CHAPTER 4: SOUTH CAROLINA'S LANDSCAPE

Introduction

Atop Sassafras Mountain, the highest peak in the State of South Carolina, a visitor can catch a glimpse of the splendid vistas of this state from above 914 m (3,000 ft.). From the mountains to the sea, South Carolina has a wide diversity of habitats, environmentally important areas, and scenic resources within the boundaries of its 8 million ha (19.9 million ac.) of land and water (USDA 2000). It is the diversity of the lands and waters of South Carolina that create the myriad environments for the State's varied fish and wildlife which help provide $54 billion to the annual natural resources economy (SCDNR news release, 2013).

Demographics and Economics

In 1790, South Carolina's total resident population numbered 249,073 people. According to data collected in 2010, the US Census Bureau estimated the population density of South Carolina to be 153.9 people per square mile (or roughly 4.2 million people). Of the over 19 million acres of land in the State, approximately 12% is publicly owned while 88% is privately owned (SCFC 2010). The vast majority of the State is characterized as nonfederal rural lands ('nonfederal' referring to all lands in private, municipal, state or tribal ownership). Land use on nonfederal lands in the State, which total 18,115,500 acres, is primarily forestland. South Carolina saw an increase in urbanized areas from 1 million acres in 1968 to 2.5 million in 2006 (SCFC 2010).

According to results of the most recent forest resource assessment, 13 million acres of land in South Carolina are forested. This represents 67% of the land area of the State. The remaining 6.3 million acres is mostly relegated to agriculture and urban centers. Non-industrial private owners, including individual and corporate timberland owners not associated with the forest products industry, own 77 % of these lands. Timberland ownership under corporate control has increased in recent years to 18 %. The percentage of forests managed by the forest products industry has decreased from 16% in 2001 to 11% in 2006 due to large land liquidations by timber companies. Public land ownership increased to 7%. These relationships are illustrated in Figure 4-1.

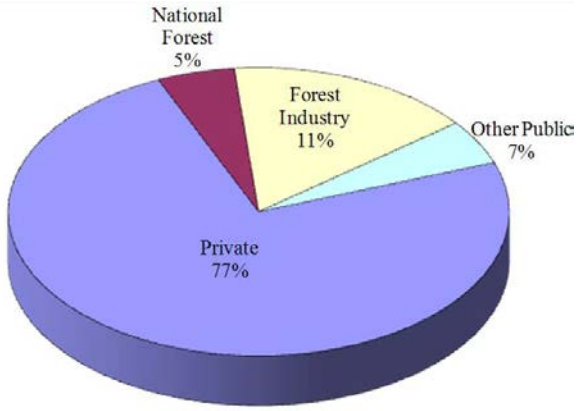

FIGURE 4-1: Distribution of forested land by ownership class in South Carolina (USFC 2010).

Of the 13 million acres of forest land in South Carolina, 6.8 million is in hardwoods and 5.9 million is in softwoods. Of these softwoods, 3.1 million is planted pine. The most common covertype in the softwood group is loblolly-shortleaf pine which accounts for 5.3 million acres in the State. Forestry employees approximately 45,000 workers and contributes $17.4 billion to South Carolina's annual economy. [SCFC 2010]

With an increase in the human population comes an increase in wildfires in the State. There are approximately 3,000 wildfires each year in South Carolina. Prescribed burns are conducted on about 525,000 acres each year, but it is estimated that twice this amount is needed to adequately provide a fire regime to manage fuel loads, maintain fire-dependent flora, and provide habitat enhancement for wildlife. The problems faced by prescribed fire managers include liability concerns, smoke management issues, and forest fragmentation so that there are fewer large tracts to burn. [SCFC 2010]

From 1968 to 2006, agriculture has declined in South Carolina by 60% or approximately 2 million acres. Some has been converted to timber production while most tracts have become developed (SCFC 2010). South Carolina had approximately 12,200 acres under agricultural production in 1950, but by 2011, it had dwindled to 4,900 acres (USDA-ERS 2013). At the same time and over the same period, the number of farms in South Carolina has decreased from 147,000 to 26,000 (USDA-ERS 2013). The market value (total cash receipts) of agricultural products sold in 2011 totaled over $2.5 billion with highest rankings occurring in the following top 10 outputs: (1) poultry (broilers), (2) turkeys, (3) greenhouse/nursery production, (4) cotton, (5) cattle/calves, (6) corn, (7) chicken eggs, (8) soybeans, (9) wheat, and (10) peaches (USDA 2012). Counties in South Carolina with consistently high agricultural yields are Kershaw, York, Dillon, and Orangeburg. Livestock production is typically high in Anderson, Newberry, Kershaw, Lexington, Oconee, Aiken, Saluda, and Orangeburg counties (USDA 2012). As of January 2013, there were approximately 28 USDA certified organic farms registered by the National Organic Program (NOP) in South Carolina (USDA-AMS 2013).

South Carolina is rich in non-fuel raw minerals with a total of over $789 million produced in 2007. The most common minerals produced in South Carolina are, in descending order, cement, crushed stone, construction sand and gravel, industrial sand and gravel, kaolin, crude vermiculite, and common clays. Of all 50 states, South Carolina was ranked 26th in 2007 in total non-fuel mineral production value. Portland and masonry cement still leads South Carolina's mineral commodities. [US Department of the Interior 2007]

Climate

South Carolina has a humid, subtropical climate. The average annual precipitation is about 125 cm (49 in.) per year with the coast receiving approximately127 cm (50 in.) and the Blue Ridge receiving up to 203 cm (80 in.) per year. Average January temperatures range from 10ºC (50 ºF) near the coast to 3ºC (38ºF) in the mountains; July temperatures average 27ºC (81ºF) near the coast and 22ºC (71ºF) in the mountains. The growing season ranges from 200 to 290 days. During the winter months, the State is typically under a continental air mass that is cold and dry, while during summer, the Bermuda high-pressure cell in the Atlantic drives much of the weather. Heat and humidity prevail when clockwise circulation around the Bermuda High brings a

southerly flow of air from the Gulf of Mexico, a pattern that becomes rather stable as the mountains in the northwestern part of the State block any cool fronts which might arrive from the North. Our climate is expected to continue to warm over the coming years and bring with it changes in precipitation patterns and tropical storm intensities (Perry et al. 2012). The SCDNR will be monitoring climate change and how it affects our natural resources.

Aquatic Resources

South Carolina possesses over 17,703 km (11,000 mi.) of permanently flowing rivers (Beasley et al. 1988) and 48,280 km (30,000 mi.) of streams (SCDNR data). All of the streams and rivers that drain a region are collectively called a drainage basin. The precipitation that falls in the state is drained by four major river systems or basins. These include the Savannah, Santee, Pee Dee, and Ashepoo/Combahee/Edisto (ACE). Sometimes these are re-divided into 7 drainage basins (Figure 4-2) in the State: the Pee Dee, ACE, Savannah, Broad, Congaree/Lower Santee, Catawba/Wateree, and Saluda. These, in turn, are made up of 39 sub-basins or HUCs. Except for the ACE Basin, each of these basins originate in the Blue Ridge Ecoregion and pass through the Piedmont, Sandhills, Coastal Plain, and Coastal Zone. Part of the ACE Basin, the Edisto River is the third longest undeveloped free-flowing river in the Southeastern United States. Twenty of South Carolina's rivers connect directly with the State's coastal estuaries. There are 11 major lakes in South Carolina; all are man-made. The SCDNR's State Lakes Program stocks and manages 17 small lakes and ponds across the State, a majority of which are in the Piedmont. South Carolina's major water bodies, rivers, and bays are illustrated in Figure 4-3.

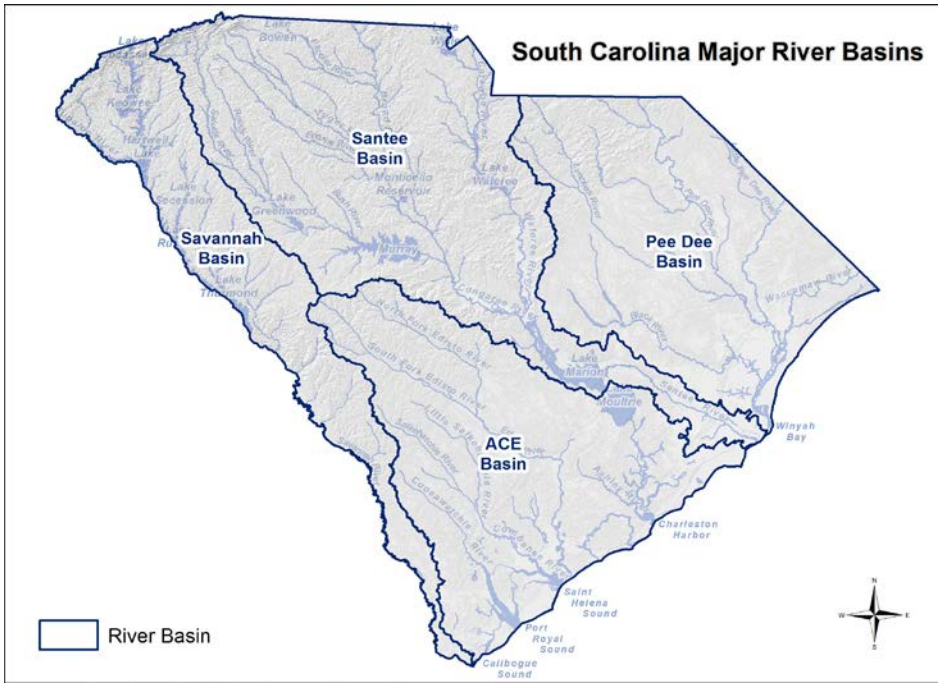

FIGURE 4-2: South Carolina's main river basins

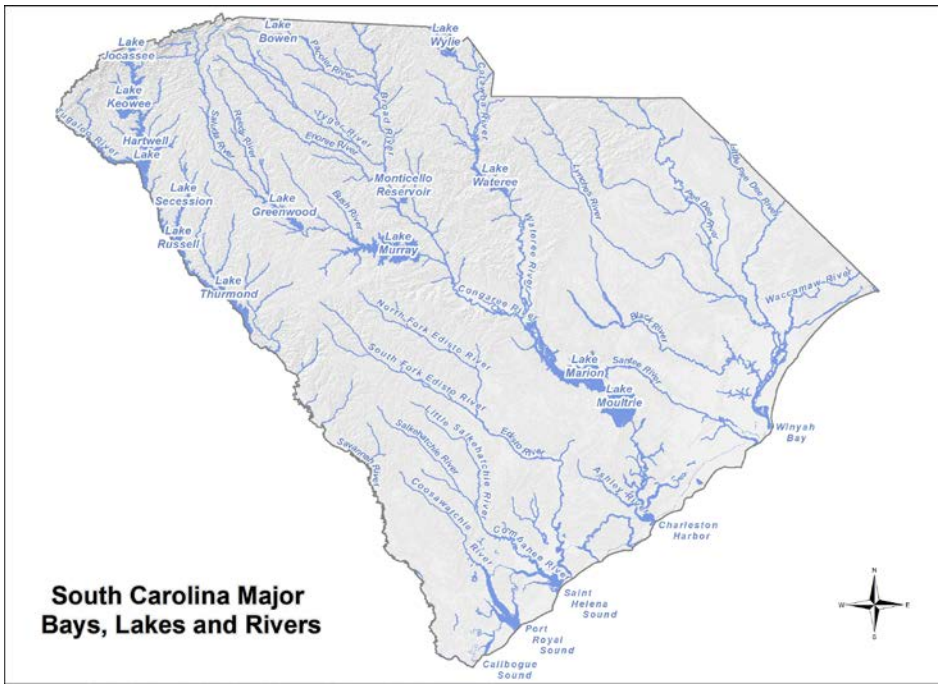

FIGURE 4-3: South Carolina's major bays, lakes, and rivers

Soils

Of the 15,000 and 20,000 soils in the United States, South Carolina has 265. South Carolina soils typically have an organic matter content of less than 5% (closer to 1% or less). Some wetland soils, however, may have greater than 50%. [Scharf 2010]

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

Soil texture becomes finer the further west and northward into the State. The "Sandhills", named after very old dune remnants, have surface soils that range from a fine sand to loam in texture. As with the Coastal Plain soils, Sandhills soils have minimal organic matter, yet because of the mineral portion, they have a greater cation exchange capacity and water holding capacity. They are among the most fertile in the State. Many have a finer textured subsoil (clay hardpan) that can limit deep rooting, and result in horizontal movement of rapidly percolating waters above the hard pan to receiving water bodies.

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

rainfall can result in surface water runoff and minimal infiltration. [Dara Park, Clemson Univ., email correspondence July 26, 2013]

General Ecoregion Descriptions

Many habitat types in South Carolina are strongly associated with certain geographic areas or physiographic regions within the state. Habitats in this strategy have been grouped according to five widely recognized regions, called "ecoregions" (Figure 4-4). The primary source of information on the ecoregions of South Carolina and surrounding states is the map and accompanying definitions from Griffith et al. (2002), with supplementary information for South Carolina taken from Myers et al. (1986). This chapter provides a summary of the general landscape and current condition of the 5 ecoregions of South Carolina. In some of the species accounts in the Supplemental Volume, these ecoregions are further divided into the Blue Ridge, Upper Piedmont, Middle Piedmont, Lower Piedmont, Slate Belt, Sandhills, Inner Coastal Plain, Upper Coastal Plain, Outer Coastal Plain, and the Lower Coastal Plain.

Blue Ridge Ecoregion – A narrow belt forming the Southeastern terminus of the Blue Ridge Physiographic Province, ranging from about 366-975 m (1,200-3,200 ft.) in elevation, characterized by steep slopes on Paleozoic crystalline rocks, narrow river valleys, and high-gradient streams; predominantly vegetated by extensive hardwood and hardwood-conifer forests.

Piedmont Ecoregion – A portion of the Piedmont Physiographic Province characterized by rolling hills with highly weathered soils, often severely eroded, overlying mostly Paleozoic crystalline rock substrates, with low-gradient streams on narrow floodplains; vegetation consists mostly of pine and pine-hardwood forests interspersed with agricultural land.

Sandhills Ecoregion – A nearly continuous belt of broad, rolling hills along the Fall Line, generally having sandy soils derived from coarse Cretaceous and Tertiary marine sediments; predominantly vegetated by pine forests interspersed with agricultural land, with hardwood forests on narrow floodplains along medium-gradient streams.

Coastal Plain Ecoregion – A series of broad belts derived from a variety of marine sediments, all oriented more or less parallel to the coastline, the innermost consisting of rolling hills and the outermost consisting of flat terraces. The vegetation consists of pine-dominated forests interspersed with agricultural land on better-drained sites, hardwood forests occupying broad floodplains along low-gradient streams, and extensive pine forests on less well-drained terraces.

Coastal Zone/Marine Ecoregion –This zone comprises the seaward extension of the Coastal Plain Ecoregion, extending from the inland boundary of saltwater influence, seaward to the artificial three-mile offshore limit. Habitat types range from forested variants of Coastal Plain types at inland sites, seaward to sand flats and pine-hardwood forests on unstable emergent coastal sediments, and finally to emergent marshes and submerged bottoms in association with open water.

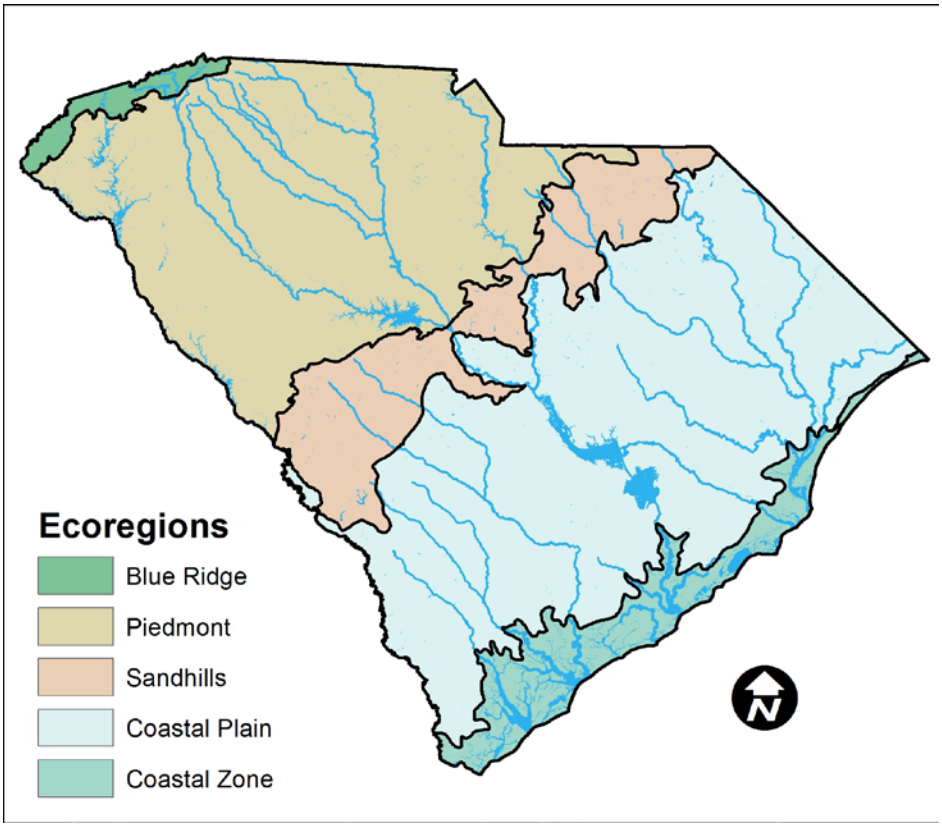

FIGURE 4-4: The 5 ecoregions of South Carolina. Source: Modified from Griffith et al. (2002). The Coastal Plain-Coastal Zone boundary is modified to conform to the legal delineation of the boundary between freshwater and saltwater zones for fisheries management purposes.

The SCDNR and its partners have done a tremendous job of conserving valuable habitat in each ecoregion of the State. The following tables illustrate that fact; Table 4-1 summarizes the percentage of each ecoregion protected in South Carolina while Table 4-2 shows the statewide acreages in conservation status by ownership.

Table 4-1: Ecoregion Acreages

	Ecoregion Area (Acres)	Ecoregion Area (Hectares)	Conservation Areas (Acres)	Conservation Area (Hectares)	Percentage in Conservation Status
Blue Ridge	303,193	122,698	167,479	67,776	55.2%
Piedmont	6,895,523	2,790,519	427,232	172,895	6.2%
Sandhills	2,345,771	949,300	333,154	134,823	14.2%
Coastal Plain	8,927,070	3,612,657	854,352	345,744	9.6%
Coastal Zone	1,508,820	610,598	457,311	185,067	30.3%
Total	**19,980,377**	**8,085,772**	**2,239,528**	**906,305**	**11.3%**

Table 4-2: Statewide Acreages In Conservation Status		
Type	**Acres**	**Hectares**
Federal	1,009,889	408,687
State	462,297	187,085
Private	674,351	272,900
Military	106,371	43,047
Total	**2,252,908**	**911,720**

Invasive Plant Species in Terrestrial and Aquatic Habitats

Throughout all of South Carolina's ecoregions, non-native invasive invasive plant species threaten to disrupt the community composition, structure and function of a variety of habitats and may also have adverse impacts on agriculture. While many non-native species are benign, invasive exotic plants are characterized by their ability to spread rapidly through the environment and may alter entire landscapes within the span of one to three growing seasons. Serious infestations generally result in a significant loss of biodiversity in impacted areas. According to the South Carolina Exotic Pest Plant Council (2004), approximately 100 million acres in the United States already bear some environmental degradation due to invasive plant species. Recognizing potential threats and generating public awareness and support is the first step in preventing further spread of invasive plants. Management to recapture sites already affected presents an enormous on-going effort. Roughly 90 exotic pest plant species have been identified as posing potential to severe threats to South Carolina's terrestrial habitats. Aquatic habitats are also affected by noxious weeds, with tremendous removal and control efforts provided by SCDNR, Clemson University, and others. In a combined effort, through the South Carolina Aquatic Invasive Species Task Force (2008), a list of noxious weeds for aquatic and wetland habitats has been developed. Terrestrial and aquatic invasive plants are listed in Appendices 5 and 6.

Land Covertype Classification System

A major component of this revision includes updates to the current landscape chapter that provide a more comprehensive way of describing and mapping priority habitats within the State. For the initial SWAP preparation (previously referred to as the CWCS), the principal source of information for terrestrial habitat definitions was Nelson's (1986) classification of South Carolina's natural communities. In the previous edition, no GIS supporting maps were included in the Plan. Habitats within the chapter were described in narrative form and were not mapped within the ecoregions. Given the utility that GIS support maps provide, we felt that their addition was an appropriate measure to update our plan that would also echo neighboring states' efforts. A Priority Habitats Technical Team was assembled in 2011 to guide the revision process.

As GAP data has been criticized for its low accuracy rate, it was proposed to use it as a support system for land covertypes, which were loosely based on Nelson's *Natural Communities of South Carolina*, and not as the sole basis for classifications. Utilizing our Technology Development Program staff, SC GAP data were isolated by ecoregion and then re-classified to "fit" into the original habitat classes creating the crosswalk table found in Appendix 4. SC GAP

habitat class descriptions—found in the 2001 final report entitled, *"A GAP Analysis of South Carolina"*—and expertise from the Heritage Trust staff were used to justify merging of the GAP map units into their respective CWCS original habitats. SC GAP data actually identified more land covertypes within the ecoregions, therefore, providing a more comprehensive overview of the actual habitats present.

By merging the SC GAP data into the CWCS habitat types (which thus became the new 2015 SWAP classification), land covertypes can now be supported with GIS data, with the intent to "clip" out each ecoregion, and provide a map illustrating those covertypes that fall within the area discussed.

Some land covertypes rarely provide quality habitat for a majority of wildlife but are nonetheless a part of the landscape. Cultivated land and pasture, recently disturbed land, and urban areas are three such types mapped by GAP but not discussed in terms of habitat qualities, only habitat possibilities if their current condition were to be enhanced for wildlife. They are discussed here in lieu of under each ecoregion.

The cultivated land and pasture land covertype can include current agricultural fields, old field sites, hay meadows, residential lawns, golf courses, and livestock pastures. It may also include low density housing in rural / small farm settings and associated outbuildings and pastures (GAP 2001). Although it has a relatively low habitat value in its current state, cultivated land and pasture is a crucial land covertype to consider for conversion to native vegetation on private lands. Farm Bill programs have been instrumental in funding conservation practices on these lands. Pollinator habitat can be enhanced in agricultural fields by leaving natural areas out of production and protecting hedgerows, abandoned fields, bare soil or sand, and snags (Heinz Center 2013). Several species of pollinating insects are included in South Carolina's SWAP and would benefit from these efforts.

Recently disturbed land is transitional land characterized by sandy, bare soil and/or recently cleared forest. Because of the limitations of GAP data, including the time period and maps used to create GAP, the current state of this covertype is relatively unknown. Therefore, the potential of these areas to proceed through successional stages is there, along with the variety of new habitats this would provide wildlife and plants along the way. However, these same sites are often "recently disturbed" because they are in the process of being developed into housing developments and the like.

Two types of residential development are associated with urban areas; high and low. High density residential development occurs near cities; forest and other green areas are interspersed with urban areas in low-density residential developments (GAP 2001). The sprawling, unplanned development that has accompanied South Carolina's rapid growth in recent decades is accelerating the conversion and fragmentation of the State's landscape. Some portions of the State are building on or paving over the land at a rate five to six times that of their associated population growth. The resulting loss of green spaces affects not only the quality of life in urban areas; it also denies residents ready exposure to the underlying natural values present in undeveloped lands. If people cannot experience nature close to home, they are less likely to value it wherever they encounter it. As human populations continue to increase and sprawl,

urban areas will play an ever-changing role in habitat loss, fragmentation, and species distributions.

Important elements in the urban environment are those remnants of the original natural landscape, or farm and forest lands within an urban setting that retain some natural character. These areas support wildlife habitat, recreational opportunities, green space, and limited ecosystem functions. They can enhance the quality of life within urban settings, and may provide important linkages with other natural landscapes. Urban green spaces offer residents and visitors outdoor opportunities for exercise, relaxation, and appreciation of nature, especially for those who are unable to afford alternatives. Parks, squares, gardens, and greenways help maintain higher property values, and attract workers in the new economy who can choose to live where the quality of life is high. Beautiful green spaces are an essential part of the shared civic spaces which create our sense of place and community.

Despite their comparatively low habitat value relative to wilderness areas, well-managed urban settings can provide important ecological functions and benefits. Urban trees, shrubs, and grasses provide habitat for many of the more common species of birds, mammals, reptiles, and amphibians. This vegetation also filters air pollution, cools air temperatures, absorbs noise, reduces soil erosion, removes water pollution, controls runoff volume and velocity, and increases groundwater infiltration. High-rise office buildings can provide nesting ledges for Peregrine Falcons and Least Terns while the buildings themselves can be built to LEED certification standards (such as using bird-safe exterior glass) to avoid some of the detrimental impacts of the buildings' footprints on the landscape. Nighttime lighting adjustments and encouraging pet owners to keep their cats indoors also help protect native wildlife in the urban environment. In addition, conservation-minded zoning recommendations can be made to maintain travel corridors and a mosaic of appropriate habitat interspersed with urban or suburban areas.

The Gray Kingbird, one of South Carolina's priority species, appears to be well-adapted to living in developed habitats, as it is a common visitor to farms and suburbs which provide foraging opportunities on agricultural pests and insects (Smith and Jackson 2002; Wetmore 1916). It is less sensitive to human disturbance than other species. Several other bird species that have adapted to urban and suburban landscapes include hawks, hummingbirds, orioles, woodpeckers, Purple Martins, Barn Swallows, and Chimney Swifts. In all, over 100 native bird species utilize these areas for breeding or stop-over habitat during migration (NBCI 2013). Eastern glass lizards, relatives of the two priority glass lizards in the SWAP—island and mimic—also can be quite common in urban and suburban sites.

Residential neighborhoods can still provide for wildlife when homeowners landscape with native plants, provide nesting sites, and provide alternative food and water sources. The National Wildlife Federation (NWF) has a program for certifying landscapes as "backyard habitat." In 2013, the South Carolina Chapter of the NWF reported that the State of South Carolina was number one in the country in the number of certified wildlife habitats per capita.

Priority Habitats and Focus Areas

All habitats are important to maintain as each contributes to the diversity of the State of South Carolina; therefore any habitat can arguably be a priority. However, for the purposes of this Action Plan, priority habitats are defined as any habitat type that is optimally suited for one or more priority species. In the 2005 version of the SWAP, priority species were listed within the various habitat narratives. As this did not prove to be a user-friendly format, the priority species habitat associations have instead been compiled in Appendices 1 A-D as a table in which X's designate what habitat(s) the species can be found in by region of the State. These habitat associations were determined by consulting the scientific literature, taxa team members, and experts on particular species. The Land Manager's Guide series by The Nature Conservancy (those of Wilson 1995, Hamel 1992, and Trani et al. 2007) was consulted as well. Marine species have their own table whereas freshwater aquatics and terrestrial species have their own which are sorted by ecobasin and by ecoregion, respectively.

The following ecoregion sections contain descriptions of habitats typical of that ecoregion as well as the priority species that may utilize that habitat if all required conditions are met. Embedded within these main habitats are microhabitats which may be crucial to the continued existence of many priority plants and animals as well as more common species. The SCDNR has further defined some general "conservation opportunity areas" (focus areas) that encompass terrestrial and aquatic habitats, some with known element of occurrence records of priority species, and created a map (Fig. 4-5) to guide its conservation efforts. South Carolina's SWAP and State Forest Action Plan were reviewed simultaneously for common priorities so that the maps that appear in each document express shared values. The boundaries of these focus areas are generalized and dynamic; they can change as new information becomes available. In terms of funding under the State Wildlife Grants (SWG) Program, geographic location of a project will not be the sole determining factor in whether or not projects are considered.

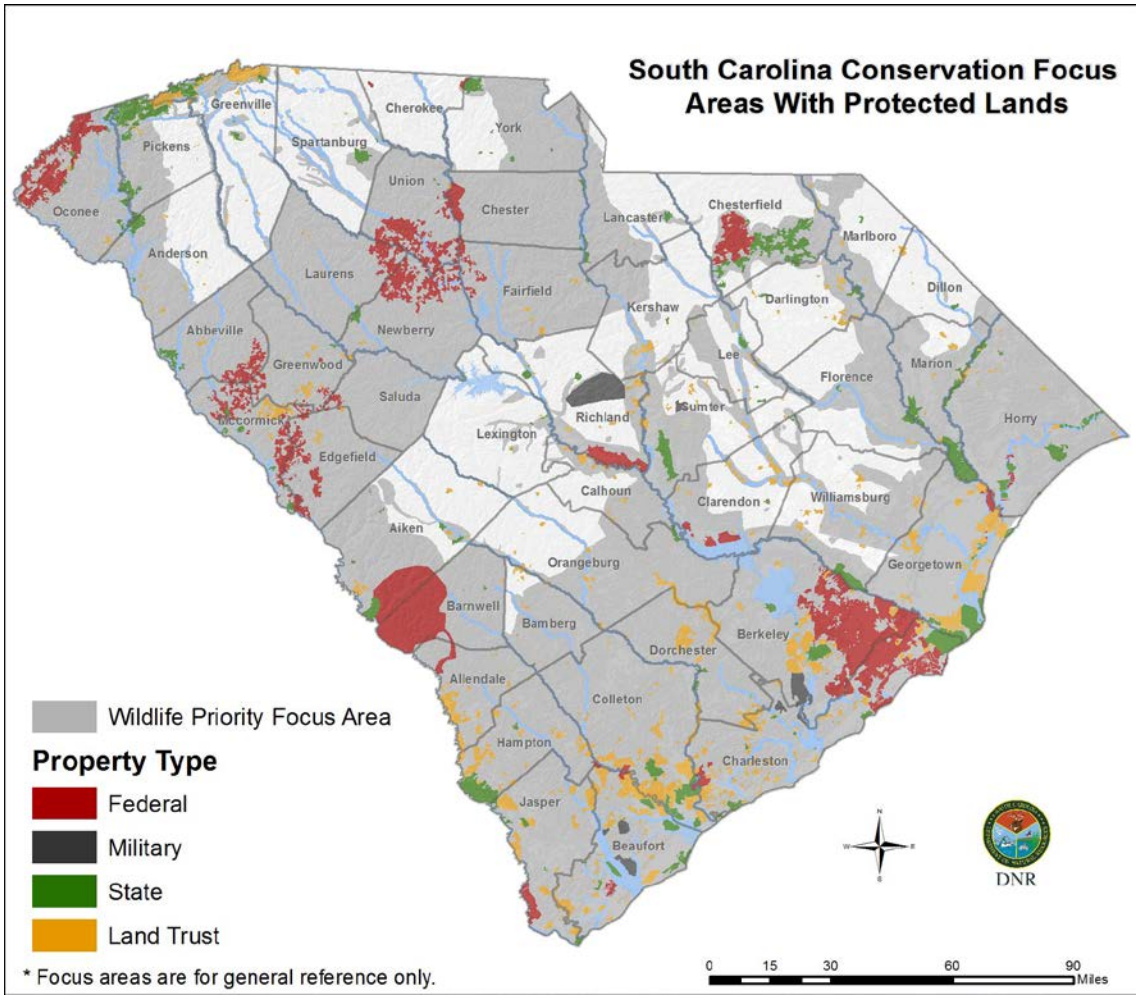

FIGURE 4-5: SWAP Conservation Opportunity Areas in gray and currently protected lands in SC (colored). Map derived from considering the 2013 Northern Bobwhite Habitat Restoration Plan for SC, SC Forest Action Plan, the 2005 SC Comprehensive Wildlife Conservation Plan, Conservation Blueprint 1.0, ACJV bird data, Heritage Trust records, and many other focus area maps used by SCDNR and its conservation partners.

Blue Ridge Ecoregion

General Overview

South Carolina's mountains are part of a multi-state region within the Southern Appalachians known as the Southern Blue Ridge Escarpment. The Escarpment forms an abrupt transition between higher mountains in adjoining states and the Piedmont. High-gradient streams fed by high annual rainfalls carve the mountain landscape (Griffith et al. 2002). In fact, the Jocassee Gorges area of the State receives the second highest rainfall in the continental US. It also boasts one of the highest concentrations of waterfalls in the Eastern US. A portion of the mountain region's northern boundary in South Carolina is formed by the Eastern Continental Divide, which provides resource managers with the rare opportunity of working with ecological and jurisdictional boundaries.

Although the Blue Ridge in South Carolina constitutes a small portion of the State's land area (328,500 acres or 1.69% of the total area), it supports the most extensive upland hardwood forest complex in the State. The region is rich in floral diversity, best expressed in the mixed mesophytic forest vegetation community (Braun 1950), and described as moist broad-leaved forests that can harbor over 30 different tree species and many more types of fungi and ferns. Other biological resources unique to the region include a viable black bear (*Ursus americanus*) population extending across the North Carolina, Georgia, and South Carolina state lines; sustained nesting of Peregrine Falcons (*Falco peregrinus*) following reintroduction in the 1980s; and self-sustaining populations of native Eastern Brook Trout (*Salvelinus fontinalis*). The Jocassee Gorges area of the State was named one of "50 of the World's Last Great Places—Destinations of a Lifetime" by the National Geographic Society in 2012. The 124 km (77 mi.) long Foothills Trail winds through scenic vistas along the Blue Ridge Escarpment and connects to the 684 km (425 mi.) Palmetto Trail leading to the coast.

Overstory, understory, shrub and herbaceous plant communities of the Blue Ridge are generally related to topography, elevation, slope, soil type, and other particular aspects of a site (Abella 2002). A few specialized habitat types, such as bogs or rock faces, are present due to unique geological formations. Rare plants—approximately 60 in all—abound in the Jocassee Gorges area, including 90% of the global population of the rare Oconee bells (*Shortia galacifolia*). Habitat types in the region generally blend from one type to the next with the rare abrupt transition. Because of these intergradations of communities, very few animal species are strictly associated with any single habitat type.

At higher elevations, the current landscape consists of large tracts of unbroken forest. The overall condition is best described as trending toward mid-successional, relatively lacking in both the early-successional stages resulting from disturbances and the late-successional or "old growth" stages characterized by canopy openings and other complexity-providing structures. Major biological changes to forest community composition within historic times include the pathogenic destruction of the American chestnut (*Castanea dentata*) as the dominant canopy tree species, the removal of the Eastern cougar (*Felis concolor*) and red wolf *(Canis rufus)* as the top predators, and the extinction of both the Carolina parakeet (*Conuropsis carolinensis*) and elk (*Cervus canadensis).*

Eighteenth century European settlers cleared flatter sites at all elevations for agricultural settlements and utilized wood from surrounding forests for a variety of purposes (SCDNR, 1998). Beginning in the late 19th and early 20th centuries, industrial development in the upper Piedmont led to a period of extensive timber extraction. Early logging operations focused on removing oaks and tulip poplar from cove and mid-slope forests for construction timbers (SCDNR 1998; Abella 2002). Later, logging operations utilized a network of temporary roads that penetrated the entire region. Therefore, between the early intensive logging at lower elevations and more recent logging roads accessing higher elevation sites, almost all sites in the region have been subjected to timber extraction in some form.

Beginning in the mid-20th century, a series of land consolidations began, which shifted ownership toward public and quasi-public purposes. In 1963, the Jocassee Gorges property was purchased by the Duke Power Company for hydropower development, a transfer that set the

stage for the property's ultimate acquisition by the SCDNR in 1998. Other significant transfers in modern times include Sumter National Forest in Pickens and Oconee Counties; Poinsett and Table Rock Reservoirs in Greenville County; Table Rock, Jones Gap, and Caesars Head State Parks; and several other acquisitions by the SCDNR.

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

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

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

Land Covertypes

Habitat definitions primarily follow the Landscape Ecological Classification of Abella (2002), which is based on a multivariate analysis of geomorphology and vegetation on late-successional sites (more than 70 years since timber harvest) in the Jocassee Gorges. To give a broader picture of habitat types across the region, the work of Patterson (1994) for the Ellicott's Rock area in the extreme Northwestern corner of the region is incorporated, as are a number of classifications based on vegetation composition and structure, notably Nelson (1986). Variation of habitat characteristics within the region has not been systematically quantified, although white pine-dominated types are more prevalent in the western portion of the region. Some qualitative differences in vegetation composition between the Ellicott Rock and Jocassee Gorges areas have also been observed (Camp 2004). Figure 4-6 defines the covertypes associated with the Blue Ridge Ecoregion. Species-habitat associations are presented in Appendices 1 A-D while the faunal makeup of the habitats are described in more detail within this chapter (4).

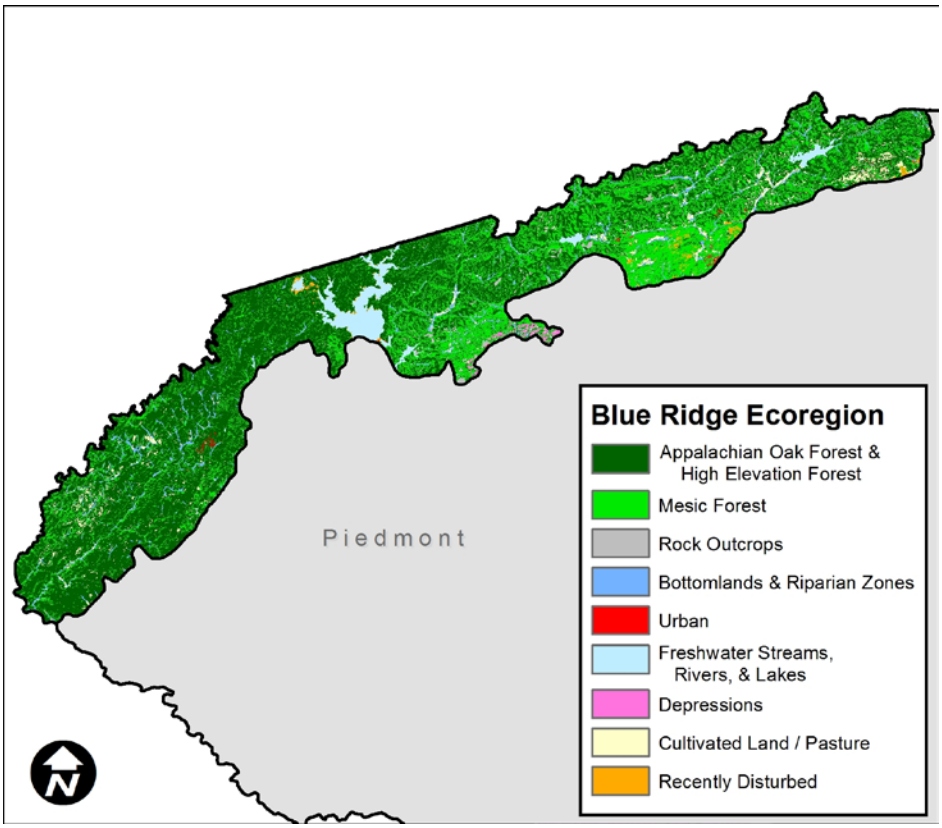

FIGURE 4-6: Land covertypes of the Blue Ridge Ecoregion.

Appalachian Oak Forest *(within Appalachian Oak & High Elevation Forest layer)*	Oak and oak-pine forests compose the predominant vegetation type throughout the Blue Ridge Ecoregion. Vegetation composition and structure is highly variable, depending primarily on exposure and position on slope and, secondarily, on soil moisture. Ridgetops and exposed upper slopes support an open canopy forest of oak species such as scarlet, black, and chestnut oak and/or mixed pine-oaks. The understory is open and groundcover is sparse; blueberry is a characteristic groundcover. Upper portions of hill slopes and exposed nose slopes typically support a canopy dominated by chestnut oak, with numerous hardwood co-dominants, and a shrub layer dominated on some sites by dense stands of mountain laurel. More mesic lower slopes—particularly north-facing slopes at intermediate and low elevations—and sites along small streams and ravines, support diverse hardwood species, typically including white oak, tulip poplar, Fraser magnolia, and red maple. Diverse shrub and herbaceous species are also present, along with widely spaced clumps of mountain laurel. Early-successional sites dominated by grasses, shrubs, and seedlings or saplings of numerous tree species are included in the definition of this habitat type. This covertype may also contain sporadic patches of planted pine for timber production.
High Elevation Forest	In South Carolina, this land covertype is limited to the highest peaks.

(within Appalachian Oak & High Elevation Forest layer)	Occurring at scattered sites at over 900 m elevation, South Carolina represents the southern limit of this habitat (Braun 1950). Several canopy trees, other plant species, and a few priority wildlife species are also at their southern range limits. Canopies consist of red maple, chestnut oak, northern red oak, black oak, hickory, and tulip poplar. Herbaceous species diversity is high, but less than that occurring in mesic hardwood/bloodroot or cove forests. High-elevation forest is distinguished from other forests by the lack of calciphilic species and the dominance of red maple and chestnut oak. On steep to very steep upper to middle slopes with northerly aspects, vegetation is dominated by northern red oak with or without lesser amounts of chestnut oak and red maple. Rosebay rhododendron or great laurel (*Rhododendron maximum*) forms a dense continuous subcanopy, and on more exposed sites, Piedmont or small-leaf rhododendron (*Rhododendron minus)* becomes more dominant.
Low Elevation Basic Mesic Forest *(within Mesic Forest layer)*	Low elevation mesic forest occupies relatively sheltered, well-drained sites on concave landforms and lower slopes. It is a rare type within the ecoregion, occurring only on sites exhibiting unusually deep soils. It corresponds to the mixed mesophytic forest of Braun (1950), which is recognized for its rich floristic composition. Tulip poplar typically dominates the overstory, and Carolina silverbell is a characteristic species in the mid-story or understory. The shrub layer is typically sparse or absent. Herb species richness and cover are highest in this type and characteristic ground flora species include bloodroot, foamflower, silverbell, partridge berry, cane and ginseng. Mixed mesophytic forests are recognized generally as habitats within the Southern Appalachians that support high densities and/or provide optimal habitat for many species of breeding birds and also have high salamander species diversity (Hunter et al. 1999).
Low Elevation Acidic Mesic Forest *(within Mesic Forest layer)*	Low elevation acidic mesic forest occurs on well-drained, relatively sheltered sites in stream bottoms, along ravines of small streams, or on hill slopes. This land covertype is more prevalent on North-facing slopes or lower positions on other slopes. Eastern hemlock is the characteristic tree, occurring either as the dominant overstory or understory tree, while rhododendron dominates the shrub layer, occurring in thickets or solitary clumps. Tulip poplar, white pine, hickories, sweet birch, beech, and basswood are common associates. White pine becomes much more dominant along with hemlock in the Ellicott Rock /Chattooga River basin in the western portion of the Blue Ridge. This land covertype provides critical habitat for wildlife species associated with riparian habitats.

Rock Outcrops	Rock outcrops of widely varying sizes and slopes occur throughout the region. Slopes range from nearly horizontal to nearly vertical. The more extensive and exposed outcrops have their own characteristic vegetation and habitat features. Vegetation ranges from none, (bare rock) to a mosaic of herbaceous plant, shrub, and tree-dominated communities. Successional trees, such as eastern red cedar (*Juniperus virginiana*) and Virginia pine (*Pinus virginiana*) are common at these sites. Crevices and ledges can only provide habitats for larger plants once sufficient soil has accumulated. Vegetative communities are relatively unstable. A cliff or dome may also have a significant area of wet seepage zones.
Bottomlands and Riparian Zones	This land covertype forms the riparian vegetation zone on streams and rivers—typically along wadeable or navigable streams that are wide enough to prevent canopy closure—at scattered locations with a suitable substrate of seasonally flooded rocky or alluvial soils. It exhibits variation in size and persistence. At the base of the escarpment, this habitat also occupies broad floodplains, where it grades into the floodplain forest types of the upper Piedmont (Barry 1980). Alder (*Alnus* spp.) is a characteristic species that occurs at a relatively high abundance along with mixed canopy species. Common shrubs are yellow root (*Xanthorhiza simplicissima*), Virginia willow (*Itea virginica*), azalea (*Rhododendron* spp.) and occasionally black willow (*Salix nigra*) and sweet pepperbush (*Clethra alnifolia*).
Depressions	At high elevations, this land covertype tends to be small in area with a seasonally variable water table. When bedrock is close to the soil surface, such as in the case of exposed granitic domes, perched water tables may form acidic, ombrotrophic bogs, while stream-fed depressions tend to be higher in mineral content. In either type, dense mats of peaty soils are dominated by *Sphagnum* spp. and a variety of grasses, sedges, and low shrubs. The overall community structure may even follow the course of stream channels over slopes forming cataract bogs.
Moist or Wet Types Due to Unique Landform *(specialized habitat not mapped at this scale)*	Highly variable landforms within the Southern Blue Ridge Ecoregion include numerous wet places that increase local and regional habitat diversity. Open seeps of variable size occur on granitic cliffs and domes. Spray cliffs occur in spray and splash zones at the edges and bases of waterfalls. Upland bogs form in poorly drained wet seepage areas at the heads of small streams, which are nearly always saturated. Upland bogs are characterized by sphagnum (*Sphagnum* spp.) and other bog species such as orchids and sedges. Vegetation in upland bogs is apparently fire-controlled. Without burning, succession leads to a wetland community dominated by woody

	vegetation.
Grassland and Early-Successional Habitats *(specialized habitat not mapped at this scale)*	Early-successional habitats are found throughout the state but reach their greatest extent in the Coastal Plain Ecoregion. These habitats are generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual forbs, perennial bunchgrasses, and variable coverage of shrubs and small trees. A variety of open land covertypes represents this category and can include native prairies, savannas, old field sites, open canopy gaps, shrub-scrub thickets, recently-cleared forests, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports and various urban open spaces are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high quality, early-successional habitat (see Cultivated Land and Pasture). Minor modifications to agricultural land use, such as replacing introduced grasses with native grasses, using native grasses in filter strips and grassed waterways, and implementing no-till or strip-till in crop fields can result in dramatic improvements to quality of early-successional habitat. Maintenance of early-successional habitat requires periodic repeated disturbance or disruption of the existing vegetative community. Purposeful management of early-successional habitat is usually accomplished through the use of timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5 years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of variety of successional—or seral—stages. Early-successional habitat types have declined dramatically over the past 70 years primarily due to changing agricultural practices, forest succession, fire suppression, and urban / suburban encroachment. A large portion of existing early-successional habitat occurs on privately owned lands. One of the greatest challenges to maintaining priority species associated with this particular land cover is private land outreach and technical assistance.

Freshwater Streams, Rivers, and Lakes

Although the Blue Ridge is the smallest ecoregion in South Carolina, encompassing only 1,204 km^2 (465 mi.^{2}), it harbors a diverse and unique aquatic community. The Blue Ridge Ecoregion cuts across the top of two major South Carolina drainages, the Savannah and the Santee, forming two ecobasins: the Savannah-Blue Ridge and the Santee-Blue Ridge (Fig. 4-7).

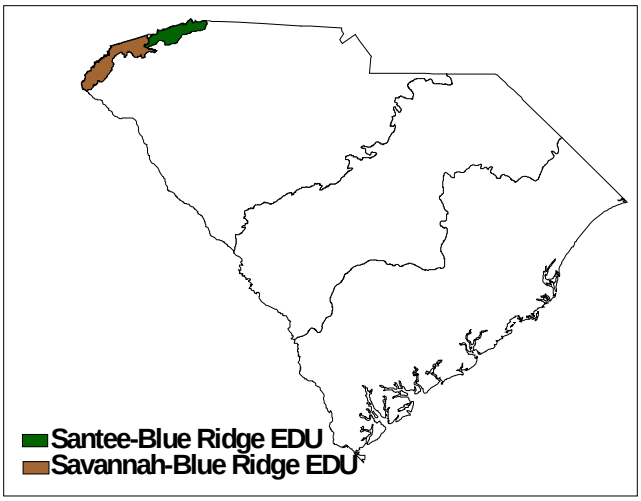

FIGURE 4-7: Drainages of the Blue Ridge Ecoregion

The Blue Ridge Ecoregion is the least developed ecoregion in the State and is primarily forested. Nearly 50% of the land in the Blue Ridge is protected to some degree. Three large tracts account for most of the protected land. These are the Sumter National Forest, the Jocassee Gorges Recreation Area, and the Greenville Watershed Easement.

Wadeable streams are the dominant aquatic classification in the Blue Ridge Ecoregion, and overall water quality is good. Wadeable streams are defined as streams with Strahler stream orders of 0 to 3 that generally can be waded comfortably throughout most of the year. Wadeable streams in the Blue Ridge are typically high gradient with clear water and a mixture of bedrock, gravel, coble, and sand substrates. These streams contain a variety of habitats including riffles, runs, pools, glides, and cascades. At higher elevations, many of these streams contain cascades and waterfalls.

Navigable streams are less common in the Blue Ridge Ecoregion with only about 32 km (20 mi.) of free-flowing stream within South Carolina. These streams are generally defined as being large enough to operate watercraft, if only a canoe, and are generally

too deep to be waded throughout most of the year. The Chauga and Chattooga Rivers are examples of navigable streams in the Blue Ridge. Navigable streams in the Blue Ridge contain a myriad of aquatic habitats including riffles, shoals, pools, runs, and glides in various combinations. These streams are somewhat more productive then the wadeable streams, despite being generally swift flowing and clear. Substrate in these habitats is primarily bedrock, gravel, cobble and sand. Lakes of the area are man-made, with artificial species management; they are not really pertinent habitat for the conservation of native species.

Challenges to conservation of aquatic fauna in these two ecobasins are similar to other ecobasins in the State and primarily include impacts associated with impoundments, non-point source pollution, and the introduction of non-native species. Point source pollution is not a significant problem in the Blue Ridge Ecoregion at this time. Sedimentation is the primary form of non-point source pollution in the Blue Ridge Ecoregion as it is throughout the State. Erosion from residential and commercial development as well as transportation and utility construction projects is the primary source of sedimentation in streams. Poor agricultural and silvicultural practices also contribute significantly to stream sedimentation.

Introductions of non-native species also threaten native fauna in the Blue Ridge Ecoregion. Introduced Rainbow Trout and Brown Trout displace the native Eastern Brook Trout and may prey on native nongame fishes as well. Introductions of Spotted Bass to Lakes Jocassee and Keowee have displaced the native "Bartram's" Redeye Bass and further threaten the fish through hybridization.

Cold and cool water species, particularly our only native trout the Eastern Brook Trout, face an uncertain future with a changing climate. Many of these species are at the southern extent of their ranges, and increases in water temperature may affect their ability to persist in South Carolina. Our ability to predict the consequences of climate change is limited by uncertainty in climate predictions compounded by complexity in ecological system behavior. However, data collected during the South Carolina Stream Assessment are being used to attempt to model potential consequences of climate change for streams in the State.

Santee-Blue Ridge EDU

The Blue Ridge portion of the Santee drainage originates in South Carolina as the headwaters of the Saluda River, which flows southeast and is a major tributary to the Santee River. The ecobasin encompasses approximately 453 km^2 (175 $mi.^2$). Most of the land is privately owned; however, a significant portion is protected by state, municipal and private entities. The ecobasin encompasses approximately 394 km (245 mi.) of lotic habitat. There are 409 km (254 mi.) of wadeable streams in the Santee-Blue Ridge Ecobasin. The largest two impoundments, North Saluda Reservoir and Table Rock Reservoir, total only 615 ha (1,519 ac.).

Sampling by SCDHEC (1998a) found that only 1 of 13 sites (8%) was designated as impaired; that impairment was based on the absence of aquatic fauna.

In the Santee-Blue Ridge Ecobasin, 20 km (12.5 mi.) of stream habitat have been lost to impoundments, including North Saluda Reservoir and Table Rock Reservoir. Impoundments

affect native aquatic fauna through direct loss of habitat as lotic habitat is converted to lentic habitat, which favors competitive and often predacious species such as Largemouth Bass and other centrarchids. In addition, impoundments often negatively impact unimpounded stream reaches downstream due to altered hydrologic and thermal regimes (Cushman 1985), modified stream channel morphology, and increased erosion and sedimentation (Waters 1995), ultimately reducing suitable habitat for native aquatic fauna (Helfrich et al. 1999; Tiemann et al. 2004).

Savannah-Blue Ridge EDU

The Blue Ridge portion of the Savannah drainage originates in the mountains of South Carolina, North Carolina and Georgia. Major tributaries in the ecobasin include the Chauga, Chattooga and Toxaway rivers. The ecobasin encompasses approximately 733 km^2 (283 $mi.^2$). Most of the land is publicly owned with a significant portion protected by federal and state entities including the Sumter National Forest Wild and Scenic River Corridor along the Chattooga River. The ecobasin encompasses approximately 599 km^2 (372 mi.) of lotic habitat and 3,358 ha (8,298 ac.) of impoundments. Most of the impounded area is a result of Lake Jocassee 2,979 ha (7,362 ac.) and the headwaters of Lake Keowee 221 ha (547 ac.). There are 586 km (364 mi.) of wadeable streams in the Savannah-Blue Ridge Ecobasin.

In the Savannah-Blue Ridge Ecobasin, 5 of 27 sites (19%) sampled by the South Carolina Department of Health and Environmental Control were designated as impaired, primarily due to mercury or total phosphorous contamination (SCDHEC 2003a). Fish consumption advisories have been issued for Lake Jocassee and the Seneca River arm of Lake Hartwell (SCDHEC 2003a).

Impoundments in the Savannah-Blue Ridge ecobasin have negatively affected a significant portion of habitat for native aquatic species. Nearly 64 km (40 mi.) of historically free-flowing streams within the ecobasin have been impounded; most of the stream habitat lost (40 km or 25 mi.) was due to the impoundment of the Toxaway River to form Lake Jocassee.

Region-wide Challenges

Most forests in the region are in mid-successional stages; therefore the forest structure is not optimal for many priority bird species (Hunter et al. 1999) and possibly species in other taxa. As forests mature, an optimal age structure is expected to develop; however, management practices that favor a faster transition or provide some of the characteristics of mature forest would benefit many priority species.

The hemlock wooly adelgid (*Adelges tsugae*) threatens to eliminate eastern and Carolina hemlocks from the region's forest over time. Originally confined to the New England states (McClure 1987), this exotic insect pest first appeared in the Southern Appalachians around 2002. Other potentially destructive insects, parasites, and diseases that have been reported from other locations near the Blue Ridge Ecoregion include the Emerald ash borer (*Agrilus planipennis*), gypsy moth (*Lymantria dispar*), dogwood anthracnose disease, and sudden oak death (SOD).

Fire exclusion, which has been the practice since the early 1900s, may be leading to landscape-level changes in forested lands. These changes include the gradual replacement of oak species by less fire-tolerant species in the overstory and the increased dominance of ericaceous plants in the shrub cover (Abella 2002). Concurrently, several studies indicate that early-successional habitat, which provides obligate or optimal habitat for some priority species, may be lacking (Abella 2002; Camp 2004).

At lower elevations and at scattered locations at higher elevations, the region is experiencing a boom in development. This activity is spurred in part by the attraction of nearby mountain scenery which is enhanced by the large public land base protecting the views. If present trends continue, the predominant mix of agricultural lands and woodland existing at lower elevations will be further supplanted by residential and recreational developments. As a consequence of this region-wide shift in land use, the suitability of private land for priority species will change. As the mountains become accessible to more people, recreation pressure will increase, a trend already in progress. Increasing human populations can be expected to lead to increasing numbers of human-wildlife conflicts.

Based on data and analyses of air quality sources within the Southern Appalachian region, concentrations of potentially damaging air pollutants are relatively low along the Blue Ridge, and susceptibility of streams and vegetation to impacts from atmospheric pollution in this region is also relatively low (SAMAB 1996). However, impacts have been reported from other portions of the Southern Appalachians, so this situation should continue to be monitored.

Major recreation resources such as the Foothills Trail and popular state parks such as Table Rock, Mountain Bridge, and Jones Gap, as well as the Jocassee Gorges acquisitions have stimulated demand for recreational access to public lands within the Blue Ridge Escarpment. A new observation tower on Sassafras Mountain is being constructed to encourage visitors to experience the highest point in South Carolina. Although accounts of visitation trends are currently anecdotal, visitation and demand for services is increasing dramatically. The second regional trail to traverse the escarpment, the Palmetto Trail, is also nearing completion and is expected to draw additional interest and traffic to the region. Managing agencies face competing demands for access by users whose interests are not always compatible. Impacts of recreational uses on the resource base vary by intensity and type, posing challenges to meeting resource-based management objectives.

Piedmont Ecoregion

General Overview

The Piedmont Ecoregion occupies a 161 km-wide (100 mile-wide) area between the Southern Blue Ridge Escarpment and the Sandhills Ecoregion. The northwestern boundary is generally considered to be the base of the Blue Ridge Escarpment; the division between the crystalline rocks of the Piedmont and the sedimentary rocks of the Sandhills represents the southeastern boundary of this ecoregion. The Piedmont-Sandhill contact zone is marked in many river channels by shoals and rock ledges that collectively form the "fall line" (as the Piedmont "falls away" into the flatter Coastal Plain). Gently rolling hills with many stream-cut valleys

characterize the region with only a few level floodplains. In the lower Piedmont, there are relatively few sharp breaks in topography except along major river valleys.

To a greater degree than in other regions, the vegetation in the Piedmont has been altered by human activity. Cotton agriculture changed much of the original hardwood and shortleaf pine (*Pinus echinata*) forests into fields. Fields eroded, often losing all topsoil. By the 1930s various factors, including the Great Depression and boll weevil outbreaks, as well as severe erosion led to widespread farmland abandonment in the Piedmont.

Loblolly pine (*Pinus taeda*) was introduced to the Piedmont during the 19th century as a cash lumber crop; this pine now dominates much of the region. According to a US Forest Service survey, loblolly-dominated pine forests occupy over 2 million acres in South Carolina's Piedmont (Conner and Sheffield 2000). Pine plantations are generally poor wildlife habitat, however, lacking in both the food and cover needed by native wildlife.

Although loblolly pine plantations are found throughout the region, they are much more prevalent in some areas, in particular the southwestern Piedmont. By contrast, habitat in the vicinity of York County retains substantial, if fragmented, acreage of hardwood forest. Kings Mountain State Park features a good example of Piedmont upland hardwood forest.

By definition, early-successional habitats have a limited longevity without repeated disturbance. The habitat structure and vegetative composition changes as succession progresses; many wildlife and plant species are adapted to different stages within the early-successional continuum from bare earth through mature forestland. Managing for species dependent upon early-successional habitats presents several management challenges, including the need to identify which successional stage is most appropriate for the species or assemblage of interest, and the need for repeated management actions to maintain suitable habitat.

The extent and quality of early-successional habitats has been greatly dependent upon human land use patterns. While there is some uncertainty as to the extent of early-successional habitats prior to European settlement, it is likely that many early-successional species' populations peaked in the early 1900s with extensive forest clearing and low-intensity agricultural operations. In the second half of the 20th century, the quantity and quality of early-successional habitats diminished due to fire reduction, increasing development, encroachment of exotic vegetation, changing agricultural and forestry practices, and fragmentation of habitat patches into small, isolated units (Cobb et al. 2002; Johnson and Igl 2001; Thompson and DeGraaf 2001; Warner 1994). Populations of many species that depend on these habitats have also declined during this time period (Hunter et al. 2001).

Historically, the Piedmont in York County contained some prairie-type habitats (Barden 1997) with high plant and insect diversity. Around the time of colonization, these Piedmont prairies were maintained through fire and herbivore grazing. Today, remnant tracts of prairie are found primarily along powerline right-of-ways and sites managed specifically for prairie restoration and maintenance.

A considerably smaller portion of forestland is in public ownership in the Piedmont than in the Blue Ridge Ecoregion. The US Forest Service is the primary agent of land protection in the Piedmont with two large Ranger Districts of the Sumter National Forest, the Long Cane and the Enoree, which are located within the region. Actual public ownership within the authorized National Forest boundaries is, however, extremely fragmented. Most of the land in the Piedmont is held by corporate or other private ownerships not associated with the forest product industry (Conner and Sheffield 2000).

Severe soil erosion during the 19th and early 20th centuries has had lasting effects beyond the obvious changes to Piedmont uplands. When large quantities of soil were carried from cotton fields and denuded forests, a portion of the soil was deposited onto Piedmont floodplains (Fox 2000). Today, there is an average of 1.2 m (4 ft.) of surficial sediments, not present prior to European colonization, in the floodplains of most Piedmont streams. Streams typically continue to flow at the original level; therefore, many modern streams are deeply entrenched with one or both banks rising abruptly to about 1.2 m (4 ft.) above the streambed.

Even though agricultural land use practices improved and farming declined during the 20th century, floodplain sediments persisted, overlying former Piedmont wetlands. These wetlands probably featured numerous depressions of swamp tupelo (*Nyssa biflora)* and willow oak (*Quercus phellos)* that served as natural green-tree reservoirs for ducks and other wildlife (Ron Ahle, SCDNR, pers. comm.). Over time, floodplain sediments will be transported downstream as meandering streams erode and re-deposit sediments, but this is a slow process and is hampered, in some cases, by stream channelization.

Land Covertypes

The rolling uplands of the Piedmont landscape are predominantly a mosaic of agricultural land and managed woodland with a history of clearing and economic use that dates back to the earliest times of European settlement. Hardwood-dominated forests occupy relatively narrow floodplains and scattered upland sites, while pine and pine-hardwood forests occupy the majority of forested upland sites. The resulting landscape does not constitute suitable habitat for many area-sensitive wildlife species or for species associated with either early or late-successional conditions. Most of the priority species considered in the SWAP that occur in the Piedmont fall into one or more of these categories. Figure 4-8 defines the covertypes associated with the Piedmont Ecoregion. Species-habitat associations are presented in Appendices 1 A-D while the faunal makeup of the habitats are described in more detail within this chapter (4).

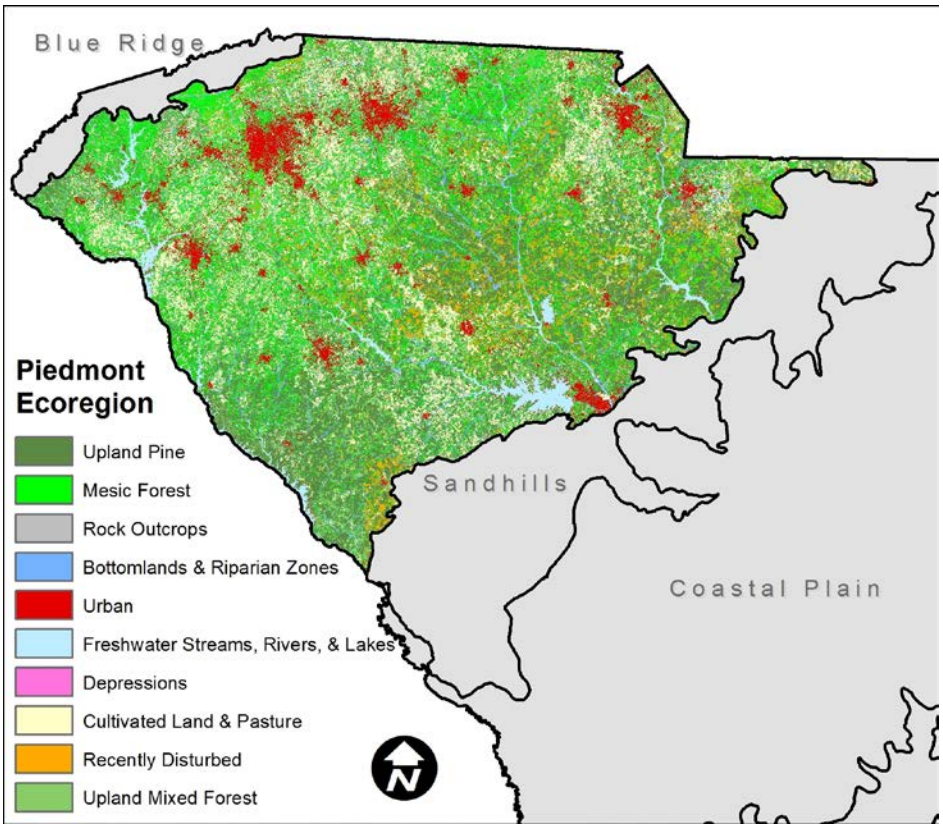

FIGURE 4-8: Land covertypes of the Piedmont Ecoregion.

Upland Pine	Many upland pine forest communities in the Piedmont Ecoregion are artifacts of past or current silvacultural practices. Such monocultural stands of loblolly (*Pinus taeda*) or Virginia pine (*P. virginiana*) are typically characterized by dense, closed canopy forests with little to no understory and low diversity in the herbaceous layer. In contrast, naturally occurring upland pine communities may consist of open, mixed-species stands of loblolly (*P. taeda*), Virginia (*P. virginiana*) and shortleaf pine (*P. echinata*). A sparse canopy layer permits enough light penetration to sustain occasional shrub thickets composed of Blueberries (*Vaccinium*), hawthorns (*Crataegus*) and other woody perennials. Open grassy savannas dominated by big bluestem (*Andropogon*) and little bluestem (*Schizachyrium*) sprawl throughout this landscape and may carry the occasional wild fire.
Mesic Forest	Mesic forests are typically associated with water bodies and natural levies where overflow accumulates during periods of high rainfall. This habitat type may have been more common in the Ecoregion prior to sedimentation from erosion processes during the 'dust bowl' era. This habitat is typically characterized by closed canopy hardwood forests with *Nyssa biflora*, *Acer rubrum*, *Liquidambar styraciflua*, and *Liriodendron tulipifera*. The understory may be dense to sparse but typically composed of smaller tree species and

	infrequently shrubs. Where understory is sparse to absent, a rich herbaceous layer may be found with numerous springtime ephemerals such as *Trillium spp.* and *Arisaema spp.*
Rock Outcrops	Rock outcrops of widely varying sizes and slopes occur throughout the region. Slopes range from nearly horizontal to nearly vertical. The more extensive and exposed outcrops have their own characteristic vegetation and habitat features. Vegetation ranges from none, (bare rock) to a mosaic of herbaceous plant, shrub and tree-dominated communities. Successional trees, such as eastern red cedar (*Juniperus virginiana*) and Virginia pine (*Pinus virginiana*) are common on these sites. Crevices and ledges can only provide habitats for larger plants once sufficient soil has accumulated. Vegetative communities are relatively unstable. A cliff or dome may also have a significant area of wet seepage zones.
River Bottoms *(within Bottomlands & Riparian Zones layer)*	River bottoms or "bottomland forests" consist of hardwood-dominated woodlands with moist soils that are usually associated with major river floodplains. Characteristic tree species include sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), laurel oak (*Quercus laurifolia*), cherrybark oak (*Quercus pagoda*), and American holly (*Ilex opaca*). A subtype dominated by bald cypress (*Taxodium distichium*) and water tupelo (*Nyssa aquatica*) occurs on lower elevation sites, but is not as prevalent as in the broader floodplains of the coastal plain. Compared to the coastal plain, the floodplains of major rivers in the Piedmont are confined by topography to relatively narrow corridors.
Piedmont Small Stream Forest *(within Bottomlands & Riparian Zones layer)*	Piedmont small stream forests are distinguished from forest communities on larger floodplains because of differences between the scales of the ecosystems. In smaller floodplains, the levees, sloughs, and ridges are largely absent or poorly developed. Flooding regime is also more variable between small watersheds than larger ones. Soils are various alluvial types that are seasonally or intermittently flooded. The forest has an open to dense understory or shrub layer and a sparse to dense herb layer. The canopy has a mixture of bottomland and mesophytic trees including river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), American elm (*Ulmus americana*), hackberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), and red maple (*Acer rubrum*).
Cove Forest *(within Bottomlands &*	Cove forests are botanically diverse, well-developed hardwood forests occurring on scattered rich, and generally small, sites (less than 81 ha or 200 ac.). These forests usually occur on protected bluffs

Riparian Zones layer)	in association with small stream forests or river bottoms. No single species tends to dominate. Shrub species are usually numerous and the herbaceous flora is fairly rich, with many spring ephemerals. The canopy and understory are composed of hardwoods including beech (*Fagus grandifolia*), tulip poplar (*Liriodendron tulipifera*), black gum (*Nyssa sylvatica*), sourwood (*Oxydendrum arboreum*), white oak (*Quercus alba*), northern red oak (*Q. rubra*), black oak (*Q. velutina*), sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), southern sugar maple (*A. saccharum*), basswood (*Tilia heterophylla*), ironwood (*Carpinus caroliniana*), flowering dogwood (*Cornus florida*), American holly (*Ilex opaca)*, witch-hazel (*Hamamelis virginiana)* and hop-hornbeam (*Ostrya virginiana*).
Depressions	While Piedmont depressions, or high ponds, may occasionally be referred to as Carolina bays, they do not necessarily share the same geological history and may play host to an entirely different vegetative community. Often characterized by perched water tables over clay basins, high ponds are usually dependent on rainfall and may be associated with an out-flowing stream channel during periods of heavy precipitation. Frequently converted for agricultural purposes, these fishless waters play an important role in the reproductive cycle of many pond breeding amphibians. Their relative isolation also tends to coincide with specialized emergent plant communities which may include uncommon herbaceous species such as Harperella (*Ptilimnium nodosum*) and *Coreopsis rosea*.
Upland Mixed Forest	Occurring throughout the State but most characteristic of rolling uplands in the Piedmont, oak-hickory forest is a widely distributed community that varies from site to site. Occurring in highly fragmented stands, later successional stages tend to be made up of a diverse assemblage of hardwoods, primarily oaks and hickories, as co-dominants in combination with pines. Understory, shrub and herbaceous layers are present in varying degrees, represented by diverse woody and non-woody species. Vegetation on most sites consists of early- to mid-successional managed stands of pine and pine-hardwood forest. The understory in pure pine stands is often open, but in mixed or older stands, it is dominated by the hardwoods characteristic of the site. Common pine species of the Piedmont include shortleaf (*Pinus echinata*) and loblolly (*P. taeda*), with the former better adapted to dry, fine textured upland soils and loblolly achieving maximum growth on deep soils with good moisture and drainage.
Grassland and Early-Successional Habitats	As in other ecoregions, a variety of grassland and early-successional habitats are present, either as transitional vegetation following forest disturbances or as managed areas. Early-successional habitats are

(specialized habitat not mapped at this scale)	generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual forbs, perennial bunchgrasses, and variable coverage of shrubs and small trees. A variety of open land covertypes represents this category and can include native prairies, savannas, old field sites, open canopy gaps, shrub-scrub thickets, recently-cleared forests, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports and various urban open spaces are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high quality, early-successional habitat (see Cultivated Land and Pasture). Minor modifications to agricultural land use, such as replacing introduced grasses with native grasses, using native grasses in filter strips and grassed waterways, and implementing no-till or strip-till in crop fields can result in dramatic improvements to quality of early-successional habitat. Maintenance of early-successional habitat requires periodic repeated disturbance or disruption of the existing vegetative community. Purposeful management of early-successional habitat is usually accomplished through the use of timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5 years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of variety of successional, or seral, stages. Early-successional habitat types have declined dramatically over the past 70 years primarily due to changing agricultural practices, forest succession, fire suppression, and urban / suburban encroachment. A large portion of existing early-successional habitat occurs on privately owned lands. One of the greatest challenges to maintaining priority species associated with this particular land cover is private land outreach and technical assistance.

Freshwater Streams, Lakes, and Ponds

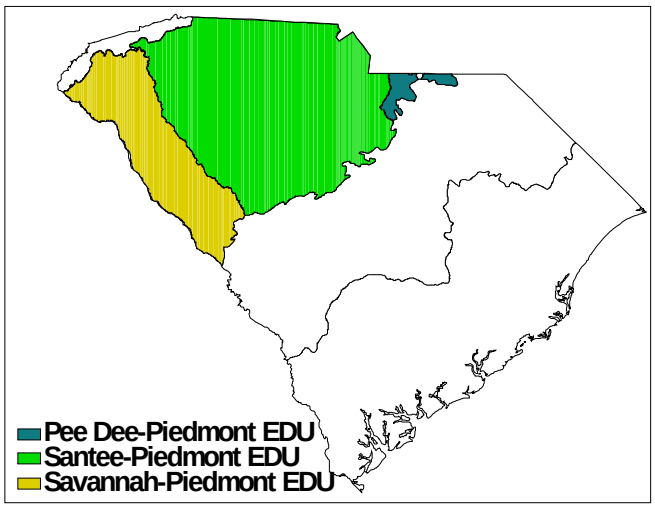

FIGURE 4-9: Drainages of the Piedmont Ecoregion

The Piedmont Ecoregion extends south of the Blue Ridge to the Fall Line near Columbia, South Carolina and from the Savannah River east to the Pee Dee River. Encompassing 24 counties and 27,941 km^2 (10,788 $mi.^2$), the Piedmont is the largest physiographic province in South Carolina. The Piedmont is an area with gently rolling hills dissected by narrow stream and river valleys. Forests, farms and orchards dominate most of the land. Elevations range from 114 to 305 m (375 to 1,000 ft.). Freshwaters in the Piedmont Ecoregion total approximately km 17,703 km (11,000 mi.) of streams and rivers with over 777 km^2 (300 $mi.^2$) of major impoundments. By length, first- through fourth-order (wadeable) streams comprise the primary aquatic habitat type. At higher elevations, Piedmont streams may exhibit moderate gradient with coarse substrates including cobble, gravel, and bedrock. Lower elevation Piedmont streams generally have less gradient with substrates primarily consisting of sand, gravel, and silt. Piedmont streams are typified by long runs of intermediate depth separated by shallow riffles and deeper pools. The Piedmont Ecoregion cuts across the top of 3 major South Carolina drainages, the Savannah, the Santee, and the Pee Dee, forming 3 ecobasins: the Savannah-Piedmont, Santee-Piedmont and Pee Dee-Piedmont.

In the not too distant past, forests and farms dominated the land cover in the Piedmont Ecoregion. However, the vast majority of Piedmont forests were cleared at some point during the last two centuries to develop crop and pasture lands. Most Piedmont streams are now heavily silted due to the agricultural development of the Piedmont's modest slopes and highly erodible soils.

Wadeable streams are the dominant habitat in the Piedmont and are defined as those with Strahler stream orders of 0 to 3; they are generally comfortably wadeable throughout most of the year. Wadeable streams in the Piedmont posses different characteristics based chiefly on their gradient. Streams in the Inner Piedmont (just below the Blue Ridge) typically have moderate gradients with clear to moderately turbid water. Substrates in those streams are generally sand, gravel, and coble with boulders and exposed bedrock occurring less frequently. These streams contain a variety of habitats including frequent long stretches of riffles and runs separated by short sections of pools and glides. As one moves south and east through the Outer Piedmont toward the Fall Line, wadeable streams have less gradient; runs and riffles become less frequent and shorter in length, while slow-flowing pools comprise the majority of habitat. Outer Piedmont streams are generally turbid, carrying a heavy sediment load from both historic and current conversion of forested land to agriculture and silviculture. These streams have substrates of mostly sand, silt, clay, and detritus.

Navigable streams are common in the Piedmont Ecoregion and include large rivers like the Savannah River, Saluda River, Broad River, and Catawba River, as well as smaller rivers like the

Reedy River, Enoree River, and Fishing Creek. These streams are generally defined as being large enough to operate watercraft, if only a canoe, and are generally too deep to be waded throughout most of the year. These larger streams are more productive than their smaller counterparts and typically carry a heavy sediment burden. Substrates are typically sand, clay, and detritus, although the high gradient areas produce shoals and riffles that contain gravel, cobble and, occasionally, exposed bedrock and boulders. All of the large rivers (Savannah, Saluda, Broad, and Catawba) and many of the smaller rivers (Reedy, Enoree, and Tyger) have been impounded somewhere along their course. These impoundments have forever altered the natural hydrographs of these rivers and the habitats they contain.

Savannah-Piedmont Ecobasin

The Savannah River drainage originates in the mountains of North Carolina and Georgia. The Savannah River flows southeast along the border of South Carolina and Georgia through the Piedmont for approximately 211 km (131 mi.) on its way to the Atlantic Ocean. Major tributaries to the Savannah River in the South Carolina portion of this ecobasin include the Tugaloo River, Seneca River, Chauga River, Rocky River, Little River and Stevens Creek.

The ecobasin encompasses 36 watersheds and approximately 7,457 km^2 (2,879 $mi.^2$). The ecobasin contains 5,356 km (3,328 mi.) of lotic habitat with 370 km^2 (143 $mi.^2$) of impoundments. Most of the impounded water occurs in 4 large reservoirs: Lake Keowee (6,884 ha or 17,010 ac.), and the South Carolina portions of Lake Hartwell (35,187 ha or 35,187 ac.), Lake Russell (6,154 ha or 15,207 ac.), and Thurmond Reservoir (8,619 ha or 21,297 ac.).

Primary conservation targets within the ecobasin include the Stevens Creek watershed in Greenwood and McCormick Counties, the Turkey Creek watershed in Edgefield County and the main stem Savannah River in Edgefield and Aiken Counties (Smith et al. 2002). The Stevens Creek and Turkey Creek watersheds are home to several mussels on South Carolina's Priority Species List including the brook floater, yellow lampmussel, creeper and the federally endangered Carolina heelsplitter. At least 13 priority fish species are also found in this ecobasin, including the Christmas darter, Savannah darter and turquoise darter. The main stem of the Savannah River in Edgefield and Aiken Counties is home to the Robust Redhorse and federally endangered Shortnose Sturgeon as well as several other priority fish species. Several priority mussel species (barrel floater, pod lance, Roanoke slabshell, yellow lampmussel, rayed pink fatmucket, and Savannah lilliput) are also found in the main stem Savannah River.

Water quality in this ecobasin was designated as impaired at 65 of 138 sites (47%) sampled by SCDHEC in 2003. Recreational uses were not supported at 30 sites due to the presence of fecal coliform bacteria. Aquatic life uses were not supported at 28 sites due to copper contamination, paucity of aquatic fauna, low dissolved oxygen concentrations, or abnormal pH values. Fish consumption advisories have been listed for 7 sites including Lake Hartwell, Lake Jocassee, Lake Russell, and the Chauga River (SCDHEC 2003a). Fish consumption advisories are due to mercury and PCB contamination.

Approximately 735 km (457 mi.) of streams within the Savannah-Piedmont Ecobasin have been impounded. Seven dams have been erected on navigable streams to form large impoundments,

and 210 smaller dams have impounded smaller streams (small reservoirs and farm ponds). Approximately 177 km (110 mi.) of the 211 km (131 mi.) of the Savannah River that occur within the ecobasin have been impounded by main stem reservoirs including Lake Hartwell, Lake Russell, and Thurmond Reservoir. The Stevens Creek hydroelectric dam on the Savannah River represents an impediment to diadromous fish movement within the Basin. Notable species affected include Striped Bass, American Shad, Blueback Herring, and American Eels. Passage is needed to accommodate both upstream migration of adults and outmigration of adult and juvenile fishes. Priority mussel species will also benefit from fish passage, as fish are a dispersal mechanism for mussels.

Excessive inputs of nutrients and other chemicals also degrade water quality. There are 128 active discharges permitted by SCDHEC within the ecobasin (SCDHEC 2003a). Of those, the majority (70 discharges) are industrial, while the remainder are from municipal (31 discharges) and community sources (27 discharges). CAFOs also add non-point source pollution. There are 120 agricultural facilities permitted by SCDHEC within the ecobasin, the majority of which are poultry operations (8 small farms, 54 medium farms, and 27 large farms). The remaining facilities include dairy farms (16 small and 1 medium operation), and 8 small swine farms. On a statewide basis the amount of agricultural activity within the ecobasin is moderate (just over 4agricultural operations per 259 km^2 (100 $mi.^2$) which probably doesn't significantly threaten water quality throughout the ecobasin. However, within the Tugaloo River/Lake Hartwell watershed there are many agricultural facilities (55, or approximately 41 per 259 km^2 or 100 square miles). These are primarily poultry operations that may significantly impact water quality within the watershed. Other agricultural operations such as row crops (corn and wheat) and pastureland also contribute to non-point source pollution of sediments and nutrients.

Poorly planned industrial, residential, and commercial development has resulted in significant negative impacts to aquatic resources within the ecobasin. Overall, a moderate amount of industrial, residential, and commercial growth can be expected for the ecobasin (SCDHEC 2003). Moderate to high levels of growth are expected in the upper third of the ecobasin along the I-85 corridor. Areas likely to experience high growth include Clemson, Easley, and Anderson. Growth in the lower portion of the ecobasin will be slower because the Sumter National Forest encompasses much of the land, limiting development opportunities.

The Stevens Creek watershed in Edgefield, McCormick, and Greenwood Counties is known to be a unique aquatic resource. Priority fish species such as the Christmas darter and imperiled mussels such as the Carolina heelsplitter reside in streams of this watershed. Tributaries such as Hard Labor Creek drain the region around metropolitan Greenwood, South Carolina. This is an area of rapid urban growth and increased human population. Impacts to the watershed from point and non-point sources can have a degrading effect on the aquatic community downstream.

Santee-Piedmont Ecobasin

The upper Santee River drainage originates mostly in the south central Piedmont of North Carolina, but receives some input from the mountains of South Carolina and North Carolina through the Saluda and Catawba River systems, respectively. The Broad River and Catawba-Wateree Rivers are the dominant rivers in this ecobasin. The Broad River flows nearly directly

south from North Carolina to Columbia, South Carolina where it merges with the Saluda River at the fall line to form the Congaree River. As the Broad River flows south, it picks up inputs from the Pacolet River, Tyger River, and Enoree River along the western portion of the drainage and Kings Creek, Turkey Creek, Sandy River, and Cedar Creek from the eastern portion of the drainage. The Catawba River originates on the eastern slope of the Blue Ridge in North Carolina and flows through the Inner Piedmont and Charlotte, North Carolina before entering South Carolina. The Catawba flows south through South Carolina until it is impounded to form Lake Wateree and thereafter is known as the Wateree River. The Wateree River continues to flow south through the Southeastern Plains until it merges with the Congaree River to from the Santee River.

The Santee-Piedmont Ecobasin is the largest in the State, containing part or all of 84 watersheds and encompassing 19,694 km^2 (7,604 $mi.^2$). The ecobasin contains approximately 18,547 km^2 (7,161 mi.) of stream habitat and nearly 414 km^2 (160 $mi.^2$) of impoundments. Most of the impounded area (329 km^2 or 127 $mi.^2$) is the result of five large reservoirs, including Lake Greenwood (4,029 ha or 9,957ac.) and Lake Murray (19,594 ha or 48,417 ac.) on the Saluda River, Monticello Reservoir (2,689 ha or 6,644 ac.) on the Broad River, and Lake Wylie (2,051 ha or 5,067 ac.) and Wateree Lake (4,608 ha or 11,386 ac.) on the Catawba-Wateree River.

The Santee-Piedmont Ecobasin contains several areas of conservation priority (Smith et al. 2002). Conservation targets that contain rare, threatened, and endemic species include: the Saluda River headwaters, which encompass the North Saluda River, South Saluda River and Oolenoy River watersheds located in the Inner Piedmont of Greenville and Pickens Counties; the Clouds Creek watershed in the Slate Belt Ecoregion in Saluda County; the main stem of the Broad River from the North Carolina line to Parr Shoals Reservoir in South Carolina; the Kings Creek watershed and the Clarks Fork system in the Bullocks Creek watershed located primarily in the Kings Mountain area in Cherokee and York Counties; the Six Mile Creek and Waxhaw Creek systems in the Twelve Mile Creek watershed in Lancaster County; the Gills Creek system in the Camp Creek watershed in Lancaster County; and the Wateree Creek watershed in Richland County. The Saluda River headwaters contain populations of priority fish species including turquoise darter and Carolina fantail darter. The Clouds Creek watershed contains populations of the priority fish species the Carolina darter (formerly Saluda darter) as well as at least one priority mussel species, the Savannah lilliput. The main stem of the Broad River contains priority fish species including several catostomids (Notchlip Redhorse, V-lip Redhorse, Quillback, and Highfin Carpsucker) and percids (Seagreen Darter, Carolina Fantail Darter, and Piedmont Darter). The Kings Creek watershed and Clarks Fork system contain several priority fish species including the Carolina Fantail Darter, the Seagreen Darter, and the Piedmont Darter. The Six Mile Creek and Waxhaw Creek systems contain several priority mussel species including the notched rainbow, Carolina creekshell and the federally endangered Carolina heelsplitter. The Gills Creek system also contains Carolina creekshell and Carolina heelsplitter. The Wateree Creek watershed contains several priority fish species including the Carolina Darter, the Piedmont Darter, and the Seagreen Darter.

Water quality was impaired at 279 of 468 locations (59%) sampled by SCDHEC (SCDHEC 1998a; SCDHEC 1999a; SCDHEC 2001). Recreational uses were not supported at 151 sites due to the presence of high concentrations of fecal coliform bacteria. Aquatic life uses were not

supported at 125 sites primarily due to a lack of invertebrate fauna, low pH, low dissolved oxygen concentrations, or copper contamination. Fish consumption advisories due to mercury contamination have been issued for the Wateree River below Wateree Dam to its confluence with the Congaree River, and the Saluda River from Pelzer to the Congaree River in Columbia. Only approximately 18 km or 11 river miles have been designated as Outstanding Resource Waters by SCDHEC.

Nearly 805 km (500 mi.) of streams within this ecobasin have been impounded. Roughly 50 dams have been constructed on navigable streams during the last two centuries, and nearly 700 smaller impoundments (small reservoirs and farm ponds) pepper the landscape, disrupting and fragmenting smaller streams. The Lake Murray Dam, which impounds the Saluda River to form Lake Murray, has degraded aquatic habitat in the Saluda River below the dam.

Excessive nutrient and other chemical inputs also degrade water quality within the ecobasin. There are 454 point source contributors permitted by SCDHEC within the ecobasin (SCDHEC 1998a; SCDHEC 1999a; SCDHEC 2001). Of those, 261 are associated with industry, 119 are associated with municipalities, and the remainder are associated with community discharges. Saluda River studies conducted by Hayes and Penny (2002) implicated the Ware Shoals Waste Treatment Plant (WTP) as having a depressing effect on the downstream fish community. The study indicated that species richness and abundance were reduced in the stretch of river between Ware Shoals and Lake Greenwood. CAFOs are abundant in the ecobasin as well, with 245 facilities permitted by SCDHEC (SCDHEC 1998a; SCDHEC 1999a; SCDHEC 2001). Agricultural facilities throughout the ecobasin are relatively sparse in most areas, and on a statewide basis there is only a moderate amount of agricultural activity with approximately 3 facilities per 259 km^2 (100 $mi.^2$). However, in the upper Lake Murray area, including the Clouds Creek, Little Saluda River and Bush River watersheds, there is significant agricultural activity (86 sites) with nearly 14 agricultural facilities per 259 km^2 (100 $mi.^2$).

The Saluda River Basin drains much of the Greenville-Spartanburg metropolitan area. The rapidly increasing population and accompanying development have led to significant urban sprawl and resulted in associated aquatic impacts such as stormwater runoff, non-point source chemical inputs, and stream channel alterations. Although improvements in municipal waste treatment have occurred in this area, point source pollutants add unnatural coloration and increase nutrient levels that sometimes lead to noxious algal blooms downstream in Lake Greenwood (SCDNR, unpublished data).

The I-85 corridor from Anderson, South Carolina to Charlotte, North Carolina is one of the most rapidly developing areas of the State. Impacts of road construction, residential and commercial development, and general urban sprawl have been felt in most of the major river systems (Saluda, Reed, Pacolet, Enoree, Tyger, and Broad Rivers) in this area. Water quality degradation and stream channel alteration are probably the most obvious impacts to these aquatic systems.

Pee Dee-Piedmont Ecobasin

The South Carolina Piedmont portion of the Pee Dee drainage originates just across the state line in North Carolina. The Pee Dee–Piedmont Ecobasin is the second smallest ecobasin in the state,

encompassing only 715 km^2 (276 mi.^{2}). Tributaries to the Pee Dee River included in the ecobasin are Lynches River and Thompson Creek. There are approximately 753 km (468 mi.) of stream habitat within the ecobasin and only 136 ha (337 ac.) of impounded water.

The majority of the ecobasin is a primary conservation target, including the Lynches River, Flat Creek, and Little Lynches River systems in the upper Lynches River basin located in Lancaster and Chesterfield Counties. Also, the Thompson Creek system in the upper Pee Dee basin in Chesterfield County is a high priority. Several priority fish species occur in the upper Lynches River basin, including the "Thinlip" Chub, Sandhills Chub, and "Broadtail" Madtom. In addition to those fish species, several priority mussel species populate the basin including, the brook floater, creeper, notched rainbow, and the Federally Endangered Carolina heelsplitter. The Thompson Creek system contains several priority fish species—"Thinlip"Chub, Sandhills Chub, Fantail Darter, and Piedmont Darter—as well as several species whose populations in South Carolina are entirely restricted to that system such as the Satinfin Shiner, Redlip Shiner, and Comely Shiner.

SCDHEC sampled the ecobasin in 2000 and found that water quality was impaired at 15 of 25 sites (60%), representing one of the highest ratios of impairment within the State. Recreational uses were not supported at 6 sites due to the presence of high concentrations of fecal coliform bacteria. Aquatic life uses were not supported at 9 additional sites due to lack of aquatic invertebrate diversity, low dissolved oxygen, copper contamination, or high turbidity (SCDHEC 2000).

Impoundments do not currently pose a great threat to aquatic fauna in the Pee Dee-Piedmont ecobasin. There are only 15 dams permitted by SCDHEC within the ecobasin and only 10 km (6 mi.) of impounded streams, none of which are navigable.

As with most ecobasins, especially in the Piedmont Ecoregion, erosion and sedimentation have substantially degraded aquatic habitat. Ground disturbance from development activities, agriculture and silviculture are primary sources of erosion that lead to sedimentation in Piedmont streams. In the Pee Dee-Piedmont ecobasin, more than 25% of the land within the ecobasin is agricultural, which may contribute significantly to stream sedimentation.

Excessive nutrient and other chemical inputs may degrade water quality within the ecobasin. There are 9 active point source discharges permitted by SCDHEC (2000) within the ecoregion including, 2 industrial and 4 municipal (e.g. waste water treatment plant) discharges. With 35 CAFOs, the ecobasin has the highest density of CAFOs in the State at nearly 13 per 259 km^2 (100 mi.^{2}). Most of the CAFOs are turkey (22) and poultry (12) farms. In addition to the CAFOs, other agricultural operations (row crops and pastureland) may significantly impact water quality within the ecobasin.

There is low to moderate potential for growth within the ecobasin (SCDHEC 2000). The greatest potential for development occurs in the northwestern portion of the ecobasin which is part of the Charlotte Metroplex. Future development will pose new threats to aquatic habitats and biota, particularly if those developments are not carefully planned.

Region-wide Challenges

The primary factor influencing habitat quality and quantity in the Piedmont is urban sprawl. Since World War II, population growth in the Piedmont has been rapid, outpacing growth in the United States as a whole. Migration from other regions of the United States as well as international immigration has fueled this growth. Both population growth and the land use patterns that have accompanied it have contributed to sprawl (Rusk 2003). Table 4-3 compares urbanization patterns in some of the Piedmont's major cities.

Table 4-3: A comparison of urban sprawl in the Piedmont Ecoregion	
Urbanized Area	**Urbanized Acreage Per New Resident**
USA (396 areas)	0.18
Spartanburg	0.88
Greenville	0.93
Anderson	0.99
Rock Hill	1.01

Low-density development contributes to habitat fragmentation which impacts many fish and wildlife species. In the Piedmont, development has been particularly rapid in association with the interstate highway system. Habitat fragmentation also hinders the use of prescribed fire. Therefore, most of the priority species associated with fire-dependent communities decline as development encroaches. While most birds can rapidly find and colonize early-successional habitat patches, some bird species—grassland birds in particular—are area sensitive and will not use small patches of habitat surrounded by forest or developed areas. The Northern Bobwhite may require large areas of contiguous habitat (greater than 2,023 ha or 5,000 ac.) for long-term population viability (Guthery et al. 2000). The isolation of suitable early-successional habitats may be most problematic for mammals, reptiles, and amphibians that have limited dispersal ability and may suffer high mortality when traveling through unsuitable habitats.

Concerns about liability, air quality, social acceptance, and smoke management, as well as the lack of landowners with experience and equipment to conduct prescribed burns, has limited the use of fire on private lands. Similar to the coastal regions, fire was once an important natural feature of the Piedmont (Frost 1998). Pre-settlement oak-hickory forests experienced surface fires that were frequent, of low intensity, and that were sustained by fine grass, pine needles and hardwood litter. An absence of fire leads to forest stands dominated by fire-intolerant species such as maple, beech, and sweet gum. The pre-settlement mean fire return interval was 4 to 6 years in many parts of the Piedmont, while in certain places, fires burned almost every year. Early European explorers described small, open prairies on the upper Piedmont maintained by annual fall burns conducted by Native Americans.

Piedmont prairies contain highly diverse and specialized plant and insect communities, and only small remnant tracts remain in South Carolina. Fire and/or other low-intensity soil disturbances, such as light disking at the proper time of year, are necessary for the maintenance of prairie communities. Current restoration efforts are focused on plant

conservation and have been implemented on small acreages that have limited value for area-sensitive grassland species such as the Grasshopper Sparrow and the Eastern Meadowlark.

Challenges to conservation of aquatic fauna in these three ecobasins are similar to other ecobasins in the State and primarily include impacts associated with impoundments, non-point source pollution, point source pollution, poorly planned development, and introductions of non-native species.

Impacts from hydropower development have substantially altered and degraded a significant portion of habitat for most native aquatic species. Nearly 1,561 km (970 mi.) of streams within the ecoregion have been impounded. Roughly 57 dams have been constructed on navigable streams during the last two centuries, and more than 900 smaller impoundments, including farm ponds, pepper the landscape, disrupting and fragmenting smaller streams. Dams result in a loss of connectivity and negatively affect aquatic biota both above and below the impoundment (Doeg and Koehn 1994; Kanehl et al. 1997; Tiemann et al. 2004) through direct loss of habitat as lotic habitat is converted to lentic habitat. This favors competitive, and often predacious, species including Largemouth Bass and other centrarchids. In addition to direct loss of habitat, impoundments often impact the unimpounded stream reaches downstream through altered hydrologic and thermal regimes (Cushman 1985), modified stream channel morphology, and increased erosion and sedimentation (Watters 1996); all of which ultimately reduce suitable habitat for native aquatic fauna (Helfrich et al. 1999; Tiemann et al. 2004). Impoundments on the Savannah River, Saluda River, Broad River and Catawba-Wateree River have disrupted the historic migrations of anadromous species (American Shad and Striped Bass) that once represented culturally and economically important fisheries. Fish passage is also critical in allowing the dispersal of mussels, since larval mussels are parasitic on the gills of host fishes and are dispersed by the fish prior to settlement.

Although a large portion of the ecoregion is currently forested, most of the forests were cleared at some point during the last two centuries to develop crop and pasture lands. Forest and tilling of the Piedmont's highly erodible soils has resulted in streams that are still heavily silted. Modern soil conservation practices, such as the creation of Streamside Management Zones (SMZs), have reduced those impacts, but sedimentation from non-point and point sources remains a significant detriment to Piedmont streams today. Farmers that have neglected to implement soil conservation practices further compound sedimentation problems in Piedmont streams. Ground disturbance from development activities, agriculture, and silviculture are primary sources of erosion that lead to sedimentation in Piedmont streams. Corporate and private timber managers that fail to follow Best Management Practices (BMPs) further contribute significant siltation and other non-point source pollution within the ecoregion. Streambank erosion due to loss of riparian areas, livestock grazing, and altered hydrology also contribute to sedimentation in Piedmont streams.

Excessive nutrients and other chemical contamination also negatively affect water quality in the ecoregion. Point source discharges from industrial, municipal, and community sources add nutrients and other pollutants to the receiving streams, rivers and lakes. In addition to those sources of pollution, agricultural operations also impact water quality. Nationwide, pollution

from agricultural sources is the greatest impairment to streams and lakes (SCDHEC 2003a). The Piedmont has the highest density of permitted discharges within the State and the second highest density of concentrated animal feeding operations (CAFOs) with nearly 5 agricultural operations per 259 km^2 (100 $mi.^2$). Water quality in the Piedmont was impaired at 57% of the sites sampled by the SCDHEC (1998a, 199a, 2000, 2001, 2003a), which is the second highest impairment rate among the four aquatic ecoregions in the State. Recreational uses were impaired at nearly 30% of the sites sampled due to the presence of high concentrations of fecal coliform bacteria. Fecal coliform bacteria are present in the digestive tract of warm-blooded animals; although fecal coliform bacteria are not generally harmful to humans, they do indicate that surface waters may contain disease-causing pathogens (SCDHEC 1998a, 1999a, 2000, 2001, 2003a). More than one quarter of the streams sampled by SCDHEC within the ecoregion did not support aquatic life uses. Those stream sites do not possess sufficient water quality to maintain a balanced aquatic community of plants and animals.

Introductions of non-native fish species may threaten native aquatic fauna in the Piedmont. Smallmouth Bass, Spotted Bass, Muskellunge, Flathead Catfish, and Blue Catfish are established in portions of the ecoregion. The effects of these introduced species on native game and nongame species is not currently well known. Flathead Catfish introductions into the Savannah River, Saluda River, and Catawba River Basins as well as Blue Catfish introductions into the Savannah River, Broad River, and Catawba River Basins likely pose the greatest risks to native fauna. Flathead Catfish have been shown to prey on bullheads, darters, shad, suckers, and sunfish. Severe declines in native species, particularly bullheads and sunfish, have been observed after the introductions of Flathead Catfish (Guire et al. 1984; Jenkins and Burkhead 1993; Bart et al. 1994). The introduced Spotted Bass and Smallmouth Bass in the Savannah River and its tributaries threaten the native Redeye Bass through competition and hybridization.

Introduction of nonnative invertebrates also pose a threat to the native fauna. The Asian clam, *Corbicula fluminea*, has been introduced and has spread throughout the United States, including into South Carolina. The effects of *Corbicula* on native species are not well understood. A review of the literature on the interactions between *Corbicula* and native mussels (Dillon 2000) indicated that most field studies failed to find any significant negative effects on native species, although a few detected reductions in growth of mussels. The red swamp crayfish has been introduced to South Carolina as well and has been observed at several locations in the Coastal Plain, but has yet to be identified in the Piedmont. However, there have been very few crayfish inventories conducted, none of which have been initiated on a statewide basis. In North Carolina, the red swamp crayfish has become established in all drainages of the Coastal Plain and Eastern Piedmont Plateau and appears to have extirpated all the native crayfish at one location (Cooper 2003). Introduced crayfish are believed to be the biggest threat to native crayfish species (Lodge et al. 2000 a,b), and the risk to our native species is great if further introductions or if extensive spread of nonnative crayfish occurs.

Rapid development in the Piedmont, especially in the Upstate, has included substantial highway construction. The requirement for sand in road construction has resulted in sand mining operations in the main stem or riparian areas of many Piedmont rivers and streams. Sand mining not only causes bank stability problems and loss of riparian areas at the mining site but instream impacts as well. Mining operations affect physical and chemical habitat and can negatively affect

biological communities (Nelson 1993) and recreational uses (Hartfield 1993). Physical impacts on instream habitat include increasing bedload materials and turbidity, changing substrate type and stability, and altering stream morphology (Nelson 1993). Physical habitat alterations associated with sand mining can adversely affect the biological community by decreasing reproduction and survival of fishes (Stuart 1953; Newport and Moyer 1974) and distribution and composition of other aquatic organisms (Buck 1956; Trautman 1957; Newport and Moyer 1974).

Sandhills Ecoregion

General Overview

The Sandhills Ecoregion is the inland portion of the Coastal Plain that borders the Fall Line. This ecoregion is frequently recognized as a physiographic province distinct from the Coastal Plain, although some researchers incorporate the Sandhills within a broader area known as the "Inner Coastal Plain." The Sandhills form a discontinuous belt of varying width of deep sands across the middle of the State (Porcher and Rayner 2001).

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

Compared to the adjoining Piedmont Ecoregion and Upper Coastal Plain, upland forest cover in the Sandhills Ecoregion is relatively unbroken. However, numerous cycles of pine removals and exclusion of fire have left a vast, rather monotonous forest cover over much of the landscape, consisting of small longleaf pines, turkey oak, and other scrub oak species. Forest in this condition is not suitable habitat for South Carolina's priority species. Indeed, the prevalence of forest in this condition is a primary source of concern for many of these priority species.

Considerable effort is being made by the forestry community and other conservation groups to encourage the production of saw timber-size longleaf pines and a more liberal application of fire. Historically, slash pine was planted approximately 161 m (100 mi.) north of its natural range on many thousands of acres in the Sandhills region but over the last few decades, public and private landowners have been replacing it with longleaf pine. Much of our knowledge base concerning longleaf pine planting is from the SC Forestry Commission based on methods utilized on Sandhills State Forest. This knowledge has greatly impacted longleaf pine restoration across all of its range. Longleaf pine seedlings and technical guidance for establishing longleaf stands are also becoming increasingly available.

Significant public land holdings in the Sandhills Ecoregion include: the US Army installation at Fort Jackson and the Army National Guard Leesburg Training Site; the Sandhills National Wildlife Refuge; Sandhills State Forest; major portions of the Savannah River Site; and

Hitchcock Woods (operated by a private foundation). Although the impetus for conservation-oriented management on many of these facilities stems from the listing status of the Red-cockaded Woodpecker (RCW), the intended future condition of many forested tracts on these lands is a longleaf pine-wiregrass community, with a significant portion of longleaf pine stands reaching older age classes.

Impoundments have been constructed in Sandhills streams for many centuries. In the 18th and 19th centuries, these were built to provide power and water for gristmills, and indeed most of these old mill ponds are still in existence. As agriculture continued to expand in the Sandhills Ecoregion, farm ponds were constructed to provide irrigation for agricultural fields. The number of small impoundments in blackwater streams increased dramatically during the 1960s and 1970s (Melven pers. comm.), and this trend continued through to the end of the century. There were approximately 1,100 farm ponds in Lexington County as of 1970 (Lawrence 1976) and there are now more than 4,000 (Deaderick pers. comm.). In a study of the Edisto River Basin, most of the wetland alterations documented in the North and South Forks of the Edisto River were found to have occurred in the headwater streams where the relatively steep and narrow valleys in the Sandhills represent favorable farm pond sites. Very few headwater streams in the Edisto Basin were found without impoundments (Marshall 1993).

Land Covertypes

Although xeric sandy soils predominate, the rolling terrain and variations in soil and subsoil composition provide significant local variation in habitat composition. The principal habitat of this ecoregion is Sandhills pine woodland, with local structure and composition influenced mainly by fire history. Fire is a dominant factor in the ecology of this region. Sandhills pine forests are a fire climax community; as such, these forests are dependent on frequent ground fires to reduce hardwood competition and to perpetuate pines and grasses.

Deep sand ridges ranging from 91 to over 183 m (300-600 ft.) above mean sea level are one of the most striking and dominant features of the Sandhills Ecoregion. Ridge tops of pure Lakeland and Kershaw Sands, some up to 9 m (30 ft.) in depth (Wharton 1978), support the most extreme xeric scrub communities of longleaf pine and turkey oaks. The sandy soils on the ridges, excessively drained with low available water capacity, are low in fertility due to rapid leaching and possess little to no leaf litter (Lawrence 1976). The drier sand ridges are suitable for agriculture only when managed through fertilization and irrigation. These ridges can support timber production, particularly of longleaf pine, which is well adapted to deep, dry sandy soils.

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

Rainwater rapidly percolates through the sand ridges until it reaches hardpan, at which point it moves laterally until emerging at the surface on side slopes or near the base of sand ridges. These natural seepage areas result in distinctive wetland habitats embedded within the xeric

forests and woodlands. The community type that develops is determined by the amount of water, the position on the slope, and—especially—by fire. In the absence of fire, this wetland habitat can be forested with longleaf or pond pines (*Pinus serotina*) growing over a dense evergreen pocosin-like shrub layer or, with frequent fire, it can be an open hillside herb bog. Seepage accumulating at the base of the sand ridges results in a saturated zone that supports a streamside pocosin forest. Figure 4-6 illustrates the distribution of land covertypes in the Sandhills Ecoregion. Species-habitat associations are presented in Appendices 1 A-D while the faunal makeup of the habitats are described in more detail within this chapter (4).

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

Figure 4-10 defines the covertypes associated with the Piedmont Ecoregion, and the habitat types are summarized in text format. Species-habitat associations are presented in Appendices 1 A-D while the faunal makeup of the habitats are described in more detail within this chapter (4).

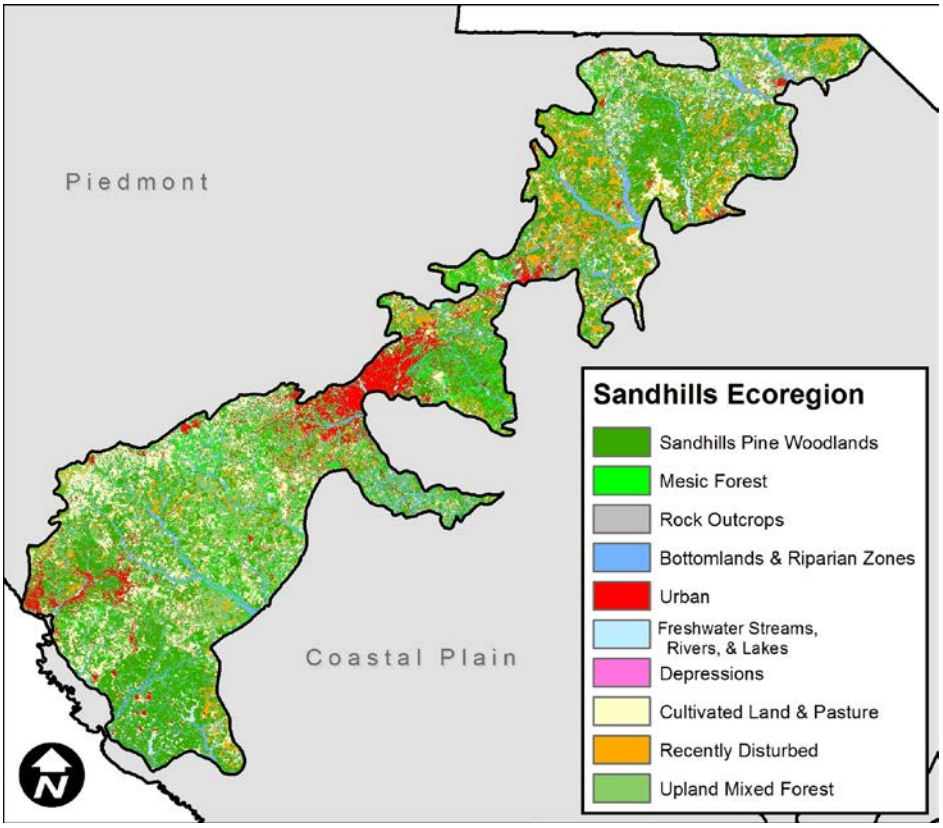

FIGURE 4-10: Land covertypes of the Sandhills Ecoregion.

Sandhills Pine Woodlands	Pine woodland is the characteristic vegetation on the sandy soils that define the region. On deep, well-drained sands, a longleaf pine (*Pinus palustris*) canopy with a subcanopy of turkey oak and other scrub oak species prevails. On lower or middle slopes, or on sites with relatively high amounts of organic matter, other pine species may share dominance with longleaf and a more diverse understory and herbaceous layer is present. On lower slopes sufficiently protected from fire, succession can proceed to oak-hickory forests similar to those of the Piedmont Ecoregion. Several priority species favor the longleaf pine-wiregrass community: a canopy composed of longleaf pine, an open understory, and a diverse herbaceous layer with extensive wiregrass *(Aristida* spp.) cover. The longleaf pine-wiregrass subtype is dependent on fire for maintenance. Wiregrass and leaf litter generally carry fire well and longleaf pine is well adapted to fire dependent communities. Where fire is excluded, turkey oak and other scrub oak species increase in abundance.
Mesic Forest	Usually associated with water bodies and natural levies, these forest communities may vary from closed canopy hardwood stands with little to no shrub layer to dense pocosin-like thickets with numerous ericaceous evergreen shrubs dotted with Pine species. At the interface with the Piedmont, hardwood dominants typically include *Taxodium distichum*, *Nyssa biflora*, *Acer rubrum*, *Liquidambar styraciflua*, *Liriodendron tulipifera*. Habitats closer to the Coastal Plain may include a sparse to dense shrub layer with *Pinus serotina* and *Pinus palustris* in the overstory. *Vaccinium* spp. may be present in the shrub layer.
Rock Outcrops	Confined to the inland-most portions of the Sandhills Ecoregion, at the boundary with the Piedmont, this habitat type roughly follows the geological fall line. Characterized by open, glady habitats with highly alkaline soils, there is little to no canopy layer and a dominant herbaceous layer. Numerous dry-adapted wild flowers and grasses predominate. While this habitat type is a minor component of the Sandhills Ecoregion, it may provide significant resources for wildlife cover and foraging at the periphery of surrounding forested lands.

Blackwater Stream Systems *(within Bottomlands & Riparian Zones layer)*	Tributary streams rising in the Sandhills and Coastal Plain are commonly known as "blackwater streams" for the color of tannins that leach from decaying vegetation. Forests on the narrow floodplains formed by these streams typically have a canopy dominated by swamp tupelo *(Nyssa biflora)* and red maple *(Acer rubrum)*. On broader sites, bald cypress *(Taxodium distichum)* can become an important canopy species. Tulip poplar *(Liriodendron tulipifera)*, sweet gum *(Liquidambar styraciflua)*, pond pine *(Pinus serotina)*, loblolly pine *(Pinus taeda)* and laurel oak *(Quercus laurifolia)* are important associates. The shrub layer is open in areas subjected to the most flooding, or it can be fairly dense and pocosin-like in areas subject to infrequent flooding. Headwaters and wet flats immediately above the floodplain can support dense, pocosin-like shrub thickets or, under suitable fire conditions, pure stands of Atlantic white cedar (*Chamaecyperus thyoides*).
River Bottoms *(within Bottomlands & Riparian Zones layer)*	The State's major rivers transect the Sandhills, forming broad floodplains similar to those in the Coastal Plain. Steep bluffs occur where rivers have cut into Sandhill formations with an erosion-resistant iron-bearing sandstone layer. Hardwood-dominated woodlands form the characteristic vegetation. As in the Coastal Plain, characteristic trees include sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda)*, water oak (*Quercus nigra*), willow oak (*Quercus phellos*), laurel oak *(Quercus laurifolia)*, cherrybark oak (*Quercus pagoda*) and American holly (*Ilex opaca*). The Cypress-tupelo swamp subtype occurs on lower elevation sites as seasonally flooded swamps. Dominant trees are bald cypress *(Taxodium distichum)*, water tupelo (*Nyssa aquatica)*, water-elm (*Planera aquatic)* and red maple *(Acer rubrum)*.
Depressions	Clay lenses and other confining layers support a variety of permanently and semi-permanently flooded isolated freshwater wetlands throughout the Sandhills Ecoregion. Landforms include natural and artificial ponds dominated by cypress and/or swamp tupelo. Varying amounts of peat accumulation and fire frequencies produce shrub-dominated pocosins or grass-sedge-herb-dominated depression meadows. Upslope from these lowland habitats, the transition to well-drained uplands supporting Sandhills pine woodland is often abrupt.
Seepage Slopes *(specialized habitat not mapped at this scale)*	Seepage slopes occur on sites having a hard clay moisture-confining layer underlying the sandy soil, such as iron-bearing sandstone or kaolin deposits. Water percolating downhill is forced to the surface, which results in seasonally or permanently saturated soils. Vegetation is variable, depending

	on position on the slope, the amount of peat accumulation, and fire history. Dense shrubland composed of several fire-tolerant species, with an open canopy of pond pine *(Pinus serotina)* is typical. The shrubland community intergrades with open grass-sedge vegetation on wetter seeps that are regularly burned or maintained in an open condition by mechanical clearing or herbicide application. Steeper slopes support a mixture of pine species, including longleaf pine and Virginia pine and a characteristic shrub layer of titi *(Cyrilla racemiflora)*, sand myrtle *(Leiophyllum buxifolium)*, mountain laurel *(Kalmia latifolia)*, and inkberry *(Ilex glabra)*.

Upland Mixed Forest	Oak-hickory forest is a widely distributed community that varies from site to site. Occurring in highly fragmented stands, later successional stages tend to be made up of a diverse assemblage of hardwoods, primarily oaks and hickories, as co-dominants in combination with pines. Understory, shrub and herbaceous layers are present in varying degrees, represented by diverse woody and non-woody species. Vegetation on most sites consists of early- to mid-successional managed stands of pine and pine-hardwood forest. The understory in pure pine stands is often open, but in mixed or older stands, it is dominated by the hardwoods characteristic of the site. Common pine species of the Sandhills include shortleaf (*Pinus echinata*) and loblolly (*P. taeda*), with the former better adapted to dry, fine textured upland soils and loblolly achieving maximum growth on deep soils with good moisture and drainage.
Grassland and Early-Successional Habitats *(specialized habitat not mapped at this scale)*	As in other ecoregions, a variety of grassland and early-successional habitats are present here, either as transitional vegetation following forest disturbances or as managed areas. Early-successional habitats are generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual forbs, perennial bunchgrasses, and variable coverage of shrubs and small trees. A variety of open land covertypes represents this category and can include native prairies, savannas, old field sites, open canopy gaps, shrub-scrub thickets, recently-cleared forests, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports and various urban open spaces are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high quality, early-successional habitat (see Cultivated Land and Pasture). Minor modifications to agricultural land use, such as replacing introduced grasses with native grasses, using native grasses in filter strips and grassed waterways, and implementing no-till or strip-till in crop fields can result in dramatic improvements to quality of early-successional habitat. Maintenance of early-successional habitat requires periodic repeated disturbance or disruption of the existing vegetative community. Purposeful management of early-successional habitat is usually accomplished through the use of timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5

	years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of variety of successional, or seral, stages. Early-successional habitat types have declined dramatically over the past 70 years primarily due to changing agricultural practices, forest succession, fire suppression, and urban / suburban encroachment. A large portion of existing early-successional habitat occurs on privately owned lands. One of the greatest challenges to maintaining priority species associated with this particular land cover is private land outreach and technical assistance.

Freshwater Streams, Rivers and Lakes

[A large proportion of the freshwater streams, rivers, and swamps in the Sandhills Ecoregion were mapped within the Bottomlands and Riparian Zones covertype. Also, the aquatic habitats discussed in this ecoregion are discussed in the framework of the larger Southeastern Plains instead of just the Sandhills.]

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

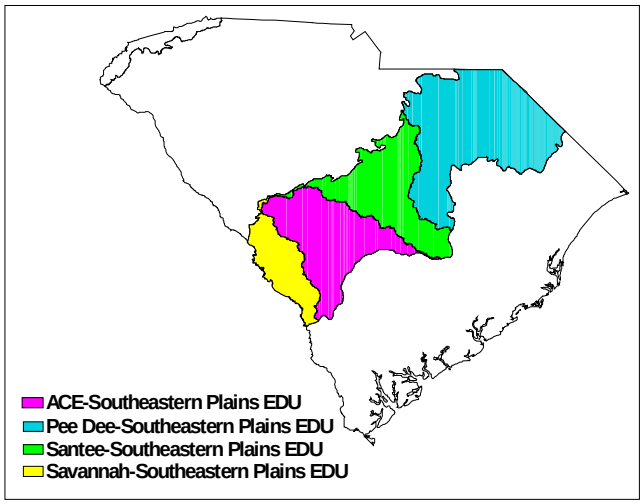

FIGURE 4-11: Drainages of the Sandhills/Southern Plains.

Portions of all of South Carolina's major river basins occur in the Sandhills Ecoregion (Fig. 4-11).
The region denoted the Southeastern Plains encompasses the Sandhills and Upper Coastal Plain and is sandwiched between the Piedmont to the north and the Lower Coastal Plain to the south. (This follows the Griffith et al. 2002 ecoregion map before its modification for Fig. 4-4.) It extends northwest from the Savannah River to the Pee Dee River. The Southeastern Plains encompasses portions of 24 counties and 23,584 km^2 (9,106 $mi.^2$). Just below the Fall Line, the region is dominated by sandy soils with scrub vegetation on moderate sloping lands. This portion is known as the Sandhills and varies in elevation from 76-137 m (250-450 ft.) above mean sea

level. Moving toward the coast, the topography is reduced to gentle sloping and then to nearly level lands with elevations of 130-137m (25-450 ft.).

Wadeable streams are the dominant aquatic habitat in the Southeastern Plains Ecoregion and provide most of the habitat for aquatic animals on South Carolina's Priority Species List. Wadeable streams are those with Strahler stream orders of 0 to 3; generally, these are streams that can be waded comfortably throughout most of the year. These streams are often bordered with pond-like backwaters and swamps. Wadeable streams in the Southeastern Plains are mostly low gradient, although some near the Fall Line have swifter flows. In moderate flowing areas, the substrate is chiefly clean shifting sand; with the absence of rocks in most streams, logs and debris jams provide habitat for aquatic fauna. In slow flowing areas, substrate is comprised of finer materials such as mud, clay, silt, and fine detritus. Most Southeastern Plains streams that receive ample sunlight are well vegetated with aquatic macrophytes. The streams that flow through the ecoregion are often termed "blackwater" due to their tannin-stained waters.

Navigable streams are less common in the Southeastern Plains, but provide habitat for many priority species. These streams are generally defined as large enough to operate watercraft, if only a canoe and are usually too deep to be waded throughout most of the year. The Pee Dee River, Lynches River and Edisto River are examples of navigable streams in the Southeastern Plains. These lazy meandering streams have substrates of mostly shifting sand in the flowing areas while finer materials (silt, clay and detritus) are deposited in the pools. As with the smaller streams in the ecobasin, the navigable streams are also "blackwater," stained by the decomposition of organic materials.

The lower portion of the Southeastern Plains, known as the Atlantic Southern Loam Plains, contains the highest concentration of Carolina bays in the State. Carolina Bays are shallow, elliptical depressions of unknown origin, many of which contain water throughout the year. The waters in Carolina bays are highly acidic, which limits the number of fish species. However, some sunfish and minnow species populate these depressions. Carolina bays may be important habitat for some rare crayfish species, as several have been observed in these formations. However, data on the crayfishes associated with Carolina bays is particularly lacking; more surveys are needed in order to determine the importance of these depressions as crayfish habitat.

Savannah–Southeastern Plains Ecobasin

The Savannah-Southeastern Plains Ecobasin extends from the southern portions of Edgefield County south to the southern portion of Allendale County. It includes about 137 km (85 mi.) of the Savannah River as it meanders toward the Coastal Plain and ultimately the Atlantic Ocean. Major South Carolina tributaries to the Savannah River in the ecobasin include Horse Creek, Hollow Creek, Upper Three Runs Creek, and Lower Three Runs Creek. The ecobasin encompasses most of 6 watersheds and parts of 10 others in its 2,538 km^2 (980 $mi.^2$). The ecobasin contains 1,576 km (979 mi.) of lotic habitat and 2,600 ha (6,425 ac.) of lentic habitat, primarily impoundments. A small portion of the lentic habitat is comprised of Carolina bays. The largest impoundment in the ecobasin is Par Pond 1,195 ha (or 2,953 ac.) on the Savannah River Site property. The next largest reservoir is Langley Pond (122 ha or 301 ac.) near Langley, South Carolina. Other impoundments in the ecobasin total less than 61 ha (150 ac.).

Primary conservation targets in the ecobasin include the main stem Savannah River in Aiken and Allendale Counties, Upper Three Runs Creek and its tributaries in Aiken and Barnwell Counties, and the Brier Creek system in Allendale County (Smith et al. 2002). The main stem of the Savannah River within the ecobasin contains several aquatic animals on South Carolina's Priority Species List including Shortnose Sturgeon and Robust Redhorse, as well as several mussel species (pod lance and Savannah lilliput). Priority fish species in Upper Three Runs Creek and its tributaries include the Savannah Darter and Turquoise Darter. The Savannah Darter and Bluebarred Pygmy Sunfish inhabit the Brier Creek system.

Water quality was impaired at 17 of 40 sites (43%) sampled by the South Carolina Department of Health and Environmental Control (SCDHEC 2003a). Aquatic life uses were not supported at 2 sites due to a lack of invertebrate diversity or abnormal pH. Recreational uses were not supported at 8 sites due to the presence of high fecal coliform bacteria concentration. Fish consumption advisories were listed for several areas due to mercury contamination, including Flat Rock Pond, Langley Pond, Vaucluse Pond, and the Savannah River. No streams within the ecobasin are considered outstanding resource waters by SCDHEC.

Approximately 87 km (54 mi.) of streams have been impounded in the ecobasin. Nearly 90 dams are present in the ecobasin, 10 of which impound navigable streams, forming small reservoirs. Most of the dams occur in the Horse Creek (34 dams) and Hollow Creek (26) watersheds.

There is comparatively little agricultural activity within the ecobasin, with only 6 active permitted agricultural operations. However, point source discharges are abundant. The ecobasin has the highest density of point source discharges in the State with more than 6 per 259 km^2 (100 $mi.^2$). Most of those discharges (5.5 per 259 km^2 or 100 $mi.^2$) are from industrial sources, giving the ecobasin the highest density of industrial discharges in the State.

There is moderate growth potential in the ecobasin. Residential and commercial growth in the vicinity of North Augusta and Aiken is expected and will have negative effects on aquatic environments if those developments are not carefully planned.

ACE–Southeastern Plains Ecobasin

The ACE–Southeastern Plains Ecobasin is the only ecobasin in the State to originate entirely in

the Southeastern Plains Ecoregion. The headwaters of the North and South Forks of the Edisto River originate in the extreme southern portion of Edgefield and Lexington Counties. The headwaters of the Salkehatchie River originate in Barnwell County. Major tributaries to the North Fork Edisto River in the ecobasin include Black Creek, Bull Swamp Creek, and Caw Caw Swamp. Major tributaries to the South Fork Edisto River include Shaw Creek, Dean Swamp Creek, Little River, and Roberts Swamp. The ecobasin includes portions of 27 watersheds and covers 5,747 km^2 (2,219 $mi.^2$). The ecobasin contains approximately 2,239 km (2,117 mi.) of lotic habitat and 9,047 acres of lentic habitats. There are no major reservoirs within in the ecobasin, and largest lentic areas (more than 730 ha or 5 ac.) are primarily Carolina bays.

Primary conservation targets in the ecobasin include the upper portion of the South Fork Edisto River in Aiken, Barnwell, and Orangeburg Counties; the main stem of the lower North Fork Edisto River in Orangeburg County; and Black Creek, a tributary to the North Fork Edisto River in Lexington County (Smith et al. 2002). Priority fish species in the upper South Fork Edisto River include the "Broadtail" Madtom, Savannah Darter, Turquoise Darter, and Blackbanded Sunfish. The lower North Fork Edisto River and its tributaries provide habitat for the "Broadtail" Madtom, Bluebarred Pygmy Sunfish and Savannah Darter as well as the Federally Endangered Shortnose Sturgeon.

Water quality was impaired at 33 of 77 sites (33%) sampled by SCDHEC (SCDHEC 1998b; SCDHEC 2003b). Aquatic life uses were not supported at 13 sites due to lack of invertebrate diversity (7 sites), low dissolved oxygen concentrations (4 sites) and abnormal pH values (2 sites). Recreational uses were not supported at 15 sites due the presence of high fecal coliform bacteria concentrations. Fish consumption advisories were listed for the Salkehatchie River below US 301, the South Fork Edisto River below Aiken State Park, and the Orangeburg County portion of the North Fork Edisto River. No streams within the ecobasin are considered outstanding resource waters by the SCDHEC. Many dams (368) impound approximately 175 km (109 mi.) streams within the ecobasin, but none of them impound navigable streams.

On a statewide basis, the ecobasin contains a moderate number of point source discharges. There are 57 active discharges permitted by SCDHEC within the ecobasin, 28 of which are from industrial sources, 19 from municipal sources, and 10 from community sources. The ecobasin has the second highest density of agricultural operations in the state with nearly 11 operations per 259 km^2 (100 $mi.^2$). There are 244 permitted active agricultural operations within the ecobasin, most of which are poultry farms (42 large, 129 medium, and 32 small). Other significant agricultural operations include swine farms (17), dairy farms (13), and peach orchards (6). The highest concentration of agricultural operations occurs in the upper portion of the North Fork Edisto River drainage where 113 permitted farms are located in the Chinquapin Creek/Lightwood Knot Creek and Black Creek watersheds.

Development throughout most of the ecobasin is not a major concern. There is low potential for growth in most areas. The Caw Caw Swamp watershed and North Fork Edisto River watershed may be negatively affected by development in the vicinity of Orangeburg. There is high potential for commercial development in the Shaw Creek watershed northeast of Aiken, near the intersection of I-20 and US 1.

Santee–Southeastern Plains Ecobasin

The upper extent of the Santee-Southeastern Plains Ecobasin is the Fall Line, which runs through central Lexington, Richland, and Kershaw Counties. The ecobasin extends southeasterly to the upper portion of Berkeley County and includes 3 major rivers. The Congaree and Wateree merge to form the Santee River southeast of Columbia. Major tributaries to the Congaree River include Congaree Creek, Gills Creek, and Cedar Creek. Major tributaries to the Wateree River include Five and Twenty Mile Creek, Big Pine Tree Creek, Colonel's Creek, and Beech Creek. The ecobasin contains all of 17 watersheds and portions of 30 others, and covers 5,346 km^2 (2,064 $mi.^2$). The ecobasin contains approximately 3,589 km (2,230 mi.) of lotic habitat and 379 km^2 (146 $mi.^2$) of lentic habitat, most of which is contained in Lake Marion (352 km^2 or 136 $mi.^2$). Big Pine Tree Creek near Camden South Carolina is a primary conservation target in the ecobasin as it holds one of very few known Carolina Pygmy Sunfish populations.

Water quality was impaired at 50 of 127 sites (39%) sampled by SCDHEC (SCDHEC 1998a; SCDHEC 1999a; SCDHEC 1999b). Aquatic life uses were not supported at 14 sites primarily due to a lack of invertebrate diversity (4 sites) and low dissolved oxygen (5 sites). One site was contaminated with tin. Recreational uses were not supported at 24 sites due the presence of high concentrations of fecal coliform bacteria. Fish consumptions advisories were listed for 12 sites, primarily due to the presence of mercury (11 sites). Fish consumption advisories have been listed for the Congaree River from Columbia to the Santee River, the Wateree River along its entire length within the ecobasin, Lake Marion, Cary's Lake, Windsor Lake, and Sesquicentennial State Park.

There are 378 km (235 mi.) of impounded streams in the ecobasin, most of which (238 km or 148 mi.) results from the impoundment of the Santee River to form Lake Marion. There are 295 dams permitted by SCDHEC within the ecobasin. Hydroelectric peaking operations on rivers (Saluda, Broad, and Wateree) located in the Piedmont have had significant negative impacts on the integrity of the Congaree and Wateree rivers in the Southeastern Plains. Rapidly fluctuating flows associated with hydroelectric peaking have lead to decreased bank stability, allowing the banks to slough-off into the rivers, increasing sedimentation.

Excessive nutrients and other chemical inputs from both point and non-point sources are a serious threat to water quality within the ecobasin. The ecobasin has the second highest density of active discharges permitted by SCDHEC with more than 6 discharges per 259 km^2 (100 $mi.^2$). There are 128 active discharges permitted by SCDHEC within the ecobasin; 80 of which are from industrial sources, 33 from community sources and 14 from municipal sources. There are 114 active agricultural operations within the ecobasin; most are poultry and turkey farms (14 large, 45 medium, and 4 small). Other significant agricultural operations include 33 manure brokers and nine swine farms (2 medium-sized and 7 small).

Residential, industrial, and commercial development in the northern portion of the ecobasin poses a significant threat to aquatic habitats. Significant growth is occurring in the Lexington, West Columbia, Columbia, and northeast Columbia areas, threatening water quality and aquatic habitats in the Congaree River, Congaree Creek, and Gills Creek watersheds. Development pressure is also great in the Wateree River watersheds near Camden and Lugoff. The Spears Creek watershed can also expect moderate to high residential, commercial, and industrial

growth.

Pee Dee–Southeastern Plains Ecobasin

The Pee Dee-Southeastern Plains Ecobasin is located in the northeast corner of the State, originating in Chesterfield, Marlboro, and Dillon Counties and flowing through parts or all of Kershaw, Darlington, Florence, Lee, Marion, Sumter, and Clarendon Counties. The ecobasin contains 3 major rivers including the Lynches, Pee Dee, and Little Pee Dee as well as the headwaters of the Black River. The Lynches River originates just north of South Carolina in the Piedmont of North Carolina. It flows about 34 km 114 km (21 mi.) through the South Carolina Piedmont before entering the Pee Dee-Southeastern Plains Ecobasin, then flows another 114 km (71 mi.) until it enters the Coastal Plain, picking up inputs from 2 major tributaries, Buffalo Creek and the Little Lynches River, along the way. The Pee Dee River originates in the southern portion of the North Carolina Piedmont and Southeastern Plains. Within the Pee Dee-Southeastern Plains Ecobasin, the Pee Dee River flows about 148 km (92 mi.) before entering the Coastal Plain. Major tributaries to the Pee Dee River include Thompson Creek, Crooked Creek, Black Creek and Jefferies Creek. The Little Pee Dee River originates in the Southeastern Plains of North Carolina and flows approximately 119 km (74 mi.) through the Pee Dee-Southeastern Plains Ecobasin before entering the Coastal Plain of South Carolina. The primary tributary is Buck Swamp. Pocataligo River and Black River Swamp are the main tributaries of the Black River. Both originate within the ecobasin and flow southeast before entering the Coastal Plain and merging to form the Black River. The ecobasin contains all of 11 watersheds and parts of 46 others, and covers 9,920 km^2 (3,830 $mi.^2$). There are about 7,388 km (4,591 mi.) of lotic habitat and 96 km^2 (37 $mi.^2$) of lentic habitat. There are no major reservoirs within the ecobasin. The largest lentic areas are Big Bay (1,002 ha or 2,476 ac.), a Carolina bay, and Lake Robinson (833 ha or 2,058 ac.), an impoundment on Black Creek.

Areas of primary conservation concern include the upper Lynches River and its Sandhills tributaries in Chesterfield, Kershaw, Lee, and Darlington Counties; the upper Pee Dee River between Marlboro and Chesterfield Counties; and Sandhills tributaries to the Little Pee Dee River along the border of South Carolina and North Carolina in Marlboro and Dillon Counties (Smith et al. 2002). The upper Lynches River is home to several aquatic priority species including fish (Sandhills Chub, "Thinlip" Chub, and "Broadtail" Madtom) and mussels (brook floater, creeper, notched rainbow, and the Federally Endangered Carolina heelsplitter). The main stem of the upper Pee Dee River contains several fish ("Carolina" Redhorse, Robust Redhorse, and the Federally Endangered Shortnose Sturgeon) and mussel (yellow lampmussel and Roanoke slabshell) priority species. Sandhills tributaries to the Little Pee Dee River contain Sandhills chub and once harbored populations of pinewoods darter that may now be extirpated from the State.

Water quality was impaired at 57 of 134 sites (43%) sampled by SCDHEC (SCDHEC 2000). Aquatic life uses were not supported at 28 sites due to low dissolved oxygen concentrations (17 sites), copper contamination (4 sites), abnormal pH values (4 sites), and lack of invertebrate diversity (3 sites). Recreational uses were not supported at 19 sites due to the presence of high concentrations of fecal coliform bacteria. Fish consumption advisories were listed for 10 sites due to mercury contamination including every major river within the ecobasin (Pocotaligo River, Lynches River, Great Pee Dee River, and Little Pee Dee River) and 2 small impoundments: Louthers Lake and Lake Robinson.

The 291 dams located in the ecobasin impound 241 km (150 mi.) of streams; 16 of those dams impound navigable streams.

There are 128 active discharges permitted by SCDHEC within the ecobasin, including 76 industrial discharges, 40 municipal discharges, and 12 community discharges. The highest concentration of those discharges (28) occurs in the Pocotaligo River watershed near Shaw Air Force Base and the town of Sumter. There are 226 agricultural facilities permitted by SCDHEC within the ecobasin, primarily poultry and turkey farms (15 small, 126 medium, and 18 large) and swine farms (22 small, 19 medium, and 19 large).

The construction of a proposed new interstate highway (I-73) running from Michigan to Myrtle Beach has the potential to result in significant impacts to the aquatic resources of this ecobasin. The final route for the highway has not been established so it is unknown which resources will be impacted.

Development pressure is expected to be high in the Black Creek and Jeffries Creek watersheds. Those watersheds encompass Hartsville, Darlington, and Florence. Major industrial expansion is expected beyond the several large industrial parks that are already located along the western side of Florence. Increased water withdrawals and point source discharges that accompany development could potentially have severe impacts on aquatic habitats in the main stem of the Pee Dee River.

Region-wide Challenges

The rate of urbanization has increased in the Sandhills Ecoregion over the past two decades, primarily in the Aiken, Columbia, Camden, and North Augusta areas. Tracts of land with existing ponds are especially sought after for residential development which tend, therefore, to be concentrated around the ponds and where there is often very little buffer of natural vegetation remaining between the home sites, roads, and ponds.

Although land management practices that favor restoration of the longleaf pine ecosystem are gaining widespread acceptance, significant alterations continue to affect transition areas between uplands and wetlands. These alterations typically occur when access roads or firebreaks are placed at the upland-wetland boundary, which effectively excludes fire from the wetlands. The result is a closed canopy forest, rather than a complex of dense shrub (pocosin) and grass-sedge successional stages that would occur under a more natural fire regime.

The longleaf pine ecosystem, the dominant natural vegetation type in the Sandhills Ecoregion, is one of the most imperiled ecosystems in the country with only 3% of its original extent considered to be in a relatively natural condition (Frost 1993). Even in areas where longleaf pine remains, fire suppression has severely impacted the ecosystem. Fire suppression in the Southeastern United States began to be institutionalized between 1910 and 1930 (Frost 1993; Ware et al.1993). This practice severely affected the remaining patches of the longleaf pine ecosystem, resulting in a change in species composition and forest structure. In recent years, some areas have been restored or are in the process of being restored with the use of prescribed

fire. This practice has been limited, however, because of the costs associated with prescribed fire and because of other risks associated with prescribed burning, including problems with smoke management.

Economic considerations have also affected timber management practices. Conversion of areas to tree species not usually associated with the Sandhills region have also contributed to the decline of the longleaf pine ecosystem. Many land managers have planted pine species other than longleaf because they were less expensive to plant and produced a superior mid-term return on investment.

Challenges to the conservation of aquatic fauna in the Southeastern Plains Ecoregion are similar to other ecobasins in the State and primarily include impacts associated with impoundments, non-point source pollution, point source pollution, poorly planned development, and the introduction of non-native species.

There is only one major impoundment (Lake Marion) in the Southeastern Plains; however, dams still have a significant impact on aquatic resources within the ecoregion. With more than 1,000 dams impounding 550 miles of streams, there are more dams in the Southeastern Plains Ecoregion than any other; the density of dams within the ecoregion is second only to the Blue Ridge. Dams result in a loss of connectivity and negatively affect aquatic biota both above and below the impoundment (Doeg and Koehn 1994; Kanehl et al. 1997; Tiemann et al. 2004). Impoundments affect native aquatic fauna through direct loss of habitat as lotic habitat is converted to lentic habitat; the latter favors competitive and often predacious species like Largemouth Bass and other centrarchids. In addition, impoundments often negatively affect unimpounded downstream reaches by altering hydrologic and thermal regimes (Cushman 1985), modifying stream channel morphology, increasing erosion and sedimentation (Waters 1995), and ultimately reducing suitable habitat for native aquatic fauna (Helfrich et al. 1999; Tiemann et al. 2004). Dams also prevent migrations of native anadromous fish (shad species, Striped Bass, and sturgeon) to their historic spawning grounds.

Forest clearing, soil tilling, and channelization in the vicinity of Southeastern Plains streams have resulted in streams that are heavily silted. Modern soil conservation practices and lower potential for channelization have reduced those impacts, but sedimentation from non-point and point sources remains a significant detriment to streams. Development activities, agriculture, and silviculture are primary sources of erosion that lead to sedimentation in streams. Corporate and private timber managers that fail to follow Best Management Practices (BMPs) contribute to siltation and other non-point source pollution within the ecoregion. Stream bank erosion due to loss of riparian areas, livestock grazing, and altered hydrology also contribute to sedimentation in streams. During the past century, many streams in the Southeastern Plains were channelized to improve drainage of croplands. Channelized streams lead to increased erosion of cropland and increased sedimentation of the receiving streams (Etnier and Starnes 1993). The result of channelization was changing many streams into straight, shallow ditches with severely depressed populations of aquatic fauna.

Excessive contamination by nutrients and other chemicals also negatively affect water quality within the ecoregion. Point source discharges from industrial, municipal, and commercial

sources add a variety of chemical pollutants to the receiving streams, rivers, and lakes. In addition, non-point source discharges from agricultural operations negatively affect water quality. Nationwide, pollution from agricultural sources is the greatest cause of impairment to streams and lakes (SCDHEC 2003). The Southeastern Plains has the second highest density of permitted discharges within the State and the highest density of Concentrated Animal Feeding Operations (CAFOs) with approximately 6.5 operations per 259 km^2 (100 $mi.^2$).

Water quantity is also a problem in Southeastern Plain streams. Water withdrawal for irrigation is a common practice in the ecoregion. During summer months, some streams are completely dewatered due to uncontrolled irrigation of croplands. Furthermore, many pond-owners will close their drain structures during dry periods in an attempt to maintain aesthetic water levels, thereby dewatering the stream below.

Introductions of non-native species have had a significant impact on native aquatic fauna in the Southeastern Plains Ecoregion. Buffalo (fish), Common Carp, Flathead Catfish, and Blue Catfish are established in several drainages. Flathead Catfish and blue catfish introductions probably pose the greatest direct risks to native fauna. Flathead Catfish have been shown to prey on bullheads, darters, shad, suckers, and sunfish. Severe declines in native species, particularly bullheads and sunfish, have been observed after the introductions of Flathead Catfish (Guire et al. 1984; Jenkins and Burkhead 1993; Bart et al. 1994). It is not well known what effects buffalo have on the native community, but it has been suggested that they may be a factor in the decline of some catostomids in the Pee Dee River (Wayne Starnes, pers. comm.). Common Carp occur in every South Carolina drainage and are considered a pest; however, their impact on native fauna is not well known. Common Carp disrupt aquatic habitats by rooting around in the substrate where they uproot aquatic plants and increase turbidity and siltation. Common Carp have also been shown to prey on the eggs of other fish species.

The Asian clam, *Corbicula fluminea*, has been introduced and has spread widely throughout the United States, including into South Carolina. The effects of *Corbicula* on native species are not particularly well understood. According to a review of the literature on interactions between *Corbicula* and native mussels (Dillon 2000), most field studies failed to find any significant negative effects on native mussels, although a few detected reductions in growth. Three invasive snail species (*Viviparus georgianus*, *V. purpureus*, and *Bellamya/Cipangopaludina japonica)* are present in Lakes Marion and Lake Moultrie, but their impact on native fauna is not known.

The red swamp crayfish has been introduced to South Carolina and has been observed at several locations in the Southeastern Plains and other portions of the Lower Coastal Plain, but it is unclear how widespread it is in the state. The lack of survey work since its introduction and the difficulty distinguishing the red swamp crayfish from one of the native species have made it particularly difficult to determine the extent of its introduced range. In North Carolina, it has become established in all drainages in the Coastal Plain and Eastern Piedmont Plateau and appears to have extirpated all the native crayfish at one location (Cooper 2003). Introduced crayfish are thought to be the biggest threat to native crayfish species (Lodge et al. 2000 a,b); the risk to our native species is great if further introductions or extensive spread of the red swamp crayfish occur.

Sand mining operations have been initiated or are ongoing in the main stem or riparian areas of many Southeastern Plains rivers. Instream sand mining is a significant threat to aquatic resources within the ecoregion. Sand mining not only causes bank stability problems and loss of riparian areas at the mining site, but within the stream, this activity adversely affects physical and chemical habitat and can negatively affect biological communities (Nelson 1993) and recreational uses (Hartfield 1993). Physical impacts on instream habitat include increasing bedload materials and turbidity, changing substrate type and stability, and altering stream morphology (Nelson 1993). Physical habitat alterations associated with sand mining can adversely affect the biological community by decreasing reproduction and survival of fishes (Stuart 1953; Newport and Moyer 1974) and distribution, composition, and reproduction of other aquatic organisms (Buck 1956; Trautman 1957; Newport and Moyer 1974).

Coastal Plain Ecoregion

General Overview

The Coastal Plain is the largest ecoregion in South Carolina. Land elevation in this ecoregion begins at 82-91 m (270-300 ft.) at the inland boundary with the Sandhills Ecoregion and reaches nearly to sea level at the Coastal Zone boundary. Although the Sandhills Ecoregion shares some of the geological history and physical features and is included in some definitions of the Coastal Plain, wildlife habitats in the two regions differ in some important respects. Therefore, the Coastal Plain and Sandhills are treated as separate regions in the SWAP.

From a land use standpoint, the Coastal Plain consists of two significantly different landscapes. An inner belt is predominantly composed of cropland, with forest limited to small patches and hardwood "stringers" along creeks. An outer belt, sometimes called the "flatwoods", is primarily pine-dominated forest. Bisecting both belts are major floodplains which are largely forested. Most public lands in the region have a strong wildlife management focus, including an emphasis on threatened and endangered species and other species of concern; for planning purposes, the lands are considered "protected."

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

Grasslands or early-successional fields include those with cover provided by grasses and/or weeds with few, if any, trees. These sites also include managed open areas such as meadows, pastures, and golf courses, with or without damp depressions. These fields occur throughout the region, but are more extensively in the inner "agriculture belt." Pine woodlands include all pine-

dominated forests throughout the ecoregion and include tracts that occupy a variety of soil moisture characteristics excluding floodplains. The canopy is dominated by one or several species of pine: generally loblolly (*Pinus taeda*) or longleaf (*Pinus palustris*), depending on elevation, soil type and silvicultural history. Dense shrub thickets of hollies (*Ilex* spp.) and wax myrtle (*Morella cerifera*) may be found within these stands as well.

Finally, the river bottoms of the Coastal Plain include a variety of hardwood and hardwood-pine communities that occupy the floodplains of small streams and infrequently flooded flats that are associated with streams or rivers. These flats are often characterized by the presence of American beech (*Fagus grandifolia*) and occur in scattered locations on sheltered sites with moist soils, particularly on North-facing river bluffs and on the slopes of drains and creeks.

The rivers and streams that occur in South Carolina's Coastal Plain are often called blackwater systems. These soft tannin stained waters are acidic and drain oxygen-poor floodplain swamps. This naturally occurring condition of low pH and low oxygen make the low-gradient Coastal Plain rivers and streams a place where elemental mercury can be methylated and mobilized into the food chain. Bio-magnification of methyl-mercury loads occurs in these systems resulting in the promulgation of consumption advisories for piscivorous fish and other animals.

Wadeable streams, as with the other ecoregions, are the dominant aquatic habitat in the Coastal Plain and provide a large portion of the habitat for aquatic animals on the priority species list. Wadeable streams are those with Strahler stream orders of 0 to 3 that are generally comfortably wadeable throughout most of the year. These streams are often bordered with pond-like backwaters and swamps. Wadeable streams in the Coastal Plain are low-gradient with sluggish flows. Although some of the larger streams may have moderate currents, they lack whitewater. In the moderate flowing areas, the substrate is chiefly clean shifting sand.With the absence of rocks in most streams, logs and debris jams provide habitat for aquatic fauna. In slow-flowing areas, substrate is comprised of finer materials such as mud, clay, silt and fine detritus. Most Coastal Plain streams that receive ample sunlight are well-vegetated with aquatic macrophytes. Coastal plain streams can contain turbid or clear water (whether stained or not). Generally those streams that originate in the Piedmont and flow through the Coastal Plain are turbid due to the heavy sediment load they carry and are termed "brownwater." Streams that originate in the Southeastern Plains and/or Coastal Plain and are not turbid as a result of anthropogenic impacts are termed "blackwater" due to their tannin-stained waters.

Navigable streams are less common in the Coastal Plain, but provide habitat for many species on the priority list. These streams are generally defined as large enough to operate watercraft, if only a canoe, and are usually too deep to be waded throughout most of the year. The Pee Dee River, Lynches River and Edisto River are examples of navigable streams in the Coastal Plain. These lazy meandering streams have substrates of mostly shifting sand in the flowing areas while finer materials (silt, clay and detritus) are deposited in the pools. As with the smaller streams in the ecobasin, the navigable streams that originate in the southeastern plains and/or coastal plain are also "blackwater," stained by the decomposition of organic materials.

Carolina bays are common in the Coastal Plain. These shallow, elliptical depressions are of unknown origin, and many of which contain water throughout the year. The waters contained in

Carolina bays are highly acidic which limits the number of fish species. However, some sunfish, minnow, killifish, and livebearer species may populate Carolina bays. These depressions may be important habitat for some rare crayfish species, as several have been observed in these formations. However, data on the crayfishes of Carolina bays is particularly lacking, and more surveys are needed in order to determine the importance of these depressions as crayfish habitat.

Land Covertypes

The predominant land covertypes that most casual observers associate with the Coastal Plain are 1) grassland and early-successional habitats, 2) pine woodland and 3) river bottoms. Although the remaining types are less extensive, they provide habitat diversity that is important to a number of animals, especially wetland species. Figure 4-12 defines the various habitat types found in this ecoregion. Species-habitat associations are presented in Appendices 1 A-D while the faunal makeup of the habitats is described in more detail within this chapter (4).

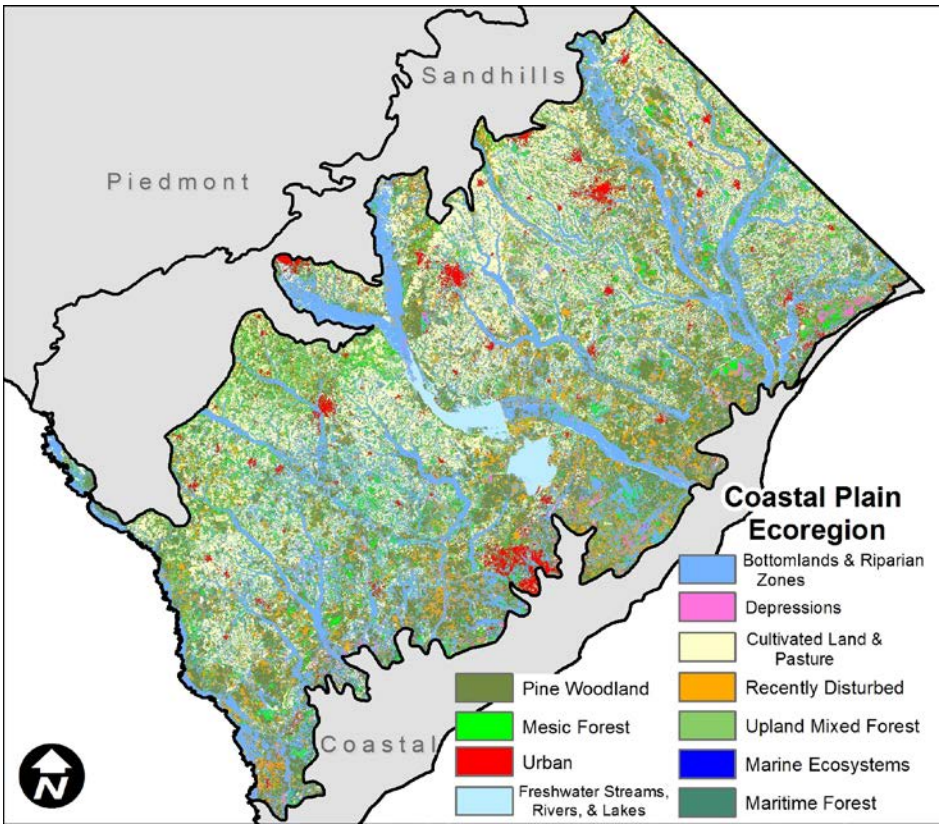

FIGURE 4-12: Land covertypes of the Coastal Plain Ecoregion.

Pine Woodland	This land covertype is assigned to all pine-dominated forests throughout the region, including those occupying a variety of soil moisture characteristics with the exception of floodplains. The canopy is dominated by one or several species of pine, generally loblolly (*Pinus taeda*), or longleaf (*Pinus palustris*), depending on elevation,

	soil type and silvicultural history. Dense shrub thickets of hollies (*Ilex* spp.) and wax myrtle (*Morella cerifera*) may be present. Higher elevation pine woodlands have abundant grasses and herbaceous cover, particularly when burning is frequent. Optimal habitat for priority species consists of open stands of longleaf pine, a sparse understory and shrub layers, and a ground cover of wiregrass (*Aristida* spp.) and diverse herbaceous species.
Sandhill Pine Woodland *(within the Pine Woodland layer)*	Sandhill pine woodland is a variation of pine woodland composed of species adapted to xeric, sandy soils. This land covertype occurs principally in the Sandhills but also on sand ridges in the Coastal Plain. It is characterized by an absence of frequent fire, a canopy of longleaf pine, and a subcanopy of turkey oak interspersed with scrub oak species and scrub-shrub cover. Frequent burning leads to the development of longleaf pine-wiregrass communities.
Mesic Forest	Pine savanna, also known as open savanna, is an important variant of pine woodland. Wet prairie, grass-sedge bog, herb bog or pitcher plant bog, are typically found in the Outer Coastal Plain on flat sites with a high water table and soil that is saturated for at least part of the year. Vegetation consists of a thin canopy of pines—almost always longleaf (*Pinus palustris*—although loblolly (*P. taeda*) and pond pine (*P. serotina*) may also be present. The understory is essentially absent or very scattered. Herbaceous flora is quite rich, consisting of many grasses and sedges. Pine flatwoods intergrade with pine savanna; like pine savanna, it is pine woodland situated on essentially flat or rolling terrain with sandy soil and a high water table. Unlike pine savanna, pine flatwoods feature a well-developed subcanopy of several tall shrub species. Pine flatwoods is the principal forest type for much of the Outer Coastal Plain. Occasional hardwood stands may line the downslopes of pine savannas and form the ecotone between these and bottomland habitats. Sweet gum (*Liquidambar styraciflua*) is an important early-successional species in these environments, but shares these habitats with several oak species such as water oak (*Quercus nigra*), laurel oak (*Q. laurifolia*), and pin oak (*Q. phellos*). Other hardwoods may include tulip poplar (*Liriodendron tulipifera*) and river birch (*Betula nigra*).

Hardwood Slopes and Stream Bottoms *(within the Bottomlands & Riparian Zones layer)*	A complex of hardwood and hardwood-pine communities occupies the floodplains of small streams, mesic bluffs and infrequently flooded flats in association with streams or rivers. Fire is infrequent, due either to the sheltered locations of these communities on bluffs or their isolation within a floodplain. Several mixed mesophytic subtypes characterized by the presence of American beech *(Fagus grandifolia)* occur in sheltered sites with moist soils, particularly on North-facing river bluffs and on slopes of drains and creeks. On upland flats within floodplains (hammocks), southern magnolia *(Magnolia grandiflora)* is frequently co-dominant with American beech. The calcareous cliff and marl forest subtype occurs on circumneutral soils derived from limestone or unconsolidated calcareous substrates such as marl. Forest structure of all subtypes is diverse, with understory, shrub and herbaceous species varying according to soil moisture and chemistry. All subtypes intergrade with blackwater stream forest or river bottom forest on lowland sides and with upland forest on upland sides.
Blackwater Stream Systems *(within the Bottomlands & Riparian Zones layer)*	Tributary streams arising in the Sandhills and Coastal Plain are commonly known as "blackwater streams" attributable to the color of tannins leaching from decaying vegetation. Forests on the narrow floodplains formed by these streams typically have a canopy dominated by swamp tupelo *(Nyssa biflora)* and red maple *(Acer rubrum)*. At broader sites, bald cypress *(Taxodium distichum)* can become an important canopy species. Tulip poplar *(Liriodendron tulipifera)*, sweet gum *(Liquidambar styraciflua)*, pond pine *(Pinus serotina)*, loblolly pine *(Pinus taeda*) and laurel oak *(Quercus laurifolia)* are important associated species. The shrub layer is open in areas subjected to the most flooding, or may be fairly dense and pocosin-like in areas subject to infrequent flooding. Headwaters and wet flats immediately above the floodplain can support dense, pocosin-like shrub thickets or, under suitable fire conditions, pure stands of Atlantic white cedar (*Chamaecyperus thyoides*).
River Bottoms *(within the Bottomlands & Riparian Zones layer)*	River bottoms, or "bottomland forests" consist of hardwood-dominated woodlands with moist soils that are usually associated with the broad floodplains of major rivers rising in the Piedmont or Blue Ridge Ecoregion. Locally, the floodplains of major Coastal Plain rivers are significant components of the landscape. Characteristic tree species include the sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), laurel oak (*Quercus laurifolia*), cherrybark oak (*Quercus pagoda*) and American holly (*Ilex opaca*). A habitat subtype dominated by bald cypress (*Taxodium distichium*) and water tupelo (*Nyssa aquatica*) occurs on lower elevation sites that is interspersed and intergrades with oak-dominated woodlands.

	Dominant trees here include the bald cypress (*Taxodium distichium*) and water tupelo (*Nyssa aquatica*), swamp gum (*Nyssa biflora*), Carolina ash (*Fraxinus caroliniana*), water elm (*Planera aquatica*) and red maple (*Acer rubrum*).
Depressions	Depression wetlands of some type occur in every ecoregion in South Carolina. These habitats are known by a number of names including vernal pool, high pond, flatwoods pond, limesink, wet weather pond, Carolina bay and several other colloquial names. Depression wetlands in the Sandhills, Coastal Plain and Coastal Zone typically formed due to the collapse of a friable subterranean layer such as limestone or sandstone forming a "slump" in the landscape. These habitats may also have formed due to natural concavities, bowls or slumps on the surface topography. These depressions will hold water given the presence of an impermeable soil layer such as clay, rock, or humate-impregnated sand. Depression wetlands are often referred to as "perched" water tables because they hold water perched above the normal sub-surface water table. They are also referred to as isolated, temporary wetlands due to the general lack of connection to surface streams and the pulsed nature of their hydrology, typically filling and drying with rainfall cycles. Some of these wetlands display unique geomorphologies, such as Carolina bays and limesinks. Carolina bays are a class of depression wetland that display both a unique shape and orientation. Carolina bays are all either oval or elliptical in shape with the long axis of the ellipse, or oval lying along a northwest to southeast alignment. There are a number of hypotheses about the origin of these features, but no conclusive data supports any one of them to date. Limesinks are typically circular on the surface with steep sides that are conical in form. Depression wetlands in the Coastal Plain can support a variety of vegetative community types ranging from pond cypress or black gum ponds, to pond cypress savannas and wet meadow communities, to pocosin and pond pine woodlands. Open water ponds, hardwood ponds, and sedge-dominated ponds may occur in other parts of the state as well. Despite the differences in origin, geomorphology, and vegetative structure, these habitats are similar in ecological function. With a few notable exceptions, these habitats are primarily linked to rainfall cycles, relying on rain to fill their basins and subsequently drying out during periods of low rainfall. The frequency of inundation may vary both in time and in location, such that most of these wetlands do not fill and dry on an annual basis.

	Depression wetland habitats are detritus-based systems. When they dry, herbaceous plants and grasses die back and desiccate, forming a detrital layer. When the basins are inundated again this detritus forms the base of a food web that can support a variety of invertebrate and vertebrate species. A number of native plant and animal species, including numerous rare species, rely on depression wetlands as a primary habitat or for some life history stage such as breeding habitat. Because these habitats fill and dry cyclically, they typically do not support large predatory fish populations. Numerous amphibian species in South Carolina breed preferentially or exclusively in depression wetland habitats. Avoidance of larval predators, such as fish, is a critical adaptive mechanism for amphibians, and one solution is to breed in fish-free habitats such as depression wetlands. As such, depression wetlands are critically important habitats for a number of amphibian species in South Carolina.
Upland Mixed Forest	The composition of the vegetation in the upland forest land covertype is similar to that of oak-hickory forest in the Piedmont, where it is a major vegetation type. In contrast, upland forest is rare in the Coastal Plain, typically occurring on fire-suppressed upland slopes near river floodplains or between rivers and tributaries, intergrading with river slope communities. Representative canopy trees include white oak (*Quercus alba*), black oak (*Quercus velutina*), post oak (*Quercus stellata*), mockernut hickory (*Carya tomentosa*), pignut hickory (*Carya glabra*), loblolly pine (*Pinus taeda*), flowering dogwood (*Cornus florida*) and black gum (*Nyssa sylvatica*). Understory, shrub and herbaceous layers are present in varying degrees, represented by diverse woody and non-woody species. Vegetation on most sites consists of early- to mid-successional managed stands of pine and pine-hardwood forest. The understory in pure pine stands is often open, but in mixed or older stands, it is dominated by the hardwoods characteristic of the site.
Maritime Forest	This land covertype is most dominant in the Coastal Zone, but a small portion is detectable with GAP mapping procedures in this ecoregion. It is most likely composed of live oak (*Quercus virginiana*) suffusely decked with Spanish moss (*Tillandsia usneoides*) and resurrection fern (*Pleopeltis polypodioides*), Southern magnolia (*Magnolia grandiflora*), cabbage palmetto (*Sabal palmetto*), laurel oak (*Quercus laurifolia*), and the occasionally loblolly pine (*Pinus taeda*). These are usually closed canopy forests in protected inner dune zones with deep sands with an understory characterized by medium-dense to sparse shrub layer that may include southern red cedar *(Juniperus silicicola),* cabbage palm *(Sabal palmetto),* American holly *(Ilex opaca),* red bay *(Persea borbonia),* wax myrtle *(Morella cerifera),* and yaupon holly *(Ilex vomitoria).*

	Maritime forests exhibit much greater species and structural diversity away from the direct effects of salt spray where deciduous trees are more common and include southern red oak *(Quercus falcata)*, water oak *(Quercus nigra)*, sugarberry *(Celtis laevigata)* and pignut hickory *(Carya glabra)*. Dogwood *(Cornus florida)*, American olive *(Osmanthus americana)*, and Carolina laurel cherry *(Prunus caroliniana)* are also common in the understory. Under fragmented canopy conditions, shrubs, including beauty-berry *(Callicarpa americana)* and red buckeye *(Aesculus pavia)* become more common, and saw palmetto *(Serenoa repens)* which reaches its northern extent of its range on Kiawah Island in Charleston County. A variant maritime forest resembling xeric pine woodland of the Coastal Plain occurs on relict dune ridges inland from the barrier island forests. This habitat has an open super-canopy of longleaf pine *(Pinus palustris)* with an understory composed of live oak *(Quercus virginiana)*, laurel oak *(Quercus hemisphaerica)*, sand live oak *(Quercus geminata)* and turkey oak *(Quercus laevis)*. Unlike typical maritime forests, maritime Sandhill forests are open and characterized by patches of bare sand and lichens, such as reindeer lichens *(Cladonia* spp.).
Grassland and Early Successional Habitat *(specialized habitat not mapped at this scale)*	As in other ecoregions, a variety of grassland and early-successional habitats are present, either as transitional vegetation following forest disturbances or as managed areas. Early-successional habitats reach their greatest extent in the Coastal Plain Ecoregion. These habitats are generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual forbs, perennial bunchgrasses, and variable coverage of shrubs and small trees. A variety of open land covertypes represents this category and can include native prairies, savannas, old field sites, open canopy gaps, shrub-scrub thickets, recently-cleared forests, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports and various urban open spaces are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high quality, early-successional habitat (see Cultivated Land and Pasture). Minor modifications to agricultural land use, such as replacing introduced grasses with native grasses, using native grasses in filter strips and grassed waterways, and implementing no-till or strip-till in crop fields can result in dramatic improvements to quality of early-successional habitat. Maintenance of early-successional habitat requires periodic repeated disturbance or disruption of the existing vegetative community. Purposeful management of early-successional habitat is usually

	accomplished through the use of timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5 years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of variety of successional, or seral, stages. Early-successional habitat types have declined dramatically over the past 70 years primarily due to changing agricultural practices, forest succession, fire suppression, and urban / suburban encroachment. A large portion of existing early-successional habitat occurs on privately owned lands. One of the greatest challenges to maintaining priority species associated with this particular land cover is private land outreach and technical assistance.

Freshwater Streams, Rivers and Lakes

[A large proportion of the freshwater streams, rivers, and swamps in the Coastal Plain Ecoregion were mapped within the Bottomlands and Riparian Zones covertype.]

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

The Lower Coastal Plain is situated directly below the Southeastern Plains and terminates at the Coastal Zone marsh. In South Carolina, it extends northwest from the Savannah River to the North Carolina State line. The Lower Coastal Plain intersects 19 counties and covers approximately 22,157 km^2 (8,555 mi.^{2}). The Coastal Plain is nearly level with elevations ranging from 8-38 m (25-125 ft.). The major aquatic habitats within the

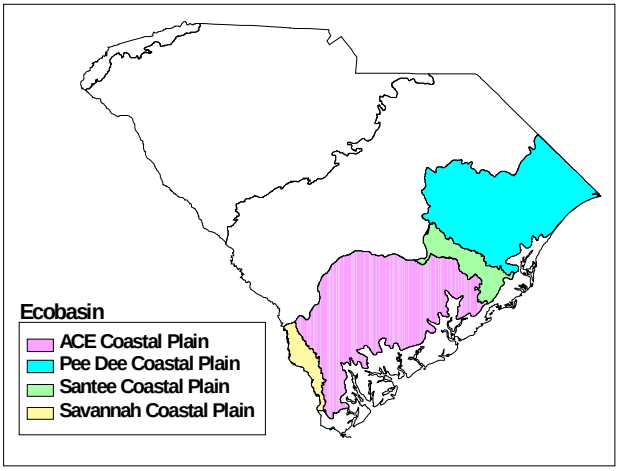

FIGURE 4-13: Ecobasins in the lower portion of the Coastal Plain Ecoregion

ecoregion include lazy meandering streams, swamps, marshes, and estuaries. Pocosins and Carolina Bays are abundant in some areas. These unique aquatic habitats are discussed in more detail in the Coastal Zone Ecoregion.

Savannah–Coastal Plain Ecobasin

The Savannah-Coastal Plain Ecobasin is located in the extreme southwest corner of the State extending from southern Allendale County through Hampton and Jasper Counties before terminating at the Coastal Zone marsh. The ecobasin includes 72 km (45 mi.) of the Savannah River as it meanders toward the coast. Primary tributaries to the Savannah River in this ecobasin include Brier Creek and Boggy Branch. The ecobasin intersects 10 watersheds and covers 906 km^2 (350 $mi.^2$). The ecobasin contains approximately 446 km (277 mi.) of lotic habitat and 251 ha (620 ac.) of lentic habitat. There are no major reservoirs within the ecobasin; the largest lentic habitat is only 26 ha (62 ac.).

Primary conservation targets within the ecobasin include the main stem of the Savannah River throughout the ecobasin and the Brier Creek/Boggy Gut Creek system in Allendale County (Smith et al. 2002). The main stem of the Savannah River contains several aquatic animals that are on South Carolina's Priority Species List including fish (Shortnose Sturgeon and Robust Redhorse) and mussels (pod lance and Savannah lilliput). The Brier Creek/Boggy Gut Creek system is home to one of the few known populations of Bluebarred Pygmy Sunfish.

Water quality was impaired at 7 of 10 sites sampled by the SCDHEC (2003a). Aquatic life uses were not supported at two sites due to a lack of invertebrate diversity and low dissolved oxygen levels. Fish consumption advisories were listed for 5 sites due to mercury contamination. Fish consumption advisories have been issued for the Savannah River and Cypress Creek. Point source pollution from within the ecobasin is not currently a major threat as there are only two active discharges permitted by SCDHEC: one municipal and one industrial. There are no active agricultural operations permitted by SCDHEC within the ecobasin. None of the streams within the ecobasin is considered an outstanding resource water by SCDHEC.

Approximately km 58 km (36 mi.) of stream within the ecobasin have been impounded. There are 15 dams permitted by SCDHEC within the ecobasin, none of which impound navigable streams. Numerous other dams not permitted by SCDHEC also occur in the ecobasin.

There is little expected growth throughout the majority of the ecobasin. One area that may experience moderate growth is the area near the town of Hardeeville.

ACE–Coastal Plain Ecobasin

The northern extreme of the ACE-Coastal Plain Ecobasin is situated in central Bamberg and Orangeburg Counties. The ecobasin encompasses parts of Allendale, Hampton, Colleton, Dorchester, Jasper, Beaufort, Berkeley and Charleston Counties before terminating at the Coastal Zone marsh. Coastal rivers in the ecobasin include the Coosawhatchie, Salkehatchie, Combahee, Ashepoo, Ashley, Edisto, and Cooper.

The Coosawhatchie River originates just north (10 km or 6 mi.) of the Coastal Plain in the Southeastern Plains and flows for about 76 km (47 mi.) through the Coastal Plain before merging with Tulifiny River to form the Broad River, which ultimately is deposited into the Atlantic Ocean at Port Royal Sound. The Salkehatchie River originates in the Southeastern Plains and flows for about 43 km (27 mi.) through the Coastal Plain before merging with the Little

Salkehatchie River to form the Combahee River, which flows for 82 km (51 mi.) through the Coastal Plain before terminating in the Atlantic Ocean at St. Helena Sound. The Ashepoo River originates in the Coastal Plain and flows for about 92 km (57 mi.), picking up inputs from Horseshoe Creek and Deer Creek before terminating at the Atlantic Ocean in St. Helena Sound. The Edisto River is formed at the confluence of the North Fork Edisto River and South Fork Edisto River. Each fork originates in the Southeastern Plains and flows for about 31 km (19 mi.) through the Coastal Plain before merging and forming the Edisto River. The Edisto River flows for about 196 km (122 mi.) through the Coastal Plain before entering St. Helena Sound and the Atlantic Ocean. As the Edisto flows through the Coastal Plain, it picks up inputs from Field Swamp, Four Hole Swamp, and Penny Creek. The Ashley River originates entirely in the Coastal Plain. Its headwater, Great Cypress Swamp, flows for about 40 km (25 mi.) until it merges with Captains Creek to form the Ashley River. The Ashley River flows for about 64 km (40 mi.) through the Coastal Plain until terminating at Charleston Harbor and the Atlantic Ocean. The Cooper River is formed at the confluence of the East Branch and West Branch Cooper River. Once a self-contained drainage, the Cooper River now receives inputs from the Santee River via a diversion canal that diverts water from Lake Marion to Lake Moultrie. The West Branch Cooper River originates at the tailrace of Lake Moultrie and flows through the Coastal Plain for about 29 km (18 mi.) before merging with the East Branch Cooper River to form the Cooper River. The Cooper River flows through the Coastal Plain for about 48 km (30 mi.), picking up inputs from the Back River, Goose Creek, and Filbin Creek along its western shore; further, Flag Creek and Yellow House Creek are picked up along its eastern shore before being deposited in Charleston Harbor and the Atlantic Ocean.

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

Primary areas of conservation concern in the ACE-Coastal Plain Ecobasin include the Jasper County wetlands in Jasper County; the Cypress/Beaver Dam Creek systems in Jasper and Hampton Counties; the Sandy Run system in Colleton County; the lower North Fork Edisto and main stem Edisto Rivers throughout the ecobasin; and the Cooper River in Berkeley and Charleston Counties. The Jasper County wetlands, Cypress/Beaver Dam Creek, and the Sandy Run systems all contain populations of Bluebarred Pygmy Sunfish and other fishes that are on South Carolina's Priority Species List. The North Fork and main stem Edisto River contain several fish species on the priority species list ("Broadtail" Madtom, Shortnose Sturgeon, Bannerfin Shiner, and Striped Bass). The Cooper River and its backwaters contain populations of Bluefin Killifish, Striped Bass and the Federally Endangered Shortnose Sturgeon.

Water quality was impaired at 72 of 115 sites (62%) sampled by SCDHEC. Aquatic life uses were not supported at 30 sites due to a lack of invertebrate diversity (13 sites), low dissolved oxygen concentrations (7 sites), zinc excursions (5 sites), abnormal pH values (3 sites), high turbidity (1 site), and chromium excursions (1 site). Recreational uses were not supported at 23 sites primarily due to high concentrations of fecal coliform bacteria. Mercury excursions were found in the tissue of fish at 19 sites. Fish consumption advisories have been issued for nearly every major water body in the ecobasin including the North Fork Edisto River, South Fork

Edisto River, main stem Edisto River, Cooper River, East Fork Cooper River, Ashepoo River, Salkehatchie River, Little Salkehatchie River, Combahee River, Coosawhatchie River, New River, Black River, Ashley River, Four Hole Swamp, Wadboo Creek, Chessie Creek, Horseshoe Creek, Lake Moultrie and Goose Creek Reservoir.

Water quantity will likely be a future challenge to the aquatic habitats of the ACE-Coastal Plain Ecobasin. Currently, an interbasin water transfer exists on the Edisto River where water is removed via the water treatment plant to support the town of Hannah and the large industries along the Cooper River.

There is a moderate amount of industrial and agricultural activity within this ecobasin. Increased industrial growth along the Cooper River, the expected large scale residential growth in the town of Hannah, and growth in North Charleston will exacerbate water quantity issues.There are 98 active discharges permitted by SCDHEC; of those active discharges 60 are industrial discharges, 26 are municipal discharges, and 12 are community discharges. There are 87 CAFOs permitted by SCDHEC; the majority of those facilities are poultry farms (17 small, 21 medium, and 10 large). Swine farms also contribute significantly to the total number of agricultural facilities with 21 sites (11 small, 9 medium, and 1 large). CAFOs are not a major threat to aquatic habitats overall, but may pose a significant threat to portions of the ecobasin. The vast majority (70 operations) of the agricultural facilities are located in the north-central portion of the ecobasin in the Edisto River Basin, primarily in the Cattle Creek, Indian Field Swamp, and Cowcastle Creek watersheds. CAFOs likely pose a significant threat in those watersheds.

There is little expected commercial, residential, or industrial development throughout most of the northern portion of the ecobasin, although, a moderate amount of commercial and residential growth can be expected along the I-95 corridor and Lake Moultrie. In the middle and southern portion of this ecobasin, uncontrolled residential, commercial, and (potentially) industrial growth is a serious threat to aquatic habitats. Many areas are experiencing high levels of commercial and residential development as spillover from Charleston. The area between Cottageville and Charleston along the US 17 corridor is one of the fastest growing areas in the State. Other areas where large-scale residential and commercial development is expected include the towns of Ridgeland and Bluffton.

Approximately 117km (73 mi.) of stream in the ecobasin have been impounded. There are 77 dams permitted by SCDHEC within the ecobasin. The majority of the impounded area is a result of Pinopolis Dam on the Cooper River that forms Lake Moultrie. The Pinopolis Dam has had a significant negative impact on the Cooper River below the dam. Currently, there is no continuous minimum flow for the Pinopolis Dam tailrace, and aquatic habitats are frequently dewatered during low flows.

Santee–Coastal Plain Ecobasin

The Santee-Coastal Plain Ecobasin originates in southeastern Clarendon County and encompasses portions of Williamsburg, Berkeley, Georgetown and Charleston Counties before terminating at the coast. The only major river within the ecobasin is the Santee River. The headwaters of the Santee originate in the Blue Ridge and Piedmont Ecoregions. The Santee River flows for approximately 130 km (81 mi.) through the Coastal Plain, receiving inputs from Echaw Creek and Wambaw Creek, until terminating at the Atlantic Ocean. The ecobasin intersects 19 watersheds and encompasses 1,606 km^2 (620 $mi.^2$). There are 921 km (572 mi.) of lotic habitat and 11 km^2 (4.4 $mi.^2$) of lentic habitats. There are no large impoundments within the ecobasin.

Ten of 16 sites (62.5%) sampled by SCDHEC (1999b) within the ecobasin were impaired. Aquatic life uses were not supported at 2 sites due to a lack of invertebrate diversity. Recreational uses were impaired at 2 sites due to the presence of high fecal coliform concentrations. Fish consumption advisories due to mercury contamination have been issued for the Diversion and Rediversion Canals, Santee River, South Santee River, North Santee River, Wambaw Creek and Wadmacon Creek.

There are 19 active discharges permitted by SCDHEC within this ecobasin. Of those active discharges, 16 are from industrial sources and 3 are from municipal sources. There is only one active agricultural operation, a medium-sized poultry farm, within the ecobasin.

Development in this ecobasin is not a major concern, but moderate growth is expected on the south side of Lake Marion and in the vicinity of the town of St. Stephen.While much of the Santee River flood plain is public land, a substantial amount is privately held; removal of tree canopy poses a threat to aquatic habitats. The increasing trend towards conversion of upland agrarian land use to smaller home sites has the potential to negatively change hydrology, nutrient loading, and sedimentation. A growing beaver population is also likely to affect streams in this ecobasin, changing habitat that favors warm lentic-adapted species over those that favor cooler lotic habitats.

There are no large impoundments in this ecobasin; roughly 11 km (6.8 mi.) of stream are impounded. There are 11 dams permitted by SCDHEC within the ecobasin, although numerous unpermitted dams also occur in the ecobasin. Aquatic habitat in the Santee River is negatively influenced by the operation of the Santee Dam upstream.

Pee Dee–Coastal Plain Ecobasin

The Pee Dee-Coastal Plain ecobasin is located in the northeast corner of the State and encompasses portions of Dillon, Lee, Horry, Florence, Marion, Sumter, Clarendon, Williamsburg, and Georgetown Counties. Several coastal rivers are located within the ecobasin, including the Black River, Lynches River, Pee Dee River, Little Pee Dee River, and Waccamaw River. The headwaters of the Black River originate in the Southeastern Plains. The Black River flows unimpounded through approximately 198 km (123 mi.) of the Coastal Plain before merging with the Pee Dee River at the coast. As the Black River flows through the Coastal Plain it picks up inputs from several major tributaries including Black Mingo Creek, Peters Creek,

Cottage Creek, Lanes Creek and Six-mile Creek. The headwaters of the Lynches River originate in the Piedmont of South Carolina and North Carolina. The Lynches flows unimpounded through approximately 124 km (77 mi.) of the Coastal Plain before merging with the Pee Dee River near Gilbert Crossroads, SC. Major tributaries to the Lynches River in the Coastal Plain include Sparrow Swamp and Lake Swamp. The Pee Dee River originates in the southern portion of the North Carolina Piedmont and Southeastern Plains and flows through about 143 km (89 mi.) of South Carolina's Coastal Plain before terminating at Winyah Bay. As the Pee Dee flows through the Coastal Plain, it picks up inputs from several significant tributaries, including Catfish Creek, Lynches River, Little Pee Dee River, Conch Creek and the Black River. The Little Pee Dee River originates in the Southeastern Plains of North Carolina and flows through approximately 119 km (74 mi.) of the South Carolina's Southeastern Plains before entering the Coastal Plain. Within the Coastal Plain, the Little Pee Dee River flows for about 105 km (65 mi.), receiving input from the Lumber River before merging with the Pee Dee River. The Waccamaw River originates in the Coastal Plain of North Carolina and flows through approximately 167 km (104 mi.) of South Carolina's Coastal Plain before terminating at Winyah Bay. Within the ecobasin, the Waccamaw River picks up significant inputs from Buck Creek, Simpson Creek, and Kingston Swamp.

The ecobasin intersects 50 watersheds and encompasses 9,044 km^2 (3,492 $mi.^2$). Within the ecobasin, there are approximately 6,027 km (3,745 mi.) of lotic habitat and 47.4 km^2 (18.3 $mi.^2$) of lentic habitats. There are no major impoundments (lakes) within the ecobasin. Approximately 58.7 km (36.5 mi.) of streams are impounded within this ecobasin. There are 73 dams permitted by SCDHEC, most of which occur on small tributary streams.

Areas of primary conservation concern in the Pee Dee-Coastal Plain Ecobasin include the Lynches River and its tributaries in Lee, Florence and Sumter Counties; the Pee Dee River from its confluence with the Lynches River to Winyah Bay; and the upper Waccamaw River in Horry County. The Lynches River contains populations of "broadtail" madtom as well as several mussel species on South Carolina's Priority Species List (brook floater, creeper and notched rainbow). The Pee Dee River and its backwaters contain several fishes on the priority list including the "Broadtail" Madtom, Robust Redhorse, Carolina Pygmy Sunfish and the Federally Endangered Shortnose Sturgeon. Several mussel species on the priority list are in the Pee Dee River, including the Waccamaw spike, yellow lampmussel, Roanoke slabshell, and rayed pink fatmucket. The upper Waccamaw contains populations of Carolina Pygmy Sunfish and "Broadtail" Madtom as well as mussel species (Waccamaw spike and yellow lampmussel).

Water quality was impaired at 70 of 110 sites (64%) sampled by SCDHEC. Aquatic life uses were not supported at 23 sites due to low dissolved oxygen levels (11 sites), abnormal pH values (5 sites), copper contamination (3 sites), lack of invertebrate diversity (3 sites), and zinc contamination (1 site). Recreational uses were not supported at 3 sites due to the presence of high concentrations of fecal coliform bacteria. Due to high levels of mercury in fish tissue, SCDHEC has issued a fish consumption advisory for the entire length of every major river (Pocotaligo River, Black River, Black Mingo Creek, Lynches River, Pee Dee River, Little Pee Dee River, Lumber River, and Waccamaw River) in the ecobasin.

There are a moderate number of point source discharges within the ecobasin with 76 active

discharges permitted by SCDHEC. Of those active discharges, 38 are from municipal sources, 31 are from industrial sources, and 7 are from community sources. There are 71 active agricultural facilities within the ecobasin, the majority (48) of which are swine farms (27 small farms, 14 medium farms, and 7 large farms). Poultry and turkey farms are also prevalent within the ecobasin, accounting for 20 operations (2 small farms, 15 medium farms, and 3 large farms).

Increased population growth accompanied by unplanned and uncontrolled industrial, residential, and commercial development is a serious threat to aquatic resources in the Pee Dee-Coastal Plain Ecobasin. The majority of the growth and the greatest threat to aquatic resources is expected to occur along the eastern portion of the ecobasin near the coast. Increased commercial and residential growth is expected along several highway corridors: US 52 connecting Florence to Charleston, US 378, and US Hwy 501 connecting I-95 to Myrtle Beach. The construction of a proposed new interstate highway (I-73) running from Michigan to Myrtle Beach, South Carolina has the potential of significantly impact the aquatic resources of this ecobasin. The final route for I-73 has not been established; therefore, the exact location for impacts is unknown. Residential and resort communities along the "Grand Strand" will strain the already significantly degraded aquatic habitats. When developed, the largest tract of currently undeveloped land (Buist Tract) in Horry County is expected to accommodate 10,000 new residents and 11 new golf courses.

Marine Ecosystems

This land covertype occurs primarily in the Coastal Zone, although according to the SC GAP data, a small portion was mapped within this ecoregion. It included any brackish or salt waters, associated with estuaries or the Atlantic Ocean coast and was supported by the National Wetland Inventory salt water class (GAP 2001). See a more comprehensive definition for Marine Ecosystems within the Coastal Zone Ecoregion.

Region-wide Challenges

Although overall urban growth rates in the Coastal Plain are not as high as those in the Piedmont and Coastal Zone Ecoregions, there are some local exceptions. The Myrtle Beach area, at the eastern-most boundary of the region, is one of the fastest growing areas in the country. Two other cities qualify as Metropolitan Statistical Areas: Florence and Sumter. Three cities in the state recently received a new designation from the Census Bureau and are known as Micropolitan Statistical Areas: Bennettsville, Dillon and Walterboro. This designation recognizes that, although these areas are small in comparison to the larger Metropolitan Statistical Areas, they nevertheless have many of the same characteristics as larger urban areas and are experiencing typical urban growth dynamics. Rural portions of two counties, Jasper and Beaufort, are also exposed to the leading edges of expansion from rapidly growing coastal cities, namely Beaufort, South Carolina and Savannah, Georgia.

Pine woodland is likely the most fire-adapted forest in North America. Historically, frequent low-intensity fires were ignited by both Native Americans and lightning. Pre-colonial fire frequencies in the southeastern Coastal Plain region have been estimated at 1-3 years. As European settlement expanded, features such as roads and plowed fields created incidental

firebreaks. By the early 20th century, fire had come to be viewed as an agent of destruction and was actively and effectively suppressed. Reduction in fire frequency to intervals greater than 5 years leads to elimination of the herb layer in pine woodlands (Frost 1990) and eliminates much of the habitat value of early-successional stages.

The benefits of prescribed burns, especially those conducted during spring and summer months, are now more widely appreciated; however, burning is increasingly hampered by liability concerns. Expanding urban areas and proliferating highways are such that the smoke from a prescribed fire often creates extremely dangerous conditions. Keeping smoke away from roads is further complicated by the highly variable nature of the weather during the spring and summer months.

Few, if any alternative treatments have, however, been developed that can compete with fire from the standpoint of effectiveness and cost. Currently, the cost per acre for a controlled burn is $15-30 while a chemical treatment is typically $65-80 per acre, or about 2-3 times as much per acre as prescribed fire. Mechanical treatments such as disking, chopping, or raking are even more expensive. However, a combination of a chemical application to "burn down" the vegetation, followed by a controlled burn, can be a very effective management regime in some cases. The competing hardwoods are controlled better, and the follow-up cool season burn cleans up the duff layer to promote the growth of native grasses and forbs for wildlife.

Challenges to conservation of aquatic fauna in the Coastal Plan Ecoregion are similar to other ecobasins in the State and primarily include impacts associated with impoundments, non-point source pollution, point source pollution, poorly planned development, and introductions of non-native species. Increased population growth and the accompanying uncontrolled residential, commercial, and industrial growth may be the greatest challenge to species and their habitats in this ecoregion, especially near the coast.

There is only one major impoundment (Lake Moultrie) in the Coastal Plain; however, dams still have a significant impact on aquatic resources within the ecoregion. There are roughly 176 dams permitted by SCDHEC, although numerous other unpermitted dams, such as those associated with farm ponds, also exist and impound 245 km (152 mi.) of stream. The presence of dams results in a loss of connectivity and negatively affects aquatic biota both above and below the impoundment (Doeg and Koehn 1994; Kanehl et al. 1997; Tiemann et al. 2004). Impoundments negatively affect native aquatic fauna by direct loss of habitat through the conversion of lotic habitat to lentic habitat, which favors competitive and often predacious species like Largemouth Bass and other centrarchids. In addition, impoundments often negatively impact unimpounded reaches downstream by altering hydrologic and thermal regimes (Cushman 1985), modifying stream channel morphology, increasing erosion and sedimentation (Waters 1995), and ultimately reducing suitable habitat for native aquatic fauna (Helfrich et al. 1999; Tiemann et al. 2004). Dams in the Coastal Plain like Pinopolis Dam also hinder the migrations of native anadromous fish including shad, Striped Bass, and sturgeon to their historic spawning grounds in the Piedmont.

Siltation resulting from clearing forests, tilling soils, and the channelization of Coastal Plain streams has altered stream morphology. Modern soil conservation practices and reduced

channelization have lessened those impacts, but sedimentation from non-point and point sources remains a significant detriment to streams today.Ground disturbance from development, agriculture, and silviculture are primary sources of erosion that lead to sedimentation in streams. When timber managers fail to follow Best Management Practices (BMPs), significant siltation occurs. Stream bank erosion due to loss of riparian areas, livestock grazing, and altered hydrology also contribute to sedimentation in streams. During the past century, many streams in the Coastal Plain were channelized to improve drainage of croplands. Channelized streams lead to increased erosion of cropland and increased sedimentation of the receiving streams (Etnier and Starnes 1993). The result of channelization changed many streams into straight, shallow ditches with severely depressed populations of aquatic fauna.

Clearing hardwoods from bottomland and cypress swamps also threatens aquatic habitat in the Coastal Plain. In addition to increasing sedimentation and erosion, the loss of canopy results in increased water temperatures that will limit the amount of available habitat for some species like Striped Bass. Timber companies, which have been proven to be good stewards of the land, are selling off large tracts of land, making floodplain timber more vulnerable to harvest by other owners.

Excessive contamination from nutrients and chemicals also negatively affect water quality within the ecoregion. Point source discharges from industrial, municipal, and commercial sources add a variety of pollutants to receiving streams, rivers and lakes. In addition, contamination from non-point sources also negatively impacts water quality. Nationwide, pollution from agricultural sources is the greatest cause of impairment to streams and lakes (SCDHEC 2003). Statewide, the Coastal Plain has a modest amount of permitted discharges and concentrated animal feeding operations (CAFOs), 2.3 and 1.9 per 259 km^2 (100 $mi.^2$), respectively. However, those discharges and CAFOs are a significant threat to aquatic habitats. Water quality in the coastal plain was impaired at 63% of the sites sampled by the SCDHEC, which is the highest impairment rate of the 4 ecoregions in the state. Recreational uses were impaired at nearly 11% of the sites sampled due to the presence of high concentrations of fecal coliform bacteria. Fecal coliform bacteria are present in the digestive tract of warm-blooded animals. Although the bacteria themselves are not generally harmful to humans, they do indicate that surface waters may contain disease-causing pathogens (SCDHEC). Of the streams sampled by SCDHEC (2003?) within the ecoregion, 23% did not support aquatic life uses, indicating the streams do not possess sufficient water quality to maintain a balanced aquatic community of plants and animals. Mercury contamination is abundant in the Coastal Plain; this contamination is a serious threat not only to aquatic fauna but also to human health and recreational uses. Fish consumption advisories have been issued for nearly every major water body in the Coastal Plain. Nearly 30% of the sites sampled by SCDHEC were impaired due to mercury contamination in fish tissue, which is the highest impairment rate in the State.

Water quantity is also a problem in Coastal Plain streams. Water withdrawal for irrigation is a common practice in the ecoregion. During summer months, some streams are completely dewatered due to uncontrolled irrigation of croplands. Furthermore, many pond owners will close their drain structures during dry periods in an attempt to maintain esthetic water levels, thereby dewatering the stream below. With rapidly increasing human populations along the coast, demand for freshwater will increase dramatically and water withdrawal from streams and

rivers as well as interbasin water transfers will be a serious threat to aquatic habitats and their natural communities.

Introductions of non-native species have had a significant impact on native aquatic fauna in the Coastal Plain Ecoregion. Buffalo (fish), Common Carp, Flathead Catfish, and Blue Catfish are established in several drainages. Flathead Catfish and blue catfish introductions probably pose the greatest direct risks to native fauna. Flathead Catfish have been shown to prey on bullheads, darters, shad, suckers, and sunfish. Severe declines in native species, particularly bullheads and sunfish, have been observed after the introductions of Flathead Catfish (Guire et al. 1984; Jenkins and Burkhead 1993; Bart et al. 1994). It is not well known what effects buffalo have on the native community, but it has been suggested that they may be a factor in the decline of some catostomids in the Pee Dee River (Wayne Starnes, pers. comm.). Common Carp occur in every South Carolina drainage and are considered a pest, but their impact on native fauna is not well known. Common Carp disrupt aquatic habitats by rooting around in the substrate, which uproots aquatic plants and increases turbidity and siltation. Common Carp have also been shown to prey on the eggs of other fish species.

The Asian clam, *Corbicula fluminea*, has been introduced and has spread widely throughout the United States, including into South Carolina. The effects of *Corbicula* on native species are not particularly well understood. According to a review of the literature on interactions between *Corbicula* and native mussels (Dillon 2000), most field studies failed to find any significant negative effects on native mussels, although a few detected reductions in growth. Three invasive snail species (*Viviparus georgianus*, *V. purpureus*, and *Bellamya/Cipangopaludina japonica*) are present in Lakes Marion and Lake Moultrie; however, their impact on native fauna is not known.

The red swamp crayfish has been introduced to South Carolina and has been observed at several locations in the Southeastern Plains and Coastal Plain, but it is unclear how widespread it is in the state. The lack of survey work since its introduction and the difficulty distinguishing the red swamp crayfish from native catfish have made it particularly difficult to determine the extent of its introduced range. In North Carolina, it has become established in all drainages in the Coastal Plain and Eastern Piedmont Plateau and appears to have extirpated all the native crayfish at one location (Cooper 2003). Introduced crayfish are thought to be the biggest threat to native crayfish species (Lodge et al. 2000 a,b); the risk to our native species is great if further introductions or extensive spread on non-indigenous crayfish occurs.

Sand mining operations have been initiated, or are ongoing, in the main stem or riparian areas of many Coastal Plain rivers. Instream sand mining is a significant threat to aquatic resources within the ecoregion. Sand mining not only causes bank instability and loss of riparian habitat at the mining site, but also causes instream impacts by changing the physical and chemical habitat. Such impacts can negatively affect biological communities (Nelson 1993) and recreational uses (Hartfield 1993). Physical impacts on instream habitat include increasing bedload materials and turbidity, changing substrate type and stability, and altering stream morphology (Nelson 1993). Physical habitat alterations associated with sand mining can adversely affect the biological community by impacting the reproduction and survival of fishes (Stuart 1953; Newport and Moyer 1974) and the distribution, composition, and reproduction of other aquatic organisms (Buck 1956; Trautman 1957; Newport and Moyer 1974).

Coastal Zone Ecoregion

The Coastal Zone is the portion of the Lower Coastal Plain that lies seaward of US Highway 17. This region includes a small portion of the mainland but is primarily comprised of tidal marshlands and associated uplands. Large sea islands that are greater in size than 1,000 ac. (404.69 ha) are included. These extend eastward to include barrier islands, Atlantic Ocean beaches, and the Atlantic Ocean shallow continental shelf offshore to South Carolina's 4.8 km (3 mi.) jurisdictional boundary. The lower approximately 32-48 km (20-30 mi.) of all of the State's coastal rivers are included in the Coastal Zone.

The inland boundary of the Coastal Zone is somewhat arbitrary relative to mainland habitats, but it is particularly relevant to riverine and alluvial habitats since Section 50-5-80 of the Code of Laws of South Carolina establishes boundaries for fresh and 'marine' waters that are generally associated with US Highway 17. These boundaries were established primarily for wildlife law enforcement concerns related to freshwater and marine fishery laws and regulations. The actual point at which riverine waters change from fresh (salinity of < 0.5 ppt) to brackish or 'marine' (salinity > 0.5 ppt) is highly variable, even on a daily basis, depending upon the combined impacts of tides and river discharge (as determined by rainfall) or water releases from dams. South Carolina experiences semi-durnal tides such that two high tides and two low tides occur approximately every 24 hours and can be described as microtidal in terms of their range of 0 to 2 m (0-6 ft.). During each approximately six-hour period from low tide (maximum ebb) to high tide (maximum flood), the point of change from fresh to brackish water—in some places existing as a "salt wedge"—may move several miles upriver, only to return downriver during the next ebb tide period.

The soils or surficial sediments (sands, silts and clays) of the Coastal Zone are derived from the Appalachian Mountains and are organized into coastal, fluvial (riverine) and aeolian (dune) deposits. Most of these deposits were transported seaward during the Quaternary Period, which began approximately 1.8 million years ago. Underlying these surficial sediments is a bedrock stratum of eroded sedimentary rocks dating back to the Tertiary Period and the Mesozoic Era, between 130 and 1.8 million years ago. With the exception of manmade quarries, the bedrock stratum within the Coastal Zone is only exposed on river banks and bottoms, in deep scoured tidal channels, and on near-shore Atlantic Ocean continental shelf bottoms as "hard bottom." The oldest sedimentary rocks are deeply buried sandstones, shales, and siltstones from the Cretaceous period (up to 130 million years old). Limestones ranging in age from 100 to 30 million years overlie these sedimentary rocks (Mathews et al. 1980).

Much of the South Carolina Coastal Zone has been adversely affected by human population growth and associated coastal development. By the early 1990s, approximately 50% of the total US human population lived in coastal areas (Moore et al. 1995), and an annual increase of 7.3% is still occurring (Appalachian State University 2008). The trend of concentrated population growth along coasts is expected to continue into the next century (Cullitan et al. 1990; SCFC 2010). In the 1990s, approximately 142 km (88 mi.) or 48.6% of South Carolina beachfront was affected by development (Kana 1988), but this number has since increased.

The rapid rate of human population growth and associated development in the Coastal Zone has fragmented forests and negatively impacted other valuable habitats, such as shrub thickets and isolated wetlands. The vast majority of protected Coastal Zone holdings are located within two regions: the ACE Basin and the Cape Romain National Wildlife Refuge.

Land Covertypes

The Coastal Zone contains the most diverse amount of habitats of any of the South Carolina ecoregions. Within this ecoregion, many habitats that are intricately linked to priority wildlife species are completely dependent upon the influence of salt water and direct management actions, such as the creation of coastal impoundments.

Diverse forest types are distributed throughout the extreme eastern portion of the Lower Coastal Plain mainland that is adjacent to estuaries and tidal river basins. Due to this proximity, large Coastal Zone islands, including barrier islands, sea islands, and many hammock islands also support forested habitats that are very similar to those found in the Lower Coastal Plain. Forested habitats distributed within both the Coastal Zone and Coastal Plain include: bottomland hardwood, pine woodland, oak-hickory or hardwood-dominated, mixed mesic hardwood and bald cypress/tupelo gum swamp. Larger landmasses within the Coastal Zone also contain grassland, early-successional habitats, and wet flatwoods. Ponds and depressions, or wetlands isolated from tidal waterways also occur in the Coastal Zone. Inter-dune ponds that are restricted to dune systems along the Atlantic Ocean beaches are also included. Figure 4-14 illustrates these Coastal Zone covertypes. Species-habitat associations are presented in Appendices 1 A-D while the faunal makeup of the habitats are described in more detail within this chapter (4).

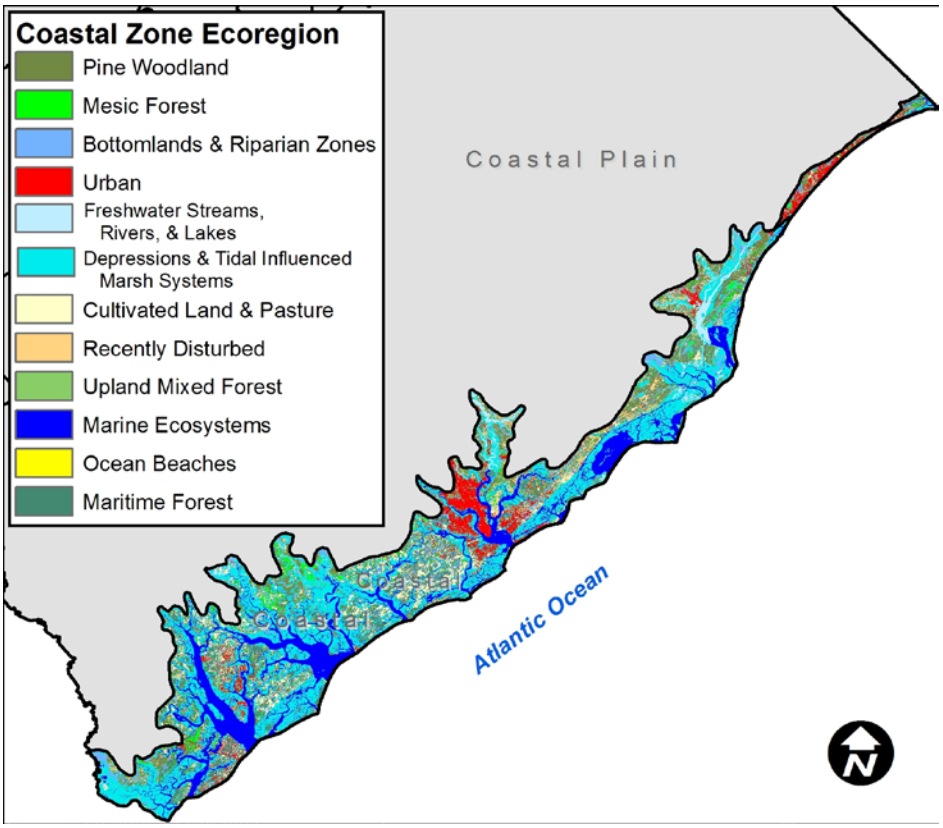

FIGURE 4-14: Land covertypes of the Coastal Zone Ecoregion.

Pine Woodland	This habitat is used to describe all pine-dominated forests throughout the region, including those occupying a variety of soil moisture characteristics except floodplains. The canopy is dominated by one or several species of pine, generally loblolly (*Pinus taeda*) or longleaf (*Pinus palustris*), depending on elevation, soil type and silvicultural history. Dense shrub thickets of hollies (*Ilex* spp.) and wax myrtle (*Morella cerifera*) may be present. Higher elevation pine woodlands have abundant grasses and herbaceous cover, particularly when burning is frequent. Optimal habitat for priority species consists of open stands of longleaf pine, sparse understory and shrub layers, a ground cover of wiregrass (*Aristida* spp.), and diverse herbaceous species. Pine savanna—also known as open savanna—is an important variant of pine woodland. Wet prairie, grass-sedge bog, and herb bog or pitcher plant bog are typically found in the Outer Coastal Plain on flat sites with a high water table and soil that is saturated for at least part of the year. Vegetation consists of a thin canopy of pines, almost always longleaf (*Pinus palustris*), although loblolly (*P. taeda*) and pond pine (*P. serotina*) may also be present. The understory is essentially absent or very scattered. Herbaceous flora is quite rich, consisting of many grasses and sedges. Pine flatwoods intergrade with pine savanna; like pine savanna, it is pine woodland situated on mainly flat or rolling

	terrain with sandy soil and a high water table. Unlike pine savanna, pine flatwoods feature a well-developed subcanopy of several tall shrub species. Pine flatwoods is the principal forest type for much of the Outer Coastal Plain. Sandhill pine woodland is another variation of pine woodland composed of species adapted to xeric, sandy soils. The type occurs principally in the Sandhills but may occur through the Coastal Plain with only limited representation on sand ridges in the Coastal Zone. In the absence of frequent fire, a canopy of longleaf pine, and a subcanopy of turkey oak prevail, interspersed with scrub oak species and scrub-shrub cover. Frequent burning leads to the development of longleaf pine-wiregrass communities.
Mesic Forest	Also found in the outer reaches of the Coastal Plain, these areas may be considered a broad transitional habitat between pine flatwoods and maritime forest. While the sparse canopy typically is dominated by longleaf pine (*Pinus palustris*) and loblolly (*P. taeda*), pond pine (*P. serotina*) may also be present. The understory consists of sporadic tall shrub species like *Ilex* spp. and members of the heath family (Ericaceae), interspersed with characteristic 'bog' species such as *Sphagnum* spp., *Sarracenia* spp., *Rhexia* spp., and grasses and sedges under open canopies. These areas are often closely associated with low-lying maritime forests dominated by live oaks, *Ilex* spp., as well as *Taxodium* and *Nyssa* spp.
Hardwood Slopes and Stream Bottoms *(within Bottomlands & Riparian Zones layer)*	This type is composed of a complex of hardwood and hardwood-pine communities that occupy the floodplains of small streams, mesic bluffs, and infrequently flooded flats in association with streams or rivers. Fire is infrequent, due either to the sheltered locations of these communities on bluffs or their isolation within a floodplain. Several mixed mesophytic subtypes characterized by the presence of American beech *(Fagus grandifolia)* occur in sheltered sites with moist soils, particularly on north-facing river bluffs and on slopes of drains and creeks. On upland flats within floodplains (hammocks), southern magnolia *(Magnolia grandiflora)* frequently shares dominance with American beech. The calcareous cliff and marl forest subtype occurs on circumneutral soils derived from limestone or unconsolidated calcareous substrates such as marl. Forest structure of all subtypes is diverse, with understory, shrub and herbaceous species varying according to soil moisture and chemistry. All subtypes intergrade with blackwater stream forest or river bottom forest on lowland sites and with upland forest on upland sites.
Blackwater Stream Systems	Tributary streams rising in the Sandhills and Coastal Plain are commonly known as "blackwater streams" for the color of tannins

(within Bottomlands & Riparian Zones layer)	leaching from decaying vegetation. Forests on the narrow floodplains formed by these streams typically have a canopy dominated by swamp tupelo *(Nyssa biflora)* and red maple *(Acer rubrum)*. On broader sites, bald cypress *(Taxodium distichum)* can become an important canopy species. Tulip poplar *(Liriodendron tulipifera)*, sweet gum *(Liquidambar styraciflua)*, pond pine *(Pinus serotina)*, loblolly pine *(Pinus taeda*) and laurel oak *(Quercus laurifolia)* are important associates. The shrub layer is open in areas subjected to the most flooding, or it can be fairly dense and pocosin-like in areas subject to infrequent flooding. Headwaters and wet flats immediately above the floodplain can support dense, pocosin-like shrub thickets or, under suitable fire conditions, pure stands of Atlantic white cedar (*Chamaecyperus thyoides*).
River Bottoms *(within Bottomlands & Riparian Zones layer)*	River bottoms, or "bottomland forests" consist of hardwood-dominated woodlands with moist soils that are usually associated with the broad floodplains of major rivers arising in the Piedmont or Blue Ridge. Locally, the floodplains of major coastal plain rivers are significant components of the landscape. Characteristic trees include sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), laurel oak (*Quercus laurifolia*), cherrybark oak (*Quercus pagoda*) and American holly (*Ilex opaca*). A subtype occurs on lower elevation sites interspersed and intergrading with oak-dominated woodlands. Dominant trees are bald cypress (*Taxodium distichium*) and water tupelo (*Nyssa aquatica*), swamp gum (*Nyssa biflora*), Carolina ash (*Fraxinus caroliniana*), water elm (*Planera aquatica*) and red maple (*Acer rubrum*).
Maritime Forest	Maritime forests are the typical forested plant community in the Coastal Zone and are found on barrier islands, salt marsh islands (including hammock islands) and mainland areas that are influenced by salt spray. Maritime forests are typically dominated by live oaks *(Quercus virginiana)*, southern magnolia *(Magnolia grandiflora)* and one or more species of pine. Typical shrubs and small trees include southern red cedar *(Juniperus silicicola)*, cabbage palm *(Sabal palmetto)*, American holly *(Ilex opaca)*, red bay *(Persea borbonia)*, wax myrtle *(Morella cerifera)*, and yaupon holly *(Ilex vomitoria)*. The herbaceous layer is usually fairly sparse due to the dense canopy cover. Maritime forests exhibit much greater species and structural diversity away from the direct effects of salt spray where deciduous trees are more common and include southern red oak *(Quercus falcata)*, water oak *(Quercus nigra)*, sugarberry *(Celtis laevigata)* and pignut hickory *(Carya glabra)*. Dogwood *(Cornus florida)*, American olive

	(Osmanthus americana), and Carolina laurel cherry *(Prunus caroliniana)* are also common in the understory. Under fragmented canopy conditions, shrubs, including beauty-berry *(Callicarpa americana)* and red buckeye *(Aesculus pavia),* become more common, and saw palmetto *(Serenoa repens)* which reaches its northern extent of its range on Kiawah Island in Charleston County. A variant maritime forest resembling xeric pine woodland of the Coastal Plain occurs on relict dune ridges inland from the barrier island forests. This habitat has an open super-canopy of longleaf pine *(Pinus palustris)* with an understory composed of live oak *(Quercus virginiana),* laurel oak *(Quercus hemisphaerica),* sand live oak *(Quercus geminata)* and turkey oak *(Quercus laevis).* Unlike typical maritime forests, maritime Sandhill forests are open and characterized by patches of bare sand and lichens, such as reindeer lichens *(Cladonia* spp.).
Hammock Island *(specialized habitat not mapped at this scale)*	 Approximately 3,500 hammock (or hummock) islands are distributed throughout the coastal tidelands of South Carolina, located inland of barrier islands. Hammock islands are most abundant (90%) within the expansive estuarine and brackish marshlands and tidal waterways of Charleston, Colleton and Beaufort Counties. Hammock islands range in size from 0.04 to 404.5 ha (0.108-999.9 ac.) and are surrounded by tidal wetlands. Most were naturally formed while some, particularly along the Intracoastal Waterway, were created by the disposal of dredged materials or sediments excavated from post-Civil War era phosphate mining. Many hammocks also occur within the delta portions of coastal river basins. As upland landforms, hammocks provide a diversity of woodland, shrub and wetland habitats. The diversity of habitats, plant communities, and associated fauna generally increase with hammock size. Islands of less than 0.4 ha (1 ac.) may be of uniformly low elevation and may become partially or completely inundated by salt water during extreme high tides. Such hammocks have few, if any, large trees and may be predominantly salt-shrub or grassland. Some very small hammocks with low elevations, precluding inundation except during extreme storm-driven tides, may

	have a few stunted specimens of live oak (*Quercus virginiana*) and/or cabbage palmetto (*Sabal palmetto*), but frequently are composed almost exclusively of stands of southern red cedar (*Juniperus virginiana* var. *silicicola*) with a narrow salt-shrub collar. Most hammock islands that are larger than 0.4 ha (1 ac.) have some cover provided by live oak (*Q. virginiana*) and cabbage palmetto (*S. palmetto*) and in at least these respects share characteristics with typical maritime forest. A narrow band of salt-shrub thicket encircles most hammocks at the marsh and upland interface. A broken band of southern red cedar (*J. virginiana* var. *silicicola*) and shrub thicket dominated by wax myrtle (*Morella cerifera*) frequently occupies the transition zone directly upland of this thicket. Seasonally-flooded depressions and high marsh or salt-shrub incursions or sloughs may extend beneath cabbage palmetto-dominated swales. Frequently, salt-tolerant grasses, sedges and herbs colonize these hydric soils where the shrub layer is absent or sparse. Portions of hammocks abutted by tidal waterways often transition abruptly from mature canopy forest to the high tide zone, with a very thin salt-shrub or high marsh collar if such occurs at all.
Upland Mixed Forest	Vegetation composition of upland forest is similar to that of oak-hickory forest in the Piedmont, where it is a major vegetation type. Upland forest is rare in the Coastal Zone, typically occurring on fire-suppressed upland slopes over calcareous deposits and often associated with shell middens. Representative canopy trees include white oak (*Quercus alba*), nutmeg hickory (*Carya myristiciformis*), sand hickory (*Carya pallida*), loblolly pine (*Pinus taeda*), with chalk maple (*Acer leucoderme*) and ironwood (*Carpinus caroliniana*).
Grassland and Early-Successional Habitat *(specialized habitat not mapped at this scale)*	Typical Coastal Plain upland grasslands or early-successional fields extend into the Coastal Zone, with cover provided by grasses and / or weeds and with few, if any, trees. These habitats are generally characterized by tree canopy coverage that is sparse or absent and herbaceous groundcover comprised of annual forbs, perennial bunchgrasses, and variable coverage of shrubs and small trees. A variety of open land covertypes represents this category and can include native prairies, savannas, old field sites, open canopy gaps, shrub-scrub thickets, recently-cleared forests, field borders, grassed waterways, and filter strips. Lawns, golf courses, pastures, hay fields, crop fields, airports and various urban open spaces with or without damp depressions are sometimes included in this habitat type but lack the floristic and structural diversity to be considered high quality, early-successional habitat (see Cultivated Land and Pasture). Minor modifications to agricultural land use, such as replacing introduced grasses with native grasses, using native grasses in filter strips and

	grassed waterways, and implementing no-till or strip-till in crop fields can result in dramatic improvements to quality of early-successional habitat. Maintenance of early-successional habitat requires periodic repeated disturbance or disruption of the existing vegetative community. Purposeful management of early-successional habitat is usually accomplished through the use of timber harvest, prescribed burning, disking, or mowing. Target species for management will determine disturbance intervals, with shorter intervals (1-2 years) favoring those species dependent on herbaceous vegetation and longer intervals (3-5 years) favoring those species dependent on shrub cover. Optimal multi-species management often dictates concurrent maintenance of variety of successional, or seral, stages. Early-successional habitat types have declined dramatically over the past 70 years primarily due to changing agricultural practices, forest succession, fire suppression, and urban / suburban encroachment. A large portion of existing early-successional habitat occurs on privately owned lands. One of the greatest challenges to maintaining priority species associated with this particular land cover is private land outreach and technical assistance.
Isolated Non-forested Uplands *(specialized habitat not mapped at this scale)*	Numerous small emergent landforms occur within inlets, sounds, bays and river deltas. These are generally sparsely vegetated and are constantly reshaped by the dynamic forces of currents, waves and wind. Such islands lying entirely within sounds and inlets and surrounded by expanses of open, relatively deep water are generally devoid of terrestrial predators, particularly raccoons. Lower-lying islands are vulnerable both to over-washing by storm-induced high tides and to salt spray from strong winds. In more sheltered situations, even though high-profile dunes are absent, vegetation develops in the form of salt tolerant grasses and low shrubs. Sandy beach, intertidal beach, and surf zone habitats may also be present. The extent and type of vegetation likely determines the utilization of such sites by nesting and resting seabirds, shorebirds, and wading birds. Emergent landforms influenced by human activity consist of diked spoil islands and shell rakes. Diked spoil islands are created by the disposal of dredged materials in previously open tidal marshlands or on previously existing uplands. Both dikes and interior areas above normal spoil pooling are usually colonized by early-successional grasses such as broom sedges (*Andropogon* spp.), and shrubs and trees including groundsel tree (*Baccharis halimifolia*), tallowtree (*Triadica sebiferum*) and sugarberry (*Celtis laevigata*). Vegetation cover becomes more dense when spoil deposition is discontinued. Although the value of

	these sites to wildlife is highly variable, spoil islands receiving sediments consisting primarily of sand with a low organic content can be manipulated to maintain an unvegetated condition to facilitate their use by seabirds and shorebirds. Shell rakes are deposits of oyster and other molluscan shells produced by wave action from wind and/or boat wakes that occur along the exposed marsh borders of inlets, sounds, bays and other large waterways. Shell rakes are particularly abundant adjacent to the Intracoastal Waterway and are highly valuable as nesting and roosting sites for American Oystercatchers (*Haematopus palliates*) and other shorebird species. High wakes are especially problematic during the summer when over-washing can destroy oystercatcher nests (T. Murphy, SCDNR, pers. comm. 2004).
Depressions	Depressions, including pools and isolated wetlands, occur throughout the Coastal Zone and may be embedded within larger habitats such as forested habitats, early-successional habitats, hammock islands, maritime forest, and diked spoil islands. Such sites are not generally identified on soil maps. In addition to the isolated wetland subtypes occurring throughout the Coastal Plain, the following subtypes are unique to the Coastal Zone (see Depressions & Tidal Influenced Marsh Systems).

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

		gradually sloping margins, occur in sandy uplands on barrier islands and within other landforms of recent origin. These pools may be embedded in non-alluvial swamp forests or other forest types within the interior of uplands, or they may lie near the perimeter of uplands and receive occasional input of water of varying salinity on exceptionally high tides. Except where soils are highly saline, many of these habitats have been colonized by the invasive, non-native Chinese tallowtree (*Sapium sebifera*).Vernal pools may be a primary source of low salinity water for birds and mammals and may serve as breeding and/or resident habitat for turtles, amphibians, and crayfish. Since these pools are only seasonally flooded, large predatory fishes are absent. Smaller vernal pools may afford the only wetland habitats on smaller islands.
	Small Depression Ponds	These may intergrade with vernal pools but are permanently flooded, except possibly during severe droughts. Obligate aquatic plants—like fragrant waterlily (*Nymphaea odorata*) or yellow pondlily (*Nuphar lutea*)—may inhabit submerged areas, and a variety of emergent and wetland species, including sedges and grasses, generally colonize shallows and intermittently exposed borders. Small

		depression ponds are generally not affected by tidal activities.
	Interdune Ponds	These are depressions located in swales between beach secondary dunes or ridges that contain permanent or vernal pools. Both vegetation and animal life in pools is largely determined by salinity. Interdune ponds, whether permanently or seasonally watered, may provide at least a short-term supply of low salinity water in areas where it is otherwise generally absent.

Estuarine Systems

Estuaries form one of the predominant landscapes of the Coastal Zone. They consist of interconnected networks of intertidal marshland with tidal channels of various sizes branching throughout, generally interfacing with marine or Atlantic Ocean waters via deep channels through sounds and bays or through smaller inlets. Listed here are the broadly recognized vegetative and geophysical components of estuaries and their inter-relationships:

Salt Marsh	Intertidal marshlands in estuarine (salinity ranges 15 to ~40 ppt) areas that are variously flooded and drained by tidal forces, with influence from lunar cycles, wind, rainfall, and river discharge, particularly within or near river deltas. Smooth cordgrass (*Spartina alterniflora*) is the dominant plant.
Black Needlerush Marsh	The portion of highest elevation salt marsh dominated by black needlerush (*Juncus roemerianus*) which often occurs in dense stands. This habitat is usually near uplands.
Salt Flat	Sparsely vegetated, hypersaline (salinity > 40 ppt), and exposed flats of sand and/or mud. Typical plants include glassworts (*Salicornia* spp.) and saltwort (*Batis maritima*).
Salt-Shrub Thicket	Bands or patches of usually low, dense shrubs that typically interface with high salt marsh and uplands. Characteristic plants include sea ox-eye (*Borrichia frutescens*), marsh elder (*Iva frutescens*), and groundsel tree (*Baccharis*

	halimifolia).
High Marsh Pool	Poorly drained pools in high salt marsh, often near uplands. Salinity is highly variable depending on the frequency and timing of tidal inputs and rainfall. Both soils and water may become hypersaline (salinity > 40 ppt).
Estuarine Intertidal Flat	Mud and sand flats in estuarine systems that have little or no vegetation and are drained on the ebb tide and flooded during high tides. Mud and sand flats may occur between marshlands, channels, and creeks or may be interspersed within marshlands.
Estuarine Intertidal Sandbar	Sandbars in estuarine systems that are partially exposed during part of most tidal cycles (i.e. spring and neap tidal cycles) and river stages but are typically submerged during high tide.
Estuarine Tidal Channels and Creeks	Tidal estuarine waterways of variable depth and with currents generated by riverine and/or tidal flows.
Estuarine Subtidal / Submerged Flat	Mud and sand flats with little or no vegetation that are inundated during all or part of each tidal cycle. Submerged flats include sand and / or mud bottom areas outside of channels and creeks, and usually lie between channel habitats and tidal marshlands.
Oyster Reef	Fringing oyster reefs and extensive reef flats primarily composed of live Eastern oysters (*Crasostrea virginica*). Oyster reefs are predominantly (>95%) intertidal and are often found in close spatial proximity to salt marshes for which they serve as natural breakwaters (fringing reefs). Oyster reefs also occur as flats between tidal channels and salt marsh.
Shell Rakes	Shell rakes are piles of "washed shell" which were at one time on the bottom of a channel, perhaps they were remnants of old subtidal oyster beds. They are so old that their shells are very light weight and over time they get moved by boat wakes, dredging and storms and gradually wash up into the high intertidal zone. They are common along the Intracoastal Waterway but also in many tidal creeks and estuaries. A survey published by the SCDNR in 1979 lists 998 washed shell deposits, 58 % of which are in Beaufort county and 36% in Charleston county. That survey says "Shell

	deposits are formed in estuarine areas where an abundance of submerged oyster shells are exposed to frequent wave action generated by prevailing winds or boat traffic" (Anderson et al. 1979). Shell rakes are favored nesting, roosting, and foraging areas for many shorebirds such as the American Oystercatcher.
Managed Impoundments	The coastal wetland impoundments of South Carolina comprise managed and formerly managed tidal wetlands. Impoundments generally occur from Georgetown County southward, coincident with the state's most extensive tidal marshlands. Salinity regimes range from fresh to brackish, depending on their water sources and management practices. A diverse assemblage of rooted floating aquatics, such as white waterlily *(Nymphaea alba),* American lotus *(Nelumbo lutea),* and pondweeds occupies managed freshwater impoundments. Emergent plants such as cattails (*Typha spp.),* southern wild rice (*Zizania aquatic*) and pickerel weed *(Pontederia spp.)* are common. Submerged and free-floating aquatic plant species also occur and include duckweed *(Lemna minor)* and bladderwort *(Utricularia spp.).* Managed brackish and intermediate emergent wetlands principally contain widgeongrass *(Ruppia maritima),* saltmarsh bulrush *(Scirpus robustus),* and dwarf spikerush *(Eleocharis parvula).* Emergent tidal marshes are common along the banks of canals of abandoned rice fields and modern-day waterfowl impoundments. Dominant species can include cutgrass (*Zizaniopsis miliacea*) or Jamaica swamp sawgrass (*Cladium jamaicense*). Intermixed among these grasses are various herbaceous plants such as pickerelweed (*Pontederia cordata*), arrowheads (*Sagittaria* spp.), and alligatorweed (*Alternanthera philoxeroides*). Shrubs and trees are present in the more elevated areas of the tidal marsh community.

	Bald cypress-tupelo swamp communities occur on abandoned rice fields and swales inland of modern-day impoundments.

Freshwater Streams, Rivers, and Lakes

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

Tidal, Fresh, and Brackish Systems

Tidal fresh and brackish systems consist of a complex of intertidal and subtidal marshlands, sandbars, mud flats and sand flats, and waterways (channels and creeks) that are subject to the mixing of salt and freshwater flows, usually in association with a freshwater source, such as a river delta. Vegetation includes both emergent marsh and submerged forms, and is predominantly comprised of grasses, sedges, and herbs with few trees and with species composition driven largely by salinity.

Marine Ecosystem

South Carolina's coastline is the 11th longest in the nation at 301 km or187 mi. If all convolutions (bays, inlets, etc.) are included, South Carolina ranks 12th with 4,628 km or 2,876 mi. of shoreline. The marine ecosystem occurs along all of South Carolina's Atlantic Ocean coastline and extends offshore to the State 4.8 km (3 mi.) jurisdictional boundary, incorporating a surface area of nearly 140,000 ha (345,946 ac.). Ocean beaches and the associated transition zones are formed primarily from unconsolidated sand and are ubiquitous features on barrier islands or ocean strands that directly front the Atlantic Ocean. Dune habitat includes sand dunes and swales, flats and pools between dunes, and between dunes and other features. Seaward of the dune system, sandy flats may occur in areas where dunes have been eroded. Beaches and associated habitats are influenced by wind-blown salt spray and sand, and may be occasionally flooded, particularly during storms. The following vegetative and aquatic habitats are generally recognized within the beach/marine ecosystem. Interdune Ponds have been discussed previously in Depressions & Tidal Influenced Marsh Systems.

Maritime Grassland	That portion of the Atlantic Ocean beach dune system vegetated by grasses and herbs. This habitat includes sand dunes, swales, and flats between dunes as well as between dunes and other features. Characteristic plants include sea oats (*Uniola paniculata*), bitter panicgrass (*Panicum amarum*), seabeach evening

	primrose (*Oenothera humifusa*), and dune waterpennywort (*Hydrocotyle bonariensis*).
Maritime Shrub Thicket	Thickets of shrubs, vines, and stunted trees often in swales within secondary dunes. Trees and shrubs must be salt tolerant and are "pruned" by wind-blown salt spray and sand. Typical plants are wax myrtle (*Morella cerifera*), red bay (*Persea borbonia*), groundsel tree (*Baccharis halimifolia*), saw greenbrier (*Smilax bona-nox*), and poison ivy (*Toxicodendron radicans*).
Intertidal Beach	The front ocean beach region that is typically inundated on flood tides and drained on ebb tides. Invertebrate fauna in the intertidal beach zone, such as the coquina clam (*Donax variablis*) and the mole crab (*Emerita talpoida*), are an integral part of the food chain for shorebirds and seabirds (e.g. Piping Plover, *Charadrius melodus*; Willet, *Catoptrophorus semipalmatus*; Sanderling, *Calidris alba*; and Red Knot, *Calidris canutus*) that forage on the intertidal beach and at the surf interface.
Surf Zone	The submerged portion of the beach area and extending offshore to a depth of 2 m (6 ft.) at any tidal stage. Marine aquatic species in this zone are heavily influenced by turbulence from wave action. As many as 98 fish and 317 macro-invertebrate species are recognized as at least occasional inhabitants of this zone.
Shallow Shelf *(Soft Bottom, Hard Bottom, Pelagic Zone)*	The portion of the Atlantic Ocean submerged continental shelf offshore to the 4.8 km (3 mi.) state territorial limit. Shallow shelf habitats can be further divided into three important types; soft bottom, hard bottom, and the pelagic zone. Soft bottom is composed of unconsolidated sediments that supply sand to the continental shelf, barrier islands, and beaches; store nutrients in the sediment; and provide critical nursery and feeding habitat to fish and invertebrates. Hard bottom supports a wide variety of invertebrate and fish species, including many species popular with recreational and commercial fishers. Hard bottom habitats are continually being discovered and mapped. The pelagic zone supports many resident nekton (water-column)

	species (i.e. those capable of determining their position in the water column against tide currents, as opposed to planktonic species) but also forms an important migration route or habitat for transient species.

Man-made Structures

Engineered, man-made structures are estimated to cover over 25% of South Carolina's nearly 145 km (90 mi.) of developed coastline. SC Sea Grant estimates that 27% of the State's shoreline is armored. Some of the most familiar of these structures include piers, boardwalks, housing and commercial development, jetties, and groins. Manmade structures can provide hard surfaces, vertical relief, and structural complexity in the water column, all of which promote the attachment of many aquatic, sessile, and sedentary species. These include algae and mosses in low salinity waters, and algae and invertebrates (e.g. hydroids, bryozoans, sponges, barnacles, oysters, and mussels) in estuarine and near-shore marine waters.

Rock seawalls and jetties provide hard substrate for the attachment of organisms in intertidal and subtidal zones, while exposed rock may be used as resting and foraging habitat for shorebirds and seabirds—most notably the Purple Sandpiper (*Calidris maritima*), which prefers rocky coast habitats that are generally rare in the Southeast. Submerged rock also provides refuge habitat for many fishes and invertebrates.

Intertidal reefs, commonly constructed of shell, refurbished crab traps, or concrete blocks, serve the same purpose as naturally occurring oyster reefs. The hard surfaces and structures are substrate for attachment of oysters and other invertebrates and the resulting communities are refuge habitat for many fish and invertebrates as well as foraging habitat for larger fish and shorebirds such as American Oystercatchers. These reefs are often used to stabilize eroding shorelines along tidal creeks and have proved effective at encouraging saltmarsh expansion.

Subtidal reefs in nearshore and offshore waters comprised of manmade structures account for a relatively small percentage of the EEZ off of South Carolina. The State's ten nearshore reef sites are generally about 30 acres (0.05 square miles) in size while the 32 offshore sites are typically 160 acres (0.25 square miles). Each site is made up of numerous individual steel or concrete structures ranging from small, prefabricated concrete modules to large steel-hulled vessels hundreds of feet in length. Each structure provides surface area for the attachment of sessile organisms including algae, barnacles, corals, sponges, hydroids, and bryozoans which become the foundation of the reef community. Once colonized by invertebrates, other marine animals such as crabs, shrimps, urchins, amphipods, and mollusks take up residence as well. Studies have documented nearly 300 invertebrate species attached to or residing on artificial reef structures. The ultimate goal of creating manmade reefs is the creation of finfish habitat for the enhancement of fisheries resources. Over 50 species of fishes have been observed on the State's artificial reefs, including both recreational and commercially important species, and in densities usually higher than in natural areas. In addition, nesting and spawning activities on these reefs attest to their use as permanent fish habitat. Artificial reefs off South Carolina have been

declared Essential Fish Habitat (EFH) by the South Atlantic Fishery Management Council (SAFMC).

Hardened structures designed for shoreline and channel protection also disrupt the natural processes of sand movement along beaches and can therefore contribute significantly to beach erosion. Seawalls and bulkheads in inland waterways can protect the immediate shoreline while potentially exacerbating erosion of the nearby, unprotected shoreline. Such structures also interfere with the nesting of sea turtles either by totally displacing nesting sites or by rendering them more susceptible to flooding.

Region-wide Challenges

Non-native plants colonize both terrestrial and wetland habitats. Such species can dominate or displace native vegetation and can occur in nearly single-species stands that present a lowered structural diversity and less desirable wildlife habitat. Both tidal low-salinity marshes and wetlands and littoral (shallow water) areas in ponds and impoundments can be densely covered in waterthyme (*Hydrilla verticillata*) or common reed (*Phragmites communis*). Dense colonies of these plants may restrict hydrological flows and capture sediment, thereby increasing the rate of eutrophication and contributing to low dissolved oxygen (DO) (McCann et al. 1996; Aulbach-Smith and deKozlowski 1996). Forested wetlands and coastal forests with damp (hydric or mesic) soils may be heavily populated with Chinese tallowtree (*Triadica sebiferum*), which quickly becomes established and out-competes more desirable native plants (J.W. McCord, SCDNR, pers. obs.). Feral non-native mammals, such as goats (*Capra hircus*) and pigs (*Sus scrofa*), inhabit Coastal Zone islands and marshlands. Goats can heavily browse vegetation, thereby reducing plant diversity, cover, and soil stability, while feral pigs can damage soils, marshes and impoundment dikes (J.W. McCord, SCDNR, pers. obs.). Non-native fishes like the Common Carp (*Cyprinus carpio*), the Flathead Catfish (*Pylodictis olivaris*), and the Blue Catfish (*Ictalurus furcatus*), may not directly impact habitats, but can alter ecosystem health through predation on or competition with native species. From marine and estuarine habitats, non-native species that are of concern as documented as invasive species (or have the potential to be) would include the Indo-Pacific Lionfish (*Pterois volitans/miles*), the swimbladder parasite of the American Eel (*Anguillicoloides crassus*), the Asian tiger shrimp (*Penaeus monodon*), and the green mussel (*Perna viridis*). Some examples of invasive freshwater invertebrates include the island apple snail and Florida apple snail (*Pomacea insularum* and *P. paludosa*, respectively), as well as the Asian clam (*Corbicula fluminea*).

Coastal development along the Grand Strand (Horry County) and barrier island beaches has reduced unique Coastal Zone habitats. A high percentage of the State's maritime forests, maritime grasslands, maritime shrub thickets, beach flats, and intertidal beaches have been negatively affected. Terrestrial habitats are physically removed to accommodate housing and other structures and natural and dynamic beach processes of erosion and accretion of sands have been altered to protect human structures and recreational interests. Hardened structures such as rocks, groins, and jetties prevent natural sand movements. Beach renourishment from sand pumped from offshore or estuarine sites is frequently therefore required to restore dune systems and beach flats. However, this often smothers marine invertebrates on the beaches, thus negatively impacting the system and its inhabitants in the short term (Peterson et al. 2000) and the long term (Jutte et al. 1999).

Beachfront habitats in South Carolina have likely been more negatively affected by anthropogenic activities than any other ecosystem. Furthermore, many priority species either presently rely, or once relied upon, such habitats. Human population growth and associated anthropogenic impacts are greater in or near the Coastal Zone than in any other ecoregion in the state.

According to the US Census Bureau, the human population within the seven counties (Horry, Georgetown, Charleston, Berkeley, Colleton, Beaufort and Jasper) that include or border portions of the Coastal Zone increased by 41.1% from 1980 to 2000; this area is predicted to undergo an additional 28.1% increase in human population from 2000 to 2020. Over the past decade, there has been a substantial increase in the proportion of the population that lives within watersheds that drain into South Carolina estuaries (Cofer-Shabica et al. 1999).

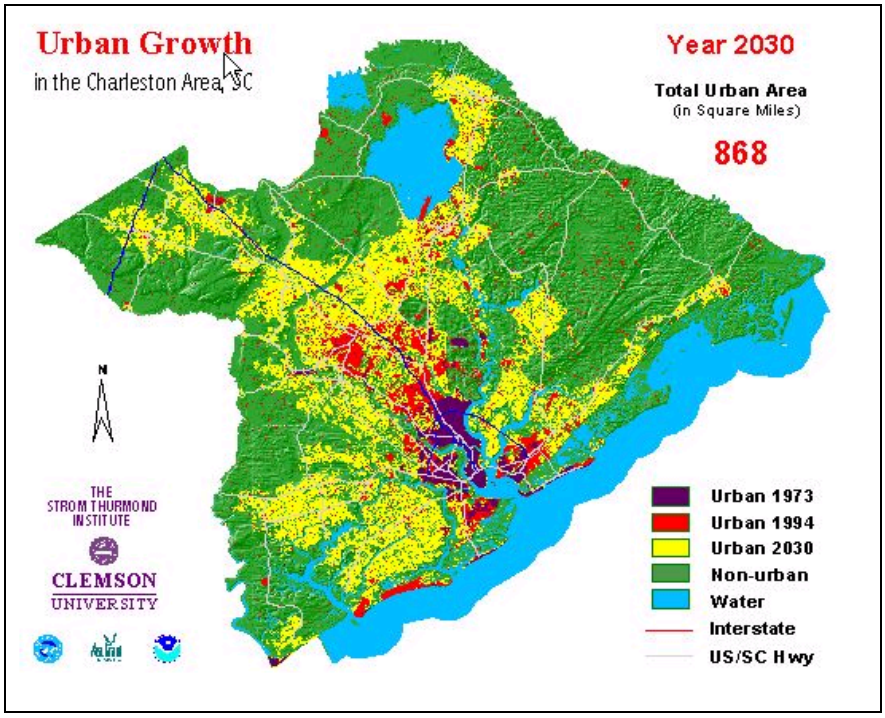

FIGURE 4-15: Projected urban land area changes for the Charleston area to the year 2030 (Allen and Lu 2000).

The urbanized area of Charleston increased by more than 400% from 1973 to 1994 and is expected to increase at a similar rate over the next several decades (Allen and Lu 2000). Figure 4-15 illustrates this scenario. Obvious impacts have been, and will continue to be, increased deforestation and forest fragmentation caused by increased residential, commercial and industrial development as well as expanded highway and other transportation corridors to support the increased population.

Both general point source and non-point source pollution also increase with population growth. Consumptive pressures relative to recreational uses of fishery resources will also accompany population growth, as will non-point source pollution specifically from watercraft and

disturbance of wildlife from increased human activity. The ultimate result is increased stress on natural habitats and natural resources within the Coastal Zone, as well as increased vulnerability of people, habitats, and fish and wildlife populations, to catastrophic events such as major hurricanes. Such predicted human population growth, and the associated impacts on wildlife and habitat, is added incentive to proactively plan for wildlife habitat conservation in the State's Coastal Zone.