service national objectives 1.1, 1.2, 3.1, 3.5, 3.6)

Strategy 6.2.1.—Conserve and acquire forestlands in priority watersheds for the purposes of protecting or restoring water quality, water supply, and aquatic habitat.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Priority forest watersheds in North Carolina maps (Figures 4f-8a and 4f-8b) Freshwater conservation watersheds map (Figure 4f-4) Forest Legacy “Areas of Need” Priority Ecosystems (State Wildlife Action Plan)	Forest Stewardship FSPP Forest Legacy BMP/NPS FDP FM FM&FD Field staff ESF/SF U&CF	Landowners NGOs (ex. Conservation groups and land trusts) CWMTF NHTF ADFPTF DENR—DWQ, DPR, DCM, DMF, DSWC NCWRC NCACF NC Woodlands NCTFS NCFA NCCES USFS USDOD NCSWCD NCRS VAD	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners responsible for land acquisition and conservation Funding for training and outreach for natural resources professionals and landowners (ex. identification of priority watersheds, conservation easements, land gifts) Funding for state and federal initiatives and programs for conservation (ex. FSPP, FDP, CREP, WRP) Conservation programs for financial and tax benefits Funding for DFR BMP/NPS Program Funding for state and federal initiatives and programs for acquisition (ex. fully funded Forest Legacy, CWMTF, ADFPTF) Funding to hire personnel to manage and oversee land that is acquired in-fee	Number of MOUs established and interagency agreements executed Amount of grant funding to support DFR BMP/NPS Program and research Number of workshops held Number of professionals trained Number of landowners in priority watersheds provided with technical services from trained professionals Number of stewardship or other management plans developed Number of acres in priority watersheds under a stewardship plan or other conservation management plan Number of projects converting impervious cover to forest cover Number of acres protected and conserved through acquisition or conservation easements Number of stream miles protected Number of endemic aquatic species protected Number of floodplain acres conserved

Objective 6.3.—Conduct education and outreach on the relationships between forests and water resources. **(Addresses key Assessment findings in sections 2c, 4a, 4e, 4h, 4i, 4j and USDA Forest Service national objectives 1.2, 2.2, 3.1, 3.4, 3.6)**				
Strategy 6.3.1: Educate natural resources professionals and landowners on how to protect water quality from nonpoint source pollution that may result from forestry operations.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Conserving Working Forestlands Map (emphasis on active sites, areas with historically-lower BMP implementation and FPG compliance rates, and environmentally sensitive areas) Priority forest watersheds in North Carolina Maps (Figures 4f-8a and 4f-8b) Freshwater conservation watersheds map (Figure 4f-4) Forest Legacy "Areas of Need" Priority Ecosystems (State Wildlife Action Plan) Urban Forest Priority Landscape Map	Forest Stewardship FSPP FPG/WQ BMP/NPS FM FM&FD Field staff I&E ESF/SF U&CF	FEOP NCCES Landowners NCACF NC Woodlands NCTFS NCAPL NCFA (Prologger) Forest Industry DENR—DLR, DWQ USACE USEPA 319/NPS Program	Funding for DFR water-quality foresters and associated technical support staff Funding for DFR BMP/NPS Program Funding for development and training on the use of preharvest planning tools Funding for educating natural resources professionals and landowners (ex. workshops, training aids, demonstration sites, website) Funding for state and federal initiatives and programs for conservation (ex. FSPP)	Number of DFR water-quality foresters Amount of funding for DFR BMP/NPS Program Amount of funding for preharvest planning tool development Number of professionals and landowners utilizing the preharvest planning tool Number of products developed (ex. webpages, workshops, demonstration sites) Number of users accessing materials through the Internet Number of workshops held Number of professionals trained Number of landowners with technical services from trained professionals Number of stewardship or other management plans developed Number of acres under a stewardship plan or other conservation management plan

Strategy 6.3.2.—Raise awareness of landowners, the general public, policy-makers, and K-12 schoolchildren on the relationship between forests, water quality, and nonpoint source pollution prevention.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Urban Forest Priority Landscape Map Priority forest watersheds in North Carolina maps (Figures 4f-8a and 4f-8b) Conserving Working Forestlands Map	U&CF I&E ESF/SF FPG/WQ BMP/NPS Forest Stewardship FSPP FM FM&FD Field staff	Landowners DENR—OEE, DLR, DWQ FEOP NCCES Water-supply utility companies Local and municipal government officials Councils of Government League of Municipalities School systems and home school organizations DPI NCACF NC Woodlands SAF NCTFS NCAPL NCFA Forest industry SGSF USFS USACE USEPA 319/NPS Program	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners Development and implementation of inter-organizational MOUs Funding to adequately staff DFR U&CF, ESF/SF, and BMP/NPS programs Funding for outreach (ex. news articles, social media, websites, e-mails, billboards and radio/television PSAs, demonstration materials) Full funding for programs (ex. Forest Stewardship Program, OEE Environmental Education programs, PLT, NC Project WET) USFS funding (ex. Redesign grants)	Number of MOUs established Number of information and outreach events, workshops, and demonstrations Number of products developed (ex. podcasts, webpages, news releases, posters, brochures, social media) Number of users accessing materials through the Internet Number of ESF/FS annual visitors Number of participants in workshops Number of stewardship or other management plans developed Number of school programs Number of youth attending environmental camps Number of PLT facilitators trained Number of school curricula projects developed Number of schools using PLT or NC Project WET in their curricula

Objective 6.4.—Offer landowners technical assistance that incorporates water-resource management with forest management. (Addresses key Assessment findings in sections 2a, 2b, 2c, 2d, 3b, 3c, 4e, 4f, 4j and USDA Forest Service national objectives 1.1, 1.2, 2.2, 3.1, 3.4, 3.5, 3.6)				
Strategy 6.4.1.—Assist landowners with assessing and managing their forests to protect watersheds or restore degraded aquatic conditions.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Priority forest watersheds in North Carolina maps (Figures 4f-8a and 4f-8b) Freshwater conservation watersheds map (Figure 4f-4) Urban Forest Priority Landscape Map Conserving Working Forestlands Map (emphasis on active sites, areas with historically-lower BMP implementation and FPG compliance rates, and environmentally sensitive areas) Forest Legacy "Areas of Need" Priority Ecosystems (State Wildlife Action Plan)	U&CF I&E BMP/NPS Forest Stewardship FSPP FDP FPG/WQ FM FM&FD Field staff N&TI GSB ESF/SF	Landowners DENR—DSWC, DWQ, DMF, DLR, DCM, EEP NRCS NCTFS NC Woodlands NCFA NCCES USACE USEPA SGSF NCWRC USFWS Private nurseries Silvicultural contractors	Funding to fully support DFR BMP/NPS Program Funding for DFR Water Quality Foresters and associated technical support staff. Funding to develop and implement DFR Forest Watershed Assistance Program Funding to educate natural resources professionals and landowners on watershed protection and restoration opportunities Funding for state and federal initiatives and programs for watershed protection and restoration (ex. FSPP, EQIP, FDP, CREP, WRP) Funding for enhancing GIS capabilities	Amount of funds to fully support DFR BMP/NPS Program, DFR Water Quality Foresters, and GIS capabilities Number of DFR Water Quality Foresters and associated technical support staff Establishment of DFR Forest Watershed Assistance Program Amount of funds for state and federal initiatives and programs for watershed protection and restoration Number of workshops, outreach materials, and events Number of participants in education and outreach activities Number of landowners assisted Number of acres under stewardship plans or other forest watershed plans Retention of forest cover Number of acres afforested and/ or reforested Linear feet of stream restored or enhanced Acres of wetlands restored or enhanced Report of stream and wetland restoration opportunities on DFR-managed lands

Strategy 6.4.2.—Evaluate and promote the utilization of forestry practices to manage nonpoint source runoff from nonforested lands in transition areas between rural, suburban, and urban environments.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Forest and/or natural cover trends in relation to impervious cover map (Figure 4f-5) Freshwater conservation watersheds map (Figure 4f-4)	BMP/NPS U&CF I&E Forest Stewardship FSPP FM&FD Field staff N&TI ESF/SF GSB	DENR—DSWC, DWQ NRCS USEPA 319/NPS Program USFS-SRS NCSU Landowners Local governments Municipal land-use planning officials Residential and commercial land developers	Identification of lead individuals and/or organization to improve coordination and collaboration among key stakeholders and partners Development and implementation of inter-organizational MOUs Funding to fully support DFR BMP/NPS Program Funding for research to assess suitability of urban forestry modeling (ex. I-Tree and UFORE models) and how forestry practices can be used to manage runoff from non-forested lands Funding for DFR Water Quality Foresters and associated technical support staff. Funding to develop and implement DFR Forest Watershed Assistance Program and creation of a North Carolina urban forest watershed manual Funding for state and federal initiatives and programs for NPS runoff mitigation and watershed protection Funding for demonstration areas and outreach project implementation Funding to educate natural resources professionals and landowners on how forestry practices can be used to manage runoff from nonforested lands	Number of MOUs established Amount of funds to fully support DFR BMP/NPS Program and DFR Water Quality Foresters Creation of a North Carolina urban forest watershed manual Number of DFR Water Quality Foresters and associated technical support staff Establishment of DFR Forest Watershed Assistance Program Number of research grants obtained and projects completed Amount of funds for state and federal initiatives and programs for managing nonpoint source runoff with forestry practices Number of workshops, outreach materials, and events Number of participants in education and outreach activities Number of landowners or communities assisted Number of acres under stewardship plans or other forest watershed plans Retention of forest cover Number of acres where forestry practices are used to manage nonpoint source runoff Number of forestry practices implemented to manage nonpoint source runoff Integration of forests and forestry practices with new or existing stormwater management, LEED principles, low-impact development (LID), and/or green infrastructure projects

Goal 7.—Enhance the benefits and sustainable management of urban forests.

Objectives and strategies under this goal are focused on sustaining and facilitating healthy urban forests across the state by promoting strategic planning and proactive management of our urban natural resources. By definition, a *healthy urban forest* is an urban forest that (1) is actively managed for long-term benefits, (2) is structurally diverse enough to withstand environmental change and periodic catastrophic events, and (3) consists of an interconnected network of green space that conserves the natural ecosystem's values and functions. To improve urban forest health and viability throughout North Carolina, strategies will focus on tree conservation and planting, strategic land-use planning and management, and local urban forest program capacity. Because the urban forest resource reaches beyond municipal boundaries, partnerships will need to be multidimensional and broad. The success of these strategies depends greatly upon increasing the awareness and knowledge level of urban forestry professionals, land-use planners, elected officials and developers. Doing so will entail (1) conducting many training programs on proper tree care and urban forest management as well as (2) developing outreach materials specific to North Carolina's needs.

Objective 7.1.—Reduce the impacts of land-use change and urbanization on forested landscapes in and around urban areas. (Addresses key Assessment findings in section 4k and USDA Forest Service national objectives 1.1, 1.2, 3.1, 3.4, 3.5, 3.6, 3.7)				
Strategy 7.1.1.—Encourage the incorporation of forests and green space in land-use planning through the principles of green infrastructure, low-impact development (LID), and sustainability certification programs.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Urban Forest Priority Landscape Map Maintaining Viable Urban Forests Map Rural Forest Priority Landscape Map	U&CF BMP/NPS Forest Stewardship FM TD&P Field staff	NC land conservation groups DENR—NHP, DPR Local governments Municipal land-use planning officials COG League of Municipalities Residential and commercial land developers RC&D NCWRC NCAPA NCCES NCSWCD NC Green Builders Assoc. NCUFC Conservation Fund Certification programs SGSF NRCS USFS	Identification of lead individuals and/or organization to improve coordination and collaboration among regional partners and grass roots organizations (ex. LEED and other sustainable certification programs) Funding to fully support DFR U&CF Program and DSWC CCAP Funding for education and outreach Funding to conduct local and regional natural resource assessments Funding to implement the use of the One North Carolina Conservation Planning Tool Funding to conduct UFORE studies Conservation programs for financial and tax benefits for landowners USFS funding (ex. Redesign grants)	Amount of funds to fully support DFR U&CF Program and DSWC CCAP Number of county and regional green infrastructure plans adopted Number of products developed (ex. podcasts, webpages, demonstration sites, guidance documents, social media) Number of education and outreach events held with municipal planners, developers, and natural resource professionals Number of restoration projects implemented for improved urban ecological function Number of sustainability certifications Number of local and regional natural resource assessments conducted Number of certification standards incorporating trees and green space

Strategy 7.1.2.—Promote and support the active management of publicly-owned urban wooded areas for multiple-use benefits.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Urban Forest Priority Landscape Map Maintaining Viable Urban Forests Map Rural Forest Priority Landscape Map	U&CF I&E Forest Stewardship FSPP FDP FM TD&P FireWise BMP/NPS GSB Field staff	NGOs (ex. The Conservation Fund) NCWRC Local governments USFS SAF NCACF and arborists Land-use planners NCCES FEOP Land trusts HOAs SGSF COG League of Municipalities NRCS	Develop partnerships with land trust organizations, local government, HOAs Funding for education and outreach (ex. newsletter articles, e-mails, displays for ESF/SF, billboards and radio/television PSAs) Funding for state and federal cost-share programs (ex. FDP, FSPP, EQIP, WHIP) Funding to educate natural resources professionals and urban landowners (ex. identification of priority urban wooded areas, Changing Roles program) Funding to develop and implement a "Community Working Forest" recognition program Funding for enhancing GIS capabilities USFS funding (ex. Redesign grants)	Number of MOUs established Number of products developed (ex. podcasts, webpages, demonstration sites, guidance documents, case studies, social media) Development of a "Community Working Forest" recognition program Number of workshops, outreach materials, and events Number of participants in education and outreach activities Number of people trained under the Changing Roles program Number of landowners or communities assisted Number of plans and acres under stewardship plans or other management plans Number of forestry practices implemented to manage urban wooded areas

Objective 7.2.—Facilitate strategic planting and maintenance of community trees for public benefits. (Addresses key Assessment findings in section 4k and USDA Forest Service national objectives 1.1, 1.2, 3.1, 3.2, 3.4, 3.5, 3.6, 3.7)				
Strategy 7.2.1.—Promote and support tree canopy analyses that model regional tree populations to determine their conditions, derived benefits, and values.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Urban Forest Priority Landscape Map (focus on Piedmont region)	U&CF GSB FM	Local governments USFS CGIA Consulting arborists COG FEOP NCCES NGOs (ex. The Conservation Fund)	Full funding for grant programs (ex. U&CF grant program) Funding to educate natural resources professionals and local governments (ex. I-Tree, CITYgreen software and training) Funding for enhancing geospatial capabilities (ex. aerial imagery, GIS, software, analysis) USFSfunding (ex. Redesign grants)	Number of tree canopy analyses conducted Number of regional cost-benefit reports for urban canopy Number of education and outreach events held Amount of outreach materials developed and distributed

Strategy 7.2.2.—Assist communities in the development of long-term goals and large-scale tree-planting plans.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Urban Forest Priority Landscape Map (focus on Piedmont region)	U&CF FM&FD Forest Stewardship FSPP T&NI Field staff GSB	Local Governments NCUFC COG Volunteer organizations Green Industry Council NC Nursery and Landscape Association Private nurseries NCCES DENR	Full funding for grant programs (ex. U&CF grant program) Funding for enhancing geospatial capabilities for tree canopy studies and inventories (ex. aerial imagery, GIS, software, analysis) Funding and personnel dedicated to providing technical services	Number of DFR U&CF staff employed to provide assistance Number of urban plans written Number of communities with tree planting or canopy goals Number of urban strategic plans addressing long-term goals Increased urban tree canopy cover
Strategy 7.2.3.—Develop guidelines for tree planting and maintenance to conserve energy and improve air quality.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Urban Forest Priority Landscape Map (focus on Piedmont region)	U&CF FHM FM&FD BMP/NPS T&NI Forest Protection	NCUFC Utility companies NCCES Local governments Nonprofit organizations DENR—DAQ, DWQ Green Industry Council Conference of Mayors NCLM UNC System	Identification of lead individuals and/or organization to improve coordination and collaboration among stakeholders Development and implementation of inter-organizational MOUs Funding to establish baseline measures of energy efficiency and air quality Funding for heat island studies	Number of MOUs established Number of partnerships developed (ex. Partnership with Conference of Mayors Climate Protection Agreement communities) Number of utility companies recognized as TreeLine USA Decrease in USEPA designated air-quality nonattainment areas Incorporation of trees into the State Implementation Plan

Objective 7.3.—Assist communities with establishing and managing their urban forests.
(Addresses key Assessment findings in section 4k and USDA Forest Service national objectives 1.1, 1.2, 2.2, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7)

Strategy 7.3.1.—Assist communities with establishing and retaining municipal tree manager positions.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Urban Forest Priority Landscape Map (focus on Piedmont region)	U&CF	Local governments NCUFC SMA NCCES	Full funding for grant programs (ex. U&CF grant program) Identification of lead individuals and/or organization to improve coordination and collaboration among stakeholders (ex. local advocacy group) Development and implementation of MOUs between local governments and other organizations Funding to provide education and technical assistance	Number of MOUs established Number of partnerships developed Number of workshops held Number of people attending trainings and workshops Number of products developed (ex. trainings, webpages, workshops) Number of ISA certified arborists and/or municipal specialists working for/in communities Number of manager positions created Number of Municipal Forester Institute graduates Number of contracts between communities and private tree care companies/consultants

Strategy 7.3.2.—Provide local governments assistance for tree inventories and enhanced GIS/spatial analysis capabilities that lead to improved management planning.

Priority Area(s)	DFR Program Areas	Key Stakeholders and Partners	Resources Needed	Measures of Success
Urban Forest Priority Landscape Map (focus on tree inventories in the Piedmont region) Rural Forest Priority Landscape Map	U&CF GSB	USFS NCCGIA Local governments RC&D COG NCCES FEOP SGSF USFS Consulting arborists NCUFC NCWRC	Full funding for grant programs (ex. U&CF grant program) Funding to educate natural resources professionals and local governments (ex. utilization of the Green Growth Toolbox) Funding for tree inventories and enhancing geospatial capabilities (ex. aerial imagery, GIS, software, analysis) Funding for training and utilization of tree inventory protocol process USFS funding (ex. Redesign grants)	Number of education and outreach events held Number of people trained Quantities of outreach materials developed and distributed Number of tree canopy analyses or tree inventories conducted Number of regional cost/benefit reports for urban canopy Amount of grants awarded to conduct tree inventories that lead to the development of urban forest-management plans Number of urban forest-management plans based on tree inventory data Number of communities participating in Arbor Day programs

Objective 7.4.—Encourage policies and guidelines that sustain urban and community forests for the public's benefit. (Addresses key Assessment findings in section 4k and USDA Forest Service national objectives 1.2, 3.1, 3.2, 3.4, 3.5, 3.6, 3.7)				
Strategy 7.4.1.—Raise awareness levels of elected officials and policy-makers on the benefits of urban trees and their management.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Urban Forest Priority Landscape Map Rural Forest Priority Landscape Map	U&CF I&E	NCUFC Local governments Nonprofit and volunteer groups NCCES/FEOP DENR NCLM USFS SGSF	Funding for outreach (ex. news articles, social media, websites, e-mails, billboards and radio/television PSAs, demonstration materials) Full funding for grant programs (ex. U&CF grant program) Identification of lead individuals and/or organization to improve coordination and collaboration among stakeholders (ex. NCLM) USFS funding (ex. Redesign grants)	Number of information and outreach events, workshops, and demonstrations Level of awareness indicated by stakeholder surveys Number of products developed (ex. podcasts, webpages, news releases, posters, brochures, social media) Number of users accessing materials through applicable websites Number of participants in outreach events
Strategy 7.4.2.—Enhance technical and professional capacity of tree-care professionals and the green industry.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Urban Forest Priority Landscape Map (focus on Piedmont region)	U&CF I&E FM&FD T&NI	Local governments NCUFC NCNLA NC Green Industry Council Consulting arborists Tree care firms ISA Southern Chapter NCCES Charlotte Arborists Association Forestry Advisory Council Private nurseries SGSF USFS NCACF	Full funding for grant programs (ex. U&CF grant program) Identification of lead individuals and/or organization to improve coordination and collaboration among stakeholders Funding to educate tree-care professionals and the green industry USFS funding (ex. Redesign grants)	Number of education and outreach events held Number of people trained Quantities of outreach materials developed and distributed Number of tree care professionals becoming certified Creation of policies and/or regulations related to professional licensing of tree-care professionals and the green industry

Strategy 7.4.3.—Improve local governments' capability to write effective tree ordinances and land-use policies.				
Priority Area(s)	**DFR Program Areas**	**Key Stakeholders and Partners**	**Resources Needed**	**Measures of Success**
Urban Forest Priority Landscape Map Rural Forest Priority Landscape Map	U&CF FPG/WQ	Local governments NCUFC City and regional planners COG NCAPA NCCES NCSU UNC School of Government Residential and commercial land developers Landscape architects Tree care industry Tree boards USFS SGSF NCWRC	Full funding for grant programs (ex. U&CF grant program) Funding for education and outreach efforts (ex. websites, workshops, media releases) Funding to maintain the ordinance database (http://www.ces.ncsu.edu/forestry/ordinance/) Funding for Internet server space and enhanced Web presence Funding for Arbor Day programs USFS funding (ex. Redesign grants)	Number of educational products developed (ex. podcasts, webpages, webinars, workshops) Number of participants in educational events Number of users accessing materials through the Internet Development of a Tree Board Academy Number of people completing the Tree Board Academy training Number of ordinances developed and updated Number of Tree City, Tree Campus, and Tree Line USA entities Amount of funding to support U&CF program Amount of grants awarded for U&CF program

Glossary

atmospheric deposition. Occurs when pollutants are transferred from the air to the earth's surface.

average annual mortality. Average annual volume of trees 5.0 inches diameter at breast height (d.b.h.) and larger that died from natural causes during the intersurvey period.

average annual removals. Average annual volume of trees 5.0 inches d.b.h. and larger removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use during the intersurvey period.

average net annual growth. Average annual net change in volume of trees 5.0 inches d.b.h. and larger in the absence of cutting (gross growth minus mortality) during the intersurvey period.

cation. An ion or group of ions having a positive charge and characteristically moving toward the negative electrode in electrolysis.

census designated places. A type of place identified by the U.S. Census Bureau to delineate incorporated places, such as cities, towns and villages, as well as populated areas that lack separate municipal government but which otherwise physically resemble incorporated places.

census water. Streams, sloughs, estuaries, canals, and other moving bodies of water 200 feet wide and greater, and lakes, reservoirs, ponds, and other permanent bodies of water 4.5 acres in area and greater.

clone. A vegetatively propagated organism, or a group of such organisms consisting of an ortet and its ramets.

coastal plain. A term used in this document with or without "North Carolina" (NC), to refer to the sections of the Coastal Plain province encompassed by North Carolina's boundaries (see **physiograpic region** in this glossary).

Community Accomplishment Reporting System (CARS). The four performance measures used to ascertain a level of function for a municipal urban forest program, as determined by the USDA Forest Service: professional staffing, tree ordinances, management plans based on scientific inventories, and tree advocacy groups providing citizen support.

composite panels. Roundwood products manufactured into chips, wafers, strands, flakes, shavings, or sawdust and then reconstituted into a variety of panel and engineered lumber products.

consumption. The quantity of a commodity, such as pulpwood, utilized by a particular mill or group of mills.

controlled burn. The use of fire under specific environmental conditions to achieve forest management objectives. Used to reduce hazardous fuel levels, control unwanted vegetation, favor desired vegetation, and improve visibility and wildlife habitat.

current forest health threats. Insects, diseases, and non-native invasive weeds currently found in North Carolina that threaten trees and forest ecosystems. Insects and diseases may be native or non-native.

diameter class. A classification of trees based on tree d.b.h. Two-inch diameter classes are commonly used by USDA Forest Service FIA, with the even inch as the approximate midpoint for a class. For example, the 6-inch class includes trees 5 through 6.9 inches d.b.h.

d.o.b. (diameter outside bark). Stem diameter including bark.

ecoregion. An area defined by environmental conditions and natural features; a region defined by its ecology. Ecoregions span state borders but share similar environmental conditions and natural features. This term has been used to describe regions of the United States for the USDA Forest Service (Bailey, 1995) and in the *NC Wildlife Action Plan* (NCWRC, 2005). Ecoregions correspond to U.S. Geological physiographic regions to some extent. *See* **physiographic region** in this glossary.

Blue Ridge Ecoregion refers to areas in North Carolina and other states that are part of the Southern section of the Blue Ridge province.

Mid-Atlantic Coastal Plain Ecoregion refers to areas in North Carolina and other states that are part of the Coastal Plain province.

Piedmont Ecoregion refers to areas in North Carolina and other states that are part of the Piedmont province.

eutrophication. An increase in the concentration of chemical nutrients in an ecosystem to an extent that increases the primary productivity of the ecosystem.

exotic species. A species that occurs outside of its native range.

extirpate. To cause extinction in a localized area.

extraterritorial jurisdiction (ETJ). Legal ability of a government to exercise authority beyond its normal boundaries.

exurban. Private forest lands with 16 to 64 housing units per square mile. Lands with these higher housing densities can still support many wildlife species and other ecological functions, although perhaps at a reduced level. However, management for commercial timber may be less likely.

family forest owners. Families, individuals, trusts, estates, family partnerships, and other unincorporated groups of individuals that own forest land. This group is a subset of nonindustrial private forest owners.

Firewise. An approach that emphasizes (1) community responsibility for wildfire planning via the design of a safe community; (2) effective emergency response; and (3) individual responsibility for safer home construction and design, landscaping, and maintenance,

forest certification. The stewardship and use of forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality, and potential to fulfill, now and in the future relevant ecological, economic, and social functions at local, national, and global levels, and that does not cause damage to other ecosystems

forest industry related. The term used in this report to encompass the NAICS sectors defined below.

NAICS. The North American Industry Classification System is used by government agencies and business to classify business establishments according to type of economic activity in the United States, Canada, and Mexico. The following NAICS sectors comprise what we refer to in this report as "forest industry related."

NAICS Sector 113 – Forestry and Logging. Industries in the Forestry and Logging subsector grow and harvest timber on a long production cycle (i.e., of 10 years or more). Long production cycles use different production processes than short production cycles, which require more horticultural interventions prior to harvest, resulting in processes more similar to those found in the Crop Production subsector. Consequently, Christmas tree production and other production involving production cycles of less than 10 years are classified in the Crop Production subsector.

NAICS Sector – 115 Support Activities for Agriculture and Forestry. Industries in the Support Activities for Agriculture and Forestry subsector provide support services that are an essential part of agricultural and forestry production. These support activities may be performed by the agriculture or forestry producing establishment or conducted independently as an alternative source of inputs required for the production process for a given crop, animal, or forestry industry. Establishments that primarily perform these activities independent of the agriculture or forestry producing establishment are in this subsector.

NAICS Sector – 321 Wood Product Manufacturing. Industries in the Wood Product Manufacturing subsector manufacture wood products, such as lumber, plywood, veneers, wood containers, wood flooring, wood trusses, manufactured homes (i.e., mobile homes), and prefabricated wood buildings. The production processes of the Wood Product Manufacturing subsector include sawing, planing, shaping, laminating, and assembling of wood products starting from logs that are cut into bolts, or lumber that then may be further cut, or shaped by lathes or other shaping tools. The lumber or other transformed wood shapes may also be subsequently planed or smoothed, and assembled into finished products, such as wood containers. The Wood Product Manufacturing subsector includes establishments that make wood products from logs and bolts that are sawed and shaped, and establishments that purchase sawed lumber and make wood products. With the exception of sawmills and wood preservation establishments, the establishments are grouped into industries mainly based on the specific products manufactured.

NAICS Sector – 322 Paper Manufacturing. Industries in the Paper Manufacturing subsector make pulp, paper, or converted paper products. The manufacturing of these products is grouped together because they constitute a series of vertically connected processes. More than one is often carried out in a single establishment. There are essentially three activities. The manufacturing of pulp involves separating the cellulose fibers from other impurities in wood or used paper. The manufacturing of paper involves matting these fibers into a sheet. Converted paper products are made from paper and other materials by various cutting and shaping techniques and includes coating and laminating activities.

NAICS Sector – 337 Furniture and Related Product Manufacturing. Industries in the Furniture and Related Product Manufacturing subsector make furniture and related articles, such as mattresses, window blinds, cabinets, and fixtures. The processes used in the manufacture of furniture include the cutting, bending, molding, laminating, and assembly of such materials as wood, metal, glass, plastics, and rattan. However, the production process for furniture is not solely bending metal, cutting and shaping wood, or extruding and molding plastics. Design and fashion trends play an important part in the production of furniture. The integrated design of the article for both esthetic and functional qualities is also a major part of the process of manufacturing furniture. Design services may be performed by the furniture establishment's work force or may be purchased from industrial designers.

Forest management type. A classification of timberland based on forest type and stand origin:

Pine plantation. Stands that (1) have been artificially regenerated by planting or direct seeding, (2) are classed as a pine or other softwood forest type, and (3) have at least 10 percent stocking.

Natural pine. Stands that (1) have not been artificially regenerated, (2) are classed as a pine or other softwood forest type, and (3) have at least 10 percent stocking.

Oak–pine. Stands that have at least 10 percent stocking and classed as a forest type of oak-pine.

Upland hardwood. Stands that have at least 10 percent stocking and classed as an oak–hickory or maple–beech–birch forest type.

Lowland hardwood. Stands that have at least 10 percent stocking with a forest type of oak–gum–cypress, elm–ash–cottonwood, palm, or other tropical.

Nonstocked stands. Stands that are less than 10 percent stocked with live trees.

forest patch. A forest tract larger than 500 acres.

forest products industry. A term used commercially that encompasses the NAICS sectors and subsectors defined for forestry.

forest type. A classification of forestland based on the species forming a plurality of live-tree stocking. Major eastern forest-type groups are as follows:

white–red jack pine. Forests in which eastern white pine, red pine, or jack pine, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, birch, and maple.)

spruce–fir. Forests in which spruce or true firs, singly or in combination, constitute a plurality of the stocking. (Common associates include maple, birch, and hemlock.)

longleaf–slash pine. Forests in which longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

loblolly–shortleaf pine. Forests in which loblolly pine, shortleaf pine, or other southern yellow pines, except longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

oak–pine. Forests in which hardwoods (usually upland oaks) constitute a plurality of the stocking but in which pines account for 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow poplar.)

oak–hickory. Forests in which upland oaks or hickory, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent, in which case the stand would be classified oak-pine. (Common associates include yellow poplar, elm, maple, and black walnut.)

oak–gum–cypress. Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent, in which case the stand would be classified as oak–pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)

elm–ash–cottonwood. Forests in which elm, ash, or cottonwood, singly or in combination, constitute a plurality of the stocking. (Common associates include willow, sycamore, beech, and maple.)

maple–beech–birch. Forests in which maple, beech, or yellow birch, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, elm, basswood, and white pine.)

Nonstocked stands. Stands less than 10 percent stocked with live trees.

forestland. Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. The minimum area considered for classification is 1 acre. Forested strips must be at least 120 feet wide.

germplasm. (1) Within an individual or group, the collective hereditary materials that are the physical basis for inheritance; the hereditary stream. (2) The genotype, with particular reference to its transmission to the next generation.

green space. Open, undeveloped land with natural vegetation.

gross growth. Annual increase in volume of trees 5.0 inches d.b.h. and larger in the absence of cutting and mortality. (Gross growth includes survivor growth, ingrowth, growth on ingrowth, growth on removals before removal, and growth on mortality before death.)

hardwoods. Dicotyledonous trees, usually broadleaf and deciduous.

Soft hardwoods. Hardwood species with an average specific gravity of 0.50 or less, such as gums, yellow-poplar, cottonwoods, red maple, basswoods, and willows.

Hard hardwoods. Hardwood species with an average specific gravity greater than 0.50, such as oaks, hard maples, hickories, and beech.

healthy urban forest. A forest that is actively managed for long-term benefits, is structurally diverse enough to withstand environmental change and periodic catastrophic events, and consists of an interconnected network of green space that conserves the natural ecosystem values and function.

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.

imminent forest health threats. Forest health threats that are not currently found in North Carolina but are in adjacent states or have the capability to invade North Carolina within the next few years.

impervious surface. Surfaces that water cannot penetrate, such as buildings and pavement.

infrastructure. A basic framework or system of public works (including transportation, communication, sewage, water, and utility systems) needed to support human activity.

introduced species. A species that exists in a given area due to human action or activity that has led to its dispersal across natural geographic barriers and/or produced conditions favorable to its growth and spread.

invasive species. A species occurring outside of its native range that is likely to cause harm to or threaten the survival of native species.

land area. The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river floodplains (omitting tidal flats below mean high tide), streams, sloughs, estuaries, and canals < 200 feet wide, and lakes, reservoirs, and ponds < 4.5 acres in area.

large community. A community with a population greater than 60,000 people.

limited-resource landowners. Traditionally under-served landholders. This group includes those who have smaller-than-average land holdings with no or limited access to substantial amounts of capital or off-farm income. This group may include beginning farmers; farmers producing for emerging or alternative markets; and certain individuals or groups, such as minority farmers who are traditionally under-served by credit and other farm service institutions (SARE, 2000).

locally significant forest health threats. Current forest health threats that can cause significant damage and impact diversity in local areas. These pests may be confined to a small geographic area, spread more slowly, or pose little ability to spread into unaffected areas.

major forest health threats. Current forest health threats that can cause significant ecological and economic damage to North Carolina's forest resources.

mass controlled pollinations (MCP). A method of tree breeding where large numbers of pollen parentage are completely controlled, eliminating pollen contamination and allowing for positive assortative mating among seed orchard parents to maximize genetic gains or specific genetic traits.

medium community. A community with a population between 10,000 and 60,000 people.

mountains. A term used in this document with or without "North Carolina" (NC) to refer to the sections of the Blue Ridge province encompassed by North Carolina's boundaries (see **physiograpic region** in this glossary).

net annual change. Increase or decrease in volume of live trees at least 5.0 inches d.b.h. Net annual change is equal to net annual growth minus average annual removals.

net 40 benefit. A benefit calculated as the cost of a tree and its maintenance accumulated over 40 years subtracted from the tree's economic and environmental benefits over 40 years.

non-native invasive pest Insects or diseases that are not indigenous to North Carolina and when introduced aggressively infest or infect forest trees and plants.

non-native invasive plant. Plants that are not indigenous to North Carolina and when introduced aggressively outcompete or otherwise impact native vegetation.

nonforestland. Land that has never supported forests and land formerly forested where timber production is precluded by development for other uses.

nonstocked stands. Stands less than 10 percent stocked with live trees.

open space. An area of land that is valued for natural processes and wildlife, for agricultural and sylvan production, for active and passive recreation, for providing other public benefits, or for any combination of these uses. Open space may be either open, forested, cropland, or pastureland that has not been converted or used to support development.

other forestland. Forestland other than timberland and productive reserved forestland. It includes available and reserved forestland that is incapable of producing annually 20 cubic feet per acre of industrial wood under natural conditions, because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness.

other removals. The growing-stock volume of trees removed from the inventory by cultural operations, such as timber stand improvement, land clearing, and other changes in land use, resulting in the removal of the trees from timberland.

ownership. The property owned by one ownership unit, including all parcels of land in the United States.

national forestland. Federal land that has been legally designated as national forests or purchase units, and other land under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III land.

forest industry land. Land owned by companies or individuals operating primary wood-using plants.

nonindustrial private forest (NIPF) land. Privately owned land excluding forest industry land.

Corporate. Owned by corporations, including incorporated farm ownerships.

Individual. All lands owned by individuals, including farm operators.

other public. An ownership class that includes all public lands except national forests.

Miscellaneous federal land. Federal land other than national forests.

State, county, and municipal land. Land owned by states, counties, and local public agencies or municipalities or land leased to these governmental units for 50 years or more.

ozone non-attainment areas. Areas not meeting the ground-level ozone standards established by the U.S. Environmental Protection Agency in 1997 and 2008.

particulate matter. Tiny subdivisions of solid or liquid matter suspended in a gas or liquid.

physiographic region. Physiographic regions are based on terrain texture, rock type, and geologic structure and history. The U.S. Geological Survey classification system has three tiers: *divisions*, which are broken into *provinces*; some provinces break further into *sections*. North Carolina crosses three provinces that encompass other states:

The *Blue Ridge province* is part of the *Appalachian Highlands division*. The Blue Ridge province encompasses mountainous lands in the Southeast, including areas of Virginia, North Carolina, and Tennessee. North Carolina's mountainous areas occur in the *Southern section* of the Blue Ridge province.

The *Coastal Plain province* is part of the *Atlantic Plain division*. The Coastal Plain province includes coastal lands in the East and Southeast from New Jersey to southern Texas.

The *Piedmont* province is part of the *Appalachian Highlands division*. The Piedmont province encompasses inland areas and foothills in the East and Southeast from Pennsylvania south to Alabama.

piedmont. A term used in this document with or without "North Carolina" (NC) to refer to areas of the Piedmont province encompassed by North Carolina's boundaries (see **physiograpic region** in this glossary).

Piedmont Crescent. A population term used to describe an area in North Carolina located in the central counties of the NC piedmont. The Piedmont Crescent stretches northeast from metropolitan Charlotte, through the Piedmont Triad cities of Greensboro and Winston-Salem at its center, to metropolitan Raleigh-Durham and the Research Triangle area at its eastern edge.

plantable space. Land not currently in tree canopy or impervious surface that may offer opportunities for tree planting.

primary processor. *See* **primary wood-using plant**.

primary wood-using plants. Industries receiving roundwood or chips from roundwood for the manufacture of products, such as veneer, pulp, and lumber.

priority places. Communities indicated as having a priority through data evaluation.

private forest. For this project, private forest includes tribal, forest industry, and nonindustrial private ownerships; it excludes public lands and private lands protected through conservation easements.

production. The total volume of known roundwood harvested from land within a State, regardless of where it is consumed. Production is the sum of timber harvested and used within a State, and all roundwood exported to other States.

pulpwood. A roundwood product that will be reduced to individual wood fibers by chemical or mechanical means. The fibers are used to make a broad generic group of pulp products that includes paper products, as well as fiberboard, insulating board, and paperboard.

receipts. The quantity or volume of industrial roundwood received at a mill or by a group of mills in a State, regardless of the geographic source. Volume of roundwood receipts is equal to the volume of roundwood retained in a State plus roundwood imported from other States.

riparian. Pertaining to a river or other natural course of water and the corridor adjoining it, including the banks and floodplain of a river.

riverine. Relating to, formed by, or resembling a river; living or situated on the banks of a river.

roguing. A systematic removal of individuals not desired for the perpetuation of a population, e.g., from a seed stand, nursery, or genetic test.

roundwood (roundwood logs). Logs, bolts, or other round sections cut from trees for industrial or consumer uses.

roundwood products. Any primary product, such as lumber, poles, pilings, pulp, or fuelwood, produced from roundwood.

rural. Private forest lands with 16 or fewer housing units per square mile. Forest lands with this housing density can generally support a diversity of economic and ecological functions commonly associated with private forests, such as management for timber, most wildlife species, and water quality.

serotinous. a pinecone or other seed case that requires heat from a fire to open and release the seed.

small community. A community with a population of less than 10,000 people.

smoke-sensitive area. An area in which smoke from outside sources is intolerable. North Carolina’s smoke-sensitive areas are calculated as a 2-mile buffer surrounding medical facilities, major roads, schools, and universities.

softwoods. Coniferous trees, usually evergreen, having leaves that are needles or scalelike.

yellow pines. Loblolly, longleaf, slash, pond, shortleaf, pitch, Virginia, sand, spruce, and Table Mountain pines.

other softwoods. Cypress, eastern red cedar, white cedar, eastern white pine, eastern hemlock, spruce, and fir.

southern Appalachian region. This term is used to describe southern parts of the Appalachian Highlands division. The area this term describes corresponds roughly to the Blue Ridge province and its Southern section.

stand age. The average age of dominant and co-dominant trees in the stand.

stand origin. A classification of forest stands describing their means of origin.

Planted. Planted or artificially seeded.

Natural. No evidence of artificial regeneration.

sustainable development. Development that integrates environmental protection, economic development, and social equity.

Sustainable Forestry Initiative (SFI). A voluntary, third-party organization that develops standards of good forest management and certifies that forests are well-managed as defined by a particular standard ensuring that certain wood and paper products come from responsibly managed forests.

sustainable forestry. The practice of meeting the forest resource needs and values of the present without compromising the ability of future generations to meet their own needs.

timber investment management organization (TIMO). A management group that aids institutional investors in managing their timberland investments. A TIMO acts as a broker for institutional clients.

timber products. Roundwood products and byproducts.

timber products output. The total volume of roundwood products from all sources plus the volumes of byproducts recovered from mill residues (equals roundwood product drain).

timber stand improvement. An intermediate treatment made to improve the composition, structure, condition, health, and growth of evenly or unevenly aged forest stands.

timberland. Forestland capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization.

tree. A woody plant having one erect perennial stem or trunk at least 3 inches d.b.h., a more or less definitely formed crown of foliage, and a height of at least 13 feet (at maturity).

tropical cyclone. An intense low-pressure system typically associated with high winds, flooding due to storm surge, and intense rainfall, and thunderstorms. Tropical cyclones are broken into three categories based on sustained wind speeds: tropical depression, tropical storm, and hurricane.

urban. Private forestland with 64 or more housing units per square mile. Such lands are less likely to be used for timber production or to contribute to wildlife habitat and water quality because of increased road density, infrastructure, and human population levels. Such forest patches, however, are often highly valued for their aesthetics, noise abatement properties, and positive effect on property values.

urban areas. Areas with a housing density of at least one house per 2 acres.

urban clusters. Areas with a housing density of one house every 2 to 16 acres.

urban heat islands. Urban areas that become warmer than their rural surroundings, forming an "island" of higher temperatures in the landscape.

urban-rural interface. The area or zone where infrastructure and other associated development from human populations meet or intermingle with rural forests and farms.

veneer log. A roundwood product either rotary cut, sliced, stamped, or sawn into a variety of veneer products, such as plywood, finished panels, veneer sheets, or sheathing.

wildfire. A rapidly spreading fire, often occurring in wildland areas, that is out of control.

wildland-urban interface. The area where homes and structures meet the natural environment of forests and wildlands.

Appendix A: Contributing Plans & Resources

Losing Our Natural Heritage: Development & Open Space Loss in North Carolina (PDF) from the Environment North Carolina Research & Policy Center, April 2007

North Carolina Division of Forest Resources Longleaf Initiative & Action Plan 2006-2010 (PDF)

Assessment of Need for the Forest Legacy Program (PDF)

Economic & Ecological Impacts Associated with Wood Chip Production in North Carolina, Integrated Research Project Summary (PDF)

Forest Inventory & Analysis Factsheet - North Carolina, 2002 (PDF)

North Carolina Division of Forest Resources Outreach Plan (PDF)

North Carolina Division of Forest Resources Urban & Community Forestry Five Year Strategic Plan (2004-2008) (PDF)

North Carolina Urban Forestry Council Report: Long Range Program (PDF)

North Carolina's Forests, 1990 (PDF)

North Carolina's Forests, 2002 (PDF)

North Carolina's Fourth Forest...a Look Before & After (PDF)

Pathways for Forestry in North Carolina (PDF)

Report of the Governor's Task Force on Forest Sustainability (PDF)

Recommendations to Increase the Productivity of Small Woodlots in North Carolina (PDF)

The North Carolina Forest Stewardship Program Five Year Work Plan, 2002-2007 (PDF)

NCDFR 2008 Annual Report (PDF)

Range-Wide Conservation Plan for Longleaf Pine
http://www.americaslongleaf.net/resources/the-conservation-plan/Conservation%20Plan.pdf

North Carolina Wildlife Action Plan http://www.wildlifeactionplans.org/north_carolina.html

North Carolina Outdoor Recreation Plan 2009 – 2013
http://www.ncparks.gov/About/plans/scorp/main.php

North Carolina Coastal Habitat Protection Plan
http://www.ncfisheries.net/habitat/chpp2k5/_Complete%20CHPP.pdf

Appendix B: GIS Processes and Data Sources

Chapter 1.

FIGURE 1b-2. Conserving Working Forest Lands Map

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference:

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Forested lands data from Southern Forest Land Assessment:
http://tfsweb.tamu.edu/main/popup.aspx?id=5818

T&E species habitat data from Southern Forest Land Assessment:
http://tfsweb.tamu.edu/main/popup.aspx?id=5818

Development Risk data from Southern Forest Land Assessment:
http://tfsweb.tamu.edu/main/popup.aspx?id=5818

Water quality point data from NC DENR Division of Water Quality. 12-digit hydrologic units from USDI Natural Resource Conservation Service Watershed Boundary Dataset:
http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/

Wood Using Mills Data from Carolyn Steppleton, USDA Forest Service, Southern Research Station, Forest Inventory and Analysis.

Forest type-group data from USDA Forest Service, Forest Inventory and Analysis program and Remote Sensing Applications Center:
http://fsgeodata.fs.fed.us/rastergateway/forest_type/

Forest health data from NC Division of Forest Resources (see process information for figure 1b-4).

Wildland fire susceptibility data from Southern Wildfire Risk Assessment WFSI layer:
http://www.southernwildfirerisk.com/

Process

Forested Lands

Step 1: Reprojected from Albers to NAD 83 State Plane. No additional processing.

T&E Species

Step 1: Reprojected from Albers to NAD 83 State Plane. No additional processing.

Development Risk

Step 1: Reprojected from Albers to NAD 83 State Plane. No additional processing.

Water Quality Watersheds

Step 1: Select all water quality sampling points where the most recent sample resulted in a finding of "excellent" water quality

Step 2: Select and export all 12-digit HUCs that intersect an excellent quality point.

Step 3: Add a field and score all excellent quality HUCs "100".

Step 4: Convert excellent quality HUCs to ESRI GRID (ex_q_hucs) where "0" represents all areas outside the excellent quality HUCs.

Hardwood and Softwood Market Strength

Step 1: Create a point feature class from latitude/longitude mill locations.

Step 2: Add integer field [SCORE]. Assign a value of 1 for all records.

Step 3: Add integer field [BUFF_M]. Assign buffer distances as follows:

Hardwood saw and pulp mills: 104,607 meters (65 miles)

Hardwood veneer and plywood mills: 128,748 meters (80 mills)

Softwood saw, pulp, and "other" mills: 104,607 meters (65 miles)

Softwood plywood, veneer, pole, post, and composite mills: 128,748 meters (80 mills)

Step 4: Separate into 4 shapefiles by species (hardwood or softwood) and source material size (pulp/composite or solid wood).

Step 5: Buffer each point shapefile using [BUFF_M] as the buffer distance field.

Step 6: Export each buffer to a separate shapefile using ETGeoWizards (http://www.ian-ko.com/) split by attributes tool. Keep species and source material groupings by separating into 4 folders.

Step 7: Using a python geo-processing script (available upon request), convert each shapefile to a grid. Set the value of the grid to the new field (1).

Step 8: Using a python geo-processing script (available upon request), add the grids in each folder using raster math. The value of the output represents the number of overlapping mill source areas by for a particular species and source material size.

Step 9: Reclassify the forest type-groups data into a softwoods and hardwoods map. For each species map, all pixels corresponding to that species (or a mix including that species) should be scored one, and all pixels that don't correspond should be scored 0.

Step 10: Calculate a score for market strength in both hardwoods and softwoods as follows:

0: There is no/limited source material- the FIA forest type-groups map indicates either no forest cover or forest cover of the wrong species.

1: There is source material but no market for the species (this class is empty in both hardwood and softwood outputs; we have at least one market within a 65- or 80- mile radius of everywhere in the state).

2: There is source material AND between 1 and 4 mills in either the pulpwood/composite or solid wood products classes.
3: There is source material and either: 5+ mills in one product class and none in the other, or between 1 and 4 mills in BOTH product classes.
4: There is source material and 1-4 mills in one category and 5+ mills in the other.
5: There is source material and 5+ mills in both categories.

The raster math statement is (Replace [species] with the forest type-group layer reclassified by species):

[species] * (1 + con([species_solidwood] >= 5,2,con([species_solidwood] > 0,1,0)) + con([species_pulp_composite] >= 5,2,con([species_pulp_composite] > 0,1,0)))

Create Priority Map
Step 1: Add the preceding products together using simple raster math. Softwood and Hardwood market strength are multiplied by 20 to scale them appropriately with layers scored 0-100. No weighting is applied.
([Hardwood Market Strength] * 20) + ([Softwood Market Strength] * 20) + [Excellent Water Quality Watersheds] + [Forested Land] + [Development Risk] + [T&E Species Habitat]
Step 2: Reclassify areas above the median score (250) as priority, and areas below the median non-priority.

FIGURE 1b-3. Protecting Forests and Communities from Wildfire Risk Map

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference:

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Wildland Urban Interface layer from Radeloff, et al.:
http://silvis.forest.wisc.edu/Library/WUI_state_download.asp?state=North%20Carolina&abrev=NC

Vacant Homes and Total Housing Units by Block-Group, Census Block Groups layer, ESRI Maps and Data DVD, Tele Atlas North America, Inc. and ESRI, April 2008.

Wildland fire susceptibility data from Southern Wildfire Risk Assessment WFSI layer:
http://www.southernwildfirerisk.com/

Process

Step 1: Reclassify WFSI by natural breaks, excluding 0, as follows:
- 0- 0
- 1- 0.001692458 - 0.010154748
- 3- 0.010154748 - 0.02538687
- 5- 0.02538687 - 0.05077374
- 8- 0.05077374 - 0.089700274
- 10- 0.089700274 - 0.431576788

Step 2: Reclassify percent vacation homes by natural breaks, as follows:
- 0- 0 – 17
- 5- 17 – 39
- 10- 39 – 92

Step 3: Reclassify all WUI Interface and Intermix areas to 10, and all other areas 0.

Step 4: Add the preceding three products together using raster math as follows:
([WFSI] * 2) + [PctVacationHomes] + [WUI]

Step 5: Reclassify areas above the median score (10) as priority, and areas below the median non-priority.

FIGURE 1b-4. Forest Health Priority Lands

Map assembled by Jason Moan, NC Division of Forest Resources

Spatial Reference:

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich

Angular Unit: Degree

Raster Information:
File Name: FH_Prior_int
Cell Size: 30x30
Source Type: Continuous
Pixel type: signed integer

Discussion

This layer was developed using two layers derived during the state assessment forest health analysis: Major Insect and Disease Threats & Imminent Insect and Disease Threats. No climate data was included due to the coarseness of much of that data; sudden oak death was also left out for this reason. This priority layer represents lands at risk of southern pine beetle, hemlock woolly adelgid, balsam woolly adelgid, littleleaf disease, annosus root rot, fusiform rust, beech bark disease, redbay ambrosia beetle/laurel wilt, emerald ash borer, asian longhorned beetle, and sirex wood wasp.

Process

Step 1: The layers listed above were split into major threats (those already present) and imminent threats (those likely to become present) through careful analysis (see appendix for each of those layers for in-depth explanation).
Step 2: These input layers had were scored with 3 classes, little to no hazard (1), moderate hazard (2), and high hazard (3).
Step 3: A 'Mean' function was performed on the two input layers using Raster Calculator.
Step 4: The output was then converted to integer to minimize the file size.
Step 5: Priority landscapes were identified as any pixels having a mean value of 2 or higher (Moderate to high hazard).

FIGURE 1b-5. Maintaining Viable Urban Forests Map

Map assembled by Alan Moore, NC Division of Forest Resources.

Projected Coordinate System: NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection: Lambert_Conformal_Conic
False_Easting: 609601.22000000
False_Northing: 0.00000000
Central_Meridian: -79.00000000
Standard_Parallel_1: 34.33333333
Standard_Parallel_2: 36.16666667
Latitude_Of_Origin: 33.75000000
Linear Unit: Meter

Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983

Prime Meridian: Greenwich
Angular Unit: Degree

Discussion

This map was created through a weighted overlay analysis using layers from figures 4k1 – 4k-13:

* Hammer et al - Urban Growth Score (13%)
* NLCD 2001 - Imperviousness (10%)
* NLCD 2001 - Tree Canopy (8%)
* US Census data - Population Density (8%)
* US Census data - Total Population (8%)
* NLCD 2001 - Absence of Tree Canopy (7%)
* SFLA - Forestland (6%)
* USDA Forest Service CARS - No Professional Staff (6%)
* NOAA data - Hurricane Risk (5%)
* NC Division of Air Quality - Ozone Nonattainment Area (5%)
* SFLA - Forest Patches (4%)
* Powell Bill data - Urban ETJ (4%)
* USDA Forest Service CARS - No Management Plan (4%)
* State Climate Office of NC data - Freezing Rain Risk (3%)
* One NC Naturally Conservation Planning Tool - Biodiversity/Wildlife Habitat (2%)
* NLCD 2001 - Plantable Space (2%)
* FEMA publication - Tornado Risk (1%)
* SFLA - Wildfire Risk (1%)
* SFLA - Site Productivity (1%)
* USDA Forest Service CARS - No Advocacy Group (1%)
* USDA Forest Service CARS - No Ordinance (1%)

Data Source

NLCD 2001 - National Land Cover Database 2001, Homer et al. (2003) and http://www.mrlc.gov/mrlc2k.asp

NOAA data - National Oceanic and Atmospheric Administration data, Tropical Storms and Hurricanes, 1950 - 2008

State Climate Office of North Carolina - Fullmann and Konrad: A winter Weather Climatology for Southeastern U.S.

US Census - 2000 Population Density by Block Group and 2000 Total Population

SFLA - Southern Forest Land Assessment by USDA Forest Service and Southern Group of State Foresters

FEMA - US Federal Emergency Management Agency Publication 361, First Edition, Chapter 2

Hammer, R. B. S. I. Stewart, R. Winkler, V. C. Radeloff, and P. R. Voss. 2004. Characterizing spatial and temporal residential density patterns across the U.S. Midwest, 1940-1990. Landscape and Urban Planning 69: 183-199

Powell Bill data - The North Carolina Department of Transportation Geographic Information Systems Unit

One NC Naturally Conservation Planning Tool - http://www.conservision-nc.net/ , Biodiversity/Wildlife Habitat Assessment Grid January 2009

NC Division of Air Quality data - Ozone Nonattainment Area data, 2008
USDA Forest Service, Urban & Community Forestry Program, Community Accomplishment Reporting System - Professional Staff, Management Plan, Ordinance, Advocacy Group

Process

Step 1: Use Raster Calculator to do weighted overlay analysis
Step 2: Apply mask created for Figure 4k-1
Step 3: Breaks determined by Natural breaks (Jenks method)

FIGURE 1b-6. Rural Forest Priority Landscapes Map

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference:

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Forested lands data from Southern Forest Land Assessment: http://tfsweb.tamu.edu/main/popup.aspx?id=5818
T&E species habitat data from Southern Forest Land Assessment: http://tfsweb.tamu.edu/main/popup.aspx?id=5818
Water quality point data from NC DENR Division of Water Quality. 12-digit hydrologic units from USDI Natural Resource Conservation Service Watershed Boundary Dataset: http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/
Wood Using Mills Data from Carolyn Steppleton, USDA Forest Service, Southern Research Station, Forest Inventory and Analysis.
Forest type-group data from USDA Forest Service, Forest Inventory and Analysis program and Remote Sensing Applications Center: http://fsgeodata.fs.fed.us/rastergateway/forest_type/
Forest health data from NC Division of Forest Resources (see process information for figure 1b-4).

Wildland fire susceptibility data from Southern Wildfire Risk Assessment WFSI layer: http://www.southernwildfirerisk.com/

Process

Hardwood Market Strength, Softwood Market Strength, T&E Species Habitat, DWQ Excellent Water Quality Subwatersheds, Existing Forest Land: See process steps for figure 1b-2
Wildland Fire Susceptibility: see process steps for figure 1b-3.
Forest Health: see process steps for figure 1b-4

Step 1: Using raster math, add the layers listed above with no weighting.
Step 2: Mask out urban areas.
Step 3: Reclassify areas above the median score (260) as priority, and areas below the median non-priority.

FIGURE 1b-7. Urban Forest Priority Landscapes Map

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference:

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Conserving and Promoting Urban Forests data from NC Division of Forest Resources (see process information for figure 1b-5).
Forest health data from NC Division of Forest Resources (see process information for figure 1b-4).
Wildland Urban Interface layer from Radeloff, et al.: http://silvis.forest.wisc.edu/Library/WUI_state_download.asp?state=North%20Carolina&abrev=NC
12-digit hydrologic units from USDI Natural Resource Conservation Service Watershed Boundary Dataset: http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/

Forested lands data from Southern Forest Land Assessment:
http://tfsweb.tamu.edu/main/popup.aspx?id=5818

Process

Promoting Forests for Water Quality
Step 1: Summarize number of total land pixels and number of forested pixels by 12-digit HUC.
Step 2: Calculate percentage forested for each 12-digit HUC.
Step 3: Convert percentage forested into a raster grid.
Step 4: Apply mask created for Figure 4k-1
Step 5: Assign a score of 100 for HUCs with less than 60% forest, 50 for HUCs between 60% and 70%, and 0 for HUCs over 70%. This puts emphasis on areas where urban forestry programs can improve water quality.

Conserving and Promoting Urban Forests
Step 1: Reclassify output layer for figure 1b-5 into 5 classes using natural breaks as follows:

20- 965 - 1,767
40- 1,767.000001 - 2,334
60- 2,334.000001 - 2,930
80- 2,930.000001 - 3,672
100- 3,672.000001 - 6,106

Protecting Urban Forest Health
Step 1: Reclass Forest Health layer (figure 1b-4) as follows:

1- 25
2- 50
3- 75
4- 100

Step 2: Apply mask created for Figure 4k-1

Protecting The Wildland-Urban Interface
Step 1: Apply mask created for Figure 4k-1 to the WUI layer created for figure 1b-3.

Create Priority Map
Step 1: Using raster math, add the layers listed above with no weighting.
Step 2: Reclassify areas above the median score (285) as priority, and areas below the median non-priority.

Chapter 2.

FIGURE 2a-2. Physiographic regions of North Carolina based upon survey unit (county) boundaries (data collected in the coastal plain units is cumulative throughout this section).

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

FIA physiographic regions data based on survey unit boundaries from USDA Forest Service, Southern Research Station, Forest Inventory And Analysis Program.

FIGURE 2a-4. Public land, private forest land, and private non-forest land in North Carolina, 2006.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System: GCS_North_American_1983

Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Public land data from NC Natural Heritage Program "Managed Areas" layer.
Private forest land data from National Land Cover Dataset, 2001.

FIGURE 2a-10. Forest-type groups of North Carolina.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference:

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Forest type-group data from USDA Forest Service, Forest Inventory and Analysis program and Remote Sensing Applications Center: http://fsgeodata.fs.fed.us/rastergateway/forest_type/

FIGURE 2b-1. North Carolina longleaf pine forest distribution in 2008 versus historic range.

Map assembled by Andrew Bailey, NC Division of Forest Resources and David Jones, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic

False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Longleaf Pine range data from USDA Forest Service, Northeastern Research Station, RWU NE-4153: http://www.fs.fed.us/ne/delaware/4153/global/littlefia/index.html .

Longleaf Pine distribution data from USDA Forest Service, Forest Inventory and Analysis program and Remote Sensing Applications Center: http://fsgeodata.fs.fed.us/rastergateway/forest_type/

FIGURE 2b-3. North Carolina shortleaf pine forest distribution in 2008 versus historic range.

Map assembled by Andrew Bailey, NC Division of Forest Resources and David Jones, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Shortleaf Pine range data from USDA Forest Service, Northeastern Research Station, RWU NE-4153: http://www.fs.fed.us/ne/delaware/4153/global/littlefia/index.html .

Shortleaf Pine distribution data from USDA Forest Service, Forest Inventory and Analysis program and Remote Sensing Applications Center: http://fsgeodata.fs.fed.us/rastergateway/forest_type/

FIGURE 2c-3. Minority population density in North Carolina by Census block group.

Map assembled by Buck Vaughn, The Conservation Fund.

Spatial Reference

Geographic Coordinate System:	GCS_WGS_1984
Datum:	D_WGS_1984
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Minority Population density from Census Block Groups layer, ESRI Maps and Data DVD, Tele Atlas North America, Inc. and ESRI, April 2008.

FIGURE 2d-3. Population by census tract (square mile) in North Carolina

Map assembled by Andrew Bailey, NC Division of Forest Resources.

Spatial Reference

Geographic Coordinate System:	GCS_WGS_1984
Datum:	D_WGS_1984
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Population density from Census Block Groups layer, ESRI Maps and Data DVD, Tele Atlas North America, Inc. and ESRI, April 2008.

FIGURE 2d-4. Average Number of Acres per Housing Unit in North Carolina in 2010

Map assembled by Andrew Bailey, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000

Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

2010 Housing density data from University of Wisconsin Silvis Lab, Housing Density GIS Data 1940-2030 (Census Partial Block Groups): http://silvis.forest.wisc.edu/Library/HousingDataDownload.asp?state=North%20Carolina&abrev=NC

Process

Step 1: Add a new field, ACRHSE10, of Type DOUBLE, to nc_hse_dens.shp .

Step 2: Calculate acres per housing unit from housing density for 2010 (247.1044 acre/sq km divided by the number of housing units/sq km equals the number of acres per housing unit): 247.1044 / [HDEN10].

Step 3: Use spatial analyst extension to convert features in nc_hse_dens.shp to raster, using ACRHSE10 as the value field, with a 30m pixel size.

FIGURE 2d-5. Average Number of Acres per Housing Unit in North Carolina in 2030.

Map assembled by Andrew Bailey, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit: Meter	

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

2030 Housing density data from University of Wisconsin Silvis Lab, Housing Density GIS Data 1940-2030 (Census Partial Block Groups): http://silvis.forest.wisc.edu/Library/HousingDataDownload.asp?state=North%20Carolina&abrev=NC

Process

Step 1: Add a new field, ACRHSE30, of Type DOUBLE, to nc_hse_dens.shp .

Step 2: Calculate acres per housing unit from housing density for 2030 (247.1044 acre/sq km divided by the number of housing units/sq km equals the number of acres per housing unit): 247.1044 / [HDEN30].

Step 3: Use spatial analyst extension to convert features in nc_hse_dens.shp to raster, using ACRHSE30 as the value field, with a 30m pixel size.

FIGURE 2d-6. Percent of land developed in North Carolina, 2010.

Map assembled by Andrew Bailey, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

1990, 2010 and 2030 housing density data (bhcs_fote20080612- bhc1990, bhc2010 and bhc2030) from David Theobold, Colorado State University. Data were developed as part of the Forests on the Edge project: http://www.nrel.colostate.edu/ftp/theobald/

Process

Step 1: Use Zonal Statistics++ tool in ArcGIS Hawth's Tools Extension to summarize bhc2010 by county boundaries. Save output in bhc2010sum.dbf.

Step 2: Add a field named [devel], type Integer, to the summary table.

Step 3: Calculate the value of [devel]: [TRS_10] + [TRS_9] + [TRS_8] + [TRS_7] + [TRS_6] + [TRS_5]+ [TRS_4] . This definition of developed includes all land with less than 40 acres per house.
Step 4: Add a field named [TotalSize], type Integer, to the summary table.
Step 5: Calculate the value of [TotalSize]: [TRS_10] + [TRS_9] + [TRS_8] + [TRS_7] + [TRS_6] + [TRS_5] + [TRS_4] + [TRS_3] + [TRS_2] + [TRS_1] + [TRS_0]. This definition of total land excludes water and protected conservation land.
Step 6: Add a field named [PctDev], type Double, to the summary table.
Step 7: Calculate the value of [PctDev]: [devel]/[TotalSize] * 100
Step 8: Join the summary table to the county boundary layer.

Repeat Steps 1-7 for bhc1990 and bhc2030

FIGURE 2d-7. Development changes in North Carolina, 1990 – 2010.

Map assembled by Andrew Bailey, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

2010 and 1990 housing density data (bhcs_fote20080612- bhc2010 and bh1990) from David Theobold, Colorado State University. Data were developed as part of the Forests on the Edge project: http://www.nrel.colostate.edu/ftp/theobald/

Process

Step 1: Join bhc2010sum.dbf, and bhc1990sum.dbf (created while making map for figure 2d-6) to county boundary shapefile.
Step 2: Add new field [DevInc9010], type double.
Step 3: Calculate [DevInc9010]: bhc2010sum.[PctDev] - bhc1990sum.[PctDev] .

FIGURE 2d-8. Development changes in North Carolina, 2010 – 2030.

Map assembled by Andrew Bailey, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

2010 and 2030 housing density data (bhcs_fote20080612- bhc2010 and bh2030) from David Theobold, Colorado State University. Data were developed as part of the Forests on the Edge project: http://www.nrel.colostate.edu/ftp/theobald/

Process

Step 1: Join bhc2030sum.dbf, and bhc2010sum.dbf (created while making map for figure 2d-6) to county boundary shapefile.
Step 2: Add new field [DevInc1030], type double.
Step 3: Calculate [DevInc1030]: bhc2030sum.[PctDev] - bhc2010sum.[PctDev] .

FIGURE 2f-1. Approximate wetland and stream mitigation site opportunities for private landowners.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667

Latitude_Of_Origin:	33.750000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Process

Step 1: Intersect National Land Cover Database (NLCD) 2001 Land Cover Dataset disturbed land classes with NRCS SSURGO Database hydric soils.

Step 2: Intersect National Hydrography Dataset (Plus) buffered by 30 meters with the NLCD 2001 Land Cover Dataset disturbed land classes.

Step 3: Merge wetland mitigation opportunities layer from step 1 with stream mitigation opportunities from step 2 to create combined mitigation opportunities.

Step 4: Erase a mask of developed land and impervious cover from NLCD and national forests, national parks, state forests, state parks, existing mitigation banks, NCEEP sites, NRCS Wetlands Reserve Program lands, NRCS Conservation Reserve Areas, NC Clean Water Management Trust Fund properties, and other conservation lands from combined mitigation opportunities

FIGURE 2f-2. Approximate nutrient offset bank opportunities for private land owners.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667
Latitude_Of_Origin:	33.750000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Process

Step 1: Intersect National Hydrography Dataset (Plus) buffered by 200 feet with the NLCD 2001 Land Cover Dataset disturbed land classes.

FIGURE 2f-3. Federally-listed species occurrences in North Carolina.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667
Latitude_Of_Origin:	33.750000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

The following map depicts the number of federally listed species that are known to occur (past or present) in each county. These data were acquired from the NC Natural Heritage Program Listed Species Database.

FIGURE 2f-4. Estimated forest carbon biomass (above- and below-ground) in North Carolina.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667
Latitude_Of_Origin:	33.750000

Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Title:	Mapping U.S. forest biomass using nationwide forest inventory data and moderate resolution information
Authors:	J.A. Blackard, M.V. Finco, E.H. Helmer, G.R. Holden, M.L. Hoppus, D.M. Jacobs, A.J. Lister, G.G. Moisen, M.D. Nelson, R. Riemann, B. Ruefenacht, D. Salajanu, D.L Weyermann, K.C. Winterberger, T.J. Brandeis, R.L. Czaplewski, R.E. McRoberts, P.L. Patterson, R.P. Tymcio
Geospatial_Data_Presentation_Form:	remote-sensing image
Series_Name:	Remote Sensing of Environment
Issue_Identification:	112:1658-1677
Publisher:	Elsevier
Online_Linkage:	<http://fsgeodata.fs.fed.us/rastergateway/biomass/>

Chapter 3.

FIGURE 3a-1. Map of North Carolina's major insect and disease threats by risk level.

Map assembled by Jason Moan, NC Division of Forest Resources
Raster name: Major_extr

Spatial Reference

Raster Information -
Cell Size (x,y): 30,30
Format: GRID
Source Type: continuous
Pixel type: Unsigned integer
Pixel Depth: 8 bit

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Linear Unit:	Meter (1.000000)
Angular Unit:	Degree (0.0174532925199433299)
False_Easting:	609601.22
False_Northing:	0.000000
Central_Meridian:	-79
Standard_Parallel_1:	34.33333333333334
Standard_Parallel_2:	36.16666666666666
Latitude_Of_Origin:	23.000000
Datum:	D_North_American_1983

Data Source

Major Insects and Disease Threats Map data source: This map is the product of a modeling effort involving the existing forest health layers listed below. All layers were reprojected into NAD 1983 North Carolina State Plane Meters and resampled to 30 meter resolution if necessary. All layers were then recoded to either 2 or 3 classes representing low, moderate, and high hazard. A Maximum function was applied to the resulting layers to create the final Major Insects and Disease Threats raster layer.

Process

Step 1. SPB Hazard map: Produced by the USDA - Forest Service Forest Health Technology Enterprise Team. Original dataset has 10 hazard categories. Data was reclassified to values NoData and 0 = 0; 1-3 = 1 (low); 4-6 = 2 (moderate); and 7-10 = 3 (high)

Step 2. "Forest Health" layer from the Southern Forest Land assessment: Layer represents the following forest health concerns:

a. Annosus root rot
b. Fusiform rust
c. Beech bark disease
d. Southern pine beetle

e. Balsam woolly adelgid
f. Hemlock woolly adelgid

The SFLA forest Health Layer represents expected mortality within 15 years for the listed pests. This information was predicted for the 2006 version of the National Insect and Disease Risk Map (NIDRM) produced by the USDA - Forest Service Forest Health Technology Enterprise Team. Original data classes were 0, 33, 67, 100. These values represent expected mortality as shown in the following: 0 = < 5%, 33 = 5-15%, 67 = 15-25%, 100 = >25%. This layer was reclassified as NoData & 0 = 0, 33 = 1 (low), 67 = 2 (moderate), and 100 = 3 (high).

Step 3. Hemlock woolly adelgid - Layer of predicted eastern and Carolina hemlock basal area from the 2006 NIDRM was used to identify areas susceptible to HWA. Data was originally at 1km resolution. Original modeled basal area ranged from 0-77. Reclassified values < 1 to 1, 1-77 to 3, and NoData to 0.

Step 4. Balsam woolly adelgid - Layer of predicted Fraser fir basal area from the 2006 NIDRM was used to identify areas susceptible to BWA. Data was originally at 1km resolution. Original modeled basal area ranged from 0-7. Reclassified values < 1 to 1, 1-7 to 3, and NoData to 0.

Step 5. Littleleaf disease - Layer of predicted loblolly and shortleaf pine basal area from the 2006 NIDRM was used to identify areas at risk of littleleaf disease. Both basal area layers were clipped to the known range of littleleaf disease in NC (http://www.srs.fs.usda.gov/sustain/report/hlth2/hlth2-33.htm). Reclassified basal area layers such that any basal area > 1 = high hazard (3), < 1 = low hazard (1). This resulted in pixel values of 1, 3, and 33 (no data). Created a weighted overlay of reclassified basal area layers with Shortleaf = 70% weight and loblolly = 30% weight. Weights were based on expert opinion. Before littleleaf layer could be modeled with other layers, a constant raster (pixel value 0) equal to the state extent had to be created and merged with littleleaf layer. This resulted in an output layer with values of 0,1,2,3. The values of 0 and 1 represented background data, so the layer was reclassified to 3 classes (1, 2, and 3) with 1 = low or no hazard, 2 = moderate hazard. and 3 = high hazard.

FIGURE 3a-2. Southern pine beetle hazard map.

Map assembled by Jason Moan, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	USA_Contiguous_Albers_Equal_Area_Conic_USGS_version
Projection:	Albers
False_Easting:	0.000000
False_Northing:	0.000000
Central_Meridian:	-96.000000
Standard_Parallel_1:	29.500000
Standard_Parallel_2:	45.500000
Latitude_Of_Origin:	23.000000
Linear Unit:	Meter (1.000000)

Geographic Coordinate System:	GCS_North_American_1983
Angular Unit:	Degree (0.017453292519943299)
Prime Meridian:	Greenwich (0.000000000000000000)
Datum:	D_North_American_1983
Spheroid:	GRS_1980
Semimajor Axis:	6378137.000000000000000000
Semiminor Axis:	6356752.314140356100000000
Inverse Flattening:	298.257222101000020000

Data Source

SPB Hazard Map data source: Data produced by USDA - Forest Service Forest Health Technology Enterprise Team.

FIGURE 3a-3. European gypsy moth quarantine map, 2008.

Map assembled by Jason Moan, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Gypsy Moth Quarantine data source: Provided by Matt Andresen - NCDA Gypsy Moth Program Coordinator. Data created by USDA - Animal and Plant Health Inspection Service

FIGURE 3a-4. Imminent forest health threats map; includes emerald ash borer, Asian longhorned beetle, redbay ambrosia beetle, and sirex woodwasp.

Map assembled by Jason Moan, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Linear Unit:	Meter (1.000000)
Angular Unit:	Degree (0.0174532925199433299)
False_Easting:	609601.22
False_Northing:	0.000000
Central_Meridian:	-79
Standard_Parallel_1:	34.33333333333334
Standard_Parallel_2:	36.16666666666666
Latitude_Of_Origin:	23.000000
Datum:	D_North_American_1983

Raster name: future_fh

Raster Information -
Cell Size (x,y): 30,30
Format: GRID
Source Type: continuous
Pixel type: Unsigned integer
Pixel Depth: 8 bit

Data Source

This map is the product of a modeling effort involving the existing forest health layers listed below. All layers were reprojected into NAD 1983 North Carolina State Plane Meters and resampled to 30 meter resolution if necessary. All layers were then recoded to either 2 or 3 classes representing low, moderate, and high hazard. A Maximum function was applied to the resulting layers to create the final Imminent Insects and Disease Threats raster layer.

Process

Step 1. Emerald ash borer hazard map: Produced by the USDA - Forest Service Forest Health Technology Enterprise Team. Original dataset has 10 hazard categories. Data was reclassified to values NoData and 0 = 0; 1-3 = 1 (low); 4-6 = 2 (moderate); and 7-10 = 3 (high)

Step 2. Asian longhorned bettle hazard map: Produced by the USDA - Forest Service Forest Health Technology Enterprise Team. Original dataset has 7 hazard categories (1-7). Data was reclassified to values NoData and 0 = 0; 1-2 = 1 (low); 3-4 = 2 (moderate); and 5-7 = 3 (high)

Step 3. Sirex woodwasp hazard map: Produced by the USDA - Forest Service Forest Health Technology Enterprise Team. Original dataset has 4 hazard categories (1,3,4,5). Data was reclassified to values NoData and 0 = 0; 1 = 1 (low); 3 = 2 (moderate); and 4-5 = 3 (high)

Steb 4. Redbay ambrosia beetle/Laurel wilt: The RAB map is a combination of three layers all of which were developed by Frank Koch and Bill Smith with USDA-FS Forest Health Monitoring National Research Team and NC State University and published by Koch and Smith in 2008 in Environmental Entomology 37(2): "Spatio-temporal analysis of

Xyleborus glabratus (Coleoptera: Circulionidae: Scolytinae) Invasion in Eastern U.S. Forests".

a. Predicted number of trees per acre of Persea borbonia developed from FIA analysis (GRID)
b. Predicted number of trees per acre of Sassafras albidum developed from FIA analysis (GRID)
c. Potential range of Xyleborus glabratus (Shapefile) based on climate matching.
   The RAB host trees per acre data was continuous and had to be converted to categorical data before comparison could occur between the layers. The sassafras and redbay layers were added together using Raster Calculator. The resulting raster had TPA values of 0-240.5. Based on expert opinion (James Johnson - Georgia Forestry Commission and Bud Mayfield - Florida Dept of Ag and Consumer Services - Division of Forestry) the data was categorized with < 10 TPA = 1 (low) and greater than or equal to 10 TPA = 3 (high). This output layer was then exported to the extent of the dataframe and extracted to the extent of the potential RAB range.

FIGURE 3a-5. Major non-native invasive imminent threats.

Map assembled by Jason Moan, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Emerald ash borer data source:
KY/VA: Dale Starkey - USFS FHM Coordinator (Pineville, LA) - Current through 12/31/09
WV: http://www.emeraldashborer.info/files/MultiState_EABpos.pdf - Current through 12/2/09
MD: http://www.mda.state.md.us/plants-pests/eab/eab_survey_map.php - Current through 3/25/09

Gypsy Moth Quarantine data source:
http://www.aphis.usda.gov/plant_health/plant_pest_info/gypsy_moth/downloads/gypmoth.pdf - Current through 5/13/09
Redbay ambrosia beetle/Laurel wilt data source: Dale Starkey - USFS FHM Coordinator (Pineville, LA) - Current through 12/31/09
Cogongrass data source: http://www.cogongrass.org/distribution/index.cfm - Current through 1/20/10

FIGURE 3b-2. Fire occurrences in North Carolina, 2000 – 2008.

Analysis completed by Justin Shedd, NC State University.
Map assembled by Andrew Bailey, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Process:

Step 1: Fires occurring from 2000-2008 were selected.
Step 2: A linear interpolation of the fire occurrence data was completed using a search radius of 100 acres (20871 feet by 20871 feet) and an output cell size of 98 feet. The fire occurrence grid was divided by the total number of years in the sample (8).

The output GRID represents the average number of fires that have occurred near that site during a year.

Data Source

NC Division of Forest Resources fire reporting database, USDA, USDI, USDOD

FIGURE 3b-3. Presumed mean interval (years) between fire return in NC under a presumed historical regime.

Map assembled by Justin Shedd - NC State University, and Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Process

Step 1: Download mean fire return interval data.
Step 2: Mask mean fire return interval data to NC boundary.

Data Source

Mean fire return interval data from Landfire Project, US Geological Survey:
http://landfire.cr.usgs.gov/viewer/

FIGURE 3b-4. Smoke-sensitive areas in North Carolina, 2009.

Map assembled by James Rogers, NC Division of Forest Resources and Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System: GCS_North_American_1983

Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Medical facilities, public schools, private schools, colleges and universities, and hospital point data is from NC OneMap: http://www.nconemap.com/Default.aspx?tabid=286 (schlpl.shp, schlnp.shp, medfacs.shp, colluniv.shp, hsp.shp)

Interstate and US highway data is from the NC Department of Transportation Integrated Statewide Road Network: http://www.ncdot.org/it/gis/DataDistribution/DOTData/default.html .

Process

Step 1: Buffer interstate and US highways, medical facilities, public schools, private schools, colleges and universities, and hospitals by 2 miles.

Step 2: Merge above buffers.

Step 3: Dissolve merged buffers.

FIGURE 3b-5. Percentage of NC homes vacant in 2000.

Map assembled by Andrew Bailey, NC Division of Forest Resources and James Rogers, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Sources:

Vacant Homes and Total Housing Units by Block-Group, 2000 Census

FIGURE 3b-6. Wildland-urban interface areas in North Carolina based on vegetation and housing density, 2000.

Map assembled by Andrew Bailey, NC Division of Forest Resources
Map Design based on WUI maps available at Radeloff et al. website.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Sources:

Radeloff, V.C., et al. University of Wisconsin-Madison:
http://silvis.forest.wisc.edu/Library/WUI_state_download.asp?state=North%20Carolina&abrev=NC

FIGURE 3b-7. NC communities at risk of wildfire, 2009.

Map assembled by Justin Shedd, NC State University and Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Prime Meridian: Greenwich
Angular Unit: Degree

Data Sources:

Southern Wildlife Risk Assessment, Sanborn Map Company:
http://www.southernwildfirerisk.com/

FIGURE 3b-8. North Carolina CWPPs, 2009.

Map assembled by Andrew Bailey, NC Division of Forest Resources and James Rogers, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System: NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection: Lambert_Conformal_Conic
False_Easting: 609601.22000000
False_Northing: 0.00000000
Central_Meridian: -79.00000000
Standard_Parallel_1: 34.33333333
Standard_Parallel_2: 36.16666667
Latitude_Of_Origin: 33.75000000
Linear Unit: Meter

Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Prime Meridian: Greenwich
Angular Unit: Degree

Data Source

CWPP data from James Rogers, NC DENR Division of Forest Resources.

FIGURE 3c-2. NC coastal areas within 6 feet of sea level.

Map assembled by Margaret Fields, The Nature Conservancy of NC.

Spatial Reference

Projected Coordinate System: NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection: Lambert_Conformal_Conic
False_Easting: 609601.22000000
False_Northing: 0.00000000

Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Sea level rise data from USDA Forest Service Southern Research Station, Southern Global Change Program.

FIGURE 3c-3. Tropical storms and hurricanes, 1950 – 2008. A storm was counted if its eye passed within 50 miles of a county.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Tropical storm and hurricane data from NOAA Coastal Services Center: http://csc-s-maps-q.csc.noaa.gov/hurricanes/download.jsp

Process

Step 1: Subset tropical storm and hurricane tracks between 1950 and 2008 from Atlantic Storms dataset.

Step 2: Buffer storm tracks by 50 miles.
Step 3: Add a field to the buffered tracks. Calculate a value of 1 to the field.
Step 4: Export each storm track buffer to a separate shapefile using ETGeoWizards (http://www.ian-ko.com/) split by attributes tool.
Step 5: Using an AML script, convert each shapefile to a grid using the shapegrid() function. Set the value of the grid to the new field (1).
Step 6: Using an AML script, add the grids using raster math. The value of the output represents the number of overlapping storm tracks, or the number of storms which passed within 50 miles.

FIGURE 3c-4. Annual freezing rain event frequency, 1948 – 2003.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

NC Climate data from the NC State Climate Office: http://www.nc-climate.ncsu.edu/climate/winter

Process

The map “Freezing Rain Dominant Events”) http://www.nc-climate.ncsu.edu/images/climate/winter/FZRA_EVENTS.jpg was digitized in ArcMap using the Georeferencing toolbar.

Chapter 4.

FIGURE 4a-8. NC certified prologgers by county.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Certified Prologgers by County data from NC Forestry Association:

http://www.ncforestry.org/WEBPAGES/PROLOGGER/PROLOGGERINDEXPAGE.htm

Processing Steps:

Step 1: Joined prologger data to county boundary shapefile.

FIGURE 4c-13. NC 8-year average of total stumpage value by county and wood-using mills, 2001 – 2008.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667

Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Stumpage Value Data from James Jeuck, NC State University Extension Forestry.
Wood Using Mills Data from Carolyn Steppleton, USDA Forest Service, Southern Research Station, Forest Inventory and Analysis.

FIGURE 4d-1. NC primary wood-using mills, 2007.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Wood Using Mills Data from Carolyn Steppleton, USDA Forest Service, Southern Research Station, Forest Inventory and Analysis.

FIGURE 4f-1. River basins of North Carolina.

Map assembled by David Jones, NC Division of Forest Resources
Map design based on Figure 5 B.1. in NC Wildlife Action Plan

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

River basins from USGS 1:250,000 Hydrologic Units dataset:
http://water.usgs.gov/lookup/getspatial?huc250k

FIGURE 4f-2. North Carolina annual precipitation.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667
Latitude_Of_Origin:	33.750000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Terziotti, S., J.L. Eimers, and J.C. Weaver. 2001. Watershed Characteristic Rating for North Carolina: U.S. Geological Survey Open-File Report 01-490 (digital data updated July 2009). http://nc.water.usgs.gov/reports/ofr01490/index.html. [Date accessed: July 2009].

FIGURE 4f-3. North Carolina annual runoff.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667
Latitude_Of_Origin:	33.750000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Gebert, W.A., D.J. Graczyk, and W.R. Krug. 1987. Average Annual Runoff in the United States, 1951-80: U.S. Geological Survey Hydrologic Investigations Atlas HA-710, scale 1:7,500,000. http://water.usgs.gov/GIS/metadata/usgswrd/XML/runoff.xml.

FIGURE 4f-4. Key subbasins for freshwater conservation: Subbasins impaired for aquatic life use support.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667
Latitude_Of_Origin:	33.750000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Map assembled using data from the following two sources:

Master, L.L., S.R. Flack, and B.A. Stein, editors. 1998. Rivers of Life: Critical Watersheds for Protecting Freshwater Biodiversity. The Nature Conservancy. http://www.natureserve.org/library/riversoflife.pdf

North Carolina Division of Water Quality (NCDWQ). 2007. North Carolina Water Quality Assessment and Impaired Waters List: 2006 integrated 305(b) and 303(d) report. http://h2o.enr.state.nc.us/tmdl/documents/2006IR_FINAL_000.pdf.

FIGURE 4f-5. Forest and/or natural cover trends in relation to impervious cover.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667
Latitude_Of_Origin:	33.750000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Forest/natural cover was summarized for each subwatershed (NRCS Watershed Boundary Dataset[WBD]: 12-digit hydologic unit) using the National Land Cover Database (NLCD) 1992 and 2001 Land Cover Datasets using the Spatial Analyst Tools/Zonal/Tablulate Area function of ArcGIS. Impervious cover was summarized from the NLCD 2001 Impervious Cover Dataset using the Spatial Analyst Tools/Zonal/Tablulate Area function of ArcGIS.

FIGURE 4f-6. Piedmont Crescent.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System: NAD_1983_StatePlane_North_Carolina_FIPS_3200

Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667
Latitude_Of_Origin:	33.750000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Discussion

This map depicts urban land from the National Land Cover Database - 2001 Land Cover Dataset. The crescent shape is a rough approximation of the area commonly referred to as the Piedmont Cresent; loosely defined as the I-85/I-40 corridor from Charlotte to Raleigh.

FIGURE 4f-7. Forecast of water demand growth 2005 – 2030 (all sectors included).

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.220000
False_Northing:	0.000000
Central_Meridian:	-79.000000
Standard_Parallel_1:	34.333333
Standard_Parallel_2:	36.166667
Latitude_Of_Origin:	33.750000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

North Carolina Rural Economic Development Center (NCREDC). 2006. Water 2030: North Carolina Water Supply and Demand Overview. http://www.ncruralcenter.org/water2030/.

FIGURE 4f -8a. Priority forest watersheds in North Carolina for water quality and quantity illustrating a subwatershed relative value.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference

Projected Coordinate System: NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection: Lambert_Conformal_Conic
False_Easting: 609601.220000
False_Northing: 0.000000
Central_Meridian: -79.000000
Standard_Parallel_1: 34.333333
Standard_Parallel_2: 36.166667
Latitude_Of_Origin: 33.750000
Linear Unit: Meter

Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Prime Meridian: Greenwich
Angular Unit: Degree

Discussion

This map was generated through a weighted overlay using the following datasets and values:

NC Conservation Planning Tool - Water Services Assessment	30%
NCREDC - Forecasted Water Demand Growth	25%
SFLA - Forestland (based on NLCD 2001 LULC)	20%
NCDWQ/NCDEH Source Water Areas - Surface Water Supply Watersheds & Groundwater Well Protection Areas	15%
SFLA - Development Level	10%

Each layer was converted to a 30x30 meter raster dataset as needed before analysis. Data was then summarized on a percent basis for each subwatershed (12-digit hydrologic unit) in the state using the NRCS Watershed Boundary dataset.

FIGURE 4f-8b. Priority forest watersheds in North Carolina for water quality and quantity illustrating a 30-meter pixel display.

Map assembled by David Jones, North Carolina Division of Forest Resources.

Spatial Reference
Projected Coordinate System: NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection: Lambert_Conformal_Conic
False_Easting: 609601.220000
False_Northing: 0.000000
Central_Meridian: -79.000000
Standard_Parallel_1: 34.333333
Standard_Parallel_2: 36.166667
Latitude_Of_Origin: 33.750000
Linear Unit: Meter

Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Prime Meridian: Greenwich
Angular Unit: Degree

Discussion
This map was generated through a weighted overlay using the following datasets and values:

NC Conservation Planning Tool - Water Services Assessment	30%
NCREDC - Forecasted Water Demand Growth	25%
SFLA - Forestland (based on NLCD 2001 LULC)	20%
NCDWQ/NCDEH Source Water Areas - Surface Water Supply Watersheds & Groundwater Well Protection Areas	15%
SFLA - Development Level	10%

Each layer was converted to a 30x30 meter raster dataset as needed before analysis.

FIGURE 4g-1. Ecoregions of North Carolina.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference
Projected Coordinate System: NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection: Lambert_Conformal_Conic
False_Easting: 609601.22000000
False_Northing: 0.00000000
Central_Meridian: -79.00000000
Standard_Parallel_1: 34.33333333
Standard_Parallel_2: 36.16666667
Latitude_Of_Origin: 33.75000000
Linear Unit: Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Ecoregion data from Southern Forest Resource Assessment, USDA Forest Service, Southern Research Station: http://www.srs.fs.usda.gov/sustain/data/ .

FIGURE 4g-2. River basins of North Carolina.

Map assembled by Andrew Bailey, NC Division of Forest Resources
Map design based on Figure 5 B.1. in NC Wildlife Action Plan

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

River basins from USGS 1:250,000 Hydrologic Units dataset: http://water.usgs.gov/lookup/getspatial?huc250k

FIGURE 4h-3. US Environmental Protection Agency tracked sites in North Carolina with biorefinery facility site potential.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200

Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Biomass Resource and EPA Traced Sites data from US EPA:
http://www.epa.gov/renewableenergyland/

FIGURE 4i-2. North Carolina open space and conservation land.

Map assembled by Andrew Bailey, NC Division of Forest Resources

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

State and Federal Lands data from NC Natural Heritage Program "Managed Areas" layer (marea.shp).

State Forests data from Andrew Bailey, NC DENR Division of Forest Resources.

The following data layers are from the July '09 NC DENR "One NC Naturally" Conservation Planning Tool:

http://wfs.enr.state.nc.us/conservision_data/July09/OpenSpace_ConservationLands_0709.zip
Mountains-To-Sea Trail and Corridor data from NC DENR Division of Parks and Recreation (app-trail.shp, mt2sea.shp, and mt2sea_status.shp).
Other Managed Lands from Lands Managed for Conservation and Open Space (lmcos.shp).
State Park Units from NC DENR Division of Parks and Recration (ncprk_0709.shp).

Figure 4k-1. North Carolina urban housing density in 2000 and designation of urban areas and urban clusters, representing land area included within the analysis.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Hammer, R. B. S. I. Stewart, R. Winkler, V. C. Radeloff, and P. R. Voss. 2004. Characterizing spatial and temporal residential density patterns across the U.S. Midwest, 1940-1990. Landscape and Urban Planning 69: 183-199

Process

Step 1: Polygon to Raster using ACRHSE00 as the value field, with a 30m pixel size
Step 2: Reclassify to Value 1=0 to 2 and Value 2=2.00001 to 16

Figure 4k-2. Priority ranking of urban areas identifying areas that would increase urban forest health and viability.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit: Meter	

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Discussion

This map was created through a weighted overlay analysis using:
* Hammer et al - Urban Growth Score (40%)
* Powell Bill data - Urban ETJ (20%)
* SFLA - Forest Patches (20%)
* SFLA - Forestland (10%)
* One NC Naturally Conservation Planning Tool - Biodiversity/Wildlife Habitat (10%)

Data Source

Hammer, R. B. S. I. Stewart, R. Winkler, V. C. Radeloff, and P. R. Voss. 2004. Characterizing spatial and temporal residential density patterns across the U.S. Midwest, 1940-1990. Landscape and Urban Planning 69: 183-199

Powell Bill data - The North Carolina Department of Transportation Geographic Information Systems Unit

SFLA - Southern Forest Land Assessment by USDA Forest Service and Southern Group of State Foresters

One NC Naturally Conservation Planning Tool - http://www.conservision-nc.net/ , Biodiversity/Wildlife Habitat Assessment Grid January 2009

Process

Step 1: Reclassify Biodiversity/Wildlife Habitat on field: Final, -1 to 0; 0 to 0; 1 to 10; 2 to 20; 3 to 30; 4 to 40; 5 to 50; 6 to 60; 7 to 70; 8 to 80; 9 to 90; 10 to 100
Step 2: Reclassify Forest Patches
Step 3: Buffer UrbanETJ by 1, 2, or 3 miles according to NC statute
Step 4: Reclassify UrbanETJ
Step 5: Reclassify UrbanGrowthScore
Step 6: Use Raster Calculator to do weighted overlay analysis
Step 7: Apply mask created for Figure 4k-1
Step 8: Breaks determined by Natural breaks (Jenks method)

Figure 4k-3. Priority ranking of named places plus associated ETJ, identifying municipalities experiencing rapid growth but currently forested.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Process

Step 1: ZonalStatistics using input value of the final raster created for Figure 4k-2 and Statistics type MEAN

Step 2: Breaks determined by sorting places by place mean and grouped according to the following: 1 - 66 places (top 10%), 67- 131 places (next 10%), 132 - 261 places (next 20%), 262 - 458 places (next 30%), Very Low 459 - 655 places (bottom 30%)

Figure 4k-4. Priority areas index identifying where urban forest areas and their associated values are most at risk from catastrophic events.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333

Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Discussion

This map was created through a weighted overlay analysis using:
* NLCD 2001 - Tree Canopy (40%)
* NOAA data - Hurricane Risk (25%)
* State Climate Office of NC data - Freezing Rain Risk (15%)
* US Census data - Population Density (10%)
* SFLA - Wildfire Risk (5%)
* FEMA publication - Tornado Risk (5%)

Data Source

NLCD 2001 - National Land Cover Database 2001, Homer et al. (2003) and http://www.mrlc.gov/mrlc2k.asp

NOAA data - National Oceanic and Atmospheric Administration data, Tropical Storms and Hurricanes, 1950 - 2008

State Climate Office of North Carolina - Fullmann and Konrad: A winter Weather Climatology for Southeastern U.S.

US Census - 2000 Population Density by Block Group

SFLA - Southern Forest Land Assessment by USDA Forest Service and Southern Group of State Foresters

FEMA - US Federal Emergency Management Agency Publication 361, First Edition, Chapter 2

Process

Step 1: PolygonToRaster digitized Tornado Occurence map
Step 2: Reclassify Tornado layer
Step 3: PolygonTo Raster Population Density by Block Group
Step 4: Reclassify Population Density layer
Step 5: Reclassify Freezing Rain Events layer
Step 6: Reclassify Hurricane Events layer
Step 7: Use Raster Calculator to do weighted overlay analysis
Step 8: Apply mask created for Figure 4k-1
Step 9: Breaks determined by Natural breaks (Jenks method)

Figure 4k-5. Priority ranking of named places identifying municipalities where urban forests and their associated values are most at risk from catastrophic events.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit: Meter	

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Process

Step 1: Use Hawth's Tools Zonal Statistics++ to determine mean of percent of maximum values calculated for figure 4k-4 within each named place

Step 2: Breaks determined by sorting places by place mean and grouped according to the following: 1 - 66 places (top 10%), 67- 131 places (next 10%), 132 - 261 places (next 20%), 262 - 458 places (next 30%), Very Low 459 - 655 places (bottom 30%)

Figure 4k-6. Priority areas index identifying areas with poor air quality, but with opportunities for tree conservation.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich

Angular Unit: Degree

Discussion

This map was created through a weighted overlay analysis using:
* NLCD 2001 - Absence of Tree Canopy (35%)
* NC Division of Air Quality - Ozone Nonattainment Area (25%)
* NLCD 2001 - Imperviousness (20%)
* US Census data - Population Density (10%)
* Hammer et al - Urban Growth Score (10%)

Data Source

NLCD 2001 - National Land Cover Database 2001, Homer et al. (2003) and http://www.mrlc.gov/mrlc2k.asp

NC Division of Air Quality data - Ozone Nonattainment Area data, 2008

US Census - 2000 Population Density by Block Group

Hammer, R. B. S. I. Stewart, R. Winkler, V. C. Radeloff, and P. R. Voss. 2004. Characterizing spatial and temporal residential density patterns across the U.S. Midwest, 1940-1990. Landscape and Urban Planning 69: 183-199

Process

Step 1: PolygonToRaster Ozone Nonattainment Area map
Step 2: Reclassify Ozone Nonattainment Area layer
Step 3: Calculate Absence of Canopy by the equation, Absence of Canopy = 100 - Tree Canopy
Step 4: Use Raster Calculator to do weighted overlay analysis
Step 5: Apply mask created for Figure 4k-1
Step 6: Breaks determined by Natural breaks (Jenks method)

Figure 4k-7. Priority ranking of named places identifying municipalities with poor air quality, but with opportunities for tree conservation.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich

Angular Unit: Degree

Process

Step 1: Use Hawth's Tools Zonal Statistics++ to determine mean of percent of maximum values calculated for figure 4k-6 within each named place

Step 2: Breaks determined by sorting places by place mean and grouped according to the following: 1 - 66 places (top 10%), 67- 131 places (next 10%), 132 - 261 places (next 20%), 262 - 458 places (next 30%), Very Low 459 - 655 places (bottom 30%)

Figure 4k-9. Priority areas index identifying areas where urban tree canopy has potential to reduce energy demands.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit: Meter	

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Discussion

This map was created through a weighted overlay analysis using:
* NLCD 2001 - Imperviousness (30%)
* US Census data - Population Density (20%)
* SFLA - Forestland (20%)
* Hammer et al - Urban Growth Score (15%)
* NLCD 2001 - Plantable Space (20%)
* SFLA - Site Productivity (5%)

Data Source

NLCD 2001 - National Land Cover Database 2001, Homer et al. (2003) and http://www.mrlc.gov/mrlc2k.asp

US Census - 2000 Population Density by Block Group

SFLA - Southern Forest Land Assessment by USDA Forest Service and Southern Group of State Foresters

Hammer, R. B. S. I. Stewart, R. Winkler, V. C. Radeloff, and P. R. Voss. 2004. Characterizing spatial and temporal residential density patterns across the U.S. Midwest, 1940-1990. Landscape and Urban Planning 69: 183-199

Process

Step 1: Reclassify Site Productivity layer
Step 2: Calculate Plantable Space by the equation, Planting Space = 100 - Imperviousness - Tree Canopy
Step 3: Use Raster Calculator to do weighted overlay analysis
Step 4: Apply mask created for Figure 4k-1
Step 5: Breaks determined by Natural breaks (Jenks method)

Figure 4k-10. Priority ranking of municipalities with the greatest potential to reduce energy demand by increasing urban tree canopy.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Process

Step 1: Use Hawth's Tools Zonal Statistics++ to determine mean of percent of maximum values calculated for figure 4k-9 within each named place
Step 2: Breaks determined by sorting places by place mean and grouped according to the following: 1 - 66 places (top 10%), 67- 131 places (next 10%), 132 - 261 places (next 20%), 262 - 458 places (next 30%), Very Low   459 - 655 places (bottom 30%)

Figure 4k-11. Priority ranking of named places identifying municipalities missing one or more of the components required to be classified as a managing urban forestry program.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Discussion

This map was created through a weighted overlay analysis using:
* US Census data - Total Population (40%)
* USDA Forest Service CARS - No Professional Staff (30%)
* USDA Forest Service CARS - No Management Plan (20%)
* USDA Forest Service CARS - No Ordinance (5%)
* USDA Forest Service CARS - No Advocacy Group (5%)

Data Source

US Census - 2000 Total Population
USDA Forest Service, Urban & Community Forestry Program, Community Accomplishment Reporting System - Professional Staff, Management Plan, Ordinance, Advocacy Group

Process

Step 1: Polygon to Raster for Total Population
Step 2: Classify to Value <10000 = 0, 10001 - 20000 = 20, 20001 - 50000 = 40, 50001 - 100000 = 60, 100001 - 250000 = 80, >250000 = 100
Step 3: Polygon to Raster for CARS data 4 times to create each layer
Step 4: Use Raster Calculator to do weighted overlay analysis
Step 5: Breaks determined by Natural breaks (Jenks method)

Figure 4k-12. Priority areas identifying areas with greatest potential to improve urban forest health and viability.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Discussion

This map was created through a weighted overlay analysis using all layers previously used:
* Hammer et al - Urban Growth Score (13%)
* NLCD 2001 - Imperviousness (10%)
* NLCD 2001 - Tree Canopy (8%)
* US Census data - Population Density (8%)
* US Census data - Total Population (8%)
* NLCD 2001 - Absence of Tree Canopy (7%)
* SFLA - Forestland (6%)
* USDA Forest Service CARS - No Professional Staff (6%)
* NOAA data - Hurricane Risk (5%)
* NC Division of Air Quality - Ozone Nonattainment Area (5%)
* SFLA - Forest Patches (4%)
* Powell Bill data - Urban ETJ (4%)
* USDA Forest Service CARS - No Management Plan (4%)
* State Climate Office of NC data - Freezing Rain Risk (3%)
* One NC Naturally Conservation Planning Tool - Biodiversity/Wildlife Habitat (2%)
* NLCD 2001 - Plantable Space (2%)
* FEMA publication - Tornado Risk (1%)
* SFLA - Wildfire Risk (1%)
* SFLA - Site Productivity (1%)
* USDA Forest Service CARS - No Advocacy Group (1%)
* USDA Forest Service CARS - No Ordinance (1%)

Data Source

NLCD 2001 - National Land Cover Database 2001, Homer et al. (2003) and http://www.mrlc.gov/mrlc2k.asp

NOAA data - National Oceanic and Atmospheric Administration data, Tropical Storms and Hurricanes, 1950 - 2008

State Climate Office of North Carolina - Fullmann and Konrad: A winter Weather Climatology for Southeastern U.S.
US Census - 2000 Population Density by Block Group and 2000 Total Population
SFLA - Southern Forest Land Assessment by USDA Forest Service and Southern Group of State Foresters
FEMA - US Federal Emergency Management Agency Publication 361, First Edition, Chapter 2
Hammer, R. B. S. I. Stewart, R. Winkler, V. C. Radeloff, and P. R. Voss. 2004. Characterizing spatial and temporal residential density patterns across the U.S. Midwest, 1940-1990. Landscape and Urban Planning 69: 183-199
Powell Bill data - The North Carolina Department of Transportation Geographic Information Systems Unit
One NC Naturally Conservation Planning Tool - http://www.conservision-nc.net/ , Biodiversity/Wildlife Habitat Assessment Grid January 2009
NC Division of Air Quality data - Ozone Nonattainment Area data, 2008
USDA Forest Service, Urban & Community Forestry Program, Community Accomplishment Reporting System - Professional Staff, Management Plan, Ordinance, Advovacy Group

Process

Step 1: Use Raster Calculator to do weighted overlay analysis
Step 2: Apply mask created for Figure 4k-1
Step 3: Breaks determined by Natural breaks (Jenks method)

Figure 4k-13. Priority ranking of named places identifying municipalities with greatest potential to improve urban forest health and viability.

Map assembled by Alan Moore, NC Division of Forest Resources.

Spatial Reference

Projected Coordinate System:	NAD_1983_StatePlane_North_Carolina_FIPS_3200
Projection:	Lambert_Conformal_Conic
False_Easting:	609601.22000000
False_Northing:	0.00000000
Central_Meridian:	-79.00000000
Standard_Parallel_1:	34.33333333
Standard_Parallel_2:	36.16666667
Latitude_Of_Origin:	33.75000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Process

Step 1: Each named place was assigned a value of 1, 2, 3, 4, or 5 for each issue, depending on where it was ranked in the Priority Places for each of the 5 issues. Very Low = 1, Low = 2, Medium = 3, High = 4, and Very High = 5.

Step 2: A total score was determined for each named place by summing its assigned values across all 5 issues.

Step 3: Breaks determined by sorting places by total score and grouped according to the following: 0-4, 5-9, 10-14, 15-19, 20-25

Appendix C: Legacy Assessment of Need

Assessment of need for the North Carolina Forest Legacy Program

Revised 2010

The Forest Legacy Program authorizes the USDA Forest Service or state governments to purchase permanent conservation easements on private forest lands.* The program acquires certain land-use rights that promote effective forest land management, while protecting the land from conversion to non-forest uses. Priority lands are those that will support continuation of traditional forest uses yet also contain scenic, cultural, and recreation resources, fish and wildlife habitats, water resources, and other ecological values that are regionally and nationally significant.. Participating landowners must follow a management plan designed for their forest. Activities consistent with the management plan--including timber harvesting and recreational activities such as hunting, fishing, and hiking--may be permitted.

Forty three states have already qualified and been enrolled in the Forest Legacy Program. A number of properties have been acquired in those states since the program's inception. Modifications in the program to broaden its appeal have prompted interest on the part of conservation groups and state agencies in North Carolina to participate.

In order for the State of North Carolina to continue to participate in the Forest Legacy Program, the state is required to produce and maintain a document assessing need for the program. The North Carolina Forest Legacy Assessment of Need (AON) establishes a factual and procedural foundation for program implementation. The assessment must describe the forest resources of North Carolina, the efforts and programs available for effective conservation in the state, and the process used in identifying where state priorities for action exist. It builds upon preceding studies, such as the North Carolina Forest Assessment (Task Force 2009-2010). Overall, the assessment focuses on link between North Carolina's forests and its citizen's quality of life.

The AON document identifies four Forest Legacy Areas (FLAs) where the protection efforts, hence funds, provided under the Forest Legacy Program should be applied. For each of the four FLAs, the document:

(1) identifies the FLA's general characteristics and environmental values at risk

(2) describes kinds of threats to those values in the FLA,

(3) identifies entities that will work together for conservation within the region defined by the particular FLA, and

(4) specifies the FLA's geographic boundaries within which properties may be considered for the program. The document presents evaluation criteria and scoring that will be used to rate potential parcels on which acquisition of property development rights will be pursued.

- Cooperative Forestry Assistance Act of 1978, 16 U.S.C. 2101 et. seq., as amended by the 1990 Farm Bill, Section 1217 of Title XII of the Food, Agriculture, Conservation and Trade Act of 1990, Public Law 101-624, 104 Stat. 3359, 16 U.S.C. 2103c; later amended by the 1996 Farm Bill, Federal Agricultural Improvement and Reform Act of 1996; Public Law 104-127; Title III, Conservation; Subtitle G Forestry; Section 374, Optional State Grants for Forest Legacy Program.

PROCEDURES USED TO IDENTIFY FLAs

Legacy Priority Area Delineation using GIS – August 2009

Justification:

The North Carolina Division of Forest Resources is required to revise priority areas for the Forest Legacy program utilizing new priority area delineation techniques, and information on the importance of forests. One new information source used in the current assessment is the Southern Forest Land Assessment, released in November of 2008. The Southern Forest Land Assessment was developed by the Southern Group of State Foresters to prioritize lands for inclusion in the Forest Stewardship Program and to identify areas under threat from development, fire, insects and disease. Thirteen GIS data information layers mapped and scored and had direct application to establishing the Forest Legacy priority areas. The new Legacy Priority Areas and ecological boundaries were summarized by subwatershed, using the National Watershed Boundary dataset (developed by NRCS). North Carolina's 1,795 subwatersheds, which scored highly for Forest Legacy program suitability, were grouped to create four Forest Legacy priority areas.

Process:

A. The GIS input layers from the Southern Forest Land Assessment were evaluated to determine which layers would best display the guiding principles of the Forest Legacy program. Five layers were chosen:

Forest Land – shows the presence of forest land. All pixels representing forest and shrubland are scored 100, and all other land cover types are scored 0.

Forest Patches –contiguous patches of forest are given higher scores as forest patch size increases. Patches were scored on a scale from 0 (<500 acres) to 100 (>5000 acres).

Threatened and Endangered Species – The state was divided into quarter-quads, and each quarter-quad was scored from 0 -100 based on how many threatened or endangered (T&E) species occurrences were found in the quarter-quad. T&E Species data is from NC Natural Heritage Program.

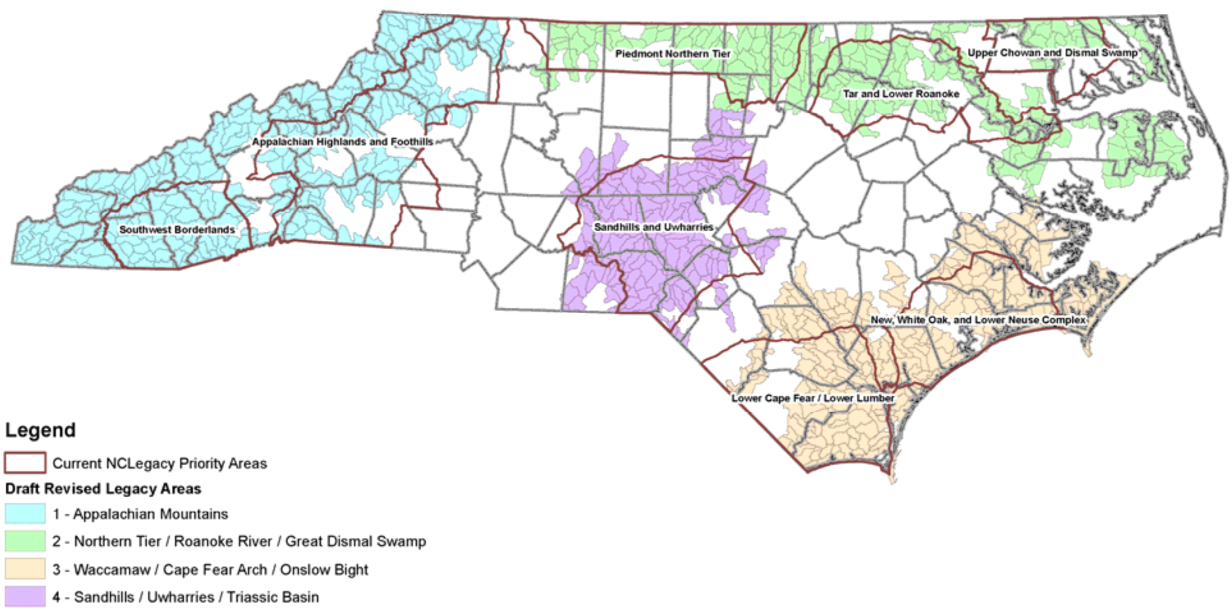
Development Threat – Based on census, roads, landcover, and population projection data. Scores increase from 0 – 100 as the magnitude of expected development between 2000 and 2030 increases. Areas that are most likely to change from rural to developed are scored 100, while areas that are either built out completely or likely to remain rural are scored 0.

Excellent Biological Classification Watersheds – all subwatersheds that contain waters sampled by the Division of Water Quality and found to have excellent biological indicators for high water quality were scored 100, and other areas scored 0 **(**this layer was developed to capture watersheds with outstanding water quality characteristics and high conservation value).

B. The five layers listed above were summed. For example, a pixel that scored 100 for Forest Land, 50 for Forest Patches, 20 for T&E Species, 70 for Development Threat, and 100 for Excellent Biological Classification Watersheds would have a total score of 340. A pixel with the highest value (100) in each layer would be scored 500.
C. Pixels on federally-owned lands were removed from the dataset, since federal land is not eligible for the Forest Legacy program.
D. Score statistics were calculated by subwatershed, and the mean score for each subwatershed was used to determine which subwatersheds should be included as Legacy program priority areas. The top 50% of the subwatersheds in NC, those with scores over 173, were chosen as the core of the Forest Legacy priority areas.
E. Four new Legacy priority areas were drawn: Appalachian Mountains, Northern Tier / Roanoke River / Great Dismal Swamp, Waccamaw / Cape Fear Arch / Onslow Bight, and Sandhills / Uwharries / Triassic Basin. Sixty-six subwatersheds with scores below 173 were added in order to maintain contiguous Legacy Priority areas. When considering which subwatersheds to add, preference was given to the highest scores.
F. In the proposed draft Forest Legacy Priority areas, 936 of North Carolina's 1,795 watersheds are selected. Their model scores for Forest Legacy suitability range from 72 to 455.

See FIGURE *C*-1 for the current and proposed Forest Legacy Priority Areas.

FIGURE *C*-1.—North Carolina Forest Legacy Areas.



Created by: A. Bailey, NCDFR, 2009

Area 1 - Appalachian Mountains and Foothills

Description of Forest Legacy Area and Important Environmental Values

The Appalachian Highlands and Foothills FLA extend from the Virginia and Tennessee borders to the South Carolina and Georgia borders along the Blue Ridge Escarpment and outlying foothill ranges. Mountain hardwood forests dominate most of the area, but the high elevation spruce-fir and acid-cove mix of yellow poplar, hemlock and rhododendron are two very important forest types also found here. In addition, pine forests occupy lands abandoned by farmers. This area is a significant resource base for the forest products industry. The timber resource has long been a vital part of local economies and still sustains an industry dependent on quality hardwood production as well as lower quality fiber. A critically important factor is that many communities have become dependent on tourism geared to the beauty and ecological integrity of the land.

Relatively large tracts in both public and private hands consisting of deed gorges and steep mountains covered with mixed hardwood exist in this FLA. Pisgah National Forest and Nantahala National Forest occupies much of the higher elevation land throughout this FLA, but many thousands of acres of corporately owned forest land and smaller privately owned forests are adjacent to the national forests. Crescent Resources LLC alone owns 25,000 acres in the Upper Catawba Basin along the river, lakes and tributaries. Wildlife habitat conservation is represented by the Nantahala and Pisgah Gamelands. Water quality protection is important because of Nantahala Lake, river-based recreation on the Nantahala and Tuckasegee Rivers, and abundant trout streams with both native and stocked populations. Water quality restoration is a hope for the Upper Little Tennessee River and would contribute to the effort to maintain downstream habitat for the endangered spotfin chub and Appalachian elktoe.

The Blue Ridge Parkway, a major factor in the region's economy, spans the western portion of this FLA that includes some of the highest mountains in the state. Tourism drives concerns for maintenance of scenic beauty and recreational values. Forest-based recreation is also extraordinarily important to the economy of this region. South Mountains (35,000 acres publicly owned) and Green River Gorge (10,000+ acres publicly owned park and gamelands are in the southern portions of the FLA. Several nationally significant Natural Heritage sites are located in the southern portion of this FLA, including the South Mountains and the Hickory Nut Gorge State Park areas.

Scenic beauty and solitude are important values particularly associated with the Appalachian Trail, which traverses this FLA from the Nantahala River to the South Carolina border. Culturally important sites include the Coweeta Hydrologic Laboratory and Cradle of Forestry in America.

The Appalachian Mountains FLA is the largest of North Carolina's FLAs. It includes Burke, Caldwell, McDowell, and Polk, Rutherford and Wilkes Counties and parts of Ashe, Alleghany, Avery, Catawba, Cleveland, Gaston, Henderson, Jackson Lincoln, Haywood, Macon, Mitchell, Surry, Swain, Transylvania, Watauga, and Yancey Counties. It includes headwaters of the Broad, Catawba, New and Yadkin river basins, subbasins in the Little Tennessee River basin, headwaters of the Savannah River, and parts of western parts of the French Broad River basin, as well as headwaters of the Ivy River in the French Broad watershed.

Current and Future Conversion Pressures

This area has long been a tourist and recreation destination and is convenient for weekend escapes from more urbanized settings to the east and south. As a result, conversion to residential development has led to encroachment on the boundaries of national forest, state forest and state park lands. Upward price pressure on private forest tracts is leading to tract liquidation especially by large corporate landowners. Property tax increases are exacerbating the temptation to sell lands for development. Ridgetop development is a particularly problematic phenomenon wherever land is privately owned, but while large-scale development has been specifically addressed by legislation, individuals are not constrained, and panoramic views are highly desirable.

In the northern part of this FLA, development in recent years has intensified with growth of the ski industry. Both second home and resort community development are therefore accelerating. In the south, the Charlotte/Hickory/Spartanburg-Greenville metro areas are among the fastest growing in the Southeast, driving suburban and second home development in this region. Land prices are escalating rapidly. Large corporate landowners are actively selling their lands--primarily to development interests--making the next few years critical. Residential, second home, and resort communities are intruding as development pressure from the Atlanta area, only 2.5 hours south from some North Carolina counties, is accelerating and as refugees from northern and eastern cities retire to this region. Many coves throughout this FLA are already entirely developed as golf course and retirement communities.

In the past decade, land prices were escalating, and either property taxes or inheritance taxes were prompting sales of lands to development interests. Many families that historically earned their living on the land were rapidly losing that ability or facing financial pressures that prompt sales to development interests. Suburbanization reduced opportunities for traditional forest uses, further inciting landowners to convert their properties to non-forest uses. However, the current economic slowdown has deterred many developers from buying land. This may offer opportunities to protect key areas if the funding and political will is there.

Goals and Objectives for Public Benefit

- Maintain large contiguous blocks of working forest lands.
- Encourage protection of scenic vistas from Blue Ridge Parkway.
- Enhance protection of water quality in the Broad, New, Upper Catawba and Upper Yadkin Rivers.
- Restore water quality in the Upper Little Tennessee River watershed and protect water quality for trout populations and in tributaries to critical habitat for the Spotfin chub (LTR)
- Buffer national forest, state forest and state park lands from encroachment.
- Buffer the Appalachian Trail, Mountains to Sea Trail and other scenic or recreational trails and routes.
- Provide habitat corridors for wildlife populations.

Potential Partnering Entities

Black Family Land Trust
Blue Ridge Rural Land Trust
Carolina Mountain Land Conservancy
Emerald Land Trust
Foothills Conservancy of North Carolina

High Country Conservancy
Land Trust for Central North Carolina
Land Trust for the Little Tennessee
National Committee for the New River
Pacolet Area Conservancy
Southern Appalachian Highlands Conservancy
North Carolina Division of Forest Resources
North Carolina Division of Parks and Recreation
North Carolina Wildlife Resources Commission
USDA Forest Service
Highlands-Cashiers Land Trust
Highlands Biological Station
Little Tennessee Watershed Association
Western North Carolina Alliance

Boundary Description

See Appendix B. Forest Legacy Area Descriptions

Area 2 - Northern Tier /Roanoke River / Great Dismal Swamp

Description of Forest Legacy Area and Important Environmental Values

The Piedmont Northern Tier FLA extends along the state's border with Virginia and includes all or parts of Alamance, Bertie, Beaufort, Tyrrell, Dare, Hyde, Caswell, Camden, Chowan, Currituck Edgecombe, Franklin, Halifax, Hertford, Gates Nash, Pitt, Person, Rockingham, Stokes, Durham, Granville, Martin, Orange, Pasquotank, Perquimans Stokes, Surry, Vance, Warren, Yadkin, Washington and Wake Counties.
Water resources of note include Dan River, Bellews Lake, Mayo Reservoir, Roxboro Reservoir/ Hyco Lake, Lake Michie, and Falls Lake. The FLA incorporates much of the Roanoke River basin in North Carolina west of US15, small portions of the Cape Fear and Yadkin-Pee Dee river basins and headwaters of the Neuse and Tar Rivers. Several headwater areas and downstream segments contain freshwater mussel populations of regional and national importance. The areas in the vicinity of the Tar and Roanoke River basins have extremely productive sites and soils for high quality hardwood production and also produce high quality habitat for wild turkey, white-tailed deer, and many non-game species. The Tar and Roanoke river basins contains some of the highest quality waters in the region, and both the striped bass recovery program and viable runs of anadromous fish species (e.g., white and hickory shad) depend on high quality water protected by forests in this FLA. The FLA includes the headwaters drainages of the Tar River, which are noted for populations of freshwater mussels. Potential exists for development of eco-tourism, as significant expansion of natural heritage presence and existing conservation easements is possible in the Lower Roanoke.

Gamelands created throughout this FLA are a major environmental feature. Butner-Falls of the Neuse Gamelands, Caswell Game Lands, Sauratown Plantation Game Lands support large white-tail deer and wild turkey populations that use extensive areas as home ranges.

State parks in this large FLA include Eno River, Hanging Rock, Medoc Mountain, Merchants Millpond and Dismal Swamp are several of the of the recreational sites in this FLA that would benefit from protection on their perimeters. Pilot Mountain State Park is adjacent to US52 and would benefit from protection near its eastern boundary.

NC State University's Hill Forest, north of Durham, serves as a key educational and research resource of historic importance. The Duke Forest is proximal to this FLA and serves research, teaching and recreational functions similar to the Hill Forest.

The Upper Chowan and Dismal Swamp region within this FLA is the oldest settled area in the state yet contains a diversity of forest types from bottomland hardwood swamps (tupelo-cypress) to upland mixed hardwoods and mixed-pine and hardwoods. Wetter sites are typically remnants of the Great Dismal Swamp and often include Atlantic whit cedar. Relatively undisturbed and remote swamplands include large sections of bottomland hardwood swamp and significant natural heritage areas associated with the Great Dismal Swamp. The Chowan River Game Lands consist of several thousand acres that serve as a centerpiece for the western part of this FLA. Timber company lands (Union Camp) and the Great Dismal Swamp National Wildlife Refuge as well as the Merchants Millpond State Park are important components of this area.

The forests in this area provide habitat for the black bear, bobcat, wild turkey, prothonatary warbler, osprey, and bald eagle.

Significant Natural Heritage Areas include Chowan Sandbanks, Chowan/Bennets Creek/ Catherine Creek Swamps, Chowan River White Cedar Swamp, Dismal Swamp Megasite, Holiday Island, Horsepen Pocosin, Meherrin River Macrosite, Merchants Millpond, The Pot Holes, Union Camp/Chowan River Natural Areas, Upper Wiccacon River Swamp, Warwick Creek Oak Flats and Slopes, Wiccacon River Freshwater Marsh, Wyanoke Sandhills.

Current and Future Conversion Pressures

Residential and commercial development from the Piedmont Triad and Research Triangle urban complexes is rapidly eroding southern margins of the large contiguous blocks of rural land in this area. All along the I-85/I-40 corridor from Durham to Burlington to Greensboro and Winston-Salem, urbanization is creating extensive development pressure. Urban workers seeking less congested areas are quite willing to commute from this region, and developers have already made inroads, seeking less expensive land for future development. Rural development threatens the connectivity and utility of the numerous areas of gamelands in this FLA. Water quality in proximity to headwaters of several rivers that support native freshwater mussel populations is threatened by sedimentation and polluted runoff from advancing development.

Properties such as Eno River State Park and NC State University's Hill Forest, north of Durham, are already being surrounded by residential development that threatens their ability to function effectively. The Duke Forest, proximal to this FLA, is already experiencing changing land use and development pressures throughout its scattered properties.

In Northeastern North Carolina, creasing population south of the Virginia line is largely coming from suburban Tidewater Suffolk and Virginia Beach to the northeast. This movement is encroaching on the rural character of this area. All areas along the northern shore of Albemarle Sound have been platted for potential development, especially expanding waterfront development.

A poor agricultural economy results in farmers cutting timber that in many cases leads to conversion to non-forest uses. While a majority of the bottomland area along the Chowan River is presently timber company land, new industry has been proposed, which would lead to new development

Goals and Objectives of FLA for Public Benefit

- Maintain large contiguous blocks of working forest lands.
- Create and maintain landscape-scale corridors connecting large designated areas of managed habitat.
- Contribute to population interchanges between the Coastal Plain and foothills of the Appalachians.
- Protect water quality and habitat for freshwater mussels.
- Enhance protection of water quality supplies and protect headwaters of the Neuse and Tar Rivers.
- Buffer Chowan River Game Lands, Great Dismal Swamp National Wildlife Refuge, Merchants Millpond State Park and other Natural Heritage Areas
- Conserve bottomland hardwood swamp forests and promote effective forest regeneration.
- Enhance protection of the Chowan River's Nutrient Sensitive Waters

Potential Partnering Entities

Black Family Land Trust
Eno River Association
Land Trust for Central North Carolina
North Carolina Coastal Land Trust
Foothills Conservancy of North Carolina

Tar River Land Conservancy
Piedmont Land Conservancy
North Carolina Division of Forest Resources
North Carolina Division of Parks and Recreation
North Carolina Wildlife Resources Commission
The Nature Conservancy
Triangle Land Conservancy
Triangle Greenways Council
Hunt Clubs in the region

Boundary Description

See Appendix B. Forest Legacy Area Descriptions

Area 3 – Waccamaw / Cape Fear Arch / Onslow Bight

Description of Forest Legacy Area and Important Environmental Values

Historically dominated by longleaf pine and its associated plant and animal communities or by bottomland hardwood swamp communities, the Waccamaw/Cape Fear/Onslow Bight FLA includes some of North Carolina's most extensive forest expanses. This spans Robeson, Bladen, Columbus, Brunswick, Sampson, Pender Onslow, Carteret, Craven, Duplin, Pender, Pamlico, Pitt, Beaufort, Robeson, Hoke, Cumberland, Sampson Lenoir, and New Hanover Counties. This area contains much of the geographically important Carolina Bay complex. Much of the area has been converted to modern pine plantations, but within these expanses, the variety of natural plant community types is still extraordinary, including such unique plants as the carnivorous Venus fly trap. Black bear habitat exists in immense blocks including virtually inaccessible swamplands.

From the Lumber River State Park on the west to extensive forest industry lands on the east, this FLA incorporates a full range of partners engaged in sustaining values of working forests in North Carolina. The Nature Conservancy manages the Green Swamp to preserve its unique natural features systems, and International Paper Company manages extensive lands primarily for timber and paper production. The NC Division of Forest Resources manages Bladen Lakes State Forest on the northern boundary of this area. Linking large public holdings, from Angola Bay and Holly Shelter Game Lands to the Croatan National Forest and the Hofmann Forest, this FLA includes immense pocosins, Carolina bays, riverine habitats and significant red-cockaded woodpecker habitat. Camp Lejeune Marine Corps Base and the New River estuary are central to this FLA. Some natural longleaf pine communities remain intact, but significant acreages have been planted in loblolly pine. The size of contiguous forest areas in this FLA is remarkable. Both intensively managed and relatively unmanaged areas exist. Features of particular interest found in this area include Great Dover Swamp, a number of large pocosins, estuaries of the White Oak and New

Rivers, red-cockaded woodpecker colonies concentrated on Camp Lejeune and the Croatan National Forest,

Natural communities of particular interest found in this area include Coastal Fringe Evergreen forest, Maritime evergreen forest, Maritime deciduous forest, Small depression pond, Vernal pool, Pine savanna, Wet pine flatwoods, Small depression pocosin, Bay forest, Peatland Atlantic white cedar forest, Pond pine woodland, High pocosin, and Low pocosin. Natural Heritage Areas that have been identified in the FLA include Lower Buck Landing Swamp, Piney Island Swamp, Net Hole Swamp, Bluff Swamp, Princess Anne Swamp, Big Sandy Ridge, Fair Bluff Swamp, Boiling Spring Lakes.

Current and Future Conversion Pressures

Historically, agricultural conversion led to drainage in extensive areas of pocosins and associated natural communities. Forests returned or were planted on much of the abandoned land. Temporary drainage and conversions of low production areas to pine plantations increased the acreage of forested land.

Now, along the coast, this area is among the fastest growing in North Carolina. Suburban sprawl surrounds Wilmington. Golf course and retirement communities are expanding at a tremendous rate on the mainland along the southern coast in Columbus and Brunswick Counties. Proximity to barrier islands and beaches prompts commercial development to take advantage of the seasonal influx of vacationers. Federal and state wetland regulations have placed a premium value on upland forested sites where development can occur. Development in the small urban centers of New Bern, Kinston, and Jacksonville has been progressively faster over recent decades and is expected to continue to accelerate. For example, highway corridor studies by the City of Jacksonville, NC, project extensive growth north and east of the city. Morehead City, Havelock, and Newport are expanding in response to the growth of the beach and retirement influx. Beach related and retirement community development in this area, as elsewhere along the North Carolina coast is predicted to continue at current or higher levels for some time into the future.

Tax burdens on working forest lands proximal to advancing development are driving the conversion process. Already forest products companies are abandoning silviculture on lands along the urban-rural interface and in some cases are developing such lands themselves rather than persist in traditional forest management in areas where congestion and proximal neighbors are likely to create adverse conditions for effective forestry.

Goals and Objectives of FLA for Public Benefit

- Maintain large contiguous blocks of working forest lands.
- Enhance protection of the Cape Fear River's Nutrient Sensitive Waters.

- Buffer unique natural areas (such as the Green Swamp, pocosins and Carolina bays) from encroaching subdivision and development.
- Enhance protection of Nutrient Sensitive Waters and forested wetlands in the Neuse and White Oak River Basins
- Provide habitat for black bears, RCWs, and a number of other protected species found in the region.
- Connect designated preserves and reduce landscape fragmentation.
- Connect Angola Bay and Holly Shelter Game Lands, Camp Lejuene, Hofmann Forest, and Croatan NF with viable corridors enabling wildlife population interactions among these large contiguous blocks.
- Buffer key habitat blocks from secondary development effects.
- Encourage prescribed burning and management for early successional species.

Potential Partnering Entities

Black Family Land Trust
Lumber River Conservancy
Northeast New Hanover Conservancy
North Carolina Coastal Land Trust
North Carolina Division of Forest Resources
North Carolina Division of Parks and Recreation
North Carolina Wildlife Resources Commission
The Nature Conservancy
North Carolina State University Forestry Foundation
USDA Forest Service
US Marine Corps

Boundary Description

See Appendix B. Forest Legacy Area Descriptions

Area 4 – Sandhills / Uwharries / Triassic Basin

This area encompasses important lands extending east and south from the Uwharrie National Forest, including the Birkhead Wilderness Area, through the Sandhills region. This FLA is located in the south-central portion of North Carolina, occupying all of Lee, Montgomery, Moore, and Richmond Counties. It also includes parts of Alamance, Anson, Chatham, Cumberland, Davidson, Harnett, Hoke, Orange, Durham, Randolph, Rowan, Robeson, Scotland, Stanley, and Wake Counties.

This FLA incorporates the central and upper Cape Fear river basin, the upper Lumber river basin, upper Neuse river basin, and the lower Yadkin-Pee Dee river basin. Water quality is important, and the included portion of the Cape Fear is designated critical habitat for the Cape Fear shiner. Headwaters of blackwater river systems are found here, and associated botanical communities are considered especially important. The Yadkin-Pee Dee river basin contains several rare, threatened, or endangered aquatic species (i.e., robust redhorse, Carolina redhorse, highfin carpsucker). The red-cockaded woodpecker, St. Francis' satyr butterfly, and three plant species (American chaffseed, rough-leaved loosestrife, and Michaux's sumac) are federally listed species inhabiting this area. About a dozen more species are candidates for future federal listing. Recreation and scenic beauty are very important components of desirable sites for golf courses and retirement communities that have existed historically and have increased in prominence in this region.

The Sandhills has long been recognized as a biologically distinct area, with a complex of plant and animal species requiring special attention. Transitional between the Coastal Plain and Piedmont, the Sandhills supports species of both physiographic regions. The Sandhills is recognized as one of the last large remaining pockets of longleaf pine. In addition to Uwharrie National Forest, which includes more than 700 historic and cultural resource sites, the Fort Bragg Military Reservation and Sandhills Game Lands are significant managed properties within this area. NC State University's Goodwin Forest is located in the center of this FLA. The Triangle Land Conservancy owns a tract at the confluence of the Deep and Rocky Rivers. Open space and recreation are important considerations in the vicinity of the Uwharrie National Forest, the Yadkin lakes and the NC Zoological Park. Alcoa and Progress Energy own lands along the Yadkin/Pee Dee. Wildlife habitat conservation is represented by the Uwharrie Gamelands

Natural communities of particular interest in the Sandhill areas include Sandhill seeps, Small depression pocosins, Streamhead Atlantic white cedar forest, Streamhead pocosin, and Piedmont transitional longleaf. An effort to develop Habitat Conservation Planning and Safe harbor agreements under USFWS leadership seeks to enhance recovery potential of RCW populations and associated species occurring in the same habitat. Longleaf restoration efforts have been initiated on several sites throughout this FLA.

The upper cape Fear River includes Triassic Basin areas and associated flood plains. Steep north facing slopes occur especially along the margins of the Triassic Basin, due to the sharp drop in elevation and consequent increased stream cutting. These areas now harbor remnant, relictual communities that are rare in the Piedmont. Another feature associated with the Triassic Basin is diabase outcrops. These diabase areas provide habitat for unique natural communities. While such geologic formations are found mostly in Durham and Granville counties, several exposures of diabase occur near Orange County's eastern border. Recent urban development in Orange County has disturbed most of these habitats.*

The Natural Communities most commonly found in the Triassic Basin include Piedmont/Mountain Bottomland Forests, Piedmont/Mountain Levee Forests, and associated slopes, especially Basic Mesic Forest. Diabase sills and dikes are nutrient rich uplands associated with the Triassic Basin, and they also support several rare plant species.

The rare species include: Cardamine dissecta (Significantly Rare – SR), Cardamine douglassii (SR), Carex jamesii (SR), Corallorhiza wisteriana (SR), Dirca palustris (Watch List), Enemion biternatum (SR), Hexastylis lewisii (Watch List), Hybanthus concolor (Watch List), Phacelia covillei (SR + FSC), Philadelphus hirsutus (Watch List), Philadelphus inodorus (Watch List), Gillenia stipulata (SR), Ptelea trifoliata (Watch List), Quercus muehlenbergii (Watch List).

In Lee County, the primary remaining natural areas are: (1) sites such as north-facing bluffs and slopes with Mesic Mixed Hardwood Forest (predominantly, but not exclusively, in the northern two-thirds of the county), (2) river floodplains supporting somewhat disturbed Piedmont/Low Mountain Alluvial Forest (and occasionally Piedmont Bottomland Forest), (3) uplands supporting secondary Dry-Mesic Oak-Hickory Forest, and (4) Streamhead Pocosins and Streamhead Atlantic White Cedar Forests at headwaters of small streams. Equally important, but occurring with less frequency, are examples of (5) Basic Mesic Forest, (6) Pine/Scrub Oak Sandhill and Xeric Sandhill Scrub, and (7) Rocky Bar and Shore

Current and Future Conversion Pressures

Golf course and retirement communities economically dominate developed portions of the FLA. As connecting roads such as NC87 and US1 near Sanford are upgraded, increasing development pressure is coming from the north as Research Triangle and Piedmont Triad commuters seek exurban housing. Fayetteville's expansion from the east also threatens. Changes in tax rates as a result of proximal development is leading to liquidation of large tracts and loss of forested lands. Subdividing large tracts for individual and community residential development is increasing in all parts of this FLA. Proximity of residences and commercial properties to
managed forests is creating problematic conditions for necessary burning prescriptions that the native vegetation communities need in order to be perpetuated.

Goals and Objectives of FLA for Public Benefit

- Maintain large contiguous blocks of working forest lands.
- Restore and conserve longleaf pine communities.
- Maintain and establish corridors connecting large managed wildlife areas.
- Provide habitat for the red-cockaded woodpecker, St. Francis' satyr butterfly, and three plant species (American chaffseed, rough-leaved loosestrife, and Michaux's sumac). All of the protected species require some degree of forest disturbance or manipulation for suitable habitat to be maintained.
- Enhance protection of water supply segments of the Cape Fear, Neuse, Yadkin-Pee Dee and Lumber Rivers.
- Protect habitat for the Cape Fear Shiner (Notropis mekistocholas) and Robust Redhorse **(***Moxostoma robustum*)
- Enhance protection of Nutrient Sensitive Waters in the Cape Fear, Neuse, Lumber and Yadkin – Pee Dee River Basins.

Potential Partnering Entities

Black Family Land Trust

Land Trust for Central North Carolina
Lumber River Conservancy
Eno River Association
NC State University College of Forest Resources
North Carolina Division of Forest Resources
North Carolina Division of Parks and Recreation
North Carolina Wildlife Resources Commission
Piedmont Land Conservancy
Sandhills Area Land Trust
USDA Fish and Wildlife Service
The Nature Conservancy
Triangle Land Conservancy
Triangle Greenways Council
Hunt Clubs in the region

Boundary Description for Sandhills and Uwharries FLA

See Appendix B. Forest Legacy Area Descriptions

Response to Feedback From 8/14/2009 Stakeholders Meeting:

A WebEx/conference call was held on Friday, August 14 with members of the State Stewardship Committee, Forest Legacy Advisory and review Committee (FLARC) and the North Carolina Forest Assessment Sustainability Working Group. The meeting was called to keep stakeholders informed as to the method used to identify the new AON areas. Endorsements by these state-level advisory committees led to creation of this assessment of need (AON) document and a process to gather information to create the new forest legacy areas (FLAs).

The following are questions were generated from the meeting:

1. Compare One NC Naturally Conservation Planning Tool Biodiversity and Wildlife Habitat Assessment (BWHA) model with SFLA T&E species to see if any advantage would be gained from using the BWHA model to represent high wildlife values.
    a. The T&E species layer is very generalized (each pixel represents a quarter-quad) and the BWHA model is very specific (each pixel represents 30 x 30 meters).
    b. The models were compared and generally highlighted the same areas for wildlife habitat.
    c. The specificity introduced by the BWH model would have emphasized core wildlife habitat areas while reducing surrounding areas.
    d. Because the SFLA T&E layer is generalized, it includes connective habitat that is exceptionally suitable for working forest.
    e. We will continue using the SFLA T&E species layer.

2. Compare the Outstanding Resource Water (ORW) watersheds layer to a layer derived from DWQ excellent biohabitat sample points.
    a. Excellent biohabitat is determined solely on scientific sampling criteria
    b. ORW is a classification that includes both biological criteria and a rulemaking process.
    c. More area is included if all watersheds with excellent biohabitat ratings are selected than if all watersheds containing ORW areas are selected.
    d. We will use excellent biohabitat sampling points to include areas of high water quality rather than ORW areas.
3. Evaluate the effect of considering adjacency to protected lands.
    a. Using buffers of conserved lands to increase scores near conserved lands creates breaks in the continuity of Forest Legacy Areas.
    b. Areas that have historically been successful working forests, and do not have outstanding topographical or historical values, tend to decrease in model value, while areas in the mountains and coast tend to increase.
    c. We will not add a layer representing adjacency to conserved lands.
4. Consider the effects of access to forestry product markets.
    a. There is no data that directly shows forestry markets and infrastructure in a format that can be readily integrated into a model of this type.
    b. There is promise of data becoming available, but it will be several months before that data can be ready. Some technical challenges to represent this data in an appropriate format must be overcome.
    c. We will reevaluate the effect of forestry market data when it becomes available.

State Stewardship Committee Members

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State Forester and Director, North Carolina Division of Forest Resources

Jennifer Bumgarner
Agriculture Advisor, Governor's Office

Marisue Hillard
Forest Supervisor, USDA Forest Service

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Executive Director, NC Farm Service Administration

Isaac Harrold
Section Manager, Wildlife Resources Commission

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Patricia Harris
Director, Soil and Water Conservation

Ed Jones
Associate Leader, Natural Resources/Community Development, NCSU Coop Extension

Pete Benjamin
Field Supervisor, US Fish & Wildlife

The Forest Stewardship Program also seeks direction, input, and cooperation with the following members of its Resource and Advisory Committee on an ongoing basis, especially during major program changes, planning efforts and procedural changes.

The Nature Conservancy

North Carolina Wildlife Federation

North Carolina Division of Water Quality

North Carolina Farm Bureau

North Carolina Society of Consulting Foresters

North Carolina Division of Land Resources

North Carolina Soil and Water Conservation Society

Society of American Foresters, North Carolina Division

North Carolina Department of Agriculture

North Carolina Forestry Association, Inc.

North Carolina Division of Water Resources

Sierra Club

North Carolina Recreation and Parks Society

North Carolina Division of Parks and Recreation

North Carolina Audubon Council

North Carolina State Grange

Southern Appalachian Multiple-Use Council

Western North Carolina Alliance

Western North Carolina Development Association, Inc., Forestry Commission

The Wildlife Society - North Carolina Chapter

North Carolina Environmental Defense Fund

Local Government Representative

State Council of Quail Unlimited

Private landowners

National Woodland Owners Association

The Conservation Trust of North Carolina

The NC Tree Farm Program

Forest Stewards Guild

NC Forestry Council

Southern Environmental Law Center

US Fish& Wildlife Service

Concerned Citizens of Tillery

Sandhills Heritage Family Trust

Cherokee Indian Agency Branch of Forestry – Bureau of Indian Affairs

Black Family Land Trust

For information concerning representatives of these organizations, please contact the North Carolina Forest Legacy Coordinator, (919) 857-4833.

Forest Legacy Application and Review Committee (FLARC)

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Appendices

Appendix A. NC Forest Legacy Program Application

Forest Legacy Parcel Evaluation Package

Appendix B. Forest Legacy Area Descriptions

North Carolina Map of Forest Legacy Areas

Area 1: Appalachian Mountains

Area 2. Northern Tier/Roanoke River/ Great Dismal Swamp

Area 3. Waccamaw/ Cape Fear Arch/ Onslow Bight

Area 4. Sandhills/Uwharries/Triassic Basin

Appendix A.

North Carolina Forest Legacy Program Application

FOR OFFICE USE ONLY

Received by: __________________________ Application Number: ___________________

Date: ______________________

APPLICANT INFORMATION:
Landowner's Name: ____
Mailing Address: ____
____
Daytime Telephone Number: _______________________
Landowner's Agent: ____
Mailing Address: ____
____
____
Daytime Telephone Number: _______________________

House District: _____________________________________
Senatorial District: __________________________________

PROPERTY INFORMATION:
Legal Description: County __________________________
Tax Map # _______________________
Accessories Plat and Lot Numbers: _____________________________________
Deed Reference (Book and Page Number): _____________________________
Current Local Zoning (where property is located)

(Include minimum lot size and road frontage requirements): ___________________________
____
____
Property's Total Forested Acres: _____________________________________
Forested Acres of Tract Offered for Forest Legacy: ______________________
Acres of Cleared/Open Land: _______________________________________

LANDOWNER GOALS AND OBJECTIVES

Describe your long term goals and objectives for this parcel:

TRADITIONAL FOREST VALUES

What is/are the "Traditional" use(s) of this forest land?

LANDOWNER COMMENTS

In your opinion, is there a "Threat of Conversion to Non-Forest Use" of the parcel proposed for enrollment in the Forest Legacy Program? Be Specific:

Do you currently have a forest management plan? ________________
If so, please provide a copy.

It is important that the following section be carefully and fully completed. The information you supply will directly affect the desirability of the parcel as well as its appraised value and, therefore, the ranking. Note that checking "yes" does not limit your ability to negotiate price and options in the future; it merely assists the Forest Legacy Committee when evaluating your parcel.

Indicate which of the following interests you desire to retain: (These should be the rights you want to retain. All other rights will become the property of the State of North Carolina upon successful completion of negotiations between the State of North Carolina and yourself.)

YES MAYBE

____ ___ Timber and wood product rights

___ ___ Water rights

___ ___ Mineral rights

___ ___ No public access

___ ___ Hunting

___ ___ Fishing

___ ___ Camping

___ ___ Hiking or other passive recreation

___ ___ Bicycling

___ ___ Horseback Riding

___ ___ Grazing

___ ___ Farming

___ ___ Construction of roads

___ ___ Motorized access

___ ___ Expansion of existing improvements

___ ___ Mushroom/Ginseng/Craft Material Collection

___ ___ Other: ____________________________________

CONFIDENTIAL

The following information shall remain strictly confidential until such time as: (1) the application is approved and all financial transactions are concluded or (2) all title holders give written permission to release the information.

FINANCIAL INFORMATION

State the value of the interests to be enrolled in the Forest Legacy Program, and the method used to determine that value (appraisal, landowner estimate, etc.)

What is/are the estimated sale price(s) of the interests being offered?

State the value of the landowner(s) contribution, if any, either in donated value of in-kind services or financial.

LIENS AND ENCUMBRANCES

List any and all liens and encumbrances on the property proposed for enrollment in the Forest Legacy Program. Examples: Utility easements, public rights of way, water flow or use restrictions, septic systems or water easements, deed restrictions, tax liens, etc.

The information provided above is true to the best of my/our knowledge and belief.

ALL TITLE HOLDERS MUST SIGN.

PRINT NAME(S) SIGNATURE DATE

_________________________ _____________________________ ________

_________________________ _____________________________ ________

_________________________ _____________________________ ________

FOR OFFICE USE ONLY

Application Number: ________________________ Date: _______________

FOREST LEGACY PROGRAM - Checklist

With your Forest Legacy Program application package, please submit four (one original and three copies) of the following for each contiguous parcel:

_____ Completed Application

_____ Name(s) and address (es) of other owner(s) of record for this tract

_____ Signed consent agreement

_____ Copy of road map indicating location of the property

_____ Copy of plat or survey map of the parcel

_____ Aerial photo (can be obtained through your local Farm Services Agency Office)

_____ Legal Description (if available)

_____ List of existing permanent improvements on the tract, including houses, barns, lakes, ponds, dams, wells, roads and other structures, and the total number of acres occupied by improvements.

_____ Map identifying all dams, dumps, or waste disposal sites on the property.

_____ Forest management plan

NOTE: All materials become the property of the State of North Carolina and are not returnable.

DISCLOSURE OF THIS INFORMATION IS VOLUNTARY; HOWEVER, FAILURE TO COMPLY MAY RESULT IN THIS FORM NOT BEING PROCESSED.

NORTH CAROLINA

FOREST LEGACY PARCEL EVALUATION PACKAGE

Directions for completing the Forest Legacy Program
Evaluation Package

COVER SHEET: The first part of the cover sheet is to be completed with information supplied on the enrollment application form. The landscape description is meant to include the physical characteristics of the surrounding area including topography, soils, and surface and ground water hydrologies: brief inventories of major vegetative groups, fish and wildlife resources, scenic resources and any other forest resources; as well as surrounding land uses. The parcel description is meant to include an in-depth description of the above mentioned items, but as they pertain to the parcel.

PARCEL EVALUATION - PART A: These pages are to be completed by the field personnel directed to do so by the land agency, in consultation with other pertinent state and local agencies or groups.

Note: both Parcel Evaluation Parts A and B forms will be used to set goals for acquiring the parcel.

SCORING: The final score will not be used as the sole factor in determining which parcel/interest should be acquired but merely as a guide to the relative values of the resource under evaluation.

Subject to funding, priority will be given to those tracts with the greatest need for conservation of the forest and related resources.

PART B. EVALUATION FACTORS FOR SPECIFIC PARCELS

The following factors will be used to quantify and qualify information that will satisfy the criteria requirements:

1. Threat by conversion to non-forest uses:

Type and Level of Threat

Various kinds and degrees of threat to valuable forested areas exist, such as encroaching housing development, improved roads, sewer and power line extension into undeveloped areas, and fragmentation of land ownership in smaller parcels. In determining the threat to a parcel, factors to consider include, but are not limited to the following:

- is in danger of conversion to non-forest use within 5 years,
- may remain wooded, but will become further fragmented,
- is currently on the open market/listed by realtors (securing one or more sites now will stem further development),
- is remote, but vulnerable,
- remnant of a forest type, and/or
- others

Factors Affecting Acquirability

Even if a forested parcel is threatened with conversion to non-forest use, protecting it under the Forest Legacy Program can only be accomplished if certain conditions exist which favor implementation. In determining prospects for a successful effort under the Forest Legacy Program, factors to consider include the following:

- property is specifically identified in terms of priority, timing, and cost in local land use plans, the state Conservation Outdoor Recreation Plan, Open Space Plans and others as appropriate,
- parcel may be available at below fair market value,
- intensity and expense of management activities to protect the property’s value is economically feasible,
- protection of the property would increase protection of public properties and protected areas, or enhance the linking of greenways,
- property can accommodate proposed priority uses and/or management activities without endangering or degrading its natural value, and/or
- property can be protected from future degradation by activities occurring on neighboring properties.

2. Contain one or more important values:

Scenic Resources:

The scenic aspects of a natural resource area may often be subjective, but there are several means of measuring the special qualities that make a given parcel stand out. In identifying scenic amenities of a parcel, these factors must be considered:

- includes locally important panoramic views and/or exceptional short view, and/or
- is situated along a designated scenic river, road or trail corridor.

Public Recreation Opportunities:

Existing or potential recreational use (especially public access) of a proposed parcel is an important component to be weighed. The following factors must be considered:

- water based recreation
- trail based and/or day use recreation
- natural resource based recreation
- adjacent land is protected

Riparian Areas:

One of the most important "products" of forest areas is water. Proper management of forest lands through institution of a Forest Legacy Area can increase the quality and quantity of water for residents of North Carolina. Factors to be included in determining the riparian value of a parcel include the following:

- is situated on a river or stream
- has extensive (over 300') river or wetland shoreline,
- includes floodplain,
- contains a minimum 50 foot strip of native trees and shrubs as a natural buffer and sediment filter,
- parcel is situated within a water supply watershed, or groundwater aquifer recharge area
- parcel provides immediate watershed/water supply protection,
- contains important wetlands.

Fish and Wildlife Habitat:

Preventing fragmentation of forest tracts into smaller units is crucial to maintaining viable populations of wildlife species. Factors to consider:

- Parcel contains desirable habitat and other ecologically recognized criteria for one or more species that include: forest interior nesting birds, significant populations of resident species, neotropical migratory birds, areas for resting and feeding of migratory species, forest inhabiting mammals, reptiles, amphibians and invertebrates.
- Parcel exhibits connective habitats, corridors, habitat linkages and areas that reduce biological isolation.

Known Threatened and Endangered Species:

As urbanization and fragmentation of forest lands continue, the need to give special attention to threatened species of fish, wildlife and plants increases. Parcels nominated for the Forest Legacy Program should be inventoried for such natural habitats that may contain imperiled species (on State list as Endangered, Threatened or of Special Concern). Factors to be considered:

- Parcel provides habitat supporting occurrence of rare, threatened or endangered species.
- Parcel is within a designated Natural Heritage Area.
- Parcel provides suitable habitat for reoccupation by rare, threatened or endangered species (either naturally or through translocation).
- Parcel adjoins or is proximal to forests included in a Habitat Conservation Plan or Safe Harbor agreement and would thereby contribute to species conservation goals.

Known Cultural/Historical Resources:

Material evidence of the earlier human occupation in North Carolina comprises a unique and irreplaceable resource, as do historic features and vernacular landscapes. Factors considered:

- Parcel contains forest related cultural resources (i.e., historic forest, historic mill or other forest industry site.)
- other historic or archeological resources (native American sites)

Other Ecological Values:

In addition to the characteristics already outlined, a parcel may exhibit additional or exceptional conditions that are important and add to the quality of the Forest Legacy Area, such as:

- parcel is part of a large block of contiguous forest land,

- will provide a corridor between other large contiguous blocks,
- includes ecological communities which are dwindling in North Carolina, and/or
- contains late successional growth forests (natural area).

3. Provide opportunities for continuation of traditional forest uses:

Maintaining traditional forest uses is important. It permits owners to remain on the land without requiring high-cost services. Positive factors which reinforce this include:

- will remain available for timber and other forest products management under a Stewardship Plan,
- will continue to serve watershed and water filtration role,
- will continue to provide fish and wildlife habitat,
- will continue to provide outdoor recreation opportunities, and
- provide opportunities for environmental education.

4. Reflect important regional values:

Through careful selection parcels should provide regional, not just local significance. The features and functions of these parcels should include:

- linkages for recreational values, such as trails, especially along rivers, greenbelts, bluffs and parcels which connect existing publicly-owned and protected lands,
- public access to boating and swimming relative to the needs of local population centers and the effects of projected land use change,
- public or private drinking water supply protection (ground or surface water),
- scenic qualities having their basis in natural and cultural landscapes,
- public benefits identified within goals and objectives for Forest Legacy Area where tract is located.

COVER SHEET

FOREST LEGACY PARCEL EVALUATION PACKAGE

______________________ Forest Legacy Area

File Number: ________________________ Date of Evaluation: ________________

Landowner's Name: ____

Parcel Location: ____

Legal Description: ____

Investigator(s): ____
____
____

Landscape Description:

Parcel Description:

Landowner's Name: ___________________________________ File Number: ____________
Evaluator(s): ____

FOREST LEGACY PARCEL EVALUATION - PART A

I. Reasons for inclusion in the Forest Legacy Program. Prioritize the following reasons for enrollment of the parcel in the Forest Legacy Program:

___ Prevent conversion/development/fragmentation of an important forest resource

___ Protection of scenic resources

___ Provide/enhance public recreation opportunities

___ Protect/enhance a watershed or important drinking water supply

___ Protect/enhance an important riparian/hydrologic area

___ Provide linkage between public properties, protected areas and greenways

___ Protect/enhance/restore fish and/or wildlife habitat

___ Protect/enhance/restore habitat of rare, threatened, and/or endangered species of plant and/or animal

___ Provide for the continuation of traditional forest uses

___ Provide opportunity to implement Forest Stewardship practices

___ Provide opportunities for environmental education

___ Provide historical/cultural uniqueness or protection

___ Provide buffers (scenic, riparian, etc.)

___ Other ____

II. Degree of threat of development/fragmentation/conversion to non-forest uses.

Yes No
___ ___ A. Parcel is in danger of conversion within 5 years.

___ ___ B. Parcel may remain wooded, but will become further fragmented

___ ___ C. Parcel is currently on the open market, or listed by realtors

___ ___ D. Securing one or more sites now will stem further development

___ ___ E. Parcel is remote, but vulnerable

___ ___ F. Parcel is under a state or federal forest management program

___ ___ G. Parcel is remnant of a forest type

___ ___ H. Parcel may remain wooded, but is in danger of being over-harvested

___ ___ I. Other

III. Factors affecting acquirability. These factors are to be taken into consideration when prioritizing parcels for acquisition.

Yes No N/A

___ ___ ___ A. The property is specifically identified in terms of priority, timing, and cost in the local land use plan, state recreation plan or open space plans.

___ ___ ___ B. Parcel may be available at below fair market value.

___ ___ ___ C. Intensity and expense of management activities to protect the propertyís values is economically feasible.

___ ___ ___ D. Conservation of the property would increase the protection of existing natural areas or enhance the linking of greenways.

___ ___ ___ E. Property can accommodate proposed priority uses and/or management activities without endangering or degrading its natural value.

___ ___ ___ F. Property is/can be protected against future degradation from activities occurring on neighboring properties.

Comments:

Landowner’s Name: ___________________________________ File Number: ____________

Evaluator(s): ____

FOREST LEGACY PARCEL EVALUATION - PART B

I. If parcel contains one or more of the following important public values, place a check mark as indicated, circle appropriate score and tally score in column to the right.

Yes No

A. Scenic Resources (maximum score 100 points)

___ ___ 1. Parcel is adjacent to or in a viewshed visible from a scenic road, river, or trail designated by the State of North Carolina or the United States.

___ ___ 2. Parcel includes locally important panoramic views and/or exceptional short views.

Scenic resources total score ____________

B. Existing or Potential Public Recreational Opportunities
(Maximum score 100 points)

___ ___ 1. Water-based recreation - boating, swimming, fishing, rafting, canoeing
___ ___ 2. Trail-based and/or day use recreation - hiking, picnicking, horseback riding, cross-country skiing
___ ___ 3. Natural resource based recreation - camping, hunting, nature touring
___ ___ 4. Adjacent land is protected or is within an adopted expansion area for a public park, forest, natural area, private nonprofit preserve, etc.

Public recreation opportunities total score _______

C. Riparian/hydrologic areas (Maximum score 150 points)

___ ___ 1. Parcel is situated on a river or stream
___ ___ 2. Parcel has extensive (over 300') river or wetland shoreline
___ ___ 3. Parcel included in 100 year flood plain
___ ___ 4. Parcel contains a minimum 50' strip of native trees and shrubs as a natural buffer and sediment filter, or such a buffer will be restored
___ ___ 5. Parcel includes a natural wetland or prior converted area that will be restored
___ ___ 6. Parcel is situated within a water supply watershed, or groundwater aquifer recharge area
___ ___ 7. Parcel provides immediate watershed/water supply protection

Riparian/hydrologic areas total score _______

Yes No
D. Fish and Wildlife Habitat (Maximum score 100 points)

___ ___ 1. Parcel contains outstanding habitat and other ecologically recognized criteria for one or more species that include:
Forest interior nesting birds
Significant populations of resident species
Neotropical migrant species
Areas for resting and feeding of migratory species
Forest inhabiting mammals, reptiles, amphibians and invertebrates
___ ___ 2. Parcel exhibits connective habitats, corridors, habitat linkages and areas that reduce biological isolation
___ ___ 3. Parcel will provide a functional buffer to protect a core habitat or corridor

Fish and Wildlife habitat total score _______

E. Known rare, threatened and endangered species. Species to be considered under this criterion are those currently listed by the Natural Heritage Program and those listed in the

Federal Register.
(Maximum score 100 points)

___ ___ 1. Parcel provides habitat supporting the occurrence of rare or endangered species
___ ___ 2. Parcel is within a designated Natural Heritage Area
___ ___ 3. Parcel provides suitable habitat for reoccupation by rare, threatened, or endangered species (either naturally or through translocation)
___ ___ 4. Parcel provides functional buffer to protect habitat for species of concern, species that are significantly rare, or that are on the NC watch list

Endangered species total score _______

F. Known cultural/historical areas (Maximum Score 100 points)

___ ___ 1. Parcel contains forest related cultural resources (i.e., historic forest, historic mill or other forest industry site, etc.)
___ ___ 2. Other historic or archeological resources (e.g., native American sites, battlegrounds, etc.)

Cultural/historic areas total score _______

G. Other ecological values (Maximum score 100 points)

___ ___ 1. Parcel is part of a large block of contiguous forest land
___ ___ 2. Parcel provides a mix of native ecological communities
___ ___ 3. Parcel includes ecological communities which are dwindling in North Carolina
___ ___ 4. Parcel contains late successional growth forests, (natural area)

Other ecological values score ________

Yes No
H. Provides opportunity for continuation of existing traditional forest uses (Maximum score 100 points)

___ ___ 1. Parcel will remain available for timber and other forest products management under a Stewardship Plan
___ ___ 2. Parcel will continue to serve watershed and water filtration roles
___ ___ 3. Parcel will continue to provide fish and wildlife habitat
___ ___ 4. Parcel will continue to provide outdoor recreation opportunities
___ ___ 5. Parcel will continue to provide environmental education opportunities
___ ___ 6. Parcel will continue to provide natural resources based research opportunities

Traditional forest uses total score _______

Yes No
I. Provides the Priority Public Benefit defined for the Forest Legacy Area where it is located. (Maximum score 150 points)

___ ___ Retains large contiguous blocks of forest (FLAs 1, 2, 3, 4, 5, 6, 7, 8)

___ ___ Protects drinking water supplies (FLAs 1, 2, 3, 4, 6, 8)

___ ___ Provides corridors for wildlife migration (FLAs 1, 2, 3, 4, 5, 6, 7, 8)

___ ___ Protects trout, mussel and/or anadromous fish habitats (FLAs 1, 3, 4, 5, 6, 7, 8)

___ ___ Provides habitat or buffers protected species habitat (FLAs 1, 2, 4, 5, 7, 8)

___ ___ Protects key scenic vistas (FLAs 3, 6, 8)

Priority benefits total score ________

TOTAL SCORE ________________

Comments:

Recommendations:

Appendix B. Forest Legacy Area Descriptions

North Carolina Map of Forest Legacy Areas

Area 1: Appalachian Mountains

The HUC12 field has the ID number for the 12-digit HUC, and the HU_12_Name is the unique name of the 12-digit HUC.

HUC_12	HU_12_NAME	ACRES
030501011002	Grassy Creek-Lower Little River	17844
030501010903	Lower Middle Little River	14960
030501010901	Upper Little River	30162
030501011004	Glade Creek-Lower Little River	11309
030501010902	Upper Middle Little River	23621
030501011001	Lambert Fork	9321
030401020105	Patterson Creek	22624
030401010103	Kings Creek	17791
030401020101	Headwaters South Yadkin River	34212
030401020106	Lower Rocky Creek	22795
030401010201	Beaver Creek	13201
030401020104	Upper Rocky Creek	19700
030401010203	Warrior Creek	16515
030401010301	Moravian Creek	15858
030401010206	Community of Ferguson-W Kerr Scott Reservoir	21239
030401020201	Headwaters Hunting Creek	36517
030401010307	Cub Creek-Yadkin River	16832
030401010407	Briar Creek-Yadkin River	9226
030401010204	South Prong Lewis Fork	23252
030401010205	North Prong Lewis Fork	22417
030401010305	Reddies River	22238
030401010406	Roaring River	10413
030401010303	Middle Fork Reddies River-South Fork Reddies River	19168
030401010304	North Fork Reddies River	18277
030401010306	Mulberry Creek	31521
030401010403	West Prong Roaring River	14750
030401010404	Middle Prong Roaring River	27922
050500010207	Naked Creek-South Fork New River	18664
030401010503	Snow Creek	11756
030401010502	South Fork Mitchell River	16103
030401010705	Lower Fisher River	24285
030401010405	East Prong Roaring River	36264
050500010209	Peak Creek-South Fork New River	17584
050500010208	Cranberry Creek	24751
050500010404	Pine Swamp Creek-Little River	14770
030401010504	Lower Mitchell River	22641
030401010702	Upper Fisher River	17316
030401010501	Upper Mitchell River	18730
050500010405	Brush Creek	22091
060101051203	Shut-in Creek-French Broad River	21991
030501010502	Upper Wilson Creek	25774

060101080603	Big Rock Creek	25985
030501010201	Armstrong Creek	18303
060101080301	Headwaters Cane River	25999
050500010204	Old Fields Creek-South Fork New River	15393
060101051201	Meadow Fork	14590
060101051103	Big Pine Creek-French Broad River	25979
060101051101	Walnut Creek	10860
060101050804	Bull Creek	14806
060101050802	Little Ivy Creek	29816
060101080302	Price Creek	14368
030501010403	Lower Warrior Fork	10049
060101080303	Upper Cane River	15563
060101080105	Big Crabtree Creek	15765
030501010402	Irish Creek	22067
060101051001	Upper Big Laurel Creek	22282
060101080203	Lower South Toe River	14732
060101051004	Lower Big Laurel Creek	27198
060101080202	Little Crabtree Creek	13932
060101051003	Lower Shelton Laurel Creek	16187
060101080305	Middle Cane River	20504
030501010506	Lower Johns River	16165
060101080304	Bald Mountain Creek	10130
030501010202	North Fork Catawba River	36054
030501010302	Lower Linville River	14878
060101080104	Grassy Creek-North Toe River	12593
060101080601	Jacks Creek	13392
060101080106	Bear Creek-North Toe River	18608
060101051002	Upper Shelton Laurel Creek	19107
030501010401	Upper Warrior Fork	23781
060101080103	Threemile Creek-North Toe River	24821
060101080205	Pigpen Creek-North Toe River	18269
060101080306	Lower Cane River	14454
030501010504	Lower Wilson Creek	18305
060101080204	Cane Creek	19621
030501010505	Middle Johns River	20501
060101080102	Plumtree Creek-North Toe River	15963
060101080602	Little Rock Creek	14788
060101080604	Hollow Poplar Creek-Nolichucky River	30081
030501010503	Mulberry Creek	26579
060101080101	Headwaters North Toe River	29438
030501010301	Upper Linville River	28375
030401010105	Laytown Creek-Yadkin River	14322
030501010501	Upper Johns River	26796

030401010102	Headwaters Yadkin River	27096
030401010101	Buffalo Creek	21149
060101030201	Upper Elk River	26842
060101030301	Headwaters Watauga River	16804
060101030303	Dutch Creek-Watauga River	19145
050500010201	Headwaters South Fork New River	22411
030401010104	Elk Creek	32340
030401010202	Stony Fork	24223
060101030202	Lower Elk River	26077
050500010202	Meat Camp Creek-South Fork New River	23548
060101030302	Cove Creek	22293
060101030304	Beaverdam Creek	13157
050500010203	Elk Creek-South Fork New River	21191
050500010205	Pine Swamp-South Fork New River	22388
050500010206	Beaver Creek-South Fork New River	26260
050500010101	Three Top Creek	15150
050500010103	Headwaters North Fork New River	26660
050500010106	Upper North Fork New River	32257
060101030102	Roane Creek Upper	25827
060101030104	Roane Creek Lower	34606
060101030305	Beech Creek-Watauga River	41109
060101030403	Little Doe River	21054
060101080605	North Indian Creek	37913
060101030402	Doe River Upper	19417
060101030401	Buck Creek	8731
060101080701	Horse Creek	13858
060101080606	Martin Creek-Nolichucky River	16610
060101080702	Camp Creek	21262
060101080402	Middle South Indian Creek	28144
060101051401	Paint Creek	16022
060101080401	South Indian Creek Upper	11226
060101051402	French Broad River-Wolf Creek	25791
060101051301	Gulf Fork Big Creek	30855
060101051302	Trail Fork Big Creek	20871
060200020601	Dooley Creek-Nottely River	18742
060200030204	Hothouse Creek	16742
060200020602	Rapier Mill Creek-Nottely River	17829
060200020302	Lower Brasstown Creek	33576
060102020306	Fontana Lake-Nantahala River	10675
060101050402	South Fork Mills River	26523
060102040401	Lake Cheoah-Little Tennessee River	23562
060102020503	Hazel Creek	32752
060102030403	Noland Creek	13351

060101050803	Upper Ivy Creek	20439
060102020101	Betty Creek-Headwaters Little Tennessee River	23187
060200020603	Nottely River	10313
060200020703	Lake Cherokee-Persimmon Creek	15931
060200020105	Shooting Creek	32606
060102020102	Middle Creek-Little Tennessee River	29103
060200020404	Lower Valley River	8848
060200020702	Grape Creek-Hiwassee Lake	22912
060102020103	Coweeta Creek-Little Tennessee River	21633
060102020302	Headwaters Nantahala River	23559
060200020202	Fires Creek	14866
060102020104	Upper Cartoogechaye Creek	14903
030601010102	Toxaway River-Lake Jocassee	16111
060102020105	Lower Cartoogechaye Creek	21853
060200020903	Shuler Creek	12250
060102020203	Lower Cullasaja River	24152
060200020401	Headwaters Valley River	26541
060102030102	Thorpe Lake-West Fork Tuckasegee River	23517
060101050102	West Fork French Broad River	18958
060102020401	Lake Emory-Little Tennessee River	27883
060101050105	Cherryfield Creek-French Broad River	14192
060102020403	Burningtown Creek	17080
060101050201	Carson Creek-French Broad River	12623
060102040104	West Buffalo Creek	10625
060102020402	Cowee Creek	16564
060102030104	Cedar Cliff Lake-Tuckasegee River	26689
060102040102	Sweetwater Creek	9013
060101050203	Williamson Creek-French Broad River	14890
060102030101	Wolf Creek-Tuckasegee River	27691
060102030301	Savannah Creek	26219
030501050402	Cane Creek	16195
060102040107	Yellow Creek-Cheoah River	26407
060101050202	Davidson River	30181
060102030303	Scott Creek-Tuckasegee River	10586
030501050103	Cove Creek-Green River	25471
030501050501	Richardson Creek-Broad River	29716
060102030304	Conley Creek-Tuckasegee River	35066
060102020505	Lower Fontana Lake-Little Tennessee River	28273
060101060101	Lake Logan-West Fork Pigeon River	21152
060102030302	Headwaters Scott Creek	32615
060101050403	Mills River	20437
060101060103	East Fork Pigeon River	33874
030501050201	Walnut Creek	11335

060102030402	Kirkland Creek-Tuckasegee River	13087
060101050302	Clear Creek	28782
060101060203	Upper Johnathans Creek	22397
030501050701	Brushy Creek	18565
060102030401	Deep Creek	28192
030501050302	Hickory Creek-Broad River	17695
030501050303	Lake Lure-Broad River	16800
030501050604	Hinton Creek	12878
030501050304	Cedar Creek	16496
060102030202	Upper Raven Fork	14817
030501050301	Headwaters Broad River	25827
060101060301	Upper Cataloochee Creek	27558
060101060205	Crabtree Creek-Pigeon River	29952
030501050603	Wards Creek-First Broad River	24748
030501050601	Headwaters First Broad River	20844
060101060303	Walters Lake-Pigeon River	28333
060101050602	Upper Swannanoa River	14183
060101060304	Big Creek	23266
030501010102	Headwaters Catawba River	23971
060101050906	Sandymush Creek	31437
060101060305	Cold Springs Creek-Pigeon River	28333
060101050601	North Fork Swannanoa River	20316
030501010602	South Muddy Creek	25459
030501010603	North Muddy Creek-Muddy Creek	15954
060101050801	Dillingham Creek	18364
030501020101	Upper Henry Fork	33992
030501010104	Buck Creek	16435
060101051202	Spring Creek	31342
030501090203	Middle Saluda River	31502
030501051201	Upper North Pacolet River	28603
060102040403	Chilhowee Lake	31602
060102040402	Slick Rock Creek	10465
060102040305	Tellico River Upper	40877
060102040301	North River	11916
060102040303	Tellico River Headwaters	20771
060102040302	Bald River	13867
060200020902	Apalachia Lake-Hiwassee River	19623
060102020405	Brush Creek-Little Tennessee River	17496
060200020203	Sweetwater Creek-Hiwassee River	27748
060200020901	South Shoal Creek	12412
060200020303	Fall Branch-Hiwassee River	15484
060102020301	Buck Creek	9685
060200020705	Hiwassee Lake-Hiwassee River	15938

060200020201	Tusquitee Creek	27433
060102020201	Upper Cullasaja River	21905
030601010104	Whitewater River	31928
060200020403	Middle Valley River	13523
030601010202	Eastatoe Creek	31814
060102020106	Skeenah Creek-Little Tennessee River	16378
060200020701	Hanging Dog Creek	26091
060200020704	Beaverdam Creek	19508
060102020303	Nantahala Lake-Nantahala River	25026
030601010103	Horsepasture River	22943
060200020402	Upper Valley River	26034
030601010101	Lake Toxaway-Headwaters Toxaway River	15661
060101050103	East Fork French Broad River	16546
060102020202	Ellijay Creek	13206
060102020304	Whiteoak Creek-Nantahala River	28363
060102040101	Tulula Creek	18349
060102030103	Trout Creek-West Fork Tuckasegee River	13715
060102040103	Snowbird Creek	29950
060101050204	Upper Little River	26472
060102020404	Tellico Creek-Little Tennessee River	19871
060101050104	Catheys Creek	9258
060102020305	Big Creek-Nantahala River	14894
060102040105	Santeetlah Creek	20916
060102030106	Cullowhee Creek	15017
030501050101	Lake Summit-Green River	26992
060101050205	Lower Little River	12079
060102040106	Santeetlah Lake	22450
060101050101	North Fork French Broad River	24193
030501050305	Upper Cove Creek	27449
030501010303	Lake James-Catawba River	33788
060102030107	Wayehutta Creek-Tuckasegee River	12973
060102020502	Stecoah Creek	11875
060102020501	Panther Creek	14790
060102020406	Alarka Creek	22431
030501050506	Suck Creek-Broad River	23414
060102030105	Caney Fork	32864
060102020407	Upper Fontana Lake-Little Tennessee River	8984
060101050401	Boylston Creek	9889
060102030405	Fontana Lake-Tuckasegee River	18563
030501050104	Lake Adger-Green River	21247
030501050102	Hungry River	13725
060101060201	Upper Richland Creek	22753
030501050204	Wheat Creek-Green River	24137

030501050704	Beaverdam Creek	15190
060102030206	Soco Creek	28830
060101060102	Little East Fork Pigeon River-West Fork Pigeon River	20234
060101050702	Hoopers Creek	10247
060102030207	Lower Oconaluftee River	17839
030501050308	Knob Creek-Broad River	22239
030501050306	Lower Cove Creek	7532
060102030205	Lower Raven Fork	17181
060101050501	South Hominy Creek	24611
060101050705	Bent Creek-French Broad River	23831
060102030203	Bradley Fork	12742
060101050701	Upper Cane Creek	27388
030501050401	Big Camp Creek	12343
060102030201	Straight Fork Raven Fork	15586
060101060302	Lower Cataloochee Creek	11661
030501050602	Brier Creek-First Broad River	20109
030501050404	Headwaters Second Broad River	29026
030501010103	Crooked Creek	22653
060101050603	Middle Swannanoa River	25293
060101050903	Reems Creek	23313
030501020201	Upper Jacob Fork	27909
030501010101	Curtis Creek	10922
030501010604	Upper Silver Creek	17185
060101051102	Little Pine Creek-French Broad River	24106
060101080201	Upper South Toe River	27646
030501010801	McGalliard Creek-Rhodhiss Lake	30408
030501090101	Upper North Saluda River	16267
030501090102	Lower North Saluda River	32163
030501090202	Upper South Saluda River	35169
060102040404	Citico Creek	45619
030601020101	Headwaters Tallulah River	19730
030601020204	Reed Creek-Chattooga River	24550
030601020202	Headwaters West Fork Chattooga River	28024
030601020201	Headwaters Chattoga River	17957
060200020905	Coker Creek	15603
060200020907	Towee Creek-Hiwassee River	35182
060200020904	Turtletown Creek	22504
060200030208	North Potato Creek	12771
060200030201	Wolf Creek-Toccoa River	31200
050500010403	Brush Creek-New River	23865
050500010302	Grassy Creek-New River	15487
030401010701	Headwaters Fisher River	22062

050500010109	Lower North Fork New River	8743
050500010210	Prather Creek-South Fork New River	17947
050500010401	Elk Creek-New River	24605
050500010407	Crab Creek-Little River	18594
030401010804	Headwaters Stewarts Creek	22593
050500010406	Glade Creek-Little River	23311
050500010108	Helton Creek	28954
050500010107	Middle North Fork New River	17843
050500010105	Big Horse Creek	22648
060101020202	Elliot Branch-Laurel Creek	26260
050500010102	Big Laurel Creek	18661
050500010104	Little Horse Creek	13508
050500010301	Wilson Creek	23423
030401010302	Town of Wilkesboro-Yadkin River	11039
030401010401	Fishing Creek	11537
030401010402	Rock Creek-Yadkin River	7600
060101060402	Pigeon River-Cripple Creek	24405
060200020106	Chatuge Lake	17483
030501010106	Toms Creek-Catawba River	17337
030501050503	Big Horse Creek-Broad River	16039
030501010105	Mackey Creek-Catawba River	24641
060102020504	Eagle Creek	19329
060102030404	Forney Creek	19236
060102030204	Upper Oconaluftee River	13271
030501010601	North Muddy Creek	21692
050500010305	Bridle Creek-New River	16266
030401010703	Little Fisher River	24529
050500010603	Chestnut Creek	39005

Area 2. Northern Tier/Roanoke River/ Great Dismal Swamp

HUC_12	HU_12_NAME	ACRES
030101030107	Double Creek	8464
030101030302	Town Fork Creek-Dan River	17072
030101070503	Coniott Creek-Roanoke River	13378
030201010801	Flat Rock Branch-Swift Creek	21331
030201010802	White Oak Swamp	12640
030101070903	Town of Plymouth-Roanoke River	26843
030201040302	Van Swamp	13982
030401011007	Bashavia Creek-Yadkin River	30343
030101070404	Outlet Hardison Mill Creek	15990

030102030205	Cole Creek-Sarem Creek	20895
030202020403	Creeping Swamp	20216
030201030605	Town of Grimesland-Tar River	25615
030201030401	Tyson Creek-Tar River	22854
030201040104	Beaverdam Swamp	10675
030201030506	Aggie Run	29343
030201030505	Middle Tranters Creek	21970
030201040601	Acre Swamp-Pungo Swamp	27306
030201030402	Johnsons Mill Run	17424
030401011202	Forbush Creek	17564
030101070403	Headwaters Hardison Mill Creek	29093
030201030204	Town of Falkland-Tar River	12642
030202010502	Lick Creek	13947
030201010603	Biddie Toe Creek-Tar River	20158
030101070401	Headwaters Sweetwater Creek	8841
030102051003	North River	47162
030102050301	Great Dismal Swamp-Headwaters Perquimmans River	24514
030102030503	Merchants Millpond-Bennetts Creek	11207
030102030504	Bennetts Creek	19261
030202010701	Richland Creek	9052
030102050805	Swan Creek Lake-Swan Creek	9561
030202010302	Sevenmile Creek-Eno River	25120
030101070601	Gardener Creek	26132
030201050302	Pains Bay-Long Shoal River	31224
030201030202	Town Creek-Tar River	19716
030201010405	Town of Bunn-Tar River	11524
030401011302	Headwaters Muddy Creek	22398
030202010304	Crooked Creek-Eno River	26361
030202010303	Stony Creek-Eno River	30514
030101070405	Outlet Sweetwater Creek	10293
030202010601	New Light Creek	14096
030201010602	Turkey Creek	11198
030401011005	Little Yadkin River	18870
030102050803	Gum Neck Creek-Alligator River	17409
030201010402	Lower Cedar Creek	11432
030102050807	Grapevine Bay-Alligator River	23109
030101030204	Lick Creek-Lower Town Fork Creek	14349
030401011006	Grassy Creek-Yadkin River	24683
030101070901	Welch Creek	18098
030102050802	Southwest Fork-Northwest Fork Alligator River	35331
030201010401	Upper Cedar Creek	30180
030102050806	Whipping Creek Lake-Whipping Creek	23230

030101070508	Lower Conoho Creek	22173
030202010202	South Fork Little River	25041
030101070603	Broad Creek-Roanoke River	16469
030102051504	Stumpy Point Bay-Pamlico Sound	40785
030201010501	Peachtree Creek-Boddies Millpond	30271
030101070602	Devils Gut-Roanoke River	30018
030202010402	Lower Knap of Reeds Creek	12045
030202010503	Beaverdam Creek	33613
030102050103	Headwaters Kendrick Creek	24765
030202010203	Mountain Creek-Little River	21043
030401011003	West Prong Little Yadkin River	10990
030202010201	North Fork Little River	21034
030101070509	City of Williamston-Roanoke River	15369
030102050809	Stumpy Point-Alligator River	37003
030101070502	Town of Hamilton-Roanoke River	11824
030101070807	Broad Creek-Cashie River	8234
030201010704	Red Bud Creek	12136
030101030108	Vade Macum Creek	11166
030202010104	Lake Michie-Flat River	26422
030101070803	Outlet Roquist Creek	18490
030101070806	Swamp Creek-Cashie River	12131
030201010303	Bear Swamp Creek-Tar River	21155
030201010803	Moccasin Creek-Swift Creek	37086
030201020606	Outlet Fishing Creek	17637
030201010706	Lower Sandy Creek	12416
030201010204	Middle Creek-Tar River	33206
030202010401	Upper Knap of Reeds Creek	18373
030201020501	Beaverdam Swamp	11944
030201010106	Aycock Creek-Tar River	19695
030102050901	Sawyer Lake-Milltail Creek	31968
030401010902	Toms Creek	24602
030202010102	South Flat River	36181
030101070805	Wading Place Creek	17199
030201010705	Middle Sandy Creek	33446
030102050903	Goose Creek-Alligator River	28949
030101030109	Flat Shoals Creek-Dan River	28244
030201010301	Kings Creek-Tar River	18998
030102050902	Second Creek	27626
030101030504	Rock House Creek-Dan River	26960
030102050206	Riders Creek-Scuppernong River	30463
030101070305	Blue Hole Swamp-Roanoke River	27335
030102050207	Bull Creek-Deep Creek	28053
030201020504	Town of Bricks-Fishing Creek	23843

030101040201	South Country Line Creek	28426
030101030106	Big Creek	28634
030201010302	Lynch Creek	22587
030101030305	Beaver Island Creek	24780
030201020503	Town of Hickory-Fishing Creek	17085
030201010105	Rocky Creek-Tar River	28125
030101040104	Upper Hogans Creek	29155
030201020104	Lower Shocco Creek	17839
030101040202	Upper Country Line Creek	35469
030101070802	Headwaters Roquist Creek	23675
030201010101	Cub Creek	10978
030101040504	Middle South Hyco Creek	17530
030101070501	Indian Creek	20517
030201020102	Little Shocco Creek	9051
030201020304	Crooked Swamp-Fishing Creek	25383
030101030409	Town of Mayodan-Mayo River	18831
030102050904	Little Alligator River	26676
030202010103	Deep Creek	23601
030201020206	Lower Little Fishing Creek	15058
030201010703	Upper Sandy Creek	13921
030102050907	Lewis Point-Albemarle Sound	9533
030201010203	Tabbs Creek	26083
030101040502	Hyco Creek	36344
030201010202	Ruin Creek	19371
030201010104	North Fork Tar River	14455
030101070302	Flag Run Gut-Roanoke River	14359
030101040501	Reedy Fork	10257
030201010201	Fishing Creek	30051
030201020103	Middle Shocco Creek	15528
030102030703	Cricket Swamp	8119
030201010103	Shelton Creek	16158
030201010102	Headwaters Tar River	17115
030101070801	Hoggard Mill Creek	31110
030101040108	Rattlesnake Creek	15662
030101070205	Looking Glass Run	10566
030201020303	Maple Branch-Fishing Creek	31234
030101040506	Hyco Creek-Hyco Lake	13216
030101040107	Lower Moon Creek	11306
030201020205	Middle Little Fishing Creek	20867
030101040604	Headwaters Mayo Creek	21397
030101070203	Headwaters Conoconnara Swamp	23387
030201020502	Bellamy Lake-Rocky Swamp	25476
030201020302	Possumquarter Creek-Fishing Creek	20744

030101020801	Little Grassy Creek	15466
030101020802	Mountain Creek-Grassy Creek	23582
030201020202	Reedy Creek	22558
030201020203	Upper Little Fishing Creek	22471
030201020201	Bens Creek	10375
030201020401	Upper Marsh Swamp	18910
030102040803	Headwaters Urahaw Swamp	17054
030201020204	Bear Swamp	28720
030101020901	Little Island Creek	13558
030102030404	Chinkapin Creek	15599
030101070105	Occoneechee Neck-Roanoke River	20229
030101060403	Deep Creek	18752
030102050709	Pasquotank River	12328
030102030405	Wiccacon River	19881
030102030603	Holiday Island-Chowan River	20398
030101070201	Occoneechee Creek	17449
030101070202	Gumberry Swamp	22729
030101070103	Arthurs Creek-Roanoke River	18052
030102030206	Sarem Creek-Chowan River	19777
030102030601	Trotman Creek	16972
030102030203	Beasley Branch-Buckhorn Creek	11073
030102030502	Raynor Swamp	12993
030102051002	Great Swamp-North River	32282
030102030204	Headwaters Cole Creek	21111
030102050701	Folly Swamp	30245
030102051107	Tull Creek	16502
030101030105	Peters Creek-Dan River	26180
030101030404	Crooked Creek-Lower South Mayo River	25425
030101030902	Cascade Creek	27012
030101030103	Little Dan River	20611
030102040706	Mill Swamp-Fontaine Creek	36334
030101030408	Pawpaw Creek-Mayo River	19924
030101030301	Snow Creek	28004
030101040701	Headwaters Aarons Creek	18007
030401010801	Headwaters Ararat River	25677
030101060302	Great Creek-Lake Gaston	24748
030101030102	Archies Creek-Dan River	24659
030101030407	Koger Creek-North Mayo River	33906
030101030104	Elk Creek-Dan River	12423
030102040901	Cypress Creek	19703
030102020505	Union Camp Holding Pond-Blackwater River	24956
030102030202	Town of Winton-Chowan River	15090
030102050606	Cross Canal-Dismal Swamp Canal	29416

030101040601	After Bay Reservoir-Hyco River	14368
030101040203	Lower Country Line Creek	24818
030102051102	Culpeper Island-Dismal Swamp	12698
030101060303	Sixpound Creek	11406
030101020805	Beaver Pond Creek North-Grassy Creek	12039
030101040109	Cane Creek-Dan River	25015
030101040607	Big Bluewing Creek	16909
030102040902	Buckhorn Swamp-Meherrin River	27565
030102040705	Jacks Swamp	15285
030102040904	Lower Tarrara Creek	13331
030101020806	Beaver Pond Creek South-Grassy Creek	11696
030102030501	Duke Swamp	27996
030101040702	Aarons Creek-John H Kerr Reserrvoir	25145
030101020803	Beech Creek-Johnson Creek	23363
030101020804	Spewmarrow Creek-Grassy Creek	16005
030101060301	Hawtree Creek	16915
030101040105	Lower Hogans Creek	24769
030102030103	March Swamp-Somerton Creek	31614
030101020902	Island Creek	32497
030102011206	Round Gut-Nottoway River	24989
030101040603	Bowes Branch-Hyco River	16903
030102051104	Indian Creek-Northwest River	16371
030102030201	Buckhorn Creek	10328
030102011205	Mill Creek	24132
030102040908	Town of Murfreesboro-Meherrin River	20769
030102050804	Winn Bay-Alligator River	17416
030201010904	Penders Mill Run-Tar River	21851
030201010601	Lake Sagamore-Cyprus Creek	20221
030102050808	The Frying Pan-The Straights	27031
030101070902	Conaby Creek	17160
030201010304	Jumping Run-Tar River	25545
030201020601	Maple Swamp	11661
030101030502	Jacobs Creek	24027
030101030306	Reed Creek-Dan River	25839
030102050104	Outlet Kendrick Creek	31839
030101070804	Town of Windsor-Cashie River	13430
030101040503	Upper South Hyco Creek	18570
030102050106	Town of Skinnersville-Chapel Swamp	13394
030201010702	Devils Cradle Creek	9657
030101030503	Massy Creek-Dan River	17462
030202010101	North Flat River	25704
030101070303	Cypress Swamp	14385
030201020405	Cow Haul Swamp-Beech Swamp	29129

030201020602	Town of Dawson Crossroads	7922
030201020603	Upper Deep Creek	9127
030101030901	Town Creek-Dan River	22544
030201020404	Burnt Coat Swamp-Beech Swamp	24690
030101040505	Lower South Hyco Creek	15959
030101030905	Lower Wolf Island Creek	25982
030101070301	Sandy Run-Roanoke River	20198
030201020402	Beaverdam Swamp	19734
030101070204	Outlet Conoconnara Swamp	12247
030101040602	Storys Creek	27201
030201020403	Lower Marsh Swamp	21390
030101070206	Bridgers Creek-Roanoke River	21826
030102040802	Headwaters Potecasi Creek	24495
030102040906	Rogers Swamp-Corduroy Swamp	27551
030102050702	Newland Drainage Canal	32584
030102051105	Moyock Run	9707
030101030505	Matrimony Creek-Dan River	35679
030101030903	Trotters Creek-Dan River	27785
030101040605	Mayo Creek-Mayo Reservoir	17539
030101030906	Danville-Dan River	12177
030102051108	Tull Bay-Northwest River	11749
030102051206	Milldam Creek-North Landing River	14494
030102051103	US Naval Reservation-Northwest River	31139
030102040905	Barretts Crossroads-Meherrin River	27286
030401010904	Outlet Ararat River	17454
030101040106	Upper Moon Creek	20233
030401011201	Logan Creek	16915
030201030603	Headwaters Chicod Creek	16390
030201030606	Tranters Creek-Tar River	12897
030201030602	Outlet Grindle Creek	22742
030201030203	Otter Creek	31489
030202010504	Little Lick Creek-Neuse River	19822

Area 3. Waccamaw/ Cape Fear Arch/ Onslow Bight

HUC_12	HU_12_NAME	ACRES
030402080201	Upper Shallotte River	9136
030402080107	Town of Long Beach-Montgomery Slough	7610
030402060702	Big Creek-Waccamaw River	22415
030402060703	Buck Creek	35623
030402080202	Middle Shallotte River	12294
030402080105	Mill Creek	8014

030402060605	Regan Branch-Waccamaw River	8272
030300050802	Jump and Run Creek-Gully Creek	16444
030402060603	Wet Ash Swamp	19766
030300050801	Walden Creek	7588
030402060604	Bear Branch-Waccamaw River	8145
030402060506	Grissett Swamp-Seven Creeks	13162
030402080104	Scotts Branch-Lockwoods Folly River	11221
030402080103	Royal Oak Swamp	20178
030402080101	Middle Swamp	17975
030300050703	Orton Creek	13234
030402060404	Alligator Swamp	9304
030402080102	Headwaters Lockwoods Folly River	11633
030402060602	Gore Lake-Gore Creek	21879
030300050701	Liliput Creek	15875
030402060601	Horse Pen Swamp-Waccamaw River	14505
030402060403	Upper Juniper Creek	33617
030402060401	Bear Pen Islands Swamp	9459
030300050602	Bell Swamp-Rice Creek	28958
030300050502	Town of Woodburn-Sturgeon Creek	10143
030300050503	Brunswick River-Cape Fear River	18254
030402060303	Green Swamp-Big Creek	28017
030300050302	Middle Livingston Creek	17637
030402031103	Lower Porter Swamp	25426
030300050303	Lower Livingston Creek	18229
030402060305	Bogue Swamp	24937
030300050406	Hood Creek	26939
030300050204	Middle Turnbull Creek	13903
030300060802	Canty Mill Creek-Black River	17058
030402060405	Lower Juniper Creek	29279
030402031404	Lumber River	21401
030402060402	Honey Island Swamp	25520
030300060801	Clear Run-Black River	15390
030300070605	Angola Creek	16838
030300060408	Turtle Branch-Great Coharie Creek	11170
030300070604	Upper Holly Shelter Creek	17651
030300060206	Peters Creek-South River	21409
030300060506	Lower Stewarts Creek	14548
030202040404	Northwest Creek-Neuse River	15919
030402031104	Flowers Swamp-Lumber River	24452
030300050501	Indian Creek-Cape Fear River	18164
030300050407	Grist Mill Branch-Cape Fear River	10537
030402060302	Slap Swamp	10938
030300070809	Ness Creek-Northeast Cape Fear River	17715
030402060301	Sasspan Branch-Boggy Branch	27921
030300050405	Mitchell Landing-Cape Fear River	20187
030300070807	Prince George Creek-Northeast Cape Fear River	20474
030402030904	Brier Creek-Big Swamp	18772
030300060807	Cross Way Creek-Black River	13578
030300050403	Carvers Creek	13672
030300070705	Lower Long Creek	13709

030300060806	Lyon Creek	27705
030402031005	River Swamp-Lumber River	13009
030402060103	Elkton Swamp	26271
030300070806	Turkey Creek	9315
030402030902	Peters Branch-Big Swamp	12287
030300070805	Island Creek-Northeast Cape Fear River	24429
030300060704	Lower Moores Creek	12225
030300070803	Trumpeter Swamp	12809
030402031003	Jacob Swamp-Lumber River	17138
030300050401	Hammond Creek	22686
030300050402	Frenchs Creek-Cape Fear River	27225
030300070704	Middle Long Creek	18495
030300060603	Lower Colly Creek	25879
030300070804	Harrisons Creek	23433
030300070703	Rileys Creek	21117
030300060805	Rowan Creek-Black River	26201
030300060804	Colvins Creek	13427
030300070802	Pike Creek-Northeast Cape Fear River	34936
030300060703	Middle Moores Creek	20620
030300060602	Middle Colly Creek	25695
030300050206	White Lake-Cape Fear River	19631
030300060701	White Oak Branch	12659
030300070610	Ashes Creek	21209
030300070801	Burgaw Creek	19660
030300050205	Lower Turnbull Creek	21187
030300070607	Middle Shaken Creek	22963
030300070701	Bee Branch-Cypress Creek	13945
030300070608	Lower Shaken Creek	11230
030300070606	Upper Shaken Creek	20016
030402030705	Lewis Mill Branch-Big Swamp	13924
030300070702	Upper Long Creek	22653
030300060803	Kings Branch-Black River	22499
030300060702	Upper Moores Creek	13400
030402030703	Goodman Swamp	12550
030300060208	Lake Creek-South River	34298
030300070609	Lower Holly Shelter Creek	16451
030300060601	Upper Colly Creek	26250
030203020209	Stones Creek	7641
030203010103	Black Swamp Creek	22402
030203010106	Black Swamp Creek-White Oak River	11511
030202020607	Hog Island-Neuse River	8214
030402060204	Cypress Creek-White Marsh	25414
030300050504	Barnards Creek-Cape Fear River	14319
030300050601	Upper Town Creek	34294
030300050603	Lower Town Creek	17585
030402031303	Ashpole Swamp	8669
030402031207	Coward Swamp-Ashpole Swamp	8789
030300050301	Upper Livingston Creek	28745
030402060306	Boggy Swamp-Waccamaw River	27875
030202040501	Goose Creek	23793

030300070611	Lewis Creek-Northeast Cape Fear River	34873
030300050104	Phillips Creek-Cape Fear River	28162
030300060207	Smith Mill Pond Run-South River	23267
030300070503	Lower Doctors Creek	20861
030300070603	Shelter Swamp Creek	31806
030300060205	Cypress Creek	12046
030300070502	Upper Doctors Creek	14686
030300070602	Headwaters Sandy Run Swamp	17044
030300050201	Ellis Creek	35249
030300070601	Angola Swamp	31400
030300060510	Tarkill Branch-Six Runs Creek	12424
030300050203	Upper Turnbull Creek	21411
030300070501	Duff Creek	13426
030203020206	Wallace Creek	13320
030300070401	Ninemile Creek	11532
030300070405	Oakie Branch-Northeast Cape Fear River	22039
030300050103	Harrison Creek	31171
030300060509	Quewhiffle Creek-Six Runs Creek	16639
030300070403	Cypress Creek	22327
030300070504	Upper Rockfish Creek	30981
030300060204	Beaver Dam Creek	16439
030300060305	Rattlesnake Branch-Little Coharie Creek	20507
030300060203	Gum Swamp-South River	17204
030203020204	Headwaters Southwest Creek	17029
030203020202	Little Northeast Creek	14999
030203010201	Grants Creek	8660
030300070305	Maxwell Creek-Stocking Head Creek	22353
030203010203	Mulberry Creek-White Oak River	8515
030300070402	Back Swamp	23361
030203010204	Hadnet Creek	11427
030203020201	Wolf Swamp-Northeast Creek	21334
030203010104	Starkys Creek	9870
030203010401	Upper Newport River	21381
030203020104	Blue Creek-New River	39327
030300070307	Persimmon Branch-Northeast Cape Fear River	26683
030203010105	Holston Creek	9751
030203010402	Middle Newport River	24602
030203010403	Black Creek	8540
030203020103	Cowhorn Swamp-New River	18267
030203010404	Harlowe Creek	7959
030203010202	Hunters Creek	21766
030203010405	Core Creek	8079
030300070206	Dark Branch-Northeast Cape Fear River	12181
030203010101	Headwaters White Oak River	17332
030203010102	Town of Maysville-White Oak River	20289
030203010602	Great Island-Horse Island	10082
030202040504	Cherry Point-Hancock Creek	18155
030300070105	Lower Goshen Swamp	23273
030202040602	Clubfoot Creek	23611
030202040103	Outlet Tuckahoe Swamp	21338

030202040301	Mill Creek	23049
030202040105	Town of Comfort-Trent River	35131
030201050402	Styron Bay-Cedar Inlet	23375
030202040303	Headwaters Brice Creek	28772
030202040502	Cherry Point Marine Corps Air Station-Slocum Creek	37612
030202040604	Adams Creek	35299
030202040201	Chinquapin Branch	11857
030202040104	Joshua Creek-Trent River	12636
030202040701	South River	33065
030202040901	West Thorofare Bay-Long Bay	25622
030202040302	Island Creek-Trent River	26684
030202040204	Town of Trenton-Trent River	43012
030202040203	Health Mill Run-Beaver Creek	13686
030202040503	Beard Creek	17390
030202020605	Headwaters Bachelor Creek	23570
030202020601	Headwaters Core Creek	20898
030202040403	Outlet Upper Broad Creek	11606
030202040704	Turnagain Bay-Rattan Bay	21365
030202040402	Headwaters Upper Broad Creek	19639
030202040801	Upper Bay River	26415
030202020602	Outlet Core Creek	26615
030202020604	Pinetree Creek-Neuse River	21063
030202020306	Mosley Creek	31867
030202020506	Swift Creek	16940
030202020504	Headwaters Little Swift Creek	25490
030201040205	Headwaters South Creek	25919
030202020603	Halfmoon Creek-Neuse River	31962
030202020505	Fisher Swamp-Little Swift Creek	18356
030202020502	Mauls Swamp	10746
030201040202	Headwaters Durham Creek	24964
030201040701	Campbell Creek-Goose Creek	33998
030201040106	Headwaters Blounts Creek	27766
030201040203	Outlet Durham Creek	13917
030201040109	Duck Creek-Pamlico River	25394
030201040108	Goose Creek	9568
030402060704	Bellamy Branch-Waccamaw River	13189
030402060701	Cawcaw Swamp	25907
030300070505	Sills Creek	14359
030300050404	Weyman Creek	16516
030402030802	Jackson Swamp-Big Swamp	27591
030402030704	Bryan Millpond-Black Swamp	7997
030202040206	Town of Pollocksville-Trent River	17523
030202040106	Little Chinquapin Branch-Trent River	8532
030202040304	Outlet Brice Creek	13661
030202040205	Beaverdam Creek-Trent River	22898
030202040305	City of New Bern-Trent River	14458
030202020606	Outlet Bachelor Creek	16387
030202040401	City of New Bern-Neuse River	14210
030402060304	Lake Waccamaw	10125

Area 4. Sandhills/Uwharries/Triassic Basin

HUC_12	HU_12_NAME	ACRES
030401040104	Goulds Fork	16201
030402040101	Headwaters Gum Swamp Creek	21542
030402030301	Town of Wagram-Lumber River	20658
030401040105	Lower Brown Creek	30032
030402010301	Cartledge Creek	19543
030401040503	Savannah Creek	9125
030402030203	Big Muddy Lake-Big Muddy Creek	12465
030300030303	Lower Mclendons Creek	19772
030401030503	Barnes Creek	15414
030401030605	Beaverdam Creek-Yadkin River	42390
030300030601	Big Govenors Creek	26153
030402010402	Headwaters Thompson Creek	26769
030402030403	Mill Branch-Lumber River	13925
030402010306	Whortleberry Creek-Pee Dee River	10209
030402010502	Whites Creek	19762
030402010401	Deadfall Creek	20139
030402010303	Mill Creek	12244
030402010506	Crooked Creek-Lake Wallace	37244
030402030303	Town of Maxton-Lumber River	14950
030402010302	Solomons Creek	15141
030401040102	Upper Brown Creek	26054
030402040102	Richmond Mill Lake-Upper Gum Swamp Creek	13327
030402040103	Joes Creek	21755
030402010305	Everetts Lake-Marks Creek	29287
030402010203	Williams Mill Creek-Jones Creek	17998
030300040703	Carvers Creek	10835
030300040706	City of Fayetteville-Cape Fear River	18506
030300040304	James Creek	21809
030401040203	Pee Dee River-Lake Tillery	34639
030401030602	Cabin Creek	13254
030402040303	Headwaters Shoe Heel Creek	14010
030402030504	Middle Raft Swamp	24711
030402010304	Island Creek-Pee Dee River	29795
030401040103	Middle Brown Creek	28697
030402040301	Jordan Creek	12388
030402040302	Juniper Creek	23608
030402030603	Upper Big Marsh Swamp	15950
030401040501	Cedar Creek	9888
030402010102	Upper Hitchcock Creek	28323
030401040506	Pee Dee River-Blewett Falls Lake	25058
030401050706	Cribs Creek	12473
030300040604	Upper Rockfish Creek	18504
030402030206	Lower Drowning Creek	34143
030401040502	Dry Creek-Pee Dee River	14296

030402030204	Middle Drowning Creek	11214
030402010101	Rocky Fork Creek	24944
030401040205	Leak Island-Pee Dee River	21453
030401040504	Little Mountain Creek	15423
030402030205	Quewhiffle Creek	14411
030401040403	Buffalo Creek	10024
030402030104	Big Branch-Upper Drowning Creek	16785
030300040605	Upper Puppy Creek	14220
030300040603	Nicholson Creek	12448
030300040601	Juniper Creek	8370
030401040404	Little River	20080
030300040602	Headwaters Rockfish Creek	29460
030402030202	Aberdeen Creek	24075
030402030103	Naked Creek	25026
030402030201	Horse Creek	27846
030401040505	Mountain Creek	32563
030401040402	Big Town Creek-Little River	27580
030300040402	Deep Creek-Little River	11019
030401040401	Cheek Creek	20719
030402030101	Jackson Creek	17555
030300040303	Crystal Lake-Mill Creek	12808
030300040301	Nicks Creek	17645
030402030102	Headwaters Drowning Creek	23711
030401040204	Clarks Creek	21240
030300040403	Hector Creek-Little River	12657
030401040202	Wood Run-Lake Tillery	11358
030300040308	Flat Creek-Little River	25852
030300040302	Thagards Lake-Little River	24796
030401040306	Eury Dam-Little River	31951
030300040404	Muddy Creek	10440
030300040401	Buffalo Creek	12974
030300040702	Town of Lane	11370
030401040305	Rocky Creek	18792
030300040408	Town of Twin Lakes-Little River	19677
030401040201	Mountain Creek	20796
030300040406	Jumping Run Creek	18185
030300030301	Upper Mclendons Creek	28495
030300030402	Upper Cabin Creek	19035
030401030505	Outlet Uwharrie River	20265
030300030403	Lower Cabin Creek	32284
030300040409	Stewarts Creek-Little River	17744
030401040303	Densons Creek	22263
030401030603	Riles Creek	19787
030300030302	Parkwood Branch-Richland Creek	16483
030300030405	Lower Bear Creek	8780
030300030404	Upper Bear Creek	32961
030401040304	Dicks Creek-Little River	20548
030300030406	Grassy Creek-Deep River	11392
030401030604	Tuckertown Reservoir-Yadkin River	24371
030401030504	Crow Creek-Uwharrie River	28957

030401040302	West Fork Little River	23318
030300030401	Fork Creek	30909
030401030502	Hannahs Creek-Uwharrie River	21057
030300030408	Tysons Creek-Deep River	27018
030300030407	Buffalo Creek-Deep River	30939
030401030501	Betty McGees Creek-Uwharrie River	20037
030300030604	Smiths Creek-Deep River	17172
030300030602	Indian Creek	16578
030300030208	Flat Creek-Deep River	21852
030401030405	Taylor Creek	7211
030300040101	Lick Creek	31010
030300040105	Daniels Creek-Cape Fear River	23468
030401040301	Headwaters Little River	29255
030300030605	Cedar Creek	8442
030300040106	Avents Creek-Cape Fear River	23387
030401030601	Lick Creek	21942
030300040502	Hector Creek-Cape Fear River	27434
030300030607	Georges Creek-Deep River	24816
030300030205	Lower Richland Creek	24194
030300030204	Upper Richland Creek	18082
030300040104	Gulf Creek-Cape Fear River	18695
030300030508	Harts Creek-Bear Creek	16818
030401030406	Jackson Creek-Uwharrie River	25516
030401030304	Flat Swamp Creek-High Rock Lake	31161
030300030207	Lower Brush Creek	24970
030300030608	Rocky Branch-Deep River	14483
030300040103	Buckhorn Creek	21347
030300030509	Rocky River	21305
030300030504	Tick Creek-Rocky River	19162
030300020705	Shaddox Creek-Haw River	13658
030300030505	Landrum Creek	11194
030300020703	Roberson Creek	18282
030401030401	Little Uwharrie River	27778
030300030506	Harlands Creek	10095
030300040102	White Oak Creek	29748
030300020704	Stinking Creek-Haw River	15113
030202010901	UpperMiddle Creek	36323
030401030404	Caraway Creek	31270
030401030402	Headwaters Uwharrie River	26444
030300020508	Terrells Creek	18644
030300020702	Pokeberry Creek-Haw River	18550
030300020610	New Hope River-B Everett Jordan Lake	35063
030300020701	Dry Creek-Haw River	22356
030300020509	Terrells Creek-Haw River	19017
030300020607	Morgan Creek	19077
030300020507	Collins Creek	12524
030300020506	Marys Creek-Haw River	18499
030300020606	University Lake	19052
030300020503	Cane Creek	25118
030300020601	Headwaters New Hope Creek	33303

030402010105	Lower Hitchcock Creek	8591
030402010103	Hinson Lake-Falling Creek	15864
030402010104	Middle Hitchcock Creek	13499
030300030507	Headwaters Bear Creek	16270
030401050708	Camp Branch-Rocky River	12719
030401050707	Hardy Creek-Rocky River	25830

Appendix D. Acres planted by cost share program

TABLE *D*-1.—North Carolina acres planted by cost share program (1970-2008)

Fiscal Year	FIP	ACP/EQIP	CRP	FDP	FRRP	FLEP	NCA	CREP	WRP	SIP	FRP	Total
1970*		*										12,357
1971*		*										15,795
1972		*										20,114
1973*		*										15,779
1974*		*										12,781
1975	26,875	1,336										28,211
1976	15,396	488										15,884
1977	24,062	2,002										26,064
1978	21,258	1,485										22,743
1979	22,872	1,622		7,172								31,666
1980	23,365	1,302		17,544								42,211
1981	21,709	1,963		18,124								41,796
1982	14,447	2,731		15,669								32,847
1983	13,033	3,172		14,731								30,936
1984	10,895	1,898		22,170								34,963
1985	13,163	2,900		25,510								41,573
1986	17,446	3,025		23,796								44,267
1987	12,828	3,113	14,807	29,307								60,055
1988	17,397	3,823	29,474	38,723								89,417
1989	17,976	2,738	20,762	36,359			343					78,178
1990	13,934	2,653	12,554	34,192			694					64,027
1991	17,702	2,272	1,714	39,732			785					62,205
1992	20,038	1,281	4,756	38,441			482					64,998
1993	19,218	911	3,130	37,932			820					62,011
1994	22,701	1,496	143	44,730			516		46			69,632
1995	9,938	526	57	51,285			580		54			62,440
1996	9,255	750	1,165	66,286			772					78,228
1997	5,963	531	168	60,583			454		185			67,884
1998	6,489	63	1,561	48,442	15,263		463			452		72,733
1999	4,193	36	1,005	46,441	25,805		676		389	344		78,889
2000	5,248	20	4,669	46,972	12,373		646		656	62		70,646
2001	5,005		13,399	58,595	4,759		1,323	1,777				84,858
2002	2,990		2,209	61,286	864		505	4,146	218			72,218
2003	450	15	774	54,446			339	3,065	392			59,481
2004	169		3,253	52,826		912	311	4,091				61,562
2005	35		1,598	50,273		266	182	2,959			12	55,325
2006		3	1,926	44,597		1,792	648	1,983			1,747	52,696
2007		59	2,941	47,563		1,071	461	722			455	53,272
2008		31	2,320	42,476		2,652	169	356				48,004
Total	416,050	44,245	124,385	1,176,203	59,064	6,693	11,169	19,099	1,940	858	2,214	

Represents no program that year *Prior to cost share, may include small amount of ACP

FIP=Forestry Incentives Program; ACP/EQIP=Agricultural Conservation Program/Environmental Quality Incentives Program; CRP=Conservation Reserve Program; FDP=Forest Development Program: FRRP=Forest Recovery and Rehabilitation Program; FLEP=Forestland Enhancement Program; NCA=NC Agricultural Costshare Program: CREP=Conservation Reserve Enhancement Program; WRP=Wetland Reserves Program; SIP=Stewardship Incentives Program; FRP=Forest Recovery

Appendix E: Game and Priority Species in North Carolina

TABLE *E*-1.—Game Species in North Carolina

Game species	Ecoregion		
	Southern Blue Ridge	Piedmont	Mid-Atlantic Coastal Plain
BIRDS			
Coot, American (*Fulica americana*)		X	X
Crow, American (*Corvus brachyrhynchos*)	X	X	X
Crow, fish (*Corvus ossifragus*)			X
Dove, mourning (*Zenaida macroura*)	X	X	X
Duck, American wigeon (*Anas americana*)		X	X
Duck, black (*Anas rubripes*)	X	X	X
Duck, black scoter (*Melanitta nigra*)			X
Duck, blue-winged teal (*Anas discors*)	X	X	X
Duck, bufflehead (*Bucephala albeola*)	X	X	X
Duck, canvasback (*Aythya valisineria*)	X	X	X
Duck, common eider (*Somateria mollissima*)			X
Duck, common goldeneye (*Bucephala clangula*)		X	X
Duck, common merganser (*Mergus merganser*)	X	X	X
Duck, gadwall (*Anas strepera*)		X	X
Duck, greater scaup (*Aythya marila*)			X
Duck, green-winged teal (*Anas crecca carolinensis*)	X	X	X
Duck, harlequin (*Histrionicus histrionicus*)			X
Duck, hooded merganser (*Lophodytes cucullatus*)	X	X	X
Duck, lesser scaup (*Aythya affinis*)	X	X	X
Duck, long-tailed (*clangula hyemalis*)			X
Duck, mallard (*Anas platyrhynchos*)	X	X	X
Duck, mottled (*Anas fulvigula*)			X
Duck, northern shoveler (*Anas clypeata*)		X	X
Duck, pintail (*Anas acuta*)		X	X
Duck, red-breasted merganser (*Mergus serrator*)		X	X
Duck, redhead (*Aythya americana*)		X	X
Duck, ring-necked (*Aythya collaris*)	X	X	X
Duck, ruddy (*Oxyura jamaicensis*)		X	X
Duck, surf scoter (*Melanitta perspicillata*)			X
Duck, white-winged scoter (*Melanitta fusca deglandi*)			X
Duck, wood (*Aix sponsa*)	X	X	X
Goose, brant (*Branta bernicla*)			X
Goose, Canada (*Branta canadensis*)	X	X	X
Goose, snow (*Chen caerulescens caerulescens*)			X
Grouse, ruffed (*Bonasa umbellus*)	X		
Pheasant, ringnecked (*Phasianus colchicus*)			X
Quail, northern bobwhite (*Colinus virginianus*)	X	X	X
Rail, clapper (*Rallus longirostris*)			X
Rail, Common moorhen (*Gallinula chloropus*)			X
Rail, King (*Rallus elegans*)		X	X
Rail, purple gallinule (*Porphyrio martinica*)			X
Rail, Sora (*Porzana carolina*)	X	X	X
Rail, Virginia (*Rallus limicola*)		X	X
Snipe, common (*Capella gallinago*)	X	X	X
Swan, tundra (*Cygnus columbianus*)			X
Turkey, eastern wild (*Meleagris gallopavo*)	X	X	X
Woodcock, American (Scolopax *minor*)	X	X	X

Game species	Ecoregion		
	Southern	Piedmont	Mid-Atlantic
MAMMALS			
Black bear (*Ursus americanus*)	X	X	X
Bobcat (*Felis rufus*)	X	X	X
Coyote (C*anis latrans*)	X	X	X
Eastern cottontail rabbit (*Sylvilagus floridanus*)	X	X	X
Fox squirrel (*Sciurus niger*)	X	X	X
Gray fox (*Urocyon cinereoargenteus*)	X	X	X
Gray squirrel (*Sciurus carolinensis*)	X	X	X
Groundhog (*Marmota monax*)	X	X	X
Marsh rabbit (*Sylvilagus palustris*)		X	X
Raccoon (*Procyon lotor*)	X	X	X
Red fox (*Vulpes vulpes*)	X	X	X
Red squirrel (*Tamiasciurus hudsonicus*)	X		
Virginia opossum (*Didelphis virginiana*)	X	X	X
White-tailed deer (*Odocoileus virginianus*)	X	X	X
Wild boar (*Sus scrofa*)	X		
FURBEARERS			
Beaver (*Castor canadensis*)	X	X	X
Least weasel (*Mustela nivalis*)	X		
Long-tail weasel (*Mustela frenata*)	X	X	X
Mink (*Mustela vison*)	X	X	X
Muskrat (*Ondatra zibethicus*)	X	X	X
Nutria (*Myocastor coypus*)		X	X
River otter (*Lutra canadensis*)	X	X	X
Spotted Skunk (*Spilogale putorius*)	X		
Striped Skunk (*Mephitis mephitis*)	X	X	X

TABLE *E*-2.—Priority aquatic species in North Carolina

Priority aquatic Species	River Basin																
	HR[1]	LT	FB	WT	NW	SH	BR	CT	YP	RO	CF	NE	TP	CH	PQ	LP	WO
FISH																	
American Brook Lamprey (*Lampetra appendix*)			X														
Atlantic Sturgeon (*Acipenser oxyrhynchus*)										X	X	X	X	X	X		X
Banded Killifish (*Fundulus diaphanus*)										X	X	X	X	X			
Banded Pygmy Sunfish (*Elassoma zonatum*)										X	X	X	X			X	
Banded Sunfish (*Enneacanthus obesus*)										X	X	X	X	X	X	X	X
Bigeye Jumprock (*Scartomyzon ariommus*)										X							
Blackbanded Darter (*Percina nigrofasciata*)						X											
Blackbanded Sunfish (*Enneacanthus chaetodon*)										X	X	X	X	X	X	X	X
Blotched Chub (*Erimystax insignis*)	X		X														
Blotchside Logperch (*Percina burtoni*)		X															
Blotchside Darter (*Percina burtoni*)			X														
Bluefin Killifish (*Lucania goodei*)											X						
Blue Ridge Sculpin (*Cottus caeruleomentum*)										X							
Blueside Darter (*Etheostoma jessiae*)			X														
Bluntnose Minnow (*Pimephales notatus*)	X		X	X	X												
Bridle Shiner (*Notropis bifrenatus*)												X					
Broadtail Madtom (*Noturus n. sp.*)											X					X	
Brook Silverside (*Labidesthes sicculus*)		X															
Cape Fear Shiner (*Notropis mekistocholas*)											X						
Carolina Darter (*Etheostoma collis*)								X	X	X	X	X	X				
Carolina Madtom (*Noturus furiosus*)												X	X				
Carolina Pygmy Sunfish (*Elassoma boehlkei*)																X	
Carolina Redhorse (*Moxostoma sp.*)									X		X						
Comely Shiner (*Notropis amoenus*)										X	X	X	X	X			
Cutlip Minnow (*Exoglossum maxillangua*)										X							

Priority aquatic Species	River Basin																
	HR[1]	LT	FB	WT	NW	SH	BR	CT	YP	RO	CF	NE	TP	CH	PQ	LP	WO
Dollar Sunfish (*Lepomis marginatus*)								X	X		X	X	X			X	
Everglades Pygmy Sunfish (*Elassoma evergladei*)											X					X	
Glassy Darter (*Etheostoma vitreum*)										X		X	X	X			
Highfin Carpsucker (*Carpiodes velifer*)								X	X		X						
“Hiwassee” Greenside Darter (*Etheostoma sp.cf. blenniodes*)	X																
“Hiwassee” Redline Darter (*Etheostoma sp.cf. rufilineatum*)	X																
Ironcolor Shiner (*Notropis chalybaeus*)										X	X	X	X	X	X	X	X
Johnny Darter (*Etheostoma nigrum*)										X		X	X				
Kanawha Darter (*Etheostoma kanawhae*)					X												
Kanawha Minnow (*Phenacobius teretulus*)					X												
Lake Chubsucker (*Erimyzon sucetta*)											X	X	X	X	X	X	X
Lake Phelps Killifish (*Fundulus cf. diaphanus*)															X		
Least Brook Lamprey (*Lampetra aepyptera*)												X	X				
Least Killifish (*Heterandria formosa*)											X						
Lined Topminnow (*Fundulus lineolatus*)									X	X	X	X	X	X		X	X
Logperch (*Percina caprodes*)			X		X												
Longhead Darter (*Percina macrocephala*)			X														
Mimic Shiner (*Notropis volucellus*)		X	X		X							X	X				
Mountain Brook Lamprey (*Ichthyomyzon greeleyi*)	X	X	X														
Mountain Madtom (*Noturus eleutherus*)			X														
Notchlip Redhorse (*Moxostoma collapsum*)							X	X	X	X	X	X	X				
Olive Darter (*Percina squamata*)	X	X	X														
Orangefin Madtom (*Noturus gilberti*)										X							
Pinewoods Darter (*Etheostoma mariae*)																X	
Pinewoods Shiner (*Lythrurus matutinus*)											X	X	X				
Quillback (*Carpiodes cyprinus*)			X				X	X	X	X		X					
River Carpsucker (*Carpiodes carpio*)			X														

Priority aquatic Species	River Basin																
	HR[1]	LT	FB	WT	NW	SH	BR	CT	YP	RO	CF	NE	TP	CH	PQ	LP	WO
Riverweed Darter (*Etheostoma podostemone*)										X							
Roanoke Bass (*Ambloplites cavifrons*)											X	X	X				
Roanoke Hog Sucker (*Hypentelium roanokense*)										X							
Robust Redhorse (*Moxostoma robustum*)									X								
Rosyface Chub (*Hybopsis rubifrons*)						X											
Rosyface Shiner (*Notropis rubellus*)					X												
Rustyside Sucker (*Thoburnia hamiltoni*)										X							
Sailfin Molly (*Poecilia latipinna*)											X					X	
Sandhills Chub (*Semotilus lumbee*)									X		X					X	
Sea Lamprey (*Petromyzon marinus*)											X	X		X	X		
Sharphead Darter (*Etheostoma acuticeps*)			X														
Sharpnose Darter (*Percina oxyrhynchus*)					X												
Shorthead Redhorse (*Moxostoma macrolepidotum*)								X	X	X	X	X	X	X			
Shortnose Sturgeon (*Acipenser brevirostrum*)									X		X			X			
Sicklefin Redhorse (*Moxostoma sp.*)	X	X															
Silver Shiner (*Notropis photogenis*)	X	X	X	X	X												
Smallmouth Buffalo (*Ictiobus bubalus*)			X														
“Smoky” Dace (*Clinostomus funduloides ssp.*)	X	X															
Snail Bullhead (*Ameiurus brunneus*)						X	X	X	X	X	X	X				X	
Spotfin Chub (*Cyprinella monacha*)		X															
Spotted Sunfish (*Lepomis punctatus*)											X					X	
Stonecat (*Noturus flavus*)		X	X														
Striped Shiner (*Luxilis chrysocephalus*)			X														
Taillight Shiner (*Notropis maculatus*)									X		X					X	
Tangerine Darter (*Percina aurantiaca*)	X	X	X	X													
Thinlip Chub (*Cyprinella sp. (cf. zanema)*)									X		X					X	
Tonguetied Minnow (*Exoglossum laurae*)					X												

Priority aquatic Species	River Basin																
	HR[1]	LT	FB	WT	NW	SH	BR	CT	YP	RO	CF	NE	TP	CH	PQ	LP	WO
Turquoise Darter (*Etheostoma inscriptum*)						X											
V-lip Redhorse (*Moxostoma pappillosum*)							X	X	X	X	X	X	X	X			
Waccamaw Darter (*Etheostoma perlongum*)																X	
Waccamaw Killifish (*Fundulus waccamensis*)																X	
Waccamaw Silverside (*Menidia extensa*)																X	
Wounded Darter (*Etheostoma vulneratum*)		X	X														
Yellowfin Shiner (*Notropis lutipinnis*)						X											
MUSSELS																	
Alewife Floater (*Anodonta implicata*)									X	X				X			
Appalachian Elktoe (*Alasmidonta raveneliana*)		X	X														
Atlantic Pigtoe (*Fusconaia masoni*)									X	X	X	X	X				
Barrel Floater (*Anodonta couperiana*)											X						
Box Spike (*Elliptio cistellaeformis*)								X	X		X	X	X			X	
Brook Floater (*Alasmidonta varicosa*)								X	X	X	X	X					
Cape Fear Spike (*Elliptio marsupiobesa*)											X	X				X	
Carolina Creekshell (*Villosa vaughaniana*)								X	X		X						
Carolina Elktoe (*Alasmidonta robusta*)								X	X								
Carolina Fatmucket (*Lampsilis radiata conspicua*)									X			X					
Carolina Heelsplitter (*Lasmigona decorata*)								X	X								
Carolina Slabshell (*Elliptio congaraea*)									X		X	X	X				
Creeper (Squawfoot) (*Strophitus undulatus*)							X		X	X	X	X	X				
Cumberland Bean (*Villosa trabalis*)	X		X														
Dwarf Wedgemussel (*Alasmidonta heterodon*)												X	X				
Eastern Creekshell (*Villosa delumbis*)								X	X		X					X	
Eastern Lampmussel (*Lampsilis radiata radiata*)									X		X	X	X	X		X	
Eastern Pondmussel (*Ligumia nasuta*)									X	X	X		X	X			

Priority aquatic Species	River Basin																
	HR[1]	LT	FB	WT	NW	SH	BR	CT	YP	RO	CF	NE	TP	CH	PQ	LP	WO
Green Floater (*Lasmigona subviridis*)				X	X					X		X	X				
James Spinymussel (*Pleurobema collina*)										X							
Littlewing Pearlymussel (*Pegias fabula*)	X	X															
Longsolid (*Fusconaia subrotunda*)	X	X	X														
Mountain Creekshell (*Villosa vanuxemensis*)	X																
Notched Rainbow (*Villosa constricta*)								X	X	X	X	X	X	X			
Pod Lance (*Elliptio folliculata*)									X		X					X	
Purple Wartyback (*Cyclonaias tuberculata*)					X												
Rainbow (*Villosa iris*)	X	X															
Roanoke Slabshell (*Elliptio roanokensis*)									X	X	X	X	X				
Savannah Lilliput (*Toxolasma pullus*)									X		X						
Slippershell Mussel (*Alasmidonta viridis*)		X	X														
Spike (*Elliptio dilatata*)	X	X			X												
Tar River Spinymussel (*Elliptio steinstansana*)												X	X				
Tennessee Clubshell (*Pleurobema oviforme*)	X	X	X														
Tennessee Heelsplitter (*Lasmigona holstonia*)		X	X														
Tennessee Pigtoe (*Fusconaia barnesiana*)	X	X															
Tidewater Mucket (*Leptodea ochracea*)										X			X	X		X	
Triangle Floater (*Alasmidonta undulata*)									X	X	X	X	X	X			
Variable Spike (*Elliptio icterina*)							X	X	X	X	X	X	X			X	X
Waccamaw Fatmucket (*Lampsilis fullerkati*)																X	
Waccamaw Spike (*Elliptio waccamawensis*)																X	
Wavyrayed Lampmussel (*Lampsilis fasciola*)	X	X	X														
Yellow Lampmussel (*Lampsilis cariosa*)											X	X	X			X	
Yellow Lance (*Elliptio lanceolata*)												X	X				
CRAYFISH																	
Broad River Spiny Crayfish (*Cambarus spicatus*)							X										
Broad River Stream Crayfish (*Cambarus lenati*)							X										

Priority aquatic Species	River Basin																
	HR[1]	LT	FB	WT	NW	SH	BR	CT	YP	RO	CF	NE	TP	CH	PQ	LP	WO
Carolina Ladle Crayfish (*Cambarus davidi*)											X	X					
Chowanoke Crayfish (*Orconectes virginiensis*)										X				X			
Croatan Crayfish (*Procambarus plumimanus*)											X	X					X
Edisto Crayfish (*Procambarus ancylus*)											X					X	
French Broad River Crayfish (*Cambarus reburrus*)		X	X			X											
Greensboro Burrowing Crayfish (*Cambarus catagius*)									X		X						
Hiwassee Crayfish (*Cambarus hiwaseensis*)	X																
Hiwassee Headwaters Crayfish (*Cambarus parrishi*)	X																
Knotty Burrowing Crayfish (*Cambarus nodosus*)	X																
Little Tennessee River Crayfish (*Cambarus georgiae*)		X															
North Carolina spiny crayfish (*Orconectes carolinensis*)												X	X				
No Common Name (*Orconectes sp. cf. spinosus*)		X															
Oconee Stream Crayfish (*Cambarus chaugaensis*)						X											
Sandhills Spiny Crayfish (*Cambarus hystricosus*)											X						
Santee Crayfish (*Procambarus blandingii*)																X	
Spinytail Crayfish (*Cambarus acanthura*)	X																
Tar River crayfish (*Procambarus medialis*)												X	X				
Tuckasegee Stream Crayfish (*Cambarus tuckasegee*)		X															
Waccamaw Crayfish (*Procambarus braswelli*)																X	
SNAILS																	
Christy's Elimia (*Elimia christyi*)	X																
Greenfield Rams-horn (*Helisoma eucosmium*)											X						
Magnificent Rams-horn (*Planorbella magnifica*)											X						
Panhandle pebblesnail (*Somatogyrus virginicus*)												X					
Rotund Mysterysnail (*Viviparus intertextus*)											X	X				X	
Seep Mudalia (*Leptoxis dilatata*)					X												
Smooth Mudalia (*Leptoxis virigata*)	X																

Priority aquatic Species	River Basin																
	HR[1]	LT	FB	WT	NW	SH	BR	CT	YP	RO	CF	NE	TP	CH	PQ	LP	WO
Waccamaw Siltsnail (*Cincinnatia sp.*)																X	
Waccamaw Snail (*Amnicola sp.*)																X	

[1]RIVER BASINS KEY: HR: Hiwassee River Basin, LT: Little Tennessee River Basin, FB: French Broad River Basin, WT: Watauga River Basin, NW: New River Basin, SH: Savannah River Basin, BR: Broad River Basin, CT: Catawba River Basin, YP: Yadin-Pee Dee River Basin, RO: Roanoke River Basin, CF: Cape Fear River Basin, NE: Neuse River Basin, TP: Tar-Pamlico River Basin, CH: Chowan River Basin, PQ: Pasquotank River Basin, LP: Lumber/Lower Pee Dee River Basin, WO: White Oak River Basin,

TABLE *E*-3.—Priority species for the Mid-atlantic Coastal Plain ecoregion

Priority Species	Coastal Plain Ecoregion Habitat Types									
	OPF[1]	CMF	DCW	LLP	POC	WPS	FPF	SWC	TSF	MFS
BIRDS										
American Bittern (*Botaurus lentiginosus*)									X	
American Kestrel (*Falco sparverius*)			X	X		X				
American Woodcock (*Scolopax minor*)							X			
Anhinga (*Anhinga anhinga*)							X		X	
Bachman’s Sparrow (*Aimophila aestivalis*)			X	X		X				
Bald Eagle (*Haliaeetus leucocephalus*)							X		X	
Black Rail (*Laterallus jamaicensis*)									X	
Black-necked Stilt (*Himantopus mexicanus*)									X	
Brown-headed Nuthatch (*Sitta pusilla*)			X	X		X				
Cerulean Warbler (*Dendroica cerulea*)							X			
Chimney Swift (*Chaetura pelagica*)							X			
Chuck-will's-widow (*Caprimulgus carolinensis*)	X		X	X						
Common Moorhen (*Gallinula chloropus*)									X	
Common Nighthawk (*Chordeiles minor*)			X							
Cooper's Hawk (*Accipiter cooperii*)	X		X							
Eastern Painted Bunting (*Passerina ciris*)										X
Eastern Wood-Pewee (*Contopus virens*)	X	X	X	X			X			
Glossy Ibis (*Plegadis falcinellus*)									X	
Hairy Woodpecker (*Picoides villosus*)	X	X					X			
Henslow's Sparrow (*Ammodramus henslowii*)				X		X				
Hooded Warbler (*Wilsonia citrina*)	X	X			X		X			
Kentucky Warbler (*Oporornis formosus*)		X					X			
King Rail (*Rallus elegans*)									X	
Least Bittern (*Ixobrychus exilis*)									X	
Little Blue Heron (*Egretta caerulea*)									X	
Mississippi Kite (*Ictinia mississippiensis*)							X			
Nelson's Sharp-tailed Sparrow (*Ammodramus nelsoni*)									X	
Northern Bobwhite (*Colinus virginianus*)			X	X		X				
Northern Flicker (*Colaptes auratus*)	X	X	X	X	X	X				
Northern Harrier (*Circus cyaneus*)									X	
Prairie Warbler (*Dendroica discolor*)				X	X	X				
Red-cockaded Woodpecker (*Picoides borealis*)			X	X	X	X				
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	X	X	X	X	X	X	X			
Saltmarsh Sharp-tailed Sparrow (*Ammodramus caudacutus*)									X	
Sedge Wren (*Cistothorus platensis*)									X	
Short-eared Owl (*Asio flammeus*)									X	
Snowy Egret (*Egretta thula*)									X	
Sora (*Porzana carolina*)									X	
Swainson’s Warbler (*Limnothlypis swainsonii*)		X			X		X			
Swallow-tailed Kite (*Elanoides forficatus*)							X		X	
Virginia Rail (*Rallus limicola*)									X	
Wayne's Black-throated Green Warbler (*Dendroica virens waynei*)					X		X			

Priority Species	Coastal Plain Ecoregion Habitat Types									
	OPF[1]	CMF	DCW	LLP	POC	WPS	FPF	SWC	TSF	MFS
Whip-poor-will (*Caprimulgus vociferus*)	X		X	X						
Wood Stork (*Mycteria americana*)									X	
Wood Thrush (*Hylocichla mustelina*)	X	X					X			
Worm-eating Warbler (*Helmitheros vermivorous*)		X	X		X		X			
Yellow Rail (*Coturnicops noveboracensis*)									X	
Yellow-billed Cuckoo (*Coccyzus americanus*)	X	X					X			
Yellow-crowned Night-heron (*Nyctanassa violacea*)							X		X	
MAMMALS										
Cotton Mouse (*Peromyscus gossypinus*)		X			X		X			
Eastern Fox Squirrel (*Sciurus niger*)	X		X	X						
Eastern Mole (*Scalopus aquaticus*)	X	X								
Eastern Woodrat (*Neotoma floridana haematoreia*)							X			
Least Shrew (*Cryptotis parva*)									X	
Long-tailed Weasel (*Mustela frenata*)	X	X			X	X				
Marsh Rabbit (*Sylvilagus palustris*)					X		X		X	
Northern Yellow Bat (*Lasiurus intermedius*)		X					X			
Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*)							X			
Rock Vole (*Microtus chrotorrhinus*)										
Seminole Bat (*Lasiurus seminolus*)			X	X			X			
Silver-haired Bat (*Lasionycteris noctivagans*)		X								
Southeastern Bat (*Myotis austroriparius*)							X			
Southern Bog Lemming (*Synaptomys cooperi helaletes*)					X			X		
Southern Pygmy Shrew (*Sorex hoyi winnemana*)							X			
Star-nosed Mole (*Condylura cristata*)					X		X	X	X	
White-footed Mouse (*Peromyscus leucopus easti*)										X
AMPHIBIANS										
Barking Treefrog (*Hyla gratiosa*)		X		X		X		X		
Brimley's Chorus Frog (*Pseudacris brimleyi*)		X				X		X		
Carolina Gopher Frog (*Rana capito*)		X		X		X		X		
Dwarf Salamander (*Eurycea quadridigitata*)						X	X	X		
Eastern Lesser Siren (*Siren intermedia intermedia*)								X		
Eastern Spadefoot (*Scaphiopus holbrookii*)	X	X		X		X	X	X		X
Eastern Tiger Salamander (*Ambystoma tigrinum*)				X		X		X		
Four-toed Salamander (*Hemidactylium scutatum*)	X	X					X	X		
Mabee's Salamander (*Ambystoma mabeei*)		X				X	X	X		
Many-lined Salamander (*Stereochilus marginatus*)					X					
Marbled Salamander (*Ambystoma opacum*)	X	X					X	X		
Northern Slimy Salamander (*Plethodon glutinosus sensustricto*)	X	X		X		X	X			
Oak Toad (*Bufo quercicus*)				X	X	X		X		X
Ornate Chorus Frog (*Pseudacris ornate*)		X		X		X		X		
Pine Barrens Treefrog (*Hyla andersonii*)				X	X	X		X		
Sandhills Salamander (*Eurycea sp*)							X			
Southern Dusky Salamander (*Desmognathus auriculatus*)					X		X			X
Spotted Salamander (*Ambystoma maculatum*)	X	X					X	X		

Priority Species	Coastal Plain Ecoregion Habitat Types									
	OPF[1]	CMF	DCW	LLP	POC	WPS	FPF	SWC	TSF	MFS
Striped Southern Chorus Frog (*Pseudacris nigrita nigrita*)		X				X		X		
Three-lined Salamander (*Eurycea guttolineata*)							X			
REPTILES										
American Alligator (*Alligator mississippiensis*)									X	
Black Swamp Snake (*Seminatrix pygaea*)								X		
Broad-headed Skink (*Eumeces laticeps*)	X	X				X	X			
Common Rainbow Snake (*Farancia erytrogramma erytrogramma*)									X	
Common Ribbonsnake (*Thamnophis sauritus sauritus*)							X	X	X	
Corn Snake (*Elaphe guttata*)	X	X		X		X	X			
Eastern Box Turtle (*Terrapene carolina*)	X	X					X			
Eastern Chicken Turtle (*Deirochelys reticularia*)								X		
Eastern Coachwhip (*Masticophis flagellum*)				X						X
Eastern Coral Snake (*Micrurus fulvius*)				X						X
Eastern Diamondback Rattlesnake (*Crotalus adamanteus*)				X						
Eastern Hog-nosed Snake (*Heterodon platirhinos*)	X		X	X		X				
Eastern Kingsnake (*Lampropeltis getula getula*)							X			X
Eastern Mudsnake (*Farancia abacura abacura*)								X	X	
Eastern Slender Glass Lizard (*Ophisaurus attenuatus longicaudus*)				X		X				
Eastern Smooth Earthsnake (*Virginia valeriae valeriae*)	X	X								
Glossy Crayfish Snake (*Regina rigida*)								X		
Mole Kingsnake (*Lampropeltis calligaster rhombomaculata*)	X	X		X		X				
Northern Pinesnake (*Pituophis melanoleucus melanoleucus*)				X						
Northern Scarletsnake (*Cemophora coccinea copei*)	X			X						X
Outer Banks Kingsnake (*Lampropeltis getula sticticeps*)										X
Pigmy Rattlesnake (*Sistrurus miliarius*)			X	X		X				
Pine Woods Littersnake (*Rhadinaea flavilata*)		X				X				
Scarlet Kingsnake (*Lampropeltis triangulum elapsoides*)				X		X				
Southeastern Crowned Snake (*Tantilla coronata*)			X	X						
Southern Hog-nosed Snake (*Heterodon simus*)				X						X
Spotted Turtle (*Clemmys guttata*)		X					X	X		
Striped Mud Turtle (*Kinosternon baurii*)									X	
Timber (Canebrake) Rattlesnake (*Crotalus horridus*)	X	X	X	X			X			

[1]HABITAT TYPES KEY: OPF: Oak/Pine Forest, CMF: Coastal Mesic Forest, DCW: Dry Coniferous Woodlands, LLP: Longleaf Pine Forest, POC: Pocosin Forest, WPS: Wet Pine Savanna, FPF: Floodplain Forest, SWC: Small Wetland Communities, TSF: Tidal Swamp Forest, MFS: Maritme Forest/Shrub

TABLE *E*-4.—Priority species for the Piedmont ecoregion

Priority Species	Piedmont Ecoregion Habitat Types				
	DCW[1]	OPF	PMF	FPF	SWC
BIRDS					
American Kestrel (*Falco sparverius*)	X				
American Woodcock (*Scolopax minor*)				X	
Bald Eagle (*Haliaeetus leucocephalus*)				X	
Brown-headed Nuthatch (*Sitta pusilla*)	X				
Chuck-will's-widow (*Caprimulgus carolinensis*)	X				
Cooper's Hawk (*Accipiter cooperii*)	X	X	X		
Eastern Wood-Pewee (*Contopus virens*)	X	X	X	X	
Hairy Woodpecker (*Picoides villosus*)	X	X	X	X	
Hooded Warbler (*Wilsonia citrina*)		X	X	X	
Kentucky Warbler (*Oporornis formosus*)			X	X	
Northern Flicker (*Colaptes auratus*)	X	X	X	X	
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	X	X	X	X	X
Sharp-shinned Hawk (*Accipiter striatus*)	X		X		
Swainson’s Warbler (*Limnothlypis swainsonii*)				X	
Whip-poor-will (*Caprimulgus vociferus*)	X	X		X	
Wood Thrush (*Hylocichla mustelina*)		X	X	X	
Worm-eating Warbler (*Helmitheros vermivorous*)		X	X	X	
Yellow-billed Cuckoo (*Coccyzus americanus*)		X	X	X	
Yellow-crowned Night-heron (*Nyctanassa violacea*)				X	X
MAMMALS					
Allegheny Woodrat (*Neotoma magister*)			X		
Eastern Mole (*Scalopus aquaticus*)		X	X		
Long-tailed Weasel (*Mustela frenata*)		X	X		
Rafinesque’s Big-eared Bat (*Corynorhinus rafinesquii*)				X	
Seminole Bat (*Lasiurus seminolus*)	X			X	
Silver-haired Bat (*Lasionycteris noctivagans*)			X		
Smoky Shrew (*Sorex fumeus*)				X	
Southeastern Bat (*Myotis austroriparius*)				X	
AMPHIBIANS					
Barking Treefrog (*Hyla gratiosa*)			X		X
Dwarf Salamander (*Eurycea quadridigitata*)					X
Eastern Spadefoot (*Scaphiopus holbrookii*)		X			X
Eastern Tiger Salamander (*Ambystoma tigrinum*)					X
Four-toed Salamander (*Hemidactylium scutatum*)		X	X	X	X
Marbled Salamander (*Ambystoma opacum*)		X	X	X	X
Mole Salamander (*Ambystoma talpoideum*)			X	X	X
Northern Gray Treefrog (*Hyla versicolor*)		X	X	X	X
Northern Slimy Salamander (*Plethodon glutinosus sensustricto*)		X	X	X	
Spotted Salamander (*Ambystoma maculatum*)		X	X	X	X
Three-lined Salamander (*Eurycea guttolineata*)				X	X

Priority Species	Piedmont Ecoregion Habitat Types				
	DCW[1]	OPF	PMF	FPF	SWC
REPTILES					
Bog Turtle (*Clemmys muhlenbergii*)				X	
Broad-headed Skink (*Eumeces laticeps*)		X	X	X	
Common Ribbonsnake (*Thamnophis sauritus sauritus*)				X	X
Corn Snake (*Elaphe guttata*)		X	X	X	
Eastern Box Turtle (*Terrapene carolina*)		X	X	X	
Eastern Hog-nosed Snake (*Heterodon platirhinos*)				X	
Eastern Kingsnake (*Lampropeltis getula getula*)				X	
Eastern Slender Glass Lizard (*Ophisaurus attenuatus longicaudus*)		X			
Eastern Smooth Earthsnake (*Virginia valeriae valeriae*)		X	X		
Mole Kingsnake (*Lampropeltis calligaster rhombomaculata*)		X	X		
Northern Scarletsnake (*Cemophora coccinea copei*)		X			
Pigmy Rattlesnake (*Sistrurus miliarius*)	X				
Scarlet Kingsnake (*Lampropeltis triangulum elapsoides*)		X			
Southeastern Crowned Snake (*Tantilla coronata*)	X				
Spotted Turtle (*Clemmys guttata*)			X	X	X
Timber Rattlesnake (*Crotalus horridus*)	X	X	X	X	

[1]HABITAT TYPES KEY: DCW: Dry Coniferous Woodlands, OPF: Oak/Pine Forest, PMF: Piedmont Mesic Forest. FPF: Floodplain Forest, SWC: Small Wetland Communities

TABLE *E*-5.—Priority species for the Southern Blue Ridge ecoregion

Priority Species	Southern Blue Ridge Ecoregion Habitat Types									
	SFF[1]	NHW	CFT	DCW	OPF	HER	LER	CAM	BAW	FPF
BIRDS										
Alder Flycatcher (*Empidonax alnorum*)									X	
Black-billed Cuckoo (*Coccyzus erythropthalmus*)		X	X		X					
Black-capped Chickadee (*Poecile atricapilla*)	X	X			X					
Brown Creeper (*Certhia americana*)	X	X	X		X					
Brown-headed Nuthatch (*Sitta pusilla*)				X						
Canada Warbler (*Wilsonia canadensis*)	X	X			X					
Cerulean Warbler (*Dendroica cerulea*)			X		X					
Chestnut-sided Warbler (*Dendroica pensylvanica*)	X	X								
Cooper's Hawk (*Accipiter cooperii*)		X	X	X	X					
Eastern Wood-Pewee (*Contopus virens*)			X		X					
Golden-winged Warbler (*Vermivora chrysoptera*)		X			X				X	
Hairy Woodpecker (*Picoides villosus*)	X	X	X		X					
Hooded Warbler (*Wilsonia citrina*)			X		X					X
Kentucky Warbler (*Oporornis formosus*)					X					X
Magnolia Warbler (*Dendroica magnolia*)	X									
Northern Flicker (*Colaptes auratus*)			X		X					
Northern Saw-whet Owl (*Aegolius acadicus*)	X	X								
Peregrine Falcon (*Falco peregrinus*)						X	X			
Pine Siskin (*Carduelis pinus*)	X									
Prairie Warbler (*Dendroica discolor*)				X						
Red Crossbill (*Loxia curvirostra*)	X			X						
Red-headed Woodpecker (*Melanerpes erythrocephalus*)				X	X					
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)		X			X					
Sharp-shinned Hawk (*Accipiter striatus*)	X	X	X	X	X					
Swainson's Warbler (*Limnothlypis swainsonii*)			X							X
Whip-poor-will (*Caprimulgus vociferus*)					X					
Willow Flycatcher (*Empidonax traillii*)									X	
Wood Thrush (*Hylocichla mustelina*)			X		X					
Worm-eating Warbler (*Helmitheros vermivorous*)			X	X	X					

Priority Species	Southern Blue Ridge Ecoregion Habitat Types									
	SFF[1]	NHW	CFT	DCW	OPF	HER	LER	CAM	BAW	FPF
Yellow-bellied Sapsucker (*Sphyrapicus varius*)		X	X		X					
Yellow-billed Cuckoo (*Coccyzus americanus*)			X		X					X
MAMMALS										
Allegheny Woodrat (*Neotoma magister*)						X		X		
Appalachian Cottontail (*Sylvilagus obscurus*)		X								
Eastern Fox Squirrel (*Sciurus niger*)					X					
Eastern Mole (*Scalopus aquaticus*)		X	X		X					
Eastern Spotted Skunk (*Spilogale putorius*)							X			
Eastern Woodrat (*Neotoma floridana haematoreia*)							X			
Gray Bat (*Myotis grisescens*)								X		
Hairy-tailed Mole (*Parascalops breweri*)		X			X					
Indiana Bat (*Myotis sodalis*)								X		X
Least Weasel (*Mustela nivalis*)					X					
Long-tailed Weasel (*Mustela frenata*)	X	X	X		X					
Meadow Jumping Mouse (*Zapus hudsonius*)									X	
Meadow Vole (*Microtus pennsylvanicus*)									X	
Masked Shrew (*Sorex cinereus*)	X	X	X		X					
Northern Flying Squirrel (*Glaucomys sabrinus*)	X	X								
Northern Long-eared Bat (*Myotis septentrionalis*)							X	X		
Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*)								X		
Rock Shrew (*Sorex dispar*)	X	X				X				
Rock Vole (*Microtus chrotorrhinus*)	X					X				
Silver-haired Bat (*Lasionycteris noctivagans*)		X								
Small-footed Bat (*Myotis leibii*)							X	X		
Smoky Shrew (*Sorex fumeus*)	X	X	X		X					X
Southern Pygmy Shrew (*Sorex hoyi winnemana*)		X			X					
Virginia Big-eared Bat (*Corynorhinus townsendii virginianus*)								X		
Water Shrew (*Sorex palustris*)		X								
Woodland Jumping Mouse (*Napaeozapus insignis*)		X	X							
AMPHIBIANS										
Chattahoochee Slimy Salamander		X	X		X					

Priority Species	Southern Blue Ridge Ecoregion Habitat Types									
	SFF[1]	NHW	CFT	DCW	OPF	HER	LER	CAM	BAW	FPF
(*Plethodon chattahoochee*)										
Crevice Salamander (*Plethodon longicrus*)			X		X		X			
Four-toed Salamander (*Hemidactylium scutatum*)					X				X	X
Green Salamander (*Aneides aeneus*)			X		X	X	X			
Junaluska Salamander (*Eurycea junaluska*)										X
Longtail Salamander (*Eurycea longicauda*)								X		X
Marbled Salamander (*Ambystoma opacum*)			X		X				X	X
Mole Salamander (*Ambystoma talpoideum*)									X	X
Mountain Chorus Frog (*Pseudacris brachyphona*)					X					X
Northern Slimy Salamander (*Plethodon glutinosus sensustricto*)	X	X	X		X					X
Pigmy Salamander (*Desmognathus wrighti*)	X	X	X							
Seepage Salamander (*Desmognathus aeneus*)			X		X					X
Southern Ravine Salamander (*Plethodon richmondi*)		X	X		X					
Southern Zigzag Salamander (*Plethodon ventralis*)			X		X		X			
Spotted Salamander (*Ambystoma maculatum*)		X	X		X				X	X
Tellico Salamander (*Plethodon aureolus*)		X	X		X					
Three-lined Salamander (*Eurycea guttolineata*)									X	X
Wehrle's Salamander (*Plethodon wehrlei*)					X					
Weller's Salamander (*Plethodon welleri*)	X	X								
REPTILES										
Bog Turtle (*Clemmys muhlenbergii*)									X	X
Coal Skink (*Eumeces anthracinus*)				X		X	X			
Common Ribbonsnake (*Thamnophis sauritus sauritus*)									X	
Eastern Box Turtle (*Terrapene carolina*)					X					X
Eastern Hog-nosed Snake (*Heterodon platirhinos*)			X							X
Eastern Kingsnake (*Lampropeltis getula getula*)										X
Eastern Slender Glass Lizard (*Ophisaurus attenuatus longicaudus*)					X					
Eastern Smooth Earthsnake (*Virginia valeriae valeriae*)			X		X					

Priority Species	Southern Blue Ridge Ecoregion Habitat Types									
	SFF[1]	NHW	CFT	DCW	OPF	HER	LER	CAM	BAW	FPF
Mole Kingsnake (*Lampropeltis calligaster rhombomaculata*)					X					
Northern Pinesnake (*Pituophis melanoleucus melanoleucus*)					X					
Timber Rattlesnake (*Crotalus horridus*)				X	X	X	X			X

[1]HABITAT TYPES KEY: SFF: Spruce Fir Forest, NHW: Northern Hardwoods, CFT: Cove Forest, DCW: Dry Coniferous Woodlands, OPF: Oak/Pine Forest, HER: High-elevation Rock Outcrops, LER: Low-elevation Rock Outcrops, CAM: Caves and Mines, BAW: Bogs and associated Wetlands, FPF: Floodplain Forest