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.

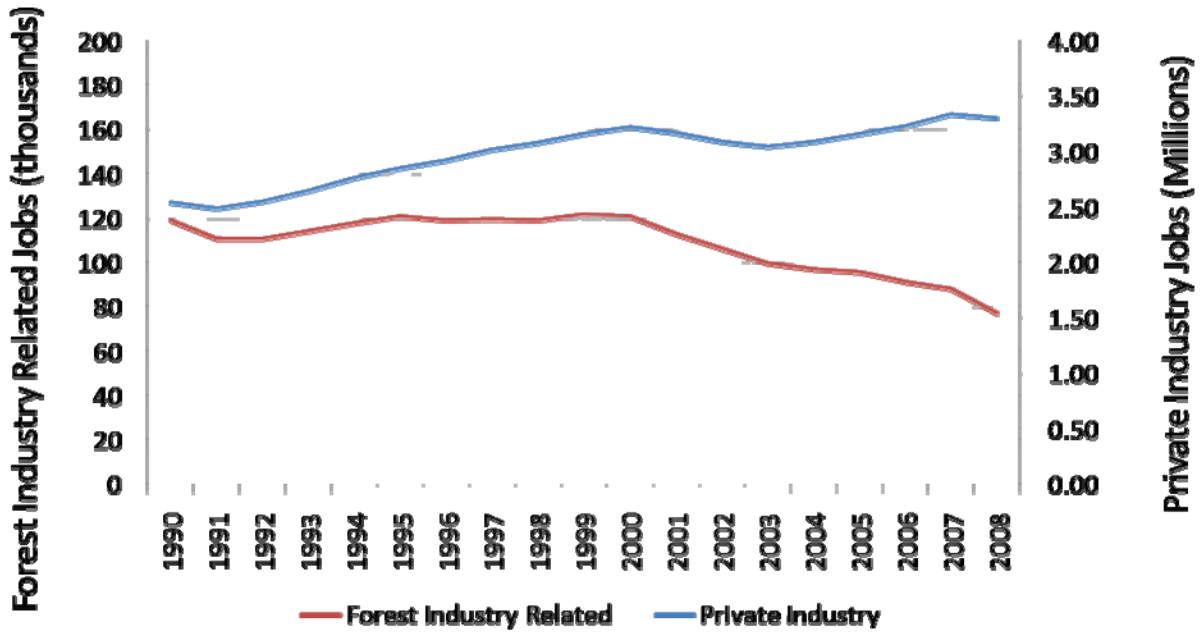
During the same period, growth in employment was enjoyed by the "custom architectural woodwork and millwork" subsector (5.6 percent annually) and the "wood kitchen cabinets and countertops" subsector (4.4 percent annually). Growth in these subsectors exceeded the average annual growth of all private 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.

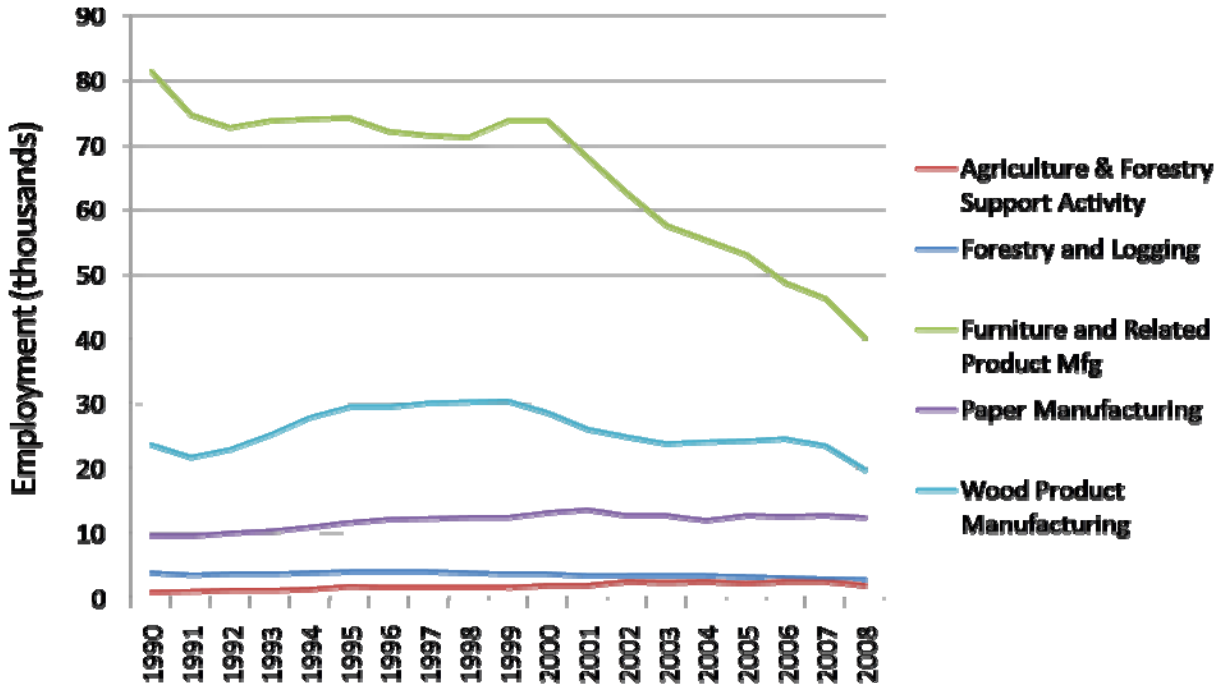
As shown in TABLE 4*a*-1, nearly every sub-sector within the Wood Product Manufacturing sector has declined in North Carolina from 1990 to 2008. The two exceptions are "engineered wood member manufacturing" and "other millwork (including flooring)." Sawmills are among the hardest hit subsectors.

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 4*a*-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).

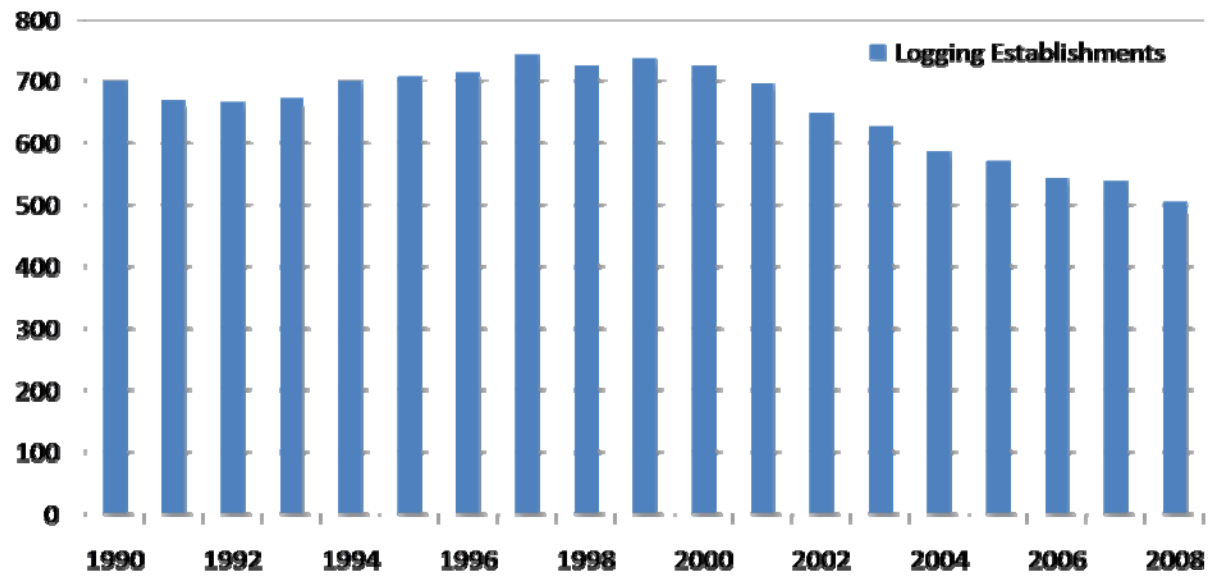
FIGURE 4*a*-4 shows the distribution of logging contractors who are currently registered as ProLoggers with the North Carolina Forestry Association (NCFA), a fair proxy for the distribution of logging contractors in the state.

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

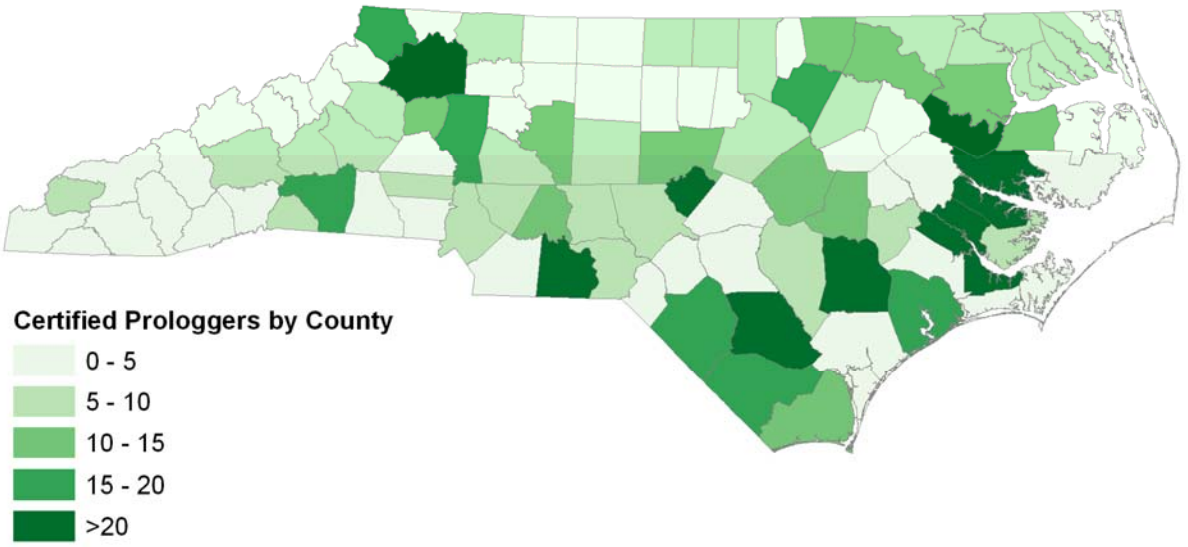
a. Forest Industry Employment

FIGURE 4a-3. Total number of logging establishments in North Carolina by year, 1990 – 2008.



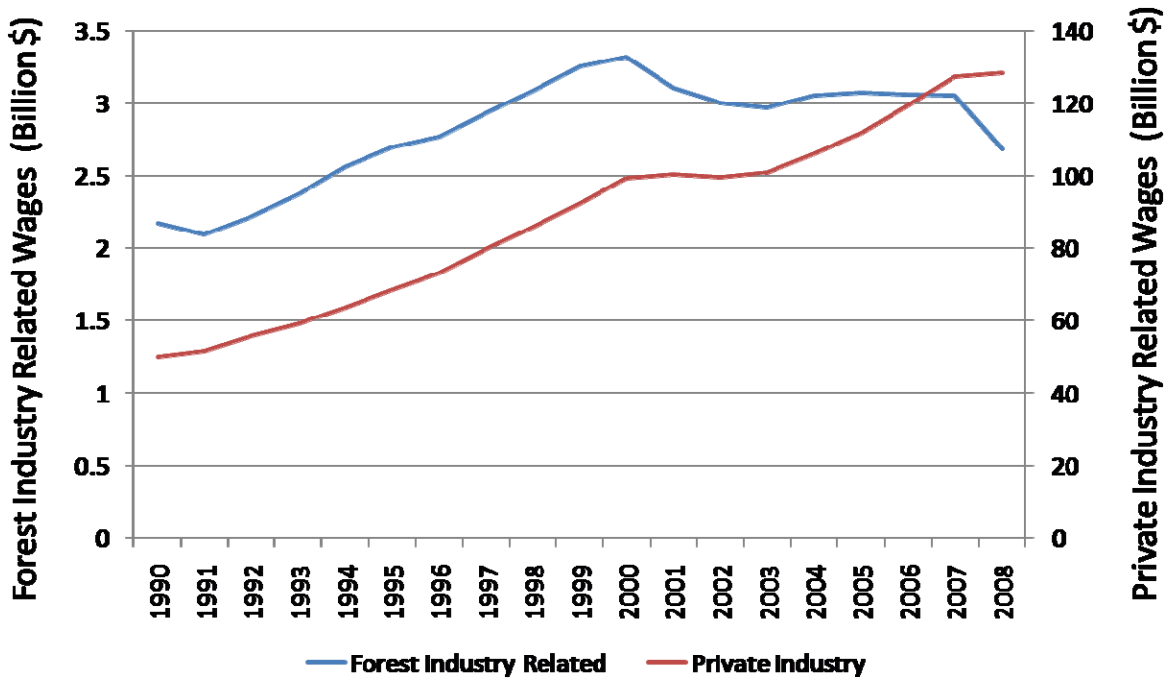
Source: NCESC

FIGURE 4*a*-4: North Carolina certified prologgers by county.



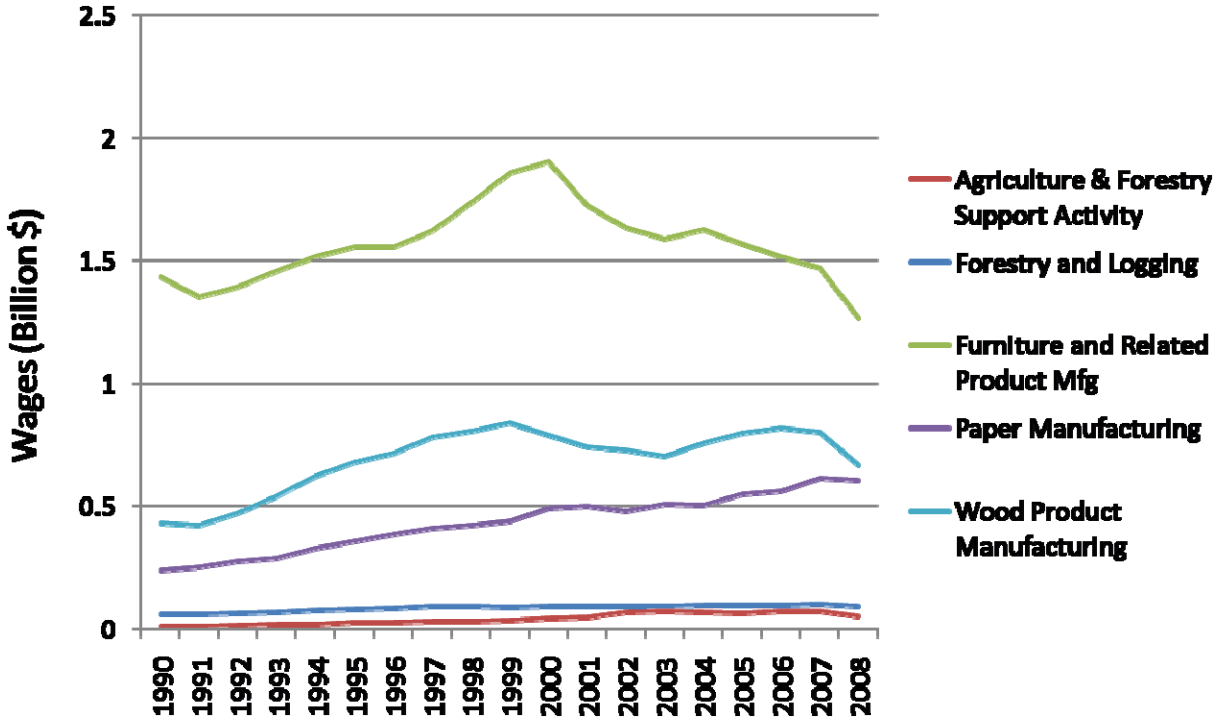
Created by: A. Bailey, NCDFR, 2010

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.

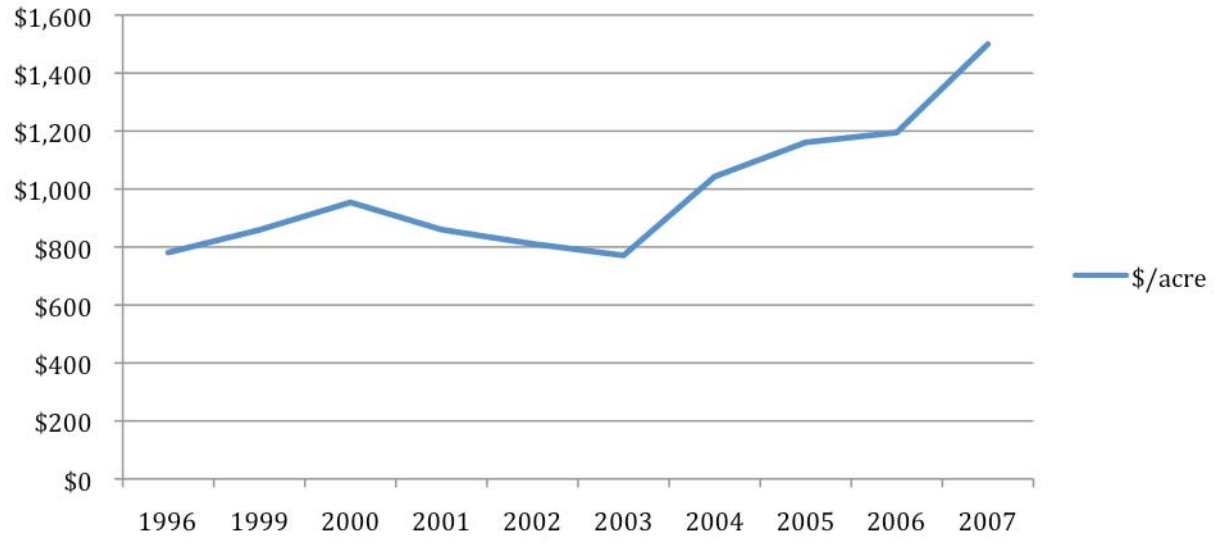
Timberland prices have risen fairly steadily since the mid-1990s, with the value of Southern U.S. timber properties approximately doubling over this time (FIGURE 4*b*-1). Two factors appear to be driving this increase: land divestitures by integrated forest products companies and a general increase in 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.

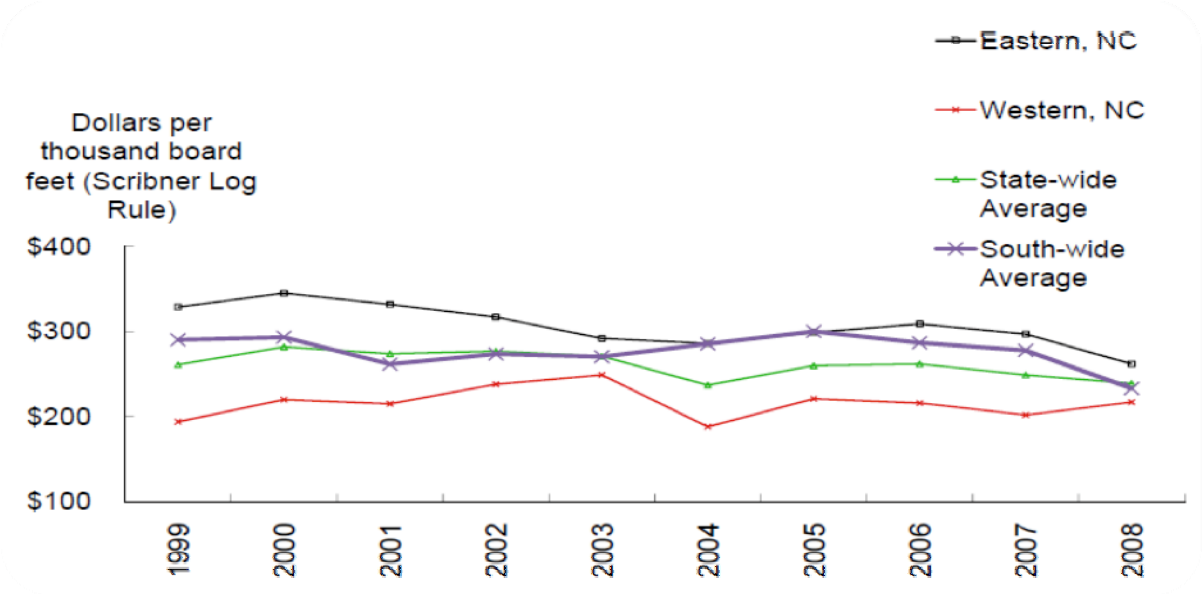
Pine Sawtimber

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

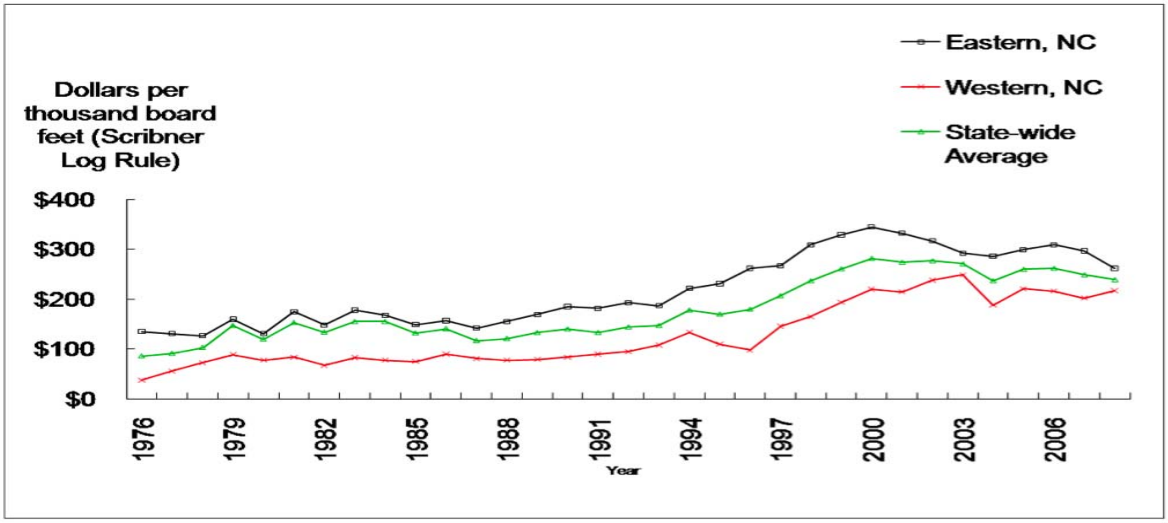
The overall trend in pine pulpwood stumpage from 1976 to 2008 was an increase in prices. Between 1976 and 1993, the prices increased sharply, particularly in the western counties of North Carolina, which saw an average annual increase of 8.6 percent. Eastern prices increased during this same period, but at the lower rate of 4.9

FIGURE 4*c*-1. Pine sawtimber stumpage price history, 1999 – 2008.



Source: Timber Mart–South, 2009

FIGURE 4*c*-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).

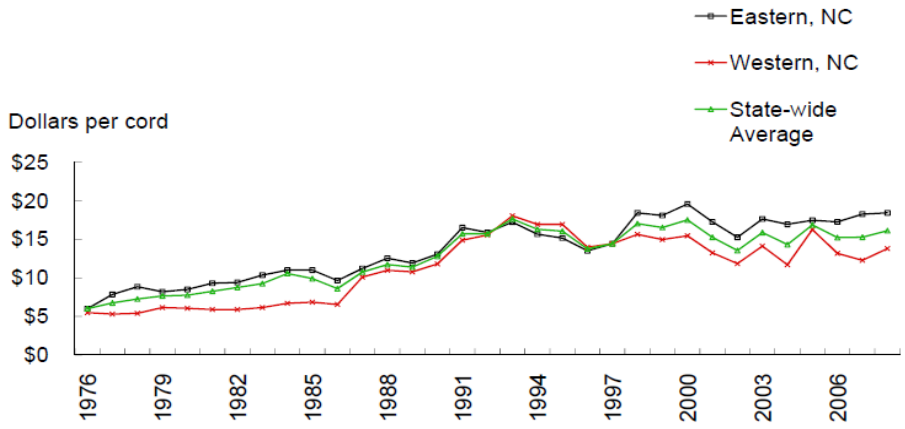
Since 1993, the rate of increase has slowed to around 1.7 percent annually for both regions of North Carolina (FIGURE 4*c*-7). Western stumpage values are historically higher than eastern North Carolina stumpage values, and both regions are below the South-wide average for hardwood pulpwood (FIGURE 4*c*-8). 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.

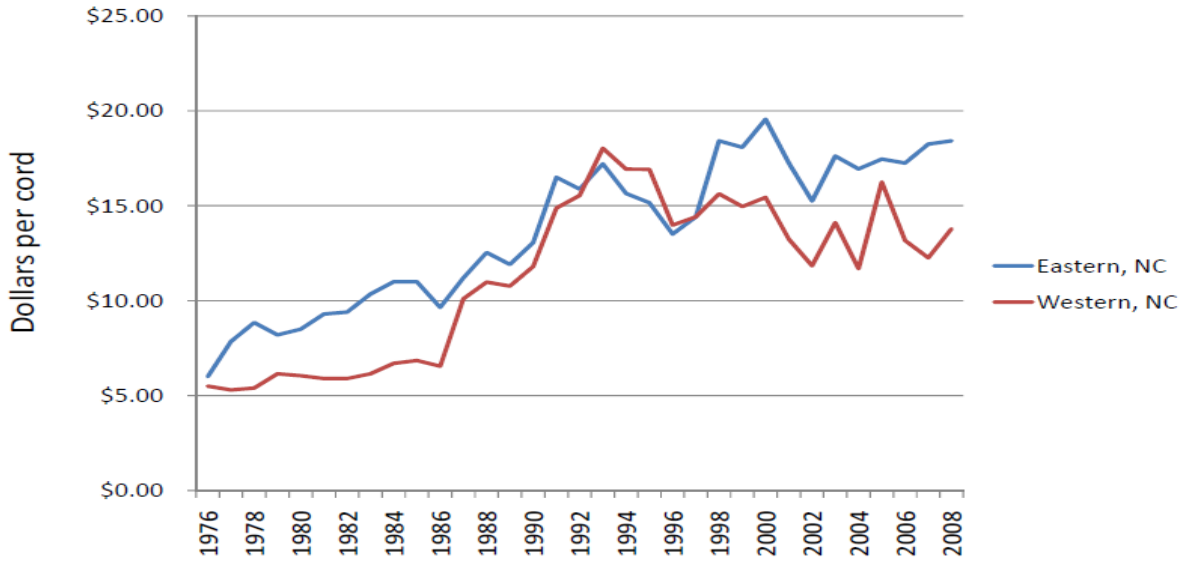
Since 1999, western North Carolina stumpage prices are increasing, but at only 0.3 percent annually (FIGURE 4*c*-10). Eastern North Carolina prices during this same time period have been increasing at an average rate of 1.25 percent annually, while South-wide prices were increasing at an average annual 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.



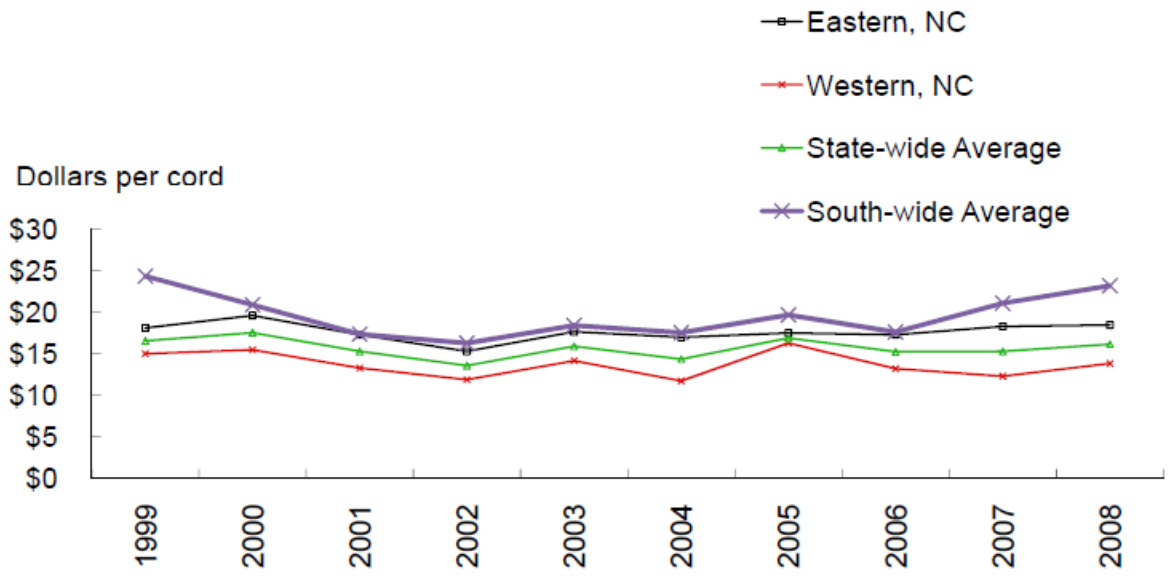
Source: Timber Mart–South, 2009

FIGURE 4*c*-4. Eastern versus western NC pine pulpwood prices.



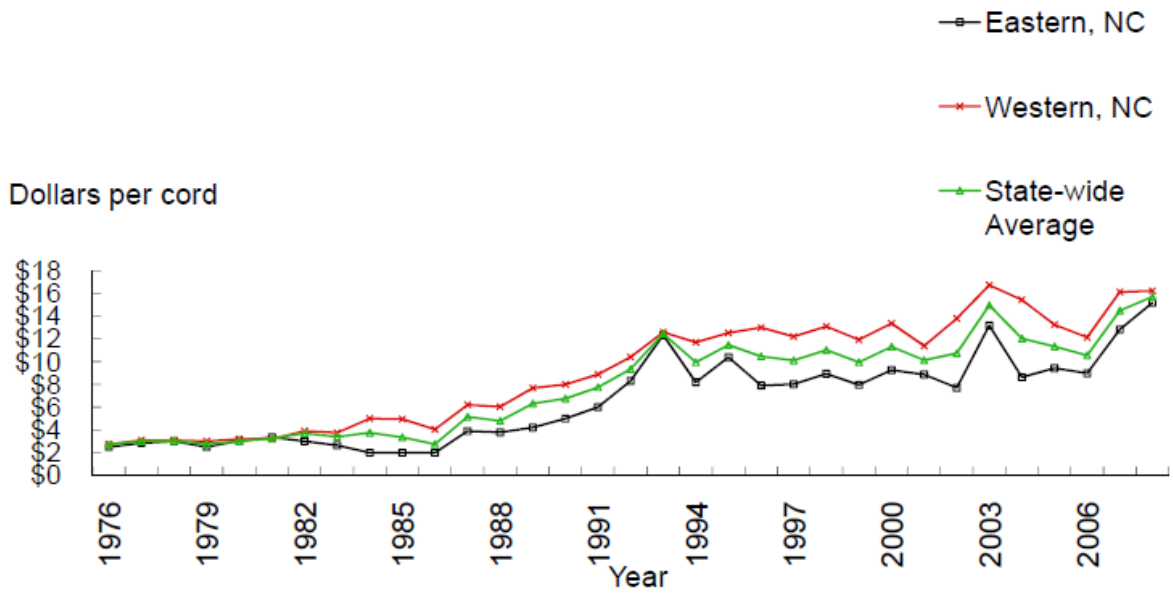
Source: Timber Mart–South, 2009

FIGURE 4*c*-5. Pine pulpwood stumpage price history, 1999 to 2008.



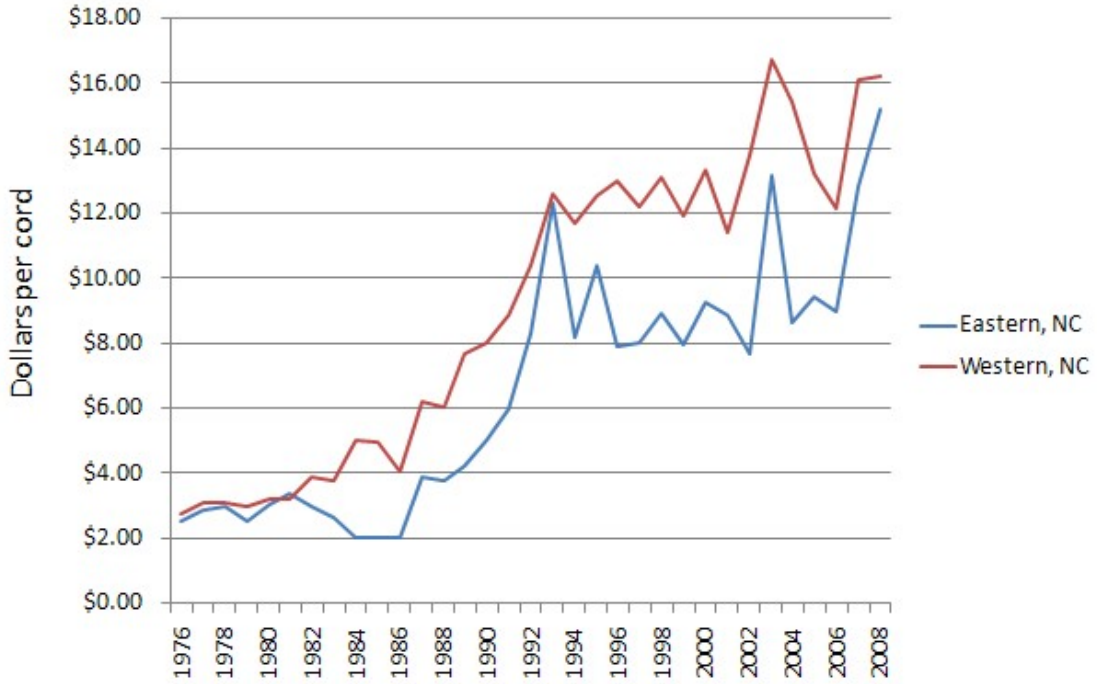
Source: Timber Mart–South, 2009

FIGURE 4*c*-6. Hardwood pulpwood stumpage prices history, 1976 to 2008.



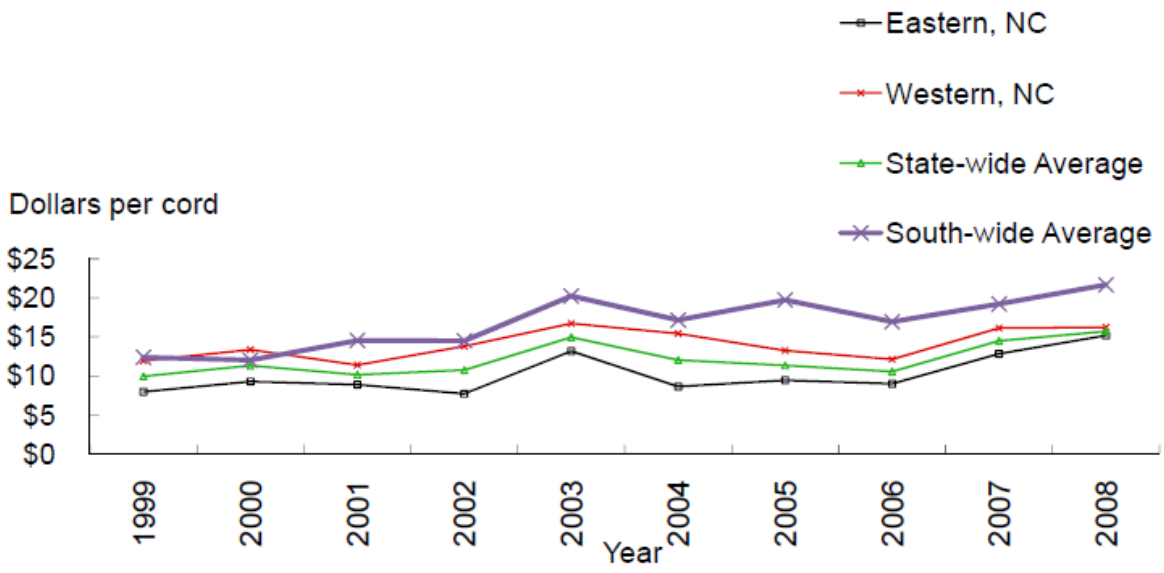
Source: Timber Mart–South, 2009

FIGURE 4*c*-7. Eastern versus western NC hardwood pulpwood prices.



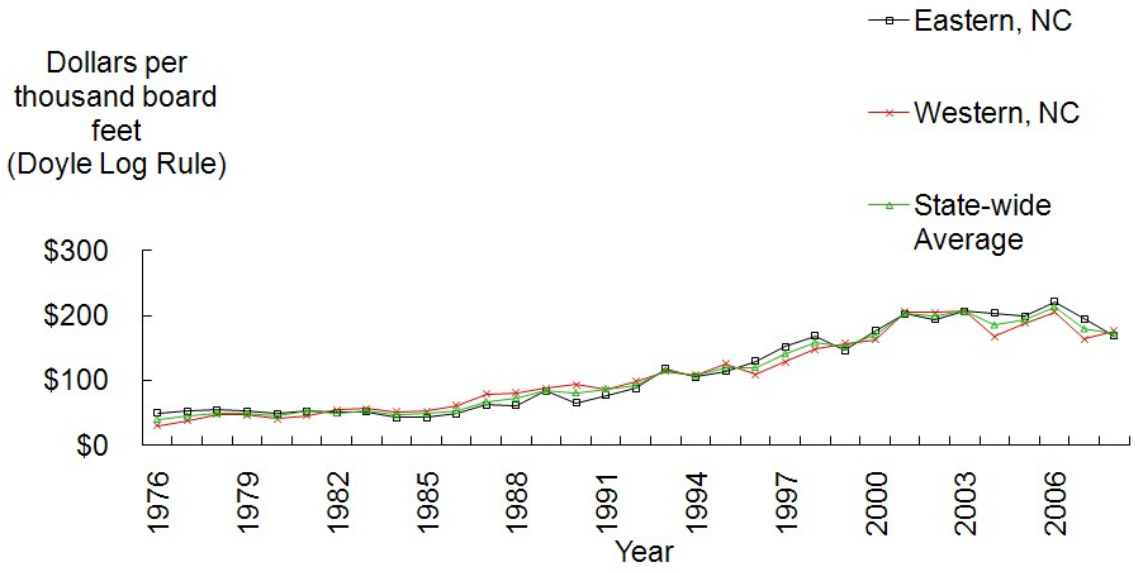
Source: Timber Mart–South, 2009

FIGURE 4*c*-8. Hardwood pulpwood stumpage price history, 1999 to 2008.



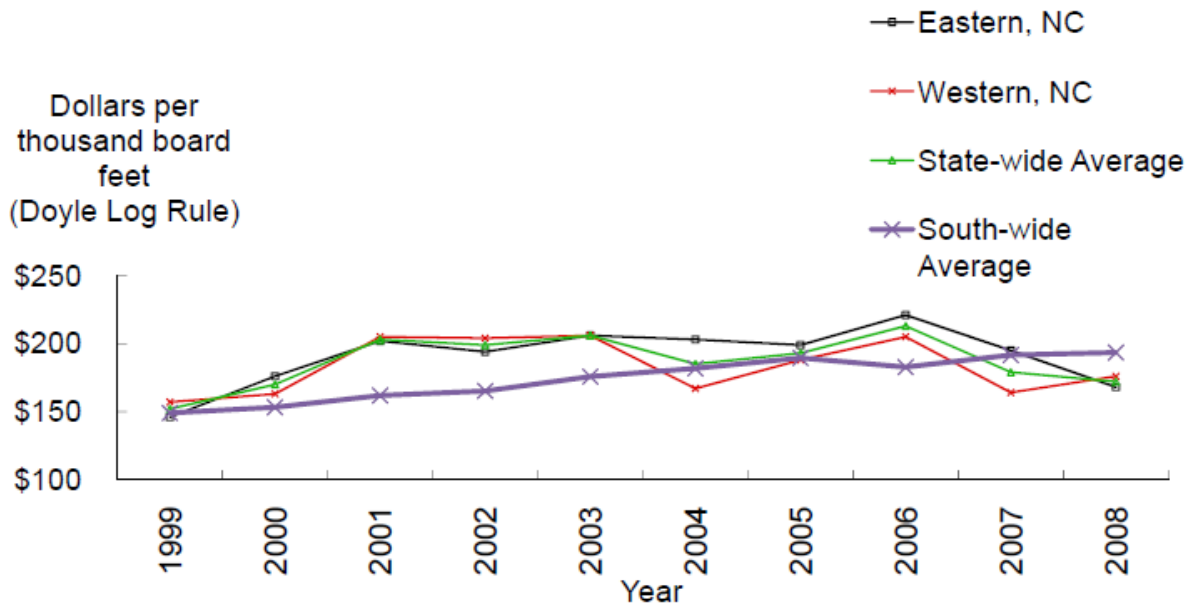
Source: Timber Mart–South, 2009

FIGURE 4*c*-9. Average mixed hardwood sawtimber stumpage prices by NC region and statewide, 1976-2008.



Source: Timber Mart–South, 2009

FIGURE 4*c*-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 4*c*-11).

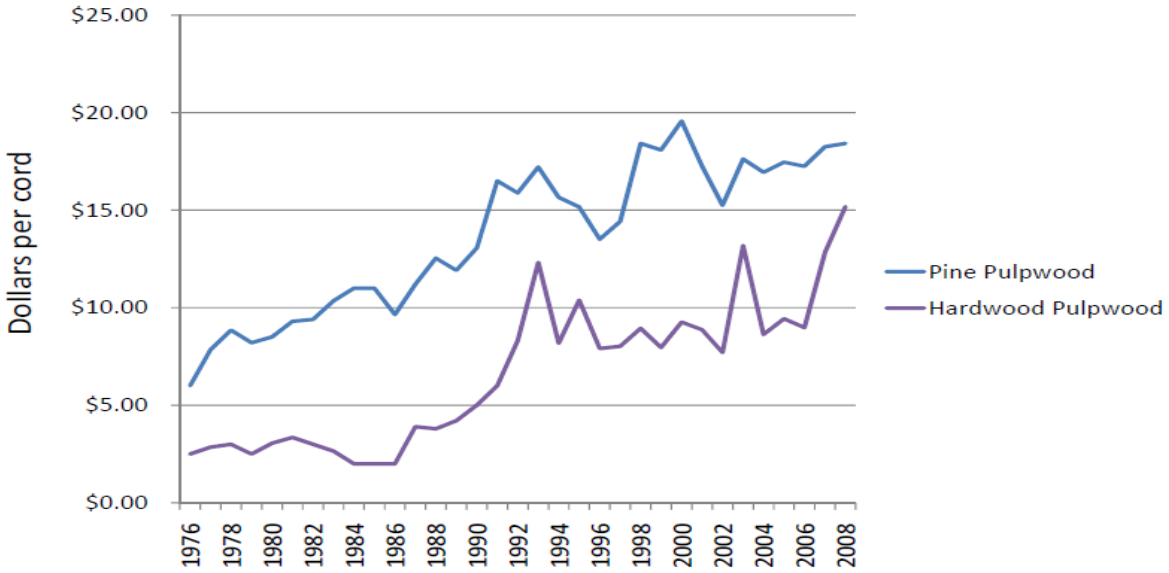
In western North Carolina, the situation is different. From 1976 to around 1993, pine pulpwood enjoyed a significant price differential over hardwood pulpwood. Beginning in 1993, the stumpage value of pine pulpwood began eroding at the average rate of 1.8 percent annually, while hardwood pulpwood increased 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 4*c*-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.

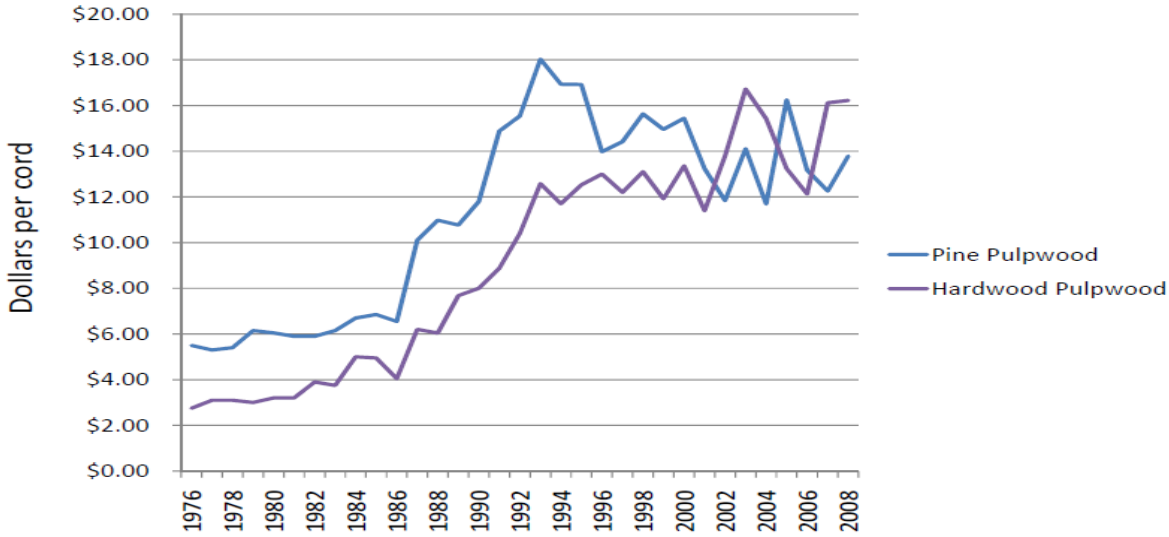
FIGURE 4*c*-13 depicts the 8-year average of county-level stumpage prices in North Carolina. Primary wood-using facilities are also displayed to help correlate stumpage values with the number and type of facilities in the drain area. Total stumpage value averaged over an 8-year period from 2001 to 2008 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 4*c*-11. Eastern NC pulpwood price comparison, pine versus hardwood, 1976 – 2008.



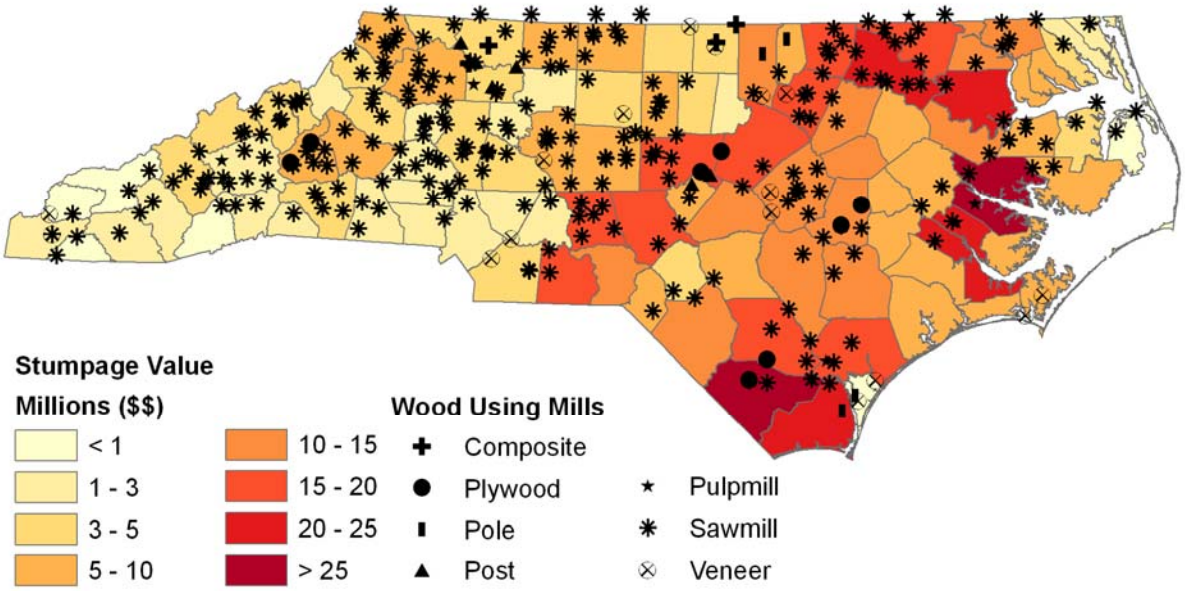
Source: Timber Mart–South, 2009

FIGURE 4*c*-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

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.

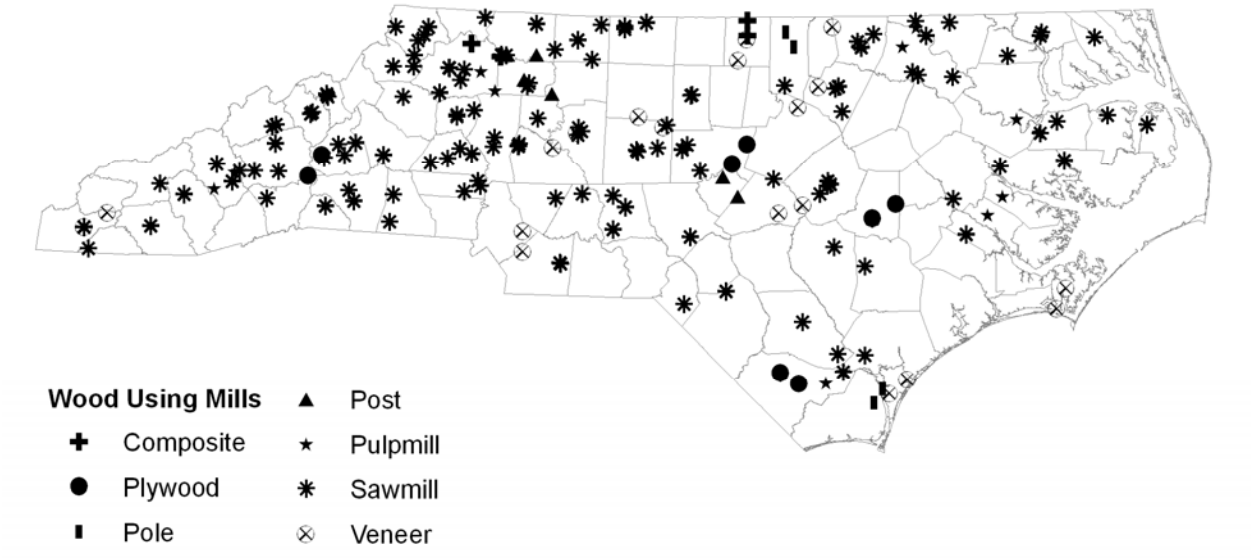
Primary Processing Facilities

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

	Year										Percent (%) Change 1990 to 2007	Annual percent (%) change
Mill Type	1990	1992	1994	1995	1997	1999	2001	2003	2005	2007		
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

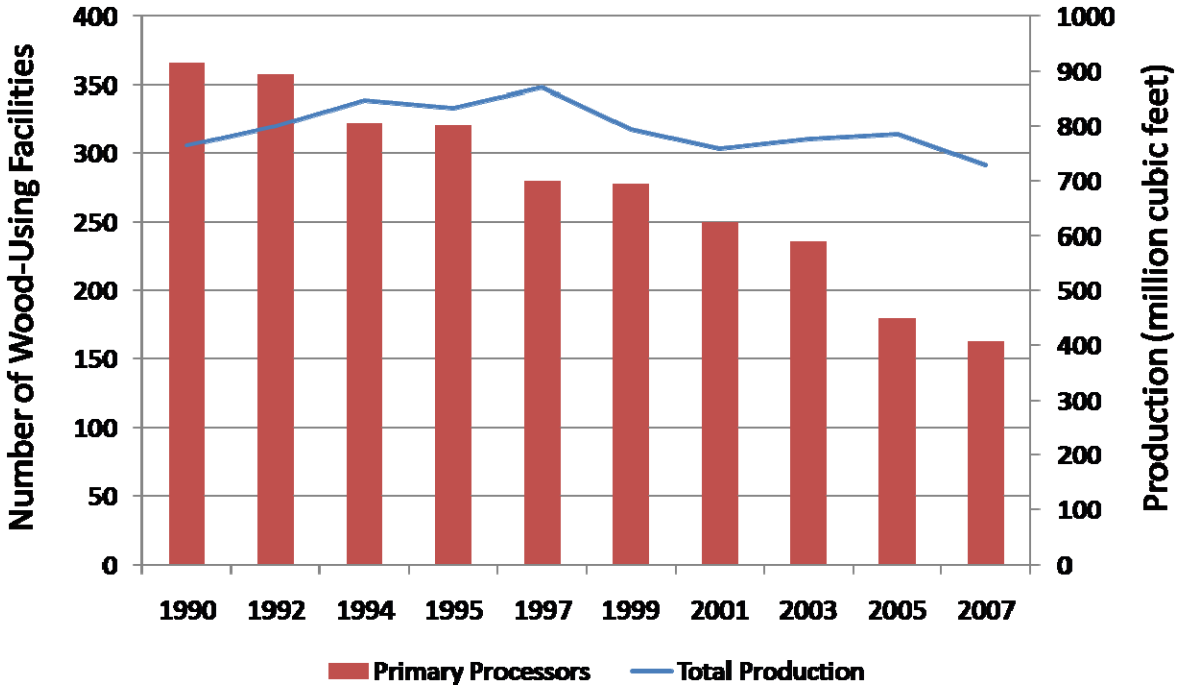
Source: Cooper, and Mann, 2009

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.

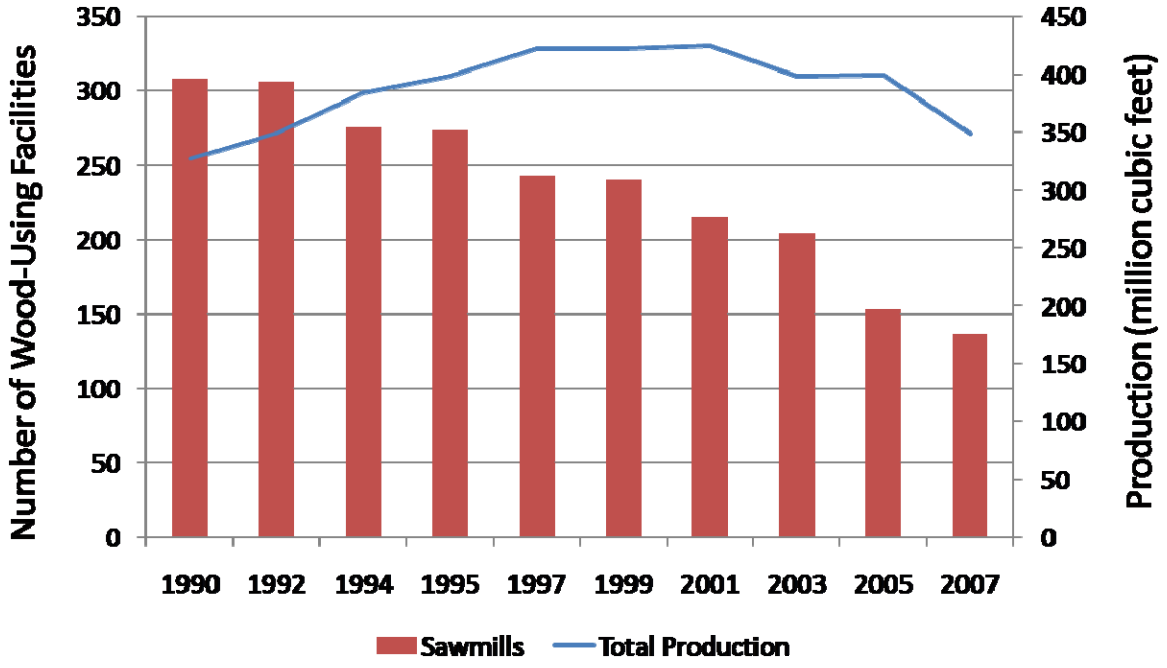
In 2007, total roundwood receipts at the 136 sawmills were 374.4 million cubic feet and accounted for 52 percent of North Carolina's total receipts for primary processors (FIGURE 4*d*-3). Softwood represented 71 percent of total roundwood receipts, while

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).

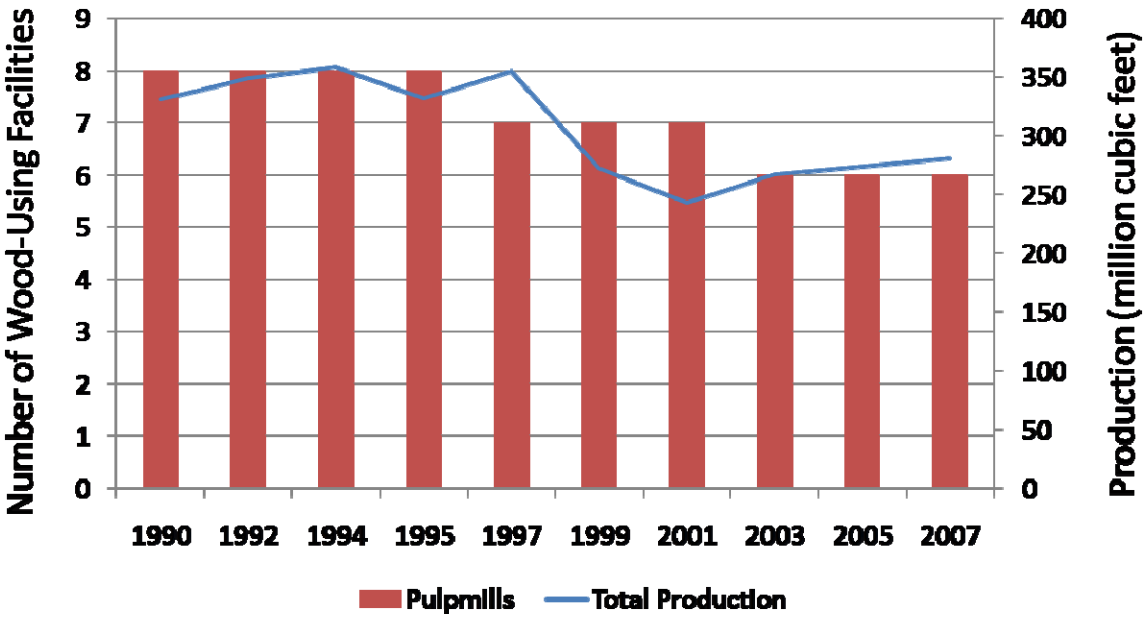
Seventy percent of the roundwood cut for pulpwood was retained for processing by NC pulp mills. Roundwood pulpwood exports amounted to 85 million cubic feet, while imports totaled 50 million cubic feet, making North Carolina a net exporter of roundwood pulpwood.

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

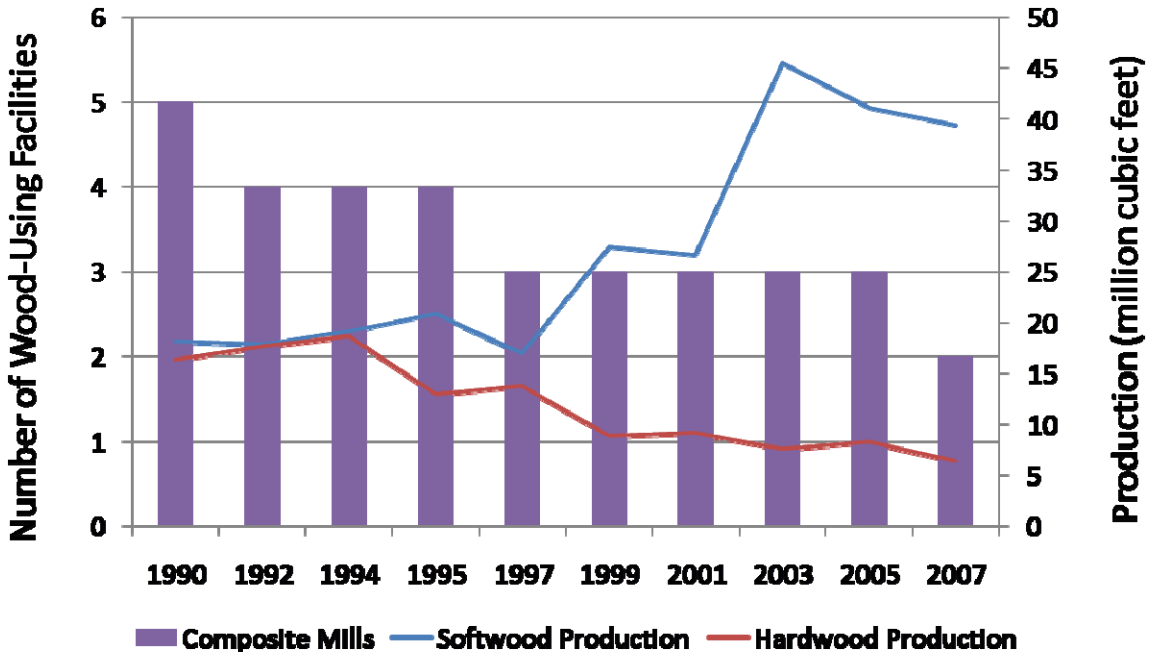
In 1990, more than 30 veneer or plywood mills were operating in North Carolina. By 2007, less than half of them remained in operation. The piedmont, with seven mills, has the most facilities, followed by the southern coastal plain with four facilities, the mountains with two, and the northern coastal 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.

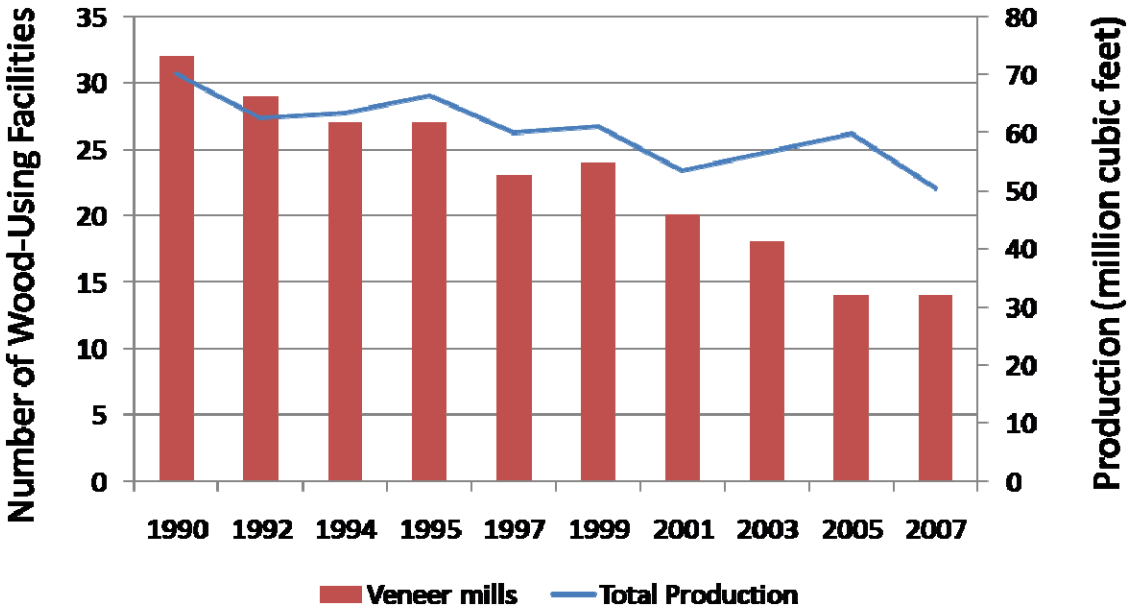
North Carolina retained 85 percent of its veneer log production for processing at veneer mills within the state. Imports amounted to 10.7 million cubic feet, while exports totaled 7.3 million cubic feet, making North Carolina a net importer of roundwood veneer logs.

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

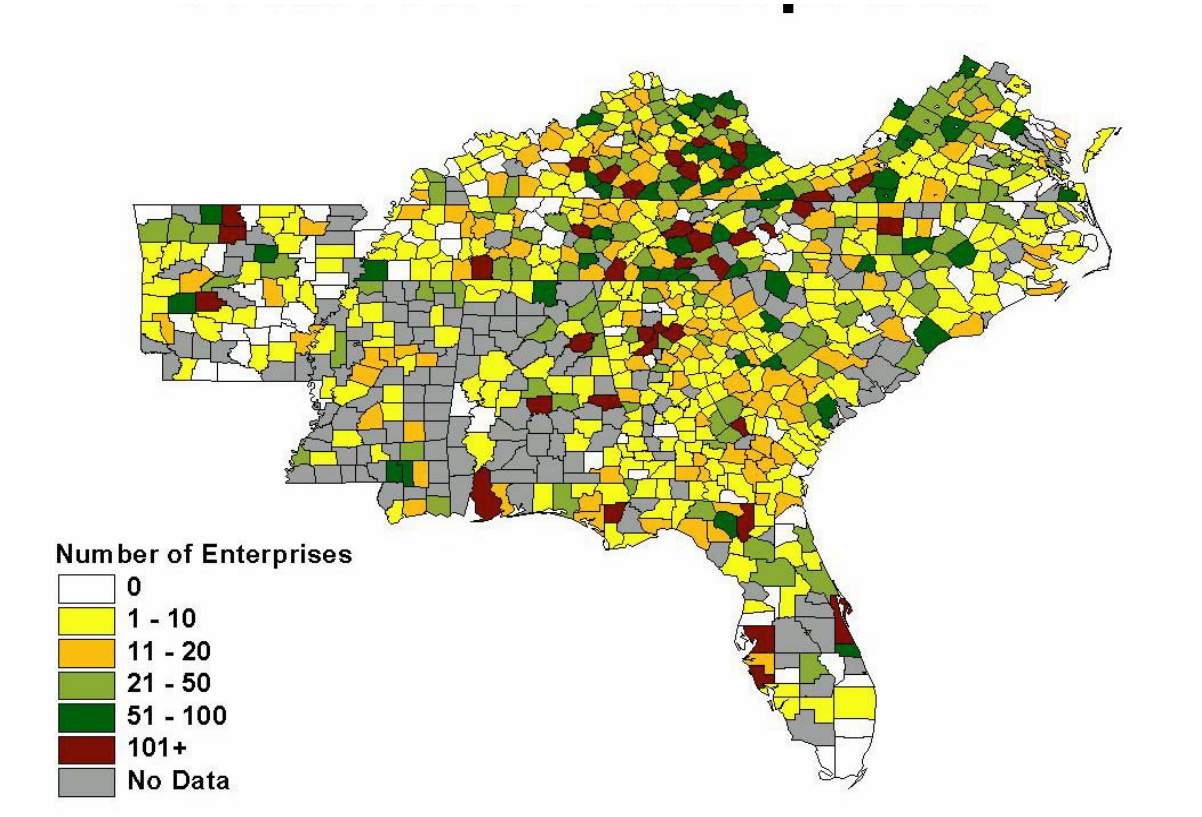
It is difficult to assess the annual impacts or economic value for most of the NTFPs because of the generally small, niche-type operations and localized markets developed around the growing, collecting, and harvesting of the forest resources that make up these products. The NC Pine Needle Producers Association 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

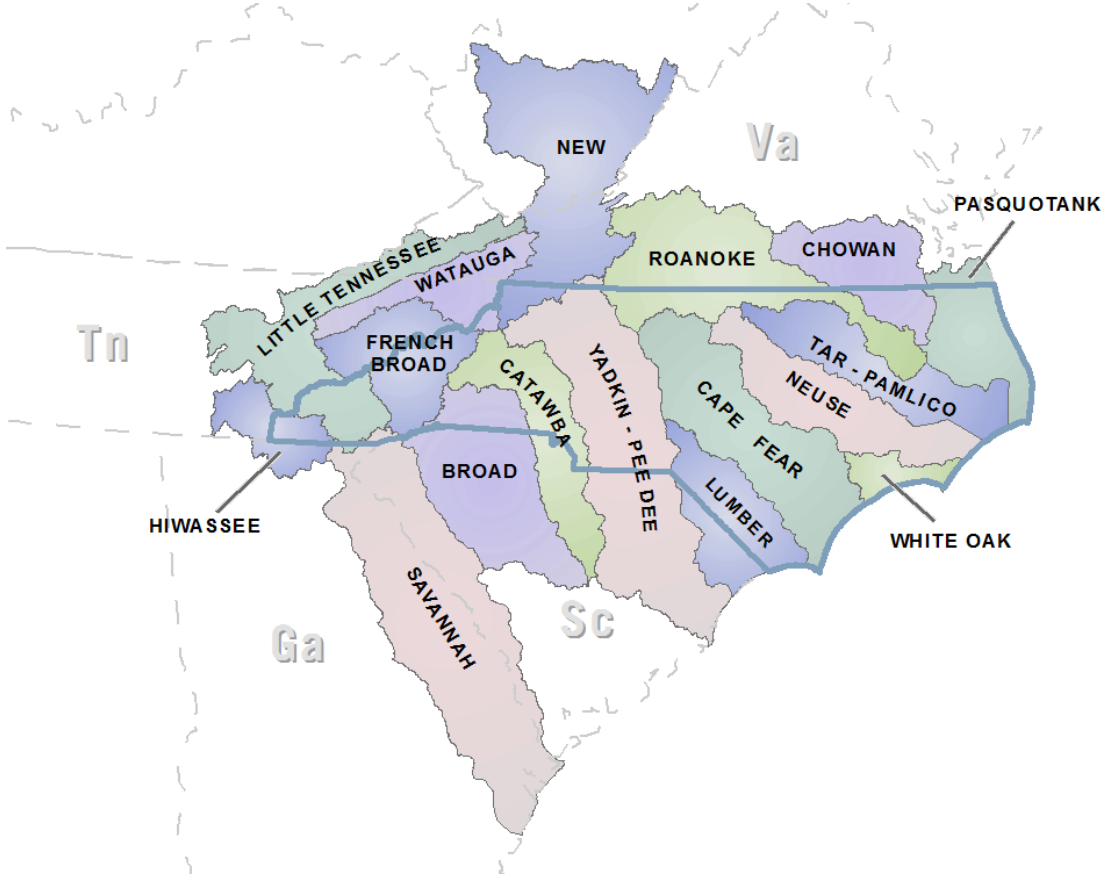
Because of North Carolina's rapid population growth over the past decade, water resources are critically important for supporting socioeconomic development as well as biodiversity, recreation, and other uses. Within the state's boundary, there are

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).

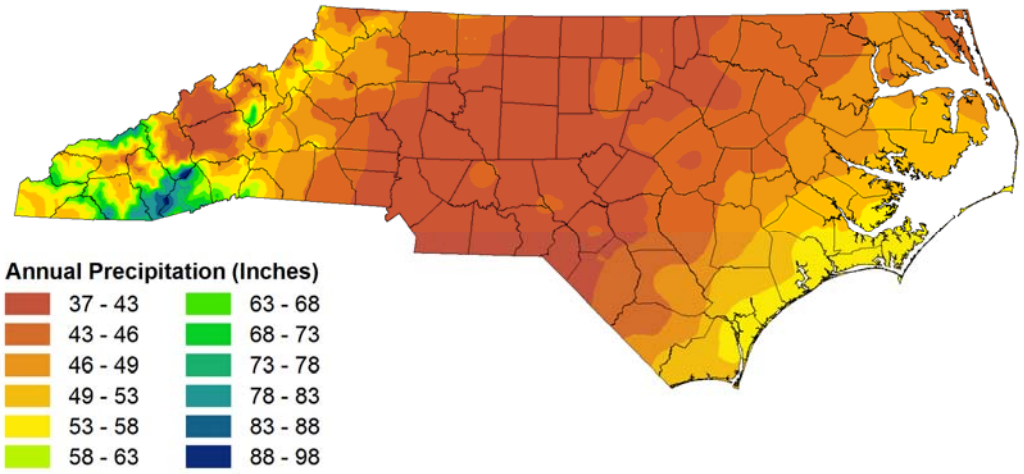
While North Carolina is fortunate historically to have abundant surface and subsurface water resources, significant population increases and land-use conversions coupled with droughts have led to decreasing water quality and quantity in some areas. One of the primary stressors on water quality and quantity 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.



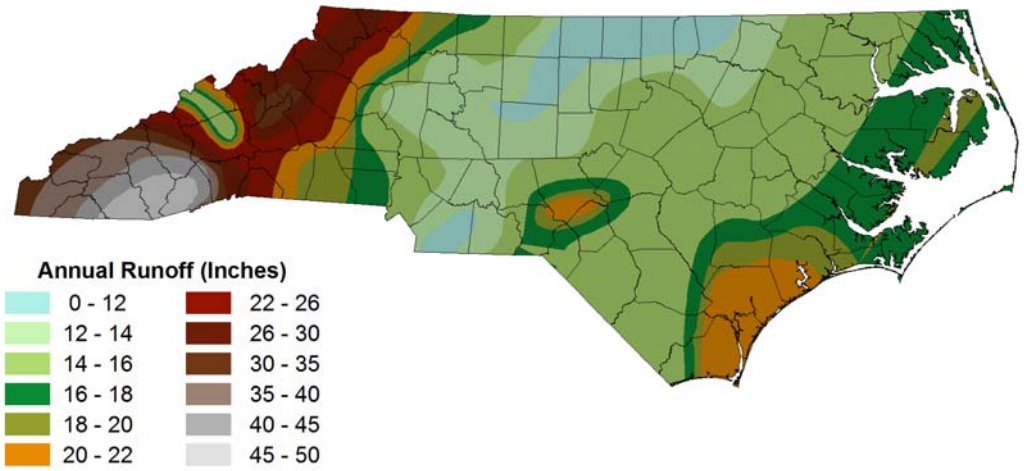
Source: NC Wildlife Resources Commission, 1999

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.

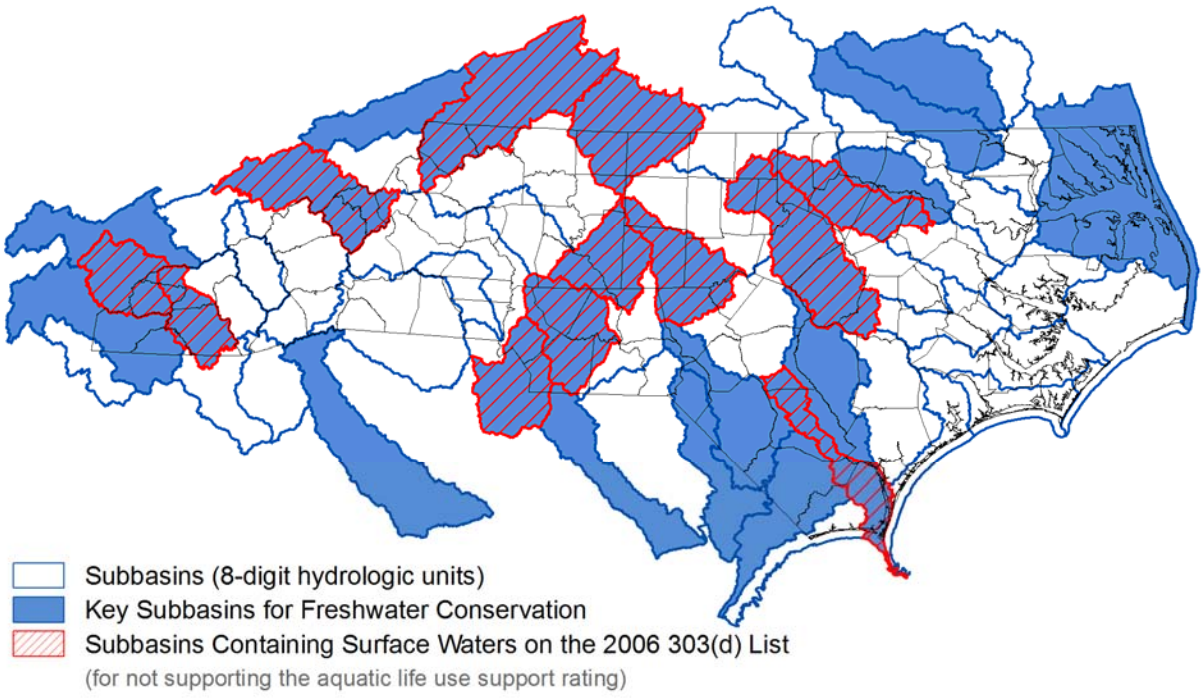
In addition, as discussed in the *NC Wildlife Action Plan*, The Nature Conservancy (TNC) identified 25 subbasins (8-digit hydrologic units) as aquatic conservation priorities for the protection of freshwater biodiversity in North Carolina (Master et al., 1998). Twelve of the 25 subbasins identified in 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.



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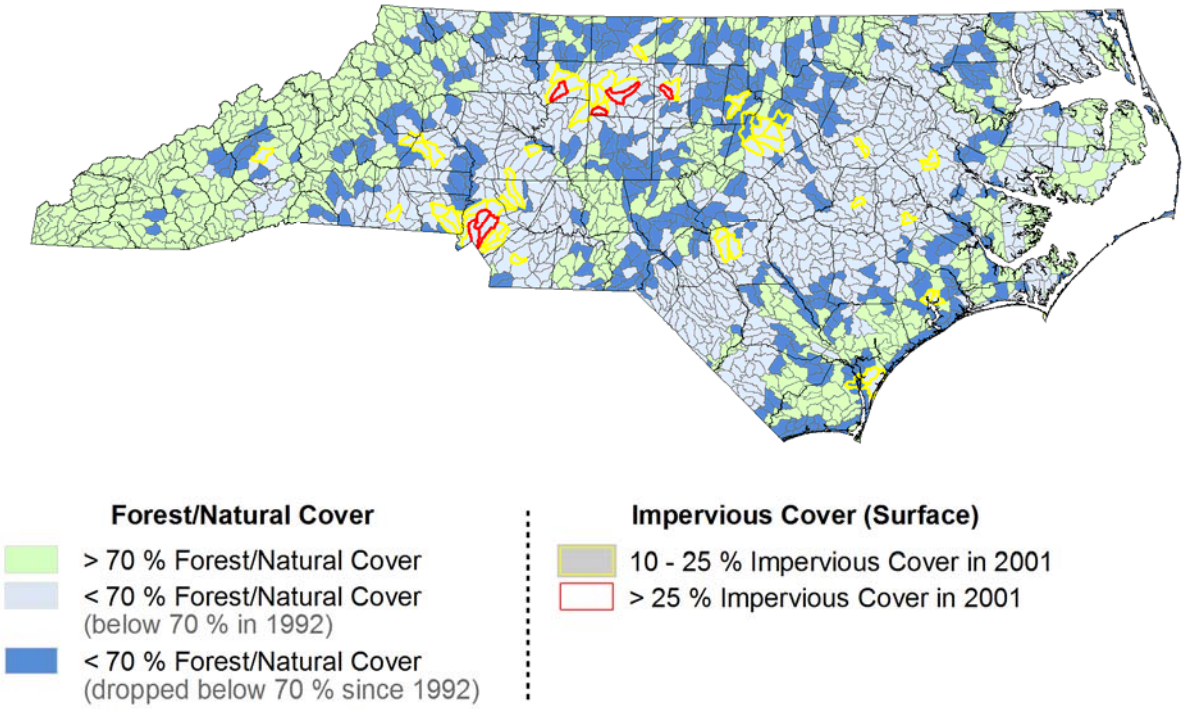
The Center for Watershed Protection (CWP) summarized the findings of several studies on water quality and watershed impervious cover (Schueler,1994), and integrated the findings into a general watershed planning model, known as the impervious cover model (ICM). The ICM predicts that most stream quality 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

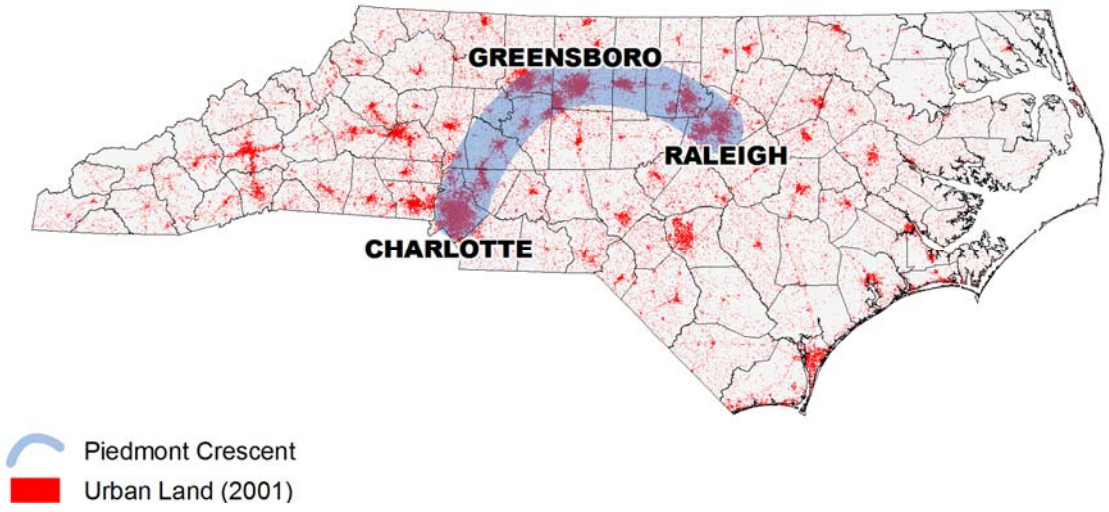
stream flows are greatly reduced during dry weather; the Cretaceous aquifers of the Coastal Plain, which have relatively slow recharge rates; and areas along the coast and on the Outer Banks, where the natural availability of freshwater is limited" (NCDWR, 2001) are customarily the areas that encounter 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.



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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.

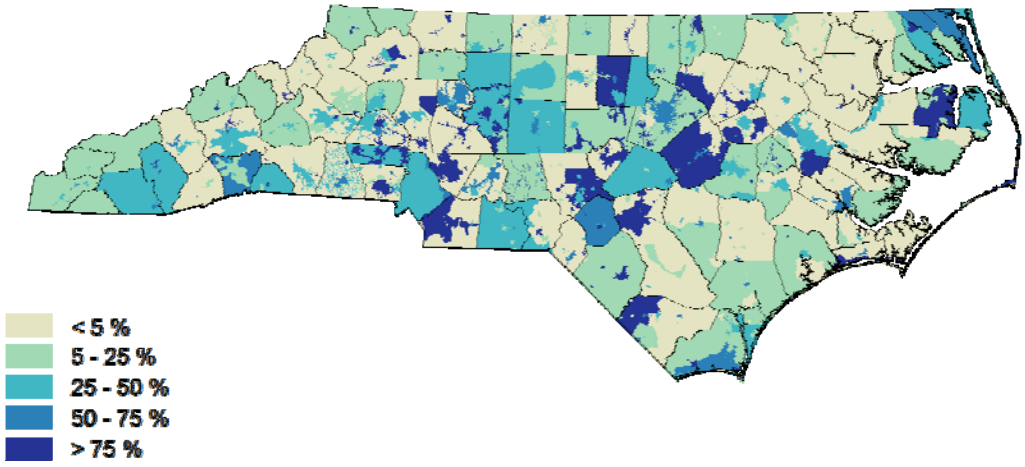
Priority Forest Watershed Assessment

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

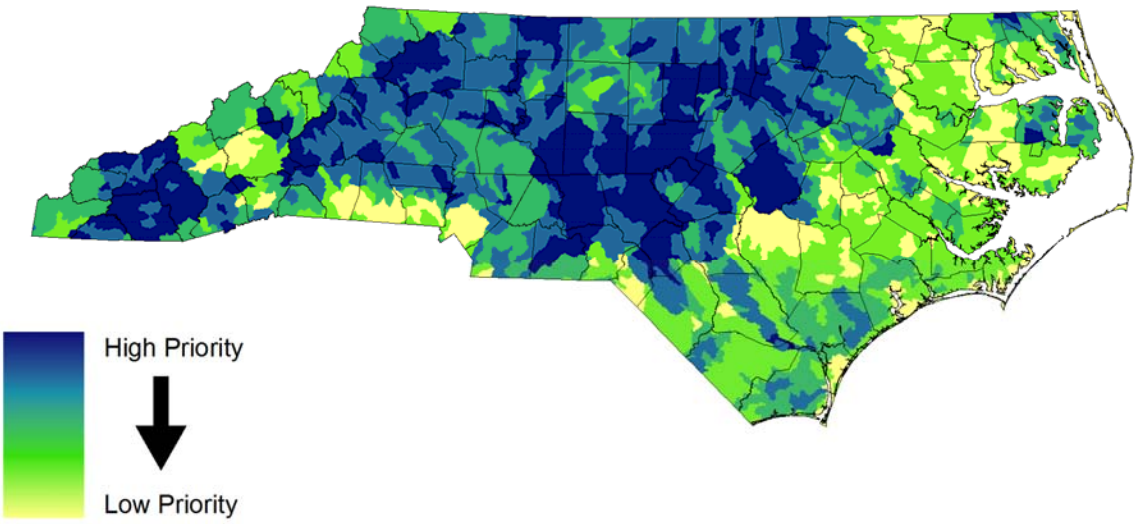
The maps in FIGURE 4*f* -8a and 4*f*-8b illustrate the priority forest watersheds with the darker shading representing the higher priority watersheds.

FIGURE 4*f*-7. Forecast of water demand growth 2005 – 2030 (all sectors included).



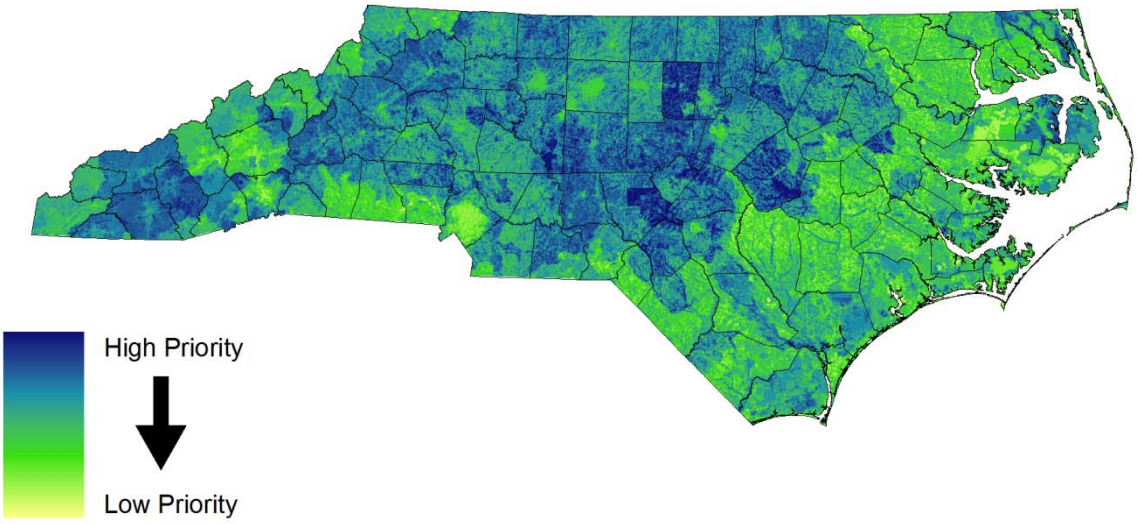
Created by: D. Jones, NCDFR, 2010

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

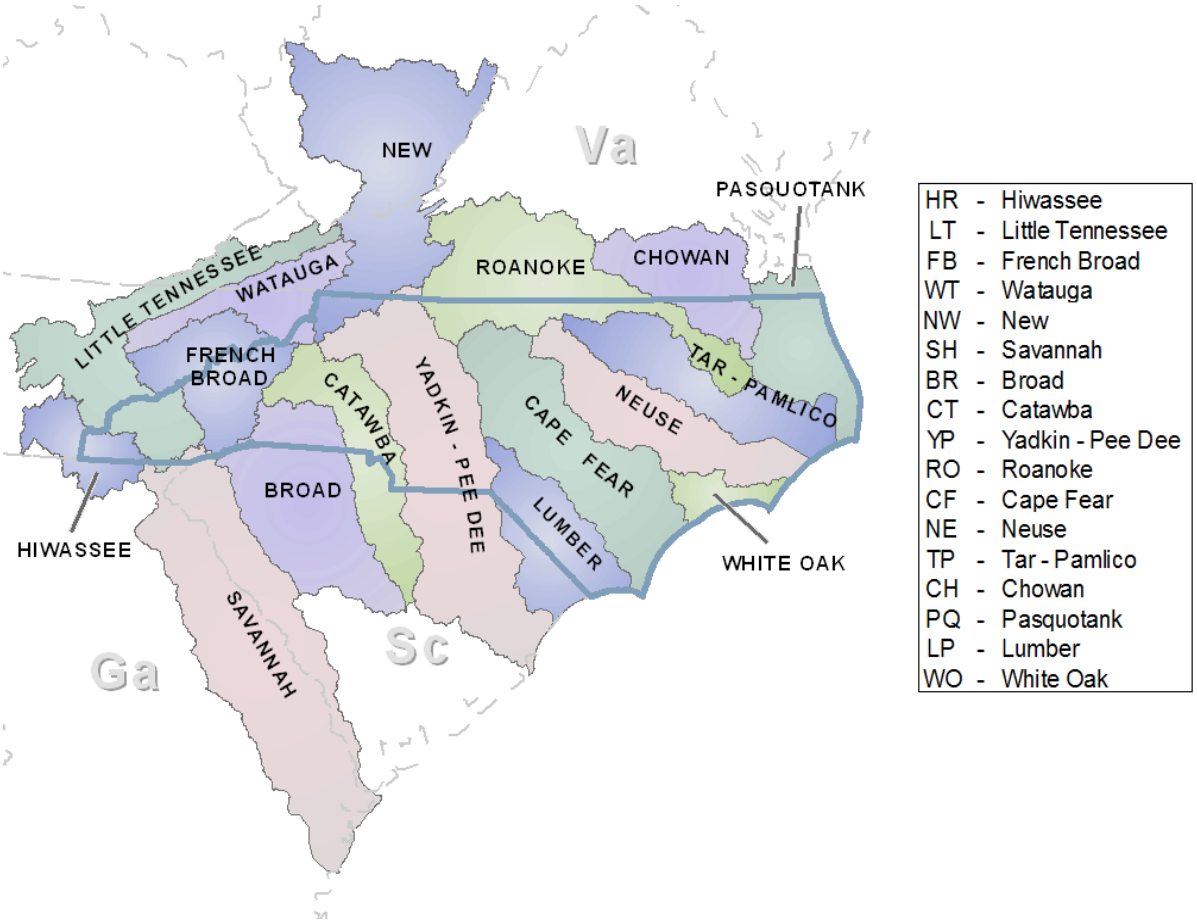
Aquatic and terrestrial systems are highly connected and interdependent. For example, upland land clearing activities can erode and send sedimentation into adjacent lowland and riparian habitats. North Carolina can make great strides if it adopts a comprehensive management strategy that links the conservation 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

FIGURE 4*g*-2. River Basins of North Carolina.



Created by: A. Bailey, NCDFR, 2010

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

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).

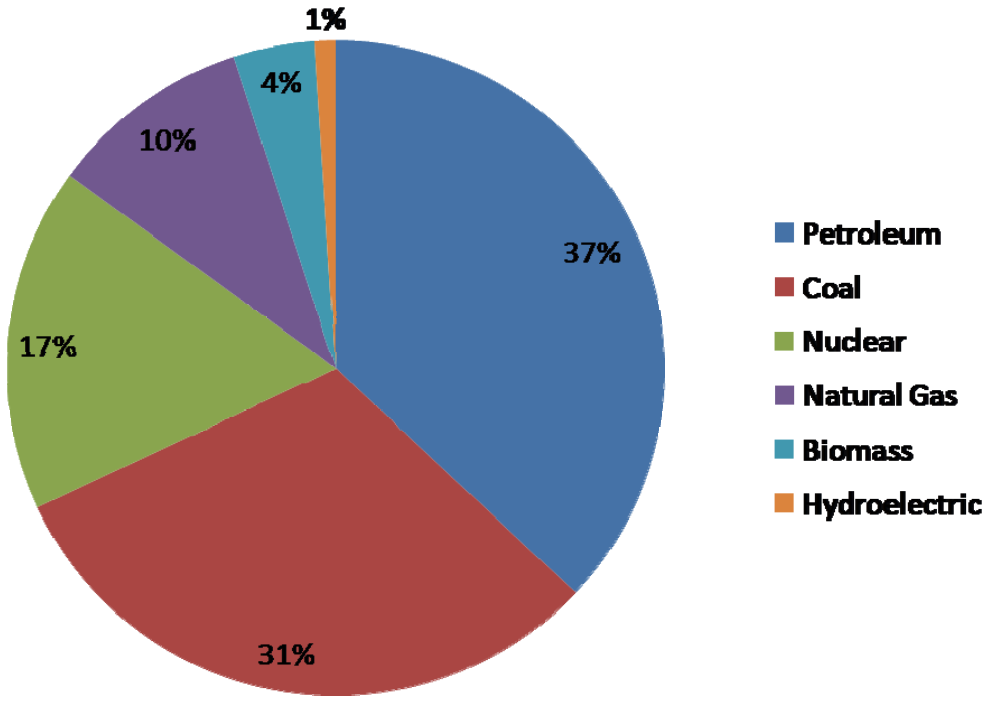
Bioenergy

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

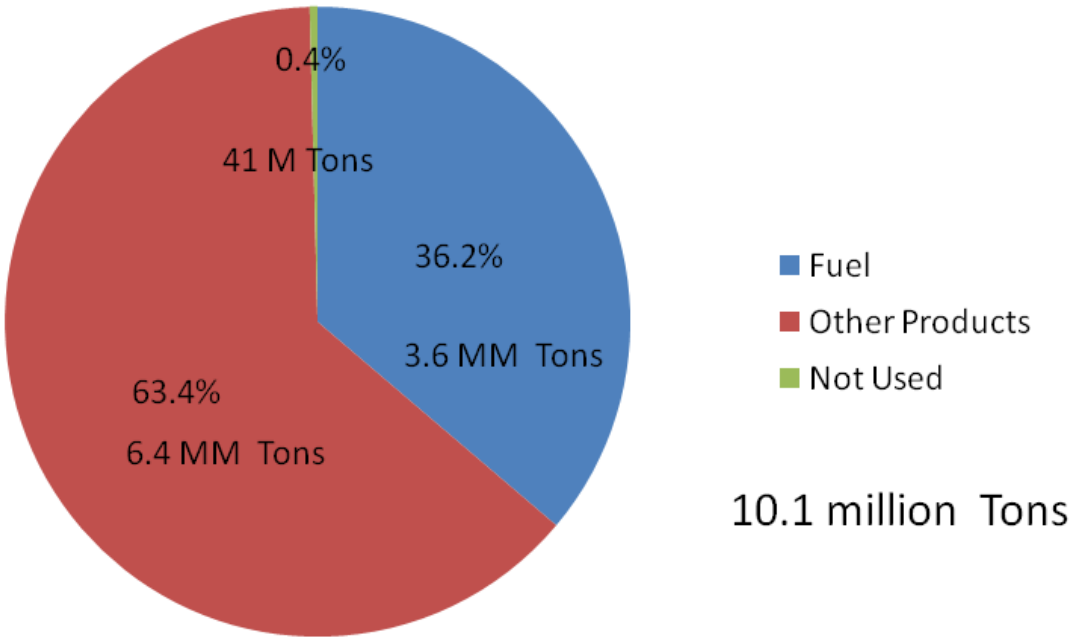
must come from in-state renewable energy sources, and 5 percent can be credited to energy efficiency measures. Municipal utilities and electric cooperatives must meet a target of 10 percent renewable energy use and energy efficiency by 2018 under slightly different rules. Eligible renewable energy resources 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

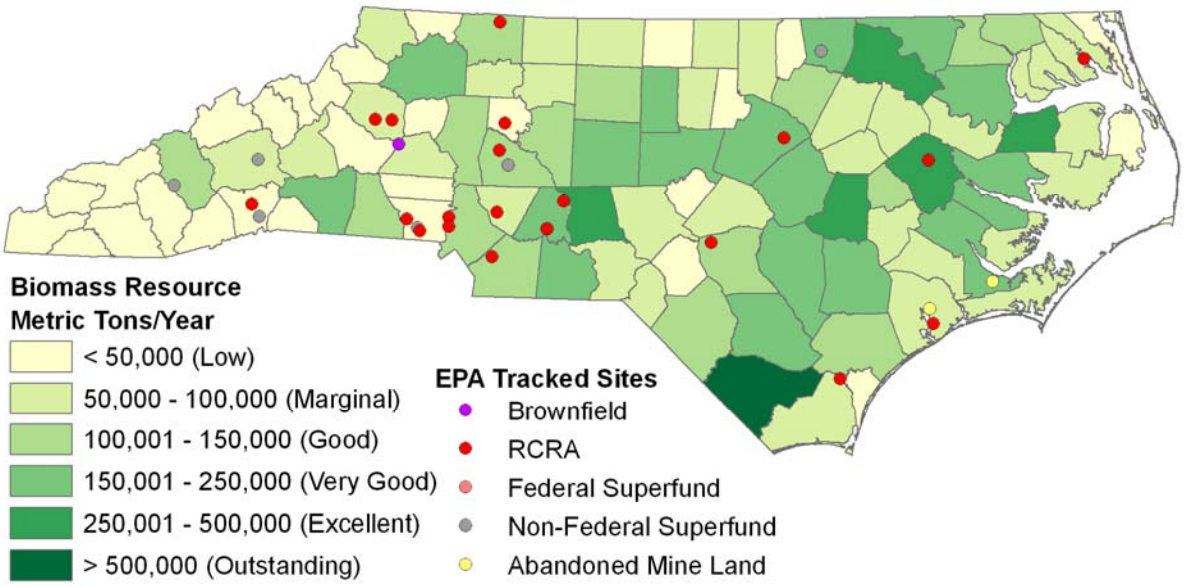
High energy costs, concerns over fossil fuel emissions, and legislation to favor renewable energy will likely contribute to new and expanded woody biomass markets. The expansion of a wood-based energy industry, however, has prompted concerns about intensified forest biomass removal and its impact on 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.

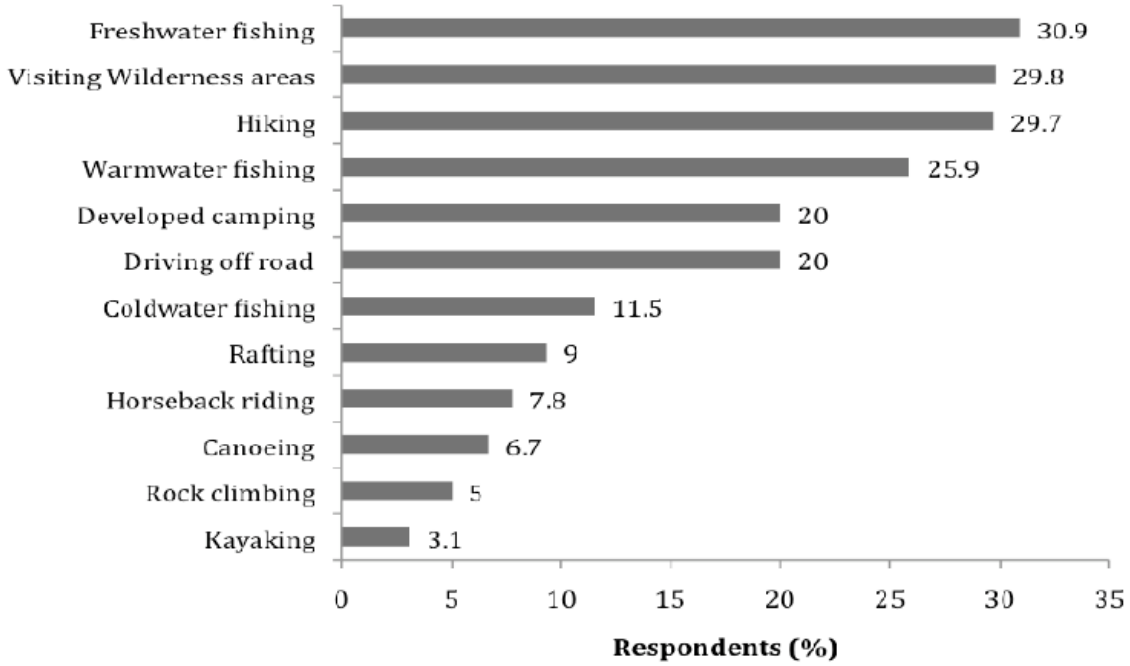
Demand for Forest-Based Recreation

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)

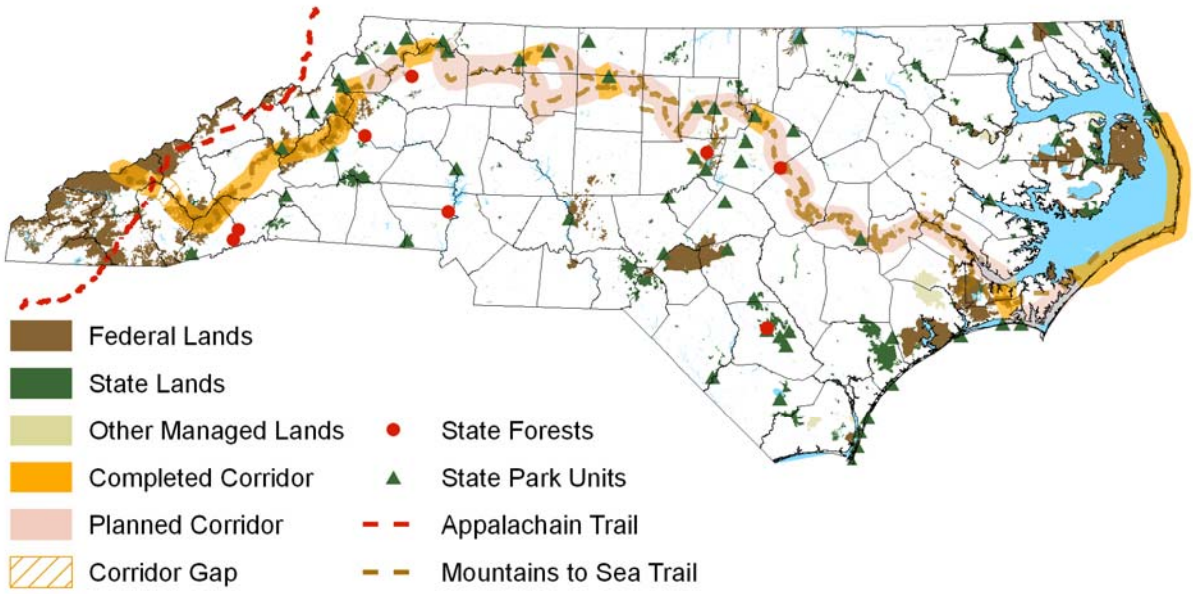
with more than one-third of that total on trip-related expenses. Those involved in fishing and hunting accounted for $1.8 million of that total and spent almost $900,000 for equipment. At least 2.8 million participants were involved in some type of wildlife or outdoor-related activity in 2005; and of 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

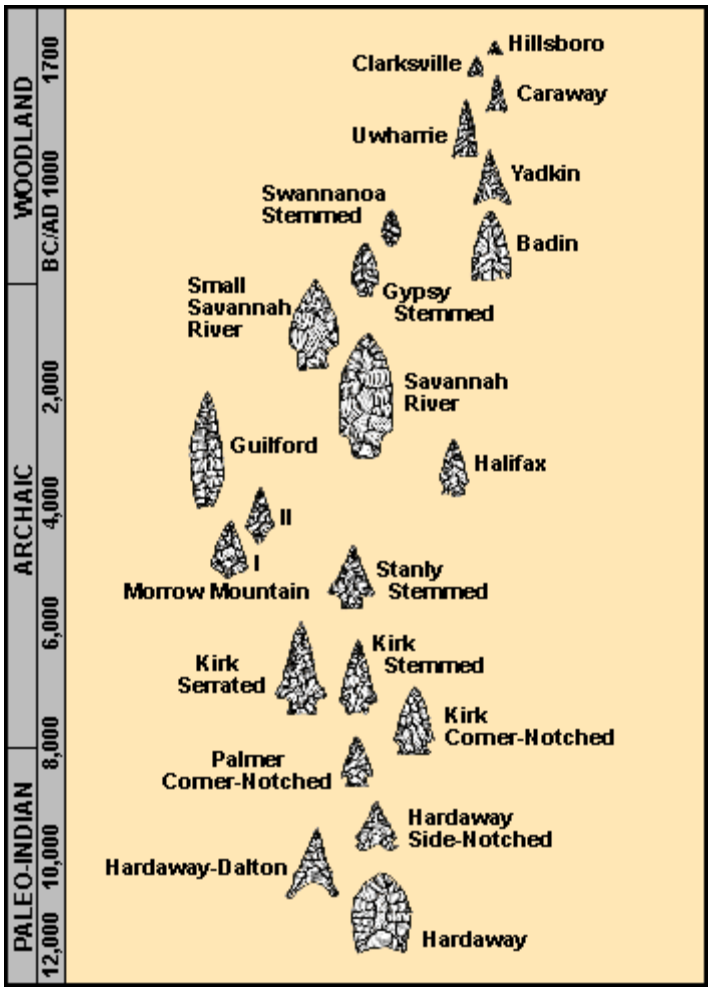
Forest Landscapes

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.

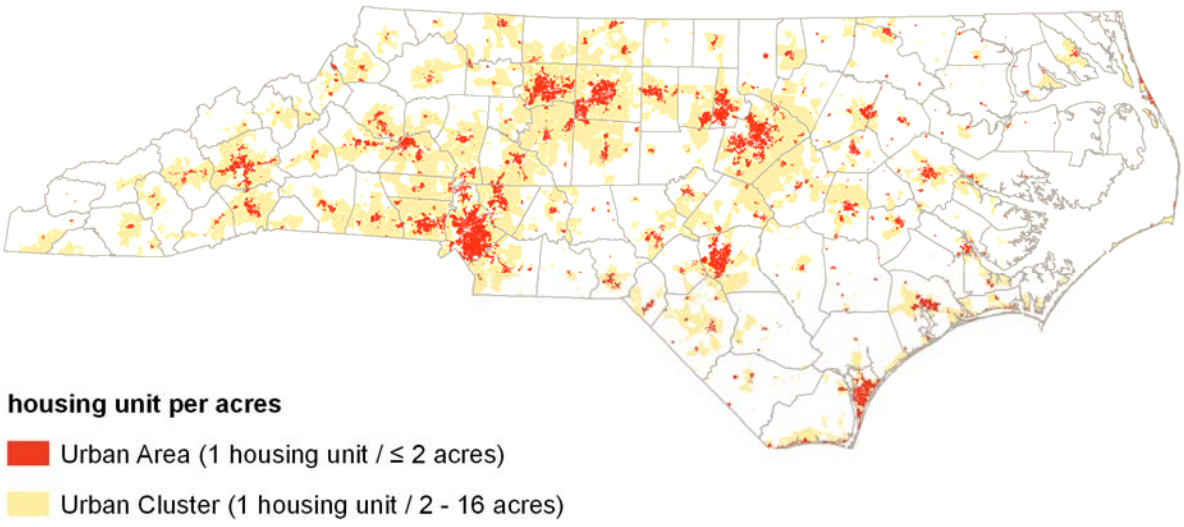
Introduction

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.

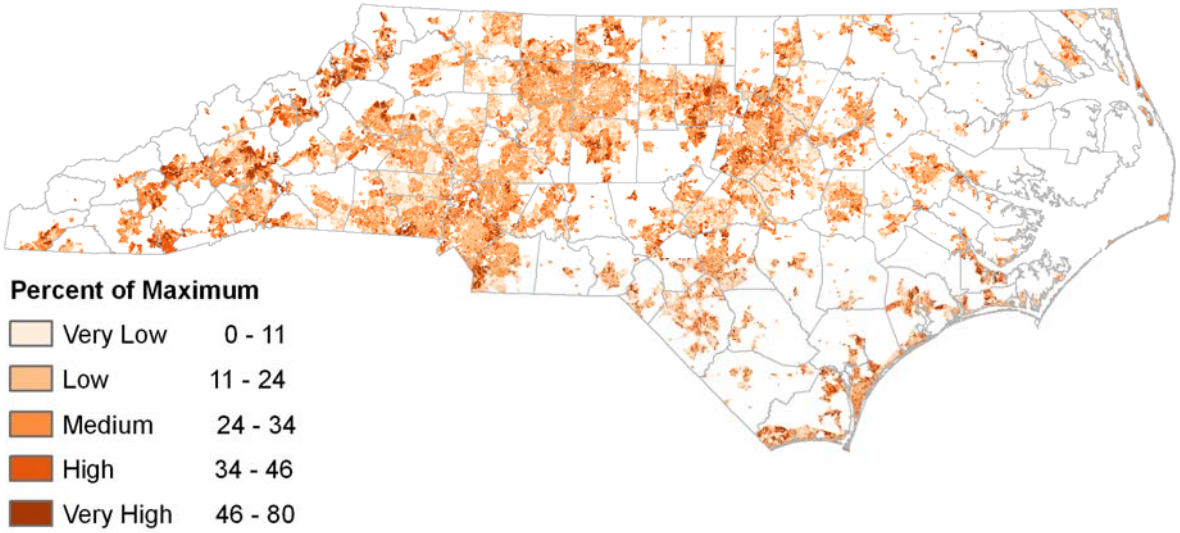
TABLE 4*k*-3.—Layer weights for Issue 1 (Changing land use patterns and increasing urbanization are threatening the health and viability of urban forests.)

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

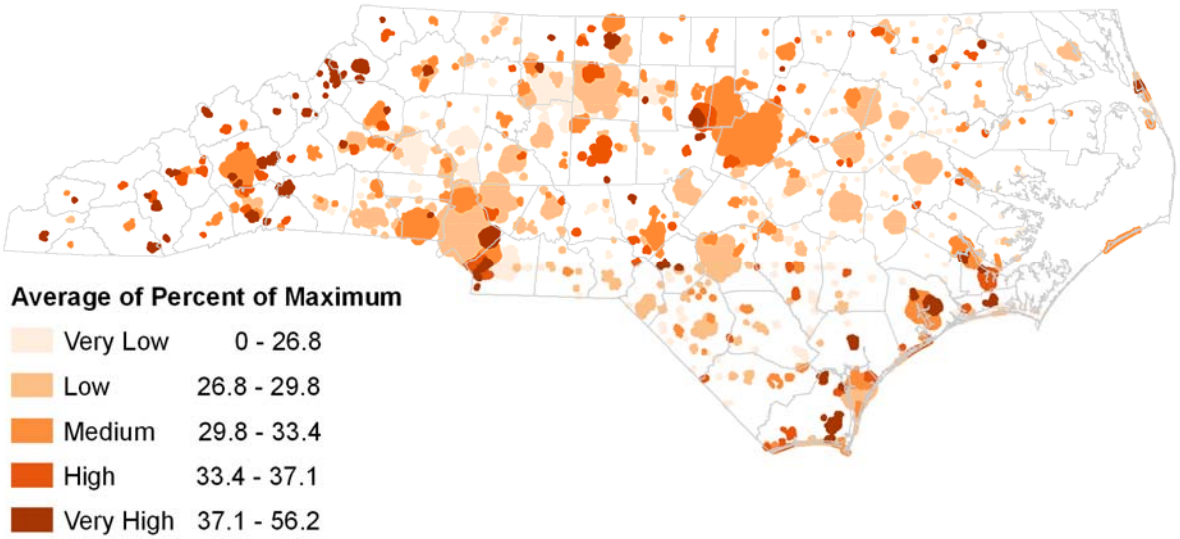
The very high and high priority ranked places are communities that have the greatest amounts of urban forest resources available to manage and where management activities could help reduce the impact of urbanization and land-use changes on the urban forest (FIGURE 4*k*-3). High priority communities varied 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.

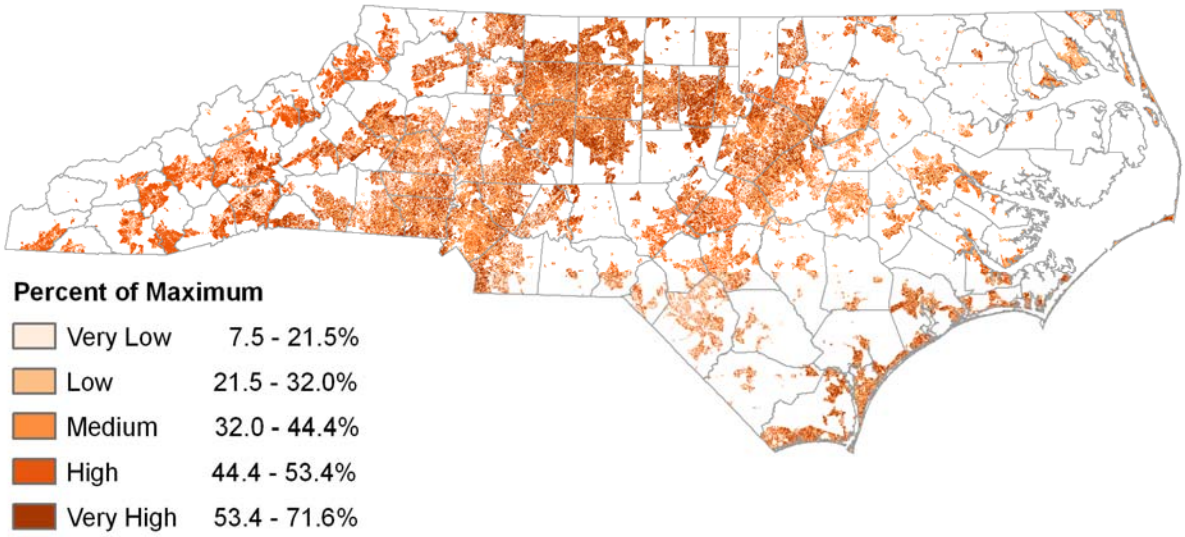
As impervious surfaces replace forest canopy and vegetation, urban “heat islands” develop. Urban heat islands are areas that become warmer than their rural surroundings, forming "islands" of higher temperatures in the landscape. On warm summer days, the air in a city can be 6 to 8°F hotter than in surrounding 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.

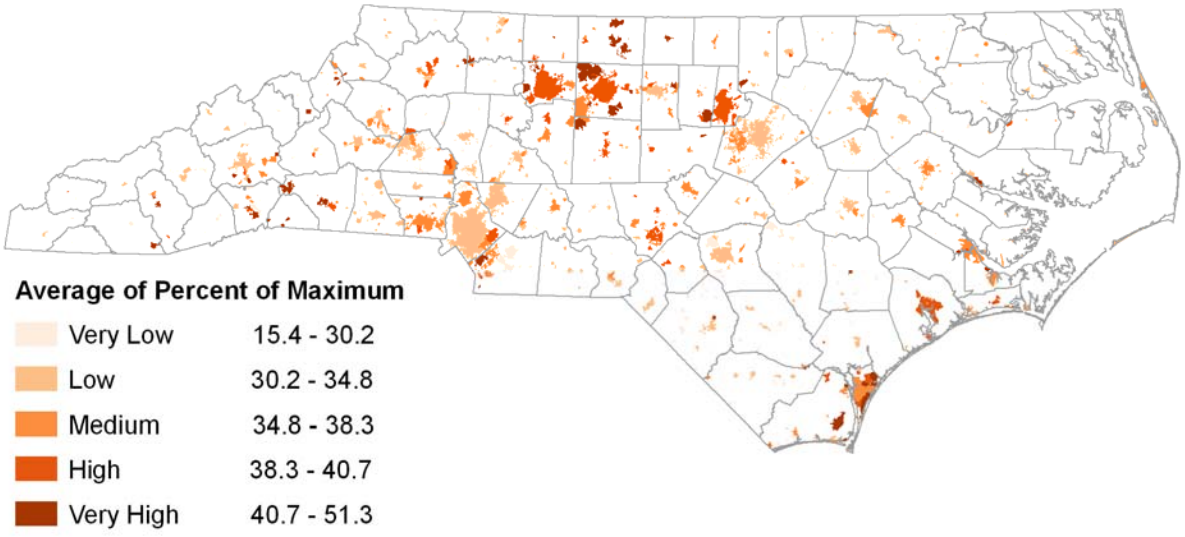
Urban and community forests provide important environmental and human health benefits, including carbon storage and sequestration, air pollution removal, surface

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).

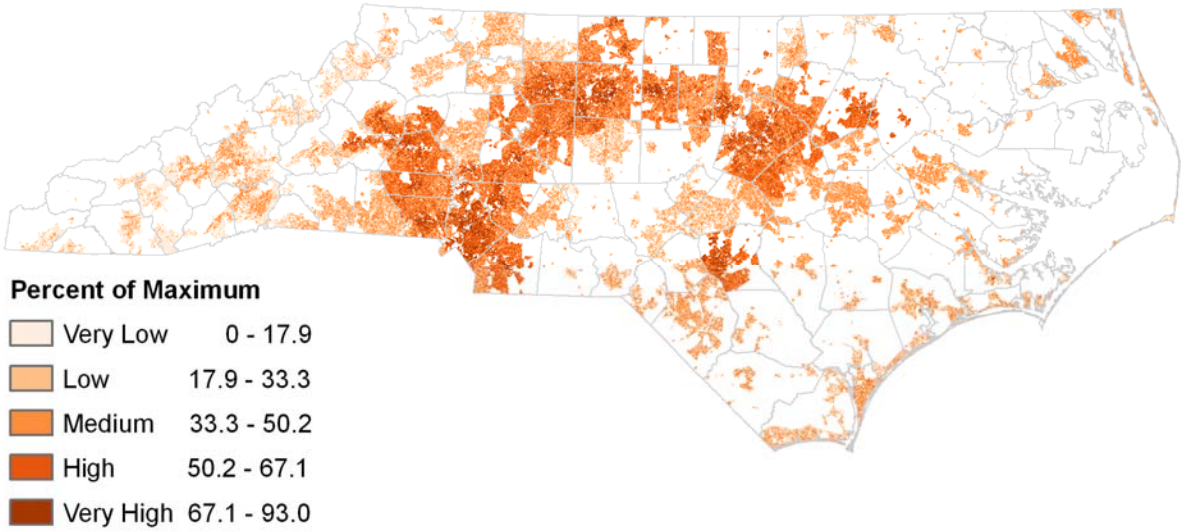
FIGURE 4*k*-7 identifies the communities where tree conservation efforts could be focused to provide the greatest impact on air quality. Most high priority municipalities are located in the NC piedmont, specifically along the I-40 and I-85 corridor. Nine of North Carolina's 13 largest cities are classified 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).

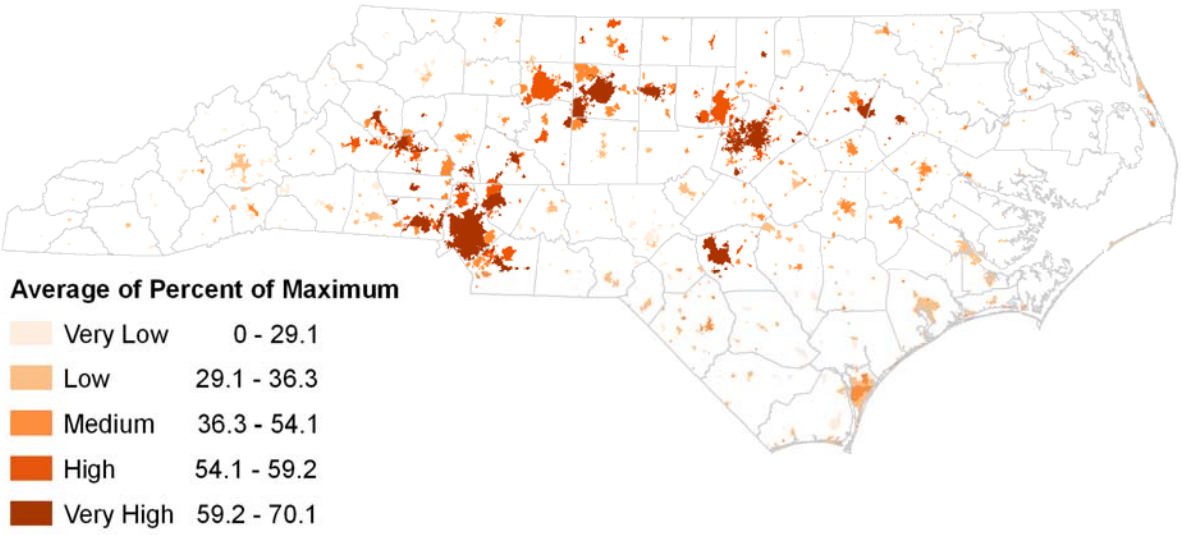
Urban trees are an underutilized tool in energy conservation efforts. A single large tree planted on the west side of a house can reduce annual cooling costs by 9 percent (Urban Forest Research, 2001.) Strategic planting of multiple trees around a building can reduce cooling costs by 15 to 35 percent, 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.



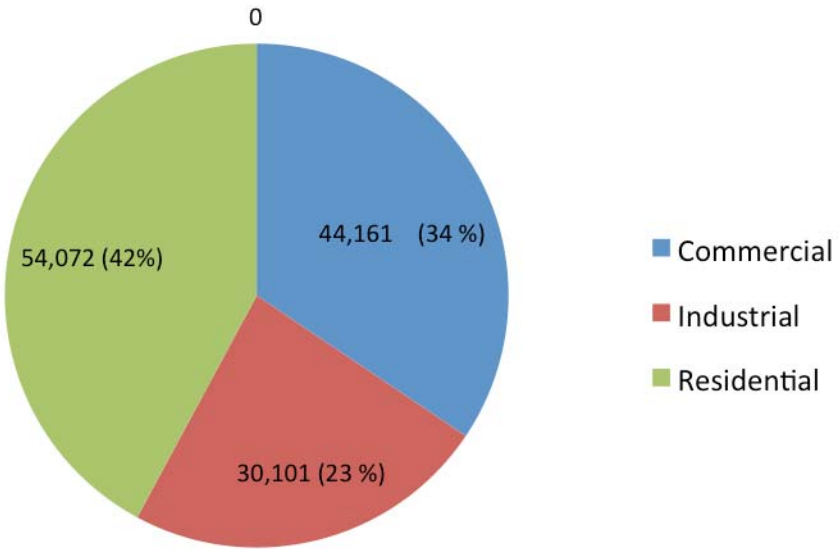
Created by: A. Moore, NCDFR, 2010

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

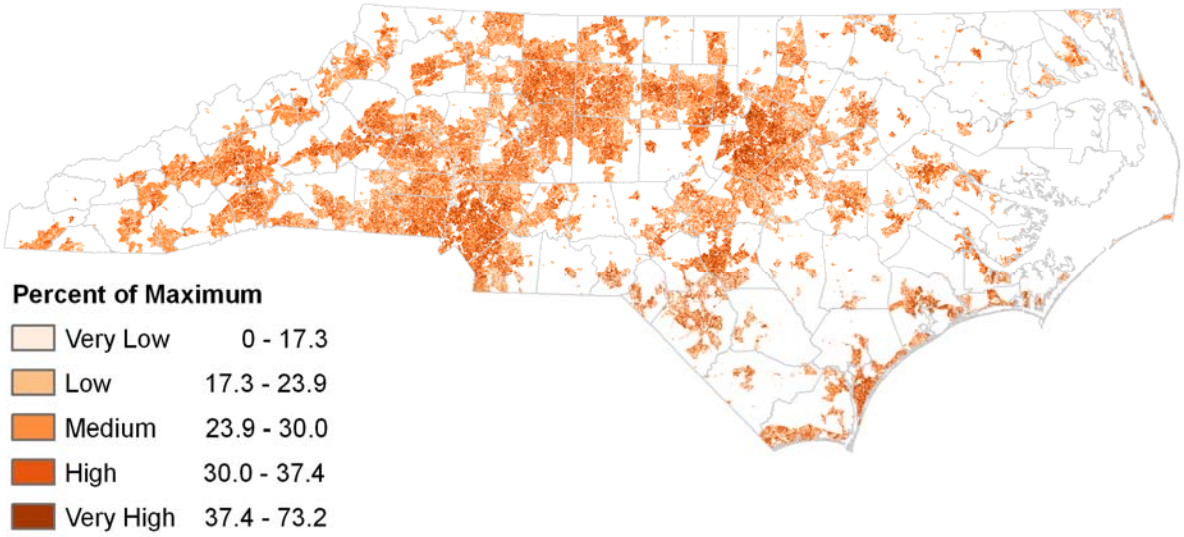
High priority areas are concentrated within and immediately adjacent to the medium and large municipalities across the state (FIGURE 4*k*-9). Communities identified on the map have the ability to reduce overall energy consumption by increasing the tree canopy, no matter what the community's priority 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.

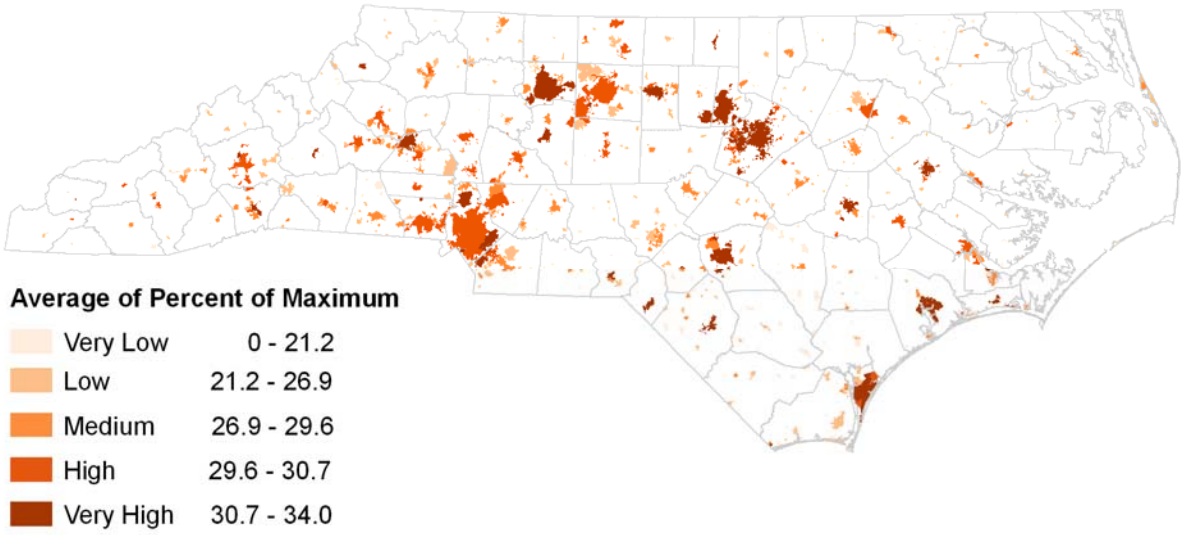
The NCDFR U&CF Program promotes the management of urban trees in North Carolina by providing technical, financial, and educational assistance to any group

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%

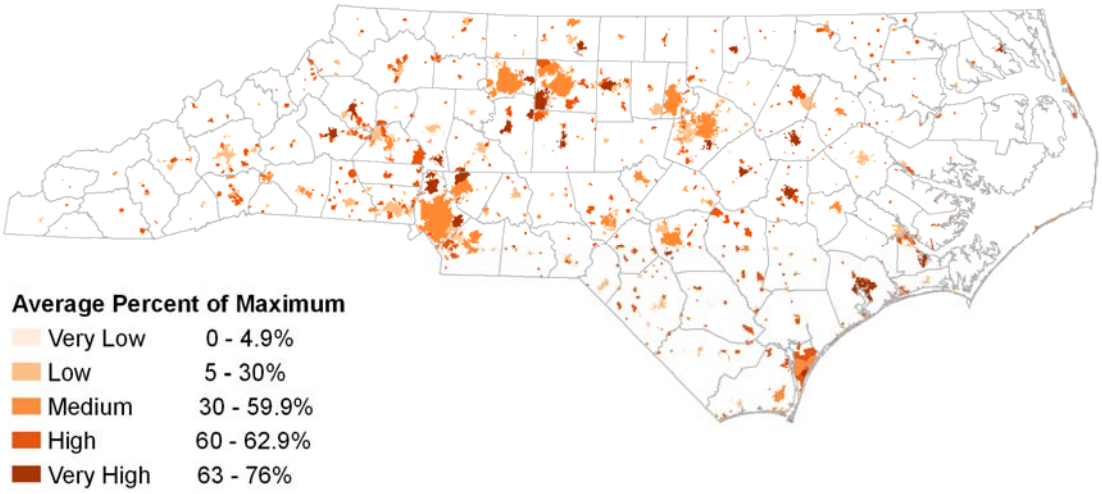
Created by: A. Moore, NCDFR, 2009

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%

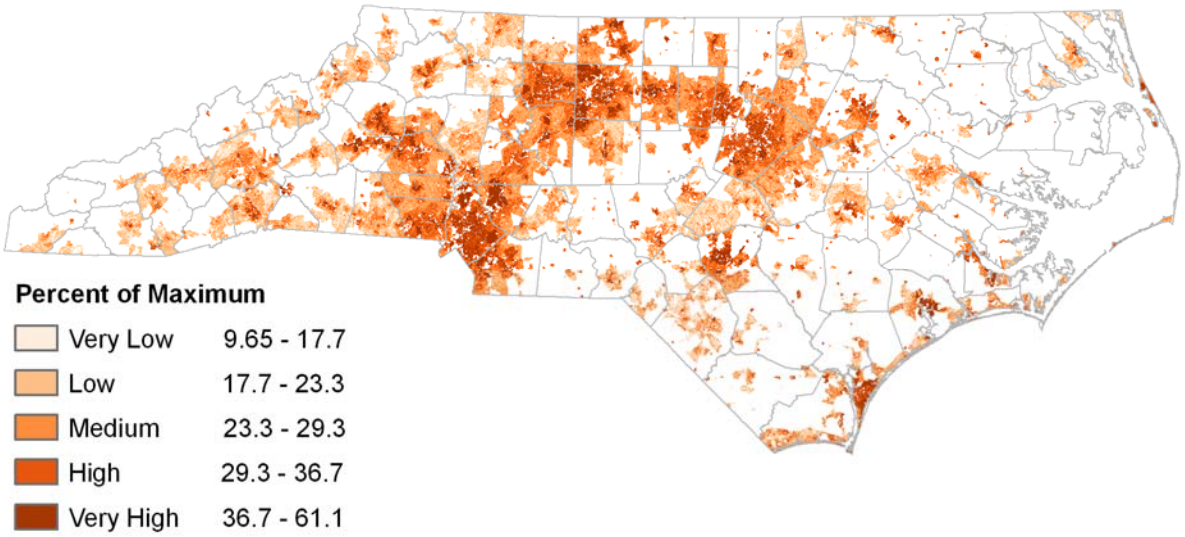
Created by: A. Moore, NCDFR, 2009

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

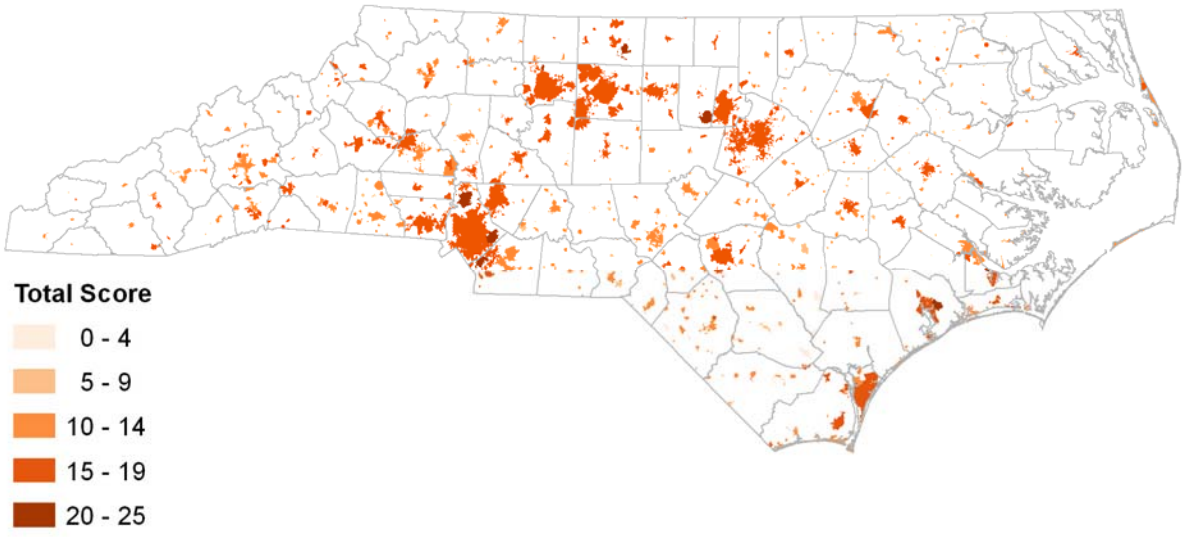
North Carolina is an urbanizing state, with a significant amount of growth expected to occur in the near future. Maintaining healthy and viable urban forests is a broad concept that brings together several key environmental and social goals and requires partnerships across jurisdictional boundaries. 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.