

ASSESSING CHANGE
IN THE
EDISTO RIVER BASIN:
An Ecological Characterization

Edited by:

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South Carolina Water Resources Commission
Report No. 177
October 1993



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ACKNOWLEDGEMENTS

This study and the report were made possible through a grant from the National Oceanic and Atmospheric Administration, Washington, D.C.

The information provided in this report was derived from the research and knowledge of many people. In particular, the contribution of Dr. James G. Gosselink is acknowledged. His work and writing in recent years, with Dr. Lyndon Lee, led to the development of the methods and conceptual approach to this study. Dr. Gosselink provided essential guidance to the work group involved with this study, and he made extensive comments on the draft reports.

Staff members of the South Carolina Water Resources Commission, Resource Assessment and Planning Division, provided essential support. The Division Director, Anne Hale Miglarese, provided oversight and consistent encouragement toward development of this study and the published report. Catherine E. Vanden Houten contributed to the introduction and Basin description presented in the Introduction and Overview chapter, and she provided review and editing support for several drafts of this report. Jim Scurry, Floyd Stayner, and Jean Coombs provided the spatial-data analysis and map graphics from the Commission's geographic information system. Chris Page gathered, sorted, and developed an array of land use and wildlife information, assisted in the Natural Area Inventory work, and reformatted many of the map graphics. Cindy Brown provided review and comments on draft reports, and contributed to the Land Use and Biological Diversity chapters with a literature review used in the chapter discussions. Noel Hill helped develop some of the tables presented in the Biological Diversity chapter.

John White and Cindy Aulbach-Smith provided extensive comments on draft reports and contributed to the Biological Diversity chapter with the discussion of methods and results from the Natural Area Inventory. The Natural Area Inventory of the Edisto Basin was a cooperative project with The Nature Conservancy's Southeast Regional Office. Dorothy Allard administered the inventory on behalf of The Nature Conservancy.

Susan Moegenburg of the Department of Zoology, University of Florida, conducted the Breeding Bird Survey analysis and contributed to the methods, results, and discussion of this analysis as presented in the Biological Diversity chapter.

Individuals from other agencies and organizations made significant contributions to the study and to the report. Those who provided substantive comments and suggestions on draft reports and/or contributed to the meetings of the study work group were: Bob Somers of the South Carolina Land Resources Commission; John Cely, Fred Holland, Bert Pittman, and Kathy Boyle of the South Carolina Wildlife and Marine Resources Department; Steve Gilbert of the U.S. Fish and Wildlife Service; Bill Baughman, Joe Collins, and Bob Fletterman of Westvaco Timberlands Division; Jim Couch of the U.S. Environmental Protection Agency; Buddy Atkins, Danny Johnson, and Rod Cherry of the South Carolina Water Resources Commission; Lamar Sanders of the U.S. Geological Survey; and Dennis DeFrancesco of the U.S. Soil Conservation Service. Roy Newcome of the South Carolina Water Resources Commission and Beverly Miller and John White of Ecological Services in Urbana, Illinois provided technical editing on most of the report.

Cover artwork is provided courtesy of the New-York Historical Society, New York, New York. The work is titled Common Snipe (*Capella gallinago*), painted by John James Audubon while visiting South Carolina in 1832. The landscape presented with Audubon's Snipe was painted by George Lehman. The illustrations presented at the beginning of each chapter in the report were created by Gene Speer of Columbia, S.C. The typesetting and design for the report were done by Van Kornegay of Columbia, S.C.

*In the beginning God created the heavens and the earth.
And God saw all that he had made,
and behold, it was very good.*

ABSTRACT

This report is a description and evaluation of ecological conditions and historical changes in the Edisto River Basin with recommendations for improving natural resource management in the future. The methods used to assess ecological conditions emphasize a landscape-level approach to address the cumulative effects of human activities on natural processes. The first chapter explains the background and purpose of the study, describes the study area, summarizes study methods and results, and outlines optional goals and plans for resource management in the region. Chapters 2 through 5 assess land use and land cover, hydrology, water quality, and biological diversity in the Edisto River Basin and provide detailed discussions of methods, results, and conclusions.

The Edisto River Basin is a 3,120 square mile region (about 2 million acres) drained by a black-water river system located in the Coastal Plain of South Carolina. The Basin is primarily rural in character, but most of the residents are employed in manufacturing and service sectors of the economy. Compared to many other regions in the southeastern United States, the Edisto River Basin is in exceptional ecological condition.

The assessment of land use and land cover showed that currently the Basin is about 56 percent forested, and that total forest cover has remained relatively stable since 1950. One-third of the Basin's forest cover consists of pine plantations — monoculture forests that have rapidly expanded in recent decades. Most of the Basin's forests are closely interconnected and an irregular pattern of forested corridors extends throughout the landscape. However, most of the forests are relatively young and high-quality forest-interior habitats seem to be quite limited. The Basin's forest conditions are far from pristine, but remain favorable for supporting many indigenous wildlife species and good water quality. Most of the Basin's stream edges (riparian zones) are covered in native vegetation. These riparian conditions are favorable for providing important wildlife habitats, corridors for wildlife movement, and improved water quality that results from the filtration of sediments, nutrients, and other contaminants flowing into the streams.

From the hydrology assessment, analysis of precipitation and streamflow indicates that only minor changes in precipitation and streamflow have occurred in the Edisto River Basin and that changes in streamflow are a result of changes in precipitation. This finding indicates that the minor increases in streamflow did not result from land use changes involving forest and vegetative cover losses. Also, there have been no significant modifications to the Edisto River stream channels to alter the hydrology. The stable trends in hydrology for the Edisto are likely to be related to the predominately natural-cover conditions of the Basin's stream-edge habitats.

The analysis of historical water quality records indicates that, while certain areas of the Basin have problems, the Edisto Basin overall has very good water quality. Water quality, as characterized by total phosphorus concentration, is generally within the EPA criterion of 0.1 milligrams per liter total phosphorus and is being maintained throughout the Basin, with the exception of the North Fork Edisto River. The North Fork also showed frequent violations of state standards for fecal coliform bacteria in the headwaters. Analysis of total phosphorus, total suspended solids, and turbidity showed highly significant and negative relationships to stream discharge. This concurrent decrease in concentration of pollutants with an increase in stream volume (increased water volume resulting from rain and runoff) suggests a dilution phenomenon characteristic of undisturbed, forested watersheds.

Very little information exists to provide a significant understanding of how the abundance and diversity of native species has changed in the Edisto Basin. Breeding Bird Surveys were analyzed and showed that no species had plummeting populations or appeared threatened with local extinction; however, more species' populations are decreasing than increasing at four of the six Breeding Bird Survey routes analyzed. Two routes in particular are showing declines for 30 to 40 percent of the species over the last 20 years. These declines coincide with land cover changes of forest loss and forest conversion to pine monoculture along these routes. The large, wide-ranging mammals native to the Edisto River Basin — bears, cougars, and wolves — have been extirpated. However, medium-sized carnivores with smaller range requirements — such as bobcats and otters — remain, and most of the raptors in the Basin appear to have increasing or stable populations. Several nationally threatened and endangered species inhabit the Edisto River Basin, suggesting that certain areas serve as a refuge for sensitive or specialized species and that the Basin contains

relatively intact and uncontaminated habitats that are rare or unique in the nation. An inventory of natural areas revealed that the relatively undisturbed, high-quality natural communities that remain in the Basin are almost all wetlands, and most of these are found in the coastal region. Few natural areas and fewer kinds of natural communities are found in the more inland portions of the Basin.

Based on the findings of this study, a broad set of goals and planning objectives are suggested as an option for consideration in future planning efforts. The suggested goals and objectives are directed toward ecological protection and enhancement of the Edisto Basin through thoughtful conservation, use, and development of the Basin's natural resources. Basin-level (or landscape-level) planning is recommended and encouraged because it can provide a framework for guiding many decisions and activities that will continue to incrementally effect ecological conditions in the Edisto River Basin.

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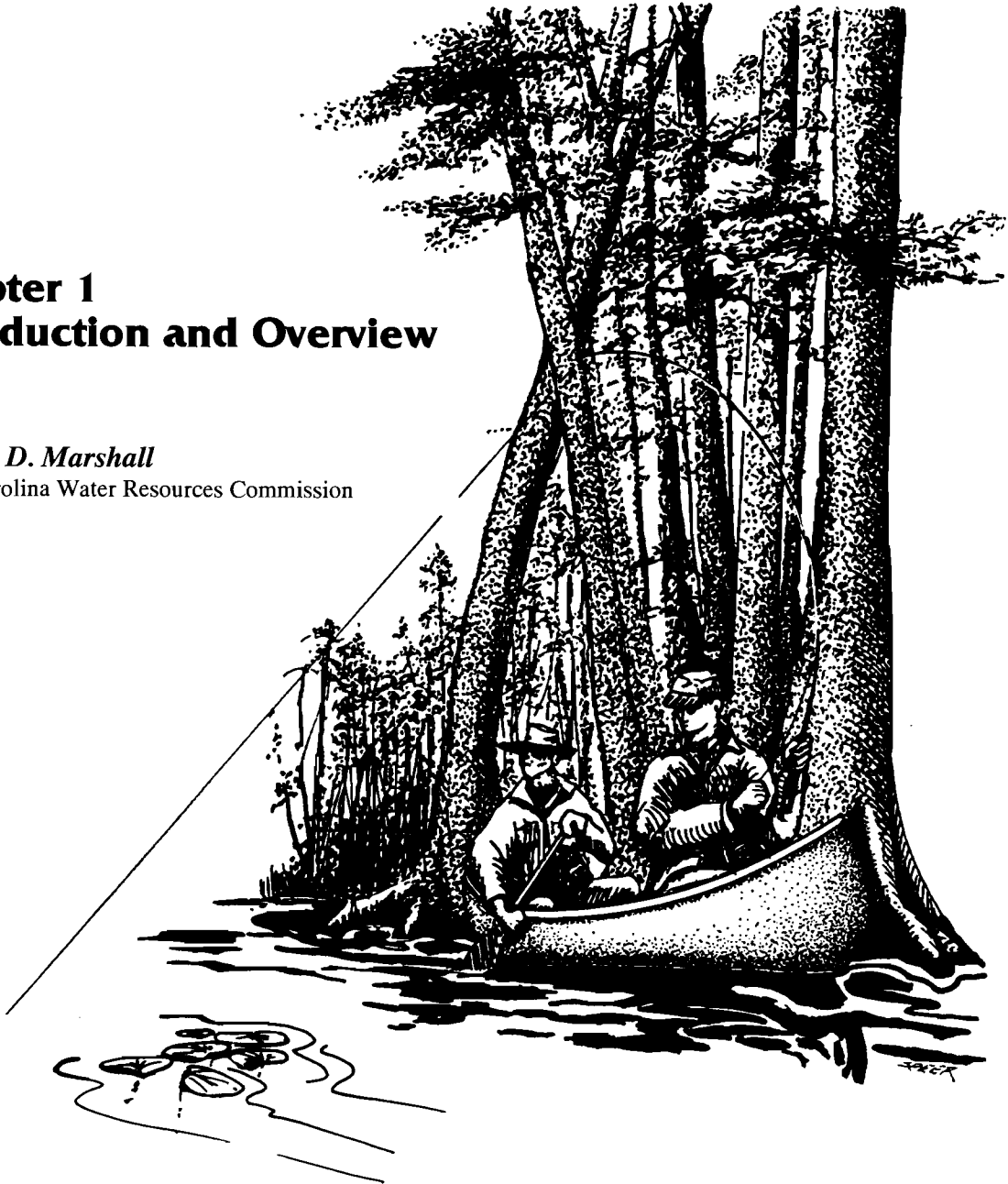
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Chapter 1 Introduction and Overview

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INTRODUCTION

The Edisto River Basin Ecological Characterization Study attempts to describe the overall ecological conditions of the Edisto River Basin. This study focuses on the land use patterns, water quality, hydrologic conditions, and biological diversity of the Basin, and addresses issues affecting environmental conservation on a regional level. Some of the most serious and difficult problems affecting our environment result from the cumulative effects, or impacts, of human activities on natural ecosystems. A description of some of the problems associated with cumulative impacts on the Edisto River Basin is provided in the report. In order to address the problems of cumulative impacts, this study applies principles of landscape ecology to planning issues that affect natural resources.

This chapter explains the background and purpose of the study, describes the study area, summarizes study methods and results, and outlines optional goals and plans for resource management. Detailed discussions of methods and results are found in subsequent chapters addressing land use, hydrology, water quality, and biological diversity in the Edisto River Basin.

Background and Context of the Study

The Ecological Characterization of the Edisto Basin is founded on the objectives of the Natural Resources Decision Support System (NRDSS) Project, conducted by the South Carolina Water Resources Commission (SCWRC). The NRDSS Project is a multiyear research and demonstration project begun in 1988 and funded by the National Oceanic and Atmospheric Administration (NOAA) and the State of South Carolina. This project was created in response to problems with the existing approach to environmental management in South Carolina — the problems of insufficient information about the resources and lack of consensus on how they should be managed. The following objectives, mutually agreed to by SCWRC and NOAA, guide the NRDSS Project:

- Develop a geographic information system for natural resource management applications in the Edisto River Basin of South Carolina; and
- Develop public policy procedures to identify the public interests in natural resources, classify and prioritize natural resources by value, and formulate alternative approaches to environmental management and regulation.

On the basis of the second of these objectives, SCWRC is developing a public policy process aimed at natural resources management on a basin-wide scale — the Edisto Basin Natural Resource Assessment Process. In short, the Natural Resource Assessment Process will provide the citizens of the Edisto Basin with the opportunity to consider what natural resources they have and how they can best use and conserve those resources. The process will incorporate the following:

- Baseline studies of ecology (this study), socioeconomics, and public opinion;
- Classification of resources into categories of use and relative value by various committees of resource experts; and
- Recommendation of priorities for resource management by a regionally representative Edisto Basin Task Force.

The information and recommendations derived from this Ecological Characterization will be provided to participants in the Natural Resource Assessment Process. This information, along with information from the other baseline studies, will provide participants in the process with a deeper understanding of the problems and issues facing the Basin and enable them to reach greater consensus on goals for the future of the Basin and its resources.



The Problem of Cumulative Impacts on Natural Resources

Cumulative impacts are the combined effects of individually minor actions and changes on the environment. They are the total effect on the environment of small-scale, incremental activities that individually seem insignificant. Cumulative impacts are often the product of complex physical, chemical, and biological interactions that have synergistic results. Cumulative impacts can have positive or negative effects. Positive effects can be seen as improvements in environmental quality resulting from a host of individually minor improvements such as sound land management practices and pollution control technologies applied and adhered to by individual landowners. Negative effects can be seen as a relatively slow deterioration of environmental quality from a host of seemingly minor assaults on air, water, land, and biological resources.

An example of a cumulative impact can be seen in the eventual degradation of a city's air quality through the output of exhaust fumes from numerous automobiles. When viewed individually, each automobile poses no significant threat to the overall condition of the city's air, however, thousands of automobiles, with engines running simultaneously, can threaten air quality. Another example is evident in the deterioration of river water quality through the interaction of runoff from urban pavements, agricultural fields, and cleared land, combined with the depletion of naturally forested flood plains. While each of these activities has some immediate impact on the environment, they also have a combined effect that can seriously threaten the ecological condition of the river corridor. Furthermore, the effects are felt on a large scale rather than simply where each activity is taking place (in other words, the activities affect the conditions downstream as well).

Contributing Factors

Cumulative impacts can be widespread and very difficult to deal with, thus posing one of the most serious threats to our natural resources and the overall quality of the environment. There are several reasons for this.

First, cumulative impacts may be viewed as "social traps," situations in which the short-run, small-scale incentives of an activity are not consistent with the long-term, overall best interest of individuals and society (Costanza 1987). For example, the individual actions that make up cumulative impacts are driven by relatively short-term profit motives of private landowners (for example, forest clearing for row crop production). Over an entire river basin, the landscape is divided into thousands of parcels of land where each individual private owner follows his or her own distinct land management objectives. Individually, these activities usually have minimal environmental costs directly associated with them. However, the combined long-term environmental cost of all such actions may be high and these costs accrue to the public, not to the landowner. As a result, cumulative impacts are easily created, yet not easily avoided.

Secondly, lack of comprehensive planning contributes to the prevalence of cumulative impacts and the difficulty in dealing with them. Comprehensive planning has several characteristics: a) considering the widest number of factors related to an issue, b) addressing long periods of time, c) including all affected regions and parties, and d) increasing the level of consensus on goals and objectives that balance and optimize environmental conservation and socioeconomic development. Comprehensive planning has the effect of proactively addressing problems and setting limits to certain activities, thus controlling cumulative impacts. In South Carolina, however, as in many other states, true comprehensive planning is virtually nonexistent. Instead, decisions affecting the natural resources of our state are made largely in an incremental, piecemeal approach, with little consideration of larger and long-term issues. Thus, South Carolina, like all other states, is confronted with the difficult problem of cumulative impacts. Regulatory programs alone do not effectively address the problem because they typically are not linked to comprehensive planning. The federal program that permits development in wetlands is an example of a reactive, rather than proactive, regulatory system that is not able to effectively deal with cumulative impacts. The common occurrence is that permitting development at one site today sets a strong precedent for permitting development at similar sites everywhere tomorrow; thus cumulative impacts continue despite regulatory programs.



A third factor that significantly contributes to widespread cumulative impacts and the difficulties associated with them is fragmented decision making. When authority for decisions affecting natural resources is divided among numerous entities without coordination, the problem of cumulative impacts is even more difficult to manage. Governmental responsibility for natural resources management is divided among numerous agencies and programs, each with its own specific mission. The result of this political and organizational structure is that individual agencies make policy decisions on individual environmental issues without the necessary consideration of “the big picture.”

Managing Cumulative Impacts

Despite the complex nature of cumulative impacts, which the preceding discussion illustrates, they can be successfully managed. However, it must first be understood that the problem of cumulative impacts is actually a two-pronged problem — a problem of both science and public policy. Thus, any effective solution must necessarily address both the scientific and the public management facets of cumulative impacts.

Science

On the scientific side of the issue, it is necessary to have appropriate methods, standards, and information in order to assess cumulative impacts. The assessment of cumulative impacts requires a refocusing from site-specific ecological analyses to broad analyses of the landscape. Such an assessment should look beyond the limited organizational or political jurisdictions of the associated agencies and encompass a larger ecologically defined landscape. Furthermore, the focus of analysis should be on the broad spectrum of natural resources within the region, not merely a select few. A solid basis for such an assessment is provided by landscape ecology, which is dealt with in greater detail later in this report.

Public Policy

On the policy side of the issue, successful management of cumulative impacts requires a new public policy approach. First, there needs to be more coordination in developing environmental policy among the various entities responsible for environmental management. Coordination of policy would help counteract the fragmented, piecemeal approach to environmental decision-making that contributes to the prevalence of cumulative impacts. Second, goals for managing natural resources must be established through meaningful input from the public. The goals should be as specific as possible and represent the public's interests and aspirations for the area of concern. As one author points out, many valid social and economic needs must be considered in addition to scientific facts in assessing the tradeoffs that exist among competing resource uses and environmental management goals (Stahkiv 1988). Goals for the protection and enhancement of the environment are in the public's interest, but such goals must be grounded in the realities of relevant ecological and socioeconomic tradeoffs and they should be made to conform with the ecological capabilities of the region.

Finally, specific plans must be made to ensure the successful implementation of the goals decided upon. These plans should reflect a thorough consideration of the ecological assessment of the area and the public goals set in the public policy process. The plans should be as comprehensive as possible and practical. Public education, landowner incentives, and coordination of existing regulatory activities are several areas that could be affected by planning efforts. Successful implementation will require ongoing public support and advocacy among the citizens of the affected region.

Landscape Ecology and Natural Resources Conservation

As mentioned above, landscape ecology provides a conceptual approach to the ecological assessment of a region and the analysis of the cumulative impacts. It is therefore helpful to take a closer look at the principles of this discipline.

Landscape ecology is defined as the study of physical and biological relationships that govern the different spatial units of a region (Gosselink and others 1990). More simply put, landscape ecology deals with large areas, the interaction of parts within these areas, the landscape



patterns of the areas, and how the patterns influences ecological processes. From a landscape ecology perspective, the cumulative effects of development activities are evaluated by examining changes in both ecological structure and functional ecological processes in a particular landscape unit. While a general landscape ecological approach is helpful in assessing cumulative impacts, a related theory — island biogeography — provides further insight into the ecology of a region.

Island biogeography concerns itself with the size, shape, and pattern of various parts (or patches) of the landscape, their isolation from each other, and the influence of these factors on ecological processes and natural diversity (Gosselink and others 1990). This particular theory is frequently applied in planning nature reserves; however, it also has useful applications in overall environmental planning and management. Diamond (1975) presented five principles from island biogeography that apply to natural reserves in a forested landscape: 1) species richness increases with forest area; 2) for a given total forest area, one large reserve will support more native interior species than two or more smaller ones; 3) for a given forest area, separate but nearby patches will support more species than patches farther apart; 4) blocks of forest connected by strips of protected habitat are preferable to isolated patches of forest; and 5) other things being equal, a circular-shaped reserve is preferable to a linear one because the former maximizes dispersal distances within the reserve and minimizes the edge relative to the interior area.

In summary, landscape ecology provides principles that can serve as a means for diagnosing the ecological health and conditions of a landscape unit. The focus of landscape ecology is on large areas, the patterns and interaction of parts within the areas, and the effects of these patterns on natural processes and biological diversity. Because of its focus on large areas, landscape ecology usually incorporates humans and human activities. Landscape ecology is therefore an applied science that deals with the natural world within which man is one actor (Forman and Gordon 1986). The effect of landscape ecology on resource management is that it broadens the perspective to a holistic one in which resources such as forests, wetlands, agricultural lands, wildlife, water, and human development are not viewed each in isolation but rather as a whole.

Terminology

In this study, the term *landscape structure* refers to the shape, pattern, and natural quality of the forests and other native vegetation as they are related to the mix of human development and land uses in the region. These factors can greatly affect the water quality, hydrology, and wildlife populations of a region like the Edisto River Basin. The terms *natural processes* and *ecological processes* (or *functions*) as they are used in this study, refer primarily to the movement of energy and support of diversity through food chains within the natural plant and animal communities; maintenance of the full array of native species, each with particular habitat requirements; movement and processing of chemicals from the land into the region's streams; and stability (that is, normal seasonal fluctuations in streamflow) and storage of flowing water as it relates to flood control and maintaining a continuous source of water in the streams.

PURPOSE OF THE STUDY

Goals

The goals of the Edisto River Basin Ecological Characterization are as follows:

- Establish a baseline description of the relative ecological conditions and historic changes in the Basin by: a) describing the existing and historical landscape structure (land use and land cover) of the Basin; b) describing the ecological processes (functions) of the Basin, specifically regarding hydrology, water quality, and biota; and c) describing the relationship between the structural and functional elements of the Basin.
- Evaluate ecological conditions relative to human values and identify potential problems affecting ecological structure and function in the Basin.
- Make recommendations for improved natural resources management to include suggested goals and an implementation plan.



Methodology

The methods of the Edisto River Basin Ecological Characterization are adapted from two sources:

- The manual of a training course offered by the U.S. Environmental Protection Agency's Office of Wetland Protection, titled *Cumulative Impact Assessment in Southeastern Wetland Ecosystems: The Pearl River*, and
- James Gosselink and Lyndon Lee's 1989 article, "Cumulative Impact Assessment in Bottomland Hardwood Forests" in *Wetlands*, Vol. 9, Special Issue.

This study takes a relatively new scientific approach and applies principles of landscape ecology to evaluate available information for hydrology, water quality, indigenous animal populations, and landscape structure (or patterns of land use and land cover). Useful types of information include long-term data sets, repeated survey data, and indicators of landscape ecological conditions. The methods are designed to assess watersheds of about 1 to 2 million hectares in size. The Edisto Basin is a 3,120-square-mile area (800,000 hectares).

As discussed previously, landscape ecology focuses on large areas, the patterns and interactions of parts within the areas, and the effects of these on natural processes and biological diversity. Applying landscape ecology to natural resource management broadens the perspective to large areas and incorporates a comprehensive approach.

Application

Human medical science provides a useful analogy that helps explain the purpose of this study and helps us understand its application. Various indicators of ecological integrity are addressed in this report that point to overall ecosystem health in the same way that pulse and body temperature point to the health of a human patient (Gosselink and Lee 1989). The purpose of this study is to assess the ecosystem health of the Edisto River Basin. The diagnostic procedures used to characterize the Basin's condition focus on changes in landscape structure and changes in ecological processes. Landscape structure refers to patterns of land use and land cover; ecological processes relate to water quality trends, changes in hydrology, and changes in populations of indigenous animals. Where information is available (for example, water quality), the ecological indicators are related to standards in the same way that human body temperature is judged by its relationship to "normal." Trends or changes, in water quality for example, are a means of judging incremental deterioration or improvement of the ecosystem. Analyses of this information are used to provide a baseline description of the relative ecological conditions of the Basin, changes that have occurred, and activities affecting those changes.

The information resulting from this study must be applied to solving problems in a new way — using a new public policy approach. To this end, the information from this study will be provided to a regionally representative Edisto Basin task force charged with developing a vision for the use and conservation of natural resources while considering economic development needs of the region. To accomplish this, an open public process is proposed to enable citizens to define the vision by identifying resource values, common goals, and priorities and to target the goals with strategies for action. The process is referred to as the Edisto Basin Natural Resource Assessment Process.

Humans need to understand their overall health conditions in order to make reasonable choices that will lead to the maintenance and improvement of their health. Likewise, the conditions of an ecosystem should be understood in order to make similar choices affecting ecological health. The point is that choices — choices made by individuals and whole communities — are what will affect a region's ecological health and quality of life. Insuring the future ecological health of an ecosystem that is coming under increasing pressures, such as the Edisto Basin, calls for some form of regionwide planning, and planning requires the establishment of publicly accepted goals and objectives.

When goals that specify desired future conditions become understood and established, then courses of action can be identified and selected to achieve those goals. In medical terms, a prescription or treatment plan is developed and adhered to by the patient. Similarly,



plans for directing the Edisto Basin's health toward desirable ecological conditions must be developed and adhered to by people and institutions that affect it.

DESCRIPTION OF THE EDISTO RIVER BASIN

Location and Size

The Edisto River Basin is located in south-central South Carolina. From its western extreme in eastern Edgefield County, the Basin extends southeastward across the Coastal Plain to the Atlantic Ocean. The Edisto River Basin is a drainage area of about 3,120 square miles (roughly 2 million acres or 800,000 hectares). The region occupies approximately one-tenth of the area of South Carolina. (See Figure 1-1 for a general location map.)

The Basin is approximately 130 miles long from Edgefield County to the ocean. The width of the Basin ranges from an approximately 30-mile-wide corridor, common for most of the upper portions, to an 8-mile-wide bottle-neck below Givhans Ferry, then to a 10- to 24-mile-wide estuarine region at the coast. Portions of 12 counties are encompassed by the Basin. These counties are: Edgefield, Saluda, Lexington, Aiken, Barnwell, Bamberg, Orangeburg, Calhoun, Dorchester, Berkeley, Charleston, and Colleton.

The approximately 250 unobstructed river miles from the Atlantic Ocean to the headwaters in Edgefield County have distinguished the Edisto as one of the longest free-flowing blackwater rivers in the United States. Much of the Edisto River and its tributaries is associated with extensive wetland areas. The Edisto River Basin is drained by four major river systems: the South Fork Edisto River, North Fork Edisto River, Edisto River (main stem) and Four Hole Swamp.

Subbasins

The North and South Forks originate in the Upper Coastal Plain, primarily in the Sandhills regions of Edgefield, Saluda, and Lexington Counties. The North and South Forks drain two subbasins of 750 and 870 square miles, respectively. These subbasins span approximately 70-75 miles and then join to form the main stem of the Edisto River. The headwaters of Four Hole Swamp subbasin originate in the Coastal Plain in Calhoun and Orangeburg Counties and drain about 650 square miles. The Four Hole Swamp system spans approximately 50 miles before it discharges into the main stem of the Edisto River. The Edisto River (main stem) eventually receives all the drainage from the North and South Forks and Four Hole Swamp. In addition, the main stem receives drainage from its own subbasin area of about 850 square miles. The main stem extends approximately 65 miles from the confluence of the North and South Forks to the Atlantic Ocean. At the coast, the Edisto River is divided by Edisto Island to form the North and South Edisto Rivers with two distinct estuaries. Most of the freshwater flow is to the south side of Edisto Island. These tidally influenced brackish streams also receive drainage from bordering salt marshes, tidal rivers, and tidal creeks. The coastal/estuarine portion of the main stem drainage is about 200 square miles.

Climate and Weather

The Edisto Basin has a mild climate with plentiful rainfall. The region's low latitudinal location coupled with its close proximity to Gulf Stream waters provides for a climate dominated by warm, moist air masses from the south. The Appalachian Mountains to the north and west of South Carolina help to shield the Basin from cold air masses of the northwest.

The average annual temperature ranges from 61° to 66° F and the average relative humidity is 50 to 55 percent in mid-afternoon and about 90 percent at dawn. The summers are hot and humid, with an average temperature of 79° F and daily maximum temperatures of 89 to 90° F. The winters are cool, with an average temperature of 48° F and an average daily minimum of about 36° F. The average annual rainfall for the Basin ranges from 42 to 52 inches. The highest precipitation occurs in Charleston, Dorchester, and Colleton Counties, about 20 miles inland from the coast, due to the upward flow of moist air moving inland from the ocean on hot summer days. Generally, during the months of spring, the Basin receives its maximum rate of rainfall. During the autumn months, September through November, rainfall is at a minimum.



THE EDISTO RIVER BASIN

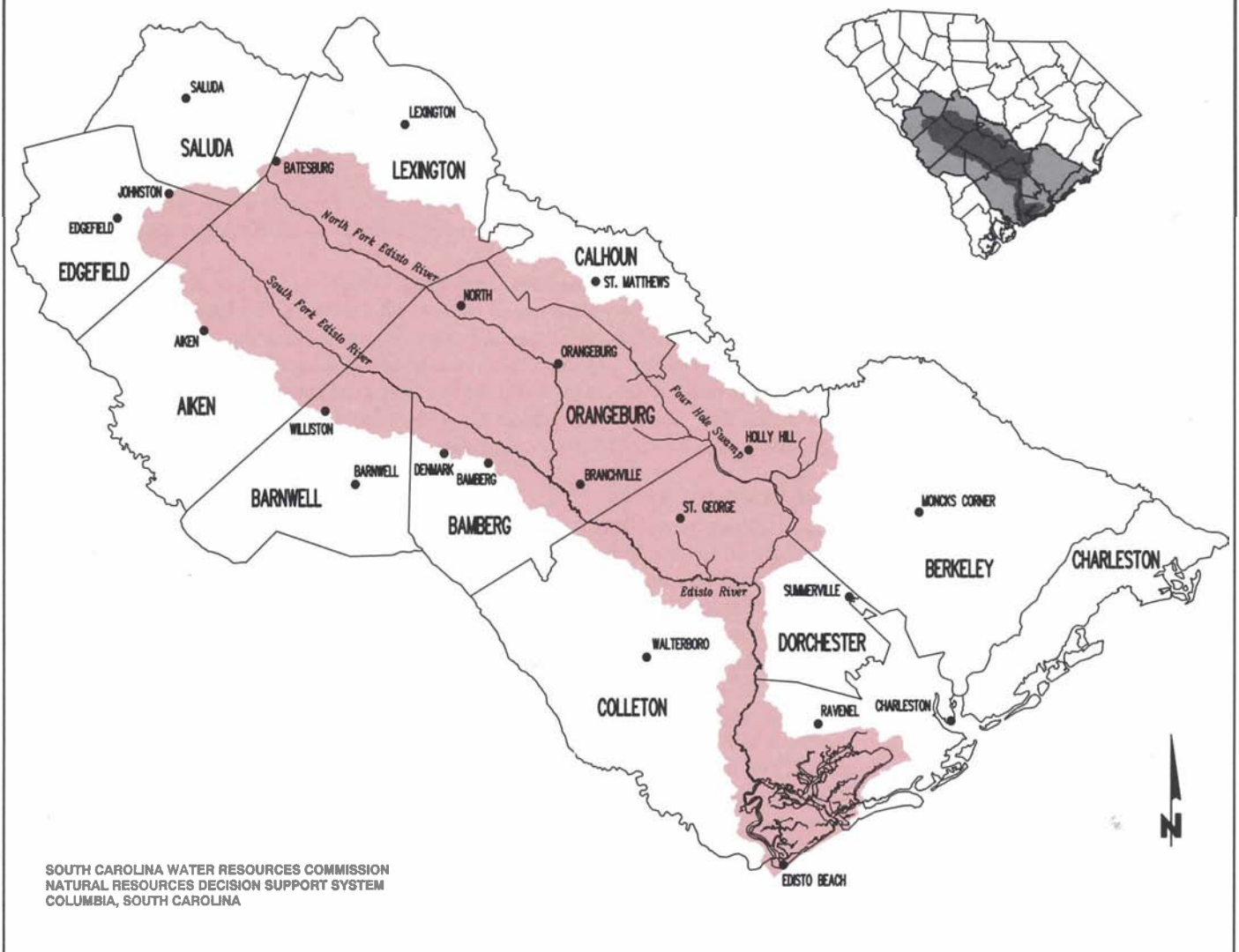


Figure 1-1. General locational map for the Edisto River Basin.



Extreme weather is usually in the form of violent thunderstorms, tropical storms, and hurricanes, as well as occasional droughts. Snowfall may occur once or twice a year in the upper portions of the Basin, but rarely near the coast. Thunderstorms are common in the summer months. The violent storms, however, usually accompany cold fronts in the spring and are characterized by lightning, hail, high winds, and sometimes tornadoes. Hurricanes and tropical storms from the Atlantic periodically cross the Basin or pass near it during the summer and early fall. They bring several days of heavy and sustained rainfall, as well as destructive winds and coastal flooding. Historically, severe droughts occur about once every 15 years in South Carolina. Less severe and less widespread droughts occur about once every 7 years (SCWRC 1983).

Landforms, Geology, Soils, and Vegetation

The Edisto Basin is underlain by the unconsolidated and consolidated sedimentary formations of the Coastal Plain. The Coastal Plain is divided into three physiographic regions, the Upper, Middle, and Lower Coastal Plain. These regions are differentiated by topographic and geomorphic features formed over millions of years when ocean levels were much higher than at present.

Beginning at the Fall Line, the Upper Coastal Plain extends southeast to a steep slope known as the Citronelle Escarpment. This ancient sand dune region includes the Carolina Sand Hills and is characterized by moderately sloped, irregularly shaped, and generally rounded terrain. The Middle Coastal Plain lies between the Sand Hills and another steep slope known as the Surry Escarpment. The Lower Coastal Plain lies between the Surry Escarpment and the Atlantic coastline. These latter two physiographic regions exhibit moderate to low relief and are marked by several terraces, each of which represents a former sea level.

Underlying the sedimentary formations of the Coastal Plain are metamorphic and igneous rocks similar in type and age to those of the Piedmont and Blue Ridge provinces of South Carolina. This basement rock has an irregular surface that dips to the south and southeast. The Coastal Plain formations consist of sediments of alluvial and marine origin that thicken from a few feet at the Fall Line to nearly 4,000 feet at Edisto Island. The Coastal Plain formations beneath the Edisto Basin include significant aquifer systems of the Middendorf, Black Creek, Tertiary limestone, and Tertiary sand formations.

Land Resource Areas

The Soil Conservation Service has divided the state of South Carolina into six land resource areas based on soil conditions, climate, and land use (U.S. Department of Agriculture 1978). These land resource areas are similar to physiographic provinces, but are based primarily on soil characteristics that provide a basis for describing potential vegetation and land uses. The Edisto Basin encompasses four of the six land resource areas: the Carolina-Georgia Sandhills, the Southern Coastal Plain, the Atlantic Coast Flatwoods, and the Tidewater Area (Figure 1-2). The two land resource areas outside of the Edisto Basin include the Blue Ridge Mountains and Southern Piedmont.

Carolina-Georgia Sandhills: This is an area of gently sloping to strongly sloping uplands that is synonymous with the Upper Coastal Plain physiographic province. Elevations range from about 250 to 450 feet with local relief in tens of feet. About two-thirds of the area is forested, predominantly pine with some upland and bottomland hardwood forest types. The remainder of the area is in cropland or pasture. The soils are mostly well drained and formed in sandy Coastal Plain sediments.

Southern Coastal Plain: This area generally corresponds to the Middle Coastal Plain physiographic province. The area has gentle slopes with increased dissection and moderate slopes in the northwestern part. Elevations range from about 100 to 450 feet with local relief in tens of feet. Generally, about half of this region is forested, a mix of mostly pine with upland and bottomland hardwood forest types. The other half of the area is mostly cropland. The soils are predominantly well drained or moderately well drained and formed in loamy or clayey Coastal Plain sediments.

Atlantic Coast Flatwoods: This is an area where a majority of the land surface is nearly level and is dissected by many broad, shallow valleys with meandering stream channels. Elevations range from about 25 to 125 feet with local relief of a few feet to about



EDISTO RIVER BASIN MAJOR LAND RESOURCE AREAS

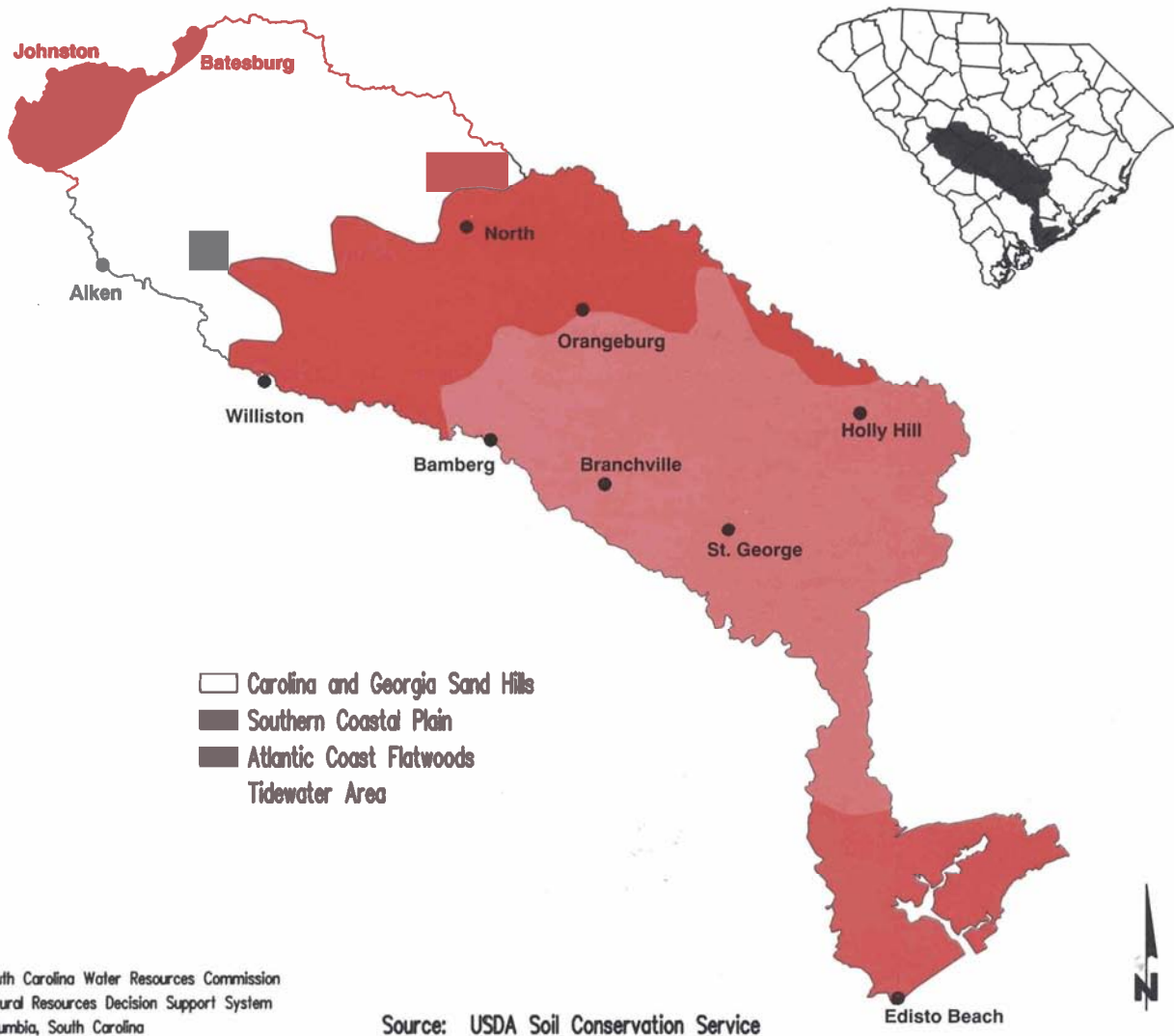


Figure 1-2. Map of the Major Land Resource Areas of the Edisto River Basin.

Land Resource Areas compared to Physiographic Provinces: Carolina-Georgia Sandhills is similar to Upper Coastal Plain; Southern Coastal Plain is similar to Middle Coastal Plain; and Atlantic Coast Flatwoods combined with the Tidewater Area are similar to the Lower Coastal Plain physiographic province.



20 feet. About one-half of the area is forested primarily with pine and bottomland hardwood forest types. The remainder of the area is predominantly cropland. The soils are moderately well drained to poorly drained and formed in sandy to clayey Coastal Plain sediments.

Tidewater Area: This area is nearly level and is dissected by many broad, shallow valleys with meandering stream channels. Most of the valleys terminate in estuaries along the coast. Elevations range from sea level to about 25 feet, and local relief is usually less than 5 feet. About two-thirds of the area is forested primarily with pine and bottomland hardwood forest types. The remainder of the area is marsh, pasture, or cropland. The soils are predominantly somewhat poorly drained to very poorly drained and formed in sandy to clayey Coastal Plain sediments.

The Atlantic Coast Flatwoods and the Tidewater Area are land resource areas that, together, generally define the Lower Coastal Plain physiographic province.

Natural Communities

The Edisto Basin supports approximately 94 natural ecological communities (not including aquatic communities). These include 21 terrestrial communities, 57 palustrine communities, and 16 estuarine communities. These communities are associated with the wet soils of the swamps and riverine bottomlands, the porous soils of the upland sandhills and coastal plain, and the mix of well drained to poorly drained soils of the coastal flatwoods. The lower flatwoods and the tidewater areas contain the most diverse assemblage of natural communities —including those typically associated with broad floodplain swamps, barrier islands, marsh islands, and major estuarine rivers. Natural communities of the Edisto Basin are addressed in greater detail in the biological diversity chapter (Chapter 5).

People and Economy

Population, education, employment, and income data were not available for the river basin alone; therefore, a socioeconomic description of the Edisto Basin is based on data from selected counties that compose a major portion of the region. These include Aiken, Bamberg, Calhoun, Colleton, Dorchester, Edgefield, Lexington, and Orangeburg Counties. Three major metropolitan areas are located just outside the Basin boundaries in Aiken, Dorchester, and Lexington Counties. Data from these metropolitan counties can skew the figures used to represent the whole Basin; however, the close proximity of the metropolitan areas has significant economic and environmental effects on the Basin. More information on socioeconomics than can be presented here is provided by a 1992 report entitled *The Economy of the Edisto River Basin* (SCWRC 1992).

Character and Population of the Study Area

The Edisto River Basin is primarily rural in character. The major economic use of land in the region is forestry related, and the secondmost is for agricultural purposes. Over the past 30 years, the percentage of forest land has decreased only slightly, while the percentage of land used for farming has declined sharply. This decline in farm land has been accompanied by an even sharper decline in the number of farms and by an increase in the average size of farms.

Of the state's nearly 3.5 million residents in 1990, about 8.5 percent (roughly 300,000 people) lived in this study area. Since 1960, the average annual rate of population growth in the region has been above that of the state as a whole. This population growth has been accompanied by an increase in total housing units at a rate above the state average. Despite this rapid population growth the region remains sparsely populated compared with the rest of the State. For example, the average population density of the state was 119 people per square mile, while the population density of the Edisto Basin counties averaged 94. These figures, however, do not tell the whole story. It is important to recognize that the metropolitan areas of Lexington, Dorchester, and Aiken Counties — with population densities of 255, 144, and 111 people per square mile, respectively — give us a skewed picture of the river basin. Thus, it is useful to look at the population densities of the remaining five counties: Orangeburg with 77 people per square mile and Bamberg, Edgefield, Calhoun, and Colleton with population densities ranging from 33 to 42 people per square mile. The racial composition of the region in 1990 was nearly identical to that of the state as a whole — the



ratio of whites to non-whites was approximately 7 to 3. It should be noted, however, that the regional (12 counties) average masks the significant diversity that exists among the counties.

Education

Educational attainment level varies among the Edisto Basin counties, but it is generally below the state average. In 1990, the Basin counties with the highest percentage of population with at least a high school diploma were Lexington, Dorchester, and Aiken — each with over 70 percent of the population having graduated from high school. In the more rural areas of Orangeburg, Bamberg, Calhoun, Colleton, and Edgefield Counties, these figures ranged from a low of 59 percent in Bamberg to a high of about 62 percent in Orangeburg and Edgefield. While these five counties have experienced increased levels of educational attainment since 1960, largely consistent with the overall statewide trend, they remained below the statewide average of 68 percent in 1990.

Employment and Income

More than 95 percent of the working population of the Edisto region is employed in nonagricultural jobs. Manufacturing has employed the greatest portion of the population since 1970, but there has been a substantial shift from the manufacturing sector to the trade and service sectors since that time. In the period between 1970 and 1990, nonagricultural employment grew at a faster pace in the Edisto Basin region than in the state as a whole.

Since 1950, the number of farms and the extent of farmland has steadily decreased and agricultural employment has decreased as well. Farming employment in the Basin area decreased by about 63 percent between 1960 and 1980 — a decrease from about 16,000 to 6,000 people. This was a faster rate of decrease than in the state as a whole. While forestry employment data are sketchy, it has been estimated that in 1980 and 1990, approximately 740 and 850 people, respectively — less than 1 percent of the Basin's population — worked for the timber industry in the Edisto Basin.

Unemployment rates in the Edisto Basin vary among the counties. In 1990, unemployment ranged from a low of about 3 percent in Dorchester County to a high of 8 percent in Bamberg County.

Between 1970 and 1989, both total personal income and per capita income grew faster in the Edisto region than it did in the state as a whole or in the state's metropolitan areas. Despite this faster growth in income, in 1989 most of the counties of the Edisto still had a lower per capita income and a larger portion of their population living below the poverty level than the state as a whole or the metropolitan areas.

Statewide, about 15 percent of the population was below the poverty level in 1989. The percentage of the Edisto Basin population living below the poverty level in 1989 ranged from approximately 8 percent in Lexington County to 28 percent for Bamberg County. Only in Lexington, Aiken, and Dorchester Counties were the residents better off than the state average in terms of economic status.

Farm income and farm-related income constituted a mere 1.6 percent of the region's total personal income in 1989. Thus, while agriculture remains an important activity for many communities and families throughout the region, the agricultural income and employment figures indicate that the farm sector's contribution to the region's economy as a whole is relatively small.

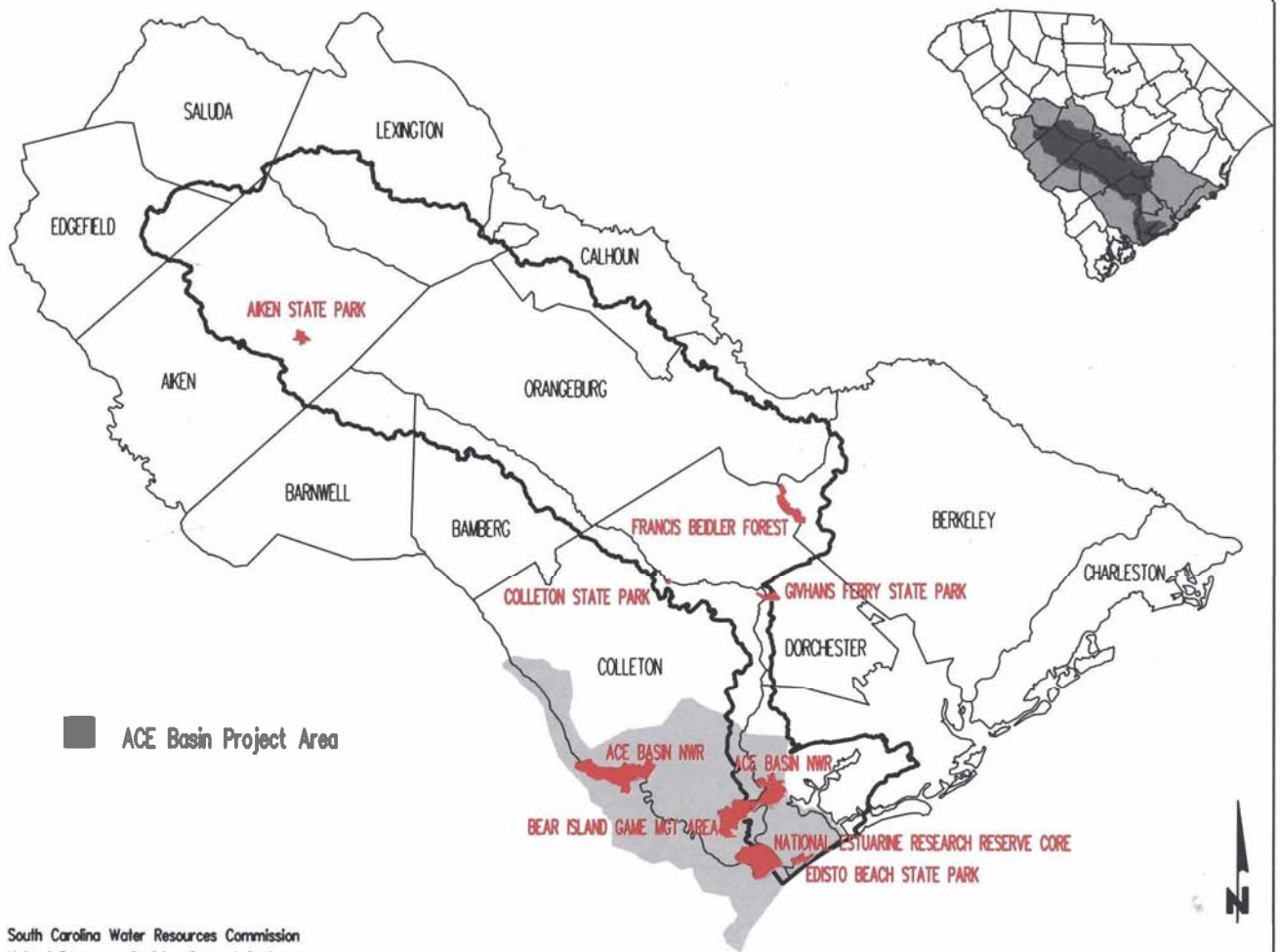
In 1989, the total cash receipts for natural resources-based products in the counties of the Edisto Basin were divided nearly equally among livestock and livestock products (36.7 percent), crops (32.5 percent), and timber and forest products (30.8 percent). Since 1980, the Edisto Basin region has accounted for more than 20 percent of the state's total cash receipts from timber and forest products.

Protected Areas

The Edisto River Basin contains a variety of protected lands. Areas under official protection as state or federal parks and wildlife refuges occupy less than 4 percent of the Basin's total area. Figure 1-3 is a map that shows the location of protected lands and land conservation projects. Much of the ACE Basin Project Area shown in Figure 1-3 lies outside of the Edisto River Basin and is therefore not included in the 4 percent figure mentioned above.



EDISTO RIVER BASIN PROTECTED AREAS



South Carolina Water Resources Commission
Natural Resources Decision Support System
Columbia, South Carolina

Figure 1-3. Location of protected areas in the Edisto River Basin.



The ACE Basin, the coastal drainage area of the Ashepoo, Combahee, and Edisto Rivers, is a region with an exceptional diversity of habitats. These include relatively pristine estuaries with extensive marshlands; forestlands with maritime, bottomland hardwood, cypress-tupelo, and pine flatwood natural communities; and an extensive system of managed estuarine impoundments. The area has been identified as one of the highest priority regions for protection under the North American Waterfowl Management Plan. It is virtually unpolluted and has an isolated, undeveloped character. These characteristics add considerably to the ecological significance and uniqueness of this coastal region. The ACE Basin has been classified as a nationally significant wildlife ecosystem by the U.S. Fish and Wildlife Service and was listed in *Significant Wildlife Resource Areas of South Carolina* 1981. The exceptional characteristics of this region have resulted in the focus of major national conservation efforts.

The ACE Basin Project is a conservation effort aimed at a contiguous 350,000-acre area in portions of four adjacent counties. The ACE Basin Project is a cooperative land conservation effort involving private land owners, U.S. Fish and Wildlife Service, South Carolina Wildlife and Marine Resources Department, Ducks Unlimited Foundation, and The Nature Conservancy. These groups are working to protect important habitats in the ACE Basin through land acquisition and conservation easements on many of the large tracts of land in the area. The U.S. Fish and Wildlife Service is working with the other cooperators to establish an 18,000-acre ACE Basin National Wildlife Refuge in the heart of the ACE Basin (USFWS 1990).

Within the Edisto River drainage area, state and federally protected lands which are now part of the ACE Basin conservation efforts include the State's 12,000-acre Bear Island Wildlife Management Area as well as Edisto Beach State Park and the 1,955-acre Grove Plantation, now part of the National Wildlife Refuge. In addition, 9,475 acres of conservation easements have been secured along the South Edisto at Hope Plantation (5,232 acres), Willtown Bluff Plantation (993 acres), and Pon Pon Plantation (3,250 acres). Other lands adjacent to the South Edisto River proposed for protection under ACE Basin efforts include Otter, Pine, and Jehossee Islands (slightly more than 10,000 acres, collectively).

Within the ACE Basin Project area, a 144,000-acre portion of the estuary of the South Edisto River and St. Helena Sound has been designated as a National Estuarine Research Reserve by the National Oceanic and Atmospheric Administration. The reserve is operated by the South Carolina Wildlife and Marine Resources Department. The core area of this reserve will consist of eight islands, predominantly marshlands, of approximately 16,000 acres that will be the object of long-term baseline research and monitoring.

The Four Hole Swamp area of Dorchester and Orangeburg Counties is an 11,000-acre braided-riverine bottomland-hardwood swamp that contains the Francis Beidler Forest, a National Audubon Society Sanctuary, reported to contain the largest old-growth stand of tupelo-cypress in the United States. U.S. Fish and Wildlife Service listed the area in *Significant Wildlife Resource Areas of South Carolina* 1981. The area supports an extremely large variety of birds, mammals, reptiles, and amphibians and many rare plants.

Other protected areas include Givhans Ferry State Park, Colleton State Park, and Aiken State Park, all located on tracts adjacent to the Edisto River.

RESULTS FROM THE ECOLOGICAL CHARACTERIZATION STUDY

The Ecological Characterization of the Edisto River Basin applies principles of landscape ecology to evaluate available information on landscape structure (or patterns of land use and land cover), water quality, hydrology, and indigenous animal populations. The information that was analyzed included long-term data sets, repeated survey data, and indicators of landscape ecological conditions. This section provides a summary of the results by describing the status of ecological conditions in the Basin and the associated assets and problems.



Basin Condition by Indices of Ecological Integrity

The indices used to determine ecosystem health, or ecological integrity, of the Edisto Basin were: loss of forest and other native vegetation, pattern of forest patches, condition of stream-edge habitat, water quality in the streams, stability of stream hydrology, and the presence of balanced indigenous plant and animal populations and natural areas. Detailed discussion of methods and results related to these indices are discussed in the subsequent chapters addressing land use, hydrology, water quality, and biological diversity. A summary of the results is provided below.

Native Vegetation Loss

Prior to European settlement, the Edisto River Basin was approximately 90 percent forest and open woodland. Native upland habitats (natural vegetative communities) covered about 70 percent of the region and about 30 percent was in native wetland habitats. Current conditions indicate that, historically, about three-quarters of the native upland habitats and more than one-third of the native wetland habitats have been converted to other land uses and vegetative cover types. The conversions were mostly to agriculture and pine plantation forests.

Today, the Basin is about 56 percent forested. The Basin is composed of 23 percent mixed upland forest, 19 percent pine plantation forest, and 14 percent wetland forest. The remaining areas of the Basin are managed for agriculture (34 percent) and urban development (3 percent), or they support nonforested wetland habitats (4 percent) and open water (2 percent). In spite of the changes that have occurred, the structure of the Edisto Basin landscape, in terms of total forest cover, is relatively intact and stable compared to other regions of the country.

The forest-cover conditions in the Edisto Basin landscape are favorable for supporting good water quality and many populations of desirable wildlife species. It is important to note, however, that much of the Basin's forestlands are intensively managed pine plantations. Plantation forests have rapidly expanded in recent decades, and currently occupy one-third of the Basin's total forest cover. Pine plantations are simplified forest communities, usually representing even-aged, single-species stands that are highly productive for timber. Plantation forests typically lack the multilayered canopy, diverse tree sizes, abundant snags and fallen trees, and the high species diversity that exist in natural communities (Van Lear 1991); however, plantation forest stands can be established and maintained in ways that improve their diversity (Hunter 1990). Within distinct forest stands biological diversity is enriched by maintaining native herbaceous and shrub plants, complex vertical structure in the forest canopy, large living trees, standing dead snags, and large downed woody debris (Van Lear 1991, Seymour and Hunter 1992). These types of characteristics are determined largely by forest management practices on individual forest stands. The landscape, however, remains the critical level at which the fate of wildlife species is ultimately determined. In forested landscapes, an interspersed pattern of different ecosystems and forest stands of varying sizes, ages, and species compositions is believed to provide the greatest biological diversity (Hunter 1990). Even though some pine plantation stands are quite extensive in the Edisto Basin, they generally remain interspersed within a landscape mosaic of native upland and wetland forests that continue to provide some of the forest habitats that are otherwise unavailable in the plantations.

Forest Patch Pattern

Forest patch analysis of the Basin's total forest cover showed that most of the forest area (56 percent of the Basin) is in a few large patches that extend through most of the landscape via the bottomlands of the streams linking upland and wetland forests into an irregular, or in some cases dendritic (branching), pattern of forested corridors. The total area of forest was 1,112,600 acres distributed among many (4,025) patches. The majority (about 70 percent) of the Basin's forests were found in five patches of 50,000 acres or more. Most of the patches were very small (less than 25 acres) and collectively contained very little of the Basin's total forest area.

The large patches in the Edisto Basin result from many narrow connections in a mosaic of forested tracts that create the irregular, dendritic pattern of forested corridors described above. A substantial portion of the habitats associated with these large patches comprises relatively exposed forest corridors and forest edges. In addition, many roads and



utility corridors crisscross the forest patches causing greater forest fragmentation than is indicated by the analysis. Therefore, the Basin's forest pattern is not as favorable for sensitive forest-interior species as may be indicated by the large patch acreages; in fact, high-quality forest-interior habitats seem to be quite limited.

Forest patch characteristics indicate that the Basin's forest pattern, although far from being in pristine condition, remains favorable for supporting many indigenous wildlife species because of extensive forest connectivity throughout the Basin. The region's extensive pine plantations contribute to the pattern of large forested patches on the landscape. The wetland forests (bottomland hardwood forests), however, are the critical link in the overall connectivity of forests in the landscape and they also appear to provide the best forest-interior habitats available in the Basin. The largely intact bottomland forest system remains favorable for supporting very good water quality in the Basin's streams.

Forest stands with older, larger trees are thought to support more wildlife species than those with younger, smaller trees (O'Neil and others 1991). Because much of the Basin's upland forests are intensively managed planted pine, the overall age of the Basin's forests is relatively young. Most (more than 70 percent) of the Basin's older forest stands (stands more than 80 years old) are bottomland hardwoods. These stands, however, only amounted to about 4 percent of all the forestland in the Basin. Twenty-four percent of all forestland in the Basin had mature stands (stands from 40 to 80 years old). Over half of these mature stands were bottomland hardwoods. These conditions further illustrate the relative importance of the bottomland hardwood forests for the maintenance of environmental quality in the Edisto Basin.

Stream-Edge Habitat Condition

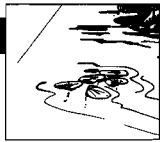
Riparian ecosystems are often the most valuable ecological components of a forested landscape (Hunter 1990). The evaluation of riparian ecosystems involved a "buffer" analysis that tallied the land use and land cover types within two stream-edge zones of different widths: one at 60 meters (about 200 feet) and the other at 125 meters (about 400 feet) from either side of the Basin's streams. The 60- and 125-meter analyses showed that a minor proportion (15 to 25 percent respectively) of the stream edges are under intensive land uses. The intensive land uses are urban (2 percent of the Basin's stream edges), agriculture (9 to 15 percent of the Basin's stream edges), and pine plantation (4 to 8 percent of the Basin's stream edges). Most of the stream-edge habitats (75 to 85 percent) are in natural cover: 33 percent as forested wetland, 14 to 19 percent as mixed upland forest, 14 to 27 percent as palustrine nonforested wetland, and 9 to 11 percent as estuarine wetland. It has been estimated that over 70 percent of the riparian ecosystems in the continental United States have been converted to other land uses (Brinson and others 1981). Because the Edisto Basin's stream edges are largely in natural cover, their condition is favorable for supporting viable riparian wildlife habitat corridors and improving water quality by reducing sediment, nutrients, and other contaminants coming into the streams.

Water Quality in the Streams

The analysis of historical water quality records from 1975 to 1991 indicates that while certain areas of the Basin have problems, the Edisto Basin overall has very good water quality. The most consistent trends observed were declining concentrations of total phosphorus and biochemical oxygen demand. This is consistent with nationwide trends resulting from municipal and industrial pollution control programs during the 1970s and 1980s.

Generally, acceptable water quality (based on the EPA criterion of 0.1 milligrams per liter total phosphorus) is being maintained throughout the Basin, with the exception of the North Fork Edisto River. The North Fork exhibited the highest mean total phosphorus concentration (0.29 mg/l) and usually exceeded the 0.1 mg/l criterion both in the headwaters and below Orangeburg. The North Fork also showed frequent violations of state standards for fecal coliform bacteria in the headwaters. The North Fork's problems are derived primarily from a combination of point and nonpoint sources (livestock and feedlot activity).

Analysis of total phosphorus, total suspended solids, and turbidity showed highly significant and negative relationships to stream discharge. This concurrent decrease in concentration of pollutants with an increase in stream volume (increased water volume resulting from rain and runoff) suggests a dilution phenomenon characteristic of undisturbed, forested watersheds. The low turbidity and total suspended solids concentrations observed



throughout the Basin also indicate that erosion loading during storm events is minimal. The ratio of nitrogen to phosphorus (N/P ratio) in the Basin's streams has been between 10 and 15 since 1983. This N/P ratio indicates a balanced aquatic ecosystem, also characteristic of an undisturbed watershed. The North Fork Edisto River, however, had the lowest N/P ratios (in other words, an excess of phosphorus) because of phosphorus entering the streams from both point and nonpoint sources.

Stability of Stream Hydrology

Analysis of precipitation and streamflow during the period 1939 to 1990 indicates that only minor changes in precipitation and streamflow occurred in the Edisto River Basin and that changes in streamflow are a result of changes in precipitation. This indicates that the minor increases in streamflow did not result from land use changes involving forest and vegetative cover losses. Also, there have been no significant modifications to the Edisto River stream channels to alter the hydrology, such as navigation or flood control projects to widen, straighten, levee, or dam the river. Stable trends in hydrology for the Edisto are likely to be related to the land use and land cover along the Basin's stream edges. The stream edges are mostly forested or in other natural vegetative cover, conditions that are favorable for water storage that supports year-round base flows (groundwater discharge to streams) and retains flood water.

Balanced Indigenous Populations and Natural Areas

Very little information exists to provide a significant understanding of how the abundance and diversity of native species have changed in the Edisto Basin. The only long-term, systematic data available are for birds, primarily the North American Breeding-Bird Surveys. Analysis of Breeding-Bird Surveys (BBS) identified 98 species of birds that were seen six or more times on one of the six BBS routes in the Edisto Basin. Of the 98 species analyzed, 24 species have populations that appear to be increasing, 37 species have populations that appear to be decreasing, and 37 species have populations that appear relatively stable. Only a few species show consistency in the direction or strength of change at all six routes; specifically, 10 species are declining and three species are increasing on most of the routes. No species had plummeting populations or appeared threatened with local extinction. However, more species' populations are decreasing than increasing at four of the six BBS routes analyzed. Two routes in particular are showing declines for 30 to 40 percent of the species over the last 20 years, which may indicate ecological instability in the lower portions of the Basin. These declines coincide with land cover changes of forest loss and forest conversion to pine monoculture along these routes.

The large wide-ranging mammals native to the Edisto River Basin — bears, cougars, and wolves — have been extirpated. Stable populations of medium-sized carnivores with smaller range requirements, such as bobcats and otters, are found in the Edisto Basin. The apparent trend of increasing and stable populations for most of the raptors in the Basin serves as evidence that the region provides stable food web support for these top-level carnivores.

There are several nationally threatened and endangered species in the Edisto River Basin which may be a positive sign of ecological integrity — showing that certain areas serve as a refuge for sensitive or specialized species. The presence of the Red-cockaded Woodpecker, Southern Bald Eagle, Loggerhead Turtle, and Shortnosed Sturgeon suggests that the Edisto River Basin contains relatively intact and uncontaminated habitats that are rare or unique in the nation.

A Natural Area Inventory (conducted by The Nature Conservancy and SCWRC) revealed that the relatively undisturbed, high-quality natural communities that remain in the Edisto River Basin are almost all wetlands, and most of these are found in the coastal region. Most of the Edisto landscape has a long history of intensive land management for agriculture and forestry; therefore, very few native upland communities of any size remain intact. The greatest number and diversity of the 132 natural areas is concentrated in the coastal region, which spans the most ecologically diverse portion of the Basin. The coastal region has nearly 80 percent of the natural areas: sites that contain flatwoods, Carolina bays, bottomland hardwoods, a full array of intertidal wetlands, and barrier island communities. Few natural areas and fewer kinds of natural communities are found in the more inland portions of the Basin.



Assets and Problems for Ecological Integrity

In further summarizing the results of the Ecological Characterization, a listing of the Edisto Basin's assets and problems was developed at a workshop held by the South Carolina Water Resources Commission in October 1992. The workshop was intended to develop a summary and synthesis of the Edisto ecological characterization study. Participants included professional and technical staff representing several state and federal agencies and a corporate landowner. Each of the participants was knowledgeable of the Edisto River Basin and environmental management issues affecting the area. The workshop participants discussed results from the land use, hydrology, water quality, and biological diversity chapters of this report and then identified assets and problems of the Basin.

Assets

Assets are characteristics or attributes that define or support and enhance the Basin's ecological integrity. Workshop participants identified the following assets for the Edisto Basin:

- Relative to other areas in the southeastern United States, the Edisto Basin is one of the most intact drainage basins; it is outstanding in terms of natural conditions.
- The Basin is relatively undeveloped (particularly on the coastal end).
- Large blocks of land are in single ownerships.
- Some areas are not suitable for anything but forest.
- The Basin has a low density of human population.
- The Basin is not heavily industrialized.
- Forest land coverage is fairly high.
- The forests are highly interconnected (when excluding most roads and utility corridors) and extend through much of the landscape following the Basin's stream network.
- Stream edges (riparian zones) are largely in good condition, covered primarily with native vegetation.
- Upland sandy soils in the area enhance water quality (through high infiltration), and the bottomland's muck soils inhibit exploitation.
- Water quality is generally good or improving, with only a few problem areas.
- The estuary exhibits a good tidal range and therefore good flushing (the area of estuary is 80 percent marsh, 20 percent water).
- The Sandhills region is an important groundwater recharge area and is relatively undeveloped.
- There are no dams on the major river system.

Problems

Problems are characteristics related to degradation of the Basin's ecological integrity. Workshop participants identified the following problems in the Edisto Basin:

- There is a poor dispersion of intact ecological communities (very few intact upland communities, but many more intact wetland communities).
- Many upland communities are degraded, are experiencing widespread loss, or are threatened with extinction.
- Harvest pressures on fisheries and other selected wildlife are significant.
- Rare and endangered plants are found in vulnerable habitats, specifically Carolina bays.
- There is a loss of natural transitional cover on outer/higher floodplains between uplands and the lower floodplains; intensive land uses have encroached on these areas.
- Pine plantations are expanding, replacing native hardwood and mixed forest stands; typically, they are simplified forest habitats with lower species diversity.
- Four Hole Swamp seems to be the most degraded of the four subbasins, yet it contains the ecologically significant Beidler Forest and adjacent swamp forest.



- Only a few large forested tracts could provide high quality interior-forest habitats for area-sensitive species.

Possible/Questionable Problems

A number of items were identified as possible problems by workshop participants, but little or no information was available to assess them. Therefore, the following are considered questionable and should be examined further.

- Rural sprawl, increased expansion of low-density development dispersed throughout rural areas, will further fragment the remaining forests and natural habitat.
- River corridor development pressures, from second homes and recreational dwellings, seem to be increasing.
- Headwater impoundments may have a negative impact on fisheries and a positive impact on water quality.
- Water supply for the cities of Charleston and Orangeburg may be threatened by the minimum flows of the Edisto River that occur during periods of drought.
- Agricultural chemicals may be a water quality concern (but were not evaluated in this study).
- Acid precipitation may be a water quality concern.

DEVELOPMENT OF GOALS AND PLANS

The need for setting goals to manage the widespread incremental deterioration of environmental quality, known as cumulative impacts, has been emphasized by nearly everyone who has studied these problems. The technically supported findings about ecosystem health and condition, and the human activities affecting the environment, must at some point be translated into societal value judgments regarding the appropriate balance of natural resource conservation and development. Goals, backed by specific, spatially based plans for a watershed are believed to be necessary to guide and improve decisions that are made in the environmental regulatory process (Gosselink and Lee 1989). Goals can provide consistency and direction to all sorts of programs affecting environmental management — programs of regulation, incentives, education, land acquisition, and economic development. The point is that the assessment of the Basin's ecological health should not be used simply to set new regulatory criteria, but rather to influence the formulation of management and protection objectives. Wetlands, forests, water, and wildlife are important and valuable resources, as are economic goods and services. The public ultimately must choose among objectives that will affect all of these resources (Stakhiv 1988).

Goal-setting — that is, choosing among objectives — must be done in a public planning process that includes all groups with an interest in the region under study. These groups would include relevant government agencies, local business and conservation interests, and people who live in the region. Currently, no such goals and recommendations from a public planning process exist for the Edisto River Basin. However, the information derived from this study is intended for use by participants in such a process, referred to as the Edisto Basin Natural Resource Assessment Process, to be conducted by the Water Resources Commission in 1993-95. Anticipating this public planning process, the October 1992 workshop participants agreed to suggest broad goals and planning recommendations to be considered by those who would be involved in the Natural Resource Assessment Process and by the public in general.

These goals and planning recommendations are intended to stimulate ideas among the readers and citizens of the Edisto Basin. The recommendations represent potential approaches that should be considered as part of an overall basinwide plan; however, no obligation to these is intended. The suggestions are presented below.

Suggested Goals for Management

The Edisto Basin is one of the few remaining blackwater stream systems in the United States that is in good ecological condition. As such, it is both a state and national resource of great



value to the citizens and to our children. It should therefore be preserved, maintained, and enhanced as an important natural resource area for future generations, where the resident population can live in a mutually sustaining relationship with the environment and visitors can have an opportunity to understand and enjoy a unique natural system. Suggested goals are:

- Develop strategies for a harmonious association of man and nature by which people can live in a mutually sustaining relationship with their environment;
- Stop landscape degradation and, at minimum, maintain current ecological conditions; and
- Strive to improve ecological conditions with regard to biological diversity, water quality, hydrology, and landscape structure.

These goals are very broad and general. It was agreed that the goals to maintain and improve the current level of ecological conditions in the Basin should be achieved by using a landscape approach. In this case, using a landscape approach implies having a basinwide focus concerned with the spatial pattern and interaction of different land uses and land cover types and the effect of these on ecological processes. Generally, in this report, ecological processes relate to how natural ecosystems support good water quality, water storage, flood control, and natural biotic diversity. Therefore, the goal implies managing the whole Basin as an integrated unit and managing the pattern of land use and natural cover in order to maintain and improve the overall ecological health of the Basin.

The goal of developing strategies (goal 1) implies the need for a comprehensive approach to managing natural resources and development in the region, an approach that is fair and of long-term benefit to all citizens.

The goals of maintaining and improving the ecological conditions of the Basin (goals 2 and 3) could be made more specific (goals must be more specific for practical use) by targeting standards that relate to the indices of ecological integrity, and by applying the standards to policies affecting land management. An example of such a standard might be to maintain 30- to 60-meter naturally vegetated buffers on all streams.

Suggested Management Plans

Goals and objectives may be implemented through the use of federal, state, and local governments, and private approaches that include education, persuasion, land purchase, easements, incentives and disincentives, and regulation. An implementation plan should be carefully developed to meet clearly stated and specific basin goals. Some options are listed below to illustrate the kinds of steps that can be taken. These options were thought to be useful for attaining the goals and managing the environmental assets and problems of the Edisto River Basin previously addressed, but by no means is this an exhaustive list. These options reflect the ideas of the workshop participants and do not constitute a management prescription endorsed by the South Carolina Water Resources Commission or any other public agency.

1. Protect natural areas.
 - a. Alert The Nature Conservancy and South Carolina Heritage Trust to seek out land purchases, land trusts, management agreements, conservation easements, and donations.
 - b. Use existing regulatory means.
 - c. Seek technical assistance such as the Man and the Biosphere Program administered by the National Park Service.
2. Maintain and improve riparian/stream-edge habitats.
 - a. Use existing regulatory means (for example, Clean Water Act Non-Point Source Program, Section 404 best management practices (BMPs) for forestry, floodplain zoning through the Federal Emergency Management Agency (FEMA), and the Conservation Reserve Program or "Swampbuster").
 - b. Promote conservation through county agents (for example, Conservation District agents, Clemson Extension agents, etc.).
3. Forestry and agricultural management that supports natural diversity and abundance.
 - a. Promote conservation through county agents (for example, Conservation District agents, Clemson Extension agents, etc.).
 - b. Develop BMPs and educate farmers and foresters in their use.

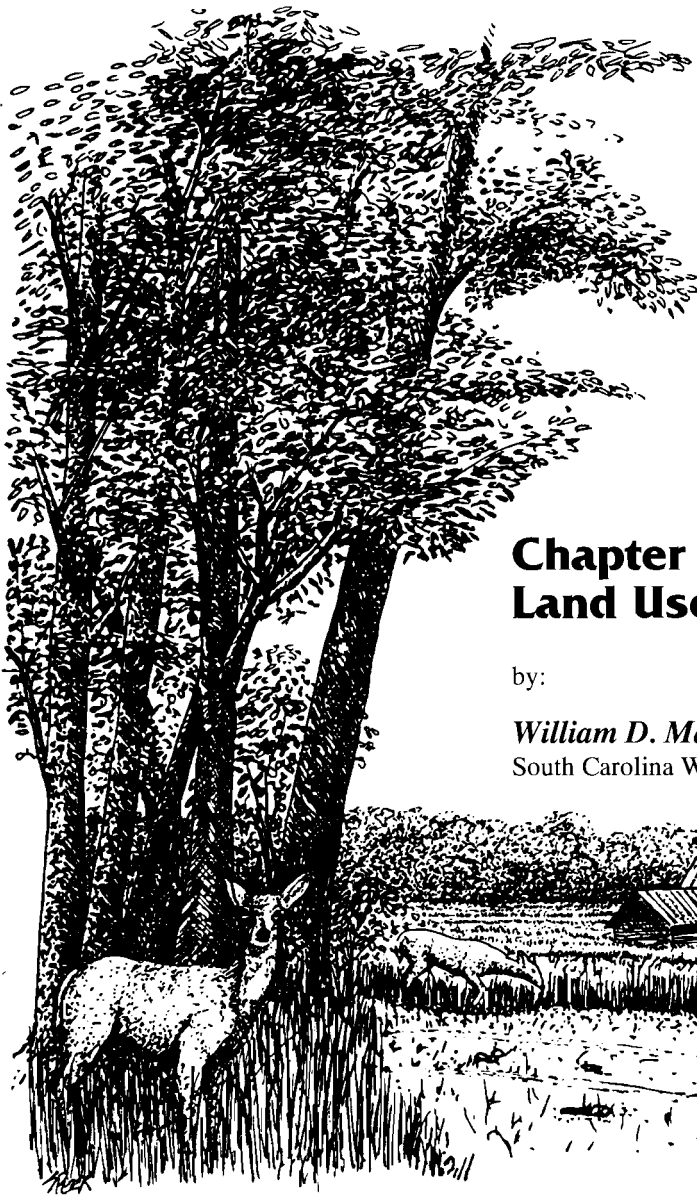


4. Restore and maintain natural fish and wildlife populations at sustainable levels.
Promote through South Carolina Wildlife and Marine Resources Department and their enforcement of regulatory programs.
5. Protect instream water flow for natural uses
Promote through South Carolina Water Resources Commission's authority to protect navigable waters.
6. Promote ecologically compatible industry and land use.
 - a. Work with South Carolina State Development Board and other parties.
 - b. Encourage local entities to promote sustainable development and land uses.
7. Promote ecological understanding and stewardship.
 - a. Bring environmental education to schools.
 - b. Establish public outreach component to Edisto Basin Natural Resource Assessment Process.
 - c. Involve volunteer citizens in monitoring programs (for example, Waterwatch).
8. Maintain and increase the extent of forest and other native vegetation cover.
 - a. Work with large land owners for sustained yield management.
 - b. Check with South Carolina Forestry Commission about reforestation (Federal incentive programs).
 - c. Develop strategies to aid farmers to diversify their source of income (for example, timber, hunting leases, etc.).
9. Maintain large contiguous blocks of forest and natural vegetation in bottomland along the major streams.
 - a. Alert The Nature Conservancy and South Carolina Heritage Trust Program to seek out: land purchases, easements, land trusts, management agreements, conservation easements, and donations.
 - b. Use existing regulatory means (regulate against conversion and for BMPs).
10. Manage for rare and sensitive indigenous species (also those with unusual habitat requirements).
 - a. Promote through The Nature Conservancy and South Carolina Heritage Trust Program.
 - b. Use existing regulatory means (for example, Endangered Species Act).
 - c. Identify species that are important to the public.
11. Increase protection of Beidler Forest and the Four Hole Swamp.
 - a. Promote development of cooperative community conservation and protection strategies (for example, a community-based land trust).
 - b. Use existing regulatory means (for example, Clean Water Act Non-Point Source Program, Section 404 BMPs for forestry, floodplain zoning through FEMA, Conservation Reserve Program, etc.).
 - c. Promote conservation through county agents (for example, Conservation District agents, Clemson Extension agents, etc.).
 - d. Contact appropriate landowners about donating conservation easements on Four Hole Swamp.
 - e. Promote actions of The Nature Conservancy and Heritage Trust Program to seek out: land purchases, land trusts, management agreements, conservation easements, and donations.
 - f. Use existing regulatory means (regulate against conversion and for BMPs).
12. Maintain Class-A Water Quality Standards
 - a. Promote through the S.C. Department of Health and Environmental Control's authority.
 - b. Enforce regulations of Clean Water Act requirements for point and non-point sources.
 - c. Increase and improve analysis for toxins in Basin streams and water wells.
13. Develop an Edisto Basin planning authority through citizen action and commitment.
Such a group could administer the basin goals and plans, seek funding sources for implementation, monitor progress toward the goals, develop an educational program for the Basin, and otherwise work to insure the future health of the Edisto Basin landscape.



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Chapter 2 **Land Use and Land Cover**

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INTRODUCTION

The distribution and proportions of various types of land use and land cover have a great effect upon the ecological functions and conditions of a landscape. As demonstrated and discussed by Gosselink and Lee (1989), the stability and character of the biological communities, the water quality, and the hydrology of a region depend largely on land uses and the proportions of different types of land cover.

This chapter will provide two things: (1) a baseline description of the current land use and land cover characteristics of the Edisto Basin, and (2) a description of historical land use changes that have occurred. The information is presented in a way that will allow for an evaluation of land use changes in the Basin and the resulting cumulative effects on ecological conditions, specifically in regard to hydrology, water quality, and populations of indigenous animals.

METHODS OF ASSESSMENT

Information Sources

The South Carolina Water Resources Commission (SCWRC), through the NRDSS Project, has developed a natural-resource based geographic information system for the Edisto River Basin. The spatial data being developed for the system are mapped at 1:24,000 scale and conform to National Map Accuracy Standards. These data were the most up-to-date available and include SCWRC 1989 land use and wetlands data as well as soils, transportation routes, hydrography, and political boundaries, all specified below.

Historical spatial data for land use and land cover in the Edisto Basin were available only since the mid-1970s. Known sources of historical land use data included satellite imagery from NASA's Landsat programs and the U.S. Geological Survey's 1977 land use data, often referred to as LUDA, which was derived from aerial photography. Another limited source included wetlands data from 1981, available only for the coastal counties and obtained in digital format from the South Carolina Coastal Council and the South Carolina Land Resources Commission.

No satellite imagery was analyzed for this study. The LUDA data, which are based on the Anderson Level II land use and land cover classification system (Anderson and others 1976), were analyzed and found to be substantially different in the level of resolution from the SCWRC 1989 land use and wetlands data. In addition, the LUDA data are of questionable quality because the source photography is quite variable in type and scale. Because of these differences and the questionable quality of LUDA, comparisons between these two spatial data sources were limited to basinwide comparisons of general land use statistics addressed later in this section.

The SCWRC 1989 land use and wetlands data were the primary source used to provide a description of current conditions of landscape structure in the Basin. The other sources used to describe historical changes are county or regional survey statistics.

Land Use and Land Cover Mapping

Digital spatial data that were used for purposes of evaluating changes in land use and land cover in the Edisto Basin are described below. These data were used in analyses conducted by staff at the South Carolina Water Resources Commission using ArcInfo software on a VAX minicomputer system. The data were as follows:

- *1989 land use data* — SCWRC, based on Anderson Level II classification (Anderson and others 1976), 1:24,000 scale, 10 acre resolution.
- *1989 wetlands data* — SCWRC, based on National Wetlands Inventory (NWI) classification (Cowardin and others 1979), 1:24,000 scale, 1 to 5 acre resolution. The land use and wetlands data were derived from 1989 National Aerial Photography Program (NAPP) 1:40,000 scale color infrared photography.
- *Soils data* — U.S. Soil Conservation Service (SCS), 1:24,000 scale, 5 acre resolution. The soils were derived from SCS county soil surveys and



represented conditions in the 12 counties of the Edisto Basin in different years as follows: Orangeburg-1984; Aiken-1981; Dorchester-1985; Lexington-1970; Charleston-1966; Colleton-1980; Calhoun-1963; Bamberg-1964; Barnwell-1973; Edgefield-1978; Berkeley-1974; Saluda-1958.

- *Digital line graphs (DLGs)* — U.S. Geological Survey (USGS), 1:24,000 scale. The DLG's were derived from USGS topographic quadrangle maps and include transportation features, political boundaries, and hydrography.
- *1981 wetlands data* — NWI, Cowardin classification (Cowardin and others 1979), 1:24,000 scale, 1-5 acre resolution. These maps were derived from 1981 National High Altitude Photography 1:58,000 scale color infrared photography.
- *1977 USGS land use data (LUDA)* — 1:250,000 scale, 40 acre resolution.

The SCWRC 1989 land use and wetlands data, the soils, and the DLG's conform to standard federal classification systems. The Anderson Level II classification (Anderson and others 1976) was used for land use and land cover in upland areas. The Cowardin classification (Cowardin and others 1979) was used for wetlands and deep water habitats; these data conform to U.S. Fish and Wildlife Service, NWI standards and specifications. The DLG's conform to USGS standards and specifications. The soils data, derived from the 1:20,000 scale SCS county soil survey maps, were remapped to 1:24,000 scale, reviewed by the SCS for map accuracy, and then were digitized. Zoom Transfer Scope methods were used for remapping soils in order to reduce the mapping scale and to remove the distortion inherent in the original county soil survey maps.

Other Information

Evaluations of historical changes and existing conditions in land use were also derived from the following additional sources of information:

- *Forest Survey data* — U.S. Forest Service, Forest Inventory and Analysis Research Unit; data on the extent and conditions of forest lands for 1947, 1958, 1968, 1978, and 1986. These data were obtained from the Forest Service grouped as summary statistics for the 12 counties, and as summary statistics for the four subbasins of the Edisto region.
- *Census of Agriculture data* — U.S. Department of Commerce, Bureau of the Census, available every 5 years since 1925; data for the extent of agricultural land, specific crops, and other farmland uses. These data were obtained as summary statistics for the 12 counties of the Edisto region.

Assessing Historical Land Use

Historical changes in the extent of forests and natural cover, agriculture, and urban development were assessed by comparing data compiled for the U.S. Forest Service's Forest Survey and the U.S. Department of Commerce, Bureau of the Census' Census of Agriculture. These data were evaluated for an area composed of all twelve counties of the Edisto River Basin and for three individual counties to assess sub-area differences. General ownership and related land use trends were assessed from the Forest Survey and the Census of Agriculture. The categories of general land use derived from the Census of Agriculture and the Forest Survey data were as follows:

- *Land in farms* — a Census of Agriculture term that represents the acreage of all land in farmer owned operations. Land in farms includes subsets of acreage for crops, pasture, and grazing lands and also woodland or "wasteland" not actually under cultivation nor used for grazing or pasture.
- *Agricultural land* — this term refers to a subset of acreage derived from the Census of Agriculture data for "land in farms." Figures for Agricultural Land were derived by subtracting "woodland not pastured" acreage from the "land in farms" acreage; each of these were listed in the Census of Agriculture. Thus derived, Agricultural Land represents farmer owned acreage for all cropland, all pastureland, and all other farmland such as house lots, barn lots, roads, ditches, and ponds.



- *Forestland* — a Forest Survey term for land at least 16.7 percent stocked by forest trees of any size, or formerly having such tree cover, and not currently developed for nonforest use.
- *Urban land* — includes urban or built-up areas inventoried in the initial phase of the U.S. Forest Service's Forest Survey procedures.
- *Other land* — where county-based land use statistics are used, this term refers to the county land area unaccounted for after summing forest land, agriculture land, and urban land.

Assessing Current Land Use

To focus on the primary elements of concern and to provide a general perspective on the mix of land uses in the Basin, the 1989 spatial data were simplified into broad categories. The broad categories were derived by lumping similar Cowardin wetland classification types and similar Anderson land use and land cover classification types. The categories of general land use derived from the 1989 data are as follows:

- *Native Forested Wetlands* — includes all Cowardin palustrine (freshwater) forested wetlands, excluding pine plantations.
- *Nonforested Wetlands* — includes all Cowardin palustrine emergent wetlands, and palustrine scrub-shrub wetlands.
- *Open Water* — includes all Cowardin palustrine, lacustrine, riverine, estuarine, and marine open water.
- *Mixed Upland Forest* — includes all Anderson upland forest types as well as the rangeland types of shrub-brush and mixed rangeland; does not include pine plantations.
- *Pine Plantation (planted pine) Upland Forest* — includes planted pine forests, as distinguished from the Anderson forestland classifications.
- *Agriculture* — includes all Anderson agricultural land uses as well as the herbaceous rangeland type.
- *Urban* — includes all Anderson urban or built-up land uses as well as mines and transitional areas.
- *Estuarine Wetlands* — includes all Cowardin estuarine brackish and saltwater wetlands, excludes open water.

Existing conditions of the landscape structure were derived from the SCWRC 1989 land use and wetlands data by analyzing the distribution and extent of the broad categories of land uses and cover types. These data were analyzed for the entire Edisto River Basin and for each of the subbasins: the North Fork, South Fork, Four Hole Swamp, and the main stem of the Edisto.

Changes in Wetlands

Several different analyses were conducted to assess changes in the extent of wetland habitats as well as land uses and alterations affecting wetland habitats of the Edisto Basin.

Rationale

Generally, wetlands are areas where saturation with water is the dominant factor determining both the nature of soil development and the types of plant and animal communities living in and on the soil. Soil that is at least periodically saturated with or covered by water is the single feature that most wetlands have in common. "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water" (Cowardin and others 1979).

Hydric soil, soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part, is one attribute used to identify an area as wetland. The technical criteria for identification of jurisdictional wetlands under Section 404 of the Clean Water Act are tied to three attributes that wetlands possess: hydrophytic vegetation, hydric soils, and wetland hydrology (FICWD 1989). Regulatory jurisdiction for wetlands must be determined in the field by judging the presence or absence of these three attributes. The



presence of hydric soil, alone, does not determine whether an area is a jurisdictional wetland, but it can indicate the type of native vegetation likely to have been found on that soil.

The purpose of this study was to assess changes in land use and land cover in the Edisto Basin, but the study did not determine the extent of jurisdictional wetlands. Because saturated soil conditions are the key factor in determining the presence of native wetland vegetation, it was assumed that the historical extent of wetland vegetation communities could be estimated by assessing the extent of selected hydric soils from the Soil Conservation Service's (SCS) county soil surveys. Likewise it was assumed that historical changes in the extent of native wetland vegetation could be estimated by comparing selected hydric soils with the 1989 NWI data.

Note that the resolution of the SCS county soil survey mapping units inevitably leads to the inclusion of some nonhydric soil areas within the map units that SCS designates as hydric. The SCS National Soils Handbook addresses this factor as follows: "The total amount of dissimilar inclusions generally does not exceed about 25 percent. Limiting inclusions should not exceed about 15 percent, and no one dissimilar soil may make up more than 10 percent of the map unit" (USDA 1983). Therefore the worst case condition for mapping accuracy means that only about 75 percent of the area mapped as hydric soil would actually be hydric. However, according to SCS soil scientists, hydric soils generally tend to have fewer inclusions and dissimilarities than other soils and would therefore be more accurate, around 85-90 percent mapping accuracy.

Assessing Wetland Change

A selected set of hydric soils from the Edisto Basin was analyzed in this study to estimate the historical extent of native wetland vegetation. The selected set of hydric soils was derived from the county hydric soils lists developed by the Soil Conservation Service. The selected set included only those hydric soils with "map unit names" determined to have a "hydric soil component" for the "whole map unit" (USDA 1986). In other words, the analysis included only those soil types determined by SCS to be uniformly hydric (see Appendix I for hydric soils list). The selected set of hydric soils was compared with the NWI wetlands data to assess changes in the extent of native wetland vegetation.

Conversion of native wetland vegetation communities to other land uses and cover types was assessed by quantifying the acreage of various land uses and cover types occurring on the hydric soils. This was determined by overlaying the 1989 land use and NWI wetlands data on the selected set of hydric soils, derived from the SCS soils data. In conducting this analysis about 68 percent of the Basin's area was derived from soil surveys of the 1980s; most of remaining area was evenly split among soil surveys from the 1970s and from the 1960s.

Changes in the spatial extent of native wetlands vegetation was assessed in the coastal area of the Basin by comparing the 1981 and 1989 NWI wetlands data. This comparison was made for only 17 quadrangles in the coastal zone because the 1981 data were available only for this area of the Basin.

In addition to determining changes in the extent of wetland vegetation, partial alterations to wetland resources were evaluated. This was done for each subbasin using 1989 NWI data to identify and quantify the *partially drained/ditched* wetlands and the *diked/impounded* wetlands in the Basin.

Stream-Edge Habitat Analysis

The contiguity of streams and stream-edge habitat for each of the perennial stream corridors of the Basin was evaluated to assess the extent to which forests and natural cover potentially protect and shelter associated streams and provide habitat for wildlife. This analysis was performed by using a GIS technique called "buffering." Buffering creates a strip along the edges of a mapped feature to any desired width. In this case the Basin's stream network was buffered, and then the buffered streams were overlaid with the land use and wetlands information to determine the percentage of various land use and cover types found within the strip of land adjacent to the stream edges.

The width of the buffers for each stream analyzed in this study was 250 meters (125 meters (about 400 feet) on each side of a stream) and 120 meters (60 meters (about 200 feet) on each side). The 250 meter buffer was a relatively wide strip for stream-edge analysis, but it was chosen in order to assess more than just the minimum areas recommended in the



literature and in Best Management Practices. Gosselink and others (1990) applied a 250 meter buffer in assessing stream edges of the Pearl River in Mississippi, and a comparison with those findings was desired. The dimension of the buffer applied to the Pearl River was apparently based on constraints resulting from the resolution of the satellite data that was used rather than on particular standards derived from scientific literature. Howard and Allen (1989) summarized recent literature concerning the value of streamside forested wetlands in the southern United States. They reported on a number of sources that suggest buffers from 8 to 31 meters may be needed to protect and maintain water quality and fisheries, and buffers up to 104 meters may be needed for wildlife. Brinson and others (1981) report that the zone within 200 meters of a stream or open water appears to be the most heavily used by terrestrial wildlife. Howard and Allen recommended, for fish and wildlife management purposes, that protected zones along perennial and small streams (streams no wider than about 10 meters) be at least 60 meters wide (30 meters on each side). For larger streams, 60 meters on either side was recommended. Because of these specific recommendations, a second buffer, of 120 meters, was included in the analysis of stream-edge habitats.

The USGS Digital Line Graphs hydrography data were used to interpret stream-order using methods described by Strahler (1964). The streams were then grouped by order to evaluate conditions among the different size classes of streams. In this analysis stream-order refers to the sequence of stream formation, beginning at the headwaters, i.e. the initial formation of a stream. The initial formation of a stream from surface or groundwater drainage would be classified as "first-order." A "second-order" stream forms after the confluence of two first-order streams. A "third-order" stream forms after the confluence of two second-order streams. A "fourth-order" stream forms after the confluence of two third-order streams. A "fifth-order" stream forms after the confluence of two fourth-order streams; and so on.

The streams were grouped as third-order, fourth-order, and fifth-order and greater. First- and second-order streams were not included in the analysis because many of these features were determined to be intermittent and were of greater spatial complexity than this analysis required.

Generally, the "fifth- and greater-order" (large streams) represented the primary river segments of the Edisto: the North Fork and South Fork of the Edisto River; the Edisto River; North Edisto River; South Edisto River; Four Hole Swamp; as well as all the major intertidal rivers and creeks on the 1:24,000 scale maps. The "fourth-order streams" (medium streams) were generally the primary tributaries of the river system — the major creeks that feed into the rivers mentioned above. The "third-order streams" (small streams) were generally the tributaries to the major creeks of the Basin.

Forest Patch Analysis

The sizes and frequency of forest patches within the Edisto Basin were derived for each subbasin and for the entire Edisto River Basin from the SCWRC 1989 land use and wetlands data. Three categories of forest were analyzed for each subbasin:

- *Total forest* — includes upland mixed forests, native wetland forests, and planted pine forests (these forest types are defined above under "Assessing Current Land Use"),
- *Total forest excluding the planted pine forests*, and
- *Native forested wetland* — includes native wetland forests and excludes planted pine forests and mixed upland forests.

Total forest was the only forest category for which the subbasins were merged in order to analyze forest patches for the entire Edisto Basin. The other two forest categories were analyzed for the subbasins only.

Patch analysis was done to assess forest fragmentation and to identify large "natural patches" of contiguous wetland and upland forest, important for supporting wildlife — particularly sensitive or threatened species. Forest fragmentation results from many different natural conditions as well typical land use patterns associated with human settlement and land development. An important point to note regarding this analysis is that the available land use and wetlands data were mapped so that most roads and utility corridors are not shown. It was obvious from other map information, however, that many roads and utility corridors fragment



the forests and natural cover of the Edisto Basin. In this forest patch analysis the Interstate and other four-lane divided highways were overlaid on the land use and wetlands data to dissect the forest patches. Only these large highways were considered because they were believed to be obvious breaks in forest connectivity and barriers to most wildlife movement.

RESULTS

Historical Changes in Land Use and Land Cover

Trends from County-Based Survey Data

Most of the historical land use data used in this study was derived from the Forest Surveys and the Census of Agriculture. These were county-based survey data (statistics representing whole counties) and provided only a general representation of land use trends in the hydrologically defined Edisto River Basin. The county-based statistics were available beginning around 1930 for agriculture and about 1950 for forests; these were published about every 5 and 10 years respectively. Figure 1-1 (in previous section) shows the hydrologically defined basin of 2 million acres in relation to the 12 county area of about 5.7 million acres.

The total acreage of all land within the 12 county area varied between 1930 and 1990, but the average land area during this period was about 5.7 million acres. The sum of acreage figures from the Census of Agriculture and the Forest Survey for any given year from 1950 to 1990 accounted for only about 80 to 90 percent of all land; i.e. an acreage gap ranging from 0.5 to 1 million acres was unaccounted for using these data. The data for agricultural land use are likely the primary source of this acreage gap. Further explanation of problems with these data is given later in this chapter (see "Current Land Use and Land Cover"). Related to the acreage gap was a sharp reduction of agricultural land uses that occurred between 1950 and 1960 due, in part, to the establishment of the Savannah River Plant (SRP) in 1952. SRP, an area of about 200,000 acres, was removed from the agricultural land use inventories in Aiken and Barnwell Counties. Forestland management continued in SRP, and the Forest Survey inventory continued as well. However, agricultural land uses in SRP were abruptly ceased in the early 1950's and the Census of Agriculture data for agricultural land reflect this change (Figure 2-1).

The extent of agriculture was fairly stable from about 1930 to 1950. Since 1950 the extent of forest cover has changed very little, but agricultural land area, even after accounting for the affects of SRP, has steadily declined. In 1950 about 3.5 million acres (62 percent) of the 12-county area of the Edisto River Basin were considered forest land (Figure 2-1). Forest acreage slowly increased in the 1950s, 1960s, and 1970s but declined in the 1980s. By the late 1980s forest acreage was nearly the same as in 1950.

Historical data for urban-related land uses were available from about 1970 to 1990. These urban land use data (see Figure 2-1) show there was a 62 percent increase in urban-related land in the 12-county area of the Edisto during this period, an increase from 265,000 acres to 430,000 acres. During this same period, agricultural land decreased 27 percent and forest land decreased 3 percent.

Figure 2-2 compares the percentages of general land use categories for 1968 and 1986 for the 12 Edisto Basin counties combined, and individually for Aiken, Orangeburg and Dorchester Counties. These three counties represent different regions of the Edisto River Basin. Aiken is representative of the upper Basin, Orangeburg represents the middle Basin, and Dorchester represents the lower Basin. As stated above, the overall trend for this 18-year period was a decrease in forest land and agricultural land with an increase in urban and other land uses. Orangeburg County was an exception for forest land use, showing a small increase since 1968.

Changes in Land Ownership

Land ownership in the counties of the Edisto Basin reflects the socioeconomic changes that have affected land use. The decline in agricultural land use since 1950 was associated with the loss of "land in farms," a Census of Agriculture statistic that represents all land in farmer-owned operations. From about 1950 to 1990, nearly 66 percent of the land in farms was lost to other land uses and ownerships, a decline from 3.3 million acres to 1.3 million acres for

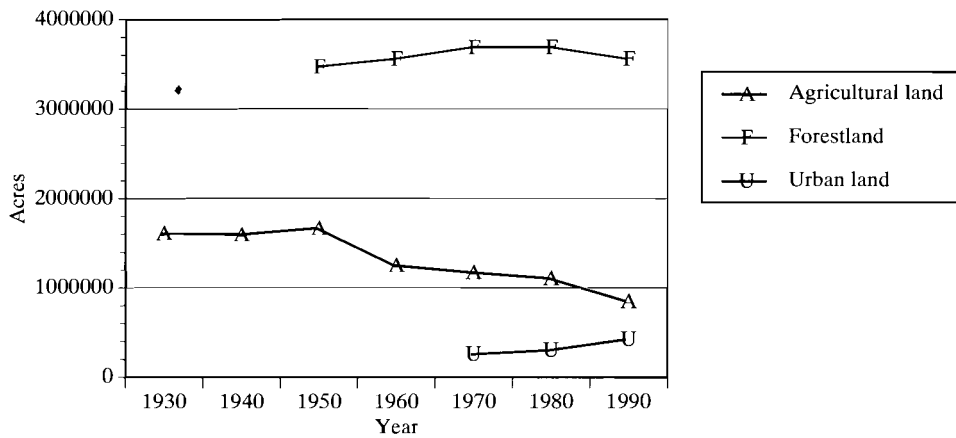


Figure 2-1. Trends in general land use categories for the 12 counties of the Edisto Basin, 1930 to 1990. Sources: U.S. Forest Service, Forest Survey and U.S. Bureau of the Census, Census of Agriculture.

the 12 counties of the Edisto Basin. The U.S. Forest Service data in the Edisto River Basin also showed a decline in farmer ownership for forestlands. From 1968 to 1986, farmer-owned forestland declined nearly 50 percent with increased ownership going to forest industry and “miscellaneous private entities,” corporate land owners and individuals other than farm operators (Figure 2-3).

Changes Based on Spatial Data

Figure 2-4 provides a comparison of the LUDA land use data from 1977 with the SCWRC 1989 land use and wetlands data for the hydrologically defined Edisto River Basin. This information was derived from land use maps and statistics rather than the county-based survey data discussed above. As previously mentioned (see “Methods”) the LUDA data are of questionable quality and were analyzed and found to be substantially different in their level of resolution from the SCWRC 1989 land use and wetlands data. However, the LUDA data did seem to provide a useful comparison for general land use changes at a basinwide scale, but not for evaluating or comparing sub-areas of the Basin. The comparison indicates that the Edisto River Basin, hydrologically defined, had similar land use trends as the 12-county area of the Edisto Basin, i.e., relative stability with only slight changes. Overall, there was a decrease in forest land (specifically upland forests), a decrease in agricultural land, and an increase in urban and other land uses (particularly nonforested wetlands).

Changes in Forest Type

As previously discussed, the extent of forest land in the Edisto River Basin declined slightly in recent decades. According to the Forest Survey data, overall forest acreage decreased about 5 percent (1,200,735 acres to 1,144,330 acres) in the Edisto drainage from 1968 to 1986. The composition of the forests, however, changed more dramatically during this period. Figure 2-5 shows that seven out of ten of the forest types inventoried by the U.S. Forest Service declined in total area since 1968 (U.S. Forest Service 1991). Three forest types, Loblolly Pine, Oak-Hickory, and Elm-Ash-Cottonwood, increased in area. The Loblolly Pine forests showed the greatest expansion (73 percent increase in area) and represents the increased use of pine plantations for timber production in the Basin. In 1968 Loblolly Pine comprised about 15 percent of the Basin’s forests; its area increased to 27 percent of the Basin’s forest by 1986 (from 179,000 acres to 309,000 acres). The Oak-Hickory forests increased by 41 percent (120,000 acres to 170,000 acres) and may have expanded because of natural forest succession in abandoned agricultural fields or fire suppression in former pine-dominated stands.

Current Land Use and Land Cover

Based on 1989 land use data (Figures 2-6 and 2-7), the Edisto River Basin area was 56 percent forested. Three-quarters of the Basin’s forestlands were mixed upland forest and pine plantation with the remainder in native forested wetlands. The native forested wetlands comprised about 14 percent of the Basin area; mixed upland forest, 23 percent; and planted pine forest, 19 percent. Agricultural land uses (which includes grasslands) made up 34



percent of the Basin area; 7 percent was in non-forested wetland (including estuarine, scrub-shrub, emergent, and open water); and 3 percent was in urban uses.

Patterns of Land Use

There are distinct patterns of land use and land cover in the Edisto River Basin that correspond to the natural characteristics of the landscape. Broad patterns of land use and cover generally correspond to the character of the soils, which is related to topography and drainage. "Land resource areas" as described by the U.S. Soil Conservation Service (see "Soils and Vegetation" and Figure 1-2 in Chapter 1) are regions based primarily on soil characteristics that provide a basis for describing the dominant vegetation and land uses in different parts of the state. Land use and land cover in the Edisto Basin (Figure 2-7) corresponds remarkably well with the land resource areas (see Figure 1-2 of the Introduction chapter).

The Edisto Basin encompasses four of the six land resource areas in South Carolina. The Carolina-Georgia Sandhills, an area that crosses the Basin near the western end, is mostly forested with a mix of pines and scrub-oaks. There are only small scattered locations of agriculture in the Sandhills area due to widespread excessively drained and infertile sandy soils. The Southern Coastal Plain, found at both the Basin's western tip and through a broad band in the middle Basin, is dominated with agricultural land uses. The fertile loamy and clayey soils of this Southern Coastal Plain area support some of the most productive agricultural land in South Carolina. The sandy and clayey soils of the Atlantic Coast Flatwoods support some very large agricultural areas; however, as the Basin narrows into a "neck" at its southeastern end, the Flatwoods become dominated with forestland — primarily pine plantations. Much of the pine plantation forests in the Flatwoods area is owned by the forest products industry that has expanded these forests over the past 25 years. The Tidewater Area supports a variety of land use and land cover, but mostly consists of forests and estuarine wetlands with some agriculture on the better drained sandy and clayey soils. Agriculture in the Tidewater Area is mostly vegetable farming.

The riverine bottomlands or floodplains remain mostly forested, and they form a dendritic or branching pattern of forested wetland corridors throughout the Basin. In many areas it can be seen that these corridors have been encroached upon, and the native vegetative cover has been converted to agriculture, pine plantation forest, and — adjacent to Orangeburg — to urban land uses (see Figure 2-7).

The city of Orangeburg is the only large urban area within the Edisto Basin and this location is likely no accident. Orangeburg lies within the heart of the productive agricultural lands and on the banks of the North Fork Edisto River, two factors that have continued to support growth and economic development in this city for more than 150 years. The river supported commerce through transportation in the past, and today the river's water supply supports a significant industrial base for the city

Land Use in the Subbasins

Maps, acreages, and percent of total area for land use and land cover categories in the Edisto River Basin and its four subbasins are provided in Figures 2-6 through 2-15.

The North and South Fork subbasins were generally very similar in land use characteristics; both were 56 percent forested and had nearly 40 percent in agricultural land (Figures 2-8 and 2-10). Proportionally, the differences between the North and South Forks were only 2 to 3 percentage points, with the North Fork having more urban land (5 percent of the area and greatest among all subbasins), and more pine plantation (19 percent) and mixed upland forest lands (29 percent). The South Fork had more forested wetlands (10 percent) and more agricultural land (40 percent).

The Four Hole Swamp subbasin had agricultural uses that occupied 42 percent of the area (Figures 2-12 and 2-13). This was the highest proportion of agricultural land among the four subbasins. Forests covered 52 percent of the area and more than one-third of the forests were forested wetlands. Pine plantations were found to be more extensive than mixed upland forests in the Four Hole Swamp and in the main stem subbasins.

Overall, the main stem had proportionally more forest area (60 percent of the area) and less agricultural area (20 percent) than the other subbasins (Figures 2-14 and 2-15). The forest lands of the main stem were equally distributed among forested wetland and mixed upland forestland with slightly more pine plantation forestland. Nonforested wetlands, primarily estuarine marsh and intertidal open water areas covered 19 percent of the main stem area — greater than six times as much as was found in the other subbasins.

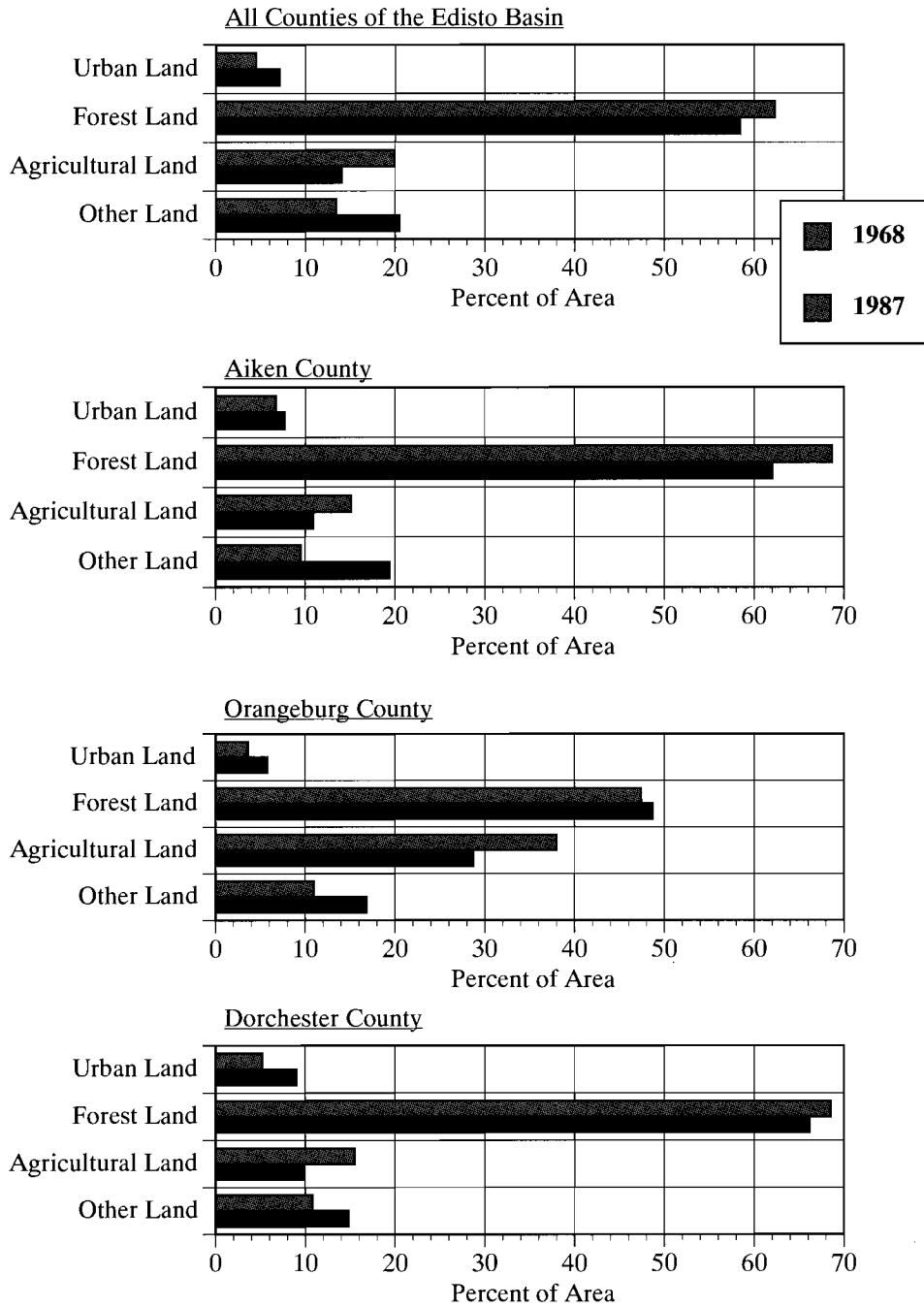


Figure 2-2. Change in land uses for counties of the Edisto Basin, 1968 to 1986. Sources: U.S. Forest Service, Forest Survey and U.S. Bureau of the Census, Census of Agriculture.

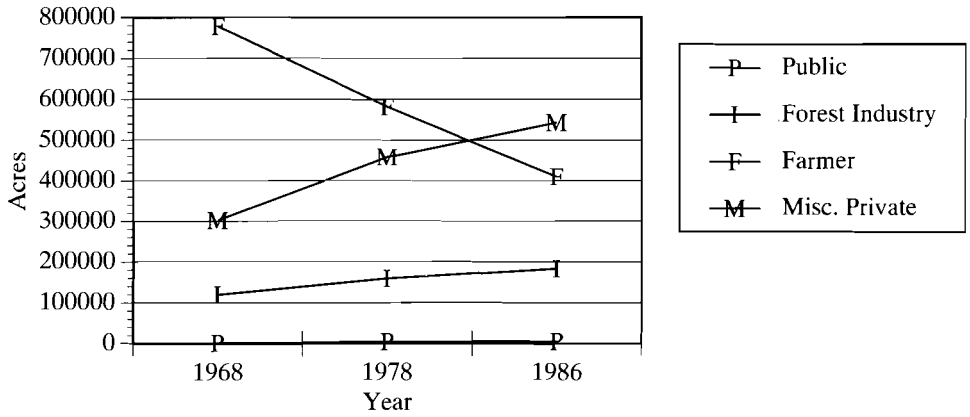


Figure 2-3. Trends in the ownership of forestland acreage in the Edisto River Basin, 1968 to 1986. Source: U.S. Forest Service, Forest Survey.

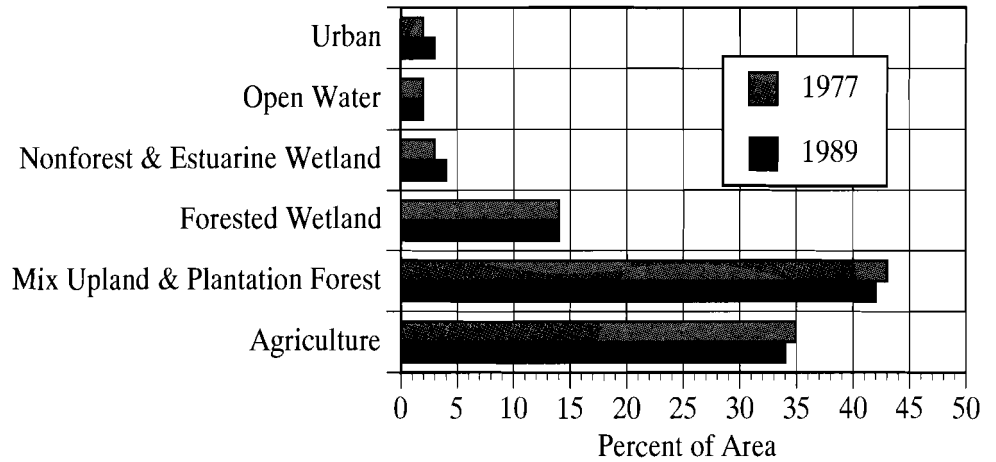


Figure 2-4. Changes in the percentage of land use categories for the Edisto River Basin, 1977 to 1989. Sources: 1977 USGS LUDA data and 1989 land use and wetlands data from SCWRC.

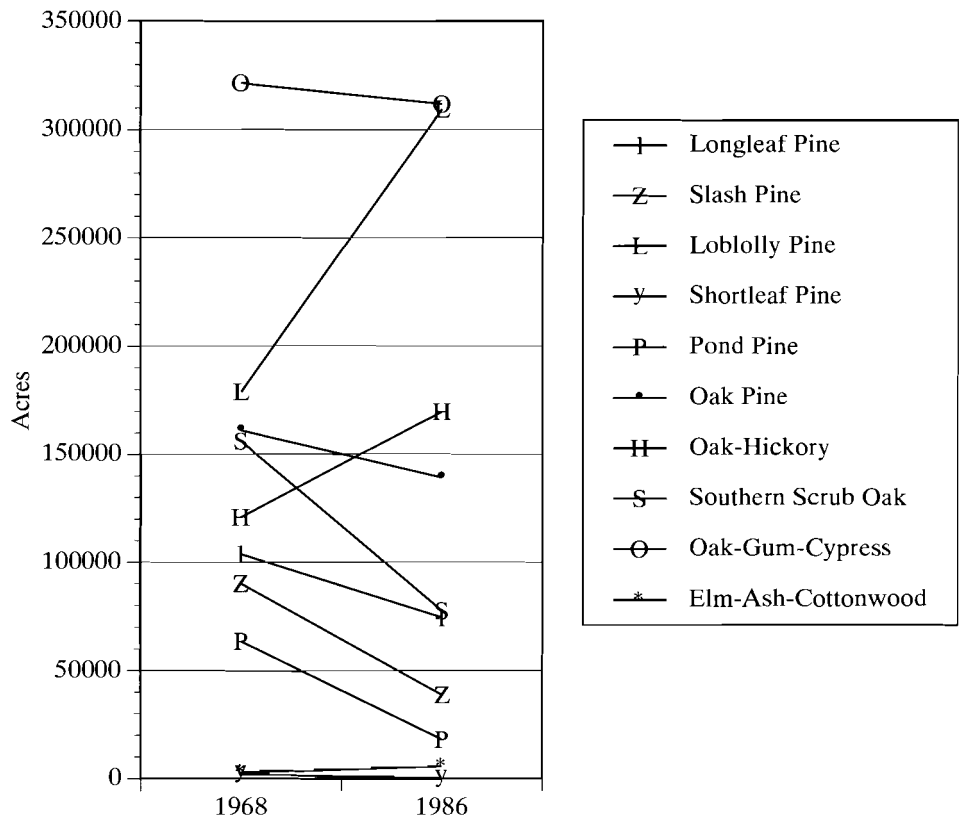


Figure 2-5. Changes in area of forest types in the Edisto River Basin, 1968 to 1986. Source: U.S. Forest Service, Forest Survey.

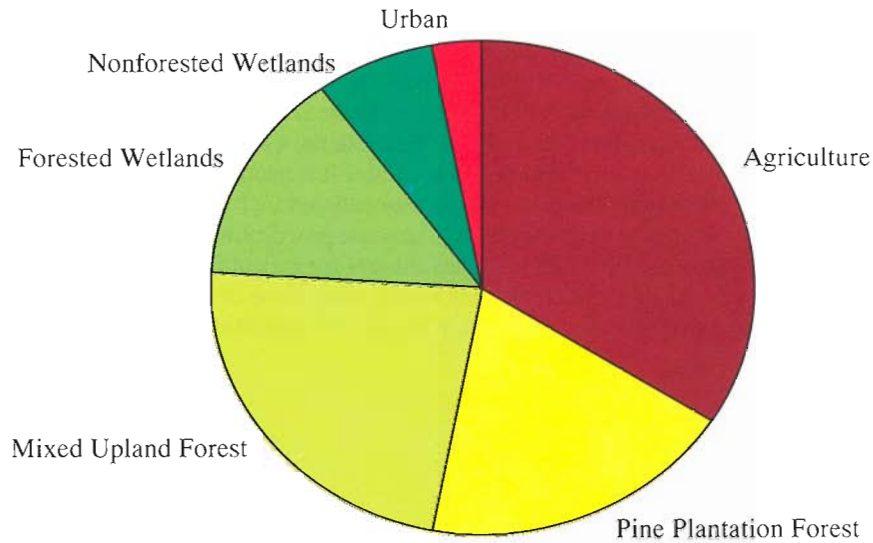


Disparities Between Data Sources

There is a disparity between the 1989 land use data and the 1986 land use statistics previously mentioned and shown in Figure 2-2. The 1989 data show 34 percent agricultural land, substantially more than the 1986 data that show only 14 percent in agriculture. Urban land differs as well; 1989 data show 3 percent and 1986 show 7 percent. Part of the reason for the disparity is that these are two completely different data sets, both in terms of quality and the area represented. The 1989 data are spatial data derived from aerial photography and represent the hydrologically defined basin. The 1986 data are census survey statistics derived from a representative sample of landowners and represent the 12 counties of the basin, a region that is more than twice the size of the Edisto drainage basin. Given these differences in the data, the disparity in urban land can be explained by the fact that the 12 county area encompasses portions of the metropolitan areas of Charleston, S.C., Columbia, S.C., and Augusta, Ga. The hydrologically defined basin area is distinct from these areas and is definitely more rural. For agricultural land, the disparity is due, in part, to the area differences but probably more related to differences in the quality of the data. Because the Census of Agriculture data are census survey statistics they are probably less accurate. It is interesting to note that for 1986 the proportion of "other land" (land apparently unaccounted for by the available survey data) was about 20 percent of the 12 county area. The same proportion, 20 percent, represents the full disparity between the 1986 and 1989 data sources for agricultural land area. This indicates that the Census of Agriculture data may simply omit some of the agricultural land inventoried by photointerpretation. This may be due to definitional differences or survey sampling limitations.



Edisto River Basin - 1989 Land Use / Land Cover



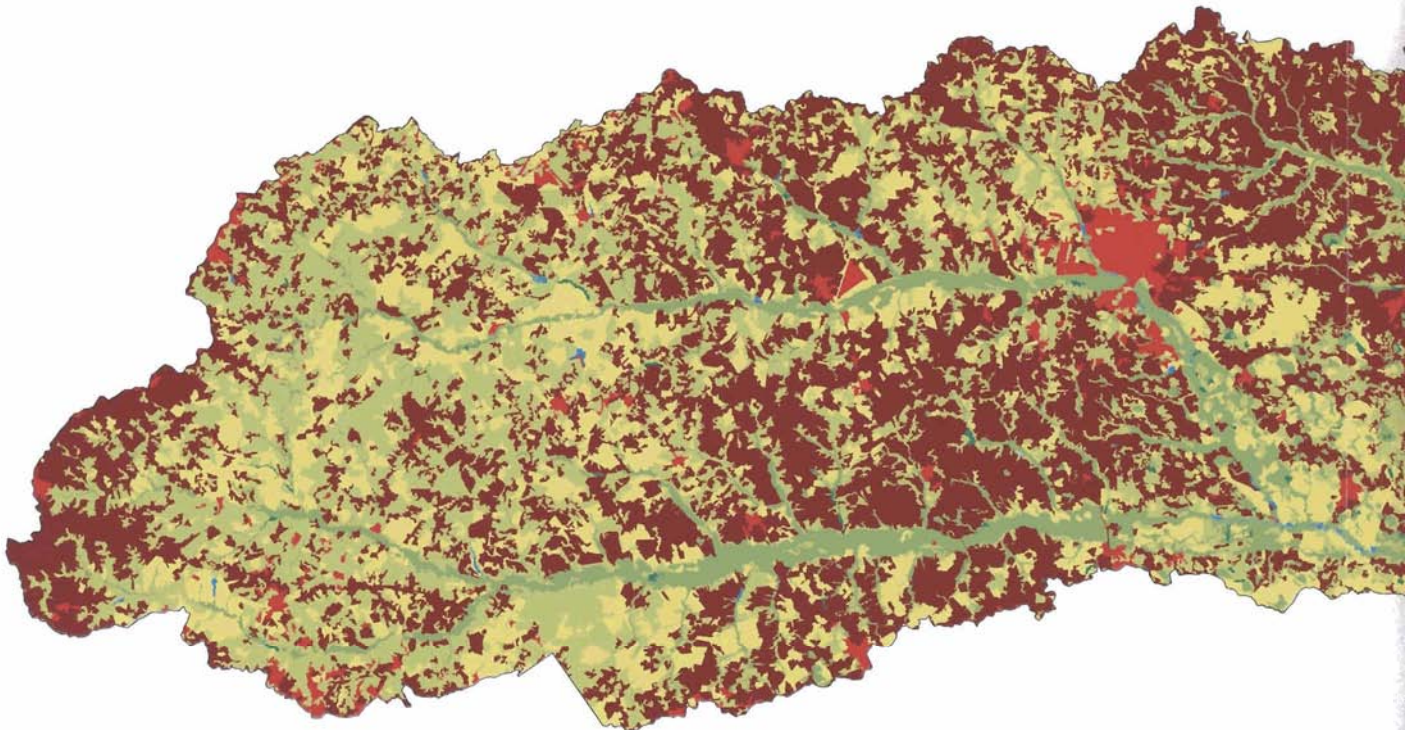
<u>Land Use / Land Cover Types</u>	<u>Acres</u>	<u>Percent of Total Area</u>
Nonforested Wetland		
Estuarine Wetland	44,730	2%
Palustrine Emergent Wetland	12,831	1%
Palustrine Scrub-Shrub	28,184	1%
Open Water	47,251	2%
Forested Wetland	278,889	14%
Upland Forest / Mixed	458,189	23%
Upland Forest / Pine Plantation	377,562	19%
Agriculture	671,123	34%
Urban	63,688	3%
Total Area	1,982,446	

Figure 2-6. Edisto River Basin: acreage and percentage of total Basin for land use and land cover types, 1989. Source: SCWRC 1989 land use and wetlands data.



1989 LAND USE/LAND COVER

Edisto River Drainage Basin



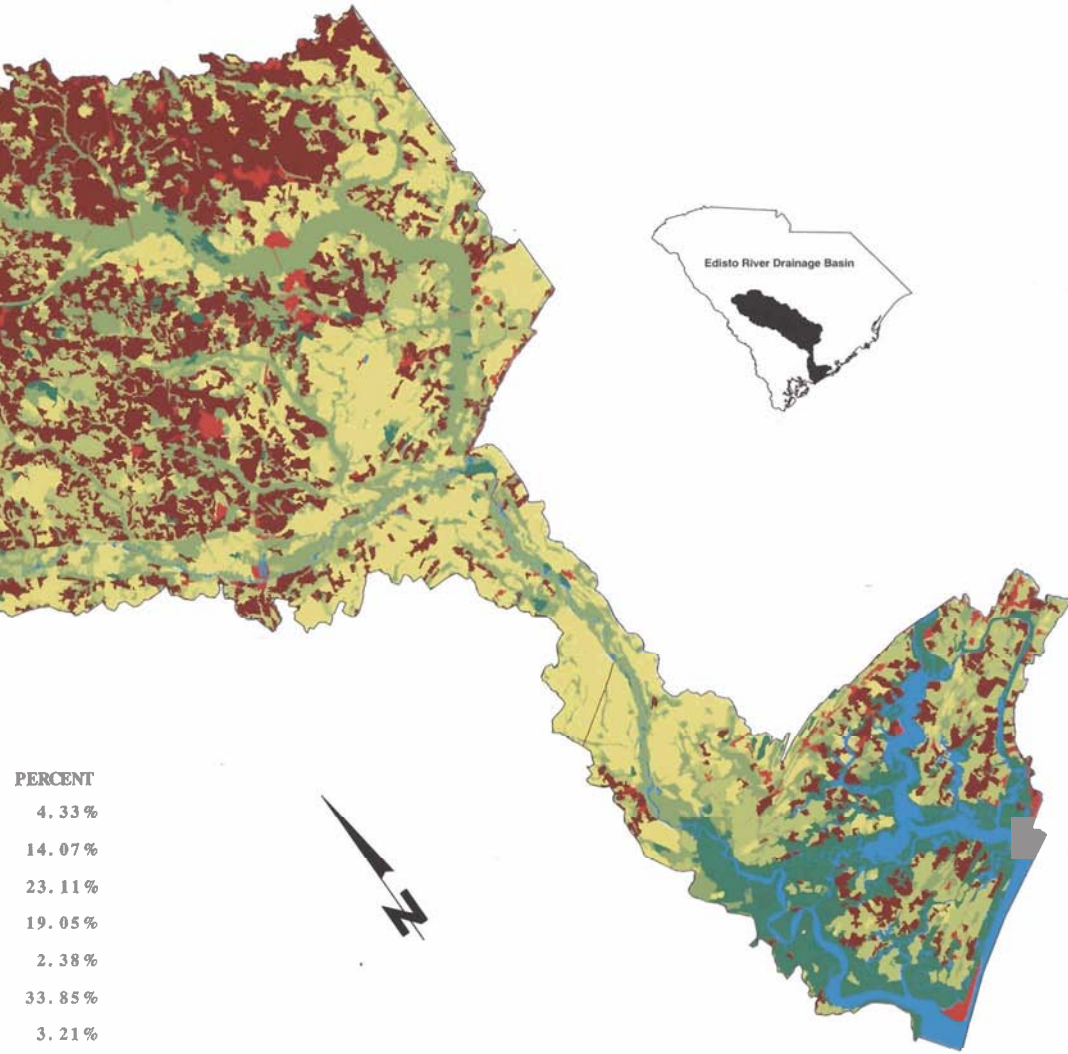
LAND USE/ LAND COVER TYPE	ACRES
NON- FORESTED WETLANDS	85,745
FORESTED WETLANDS	278,889
UPLAND FORESTED/ MIXED	458,189
UPLAND FORESTED/ PLANTATION	377,562
OPEN WATER	47,251
AGRI CULTURE	671,123
URBAN	63,688

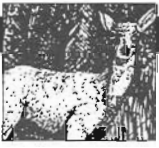
South Carolina Water Resources Commission
 Natural Resources Decision Support System
 Columbia, South Carolina



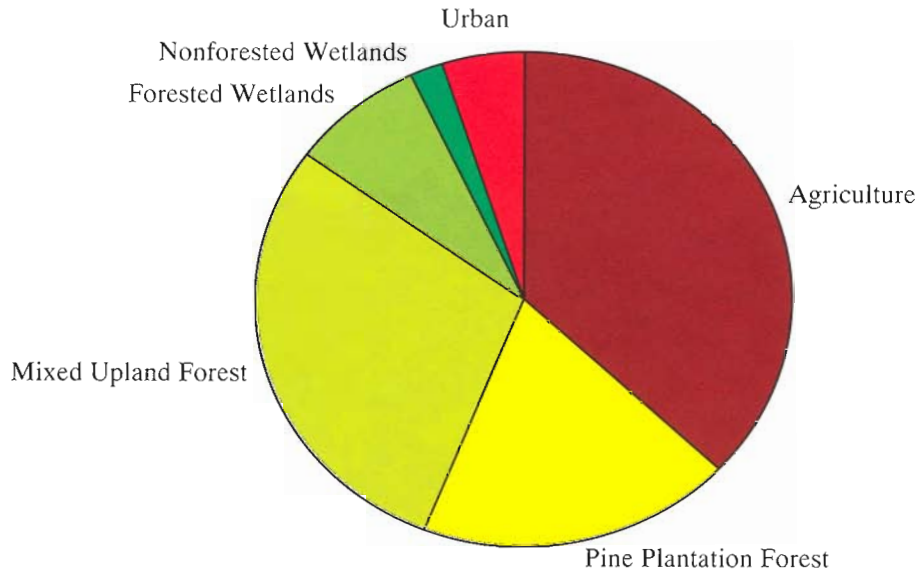
Figure 2-7. Land use and land cover map of the Edisto River Basin, 1989.

COVER TYPES





North Fork Subbasin - 1989 Land Use / Land Cover



<u>Land Use / Land Cover Types</u>	<u>Acres</u>	<u>Percent of Total Area</u>
Nonforested Wetlands		
Estuarine Wetland	0	0%
Palustrine Emergent Wetland	1,144	<1%
Palustrine Scrub-Shrub Wetland	3,783	<1%
Open Water	5,141	1%
Forested Wetland	40,448	8%
Upland Forest / Mixed	142,025	29%
Upland Forest / Pine Plantation	93,535	19%
Agriculture	178,277	37%
Urban	22,605	5%
Total Area	486,957	

Figure 2-8. North Fork subbasin: acreage and percentage of total subbasin for land use and land cover types, 1989. Source: SCWRC 1989 land use and wetlands data.

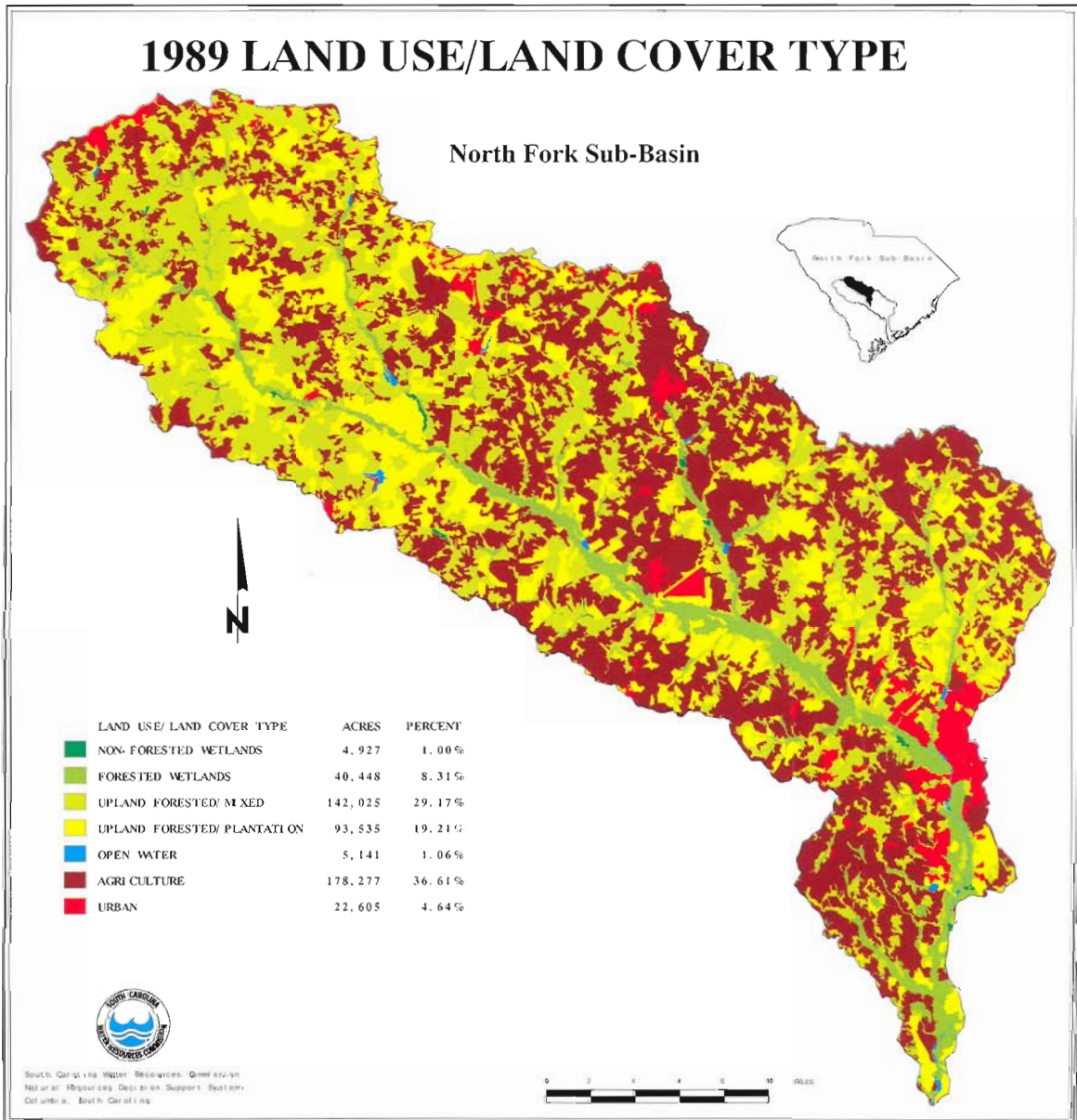
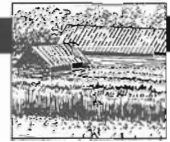
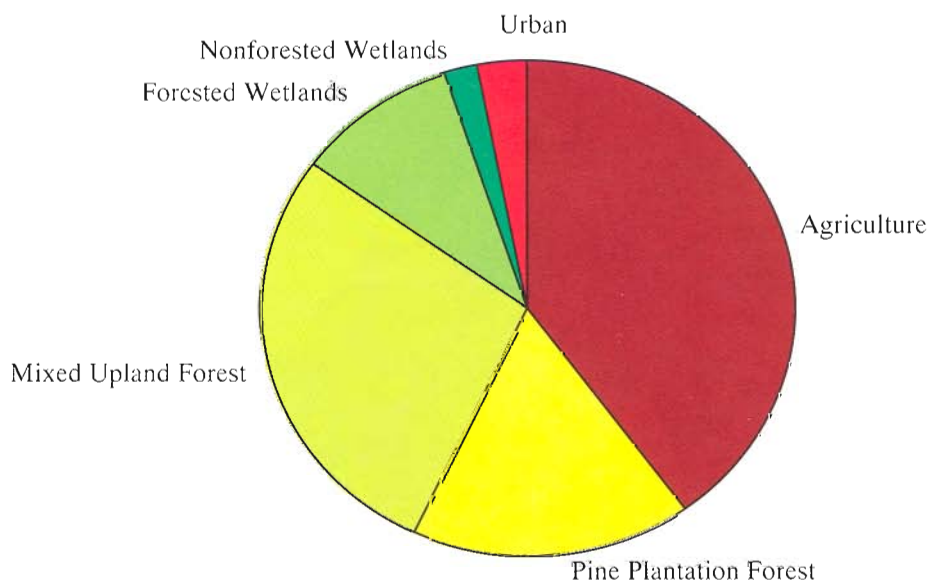


Figure 2-9. Land use and land cover map of the North Fork subbasin in the Edisto River Basin, 1989.



South Fork Subbasin - 1989 Land Use / Land Cover



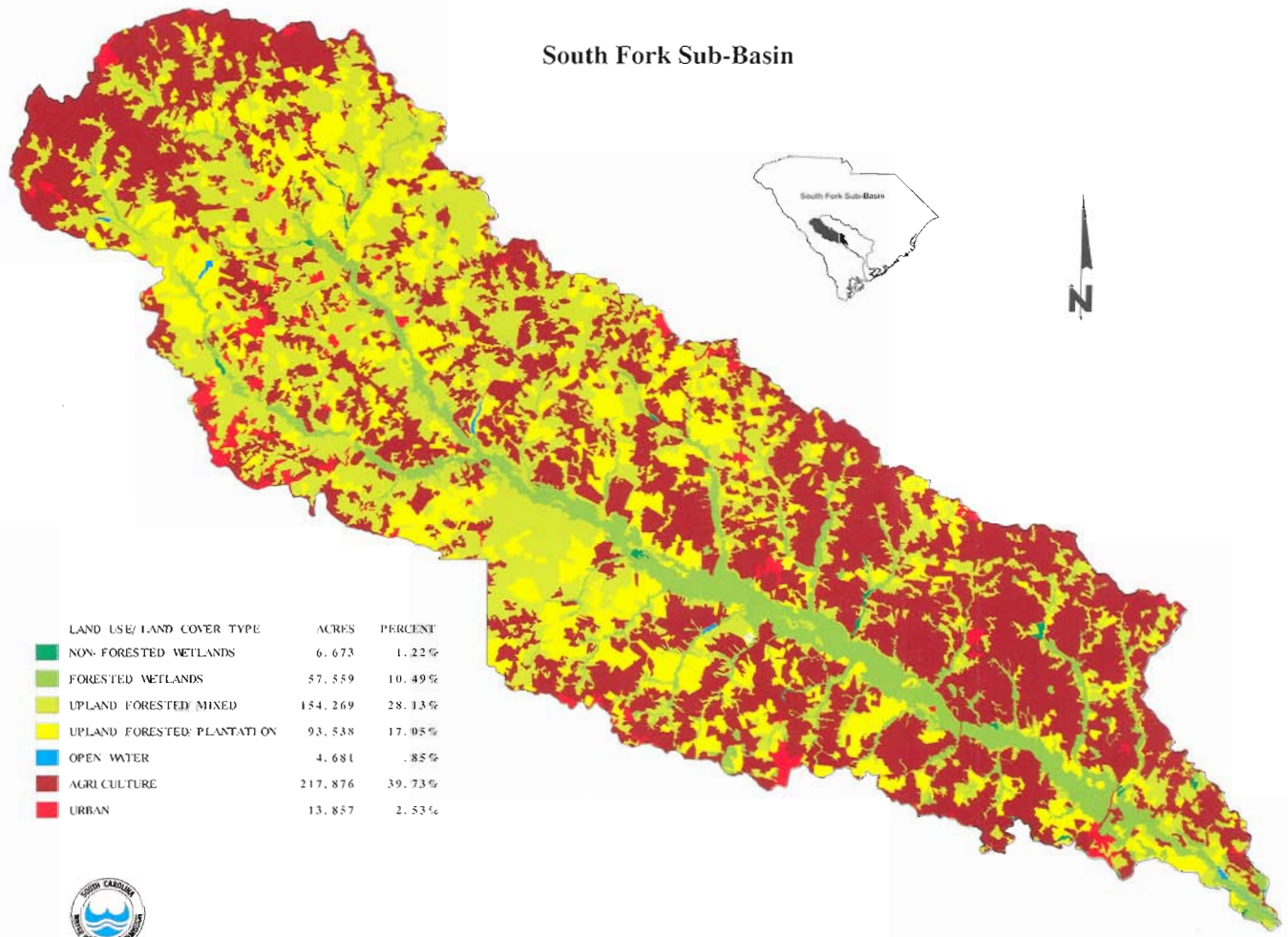
<u>Land Use / Land Cover Types</u>	<u>Acres</u>	<u>Percent of Total Area</u>
Nonforested Wetlands		
Estuarine Wetland	0	0%
Palustrine Emergent Wetland	1,698	<1%
Palustrine Scrub-Shrub Wetland	4,974	1%
Open Water	1,587	1%
Forested Wetland	57,559	10%
Upland Forest / Mixed	154,269	28%
Upland Forest / Pine Plantation	93,538	17%
Agriculture	217,875	40%
Urban	<u>13,856</u>	3%
Total Area	548,452	

Figure 2-10. South Fork subbasin: acreage and percentage of total subbasin for land use and land cover types, 1989. Source: SCWRC 1989 land use and wetlands data.



1989 LAND USE/LAND COVER TYPES

South Fork Sub-Basin



LAND USE/ LAND COVER TYPE	ACRES	PERCENT
NON- FORESTED WETLANDS	6, 673	1. 22%
FORESTED WETLANDS	57, 559	10. 49%
UPLAND FORESTED MIXED	154, 269	28. 13%
UPLAND FORESTED PLANTATION	93, 538	17. 05%
OPEN WATER	4, 681	. 85%
AGRI CULTURE	217, 876	39. 73%
URBAN	13, 857	2. 53%



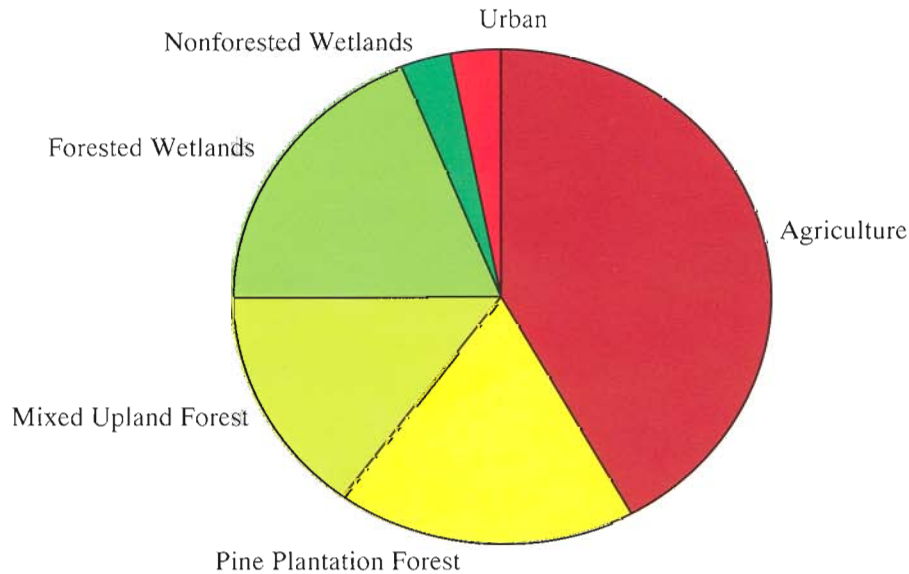
South Carolina Water Resources Commission
 Natural Resources Decision Support System
 Columbia, South Carolina



Figure 2-11. Land use and land cover map of the South Fork subbasin in the Edisto River Basin, 1989.



Four Hole Swamp Subbasin - 1989 Land Use / Land Cover



<u>Land Use / Land Cover Types</u>	<u>Acres</u>	<u>Percent of Total Area</u>
Nonforested Wetlands		
Estuarine Wetland	0	0%
Palustrine Emergent Wetland	1,502	<1%
Palustrine Scrub-Shrub Wetland	7,354	2%
Open Water	1,902	<1%
Forested Wetland	78,068	19%
Upland Forest / Mixed	60,370	15%
Upland Forest / Pine Plantation	72,511	18%
Agriculture	167,108	42%
Urban	13,607	3%
Total Area	402,424	

Figure 2-12. Four Hole Swamp subbasin: acreage and percentage of total subbasin for land use and land cover types, 1989.
Source: SCWRC 1989 land use and wetlands data.

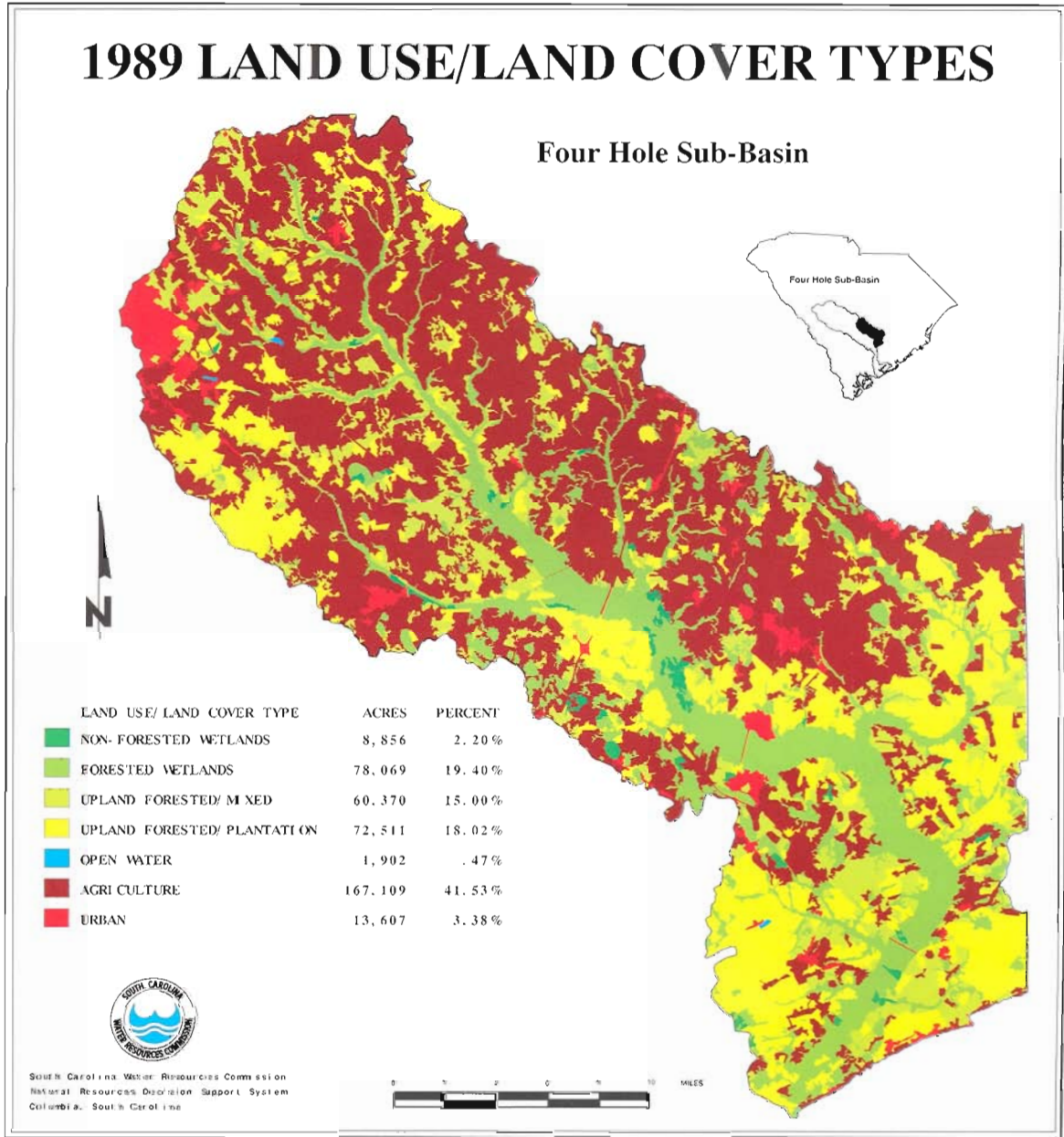
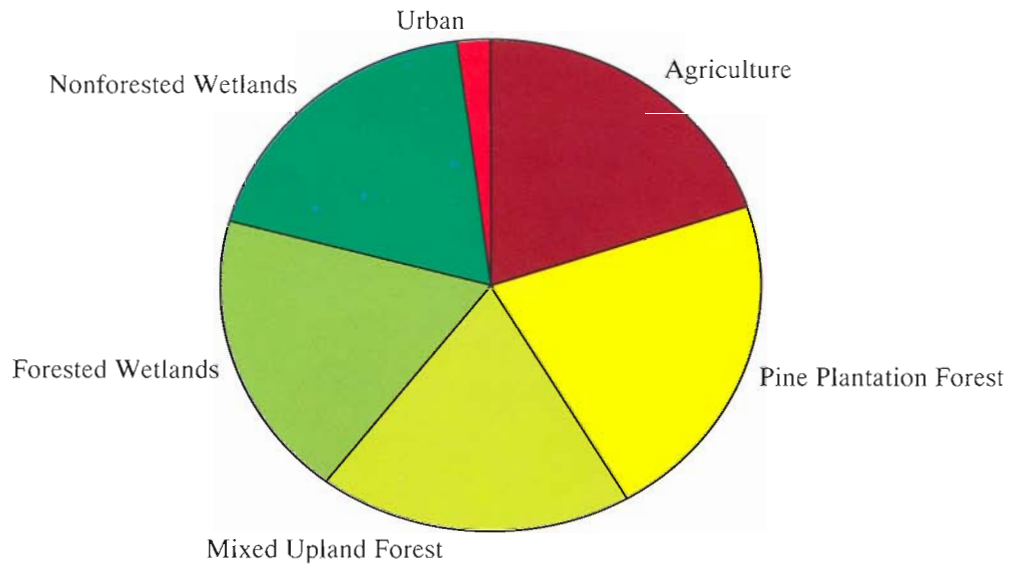


Figure 2-13. Land use and land cover map of the Four Hole Swamp subbasin in the Edisto River Basin, 1989.



Main Stem Subbasin - 1989 Land Use / Land Cover



<u>Land Use / Land Cover Types</u>	<u>Acres</u>	<u>Percent of Total Area</u>
Nonforested Wetlands		
Estuarine Wetland	44,730	8%
Palustrine Emergent Wetland	8,486	2%
Palustrine Scrub-Shrub Wetland	12,073	2%
Open Water	35,527	7%
Forested Wetland	102,814	19%
Upland Forest / Mixed	101,525	19%
Upland Forest / Pine Plantation	117,977	22%
Agriculture	107,862	20%
Urban	<u>13,619</u>	2%
Total Area	544,613	

Figure 2-14. Edisto (main stem) subbasin: acreage and percentage of total subbasin for land use and land cover types, 1989. Source: SCWRC 1989 land use and wetlands data.

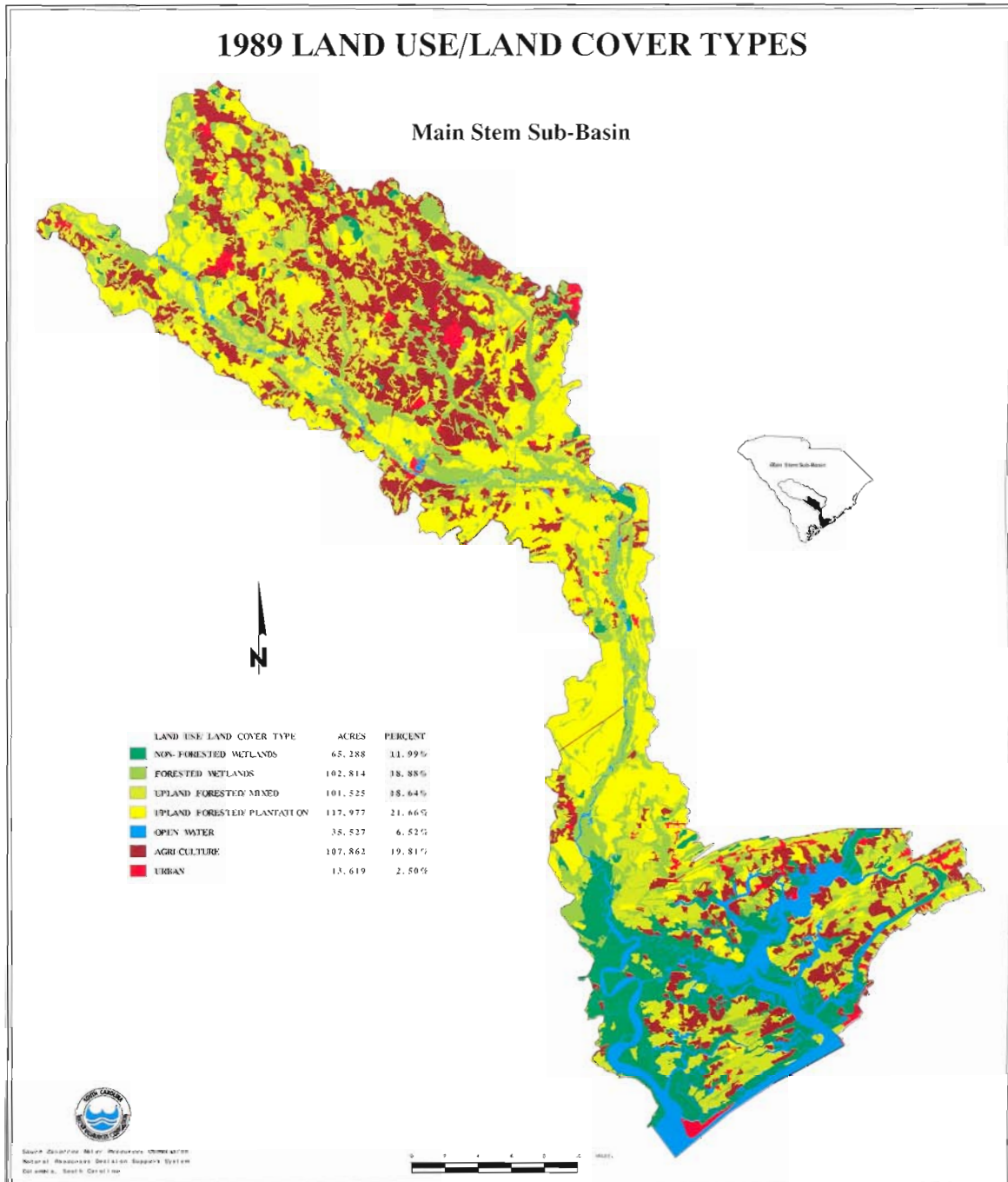


Figure 2-15. Land use and land cover map of the main stem subbasin in the Edisto River Basin, 1989.



Changes in Wetland Resources

The National Wetlands Inventory data were derived from color infrared photography and primarily represent existing native wetland vegetation and surface water. Based on the 1989 National Wetlands Inventory (NWI) data, the Edisto River Basin contained 364,634 acres of wetland habitats, an area equal to approximately 18 percent of the region. Three-quarters of these wetland habitats were palustrine forests. Table 2-1 describes the proportion of general wetland types found in the Basin.

Table 2-1. 1989 National Wetlands Inventory acreage for the Edisto River Basin.

Wetlands of the Edisto River Basin	Acres	% of total wetlands
Palustrine (freshwater) Forested Wetlands	278,889	76%
Estuarine (salt and brackish water) Wetlands	44,730	12%
Palustrine (freshwater) Scrub-Shrub Wetlands	28,184	8%
Palustrine (freshwater) Emergent (herbaceous) Wetlands	12,831	4%
Total Wetlands in 1989	364,634*	

* Total wetland acreage equals 18 percent of the total Basin area of approximately 2 million acres.

The wetland habitats of the Edisto River Basin have been affected by a variety of human land use activities. Some of these activities have resulted in a loss of area for native wetland vegetation because of conversion to other land uses and cover. Evaluating the extent of a selected set of the hydric soils in the Edisto River Basin (see "Methods" for an explanation of how the selected set was determined) provides an indication of the historical extent of native wetland vegetation. Assuming that the selected set of hydric soils chosen for this analysis is a conservative indicator of the historical extent of native wetland vegetation, then the 1989 wetland acreage compared to the hydric soil acreage suggests a conversion of roughly 39 percent of the Basin's native wetland vegetation has occurred (Figure 2-16). Comparing these data for the subbasins suggests that the greatest wetland vegetation conversions have occurred in the main stem and Four Hole Swamp — a conversion of 41 percent and 45 percent of former native wetland vegetation acreage respectively.

Note that the historical conversions indicated by the hydric soils analysis refer to habitat changes from "native wetland vegetation" to other land uses and cover types, and not necessarily to the hydrologic changes associated with filling, ditching, draining, or impounding wetlands. Some of these areas of lost native wetland vegetation may still retain saturated soil conditions (i.e. hydric soils), and depending upon the new land use, may continue important wetland ecological processes. However, food web support and biological diversity would certainly be altered by the conversion of native wetland vegetation to other cover types.

Land Uses on Hydric Soils

Comparing the selected set of hydric soils overlaid with the 1989 SCWRC land use and wetlands data provides an acreage estimate of the total conversion of native wetland vegetation to various types of land use practices in the Basin. Table 2-2 shows the results of the overlay of these two data layers. Aside from the wetlands (which were obviously expected), upland forests and pine plantations were the predominant land use/cover associated with the extent of hydric soils; these were followed by agriculture. When comparing the subbasins, agriculture, pine plantation, and urban land (the more intensive land uses) were associated with a greater portion of the hydric soils in Four Hole Swamp (36 percent of the hydric soils) followed by the main stem (at 28 percent), then the North Fork (at 20 percent) and the South Fork (at 18 percent). The large acreage of upland forests found on hydric soils may seem odd; however, these areas could represent drained wetland areas that were abandoned to natural forest succession, leading to the establishment of a mixed upland forest community on former wetlands. Mapping and classification errors also may have affected these results. The areas identified as upland forests may have actually been pine plantation forests, possibly even wetland forests. Also, a minor portion of the soils may be misidentified.



Disparity between the wetlands and soils data was evident when comparing the two data sets. For the entire Basin about 54,500 acres (or 15 percent) of the NWI wetlands did not correspond with any of the hydric soils in the overlay process. Of the 54,500 acres not associated with hydric soils, 79 percent were forested wetlands, 11 percent were scrub-shrub wetlands, 6 percent were estuarine wetlands, and 4 percent were palustrine emergent wetlands. Part of this disparity could have been due to the selection of only a subset of the hydric soils for this analysis. Other reasons for the disparity are likely the fundamental differences in methods, dates and sources of raw data, and the overall purposes of developing the two different data bases. The discrepancy may also be due to the limitations and/or errors of photointerpretation for the NWI data where transitional and/or other areas could be misidentified. In spite of the disparities, major losses of wetland vegetation due to conversion to other land uses are evident.

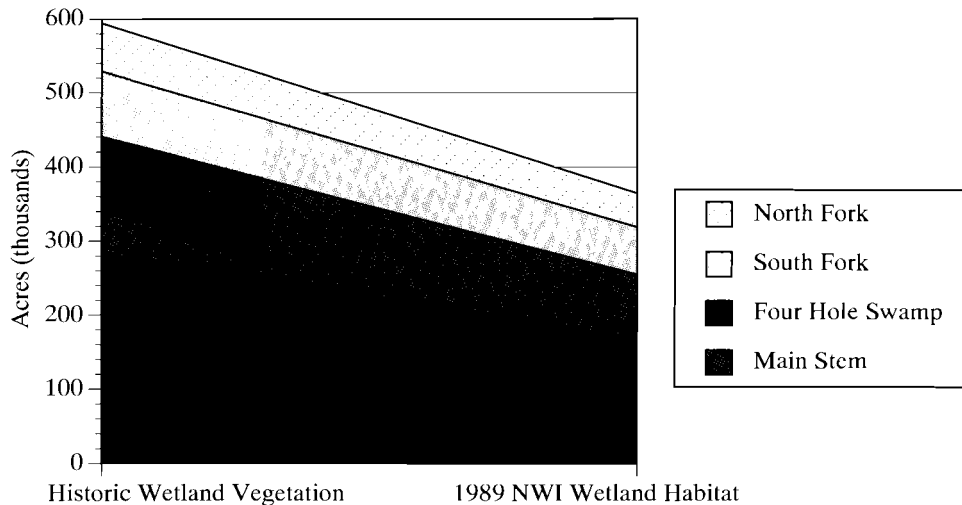


Figure 2-16. Historic acreage of native wetland vegetation (as indicated by a selected set of hydric soils) compared to 1989 National Wetlands Inventory for the Edisto River Basin.

Subbasins of Edisto Basin	Historic Wetland Veg. (hydric soils)*		1989 Wetlands		
	Acreage	% of total	Acreage	% of total	% change
North Fork	65,584	11%	45,375	12%	- 31%
South Fork	88,340	15%	64,232	18%	- 27%
Four Hole Swamp	157,043	26%	86,924	24%	- 45%
Edisto (main stem)	283,611	48%	168,103	46%	- 41%
Total Edisto River Basin	594,578		364,634		- 39%

* Date of soils data — about 68 percent of the Basin’s area was derived from soil surveys of the 1980s; most of remaining area was evenly split among soil surveys of the 1970s and the 1960s (See “Methods, Data Sources”).

Table 2-2. Area of different land use types found on a selected set of the hydric soils in the Edisto River Basin and subbasins.

Land Uses found on Hydric Soils	Acres of Hydric Soils and % of Total by Basin and Subbasin									
	Entire Basin		North Fork		South Fork		Four Hole		Main Stem	
		%		%		%		%		%
Wetlands / Water ^a	320,803	54%	38,020	58%	55,372	63%	73,358	47%	154,052	55%
Upland Forests	104,578	18%	14,414	22%	16,148	18%	26,276	17%	47,740	17%
Pine Plantations	98,984	17%	6,032	9%	5,852	6%	27,469	17%	59,631	21%
Agriculture	61,512	10%	5,910	9%	10,136	11%	27,237	17%	18,229	6%
Urban	8,702	1%	1,208	2%	832	1%	2,703	2%	3,959	1%
Total	594,578		65,584		88,340		157,043		283,611	

^a Water alone overlays about 10,700 acres or 1.8 percent of the hydric soils in the Basin



Changes in the Coastal Region

Comparing the 1989 NWI data with the 1981 NWI data that were available for 17 quadrangles in the coastal region indicated about a 5 percent loss in total acreage of native wetland vegetation over the 8-year period (Table 2-3). These data showed both increases and decreases in acreage for various types of wetland habitats. Because the 1989 and 1981 wetlands data were derived from different scales of photography, comparing the differences among the various wetland types can be subject to error. The 1989 data were derived from 1:40,000 scale photography while the 1981 data were from 1:58,000 scale photography. The differences in photo resolution affect the accuracy of quantifying absolute changes among the various wetland habitat types. Also variable conditions of ground saturation at the time of aerial photograph acquisition could lead to different results for wetland acreages. These data do, however, provide a basis for describing general patterns of change.

In general, the patterns of change among the native wetland vegetation in the coastal region indicated decreases in forested wetlands and increases in palustrine emergent and scrub-shrub wetlands. The acreage of estuarine wetlands appears to have remained relatively stable.

Table 2-3. Changes in wetlands in the coastal region of the Edisto River Basin from 1981 to 1989.

Wetlands of the Edisto Coastal Region	1981 Acres	1989 Acres	% change
Palustrine Forested Wetlands	82,735	71,355	- 14%
Estuarine Wetlands	43,999	44,730	+ 2%
Palustrine Emergent (herbaceous) Wetlands	6,325	7,778	+ 23%
Palustrine Scrub-Shrub Wetlands	4,682	7,330	+ 57%
Total Wetlands	137,741	131,193	- 5%

Altered Wetlands

About thirteen percent of the 1989 inventory of wetland habitats in the Edisto River Basin was in an altered condition due to diking and impounding or partial draining and ditching activities. Diked or impounded wetlands are created or modified by a constructed barrier or dam that obstructs the outflow of water (beaver dams are included). Partially drained or ditched wetlands are areas where the water level has been artificially lowered. Partially drained areas are still classified as wetlands because soil moisture is sufficient to support some hydrophytic species at the time of the inventory. The National Wetlands Inventory does not consider drained areas as wetlands if they no longer support hydrophytes (Cowardin 1979).

A summary of "altered wetlands" from the 1989 National Wetlands Inventory data (Table 2-4) provides acreage figures for impounded and partially drained wetlands. Overall, there were about 49,000 acres of altered wetlands in the Edisto River Basin. Slightly more than one-half of this acreage was impounded; the balance was partially drained.

Nearly 50 percent of the Edisto Basin's altered wetlands acreage was located in the main stem subbasin. Half of the altered wetlands of the main stem were found in impoundments and half were in partially drained conditions. Most of the main stem's coastal impoundments originated with the intertidal rice planting culture established in the 18th century, but are now maintained as waterfowl habitat. The partially drained wetlands are primarily a result of more recent agricultural and forestry practices.

Most of the altered wetland acreage of the North and South Fork subbasins was impounded. Most of these impounded wetlands were found in the headwaters streams where the relatively steep, narrow valleys in the sandhills make good farm pond sites. There were very few headwater streams without impoundments. In Four Hole Swamp most of the altered wetland acreage was partially drained due primarily to the relatively intensive agriculture development that has occurred in the subbasin.



Table 2-4. Altered Wetland in the Edisto River Basin and subbasins from 1989 National Wetlands Inventory data.

Subbasin	Altered Wetland Types	# of sites	Acreage	Total Acreage
Edisto (main stem)	Diked / impounded			11,557
	Palustrine Nonforest	225	5,854	
	Palustrine Forested	95	1,437	
	Lacustrine	7	168	
	Estuarine	115	4,098	
	Partially drained / ditched			12,484
	Palustrine Nonforest	358	4,147	
	Palustrine Forested	613	8,324	
	Lacustrine	0	0	
	Estuarine	1	13	
North Fork	Diked / impounded			6,607
	Palustrine Nonforest	1,917	4,155	
	Palustrine Forested	309	963	
	Lacustrine	54	1,489	
	Partially drained / ditched			502
	Palustrine Nonforest	68	218	
Palustrine Forested	33	284		
South Fork	Diked / impounded			6,052
	Palustrine Nonforest	1,677	4,152	
	Palustrine Forested	368	1,002	
	Lacustrine	47	898	
	Partially drained / ditched			2,012
	Palustrine Nonforest	147	815	
Palustrine Forested	116	1,197		
Four Hole Swamp	Diked / impounded			1,431
	Palustrine Nonforest	285	716	
	Palustrine Forested	89	373	
	Lacustrine	9	342	
	Partially drained / ditched			8,509
	Palustrine Nonforest	229	1,705	
Palustrine Forested	562	6,804		
Entire Edisto River Basin	Diked / impounded			25,647
	Partially drained / ditched			23,507
	Edisto River Basin Total			49,154



Stream-Edge Habitat

The land use and land cover adjacent to the stream edges of the Edisto River Basin was determined from a 250-meter buffer and a 120-meter buffer of the Basin's stream network. The buffered streams were then overlaid on the 1989 land use and wetlands data. Figure 2-17 and Tables 2-5 and 2-6 show the results of this procedure grouped by the stream-order and subbasins.

For the entire Edisto River Basin, the 250-meter stream-edge buffer area was in 75 percent natural cover (see Table 2-5). The stream edges consisted of 52 percent natural forestland (forested wetlands + mixed upland forest), 14 percent open water and nonforested wetlands, and 9 percent estuarine wetlands. The intensively managed land use categories of urban, agriculture, and pine plantations covered a total of 25 percent of the stream-edge buffers in the Basin; 15 percent was in agricultural land, 8 percent in pine plantations, and 2 percent in urban land uses. The 120-meter buffer results (Table 2-6) showed proportionally more natural cover (85 percent) and less of the intensive land uses (15 percent) compared with the 250-meter buffer. The 120-meter analysis evaluated a narrower strip of land along the Basin's stream edges compared with the 250-meter analysis. The net result was that upland land uses and cover types (including the intensive land uses) were proportionally reduced and the wetland cover types were increased with the 120-meter buffer analysis of the Basin.

The proportion of the different land uses within the stream-edge buffers varied among the four subbasins (Figure 2-17). Wetland forests were a major component of the stream edges of the North Fork, South Fork, and Four Hole Swamp subbasins; each with 40+ percent forested wetlands in the 250-meter buffer, and 60+ percent in the 120-meter buffer. Stream edges of the main stem, however, were covered with mostly nonforested and estuarine wetlands. Within the 250-meter buffer, mixed upland forests were more prevalent in stream-edge buffers of the North and South Fork (25 percent and 29 percent, respectively) due to greater relief and better drainage, compared to Four Hole Swamp and the main stem subbasins (13 percent and 15 percent, respectively) that have relatively flat terrain. However, the 120-meter buffer analysis showed much more similar proportions of mixed upland forests among the subbasins.

Both the 250-meter and the 120-meter buffer analysis of the Edisto Basin's third-order streams (small streams) and fourth-order streams (medium streams) showed that agricultural land was most extensive along these stream edges in the Four Hole Swamp subbasin. The 250-meter analysis, in particular, showed that agriculture was the predominant land cover type found adjacent to the small streams of Four Hole Swamp subbasin, and the intensive land uses covered more than half of its small stream buffers. In contrast however, among all the large streams of the Edisto Basin, the Four Hole Swamp subbasin had the smallest portion of intensive land uses. This is because of its uniquely wide and saturated floodplain. Basin-wide, the South Fork subbasin seemed to have had stream-edge habitats that were in the best condition overall. This was indicated by the relatively low proportion of intensive land uses found in stream buffers of the South Fork among the different stream-size categories.

Among the four subbasins, mixed upland forested stream edge was consistently greater in the North and South Forks along the small and medium size streams. Forested wetland stream edges were most extensive on the small and medium streams of the main stem and Four Hole Swamp, and on the large streams of Four Hole Swamp. Pine plantations were found to be most extensive on the edges of the small and medium streams of the main stem subbasin. The largest proportion of open water and nonforested wetland stream edges and all of the estuarine wetland edges were found along the large streams of the main stem subbasin. These were primarily the major streams of the intertidal system.

Human impacts on stream-edge habitats seem to have been greatest in the Four Hole Swamp subbasin, primarily along its creeks and small streams (third-order streams). Overall, the proportion of agricultural land within the 250-meter stream-edge buffers was greatest in the Four Hole Swamp subbasin; with 26 percent compared to only 12 percent in the other three subbasins. The more intensively managed land use categories of urban, agriculture, and pine plantations covered a total of 38 percent of the stream-edge buffers in the Four Hole Swamp subbasin compared to the other subbasins that ranged from 21 percent to 26 percent. Results from the 120-meter buffer analysis confirmed that stream edges of the Four Hole Swamp subbasin exhibit the greatest human impacts. However the 120-meter analysis also revealed that, overall, the main stem stream edges contained the same proportion of agricultural land as the Four Hole Swamp subbasin.



Table 2-5. Percentage of land use and land cover types bordering stream edges in the Edisto River Basin within a 250-meter buffer (125 meters from each side of stream).

All Streams (Third- and Larger-Order Streams)					
Land Use/Cover	Entire Basin	North Fork	South Fork	Four Hole	Main Stem
Agriculture	15%	12%	12%	26%	12%
Urban	2%	3%	1%	2%	2%
Upland Forest / mixed	19%	25%	29%	13%	15%
Forest / Pine Plantation	8%	11%	9%	10%	7%
Palustrine Forested Wetland	33%	42%	43%	44%	21%
Open Water & Nonforest Wtld.	14%	7%	6%	4%	24%
Estuarine Wetland	9%	—	—	—	19%
<i>Intensive Land Uses</i> ^a	25%	26%	22%	38%	21%

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Third-Order Streams* / Small Streams					
Land Use/Cover	Entire Basin	North Fork	South Fork	Four Hole	Main Stem
Agriculture	24%	18%	17%	37%	26%
Urban	2%	2%	1%	2%	2%
Upland Forest / mixed	28%	33%	39%	16%	21%
Forest / Pine Plantation	14%	13%	12%	14%	18%
Palustrine Forested Wetland	27%	26%	26%	28%	30%
Open Water & Nonforest Wtld.	5%	8%	6%	3%	3%
<i>Intensive Land Uses</i>	40%	31%	30%	55%	40%

Fourth-Order Streams** / Medium Streams					
Land Use/Cover	Entire Basin	North Fork	South Fork	Four Hole	Main Stem
Agriculture	15%	11%	10%	29%	11%
Urban	2%	4%	1%	4%	1%
Upland Forest / mixed	20%	26%	25%	16%	13%
Forest / Pine Plantation	11%	11%	9%	9%	16%
Palustrine Forested Wetland	45%	37%	48%	39%	54%
Open Water & Nonforest Wtld.	7%	11%	7%	4%	6%
<i>Intensive Land Uses</i>	28%	26%	20%	42%	28%

Fifth-Order and Greater Streams*** / Large Streams					
Land Use/Cover	Entire Basin	North Fork	South Fork	Four Hole	Main Stem
Agriculture	8%	3%	4%	3%	10%
Urban	2%	3%	2%	1%	2%
Upland Forest / mixed	13%	11%	11%	5%	14%
Forest / Pine Plantation	4%	7%	4%	4%	3%
Palustrine Forested Wetland	32%	72%	76%	83%	14%
Open Water & Nonforest Wtld.	23%	5%	3%	4%	31%
Estuarine Wetland	18%	—	—	—	26%
<i>Intensive Land Uses</i>	14%	13%	10%	8%	15%

^a Intensive Land Uses = agriculture + urban + pine plantation land uses.

*** Fifth-order and greater (large-order streams) — the primary river segments and the major intertidal rivers and creeks labeled on the 1:24,000 scale maps.

** Fourth-order streams — generally, the primary tributaries of the river system and the major creeks that feed into the rivers (fifth-order) mentioned above.

* Third-order streams — generally, the tributaries of the major creeks of the Basin.



Table 2-6. Percentage of land use and land cover types bordering stream edges in the Edisto River Basin within a 120-meter buffer (60 meters from each side of stream).

All Streams (Third- and Larger-Order Streams)					
Land Use/Cover	Entire Basin	North Fork	South Fork	Four Hole	Main Stem
Agriculture	9%	5%	5%	11%	11%
Urban	2%	2%	1%	2%	2%
Upland Forest / mixed	14%	13%	16%	8%	15%
Forest / Pine Plantation	4%	5%	4%	7%	3%
Palustrine Forested Wetland	33%	60%	63%	67%	16%
Open Water & Nonforest Wtld.	27%	15%	11%	6%	36%
Estuarine Wetland	11%	—	—	—	18%
<i>Intensive Land Uses</i> ^a	15%	12%	10%	20%	16%
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Third-Order Streams* / Small Streams					
Land Use/Cover	Entire Basin	North Fork	South Fork	Four Hole	Main Stem
Agriculture	11%	8%	7%	19%	11%
Urban	2%	2%	1%	2%	2%
Upland Forest / mixed	19%	21%	25%	12%	19%
Forest / Pine Plantation	9%	7%	6%	11%	15%
Palustrine Forested Wetland	48%	44%	47%	51%	51%
Open Water & Nonforest Wtld.	11%	18%	14%	5%	3%
<i>Intensive Land Uses</i>	22%	17%	14%	32%	28%
Fourth-Order Streams** / Medium Streams					
Land Use/Cover	Entire Basin	North Fork	South Fork	Four Hole	Main Stem
Agriculture	5%	4%	3%	9%	2%
Urban	2%	3%	1%	4%	1%
Upland Forest / mixed	9%	12%	12%	7%	4%
Forest / Pine Plantation	5%	5%	2%	5%	9%
Palustrine Forested Wetland	67%	55%	68%	69%	76%
Open Water & Nonforest Wtld.	12%	22%	13%	6%	8%
<i>Intensive Land Uses</i>	12%	12%	6%	18%	12%
Fifth-Order and Greater Streams*** / Large Streams					
Land Use/Cover	Entire Basin	North Fork	South Fork	Four Hole	Main Stem
Agriculture	9%	0%	2%	0%	11%
Urban	2%	2%	1%	1%	2%
Upland Forest / mixed	13%	3%	4%	1%	15%
Forest / Pine Plantation	2%	1%	2%	1%	2%
Palustrine Forested Wetland	22%	87%	88%	91%	10%
Open Water & Nonforest Wtld.	35%	7%	3%	6%	40%
Estuarine Wetland	17%	—	—	—	21%
<i>Intensive Land Uses</i>	13%	3%	5%	2%	15%

^a Intensive Land Uses = agriculture + urban + pine plantation land uses.

*** Fifth-order and greater (large-order streams) — the primary river segments and the major intertidal rivers and creeks labeled on the 1:24,000 scale maps.

** Fourth-order streams — generally, the primary tributaries of the river system and the major creeks that feed into the rivers (fifth-order) mentioned above.

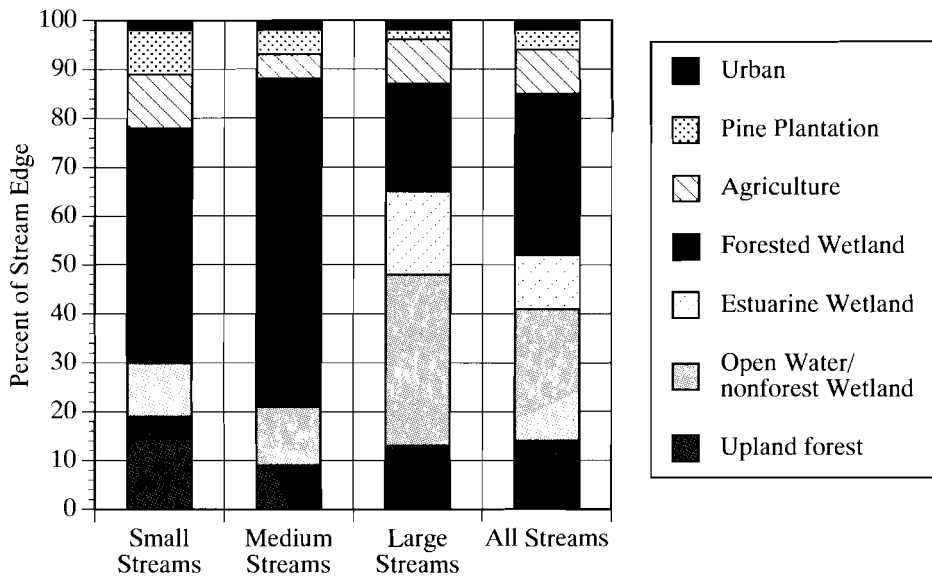


Figure 2-17. Percentage of land use and cover types bordering stream edges within a 120 meter buffer (60 meters on each side of stream) for the Edisto River Basin. Small Streams = third-order streams; Medium Streams = fourth-order streams; and Large Streams = fifth-order and greater streams.

* Third-order streams — generally, the tributaries of the major creeks of the Basin.

Forest Patch Analysis

The sizes and frequency of forest patches were determined for each of the four subbasins, and for the entire Edisto Basin using SCWRC 1989 land use and wetlands data. The categories of forest included in the patch analysis of the subbasins were total forest, total forest excluding planted pine forest (hereafter referred to as “native forest”), and forested wetland (see “Methods” for definition of categories). Total forest was the only category where the forest cover for all the subbasins was merged and analyzed for the entire Edisto River Basin.

The area of total forest for the Edisto Basin was 1,112,600 acres (56 percent of the Basin) and was distributed among 4,025 patches. Most of the patches for total forest were small (less than 25 acres) and, proportionally, the small patches occupied relatively little total area. The majority of the Basin’s forest area was found in a few very large patches: 5 patches that were each over 50,000 acres in size contained over 70 percent of the Basin’s total forest area; one patch, the largest, was nearly 376,000 acres in size (see Figure 2-19). Subbasin analyses of total forest patch sizes and frequencies for the North and South Fork (see Figure 2-20) showed a similar pattern — most of the total forest area was found in a few very large patches. Total forest area in the Four Hole Swamp and the main stem subbasins was a little more distributed among the various patch size classes but was still predominantly associated with large patches.

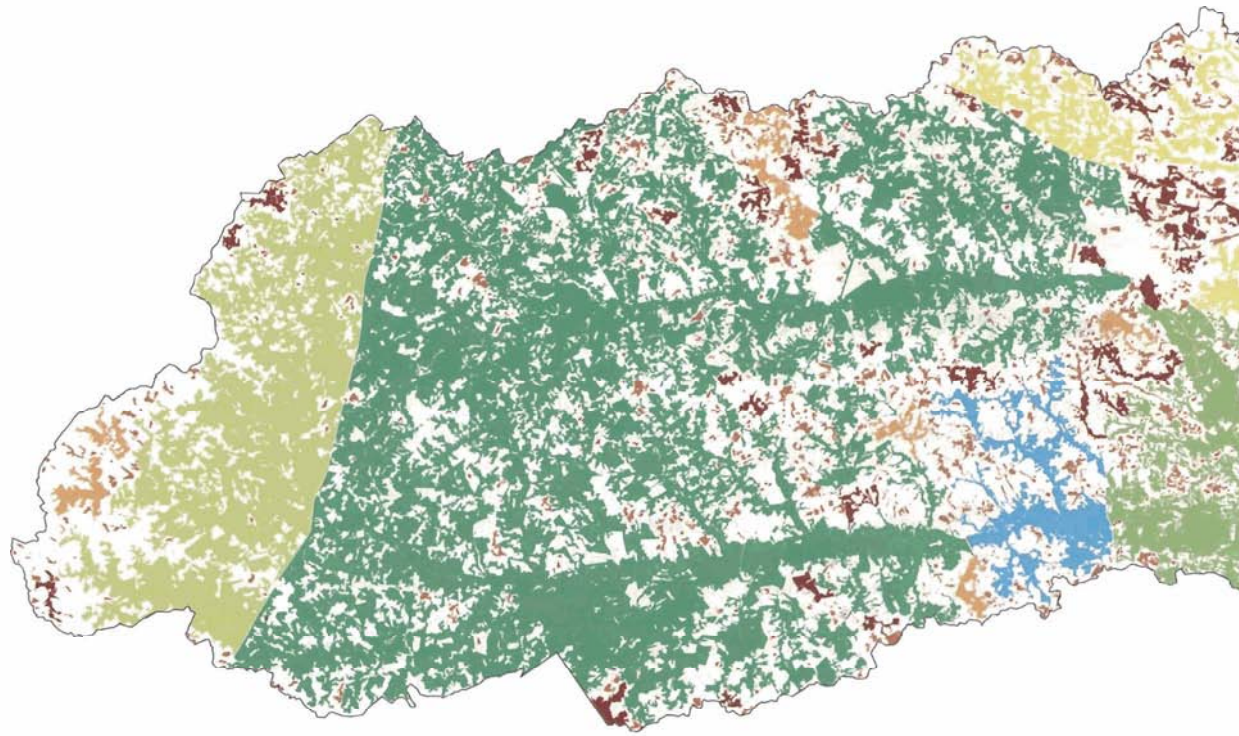
The appearance of very large patches from this analysis is misleading because it suggests large blocks of forest, providing an abundance of isolated interior forest habitats. Figure 2-18 shows that the forest patch pattern is characterized more accurately as an irregular, or in some cases dendritic, pattern of forested corridors.

The native forest category (total forest excluding planted pine forest) was more patchy than was the total forest. Native forests covered 735,800 acres of the Basin and was distributed among 7,738 patches, nearly twice the patches of total forest. The total area of native forest was more distributed among the different patch size categories than for total forest (see Figure 2-21). However, most of the patches were still among the smallest size category (less than 25 acres). The North Fork had one native forest patch that exceeded 100,000 acres. Forested wetland was the most patchy category of the three forest coverages analyzed. Forested wetland covered 279,000 acres with 11,594 patches. As with the other analyses, most of the patches were less than 25 acres in size. No large (25 to 200 thousand acres) forested wetland patches were found. The largest forested wetland patch was a 13,000 acre area located in Four Hole Swamp (see Table 2-7).



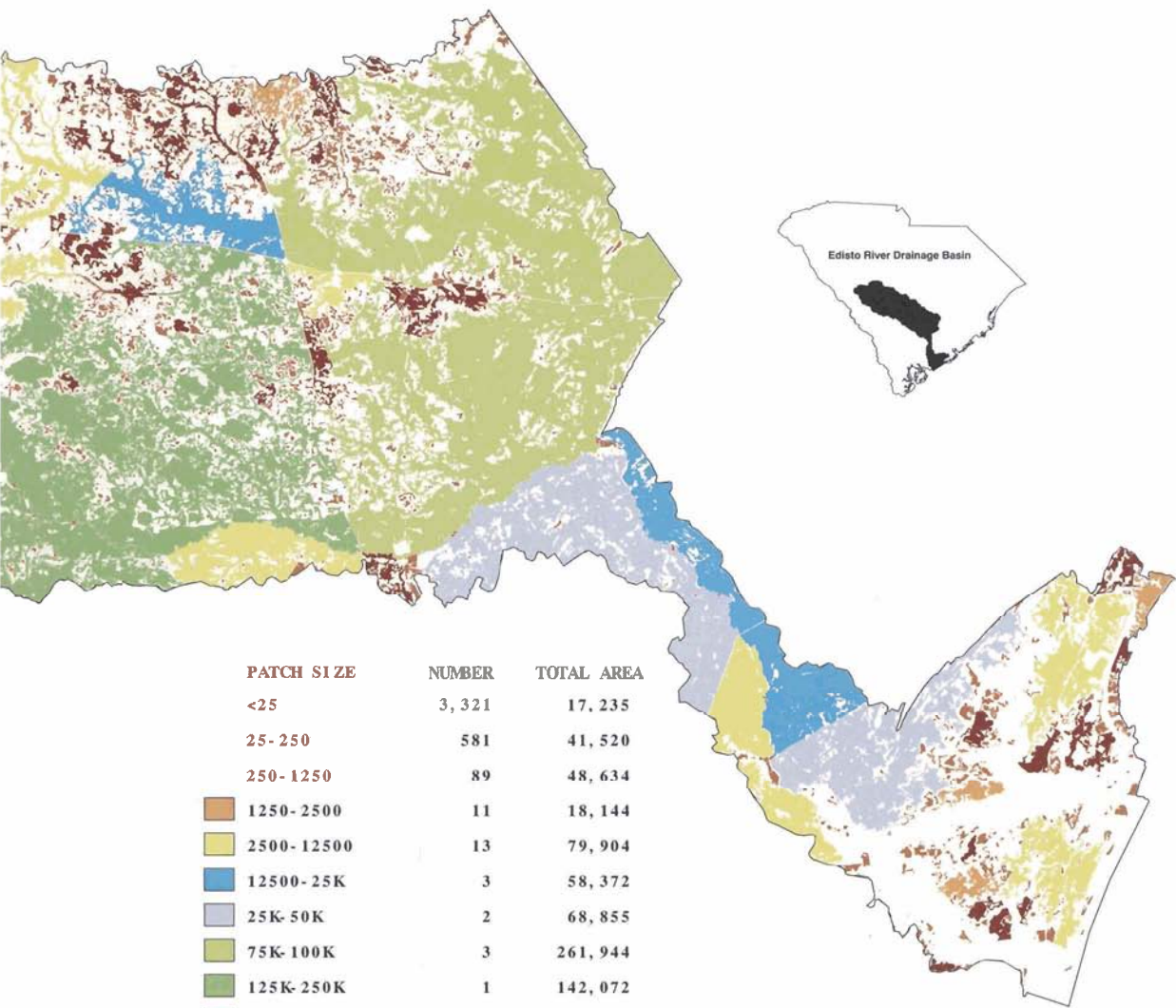
1989 FOREST PATCH CATEGORIES

Edisto River Drainage Basin



South Carolina Water Resources Commission
Natural Resources Decision Support System
Columbia, South Carolina

Figure 2-18. Distribution of forest patches (total forest) in the Edisto River Basin, showing patches by size categories, 1989.



PATCH SIZE	NUMBER	TOTAL AREA
<25	3,321	17,235
25-250	581	41,520
250-1250	89	48,634
1250-2500	11	18,144
2500-12500	13	79,904
12500-25K	3	58,372
25K-50K	2	68,855
75K-100K	3	261,944
125K-250K	1	142,072
>250K	1	375,923





Edisto River Basin Forest Patches - Total Forest

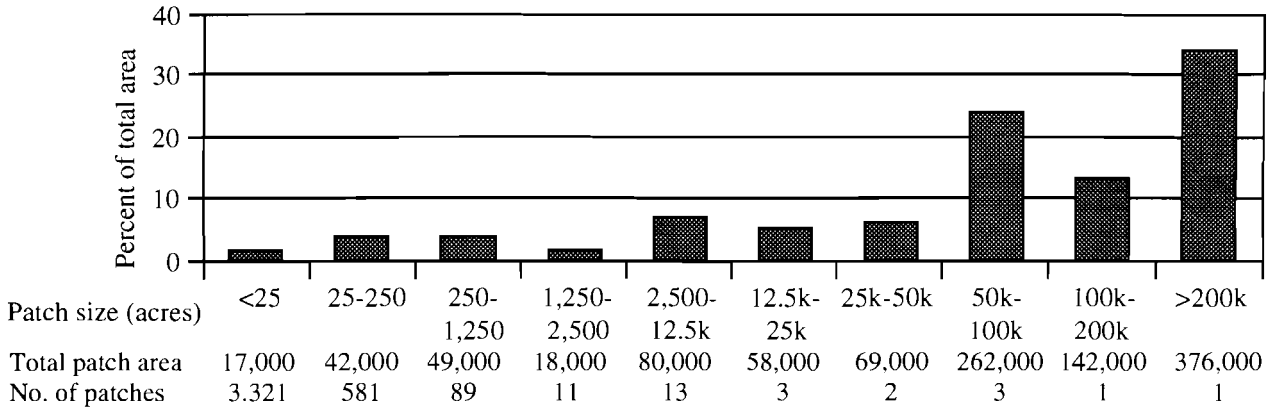


Figure 2-19. Forest patch size categories for total forest cover, presented as percentage of the total Basin area with total patch area and total number of patches given for each size category. (k = thousands)

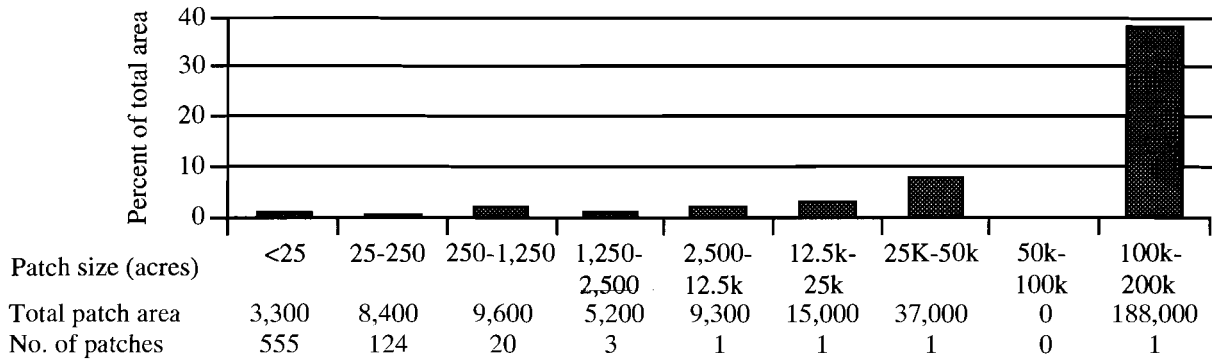
Table 2-7. Forest patch size categories for forested wetlands by percentage of subbasin area, total patch area (acres), and total number of patches for each size category.

Patch size (acres) Categories	<25	25-250	250-1,250	1,250-2,500	2,500-12.5k	12.5k-25k	25k-50k	50k-100k	100k-200k
North Fork									
Percent of area	1.5	2.5	1.5	1.4	1.4	0	0	0	0
Total patch area	7,100	12,000	7,400	6,900	7,000	0	0	0	0
No. of patches	1,470	193	15	4	2	0	0	0	0
South Fork									
Percent of area	1.5	2.7	2.0	1.5	2.8	0	0	0	0
Total patch area	8,500	15,000	11,000	8,400	15,000	0	0	0	0
No. of patches	1,738	216	20	5	3	0	0	0	0
Four Hole Swamp									
Percent of area	3.0	4.9	4.0	2.6	1.8	3.1	0	0	0
Total patch area	12,000	20,000	16,000	10,000	7,100	13,000	0	0	0
No. of patches	2,656	294	34	6	2	1	0	0	0
Main Stem									
Percent of area	2.9	6.5	6.2	1.6	1.7	0	0	0	0
Total patch area	16,000	35,000	34,000	8,900	9,100	0	0	0	0
No. of patches	4,398	471	59	5	2	0	0	0	0

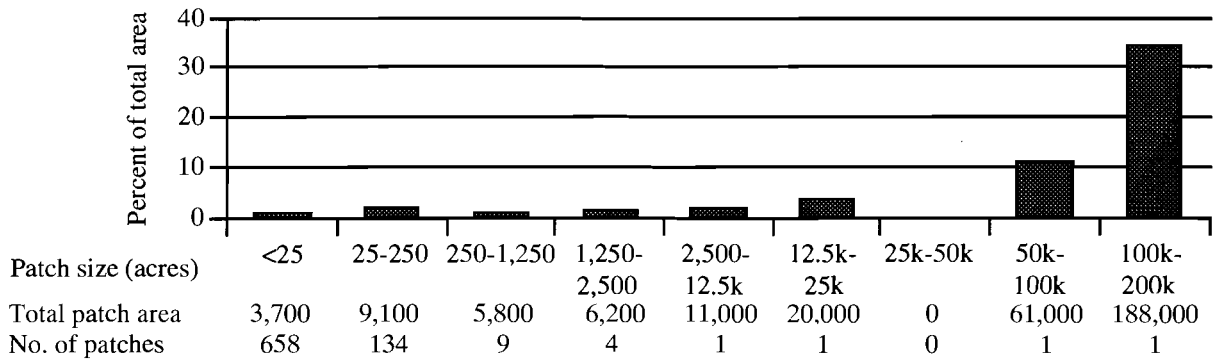
(k = thousands)



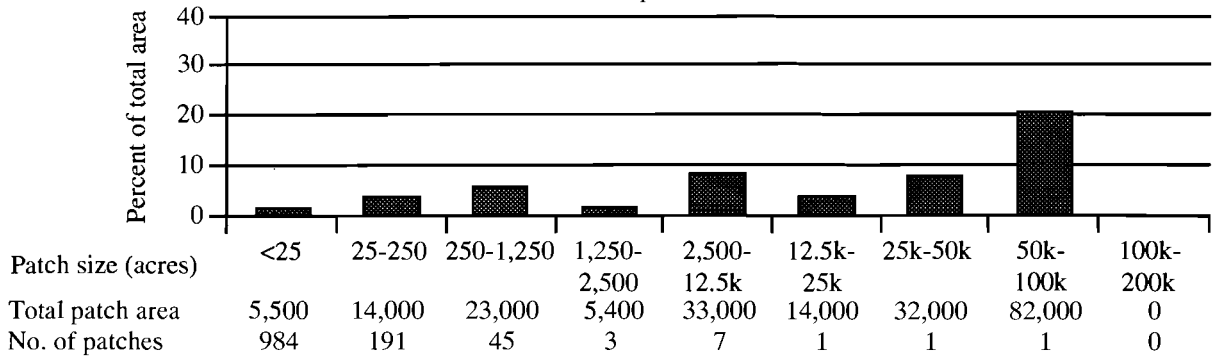
North Fork Subbasin - Total Forest



South Fork Subbasin - Total Forest



Four Hole Swamp Subbasin - Total Forest



Main Stem Subbasin - Total Forest

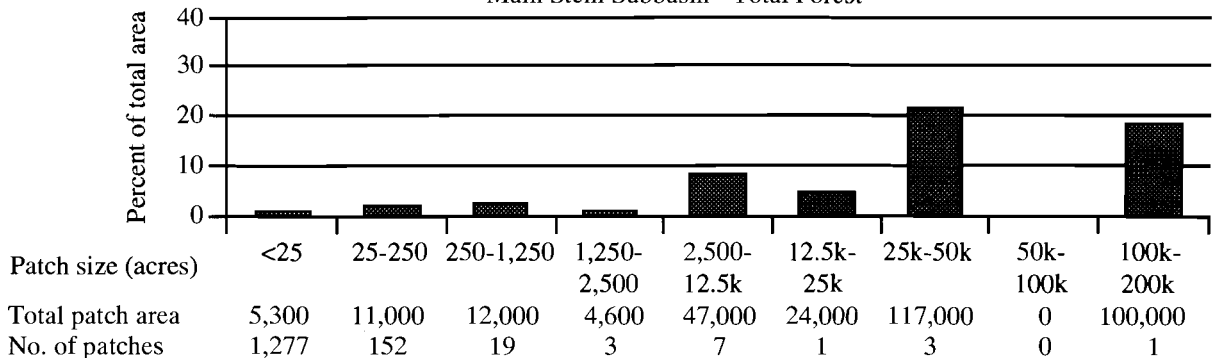
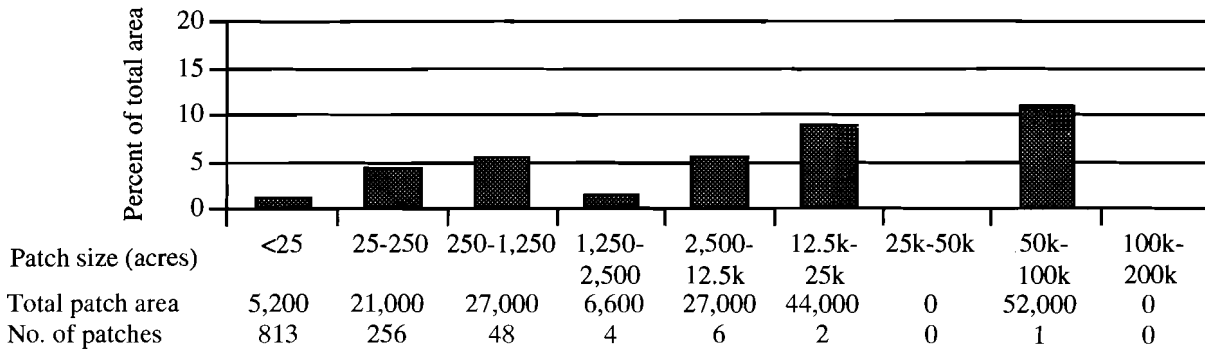


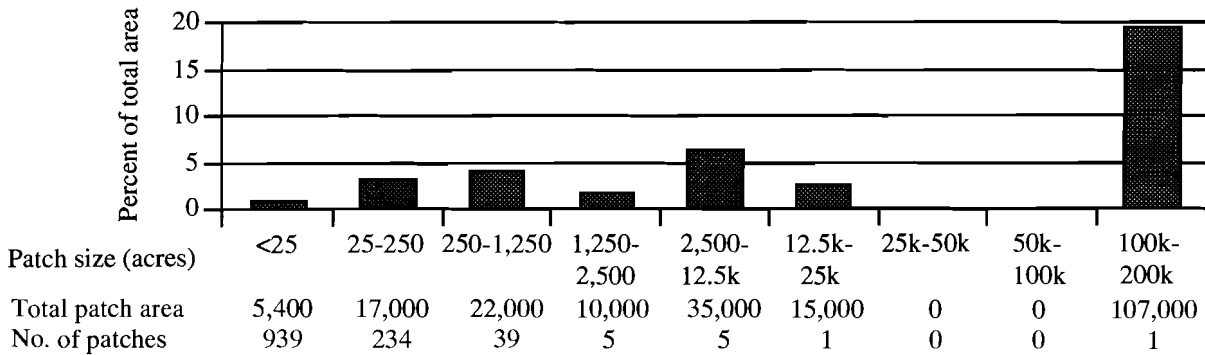
Figure 2-20. Forest patch size categories for total forest cover, presented as percent of subbasin area with total patch area and total number of patches given for each size category.



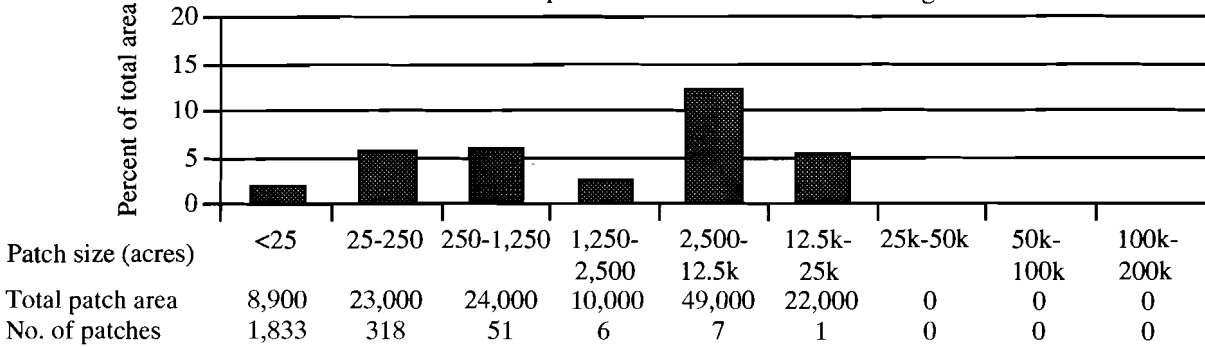
North Fork Subbasin - Total Forest Excluding Planted Pine (Native Forests)*



South Fork Subbasin - Total Forest Excluding Planted Pine



Four Hole Swamp Subbasin - Total Forest Excluding Planted Pine



Main Stem Subbasin - Total Forest Excluding Planted Pine

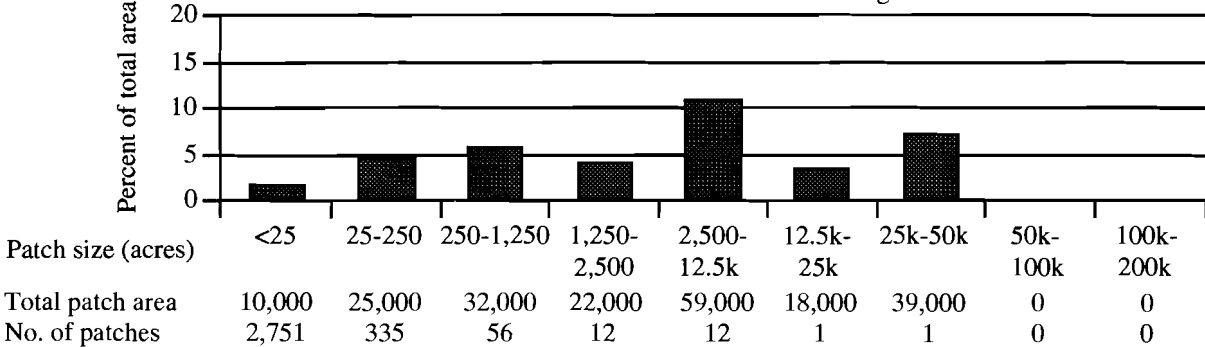


Figure 2-21. Forest patch size categories for all forests excluding planted pine by percentage of subbasin area with total patch area and total number of patches for each size category.

*Native forests includes mixed upland and wetland forests types.



SUMMARY AND DISCUSSION

Land Use Trends and Structural Change

Prior to European settlement, the land of the Edisto River Basin was probably covered with greater than 90 percent forest and open woodland (Kuchler 1964). Approximately 70 percent of the region was covered in native upland vegetation communities and about 30 percent was in native wetland communities. Settlement in the Basin began first in the coastal region along the intertidal rivers in the 1700s and slowly expanded to the inland areas. Most of the clearing of forests occurred prior to the twentieth century. Based on the available data for the 12 counties that encompass the Edisto Basin, the region was about 60 percent forested in 1950 and nearly the same in 1987. Prior to 1950 the only land use data available are for agriculture. These data indicate that the extent of agricultural land was fairly constant back to 1930. However, since 1950 there was apparently a steady decrease in agricultural land in the 12-county region, falling from 30 percent in 1950 to 16 percent in 1987. This decline in agricultural land coincided with socioeconomic changes during this period that were reflected by a 60 percent decline of land acreage in farmer-owned operations. In contrast to agricultural lands, the extent of urban land increased within the 12 counties of the Edisto Basin from about 5 percent of the area in 1968 to 8 percent in 1987.

These survey data for the counties of the Edisto Basin were not a precise measure of change in the Edisto River Basin because well over half of the 12-county area lies outside the Basin boundaries. These county-based data do, however, indicate the general pattern of change that has occurred in the Edisto region. The general pattern since 1950 has been a steady decline in the extent of agricultural land with forestland remaining relatively stable and urban land gradually expanding.

A comparison of spatial data (land use maps and statistics) from 1977 and 1989 for the hydrologically defined Basin area indicates that agricultural land decreased 4 percent (26,000 acres), forestland decreased 2 percent (24,200 acres), and urban land increased 31 percent (15,100 acres) in this 12-year period. The 1989 spatial data show that the current mix of land uses in the hydrologically defined Edisto River Basin was 56 percent forest, 34 percent agriculture, 7 percent nonforested wetland and open water, and 3 percent urban land. About a quarter of the Basin's forests were forested wetland.

These findings indicate there has been no dramatic or rapid change in general categories of land use and land cover in Edisto River Basin over the past 50 years. The major losses in acreage of forest cover for the Edisto Basin likely occurred during the 1800s; these losses resulted mostly from conversion of upland forest to agriculture. In recent decades, the changes that have occurred were the gradual expansion of urban-related land and the steady decline of agricultural land. These changes have been relatively minor compared to other areas in the country where there has been major forest clearing and conversion to agricultural development (e.g., Yazoo River Basin and Tensas River Basin discussed in Gosselink and Lee 1989 and Gosselink and others 1989).

Change in Forest Composition

Though the extent of forest cover in the Edisto Basin has remained fairly stable at between about 55 percent to 60 percent of the area for nearly 50 years, the composition of these forests has not remained the same. Conversion of natural forest and agricultural land to planted Loblolly Pine has occurred at a very rapid rate. Since 1968, seven out of ten of the forest types found in the Edisto Basin have declined in acreage; yet Loblolly Pine has nearly doubled from 15 percent of total forest area in 1968 to 27 percent in 1986. In 1968, the Oak-Gum-Cypress (bottomland hardwood) forest type was by far the most extensive in the Basin. By 1986, due to widespread planting, Loblolly Pine forests equaled the acreage of the Oak-Gum-Cypress forest that had decreased by 3 percent since 1968. The Oak-Hickory forests showed a 41 percent increase in acreage that may be the result of forest succession and fire suppression in many areas.

The changes in forest composition are directly related to changes in forestland ownership. Between 1968 and 1986, nearly 400,000 acres of forestland (33 percent of total forestland) changed hands from farmer ownership to industry, corporate, and other private



ownerships. In 1968 the forest industry owned about 25 percent of the Basin's forestland and by 1986 it had increased to 45 percent. Public ownership of forestland increased but currently remains well below one-percent of the Basin's total forestland.

Change in Wetland Resources

In 1989, 18 percent of the Edisto River Basin was covered in native wetland vegetation according to the National Wetlands Inventory (NWI) data. Three-quarters of these wetland habitats were forested wetlands distributed along the river bottoms and in the swamps, bays, and depressions of the Basin. About one-eighth of the wetlands were estuarine wetlands found in the intertidal region of the lower Basin, and the remainder were palustrine scrub-shrub and emergent types. The history of agricultural and forestry development in the region has changed the wetland habitats of the Edisto Basin.

It is assumed that certain hydric soils can serve as an indication of the historical extent of native wetland vegetation. Comparing the existing native wetland vegetation base, from 1989 NWI data, with the extent of a selected subset of hydric soils indicated that 39 percent of the Basin's native wetland vegetation (roughly 200,000 acres) has been converted to some other land use and land cover, primarily by forestry and agricultural practices. The 1989 NWI data showed that an additional 13 percent of the Basin's native wetland habitats had not been converted but were in an altered condition. About half of the altered wetlands were diked and impounded and the other half were partially drained. Impoundments were found primarily on the headwater streams as farm ponds and in the intertidal areas as former rice fields, now used for waterfowl attraction. The ditching activities were primarily associated with the intensive agricultural and forestry activities of the Four Hole Swamp and main stem subbasins. The partially ditched and drained areas may be totally lost from the region's wetlands resource base, depending upon the degree of the alteration.

Comparative data for wetland habitats were available for the coastal region of the Basin. The comparison showed differences between 1981 and 1989 NWI data: overall, a 5-percent decline in the acreage of native wetland vegetation over the 8-year interval. Generally, the estuarine wetlands remained relatively stable. The declines were in forested wetlands; the increases were in palustrine emergent and scrub-shrub wetlands. These trends may reflect forestry activities in the area — the apparent declines in forested wetlands may be due to forest clearcut harvesting which, in turn, produces more area that has regenerating bottomland hardwood forests. The additional areas of regenerating bottomland hardwood forests are photointerpreted as scrub-shrub wetlands, therefore the inventory reflects an increase in scrub-shrub wetlands which may, in fact, represent young forested wetlands.

Implications for Ecological Integrity

Several indicators of ecological integrity were proposed by Gosselink and Lee (1989) for assessing the condition of a landscape unit such as the Edisto River Basin. Proposed indices related to landscape structure were forest conversion, forest pattern, and bottomland forest contiguity — in this study, contiguity was treated as the condition of stream-edge habitat. Landscape structure has been assessed in this study by analyzing various data related to land use and land cover in the Edisto Basin.

Forest Conversion

Forest conversion was proposed as an indicator of ecological integrity in forested landscapes because from an ecological perspective the functional integrity of forested ecosystems was directly related to remaining forest area. Scientific study, however, has not developed any particular standards by which to assess forest loss as it relates to ecological integrity (Gosselink and Lee 1989). For a perspective on forest conversion, Gosselink and Lee reported that 80 percent of all bottomland hardwood forests, nationwide, have been cleared for agriculture, although along the Atlantic coastal plain some watersheds remain relatively intact. Biological diversity and water quality in streams are known to be adversely affected by forest loss. Biogeographic studies indicate that a loss of 90 percent of a habitat may result in roughly a 50 percent reduction in the numbers of animal species (Diamond 1975). Nutrient concentrations in streams generally violate EPA water quality criteria when more than 50 percent of the forests in a watershed are cut (Omernik 1977, in Gosselink and Lee 1989).



Findings from this study of the Edisto Basin indicate that, historically, about one-third of the native wetland vegetation communities (in terms of acres) have been converted and about two-thirds of the native upland communities have been converted to other land uses and cover types. The conversions have gone mostly to agriculture and pine plantation forest land uses. In spite of these changes, the structure of the Edisto Basin landscape, in terms of forest cover, is relatively intact and stable compared to other regions of the country. The forest cover conditions in the Edisto Basin probably support good water quality and many populations of desirable wildlife species.

It is important to note, however, that much of the Basin's forestlands are intensively managed pine plantations. Pine plantation forests are widespread, having rapidly expanded in recent decades; they currently occupy one-third of the Basin's total forest cover. Pine plantations are simplified forest communities, usually representing even-aged, single-species stands that are highly productive for timber. When managed on short rotations, plantations can produce more wood fiber than just about any forestry system; however, plantation forests typically lack the multilayered canopy, diverse tree sizes, abundant snags and fallen trees, and the high species diversity that exist in natural communities (Van Lear 1991). Plantations have a widespread reputation for supporting a relatively low diversity of wildlife; however, they can be established and maintained in ways that improve their diversity (Hunter 1990). Thill (1990) reports that when size, shape, and spatial distribution of clearcuts are considered, and frequent thinning and burning are practiced after pine canopy closure, intensively managed plantations furnish suitable habitat for many early-successional wildlife species — species such as deer, quail, and rabbits. However, intensive even-aged silviculture is detrimental to species requiring hardwoods, snags and cavity trees, and large, downed woody material.

Where maintaining biological diversity is a goal, silviculture practices must enrich forest structure (Sharitz and others 1992). Some important features of forest structure include the presence of native herbaceous and shrub plants, complex vertical structure in the forest canopy, some large living trees, standing dead snags, and large, downed woody debris (Van Lear 1991, Seymour and Hunter 1992). These forest structure features are site specific characteristics — they are determined largely by forest management practices on individual forest stands, and they can improve diversity at the stand-level. However, the landscape scale is the level at which the fate of wildlife species is ultimately determined (Hunter 1990). Hunter suggests that the interspersion or juxtaposition of different ecosystems, and forest stands of varying sizes, ages, and species compositions will provide the greatest biological diversity in a forested landscape. Even though some pine plantation stands are quite extensive in the Edisto Basin landscape, they generally remain interspersed with agricultural lands and other types of upland and wetland communities. Therefore, as Thill (1990) recommends, the habitats that are lacking in the pine plantations may best be provided through retention and management of the riparian forests or upland hardwoods interspersed within plantations.

Stream-Edge Habitat

The condition of forested and natural habitats along stream edges was suggested by Gosselink and Lee (1989) as an indicator of landscape ecological integrity because these areas are positively correlated with water quality, and they function as unique habitats and migration corridors for wildlife. The exact relationship of various percentages of stream-edge cover types to water quality and wildlife has not been defined. As discussed previously in the "Methods" section, the width of the stream-edge buffer appropriate for basinwide analysis has not been defined by scientific study. An optimal stream-edge buffer width to use for analysis might reflect the width of the riparian zone, and would therefore vary greatly depending on stream order and topography. Maintenance of at least a 60 meter (about 200 feet) buffer along both stream edges has been suggested for managing wildlife and would likely be adequate for protecting water quality as well (Howard and Allen 1989). Seymour and Hunter (1992) believe that intensive forestry should rarely take place within 50 to 100 meters of a water body because: riparian zones serve as buffers to protect water quality from upland disturbances; they provide visual screens for aquatic recreationists; they serve as corridors for forest species movement across the landscape; and often they support unique, diverse, and productive ecosystems. For these reasons, and because of their rarity, riparian ecosystems are often the most valuable components of a forested landscape (Hunter 1990).



Two sizes of stream-edge buffer were used for analysis in this study: a 120-meter buffer, 60 meters (about 200 feet) on either side of stream (taken from Howard and Allen 1989), and a larger buffer of 250 meters, 125 meters (about 400 feet) on either side of the stream (Gosselink and others 1990). The 250-meter stream-edge analysis showed that about 25 percent of these areas were under intensive land uses. Intensive land uses within the buffer were urban (2 percent), agriculture (15 percent), and pine plantation (8 percent). The remaining 75 percent of the stream-edge buffers were in natural cover (33 percent forested wetland, 19 percent mixed upland forest, 14 percent palustrine nonforested wetland, and 9 percent estuarine wetland). The 120-meter analysis showed that 15 percent of the Basin's stream edge was in intensive land uses (2 percent urban, 3 percent pine plantation, and 11 percent agriculture) and 85 percent was in natural cover (15 percent mixed upland forest, 16 percent forested wetland, 18 percent estuarine wetland, and 36 percent open water and nonforested wetland).

In their study of the Pearl River Basin, Gosselink and others (1990) found the stream edges, overall, to be about 85 percent forested, 10 percent agriculture, and the remainder was marsh, urban, and other uses. Though the extent of individual categories of land use varies considerably, the Edisto and Pearl basins have a similar proportion of stream edges in natural cover. In contrast, the Tensas River Basin study (Gosselink and others 1989) showed a dramatic declining trend in the percentage of forested stream edges from 54.5 percent in 1957, to 23.1 percent in 1972, to 20.9 percent in 1979, and finally to 14.7 percent in 1987. It has been estimated that over 70 percent of the riparian ecosystems in the continental United States have been converted to other land uses (Brinson and others 1981). Because the Edisto Basin's stream-edge habitats are largely in natural cover, they are considered to be relatively intact and in good condition; therefore, they are favorable for protecting water quality in the streams and providing viable riparian wildlife habitat, as discussed by Gosselink and Lee (1989).

Forest Pattern

Gosselink and Lee (1989) define forest pattern as "the size frequency distribution of forest patches" in the landscape unit. They consider forest pattern a key index of the "island" effect of biogeography that can be used to infer general conclusions about regional habitat support for sensitive and specialized wildlife species and also the maintenance of water quality. Generally, the more favorable forest patterns suggested for maintaining wildlife in a forested landscape include large blocks that contain most of the region's total forest area interspersed with smaller forested tracts — all having a high degree of connectivity to facilitate movement of species. The authors demonstrate that large blocks of forests are critical for maintaining populations of "area sensitive" and specialized species such as neotropical migrant birds and large, far-ranging mammals and raptors. Forest pattern that is characterized by continuous and intact riparian bottomland forests is also shown to be important for supporting corridors for wildlife movement, habitat for terrestrial and aquatic species, flood water retention, and water quality improvement through sediment and nutrient reduction.

The forest patch analysis showed that most of the forest area (56 percent of the Basin) is found in a few large patches that extend through most of the landscape via the bottomlands of the Basin's streams, linking upland and wetland forests into an irregular, or in some cases dendritic, pattern of forested corridors. The total area of forest (all upland mixed forest, planted pine forest, and wetland forest) was 1,112,600 acres, distributed among many (4,025) patches. Most (about 70 percent) of the Basin's forests were found in 5 patches of 50,000 acres or more. Two patches, one 142,000 acres and the other 376,000 acres, contained nearly half of the total forest area. Most of the patches were very small (less than 25 acres) and collectively contained very little of the Basin's total forest area.

The appearance of very large patches from this analysis is misleading because it suggests large blocks of forest, providing an abundance of isolated interior forested habitats. These types of habitats, which are generally rare in developed landscapes, are important for many species of birds, small mammals, reptiles, and amphibians (O'Neil and others 1991). However, in the Edisto Basin the large patches result from many narrow connections in a mosaic of forested tracts creating the irregular, dendritic, pattern of forested corridors described above. A substantial portion of the habitats associated with these large patches are relatively exposed forest corridors and forest edges.

In addition, roads and utility corridors can present substantial breaks and barriers in



forest patch contiguity. In this study, the Interstate and four-lane divided highways were included in the patch analysis to further divide the forests because these large roads were thought to be definite barriers to most wildlife migration. It should be noted, however, that many other roads and utility corridors crisscross the forest patches causing greater forest fragmentation than is indicated by the patch analysis. All roads, particularly well-maintained and heavily traveled roads, can inhibit wildlife migration to some extent. The specific effects of roads on wildlife depend upon the groups of species in question (Oxley and others 1974, Schreiber and Graves 1977, Henderson and others 1985, Lynch and Whigham 1984, all in O'Neil and others 1991).

Two subsets of total forest were analyzed: total forest excluding planted pine forest, and forested wetland. This was done to assess the contribution of various forest types to overall landscape forest pattern. The results of analyzing these subsets of the total forest area were substantial increases in the number of very small patches (less than 25 acres) and a decrease in size or elimination of the very large patches (greater than 50,000 acres); also, more patches and a greater proportion of the forest area was distributed among the medium categories of patch size (250 to 50,000 acres). Pine plantation forests contributed significantly to the pattern of large forested patches on the landscape. The wetland forests were found to be critical to overall connectivity of forest patches in the landscape.

Forest stands with older, larger trees are thought to support more wildlife species than those with younger and smaller trees (O'Neil and others 1991). The reasons for this are due to increased surface area of bole, branches, and foliage; increased production of leaves, twigs, branches, fruits, and seeds; and increased probability of decay leading to cavities and cavities of different sizes. Because much of the upland forests are intensively managed planted pine, the overall age of the Basin's forests is relatively young. As a general rule, forested landscapes with stands of many ages will support more species than a single-age landscape because various plants and animals are associated with the different stages of forest succession. Maintaining a balanced age structure (an even mix of different-age stands) in a forested landscape can accomplish two objectives: achieving a sustained yield of forest products, and providing diverse wildlife habitat (Hunter 1990). Currently, the forest-age structure in the Edisto Basin appears unbalanced (see Figure 2-22); it is dominated by younger, early successional, forest stands. Older forest stands (stands greater than 80 years old) are rare in the Edisto Basin; they compose about 4 percent (about 45,000 acres) of total forestland in the region. Most (over 70 percent) of the Basin's older forest stands were found in bottomland hardwoods. Twenty-four percent of all forestland in the Basin had mature stands (stands from 40 to 80 years old). Over half (54 percent) of these mature stands were in bottomland hardwoods. These findings illustrate the relative importance of the Basin's bottomland hardwood forests for maintenance of species diversity by providing most of the older forest habitats, habitats that are rare in the Edisto Basin. Because old-growth stands (stands roughly 200 year old or older) are very rare in the South it has been recommended that they be protected in order to ensure the biological integrity of southern forests (Sharitz and others 1992).

As suggested previously, the landscape scale is the critical level at which forest patterns must be assessed. There is no way that careful management of one small forest stand by an individual can overcome landscape-scale patterns imposed by the cumulative result of hundreds of other individuals' decisions. The interspersions of different ecosystems and forest stands of varying sizes, ages, and species compositions will provide the greatest biological diversity in a forested landscape. Note that very large forested habitats are an important landscape feature because they are required by some of the most threatened species; therefore, further forest fragmentation should be avoided (Hunter 1990). In the Edisto Basin there is substantial interspersions of forests and other habitat types; however, the balance of forest conditions seems to be leaning towards smaller and younger stands, and more Loblolly Pine plantations. The forested wetlands associated with the stream network are a vital component in the Edisto Basin landscape, creating a dispersion of different forests and ecosystems throughout the Basin. In summary, forest patch characteristics indicate that the Basin's forest pattern, though far from pristine, remains favorable for supporting many indigenous wildlife species and good water quality. The forest pattern, however, is not as favorable for sensitive forest-interior species as may be indicated by the patch analysis; in fact, high-quality forest-interior habitats seem to be quite limited.



Protected Lands

Another suggested criterion for ecological integrity was the proportion of protected land found in the landscape unit (USEPA 1988). Only a very small portion of the Basin area (less than 4 percent) is officially protected as public or privately owned land for parks, wildlife refuges, or forestland. However, the state and federal governments have dominion over an additional 2 percent of the Basin on the open waters and intertidal zones, and jurisdiction for wetlands regulation on some portion of the 18 percent of the Basin determined to support wetland vegetation. These protected and regulated lands overlap to a degree, so in total they may amount to around 20 percent of the Basin area. Since practically all the Basin's land is in private ownership, the collective actions of all the landowners has been, and will continue to be the primary factor that determines the ecological integrity of the Edisto Basin.

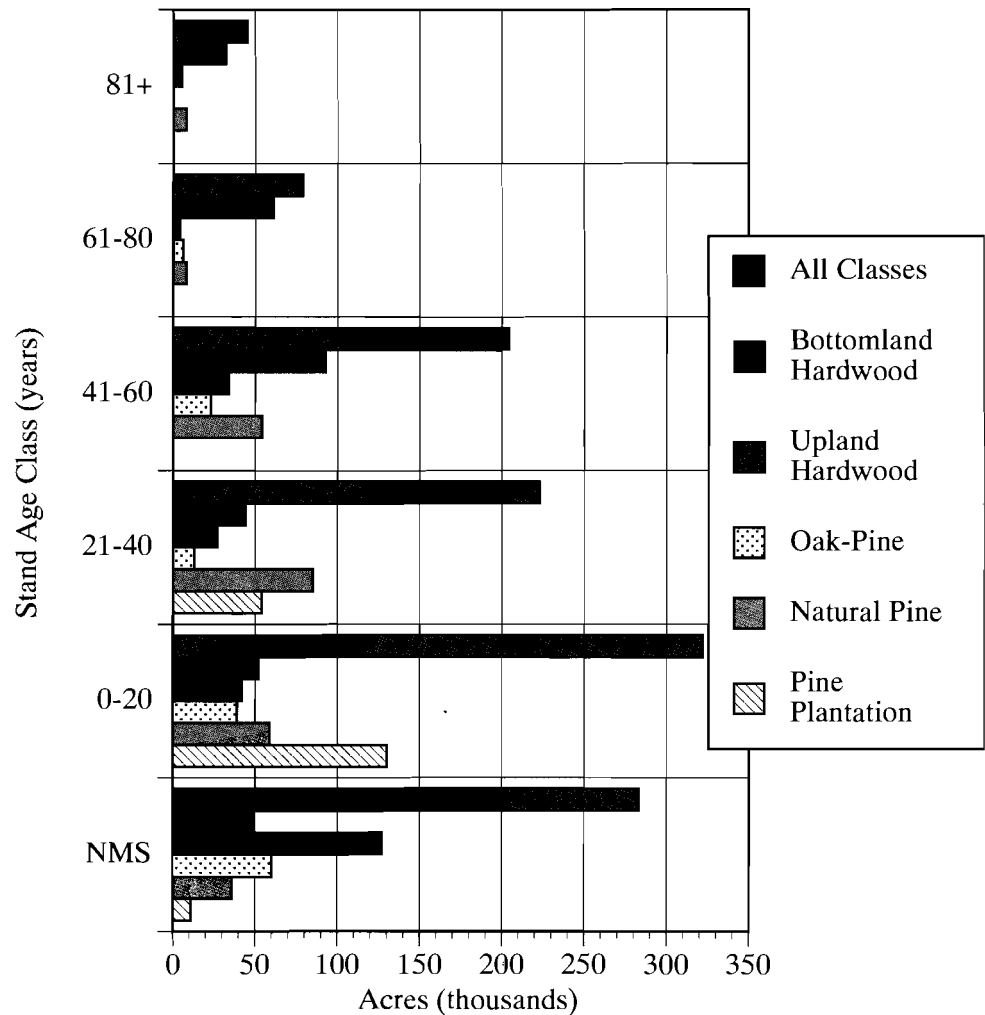


Figure 2-22. Area of forestland, by stand age and broad management classes, in the Edisto River Basin, 1986.

*NMS = no manageable stand; a U.S. Forest Service term for forestland that is less than 60% stocked with commercial species that can be featured under a single management scheme. Total Area of forestland in 1986 estimated at 1.15 million acres.

Source: U.S. Forest Service, Forest Survey.



Subbasin Comparisons

Land Use and Structural Changes

There were very few data available to accurately compare changes in landscape structure among the different subbasins of the Edisto. The available historical data were primarily based on counties, and the county boundaries do not correspond well with the subbasins. Some comparison of change can be made using the Forest Survey data, hydric soils data, and the 1989 wetlands data. The SCWRC 1989 land use and wetlands data provide a solid baseline of current landscape structure for comparison — but again, there is limited data to compare changes or trends among the subbasins.

The U.S. Forest Service (1991) Forest Survey was one source of data available for the subbasins. This information showed that the declines in forestland since 1968 were occurring mainly in the South Fork subbasin — an area decrease of 11.5 percent between 1968 and 1986. The extent of forestland was nearly constant in both the main stem and Four Hole Swamp subbasins from 1968 to 1986. The North Fork showed a small area decline of 3.7 percent. These forestry data also showed that, among the subbasins, Four Hole Swamp had the greatest increase in the Loblolly Pine forest type (123 percent increase in area from 1968 to 1986) while the North Fork had the smallest increase (about 34 percent). Loblolly Pine comprised the greatest portion of the forests in Four Hole Swamp subbasin, where 32 percent of total forestland was Loblolly Pine in 1986.

Changes in the acreage of native wetland vegetation, based on a comparison of the 1989 NWI wetlands data with a selected set of hydric soils, varied among the subbasins. The Four Hole Swamp subbasin seems to have experienced the greatest changes with 34 percent of its historical extent of native wetland vegetation (as determined by the extent of hydric soils) converted to pine plantations and agricultural land (Table 2-5). The Edisto (main stem) follows the Four Hole Swamp subbasin in the degree of change in native wetland vegetation acreage; 27 percent of these wetland areas were converted to agriculture and pine plantation. The North and South Forks showed less wetland habitat conversion to agriculture and pine plantation, with 18 and 20 percent conversion, respectively. In terms of altered wetlands, in 1989 proportionally more of the North Fork's wetlands had been altered compared to the other subbasins. Sixteen percent of the North Fork's wetlands were altered — most were impounded. In the main stem, 14 percent of the wetlands were altered; in the South Fork, 13 percent; and in Four Hole Swamp, 11 percent.

Current Structure

The SCWRC 1989 land use and wetlands data showed that the North Fork and South Fork subbasins were similar in structure. Both were 56 percent forested, and less than one-fifth of the forests were wetlands. The South Fork contained a little more forested wetland, and the North Fork had a little more pine plantation. The South Fork also had more agricultural land, at 40 percent, than the North Fork, at 37 percent. The North Fork had the most urban land among all four subbasins — 22,605 acres (5 percent of the area). The South Fork, along with the other two subbasins, each had about 13,000 acres of urban land, 2 to 3 percent of the total area.

The Four Hole Swamp subbasin had the smallest portion of forestland (at 52 percent) and the greatest portion of agriculture (42 percent). The forests of Four Hole Swamp were more than one-third forested wetland, and about one-third pine plantation and one-third mixed upland forest.

The Edisto (main stem) subbasin contained the most forestland, comprising 60 percent of its total area. The mix of forests was similar to Four Hole Swamp subbasin, with over one-third as pine plantation, but with slightly less than one-third wetland. The main stem had the smallest proportion of agriculture among the subbasins, only 20 percent. Compared to the other subbasins, wetlands were a much more dominant feature on the landscape of the main stem, with nearly 38 percent of the area in wetlands; half were forested and half were non-forested.

The stream-edge habitat within the 250 meter buffers for each of the subbasins, except Four Hole Swamp, was nearly 75 percent or greater in natural cover. Four Hole Swamp showed only 62 percent in natural cover, with the remaining stream edge used for agriculture, pine plantation, and urban land. Stream edges of the North Fork and particularly



in the South Fork subbasin had the greatest proportion of natural cover and the smallest proportion of intensive land uses in the Basin.

The size, proximity, and continuity of forest patches in the North and South Forks were nearly the same. Most of the total forest area was confined to a few very large patches that spread out over most of the landscape. The forests of the Edisto (main stem) were distributed into more patches toward the medium-size categories, but still most of the forest area was in large patches. Among the subbasins, forests in Four Hole Swamp were the most distributed among various patch sizes. Also, the upper portions of the Four Hole Swamp subbasin and the adjacent lower portions of the North and South Forks appear to have the greatest fragmentation and isolation of forests in the Basin's inland areas. The coastal areas of the main stem show a high level of forest fragmentation; however, much of this is a reflection of the natural complexity of the coastal landscape with its network of intertidal rivers and creeks and associated marshlands that dissect the landscape. Judging whether fragmentation is a positive or negative characteristic is generally determined in reference to the original natural condition of the landscape. Much of the coastal area in the main stem has naturally fragmented habitats that are undisturbed, and are therefore positive in terms of ecological integrity. In the inland areas of the Basin where extensive natural forested habitats have been lost, or are rare due to land use and development activities, fragmentation would generally be viewed in negative terms because many rare and sensitive native wildlife species require large, undisturbed habitats.

Ecological Integrity of the Subbasins

Applying the above indicators of ecological integrity to each of the subbasins does not yield markedly distinguishable results. Most of the subbasins' characteristics indicate moderate integrity. The subbasin with the greatest level of ecological integrity may be the Edisto (main stem). This subbasin had the lowest ratio of agricultural and urban land to forestland, though one-third of these forests were planted pine. More of the main stem's stream-edge habitat was in natural cover, and more land was protected and regulated than in the other areas. The main stem does, however, benefit substantially from the stable ecological conditions upstream in the other subbasins, particularly in terms of the quality of water it receives.

Four Hole Swamp would appear to be lowest among the subbasins in structural ecological integrity due to the following: the highest ratio of agricultural and urban land to forestland; the lowest percentage of natural stream-edge habitat; the greatest conversion of potential wetland to other land uses; and the most fragmented forest cover.

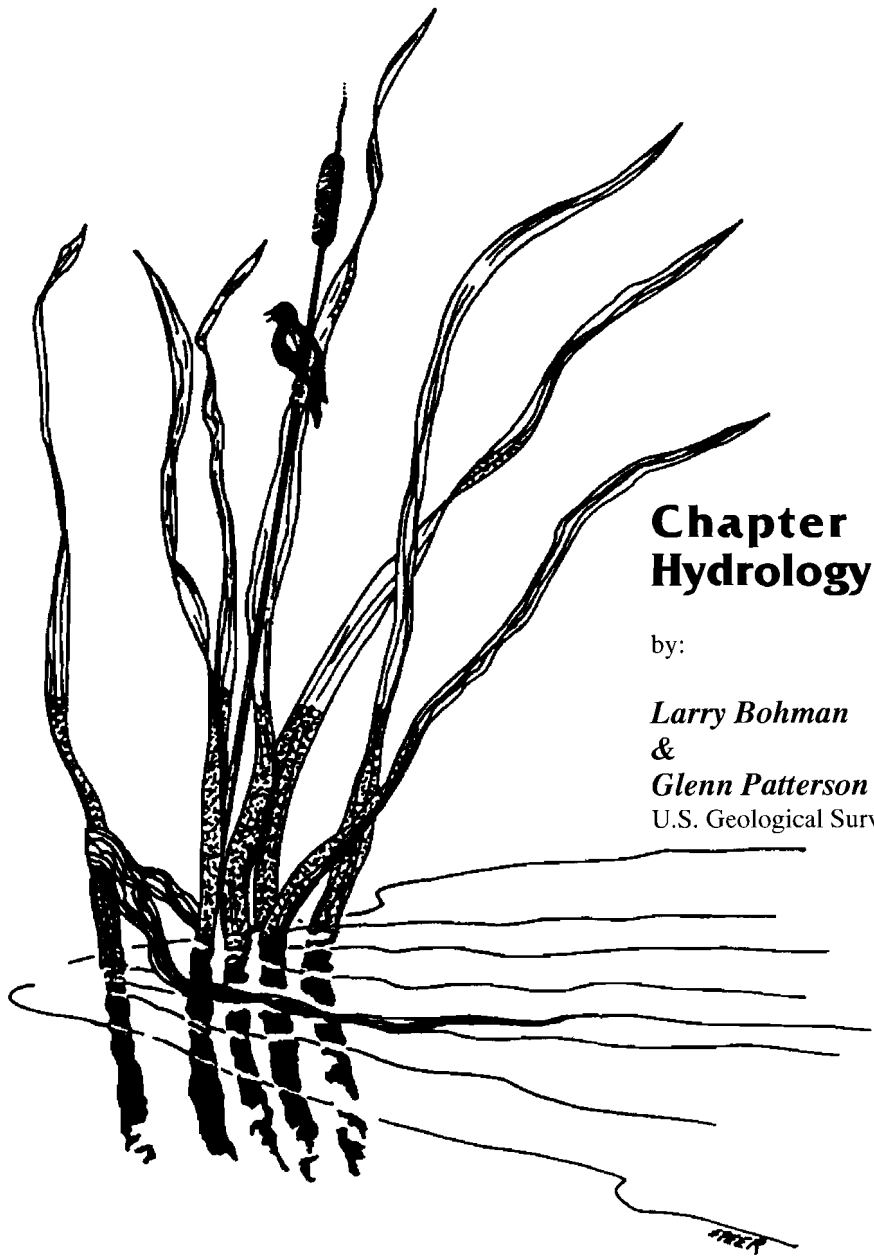


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Chapter 3 Hydrology Assessment

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INTRODUCTION

Streamflow is the long-term residual of precipitation after evapotranspiration demands and deep aquifer losses have been satisfied. Trends in streamflow reflect an integration of many hydrologic factors. A change in the location, timing, and amount of streamflow in a basin may be caused by manmade changes such as channelization, construction of reservoirs, or change in land use.

Precipitation, by contrast, is largely independent of the works of mankind and therefore provides an index for evaluating streamflow (Searcy and Hardison 1960). A change in the amount of precipitation over a period of time should cause a change in streamflow during the period.

Description of Basin Hydrology

The Edisto River Basin extends over the length of the Coastal Plain physiographic province in South Carolina. The Coastal Plain is characterized by sandy soils and gentle slopes. The ground in the Basin is like a sponge. Nearly all of the Basin's abundant rainfall infiltrates the porous soil, from which it later emerges as evapotranspiration or as streamflow.

From the headwaters to Orangeburg on the North Fork and to Bamberg on the South Fork, the Basin is in the Upper and Middle Coastal Plain (hereafter referred to as the upper Coastal Plain). This upper part of the Coastal Plain includes the Carolina Sand Hills and has higher hills (up to 600 ft above sea level), deeper valleys, and steeper slopes than the Lower Coastal Plain, which lies to the southeast of Orangeburg and Bamberg. The Lower (lower) Coastal Plain includes the Coastal Flatwoods and Tidewater land resource areas described in Chapter 1. The different topographic characteristics of the upper and lower regions of the Coastal Plain result in different patterns of groundwater flow and different interactions of groundwater and surface water. These differences are related to the length of the groundwater flow path and especially to the thickness of the unsaturated zone.

Upper Coastal Plain Hydrology

In the upper Coastal Plain the uplands between the stream valleys are high enough and porous enough to have thick unsaturated zones. Infiltrating rainwater quickly percolates below the root zone, leaving little water near the ground surface to sustain plants. Vegetation on these uplands, particularly in the Sand Hills, tends to be scrubby, sparse, low, and adapted to dry conditions. Common plants include scrub oaks, longleaf pine, and sparkleberry.

Although the surface soils in the upper Coastal Plain tend to be dry, the shallow aquifer below the water table receives abundant recharge, precisely because so little water is lost to evapotranspiration. The aquifer discharges to streams whose valleys are incised deeply enough to intersect the water table, providing some of the best-sustained streamflows in the State.

Streams in the upper Coastal Plain receive natural flow regulation because of the porous soils. There is little surface runoff, so flood peaks tend to be attenuated. The well-sustained low flows keep the streams from drying out in droughts.

Deeply incised streams are common in the upper Coastal Plain, so groundwater flow paths from the intervening ridges to the streams tend to be relatively short, on the order of 1 to 2 miles. The age of groundwater discharging to these streams as baseflow is on the order of years or decades. Just after a heavy rain significant streamflow is derived from temporarily saturated soils near the streams. Groundwater flow paths and ages in these temporarily saturated soils are much shorter.

Groundwater discharging to the upper Coastal Plain streams spends relatively little time in contact with soluble minerals, so the dissolved-solids content in the streams is low. In summary, the upper Coastal plain streams tend to have low flood peaks, high baseflows, and good water quality.

Lower Coastal Plain Hydrology

In the lower portion of Coastal Plain (the Coastal Flatwoods and Tidewater land resource areas) the land between the streams is much lower and flatter than in the upper Coastal Plain.



The water table is nearer to the land surface, and is often within the root zone. The greater availability of soil moisture is reflected in the taller, denser, hydrophytic vegetation characteristic of the area, including baldcypress, tupelo, other hardwoods, and large pines.

A proportion of the infiltrating rainwater in the lower Coastal Plain returns to the atmosphere as evapotranspiration. Recharge to the shallow aquifer is therefore less than in the upper Coastal Plain. During droughts, baseflow in the streams here is not as well sustained, and some streams go dry.

When rainfall is heavy, the water table may rise, causing flooding in low areas at the land surface. Drainage is sluggish, so floodwaters recede slowly.

The lack of high ridges between streams allows groundwater flow paths to cross drainage divides and attain greater length than in the upper Coastal Plain. In addition, in the lower Coastal Plain the deep regional aquifers discharge upward to shallower aquifers and to streams. Ground water flow paths in the lower Coastal Plain can therefore range from several miles to several tens of miles. The age of groundwater discharging to the streams as baseflow is on the order of hundreds to thousands of years.

The longer contact time with subsurface materials results in higher concentrations of dissolved substances, both organic and inorganic. The large amount of vegetation around streams in the lower Coastal Plain results in relatively high concentrations of organic acids. Concentrations of inorganic dissolved constituents, though higher than in the upper Coastal Plain, are still relatively low. Streams in both the upper and lower Coastal Plain are low in suspended sediments because of the gentle slopes, high infiltration, good vegetative cover, and coarse soils of the Coastal Plain.

The low dissolved-solids content makes Coastal Plain streams relatively poor buffers against changes in pH. The abundant organic acids in these characteristic blackwater streams causes a natural acidic condition. The streams are therefore susceptible to further decreases in pH, as from acid precipitation.

Hydrology of Blackwater Rivers

In profiling the ecology of bottomland hardwood swamps Wharton and others (1982) described the hydrology of blackwater rivers:

“These streams have narrower, less well-developed floodplains and reduced sediment loads compared to those of alluvial rivers. The waters are relatively clear, but highly colored (coffee-colored) due to the presence of organics (humic substances) derived from swamp drainages. A hydrograph of a blackwater stream is characterized by irregular discharge peaks that are due almost wholly to frontal or local weather events. Summer flooding, as well as more typical winter-spring flooding, may result from local storms. Unlike that of larger alluvial streams, the hydrograph of a smaller blackwater stream may register dry periods during which discharge may dwindle to near zero.

Groundwater seepage, or base flow, is a particularly important component of the discharge of blackwater streams. A study (Winner and Simmons 1977) of a small North Carolina Coastal Plain blackwater stream (Creeping Swamp, N.C.) resulted in a water budget in which overland runoff accounted for 6.99 inches (17 percent) and base flow runoff for 8.54 inches (20 percent) of the total precipitation of 42.24 inches. Evapotranspiration accounted for 25.91 inches (61 percent) of the rainfall. A negligible 2 percent seeped underground and was lost to the watershed” (in other words — lost to the deep aquifer system).

Purpose and Scope

The purpose of this study was to determine if trends — changes in the streamflow — have developed in the Edisto River Basin (Figure 3-1) during the period that streamflow data have been collected in the Basin. If significant changes in streamflow have occurred and cannot be explained by changes in precipitation, then other factors such as stream channel modifications and land use changes would have to be evaluated.



Data Available

Streamflow data have been collected continuously at four stations in the Edisto River Basin, dating from about 1939 to 1990, and for various periods at stations in nearby basins that have geology and physiography similar to the Edisto Basin.

The streamflow of the South Fork Edisto River near Denmark (Station No. 02173000) and the North Fork Edisto River near Orangeburg (Station No. 021735000) were considered as indicative of the streamflow in the upper Edisto River Basin. The streamflow of the Edisto River near Givhans, South Carolina (Station No. 02175000) was considered as indicative of the lower Edisto River Basin.

Monthly mean streamflow data were adjusted for diversion for municipal water supply above the North Fork Edisto River at Orangeburg (Station No. 02173500) and the Edisto River station near Givhans (Station No. 02175000). Although the amount of diversion varies throughout the year, the streamflow was adjusted by an average amount for the year. The diversions were small enough that deviations from the average diversion were considered too small to substantially influence any analysis of trends in streamflow.

ANALYZING STREAMFLOW AND PRECIPITATION

The precipitation data were first evaluated to determine if there was a significant trend or difference in occurrence and amounts of precipitation among the various stations or if there was a trend (significant changes) in the amounts of precipitation for the period of time that data had been collected at the six precipitation stations.

The streamflow data for the three streamflow stations were evaluated to determine if (1) there was a significant difference in duration and amount of streamflow for the individual stations with respect to time, (2) trends in streamflow differed with respect to upstream and downstream stations, (3) trends of streamflow were related to concurrent trends in precipitation with respect to time and (4) trends in streamflow identified in the Edisto River Basin were identifiable in nearby basins. The data collection stations are described in Table 3-1.

Techniques Used for Analysis

Several techniques were used in analyzing the precipitation and streamflow data: (1) single-mass analysis, (2) double-mass analysis, (3) the Kendall Tau Analysis, (4) the analysis of variance, (5) the analysis of covariance, (6) the box plot analysis, and (7) the regression analysis.

Single-mass analysis — A single mass analysis is a plot of accumulated values of precipitation or streamflow over time. Deviations from a straight line (a break in slope) indicate changes in the streamflow or precipitation with time but do not give any information as to the cause of the changes that have occurred.

Double-mass analysis — The theory of the double mass curve method to evaluate trends is based on the fact that a graphical accumulation of one quantity against the accumulation of another quantity during the same period will plot as a straight line so long as the data changes are proportional. The break in slope of the double mass curve means that a change in the constant of proportionality between the two variables has occurred or that the proportionality is not a constant at all rates of accumulation. If the possibility of a variable ratio between the two quantities can be ignored, a break in slope indicates the time at which a change occurred in the relation between the two quantities (Searcy and Hardison 1960). When the double mass curve is used to study trends or possible breaks in precipitation-runoff relationships, the cumulative measured streamflow should be plotted against the cumulative predicted streamflow taken from a precipitation-streamflow relation. A double mass curve of cumulative measured streamflow and cumulative precipitation should not be used because the relationship between precipitation and streamflow is seldom a constant ratio even during a period when there was no change in the relation.

Kendall Tau Analysis — The Kendall Tau method of detecting monotonic trends was used to examine several kinds of precipitation and streamflow data. In the test, the first observation is compared to all subsequent observations with the assumption that the probability of the latter value being greater is equal to 0.5. The second observation is



compared to all subsequent observations and so on. The pluses and minuses which represent comparisons in which subsequent observations were greater than or less than preceding observations, respectively, are then compared statistically to determine if one group is significantly larger than the other. For a P-level of 0.05, the 5-percent level of significance implies that if the data from the station are rejected from the analysis there is only a 5-percent chance that it should not have been. Thus, a P-level less than 0.05 indicates that a trend in the data most likely exists at that confidence level. The higher the P-level, the less likelihood there is that a trend exists in the data set.

Several types of annual streamflow data were retrieved for use in the Kendall Tau test for monotonic trends. Annual peak discharges and 7-day average annual minimum discharges were obtained from the U.S. Geological Survey, WATSTORE national data base. Additionally, the average mean monthly streamflow for the period of record for each of the three streamflow stations was plotted in order to ascertain the months with the greatest and smallest streamflow amounts. Annual statistics may not reflect trends in seasonally affected flows. For example, if the summer streamflow amounts were increasing while the winter streamflow amounts were decreasing, it is possible that the trends could offset each other and not be detected in the analysis of annual mean streamflow.

Analysis of Variance — The analysis of variance is a statistical procedure that analyzes data to determine if the variability associated with a particular time period is more than the expected random error based on the general variability of the sample population. It characterizes the means of two samples as significantly or not significantly different. In the analysis of variance the F-ratio is used to test whether the means of two groups are significantly different. This ratio compares the between-group variance with the residual within-group variance. The term Pr is a probability level associated with the F-ratio. To illustrate the interpretation of the Pr value for the F-ratio, assume an F-ratio of 10.5 and Pr value of 0.0007 (or 0.07 percent) for two groups of annual precipitation values. This means that if all the annual precipitation amounts for two sampling periods were about the same, an F-ratio of 10.5 or larger would be found only 0.07 percent of the time. A large F-ratio, which is a rare occurrence when the precipitations are about the same, means that the precipitations are not alike.

Analysis of Covariance — The analysis of covariance was used in this study to test for changes in slopes and/or intercepts of relations between two periods. This was accomplished by creating qualitative variables to represent different time periods and then testing their significance in the regression process.

Box Plot Analysis — A box plot summarizes a batch of data by indicating the location of the median, the spread, the tails, and outlying data points. When a data set is divided into groups representing different time periods, the box plots make it easier to visualize the difference in subgroup midpoints and distributions. In order to determine if the differences are significant, an area (confidence interval) is defined around each median on the basis of the hinge spread for that group and the standard deviation for the entire sample. When these confidence intervals do not overlap, the medians of the different time periods are significantly different at roughly the 5-percent level.

Regression Analysis — Regression analysis fits a linear equation to observed values of multiple independent variables and a dependent variable. The statistical packages utilized for this study included a forward-stepping algorithm in which independent variables are added one at a time. The accuracy of the regressions can be expressed by two standard statistical measures, the coefficient of determination (also noted as R^2) and the standard error of regression. The coefficient of determination indicates the proportion of the total variation of the dependent variable is explained by the independent variable. For instance, a coefficient of determination value of 0.93 would indicate that 93 percent of the variation is accounted for by the independent variables. The standard error of regression is, by definition, the standard deviation of the residuals from the regression equation and contains about two-thirds of the residuals within its range.



EDISTO RIVER BASIN SAMPLING STATIONS

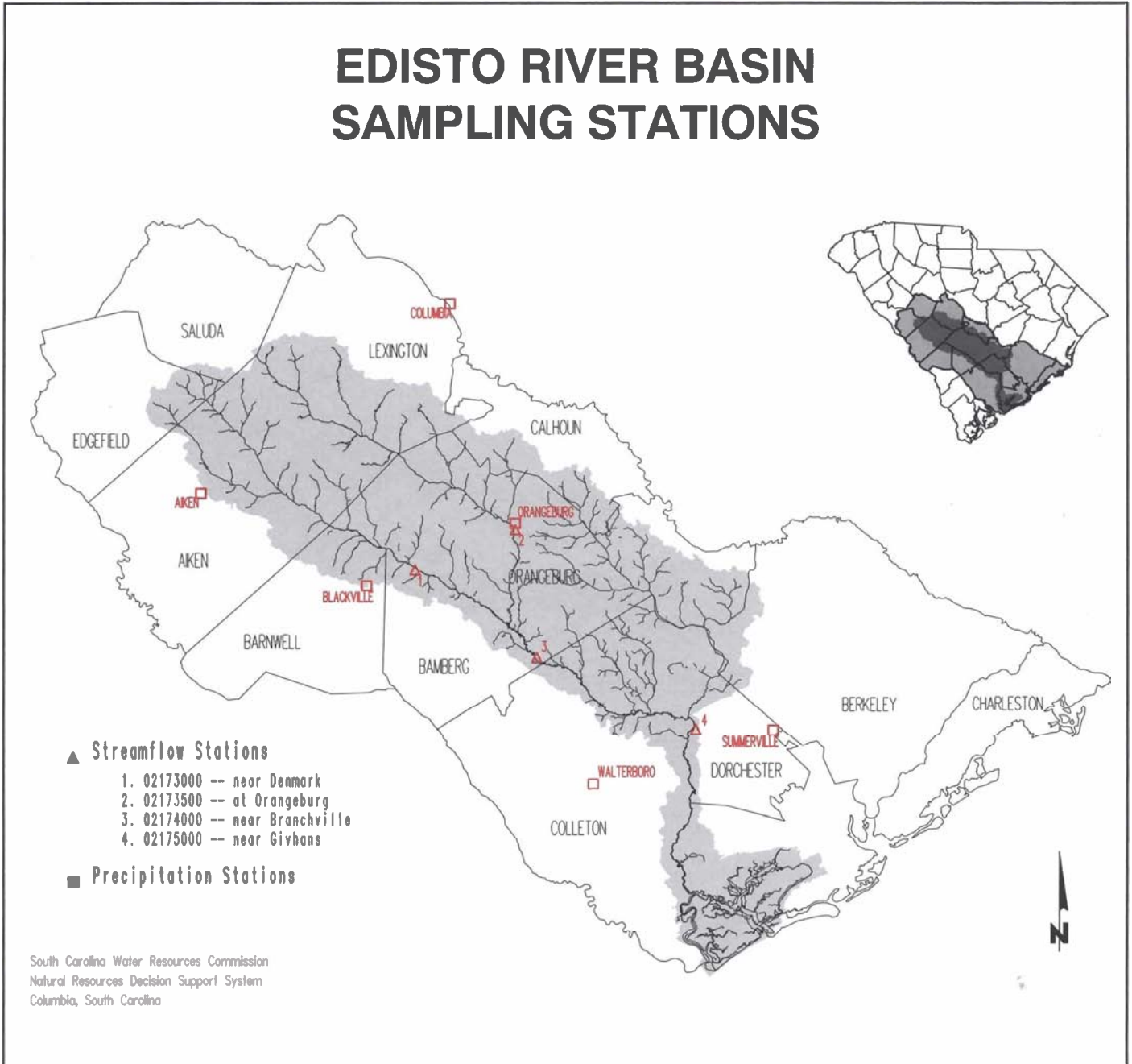


Figure 3-1. Location of data collection stations for streamflow and precipitation in the Edisto River Basin, South Carolina.



Table 3-1. Data collection stations in or near the Edisto River Basin.

		Streamflow Stations		
Station number	Station name	Drainage area (sq. miles)	Years of Record	Period of record
02173000	South Fork Edisto River near Denmark, S.C.	720	52	1931 to 1971 1980 to 1990
02173500	North Fork Edisto River at Orangeburg, S.C.	683	53	1938 to 1990
02174000	Edisto River near Branchville, S.C.	1720	46	1945 to 1990
02175000	Edisto River near Givhans, S.C.	2730	52	1939 to 1990
Streamflow Stations - Other Basins				
02136000	Black River at Kingstree, S.C.	1252	62	1929 to 1990
02198000	Brier Creek at Millhaven, Ga.	646	54	1937 to 1990
02202500	Ogeechee River near Eden, Ga.	2650	53	1938 to 1990
		Precipitation Stations		
Latitude	Longitude	Station location	Years of record *	Period of record *
33° 34'	81° 44'	Aiken, S.C.	56	1935 to 1990
33° 22'	81° 19'	Blackville, S.C.	56	1935 to 1990
33° 29'	80° 52'	Orangeburg, S.C.	56	1935 to 1990
33° 02'	80° 12'	Summerville, S.C.	56	1935 to 1990
32° 54'	80° 40'	Walterboro, S.C.	54	1937 to 1990
33° 56'	81° 07'	Columbia, S.C.	66	1925 to 1990

*Note.—Actual record length for a station might be longer. Numbers and dates reflect only period of record obtained for this study.



RESULTS OF THE ANALYSES

Precipitation

A single-mass analysis was made by using annual precipitation totals from each of the six National Weather Service rainfall stations (Figure 3-2 presents the Orangeburg station). All six stations indicated a possible change of slope starting about 1958 to 1961. For four of the six stations, single-mass curves showed a possible second break in slope at about 1974 to 76. A visual inspection of the data indicated that the 16-year period from 1959 to 1975 appeared to be wetter than the 1939 to 1958 and the 1976 to 1990 periods.

A box-plot analysis and an analysis of variance were made for the three periods 1940 to 1958, 1959 to 1975, and 1976 to 1990 (Figure 3-3). The box plots indicate that the distribution and median of the mean annual precipitation for the 1959 to 1975 period were probably significantly different (wetter) from the other two periods. The analysis of variance also indicated that the mean annual precipitation for the 1959 to 1975 period was probably significantly different from that of the other time periods.

A correlation matrix was computed for the six rainfall stations to determine if any of the data appeared to be anomalous (Table 3-2). This analysis did not indicate anomalies in the data. The Orangeburg station was most correlatable to the other stations. Orangeburg was used as an independent variable in the regression analysis to determine the predicted annual precipitation amounts for the other stations. These predicted amounts were then plotted against observed amounts in a double-mass analysis to check for consistency in the precipitation data for the other five precipitation stations. The results of this analysis indicated that the precipitation from one station was not predictable by the precipitation at another station. The coefficient of determination (R^2) was about 0.50. All the rainfall stations were considered in determining the precipitation for the Basin for the individual streamflow stations, using the Thiessen polygon method. The area weighting factors for precipitation in the drainage areas of the streamflow stations in the Edisto Basin are presented in Table 3-3.



Table 3-2. Correlation matrix for rainfall stations in or near the Edisto Basin.

	<u>Aiken</u>	<u>Blackville</u>	<u>Columbia</u>	<u>Orangeburg</u>	<u>Summerville</u>	<u>Walterboro</u>
Aiken	1.0000	0.729	0.695	0.745	0.535	0.579
Blackville	.729	1.000	.807	.694	.628	.660
Columbia	.695	.807	1.000	.699	.691	.708
Orangeburg	.745	.694	.699	1.000	.597	.622
Summerville	.535	.628	.691	.597	1.000	.777
Walterboro	<u>.579</u>	<u>.660</u>	<u>.708</u>	<u>.622</u>	<u>.777</u>	<u>1.000</u>
	4.283	4.518	4.357	4.600	4.228	4.346

Table 3-3. Area weighting factors for precipitation in the drainage areas of the streamflow stations in the Edisto Basin.

Station Number: 02173000 at South Fork Edisto River, Denmark, S.C.

<u>Aiken</u>	<u>Blackville</u>	<u>Columbia</u>	<u>Orangeburg</u>	<u>Summerville</u>	<u>Walterboro</u>
0.57	0.43	--	--	--	--

Station Number: 02173500 at North Fork Edisto River, Orangeburg, S.C.

<u>Aiken</u>	<u>Blackville</u>	<u>Columbia</u>	<u>Orangeburg</u>	<u>Summerville</u>	<u>Walterboro</u>
0.15	0.06	0.39	0.40	----	----

Station Number: 02175000 at Edisto River near Givhans, S.C.

<u>Aiken</u>	<u>Blackville</u>	<u>Columbia</u>	<u>Orangeburg</u>	<u>Summerville</u>	<u>Walterboro</u>
0.19	0.16	0.10	0.38	0.10	0.07

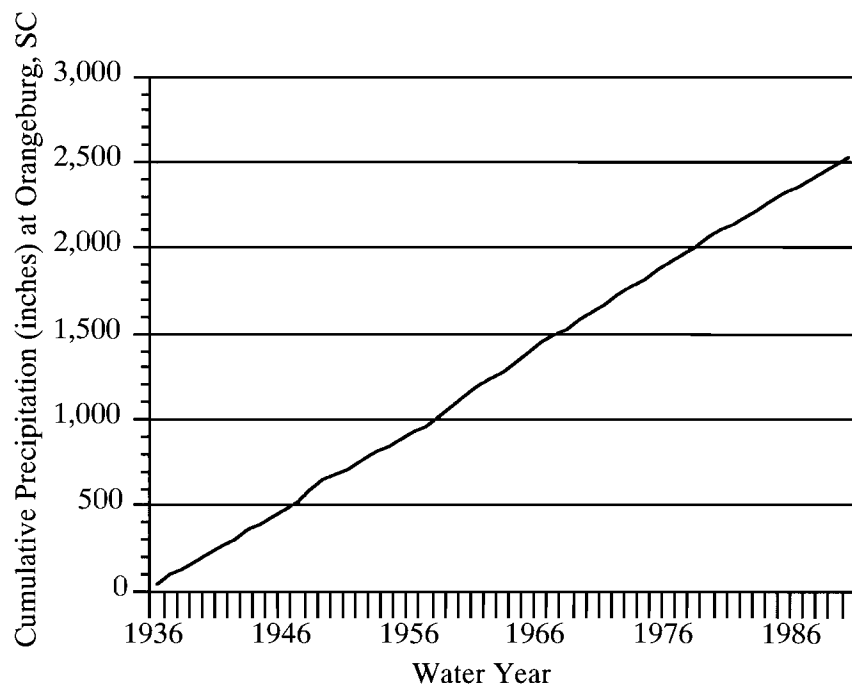
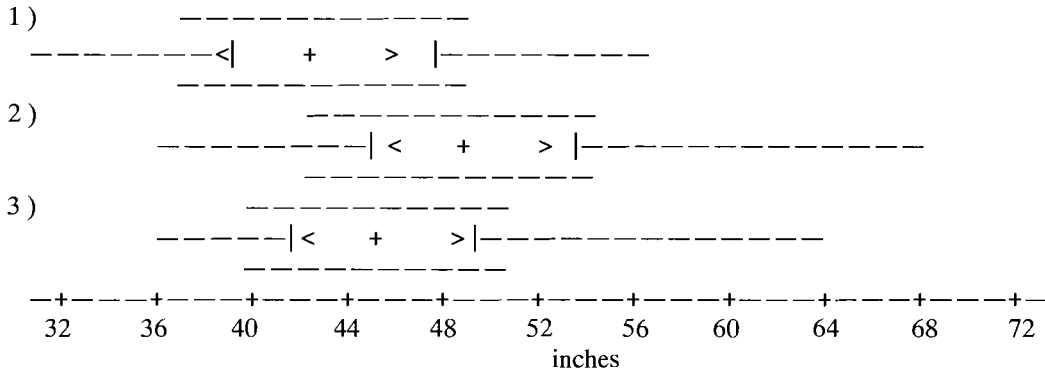


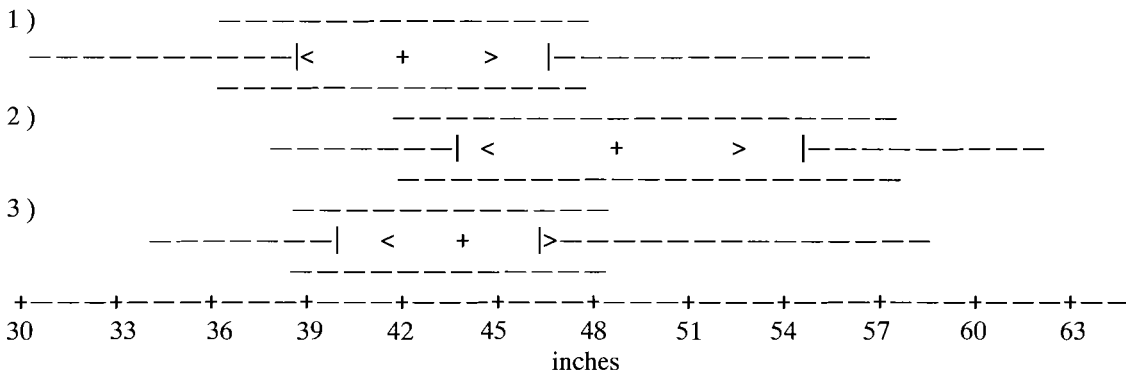
Figure 3-2. Cumulative annual precipitation for the Orangeburg, S.C., weather station for the period 1937 to 1990.



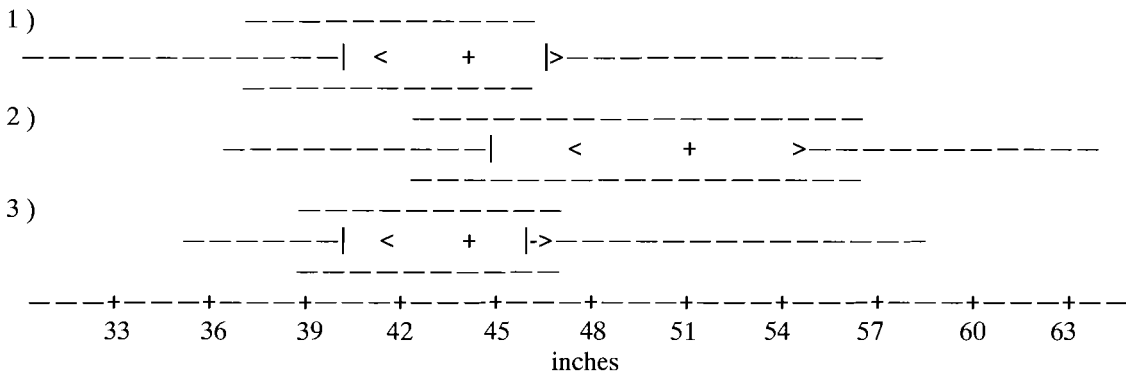
Precipitation — South Fork Edisto River Drainage Area



Precipitation — North Fork Edisto River Drainage Area



Precipitation — Edisto River (main stem) Drainage Area



Period 1) = 1940 to 1958
 Period 2) = 1959 to 1975
 Period 3) = 1976 to 1990

| = Hinges (25th and 75th percentile values, approximately)
 + = 50th percentile value (median)
 <> = 95-percent confidence limits for median value

Figure 3-3. Box plots of precipitation for drainage areas of the South Fork near Denmark, S.C., North Fork near Orangeburg, S.C., and Edisto River near Givhans, S.C. for three periods from 1937 to 1990.



Streamflow

Kendall Tau Trends Analysis

The annual peak streamflow, the 7-day streamflow, the high 3-month streamflow, the low 3-month streamflow, the 90-day annual minimum streamflow, and the 1-day annual minimum streamflow for the South Fork Edisto River near Denmark, the North Fork Edisto River near Orangeburg, and the Edisto River near Givhans were then tested for trends by using the Kendall Tau method (Hirsch and others 1982). February, March, and April were selected as the “high 3-month” streamflow period, and September, October, and November were selected as the “low 3-month” streamflow period. The North Fork Edisto River at Orangeburg, station number 02173500, had the lowest P-level. The 1-day annual minimum streamflow at the North Fork Edisto River near Orangeburg, station number 02173500, also indicated a possible trend (P-level 0.047) but the 90 day annual minimum flow at this station did not indicate a trend in the discharge. No other indications of possible trends in stream discharge were identified. The P-levels for the various groupings of streamflow characteristics are presented in Table 3-4.

Table 3-4. P-Levels resulting from Kendall Tau trends analysis for groupings of streamflow characteristics at streamflow stations.

Grouping	Stations		
	South Fork	North Fork	Edisto River at Givhans
Annual peak streamflow	0.348	0.298	0.316
7-day low streamflow	.597	.061	.783
high 3-month streamflow	.807	.994	.389
low 3-month streamflow	.679	.548	.434
1-day annual minimum flow	.754	.047	.689
90-day annual minimum flow	.639	.360	.986

Double Mass Trends Analysis

The Searcy and Hardison method for determining trends in streamflow was used in the analysis. The Searcy and Hardison method requires that the “effective precipitation” for the drainage area of each station be determined. Searcy and Hardison (1960) in discussing effective precipitation state that —

“The amount of precipitation that fell the previous year is one of the factors that affects the relationship between precipitation and runoff and causes the points on a graph of annual precipitation plotted against annual runoff to assume a ‘shotgun’ pattern. Generally the scatter of the points can be reduced by plotting an effective precipitation instead of an observed precipitation. Using an effective precipitation is one way of making allowance for the variable amount of water carried over from one year to another as groundwater storage in the Basin. The effective precipitation (P_e) commonly used is that proportion of the current year’s precipitation (P_0) and the proportion of the preceding year’s precipitation (P_1) that furnishes the current year’s runoff or $P_e = aP_0 + bP_1$.

The sum of the coefficient (a and b) must equal unity. The coefficients of a and b can be determined by rank correlation...”

The coefficients computed for the three stations in the Edisto Basin were all similar in magnitude and are shown in Table 3-5.

Table 3-5. Coefficients computed to determine effective precipitation

South Fork Edisto River near Denmark, S.C.	Station Number: 02173000	a = 0.75	b = 0.25
North Fork Edisto River at Orangeburg, S.C.	Station Number: 02173500	a = 0.77	b = 0.23
Edisto River near Givhans, S.C.	Station Number: 02175000	a = 0.78	b = 0.22

a = the proportion of the current year's precipitation (P0) and b = the proportion of the preceding year's precipitation (P1). Together these furnish the current year's runoff.

Using these equations, an effective precipitation was computed for each year of streamflow for each station. Next, the least-squares multiple regression analyses were then performed to determine the relationship between the annual streamflow (RO) in inches and effective precipitation (Pe). These annual streamflow equations are shown in Table 3-6 with their standard error and coefficient of determination. The equations were then used to compute a predicted streamflow amount for each year of record at each station. The double-mass curve (plot of cumulative observed and cumulative predicted annual runoff) was then plotted (South Fork station shown in Figure 3-4).

Table 3-6. Annual streamflow equations with standard error and coefficient of determination

Station number	Equation	Standard error (in/yr)	Coefficient of determination (R ²)
02173000	RO = (0.533 * Pe) - 11.42	2.72	0.68
02173500	RO = (0.534 * Pe) - 9.45	2.28	0.73
02175000	RO = (0.655 * Pe) - 17.71	2.40	0.78

Minor breaks hidden by the smoothing of a double-mass curve were magnified for detailed study by using a residual-mass curve. The residual-mass curve is computed by plotting cumulative residuals from the regression analysis against the year of occurrence. Using both the double-mass and residual-mass curves, a possible trend was observed in the South Fork data (station number 02173000) beginning about 1981 (see Figure 3-5). This was coincidental with the end of a period of no streamflow data (1971 to 1980). A covariance test was performed to see if the relations described by the above equation for the South Fork varied by time period used. The result was that a statistically significant difference did exist between the two periods before and after 1981. Other periods (at the same station) were tested (such as known wet and dry periods) and these also showed a statistically significant difference in the relations for these periods. The conclusion drawn from this portion of the analyses was that the strength of the relationship between Pe and RO, as indicated by the low R² (0.68 to 0.78) made the double-mass analyses questionable.

Streamflow Comparisons

Next, a double-mass analysis was made to compare streamflows at stations within the Edisto River Basin. A correlation matrix of flow data among the three streamflow stations showed that the North Fork station was the most highly correlated to the other two. Another set of regression equations was developed for use in the double-mass analysis which used the North Fork (NF) flow to predict flow in the South Fork and Givhans stations. The regression equations are presented in Table 3-7.



Table 3-7. Regression equations for use in the double-mass analysis which used the North Fork (NF) flow to predict flow in the South Fork and Givhans stations.

Station number	Equation	Standard error (in/yr)	Coefficient of determination
South Fork			
02173000	$RO = (1.027 * NF) - 0.962$	1.24	0.94
Givhans			
02175000	$RO = (1.086 * NF) - 3.562$	1.60	0.90

The double-mass curves show no breaks in either the relation for the South Fork station or the Givhans station. Therefore, there does not appear to be any change in streamflow in the lower part of the Edisto Basin with respect to streamflow in the upper part of the Basin.

If all three Edisto subbasins experienced the same trend, however, the trend might not be detected by the above analysis. Therefore, outside basins were used in a double-mass analysis to detect possible trends in the Edisto River subbasins. A correlation matrix was constructed to determine which station would be the most appropriate to use as the explanatory variable in the regression analysis. Brier Creek (station number 021980) was the most highly correlated, followed by Ogeechee River (station number 02202500). Both Brier Creek and Ogeechee River gave comparable results. The coefficient of determination ranged from above 0.75 to 0.85. All of the Edisto Basin streamflow showed a break at about 1960 (plus or minus a few years). The breaks in these double-mass analyses coincided with the beginning of an especially wet climatic period. The difference in response between the Edisto and Brier Creek basins and the Edisto and Ogeechee River basins to climatic conditions may not be accounted for in the regression equations used to estimate the runoff, as evidenced by the low coefficients of determination (note that trends were not detected by the double-mass comparisons using only the Edisto Basins where the coefficient of determinations were high, that is, in the 0.90 to 0.94 range).

Finally, it was hoped that by using an outside index basin, along with some measure of antecedent basin conditions (to reflect geologic relations of rainfall for recent years to streamflow), that an improvement would be realized in the double-mass analysis. Brier Creek (BC) was used in conjunction with the current year's precipitation (P0), and lags of annual precipitation of from one (P1) to two (P2) years in a regression analysis to estimate streamflow for each of the three Edisto subbasins. The equations, standard error, and coefficient of determination are given in Table 3-8 for each regression.

Table 3-8. The equations, standard error, and coefficient of determination for regression analyses to estimate streamflow for each of three Edisto subbasins.

Station number	Equation	Standard error (in/yr)	Coefficient of determination(R ²)
South Fork			
02173000	$RO = (0.697 * BC) + (.106 * P0) + (.104 * P1) + (.064 * P2) - 7.45$	1.53	0.91
North Fork			
02173500	$RO = (0.539 * BC) + (.167 * P0) + (.128 * P1) + (.089 * P2) - 9.63$	1.22	0.93
Givhans			
02175000	$RO = (0.567 * BC) + (.249 * P0) + (.102 * P1) - 10.85$	1.80	0.88



The coefficients of determination were 0.88 - 0.91, and residual-mass plots indicated much smaller residuals than earlier equations used in the double-mass analysis. No trend was evident in the North Fork or in the South Fork streamflow data. A small but perceptible change in streamflow at the Edisto River near Givhans began about 1968 (Figures 3-6 and 3-7).

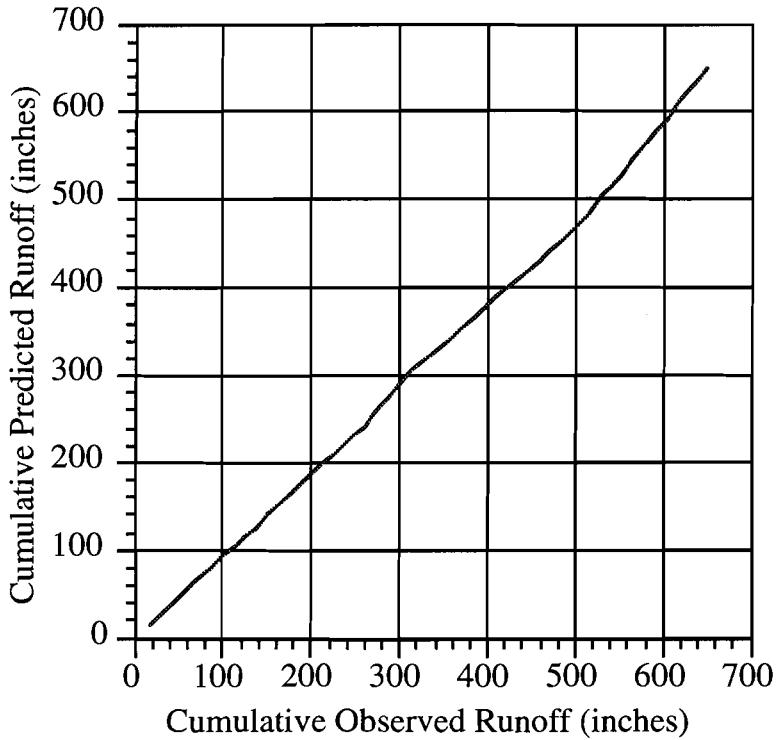


Figure 3-4. Cumulative observe annual streamflow and cumulative predicted annual streamflow based on effective precipitation (Searcy and Hardison 1960) for the South Fork Edisto River near Denmark, S.C., (02173000) for the period 1939 to 1990.

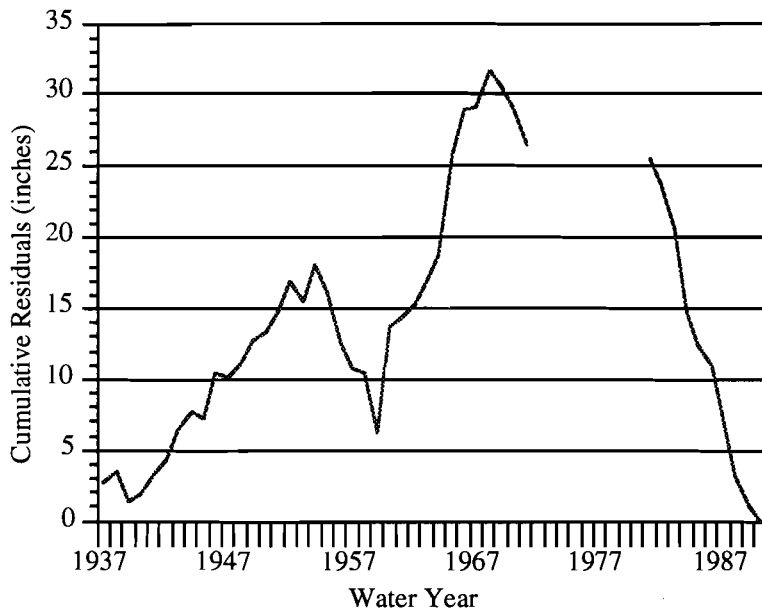


Figure 3-5. Cumulative annual residuals from predicted annual streamflow based on effective precipitation (Searcy and Hardison 1960) for the South Fork Edisto River near Denmark, S.C., (02173000) for the period 1939 to 1990.



Figure 3-6. Cumulative observed annual streamflow and cumulative predicted annual streamflow for the Edisto River near Givhans, S.C., (02175000) based on cumulative observed annual streamflow for Brier Creek near Millhaven, Ga., (02198000) for the period 1944 to 1990.

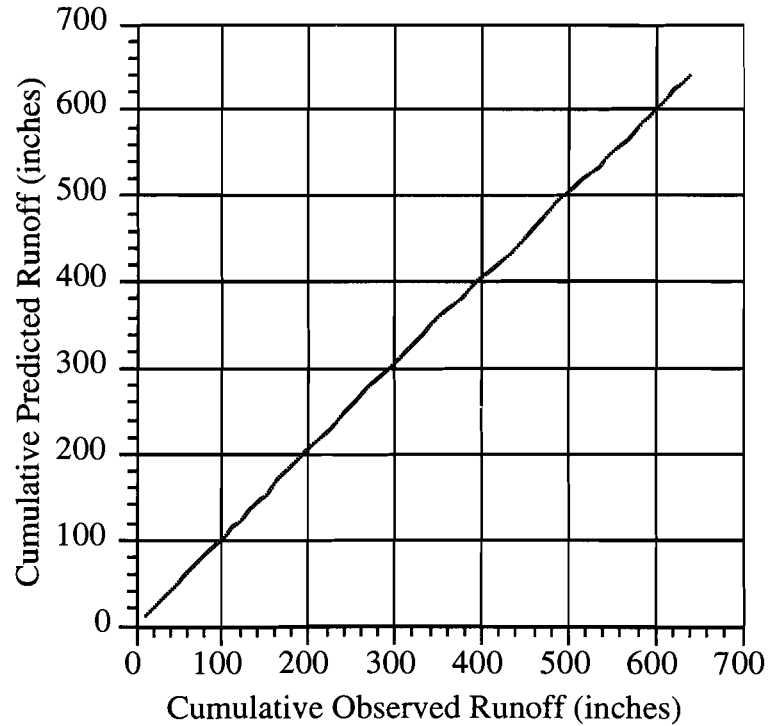
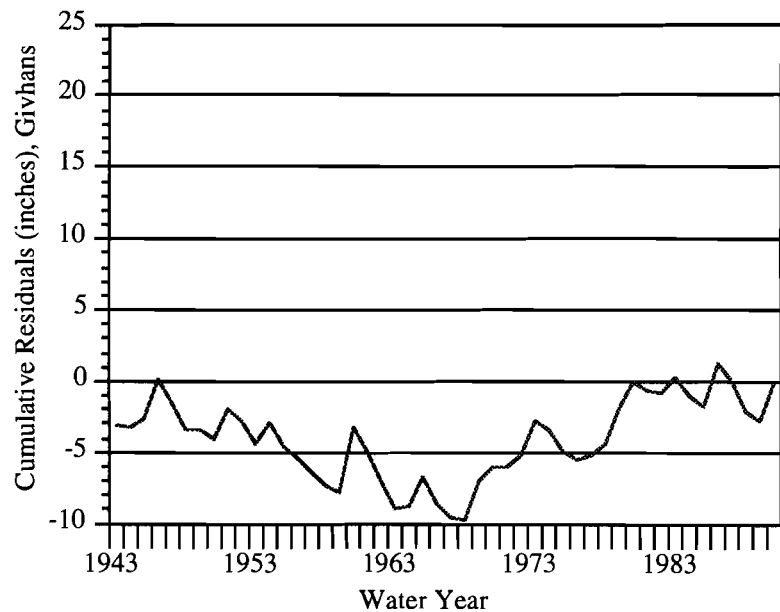


Figure 3-7. Cumulative annual residuals from predicted annual streamflow for the Edisto River near Givhans, S.C., (02175000) based on cumulative observed annual streamflow for Brier Creek near Millhaven, Ga., (02198000) for the period 1944 to 1990.





SUMMARY OF FINDINGS

Analysis of single-mass curves of precipitation and streamflow indicates that changes in precipitation and streamflow occurred in the Edisto River Basin during the period 1939 to 1990 and that changes in streamflow are a result of changes in precipitation.

Box-plots and the analysis of variance indicate that mean annual precipitation was higher during the 1959 to 1975 period than during the 1940 to 1958 and 1976 to 1990 periods. Cross-correlations of precipitation measured at six stations in and near the Edisto Basin indicated no anomalies in the data for any station and that precipitation at the Orangeburg station was the most correlatable to precipitation at all other stations. The correlation analyses further indicated that precipitation at a station is not predictable from the precipitation at another station. The coefficient of determination was very low, about 0.50.

The Kendall Tau method did not indicate any trends in the annual peak streamflow, 7-day annual low streamflows, high 3-month annual streamflows, and low 3-month annual streamflows; but it did indicate a possible trend (P-level 0.047) for the 1-day annual minimum streamflow in the North Fork Edisto River near Orangeburg. No trend was indicated, however, in the 90-day annual mean minimum flow for this station.

An analysis of double-mass curves and residual-mass curves of predicted streamflow based on the effective-precipitation method of Searcy and Hardison (1960) was inconclusive because of the low coefficients of determination (0.68 and 0.78). Comparisons of double-mass curves of streamflows for stations within the Edisto Basin indicate that streamflows were highly correlatable with one another (coefficient of determination greater than 0.90) and indicate that streamflow at any station had not significantly changed with respect to streamflow at other stations in the Basin.

Comparisons of streamflow at stations in other basins (Brier Creek and Ogeechee River) with stations in the Edisto Basin indicate that streamflow at the Brier Creek station was the most correlatable to streamflow at stations in the Edisto Basin (coefficient of determination 0.85).

Regression estimates of streamflow within the Edisto Basin using streamflow at the Brier Creek station, and lags of mean annual precipitation of 1-2 years, indicate that the standard error ranged from about 1.22 to 1.80 inches a year. The coefficient of determination ranged from 0.88 to 0.91. Double-mass analyses using this estimating equation showed no detectable trends in the North and South Fork stations. A possible insignificant trend did show up for the Givhans station.

The combined analysis, including all methods, indicates that all changes in streamflow were probably caused by changes in precipitation during the 1939 to 1990 period. Land use was not analyzed statistically with hydrology because long-term land use data for the hydrologically defined Edisto Basin are lacking, only county-based statistics of varying quality were available. However, the available data (presented in the land use chapter) suggest that land use and land cover conditions in the Edisto Basin have been fairly stable since 1950 and have probably supported the Basin's stable stream hydrology.

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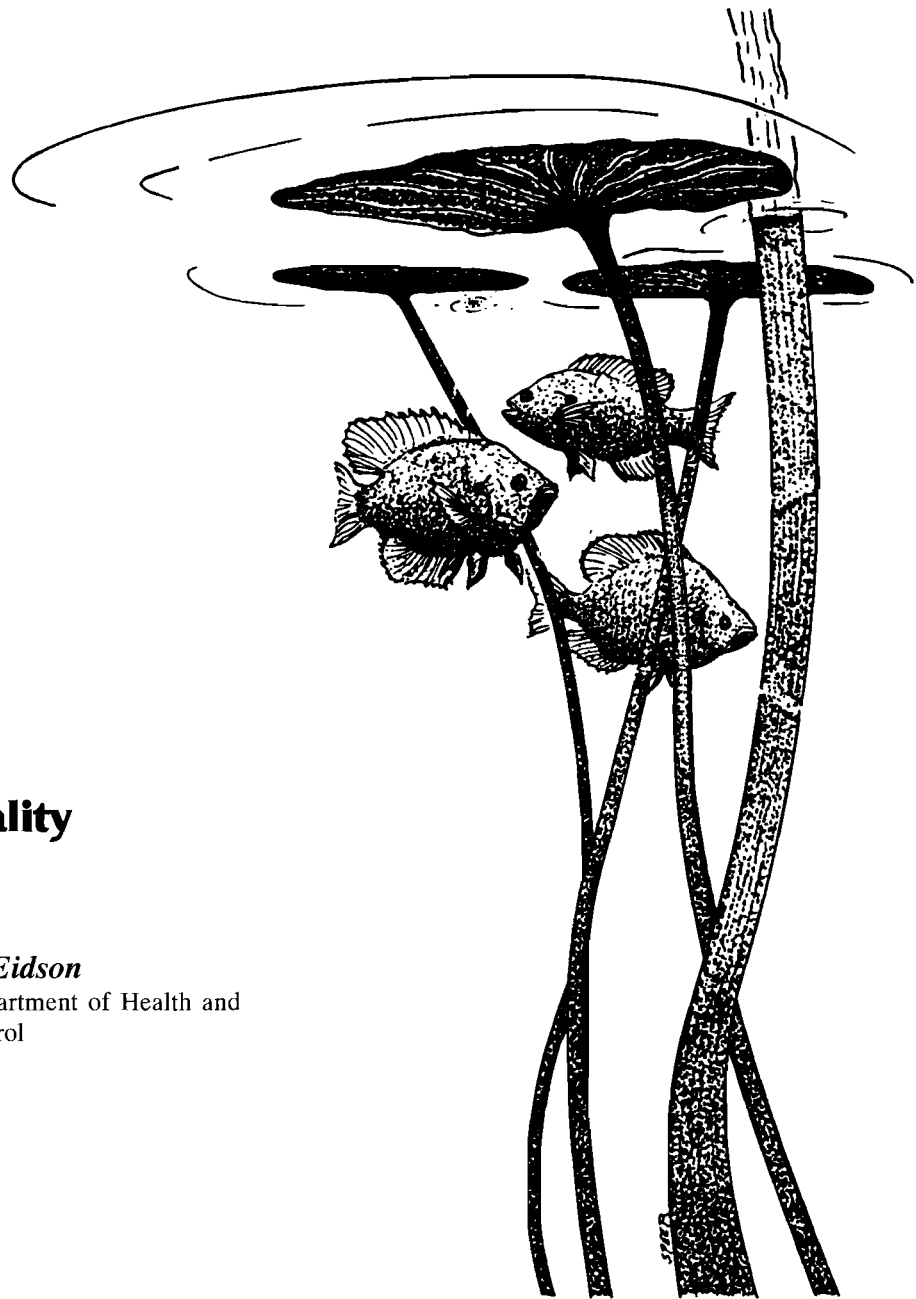
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Chapter 4 **Water Quality**

by:

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INTRODUCTION

This chapter presents an analysis of the historical patterns of water quality in the Edisto River Basin and relates pollutant concentration patterns to changes in the hydrology and land use patterns. Particular emphasis is placed on phosphorus and total Kjeldahl nitrogen because of their importance to biological productivity in freshwater ecosystems.

Phosphorus, in comparison to other major nutrients required for biological processes, is the least abundant and commonly the first to limit freshwater primary productivity. Phosphorus is tightly bound to sediments; consequently, increased concentrations in streams and lakes are usually associated with accelerated rates of land erosion and runoff. In addition, phosphorus is a constituent of agricultural fertilizers and all wastes derived from domestic sewage. Because of these characteristics and associations, the concentration of phosphorus in streams is an excellent index of cultural disturbance in developing watersheds.

Nitrogen rapidly cycles between sedimentary, aquatic, and atmospheric environments and therefore creates problems in the analysis of long-term data sets. The constituents of total nitrogen in water include total Kjeldahl nitrogen (NH_4^+ , dissolved organic N, and particulate organic N) and nitrate-nitrite. Because of the interconversions among these different forms, through nitrogen fixation, denitrification and atmospheric deposition, total Kjeldahl nitrogen is usually chosen to represent nitrogen dynamics in aquatic ecosystems.

SITE DESCRIPTION

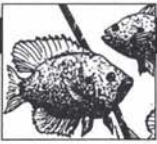
The 3,120 square miles (800,000 hectares) of the Edisto Basin study area are drained by four major rivers, the North Fork Edisto River, South Fork Edisto River, Edisto River (main stem), and Four Hole Swamp.

The North Fork, formed by the confluence of Chinquapin and Lightwood Knot Creeks, flows southeasterly for 66 miles to Orangeburg, and then southward for 27 miles to its confluence with the South Fork. The South Fork flows southeasterly 91 miles to its junction with the North Fork near Branchville. Average annual streamflow in these major tributary streams is 803 cfs (cubic feet per second) on the North Fork Edisto at Orangeburg and 797 cfs on the South Fork Edisto near Denmark. The main stem of the Edisto River, formed by the confluence of its north and south forks, flows southeasterly 48 miles to Givhans Ferry State Park, then southward 60 miles to the Atlantic Ocean. Average annual streamflow on the Edisto River is 2,033 cfs near Branchville and 2,678 cfs near Givhans. The well-sustained flows are due primarily to discharge from groundwater reserves in the Upper Coastal Plain region in which more than half of the basin is located. The lower 38 miles of the river are tidally influenced, and saline waters extend approximately 20 miles inland.

WATER QUALITY DATA INTERPRETATION

Water quality data were analyzed for 11 stations located throughout the entire Basin (Figure 4-1). Historical records of both hydrology and water quality were available for 7 of the 11 stations, with the most extensive data base obtained from the Edisto River at the Givhans Ferry State Park site. Monthly water quality data were obtained from the South Carolina Department of Health and Environmental Control and discharge records were obtained from the U.S. Geological Survey's Benchmark and NASQAN (National Stream Quality Accounting Network). Water quality characteristics of primary interest were total phosphorus (TP), total Kjeldahl nitrogen (TKN), nitrate-nitrite ($\text{NO}_{2,3}$), ammonia-ammonium nitrogen ($\text{NH}_{3,4}$), turbidity (TURB) and total suspended solids (TSS). Fecal coliform, biochemical oxygen demand (BOD), dissolved oxygen (DO), and pH were also analyzed. Nutrients, TSS, BOD, and DO are in milligrams per liter (mg/l); turbidity is in units of NTU (nephelometric turbidity units); and fecal coliform is in number of bacteria per 100 milliliters. Analyses were based on monthly values, not monthly averages. Table 4-1 provides a descriptive location and stream classification for each site.

Water quality data from each station were analyzed for long-term trends by using



EDISTO RIVER BASIN MONITORING STATIONS

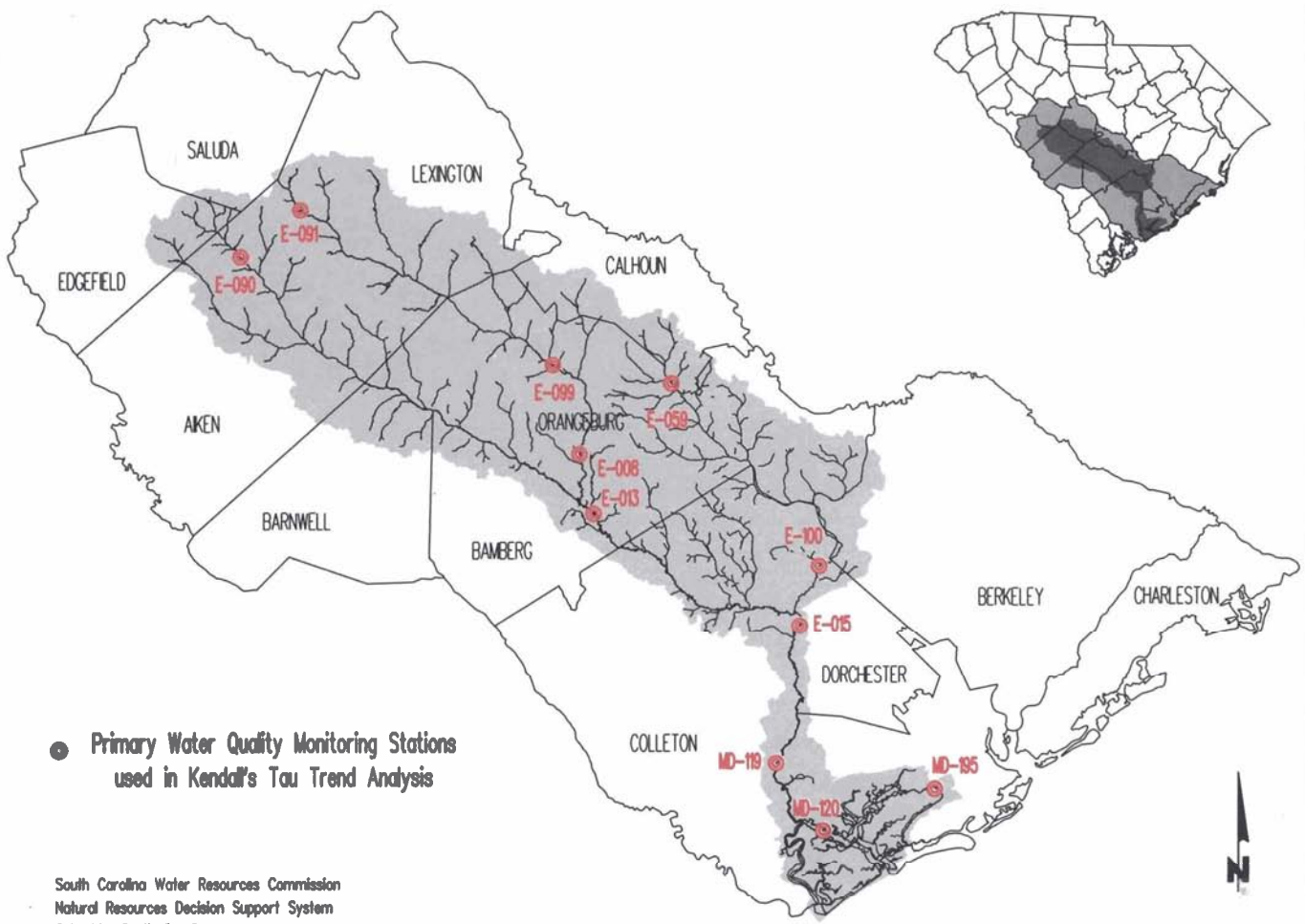
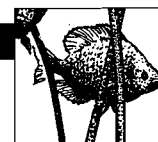


Figure 4-1. Primary water quality monitoring stations in the Edisto River Basin used in Kendall's Tau trend analysis.



the Seasonal Kendall Tau test, which is intended for monthly water-quality time series with potentially large seasonal variability. The advantage of using this nonparametric test is that outliers, missing values, or values reported as being below detection limits (DL) are valid data points and present no computational or theoretical problems. The test statistic is a one-sided standard normal deviate, Z , with the sign of the Z score indicating the direction of the trend. A probability of 0.05 was used as a significance criterion. This is the functional equivalent of a two-sided test at a significance level of 0.10. Therefore, in 90 percent of the cases, a parameter trend or no trend status should have been correctly identified. In addition, a Seasonal Kendall Slope Estimator was calculated to indicate the magnitude of the trend and provide between-site comparisons. Values recorded at detection limits were omitted from the data set.

Water quality records were flow-adjusted prior to analysis to eliminate streamflow variations as a potential cause. The flow-adjusted concentrations (FAC) were estimated through regression analysis, using the method of Smith and others (1982) and fitting the data to linear, log, hyperbolic, or inverse curves. The FAC was determined as the difference between the observed and predicted values from the best fit regression equation. Table 4-2 lists the parameters that were adjusted by station, along with the functional form for transformation. All other regression relationships were poor ($p > 0.10$) or had fewer than 24 discharge values. In these cases, the FAC was the monthly concentration. In addition, a review of laboratory methods was conducted to identify changes in procedures that might result in trend artifacts.

Table 4-1. Water quality station location descriptions and stream classifications.

Station ID	Description	Stream Classification	Watershed
E-091	North Fork Edisto River at S.C. 391 5.5 miles south of Batesburg	A	North Fork
E-099	North Fork Edisto River at S-38-74 Northwest of Orangeburg	A	North Fork
E-008	North Fork Edisto River at S-38-9 West -southwest of Rowesville	B	North Fork
E-090	South Fork Edisto River at US 1 12 miles northeast of Aiken	A, B	South Fork
E-013	Edisto River at US 78 West of Branchville	A	Edisto (main stem)
E-015	Edisto River at S.C. 61, Givhans Ferry State Park (Corresponds with USGS station 02175000)	A	Edisto (main stem)
E-059	Four Hole Swamp at S-38-50 5.3 miles southeast of Cameron	B*	Four Hole Swamp
E-100	Four Hole Swamp at US 78 East of Dorchester	B*	Four Hole Swamp
MD-119	Edisto River at US 17 12.5 miles northwest of Ravenel	A, ORW**	Brackish/ Marine
MD-120	Dawhoo River at S.C. 174 9 miles north of Edisto Beach	ORW	Brackish/ Marine
MD-195	Bohicket Creek at S.C. 700 1 mile southwest of Cedar Springs	SFH***	Brackish/ Marine

* Site specific standard (DO not less than 4 mg/l, pH 5-8.5)

** ORW Outstanding Resource Waters

*** SFH Shellfish Harvesting Waters

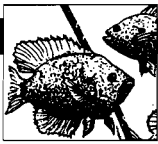


Table 4-2. Functional forms of flow adjusted parameters, by station.

Station	Parameter	Form - f(Q)	R2	Probability
E-013	NO ₂₋₃	1/Q	0.29	0.0001
E-015	TURB	1/(1+βQ)*	0.12	0.0001
	NO ₂₋₃	1/Q	0.27	0.0001
	TOC	1/(1+βQ)	0.36	0.0001
E-008	DO	1/(1+βQ)	0.12	0.0001
	NO ₂₋₃	1/Q	0.27	0.0001
	TOC	1/(1+βQ)	0.19	0.0001
E-090	TURB	1/(1+βQ)	0.10	0.0001
	DO	ln Q	0.15	0.0001
E-091	TURB	1/(1+βQ)	0.33	0.0001
	DO	1/(1+βQ)	0.13	0.0001
	NO ₂₋₃	ln Q	0.24	0.0001
	TP	1/(1+βQ)	0.49	0.0001
E-099	DO	ln Q	0.13	0.0001
	NO ₂₋₃	1/(1+βQ)	0.18	0.0001

*where β is a positive constant and Q is discharge.

Simple linear regressions of concentration versus discharge were used to reveal the controlling process for phosphorus stream input. In undisturbed forested watersheds, a negative slope is indicative of the dilution of a constant phosphorus source. In disturbed watersheds, a positive slope indicates that erosion processes and transport of total phosphorus dominate the ecosystem.

Box plots were used to show summary statistics for all parameters by station. The horizontal mark in the box is the median value; the upper and lower hinges of the box represent the interquartile range; the box width is a relative scale of sample size; and the notch height represents the 95 percent confidence interval of the median value. Stations with median values that fall within the notch area of one another are not significantly different. The central vertical lines (*whiskers*) extend up to 1.5 interquartile ranges from the end of the box. Values outside the whiskers are marked with an asterisk or a circle. An asterisk is used if the value is between 1.5 and 3 interquartile ranges of the box, and a circle is used if the value is farther away. Values that are far away from the rest of the data are outliers.

Nutrient and total-suspended-solid fluxes were determined by using data from the southernmost freshwater station on the Edisto River, located at Givhans Ferry State Park (E-015). The drainage area for this station is approximately 2,730 square miles, incorporating the North Fork, the South Fork, and Four Hole Swamp. Three methods were used to calculate mean annual loading, as described below.

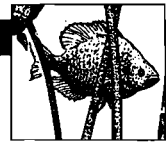
1. Daily fluxes of TP, TKN, NO₂₋₃, NH₃₋₄, and TSS were computed as the product of instantaneous daily discharge (cfs) and concentration (mg/l), and converted to kg/day. Simple linear interpolation was used to determine nutrient and sediment fluxes in the intervals between sampling events. The total load is the sum of the individual sample loads during the time interval.

2. The overall flux-weighted mean concentration of each parameter was multiplied by the mean annual discharge observed at the station for the entire period of hydrological record. Flux-weighted mean concentrations were calculated as follows:

$$C = (\sum c_i q_i t_i) / (\sum q_i t_i)$$

where c_i = concentration of the i^{th} sample; q_i = instantaneous flow for the i^{th} sample; and t_i = time multiplier for the i^{th} sample. A major assumption in this method is that the flux-weighted mean concentrations, as based on the sampling period covered by the study, is representative of the long-term flux-weighted concentrations characteristic of the station.

3. The annual flux-weighted mean concentration of each parameter was multiplied by the mean annual discharge observed at the station for the entire period of hydrological record.



RESULTS AND DISCUSSION

Trends Analysis

Table 4-3 presents a summary of water quality trends at eleven stations in the Edisto Basin. Collectively, these stations provide a representative picture of overall water quality conditions. An increasing trend is designated by 'I'; a decreasing trend by 'D'; and data not available by 'DNA.' Blank cells are indicative of no significant trends. Temporal and spatial aspects of the data sets are listed in Table 4-4.

Trends in Biochemical Oxygen Demand

Five-day biochemical oxygen demand (BOD) is the amount of oxygen consumed by respiratory processes in the decomposition of carbonaceous and nitrogenous matter in the water. The BOD test indicates the amount of biologically oxidizable material present in wastewater or in natural water. Nationally, municipal and industrial BOD loads have decreased by 46 percent and 71 percent, respectively, in the decade after the passage of the Clean Water Act in 1972 (Smith and others 1982). One-third of the current point-source BOD is contributed by industrial sources. Since the federal expenditures for municipal facilities upgrading did not reach a maximum till 1980, it is probable that much of the declines in industrial loads took place slightly earlier than the decline in municipal loads (Smith and others 1987).

Concurrent with nationwide trends, decreasing trends in BOD were observed consistently across all stations within the Edisto Basin from the period 1975 to 1991. Summary statistics show the overall BOD mean decreased by 50 percent, from 3.05 mg/l in 1975 to 1.52 mg/l in 1991 (Table 4-5). The highest percentage changes in mean concentrations were at Station E-008 (North Fork directly below Orangeburg) and Station E-013 (directly downstream from E-008, at the confluence of the North and South Forks). The average concentration at Station E-008 was 2.19 mg/l and the standard deviation was 1.237 mg/l. The analysis indicates the existence of a decreasing trend ($p < 0.0001$), and the slope estimate was -0.1 mg/l per year or -4.5 percent of the mean per year. At Station E-013, the mean concentration and standard deviation were 2.11 and 2.57 mg/l, respectively. The slope estimate was -0.1 mg/l per year or -4.7 percent of the mean per year.

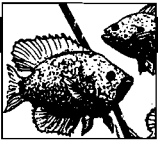
Although there are few permitted industrial and municipal facilities that discharge into the Edisto Basin, six of the eight major facilities in the entire basin discharge into the North Fork Edisto River and the Edisto River. Data collected from Stations E-008 and E-013 are used to monitor the water quality in these areas. Consequently, with the reduced BOD loads from industries and municipalities, a higher percentage change in the elimination of BOD would be expected at these sites.

Trends in Total Nitrate-Nitrite

Trends for nitrate-nitrite (NO_{2-3}) concentrations were evenly divided between increases and decreases among stations. The North Fork Edisto River and the confluence stations exhibited an increase in NO_{2-3} concentrations, while the coastal and Four Hole Swamp areas showed a decreasing trend.

Nationwide, changes in atmospheric deposition, municipal waste treatment, and fertilizer use have each been identified as a major cause of nitrate trends (Smith and others 1987). In addition, increases in NO_{2-3} have been associated with livestock population density and feedlot activity (Hem 1985). In comparing the observed NO_{2-3} trends in the Edisto Basin with land use activity, increasing trends were found to be associated with urbanized watersheds. Station E-008 (directly below Orangeburg), with a mean of 0.238 mg/l and standard deviation of 0.194 mg/l, exhibited the maximum increase in mean change of 3.4 percent per year (slope estimate = 0.002). With the concurrent decreasing trends in BOD and total phosphorus associated with waste treatment improvements at this site, drainage of nearby barnyards and septic tanks (sub-surface influences) may contribute more significantly to the NO_{2-3} load.

Station E-091, located at the headwaters of the North Fork Edisto River, exhibited the highest mean NO_{2-3} concentration. The average concentration for E-091 was 1.064 mg/l, an order of magnitude greater than all other stations. Concentrations over 1 mg/l usually are associated with waste inputs (Welch 1980), which may well be the case in this situation.



A wastewater treatment facility, directly upstream from this site, discharges into a small tributary to the North Fork Edisto River headwaters. The permit discharge limit is 1 MGD (million gallons per day). Treatment modifications have decreased the BOD load during normal operations; however, the detrimental effects of stormwater infiltration to the plant were not adequately addressed until recently. Releases of partially treated wastewater during storms have been a common occurrence. Currently, equalization ponds have been established to handle the additional load, resulting in marked improvement in downstream water quality. Confounding these conditions, the number of poultry farms and confined livestock located near this site could also contribute significantly to the $\text{NO}_{2,3}$ load.

The lowest average concentrations were at Stations MD-120 and MD-195, at 0.09 and 0.06 mg/l, respectively. As mentioned previously, the coastal waters and Four Hole Swamp experienced decreasing trends in $\text{NO}_{2,3}$ concentrations. With relatively low concentrations, interconversion of the different nitrogen species makes it difficult to interpret results. A more detailed analysis of historical land-use changes may provide insight to probable causes of trends.

Trends in Total Ammonia

From the mid-reach of the North Fork Edisto River downstream to the confluence, and for the entire South Fork Edisto River watershed, a decreasing trend in $\text{NH}_{3,4}$ concentrations was observed. The maximum decreases in mean changes averaged -2.25 percent per year at Stations E-099 and E-091, with mean values of 0.118 mg/l and 0.146 mg/l, respectively. Percentage changes decreased consistently with distance downstream for both the North Fork and South Fork Edisto Rivers. On the North Fork Edisto River, this pattern coincides with the increase in $\text{NO}_{2,3}$ concentrations. Again, the nonconservative nature of nitrogen creates problems in data analysis if detailed information on individual processes is not available. In such cases, total Kjeldahl nitrogen (TKN) is usually selected to represent the overall nitrogen dynamics within the system.

Trends in Total Kjeldahl Nitrogen

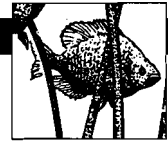
As such, only 2 of the 11 stations exhibited decreasing trends in TKN concentrations. These sites were limited, geographically, to the South Fork Edisto River (E-090) and the confluence station (E-013). Both sites had an average TKN concentrations of 0.69 mg/l and slope estimates of -0.016 mg/l or -2.3 percent of mean per year. Without major dischargers in the South Fork watershed, improved modifications in agricultural practices may be associated with the decrease in TKN concentrations.

Trends in Total Phosphorus

Total phosphorus concentrations decreased throughout the upper Edisto Basin and within Four Hole Swamp. Minimal percentage mean change (less than 0.1 percent) occurred at the headwater reaches of the North and South Fork Edisto Rivers. Maximum percentage changes were observed at Stations E-008 and E-100. Both sites are directly downstream from municipal wastewater treatment facilities. Improvement in treatment methods may account for the higher percentage mean change. As with $\text{NO}_{2,3}$, Station E-091 had the highest mean phosphorus concentration of 0.56 mg/l (Table 4-5), five-fold higher than all other stations examined. Partially treated wastewater discharged during storms may contribute significantly to these high values. Annual mean concentrations ranged from 0.41 mg/l in 1976 to 0.09 mg/l in 1991 (Table 4-5).

Trends in pH

Decreasing trends were observed at three sites in the Edisto Basin: Four Hole Swamp (E-100), Givhans Ferry (E-015), and South Edisto River (MD-119). Slope estimates ranged from -0.05 to -0.10 standard units (s.u.) per year. It is not uncommon to find low pH values in a cypress-tupelo swamp such as Four Hole Swamp, owing to the production of humic acids. The increasing ratio of $\text{NH}_{3,4}$ to $\text{NO}_{2,3}$ percentage at Station E-100, in comparison to its headwaters, is indicative of increased humic acid production. Consequently, the drainage of this slightly acidic water appears to be exerting an effect on the downstream sites. Station E-100 exhibited the most consistent decreasing trends across all the parameters analyzed, including turbidity (TURB) and total suspended solids (TSS). No significant trends for TURB or TSS were observed at any other sites.



Station	TURB	TSS	DO	FECAL	BOD	TP	TKN	NO2-3	NH3-4	PH
North Fork Drainage										
E-091	*	DNA	*		D P<0.0001 S=-0.08	D* P=0.007 S=-0.0001		I* P=0.035 S=0.001		
E-099		DNA	*		D P=0.038 S=0.026	D P<0.0001 S=-0.005		I* P=0.0006 S=0.003	D P<0.0001 S=-0.003	
E-008			*		D P<0.0001 S=-0.100	D P=0.0005 S=-0.005		I* P<0.0001 S=0.008	D P=0.0113 S=-0.003	
South Fork Drainage										
E-090	*	DNA	*		D P<0.0001 S=-0.083	D P=0.0166 S=0.0001	D P=0.0052 S=-0.0145		D P=0.001 S=-0.003	
Edisto - Main Stem										
E-013		DNA			D P<0.0001 S=-0.10	D P=0.0102 S=-0.002	D P<0.0001 S=-0.018	I* P=0.05 S=0.002	D P=0.024 S=-0.001	
E-015	*				D P<0.0001 S=-0.04					D P<0.0001 S=-0.05
Four Hole Swamp Drainage										
E-059		DNA			D P<0.0001 S=-0.083					
E-100	D P=0.05 S=-0.1	D P=0.0485 S=-0.04			D P=0.004 S=-0.05	D P<0.0001 S=-0.003		D P=0.0031 S=-0.004	D P=0.008 S=-0.002	D P<0.0001 S=-0.025
Brackish/Marine										
MD-119		DNA			D P<0.0001 S=-0.083			D P=0.004 S=-0.004		D P<0.0001 S=-0.10
MD-120		DNA			D P<0.0001 S=-0.089			D P<0.0001 S=-0.003		
MD-195		DNA			D P<0.0001 S=-0.08			D P<0.0001 S=-0.0012		

Blank Cells indicate no trend
 D=Significant declining trend
 I=Significant increasing trend
 P=One-sided significance level
 DNA=Data not available
 * = Flow adjusted concentrations

Table 4-3. Summary of the Seasonal Kendall Tau trend assessment for the Edisto Basin.

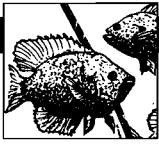


Table 4-4. Temporal range and sample number for water quality constituents, by site.

Station	TURB	TSS	DO	FECAL	BOD	TP	TKN	NO2-3	NH3-4	PH
North Fork Drainage										
E-091	126 1975-1991	DNA	126 1975-1991	136 1980-1991	195 1975-1991	122 1975-1991	176 1975-1991	121 1975-1991	184 1975-1991	142 1980-1991
E-099	135 1980-1991	DNA	122 1980-1991	132 1980-1991	133 1980-1991	138 1980-1991	131 1980-1991	126 1980-1991	135 1980-1991	138 1980-1991
E-008	181 1975-1991	139 1975-1992	127 1975-1991	140 1980-1991	184 1975-1991	172 1977-1991	163 1975-1991	127 1975-1991	167 1975-1991	168 1980-1991
South Fork Drainage										
E-090	120 1975-1991	DNA	119 1975-1991	132 1980-1991	193 1975-1991	173 1975-1991	171 1975-1991	180 1975-1991	175 1975-1991	139 1980-1991
Edisto - Main Stem										
E-013	187 1975-1991	DNA	192 1975-1991	137 1980-1991	193 1975-1991	167 1975-1991	164 1975-1991	113 1975-1991	169 1975-1991	142 1980-1991
E-015	111 1975-1991	134 1975-1991	221 1975-1991	139 1980-1991	192 1975-1991	169 1975-1991	171 1975-1991	107 1975-1991	173 1975-1991	155 1980-1991
Four Hole Swamp Drainage										
E-059	186 1975-1991	DNA	197 1975-1991	138 1980-1991	193 1975-1991	175 1975-1991	171 1975-1991	188 1975-1991	183 1975-1991	139 1980-1991
E-100	130 1980-1991	129 1980-1991	156 1980-1991	135 1980-1991	135 1980-1991	129 1980-1991	125 1980-1991	128 1980-1991	127 1980-1991	146 1980-1991
Brackish/Marine										
MD-119	186 1975-1991	DNA	193 1975-1991	68 1980-1991	188 1975-1991	172 1975-1991	152 1975-1991	177 1975-1991	173 1975-1991	132 1980-1991
MD-120	181 1975-1991	DNA	203 1975-1991	7 1980-1991	193 1975-1991	161 1975-1991	166 1975-1991	169 1975-1991	161 1975-1991	133 1980-1991
MD-195	195 1975-1991	DNA	217 1975-1991	11 1980-1991	198 1975-1991	172 1975-1991	166 1975-1991	180 1975-1991	174 1975-1991	140 1980-1991



[Basinwide		TSS	PH	FEC	FLOW	TURB	DO	BOD	NH3-4	TKN	NO2-3	TOTAL N	TP	TOC	NP RATIO
		(mg/l)	(s.u.)	(#/100 ml)	(CFS)	(nu)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg)	(mg/l)	(mg/l)	
Overall	Mean	4.44	6.67	163	1,027	7.04	7.41	2.28	0.17	0.80	0.31	1.11	0.16	9.62	12.17
	SD	4.16		172	1,511	7.57	2.18	1.47	0.26	0.55	0.39	0.72	0.23	5.47	10.01

Watershed															
North Fork	Mean	5.30	6.24	218	432	6.42	7.88	2.19	0.22	0.76	0.51	1.28	0.29	7.57	9.04
	SD	4.50		207	392	7.40	2.14	1.63	0.38	0.59	0.56	0.87	0.38	4.22	7.56
South Fork	Mean		6.67	165	52	8.52	8.77	2.05	0.15	0.69	0.45	1.15	0.10	6.46	17.20
	SD			128	43	12.20	1.94	1.57	0.18	0.61	0.24	0.67	0.10	8.70	13.01
Edisto	Mean	4.42	6.53	93	2,208	4.74	7.48	2.08	0.16	0.76	0.20	0.95	0.11	10.51	11.52
	SD	3.45		113	1,938	5.04	1.98	2.06	0.41	0.59	0.19	0.62	0.09	9.06	8.52
Four Hole	Mean	3.06	6.68	189	376	5.90	6.82	2.24	0.17	0.95	0.34	1.27	0.11	14.21	16.32
	SD	2.65		171	563	5.47	2.21	1.08	0.27	0.59	0.32	0.65	0.12	8.98	10.97
Brackish/Marine	Mean		7.20	70		9.68	6.83	2.65	0.16	0.83	0.11	0.96	0.10	11.14	12.03
	SD			100		8.73	2.12	1.27	0.26	0.52	0.24	0.68	0.07	9.92	14.57

Stations

North Fork Drainage															
E-091	Mean	3.50	6.56	431	16	9.20	8.60	2.63	0.29	0.92	1.06	2.01	0.56	7.21	7.64
	SD	2.12		221	14	9.03	2.10	1.45	0.39	0.64	0.59	0.84	0.50	3.60	7.65
E-099	Mean		5.75	129	587	3.68	7.85	1.52	0.12	0.56	0.14	0.69	0.09	6.21	11.64
	SD			112	269	4.17	2.16	0.87	0.14	0.52	0.07	0.53	0.09	3.12	7.78
E-008	Mean	5.35	6.37	134	682	5.66	7.23	2.07	0.19	0.74	0.24	0.97	0.17	8.15	8.01
	SD	4.53		126	359	6.47	1.95	1.11	0.27	0.53	0.15	0.54	0.13	4.68	5.55
South Fork Drainage															
E-090	Mean		6.67	165	52	7.38	8.77	2.05	0.15	0.69	0.45	1.14	0.10	5.54	17.20
	SD			128	43	9.25	1.94	1.57	0.18	0.61	0.24	0.65	0.10	3.11	13.01
Edisto - Main Stem															
E-013	Mean		6.31	102	1,664	5.30	7.71	2.11	0.15	0.69	0.21	0.89	0.12	8.88	10.36
	SD			99	1,133	6.56	1.98	2.57	0.19	0.38	0.19	0.42	0.11	4.10	7.99
E-015	Mean	4.44	6.74	84	2,487	4.18	7.28	2.04	0.13	0.78	0.19	0.96	0.10	10.00	12.55
	SD	3.45		126	2,192	2.68	1.96	1.38	0.26	0.53	0.19	0.53	0.06	4.66	8.84
Four Hole Swamp Drainage															
E-059	Mean		6.56	260		7.50	6.88	2.34	0.16	0.88	0.50	1.37	0.13	10.06	16.69
	SD			181		6.33	2.22	1.11	0.20	0.56	0.31	0.67	0.15	4.79	12.01
E-100	Mean	3.02	6.80	117	376	3.62	6.74	2.07	0.18	1.03	0.11	1.13	0.09	15.55	15.84
	SD	2.63		125	563	2.58	2.20	0.87	0.35	0.63	0.11	0.62	0.07	6.64	9.47
Brackish/Marine															
MD-119	Mean		6.79	67		4.17	7.31	2.26	0.13	0.80	0.19	0.97	0.10	11.52	12.44
	SD			93		4.26	2.04	1.26	0.27	0.49	0.29	0.53	0.06	5.60	9.60
MD-120	Mean		7.31	147		16.42	6.67	2.64	0.17	0.84	0.09	0.99	0.11	10.65	11.42
	SD			197		10.33	2.06	1.20	0.25	0.44	0.28	0.84	0.08	4.59	12.21
MD-195	Mean		7.48	43		8.78	6.56	3.04	0.18	0.84	0.06	0.89	0.10	8.67	10.74
	SD			37		5.70	2.19	1.23	0.26	0.55	0.09	0.56	0.06	4.61	7.91

*Represents median value

Table 4-5. Summary statistics for the Edisto Basin by watershed and station.

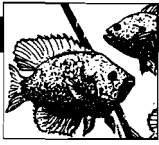
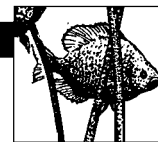


Table 4-5 continued. Summary statistics for the Edisto Basin by year.

Annual	TSS	PH*	FEC	CFS	TURB	DO	BOD	NH3-4	TKN	NO2-3	TP	TOC	NP RATIO
1975	Mean				7.12	7.58	3.00	0.08	0.72	0.42	0.06	9.33	23.99
	SD				6.59	2.15	1.11	0.05	0.44	0.64	0.04	4.25	15.38
1976	Mean				7.51	7.54	3.61	0.17	1.05	0.41	0.15	10.43	17.14
	SD				7.48	1.80	1.72	0.24	0.50	0.33	0.16	5.07	10.41
1977	Mean				8.69	7.26	3.21	0.14	0.94	0.31	0.12	9.49	16.62
	SD				9.87	1.86	3.65	0.11	0.52	0.33	0.13	5.37	15.60
1978	Mean				9.40	7.71	3.06	0.10	0.82	0.24	0.11	9.32	16.78
	SD				11.34	2.21	1.95	0.11	0.43	0.23	0.14	4.03	11.95
1979	Mean				9.81	7.35	2.54	0.10	0.60	0.35	0.15	8.51	12.52
	SD				9.19	2.26	1.23	0.17	0.42	0.50	0.19	5.02	13.65
1980	Mean	7.02	161	1,140	7.10	6.97	2.17	14.33	0.15	0.38	0.33	0.15	10.10
	SD	5.49	153	1,729	5.20	2.33	1.23	0.26	0.52	0.36	0.22	4.37	13.47
1981	Mean	4.70	138	579	7.86	6.74	2.57	0.40	1.10	0.30	0.25	8.79	8.31
	SD	3.68	160	637	10.21	2.62	1.52	0.47	1.03	0.41	0.28	6.32	5.97
1982	Mean	3.49	158	771	6.01	7.12	2.18	0.40	1.09	0.22	0.28	10.52	5.98
	SD	3.11	165	845	8.73	1.74	0.97	0.52	0.81	0.24	0.19	5.04	5.00
1983	Mean	3.71	162	1,122	5.68	7.97	2.27	0.17	0.81	0.28	0.19	8.15	11.15
	SD	2.90	171	1,715	6.08	2.55	1.03	0.24	0.57	0.31	0.25	3.35	13.49
1984	Mean	3.34	164	964	4.88	8.02	1.90	0.16	0.75	0.29	0.14	7.88	10.39
	SD	2.33	190	1,241	4.81	2.21	0.74	0.20	0.35	0.40	0.16	3.80	6.29
1985	Mean	3.57	186	829	6.17	7.67	2.44	0.19	0.80	0.27	0.14	9.25	13.14
	SD	3.78	211	1,101	6.91	2.32	1.11	0.28	0.43	0.36	0.25	6.37	7.23
1986	Mean	6.13	151	649	7.21	7.47	1.83	0.15	0.73	0.35	0.18	8.89	11.46
	SD	6.90	151	877	7.28	1.93	0.96	0.15	0.32	0.49	0.39	6.28	6.87
1987	Mean	4.57	173	789	6.84	7.36	1.88	0.12	0.76	0.32	0.17	10.12	11.29
	SD	3.88	188	1,014	7.84	1.87	0.98	0.10	0.48	0.40	0.31	6.30	6.88
1988	Mean	4.03	164	550	5.70	7.83	1.73	0.12	0.68	0.31	0.13	9.25	12.24
	SD	4.39	179	616	5.63	1.96	0.72	0.14	0.41	0.41	0.20	6.63	8.94
1989	Mean	3.89	181	982	6.36	6.89	1.90	0.12	0.75	0.25	0.10	11.54	12.30
	SD	3.99	174	1,234	5.29	2.57	1.36	0.17	0.30	0.36	0.09	4.62	7.05
1990	Mean	4.39	145	538	7.12	7.55	1.78	0.08	0.62	0.34	0.10	11.36	15.05
	SD	2.96	156	847	7.05	1.76	0.86	0.04	0.22	0.40	0.14	6.08	9.67
1991	Mean	4.83	183	4,831	9.37	6.86	1.52	0.09	0.72	0.27	0.09	13.69	14.59
	SD	2.54	146	3,907	6.75	2.03	0.63	0.08	0.30	0.33	0.07	4.64	11.19

*Represents median value



Water Quality Standards

The presence of a significant trend indicates improvement or degradation of a water resource over time. However, information regarding compliance of water quality conditions to acceptable standards is not provided. To determine if watersheds met stream use classification requirements, individual values were compared to state water quality standards or federal water quality criteria. Excursions are values higher than standards or criteria. Excursions due to natural conditions are not considered standard violations.

Dissolved Oxygen Excursions

Oxygen depletion rates are primarily a function of temperature and the availability of organic substances for microbial respiration. Stream classifications A and B require that the average daily dissolved oxygen (DO) should be no less than 5.0 mg/l and individual DO readings should never be less than 4.0 mg/l.

The Four Hole Swamp and coastal stations exhibited the highest percentage excursions of DO standards, averaging 4.8 percent beyond the 4.0 mg/l standard, and 17.5 percent beyond the 5.0 mg/l standard (Table 4-6). The natural occurrence of low DO values in these areas can be attributed to the abundance of organic material in both watersheds and limited water exchange at tidal nodes at the coast.

With the exception of Four Hole Swamp, mean DO values at freshwater stations decreased with distance downstream (Figure 4-2), concurrent with increasing total organic nitrogen and carbon (Figures 4-3 and 4-4). All sites in the North Fork Edisto River were significantly different from one another. Basinwide, excursions occurred 2.9 percent of the time from 1975 to 1991. There were no significant trends in DO values at any of the stations examined.

Fecal Coliform Excursions

The South Carolina Class A water quality standards for fecal coliform bacteria state that the waters shall not exceed a geometric mean of 200 per 100 ml, based on five consecutive samples during a 30-day period, nor shall more than 10 percent of all samples during any 30-day period exceed 400 per 100 ml. For Class B waters, the waters shall not exceed a geometric mean of 1,000 per 100 ml, nor shall more than 20 percent of all samples exceed 2,000 per 100 ml for the above-mentioned intervals.

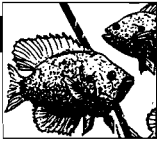
Percentage excursions from fecal-coliform standards ranged from 0.0 percent to 50.0 percent over the entire basin. As with other contraventions, Station E-091 exhibited the highest percentage of excursions (48 percent) (Table 4-6). The maximum number of excursions observed at this site occurred during the early to mid 1980s. The high percentages at Stations MD-120 and MD-195 reflected the limited number of samples.

The highest levels of fecal coliform counts were exhibited in the headwaters of the North Fork, South Fork, and Four Hole Swamp (Figure 4-2). These sites were significantly different from one another, as well as from all other stations. In contrast to the decreasing BOD levels, there were no significant trends in fecal coliform counts. The discrepancy in trends may be attributed to an additional source of fecal coliform bacteria associated with nonpoint sources, such as livestock wastes and feedlot activity.

pH Excursions

The pH standard for Class A waters is between 6 and 8 standard units (s.u.). For Class B waters, the standard is between 6 and 8.5 s.u. As is characteristic of blackwater rivers, the majority of the Edisto Basin had slightly acidic waters, associated with the production of humic acids. The colloidal humic substances contribute to the tea-colored or "blackwater" appearance.

Maximum excursion percentage was observed on the North Fork Edisto River at Station E-099. Physical characteristics of this site are dramatically different from upstream and downstream sites. The width of the river increases from approximately 20 feet to 115 feet and the sediment/water interface is covered with organic debris. Turbidity values also decrease significantly (Figure 4-4). Close examination of the excursions revealed that although the pH values were less than 6 s.u., the majority were greater than 5 s.u. In association with the above-mentioned factors, the increase in acidity may be attributed to the increased production of humic acids at this site.



Basinwide, pH excursions occurred 14 percent of the time during 1975 to 1991. As with Station E-099, the majority of the excursions were less than 6 s.u. but greater than 5 s.u. and could be attributed to natural conditions.

Total Phosphorus Excursions

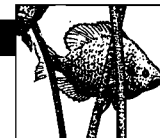
The absolute concentration of total phosphorus is an indication of a watershed's eutrophication state. Although there are no official standards for phosphorus, the USEPA's recommended criterion to prevent accelerated eutrophication is 0.10 mg/l. This standard applies only to running streams that do not flow into impoundments.

Maximum percentage excursions of 87 percent (Station E-091) and 65 percent (Station E-008) were observed in the North Fork Edisto River (Table 4-6). On an annual basis, from 1975 to 1991, the number of excursions at Station E-091 were evenly distributed through time. The average concentration at this site was 0.56 mg/l (Table 4-5). A slight decreasing trend in total phosphorus concentrations was detected at E-091, with a minimum mean change of 0.01 percent per year. Conversely, the majority of excursions at Station E-008 occurred in the early 1980s. The average total phosphorus concentration at this site was 0.17 mg/l. Station E-008 exhibited the maximum mean change (3.0 percent per year) of all the stations examined.

Median concentrations at both stations were significantly different from each other and from all other stations (Figure 4-2). With the significant decrease in average concentrations, from 0.56 to 0.09 mg/l between Station E-091 and E-099, the North Fork Edisto River appears to assimilate the incoming flux of phosphorus.

The only other significant difference observed between sites was in Four Hole Swamp. Total phosphorus concentrations decreased from an average of 0.13 mg/l in the headwaters to 0.09 mg/l near the confluence with the Edisto River, possibly indicating the swamp is functioning as a sink for phosphorus.

Basinwide, the EPA-recommended concentration of 0.10 mg/l was exceeded 39 percent of the time. If the North Fork Edisto River excursions were removed from the data base, the percentage would drop to 30 percent. For the majority of the stations, period-of-record mean phosphorus concentrations were approximately 0.10 mg/l, although the median values were usually below the EPA criterion. In 1991, the mean annual phosphorus concentration for all the stations was 0.09 mg/l, exceeding the criterion only 14 percent of the year.



Station	#Exc./N*	Dissolved Oxygen		Tot. Phosphorus (>0.1 mg/l)	Fecal Coliform (>400/100ml)	pH (6.0-8.0)
		(<4.0 mg/l)	(<5.0 mg/l)			
North Fork Drainage						
E-091 (1975-1991)**	%	1 / 199 0.50%	4 / 199 2.01%	156 / 178 87.64%	51 / 107 47.66%	11 / 139 7.91%
E-099 (1980-1991)	%	3 / 136 2.21%	4 / 136 2.94%	33 / 138 23.91%	4 / 129 3.10%	93 / 136 68.38%
					(>2000/100ml)	(6.0-8.5)
E-008 (1975-1991)	%	3 / 211 1.42%	11 / 211 5.21%	109 / 167 65.27%	0 / 134 0.00%	33 / 159 20.75%
Watershed	%	1.00%	3.40%	62.00%	14.80%	31.60%
South Fork Drainage						
					(>400/100ml)	(6.0-8.0)
E-090 (1975-1991)	%	0 / 194 0.00%	1 / 194 0.52%	47 / 173 27.17%	9 / 131 6.87%	20 / 136 14.71%
Watershed	%	0.00%	0.52%	27.17%	6.87%	14.71%
Edisto - Main Stem						
E-013 (1975-1991)	%	2 / 192 1.04%	5 / 192 2.60%	61 / 167 36.53%	1 / 136 0.74%	28 / 139 20.14%
E-015 (1975-1991)	%	6 / 219 2.74%	21 / 219 9.59%	48 / 169 28.40%	5 / 136 3.68%	15 / 152 9.87%
Watershed	%	2.00%	6.00%	32.00%	2.00%	14.00%
Four Hole Swamp Drainage						
					(>2000/100ml)	(5.0-8.5)
E-059 (1975-1991)	%	10 / 197 5.08%	31 / 197 15.74%	58 / 175 33.14%	0 / 134 0.00%	1 / 139 0.72%
E-100 (1980-1991)	%	9 / 153 5.88%	33 / 153 21.57%	37 / 129 28.68%	0 / 134 0.00%	1 / 144 0.69%
Watershed	%	5.00%	18.00%	31.00%	0.00%	0.70%
Brackish/Marine						
					(>400/100ml)	(6.0-8.0)
MD-119 (1975-1991)	%	4 / 193 2.07%	12 / 193 6.22%	53 / 171 30.99%	2 / 67 2.99%	12 / 130 9.23%
MD-120 (1975-1991)	%	8 / 201 3.98%	45 / 201 22.39%	58 / 161 36.02%	1 / 6 16.67%	6 / 132 4.55%
Shellfish Harvest						
					(>43/100ml)	(6.0-8.0)
MD-195 (1975-1991)	%	16 / 205 7.80%	49 / 205 23.90%	45 / 169 26.63%	5 / 10 50.00%	3 / 136 2.21%
Watershed ***	%	4.60%	17.00%	31.00%	4.10%	5.00%
BASINWIDE	%	2.90%	10.00%	39.00%	6.49%	14.00%

* # Exc.=Number of excursions / N=Number of samples

** Dates shown are for all parameters except fecal coliform and pH which were analyzed from 1980-1991.

*** Includes shellfish harvest and brackish/marine sites.

Table 4-6. Summary of DO, TP concentrations, and bacteria counts exceeding State Standards or USEPA recommendations within the Edisto River Basin.

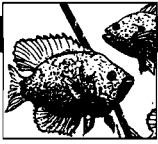
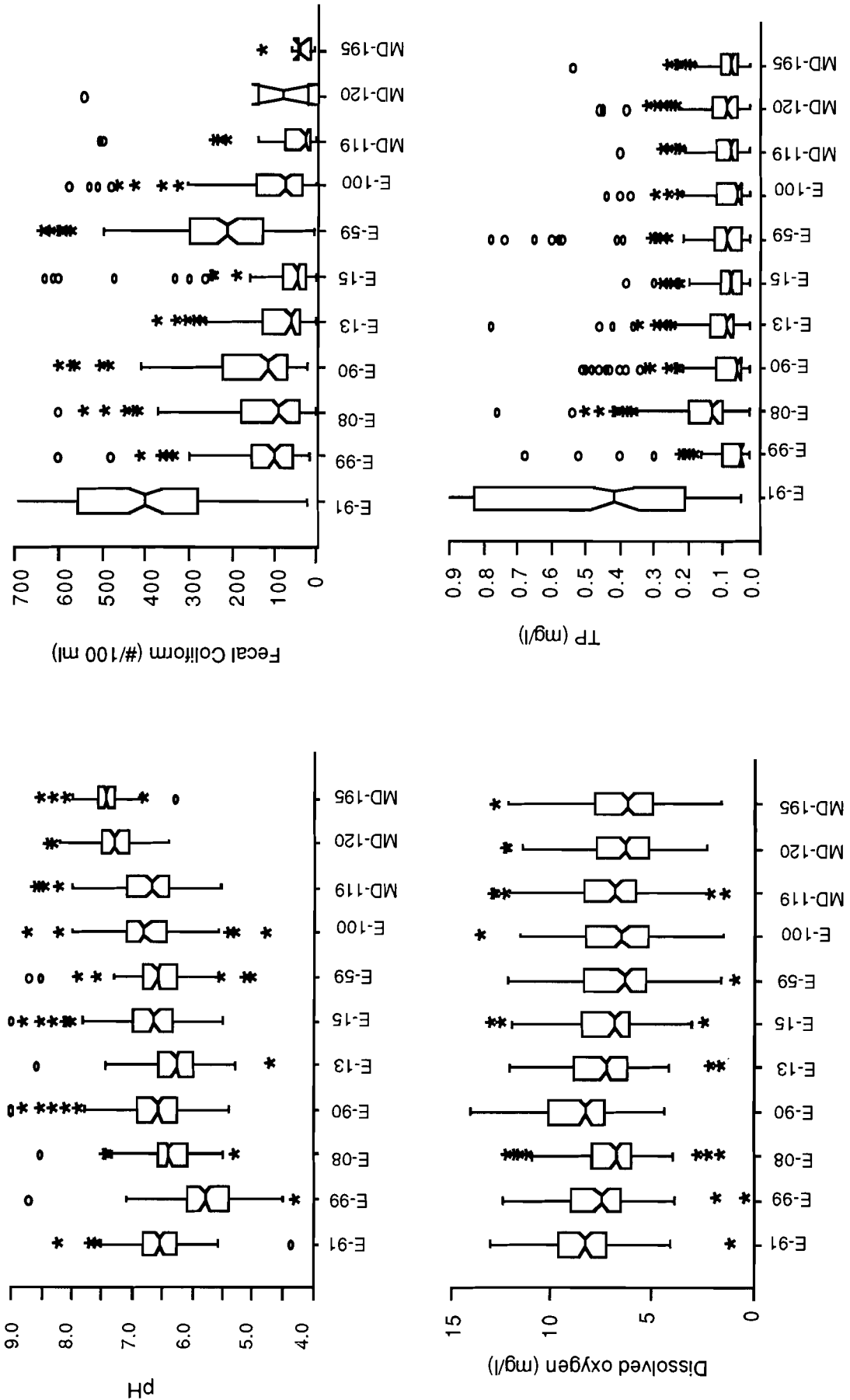


Figure 4-2. Fecal coliform, pH, total phosphorus, and dissolved oxygen levels for the Edisto Basin water quality stations.



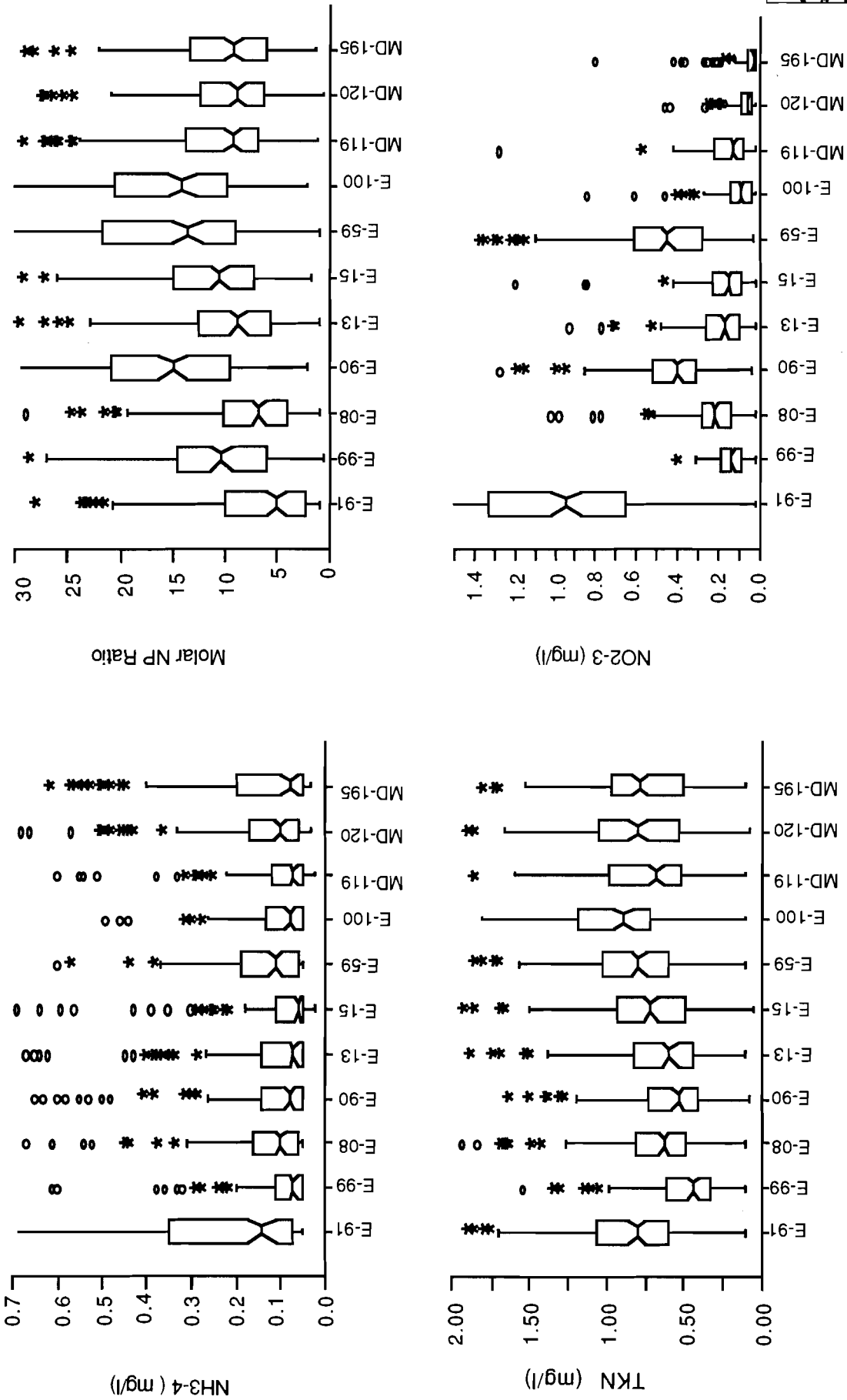
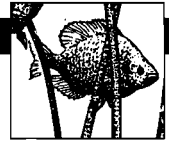


Figure 4-3. Total Kjeldahl nitrogen (TKN), NH₃-4 levels, and NP ratios for the Edisto Basin water quality stations.

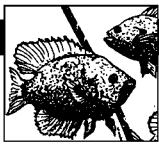
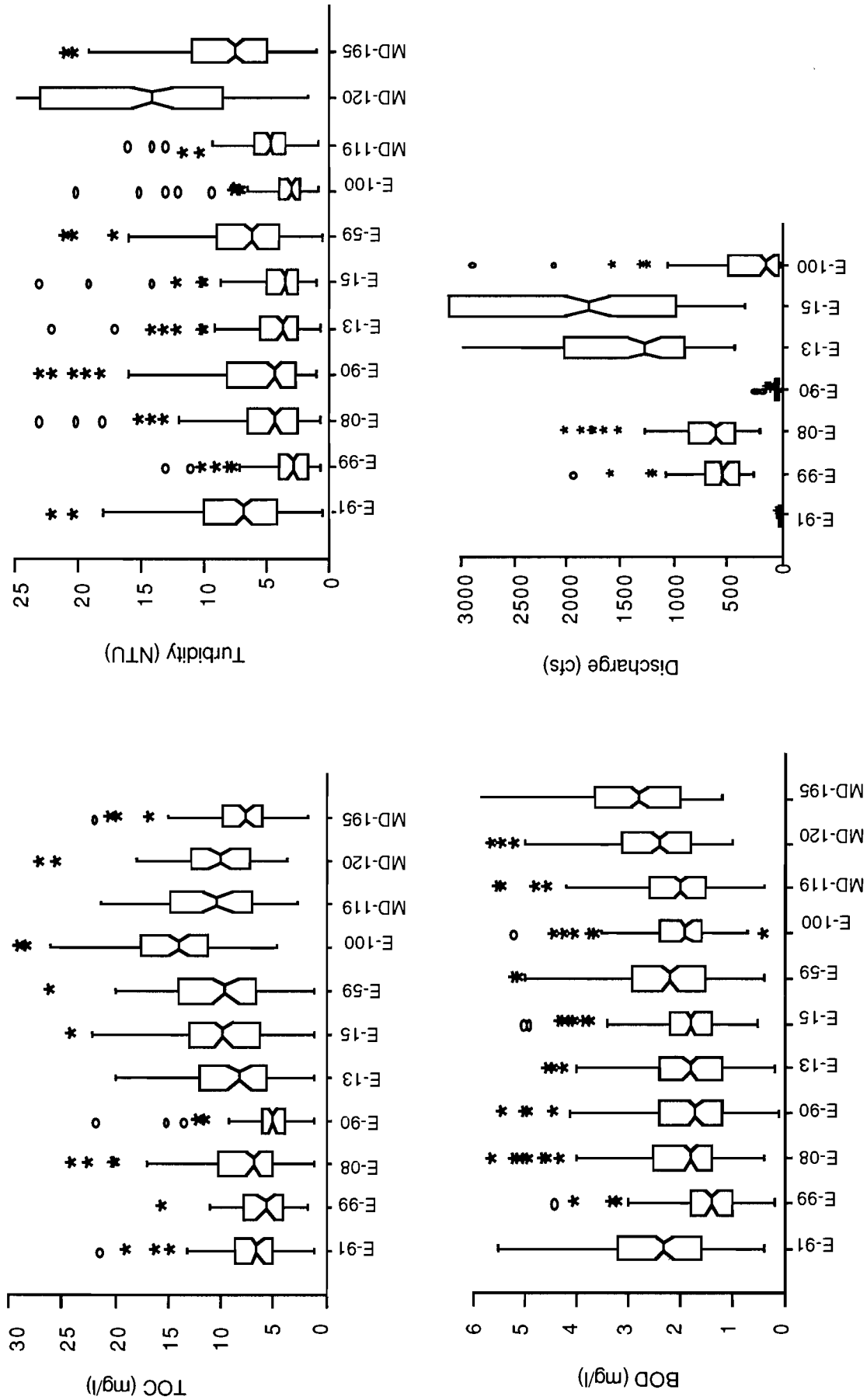
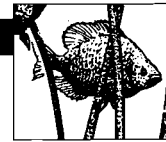


Figure 4-4. Total organic carbon, turbidity, BOD, and discharge levels for the Edisto Basin water quality stations.





Discharge Relationships

It has been well documented that in many streams, total phosphorus concentrations are related to stream discharge (Smith and others 1982). Depending on the relative importance of dilution and erosion processes, the slope of the discharge/phosphorus relationship can be negative or positive. In undisturbed forested watersheds, sediments and nutrients are conserved, minimizing the effects of erosion. A regression of concentration on discharge results in a negative slope, as nutrients and sediment loads are often diluted by increases in stream volume. Conversely, in a disturbed or cleared watershed, discharge and concentrations are positively related, characterized by nutrient additions and erosion during periods of high discharge.

For the period of study, the regression slopes of total phosphorus versus discharge were negative for the North Fork Edisto River and the Edisto River, indicative of a dilution-dominated relation (Figure 4-5). In these regressions, discharge explained 24 percent of the variability in TP concentrations in the North Fork and 4 percent of the variability in the Edisto River (Table 4-7). In addition, turbidity and stream discharge in the North Fork Edisto also exhibited a negative relationship ($r^2 = 0.06$, $P < 0.0001$). Considering both upland forest and wetland forest, 56 percent of the North Fork and 60 percent of the Edisto River (main stem) subbasins were forested. On the basis of forest cover, the negative relationships between concentrations and discharge were expected.

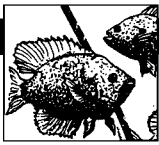
There were no significant relationships between discharge and TP concentrations at any of the other watersheds. However, a positive relationship between turbidity and discharge was observed at both the South Fork Edisto River and Four Hole Swamp, with r^2 values of 0.09 and 0.13, respectively. Discharge obviously explains little of the variability associated with the turbidity values; however, it may be indicative of some degree of disturbance within these watersheds. It should be noted that turbidity values were quite low in the Edisto Basin, with a mean of 7.0 nephelometric turbidity units (NTU) and minimum and maximum values of 0.5 and 77.0 NTU, respectively. The extremely high turbidity values were observed in the Atlantic Intracoastal Waterway, not within the freshwater subbasins. The South Fork Edisto River and Four Hole Swamp watersheds, both associated with high agricultural land use, exhibited the highest freshwater turbidity values. The positive slope of turbidity as a function of stream discharge in the South Fork Edisto River may indicate that erosion processes are exerting an influence on the water quality and eutrophication of this stream. The increasing turbidity with discharge exhibited in the Four Hole Swamp probably is also related to the resuspension of bottom materials during flooding events rather than to a flux of incoming sediment.

For the freshwater subbasins, a multisource regression was performed on turbidity and total phosphorus with stream discharge (Table 4-8). As expected in a basin where 60 percent of the area is forested or in natural cover, results showed a significant negative relationship between discharge and both constituents. Stream discharge explained approximately 5 percent of the variability in total phosphorus and 6 percent of the variability in turbidity values.

Omernik (1977) showed that a watershed that is more than 50 percent forested has typical stream total phosphorus and nitrogen concentrations of 0.036 and 0.839 mg/l, respectively. The total phosphorus concentration for the Edisto Basin was as high as 2.8 mg/l, with a mean of 0.156 mg/l. The total nitrogen concentrations averaged 1.11 mg/l and ranged from 0.13 to 9.36 mg/l. Thus, on the basis of forest cover, both total phosphorus and nitrogen levels were much higher than would be suggested by Omernik's research. Omernik's study was conducted nationwide, incorporating many streams in colder climates associated with granite and/or other hard-rock substrates. Concurrent with the findings of Gosselink and Lee (1989), the higher nutrient levels found in the Edisto Basin may simply be characteristic of southern coastal plain sedimentary environments.

Nitrogen / Phosphorus Ratios

Nitrogen / phosphorus (N/P) ratios are used to determine which nutrient is limiting to aquatic primary productivity. The N/P ratio varies with trophic state and decreases with increased eutrophication (Welch 1980). Stricter control of loading on the limiting nutrient is often justified, as it indicates which nutrient poses the greatest threat of cultural eutrophication.



Based on the N/P ratio of living plant tissue, a molar ratio of 10 to 15 reflects a balanced ecosystem (Hecky and Kilhan 1988). In freshwater systems, phosphorus is considered the limiting nutrient at N/P ratios above 15, and nitrogen is limiting below the ratio of 10.

The headwaters stations of each watershed exhibited the largest deviations in N/P ratios. The lowest total N/P ratio of 7.6 was observed at Station E-091 in the North Fork, indicating that N and not P may be the critical nutrient for water quality control at this site (Figure 4-6). Within the past five years, the eutrophic state of the North Fork River has shown improvement, with an N/P ratio increasing from 3.55 to 14.39. The South Fork Edisto River exhibited the highest N/P ratios, ranging from 7.38 to 28.88 with an average of 17.20. Four Hole Swamp exhibited an increasing trend in N/P ratios over time, with the system becoming more phosphorus limited. N/P ratios at the Edisto River were the most reflective of a balanced ecosystem, with an average ratio of 12.5.

From 1975 to 1991, the lowest N/P ratios observed, for all stations examined, occurred in the early 1980s. Stream discharge and rainfall significantly decreased during this period; subsequently, high phosphorus concentrations lowered the N/P ratios. Basinwide, for the period of record the molar N/P ratio averaged 12.2 (with a range of 8.31 to 23.99). Since 1983 the annual mean ratio has been between 10 and 15, indicative of a balanced ecosystem.

Nutrient Fluxes

Fluxes of nutrients and sediments from the Edisto Basin were determined by using data from the southernmost freshwater monitoring station, E-015, at Givhans Ferry State Park. The drainage basin for Station E-015 encompasses the North Fork, South Fork, Edisto River, and Four Hole Swamp watersheds. Of all the stations examined, this site perhaps best represents overall water quality conditions for the basin. Discharge is typically four or more times the discharge measured in the North and South Fork Edisto Rivers. Strong seasonal peaks in discharge coincide with storm events (Figure 4-7).

The total mass flux of nutrients and suspended sediments, as the sum of daily fluxes, is summarized in Table 4-9. Annual flux-weighted loading estimates were approximately 19.5 percent higher than interpolated loading estimates for nutrients and 18 percent higher for total suspended solids. The use of annual flux-weighted values in the calculation of annual loads maximizes the weight of episodic events, such as the high nutrient concentrations observed in the early 1980s (Figure 4-7). Conversely, by the nature of the process, interpolations smooth the data set, often underestimating extreme values. The second methodology used the period-of-record flux-weighted mean (identical to the flow-adjusted load value) to estimate total annual loads. A major assumption in this method is that the flux-weighted mean concentrations, as based on the sampling period covered by the study, is representative of the long-term flux-weighted concentrations characteristic of the station. This method produced mid-range loading estimates for total phosphorus and total suspended solids and the lowest estimates for total Kjeldahl nitrogen.

For the period of study, the regression slopes of nutrient and sediment loads versus time were negative, indicating a decreasing trend (Table 4-7). High annual loads were primarily associated with increased stream discharge (the increased loadings were associated with the rains following Hurricane Hugo in 1989 (Figure 4-7) and an increase in discharge during 1991). An exception to this phenomenon occurred in the early 1980s. Following a long period of high stream volume, discharge decreased significantly in 1981. Although an increase in phosphorus and nitrogen inputs to the system was unlikely at this time, high concentrations were observed because the dilution process had been significantly hindered (Figure 4-8).

Flow-adjusted loads average 0.08 g/m³ for total phosphorus (Table 4-9) and is well within the permissible level of less than 0.12 g/m³ recommended by Gosselink and Lee (1989). Point and nonpoint source contribution of 55 percent and 45 percent, respectively, were determined by using the loading coefficients associated with land use to estimate nonpoint-source flow-adjusted values. Nationwide, nonpoint-source pollution accounts for 53 percent of the total phosphorus load (Cooley 1976). Percentages from this study for nonpoint-source contributions were slightly lower than the national average.

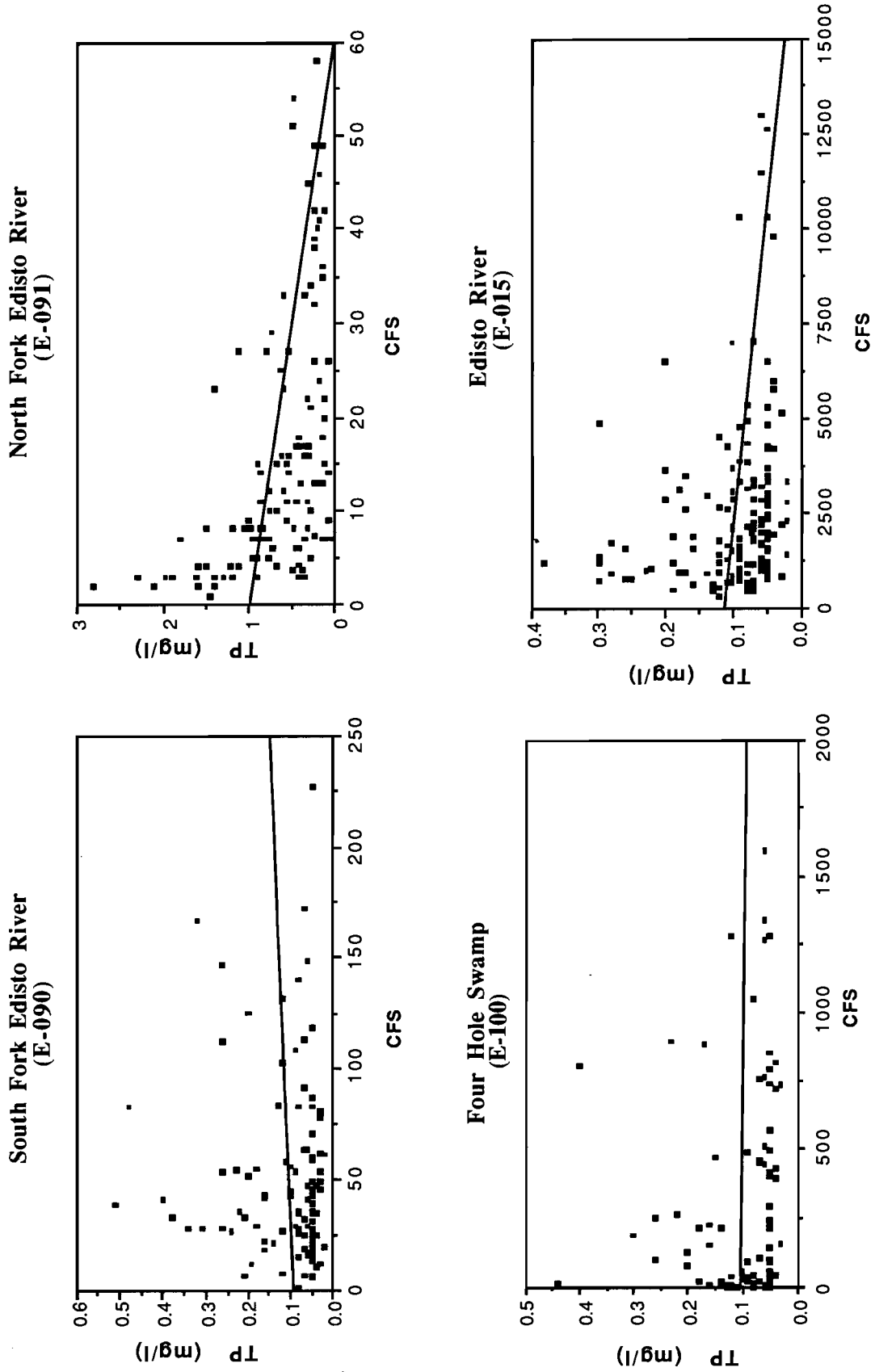
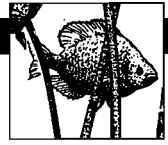
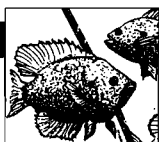


Figure 4-5. Total phosphorus and discharge relationships for selected watersheds within the Edisto Basin.



Four Hole Swamp

DEPENDENT	INDEP.	SLOPE	PROB	R2	N
PHOS	TKN	+	0.0001	0.74	284
PHOS	TSS	+	0.004	0.67	122
PHOS	NH4	+	0.0001	0.049	298
PHOS	NO2	+	0.028	0.016	298
PHOS	DATE	-	0.058	0.012	304
TKN	NH4	+	0.0001	0.294	289
TURB	TSS	+	0.001	0.091	120
TURB	NO2	+	0.0001	0.114	290
TURB	CFS	+	0.0001	0.138	87
TSS	NO2	+	0.0001	0.114	120
TSS	DATE	-	0.005	0.061	128
NH4	DATE	-	0.008	0.023	310
NO2	DATE	-	0.0001	0.06	315
FA-PHOS	FA-TKN	+	0.0001	0.384	83
FA-PHOS	DATE	-	0.0001	0.181	86
FA-TURB	FA-TSS	+	0.023	0.065	79
FA-TURB	DATE	-	0.05	0.04	87
FA-TSS	DATE	-	0.004	0.094	85

Edisto River

PHOS	TKN	+	0.002	0.03	311
PHOS	NH4	+	0.0001	0.046	321
PHOS	DATE	-	0.013	0.018	334
PHOS	CFS	-	0.002	0.035	280
TKN	NH4	+	0.0001	0.132	322
TKN	DATE	-	0.001	0.032	334
TKN	CFS	-	0.03	0.017	278
TURB	TSS	+	0.007	0.058	126
TURB	DATE	-	0.005	0.021	372
NO2	DATE	-	0.006	0.021	360
FA-PHOS	FA-TKN	+	0.0001	0.045	265
FA-PHOS	DATE	-	0.007	0.025	280
FA-TURB	FA-TSS	+	0.001	0.085	126
TP LOAD	DATE	-	0.0001	0.012	6210
TKN LOAD	DATE	-	0.0001	0.008	6210
TSS LOAD	DATE	-	0.0001	0.01	6210

Brackish/Marine Watersheds

PHOS	TKN	+	0.0001	0.103	451
PHOS	TURB	+	0.003	0.018	466
PHOS	NH4	+	0.001	0.022	480
TKN	TURB	+	0.03	0.11	441
TKN	NH4	+	0.0001	0.245	462
TURB	NO2	-	0.012	0.013	480
NO2	DATE	-	0.0001	0.041	524

North Fork Edisto River

DEPENDENT	INDEP.	SLOPE	PROB	R2	N
PHOS	TKN	+	0.0001	0.064	453
PHOS	TURB	+	0.013	0.014	446
PHOS	NH4	+	0.0001	0.053	467
PHOS	NO2	+	0.0001	0.417	474
PHOS	DATE	-	0.016	0.012	482
PHOS	CFS	-	0.0001	0.242	373
TKN	TURB	+	0.0001	0.102	429
TKN	NH4	+	0.0001	0.388	456
TKN	NO2	+	0.003	0.02	458
TKN	DATE	-	0.001	0.026	463
TKN	CFS	-	0.0001	0.039	357
TURB	TSS	+	0.0001	0.104	131
TURB	NH4	+	0.0001	0.024	445
TURB	NO2	+	0.0001	0.026	461
TURB	DATE	-	0.008	0.014	498
TURB	CFS	-	0.0001	0.062	375
NH4	NO2	+	0.016	0.012	476
NH4	DATE	-	0.002	0.02	481
NH4	CFS	-	0.0001	0.037	371
NO2	CFS	-	0.0001	0.408	374
DATE	CFS	-	0.036	0.011	392
FA-PHOS	FA-TKN	+	0.0001	0.054	356
FA-PHOS	DATE	-	0.0001	0.044	373
FA-TKN	FA-TURB	+	0.0001	0.104	345
FA-TKN	DATE	-	0.003	0.025	357
FA-TURB	FA-TSS	+	0.0001	0.113	117

South Fork Edisto River

DEPENDENT	INDEP.	SLOPE	PROB	R2	N
PHOS	TKN	+	0.0001	0.099	162
PHOS	NH4	+	0.0001	0.123	168
PHOS	NO2	+	0.0001	0.087	168
TKN	TURB	+	0.003	0.06	149
TKN	NH4	+	0.0001	0.318	166
TKN	DATE	-	0.015	0.035	170
TURB	CFS	+	0.001	0.097	119
NH4	DATE	-	0.02	0.031	174
FA-PHOS	FA-TKN	+	0.0001	0.624	110
FA-PHOS	FA-TURB	+	0.0001	0.155	110
FA-PHOS	DATE	-	0.0001	0.104	115
FA-TKN	FA-TURB	+	0.0001	0.907	110
FA-TKN	DATE	-	0.009	0.061	111
FA-TURB	DATE	-	0.016	0.052	110

Table 4-7. Listing of regressions for highly significant relationships, by watersheds, from 1975 to 1991.



FRESHWATER WATERSHEDS

DEPENDENT	INDEPENDENT	SLOPE	PROB	R2	N
PHOS	TKN	+	0.0001	0.048	926
PHOS	TURB	+	0.003	0.009	910
PHOS	NH4	+	0.0001	0.059	956
PHOS	NO2	+	0.0001	0.385	974
PHOS	CFS	-	0.0001	0.05	765
TKN	TURB	+	0.0001	0.054	883
TKN	NH4	+	0.0001	0.29	945
TKN	NO2	-	0.005	0.008	954
TKN	DATE	-	0.0001	0.027	967
TURB	TSS	+	0.0001	0.95	258
TURB	NH4	+	0.0001	0.013	908
TURB	NO2	+	0.0001	0.018	946
TURB	DATE	-	0.002	0.009	1045
TURB	CFS	-	0.02	0.06	795
TSS	CFS	-	0.064	0.014	253
NH4	NO2	+	0.0001	0.013	984
NH4	DATE	-	0.001	0.012	996
NH4	CFS	-	0.001	0.015	767
NO2	CFS	-	0.0001	0.103	782
DATE	CFS	-	0.0001	0.057	866
FA-PHOS	FA-TKN	+	0.0001	0.065	731
FA-PHOS	FA-TURB	+	0.002	0.013	733
FA-PHOS	DATE	-	0.001	0.013	768
FA-TKN	FA-TURB	+	0.0001	0.076	711
FA-TKN	DATE	-	0.0001	0.019	746
FA-TURB	FA-TSS	+	0.0001	0.083	244
FA-TURB	DATE	-	0.034	0.006	795

FA represents flow-adjusted concentrations.

BRACKISH/MARINE WATERSHEDS

DEPENDENT	INDEP.	SLOPE	PROB	R2	N
PHOS	TKN	+	0.0001	0.103	451
PHOS	TURB	+	0.003	0.018	466
PHOS	NH4	+	0.001	0.022	480
TKN	TURB	+	0.03	0.11	441
TKN	NH4	+	0.0001	0.245	462
TURB	NO2	-	0.012	0.013	480
NO2	DATE	-	0.0001	0.041	524

Table 4-8. Listing of regression statistics for highly significant relationships for the period from 1975 to 1991.

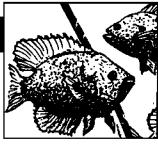
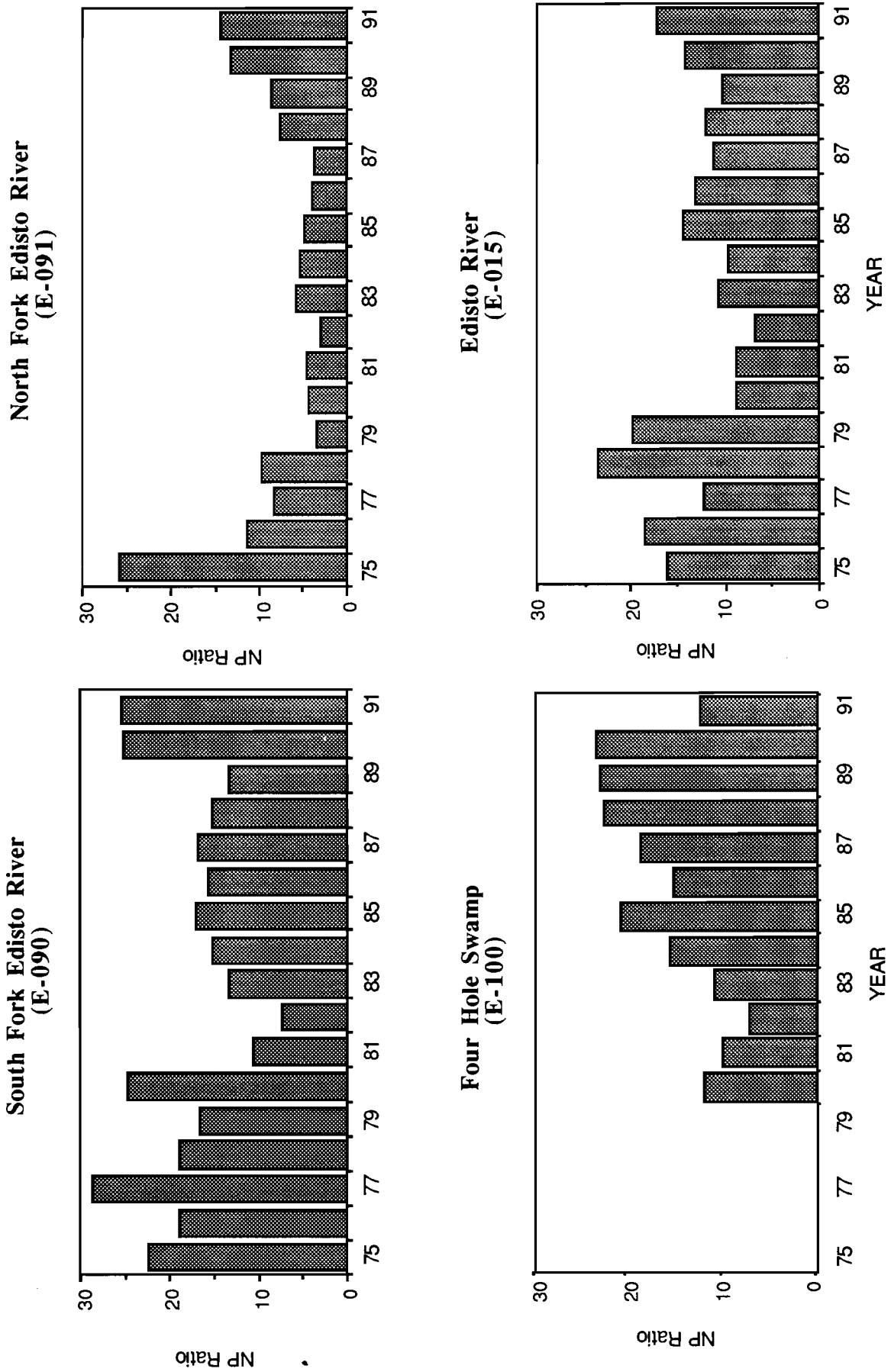


Figure 4-6. Molar nitrogen to phosphorus ratios for freshwater watersheds within the Edisto Basin.



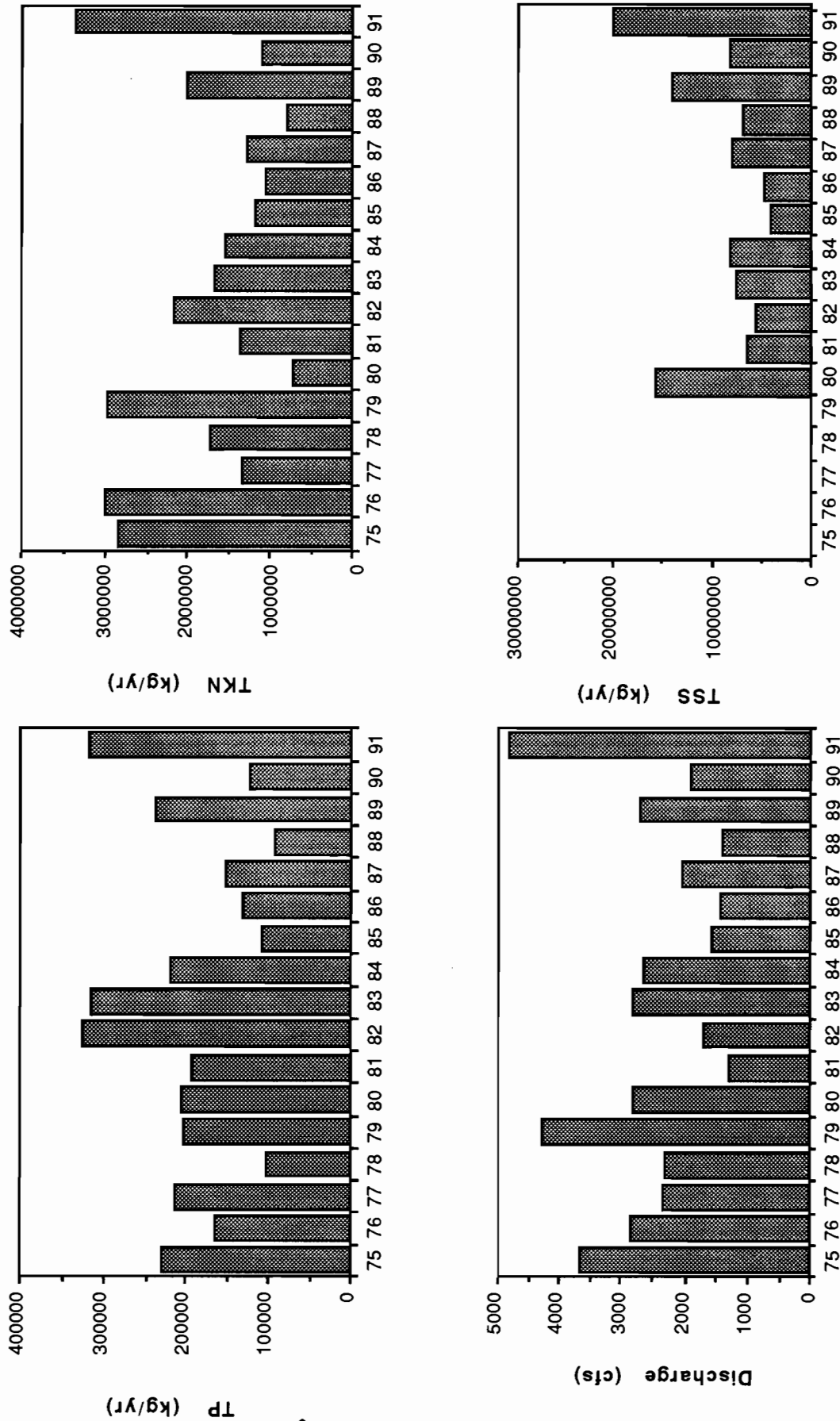
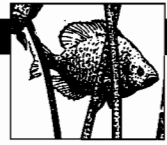


Figure 4-7. Annual fluxes of total phosphorus (TP), total Kjeldahl nitrogen (TKN), total suspended solids (TSS), and discharge in the Edisto River at Givhans Ferry State Park.

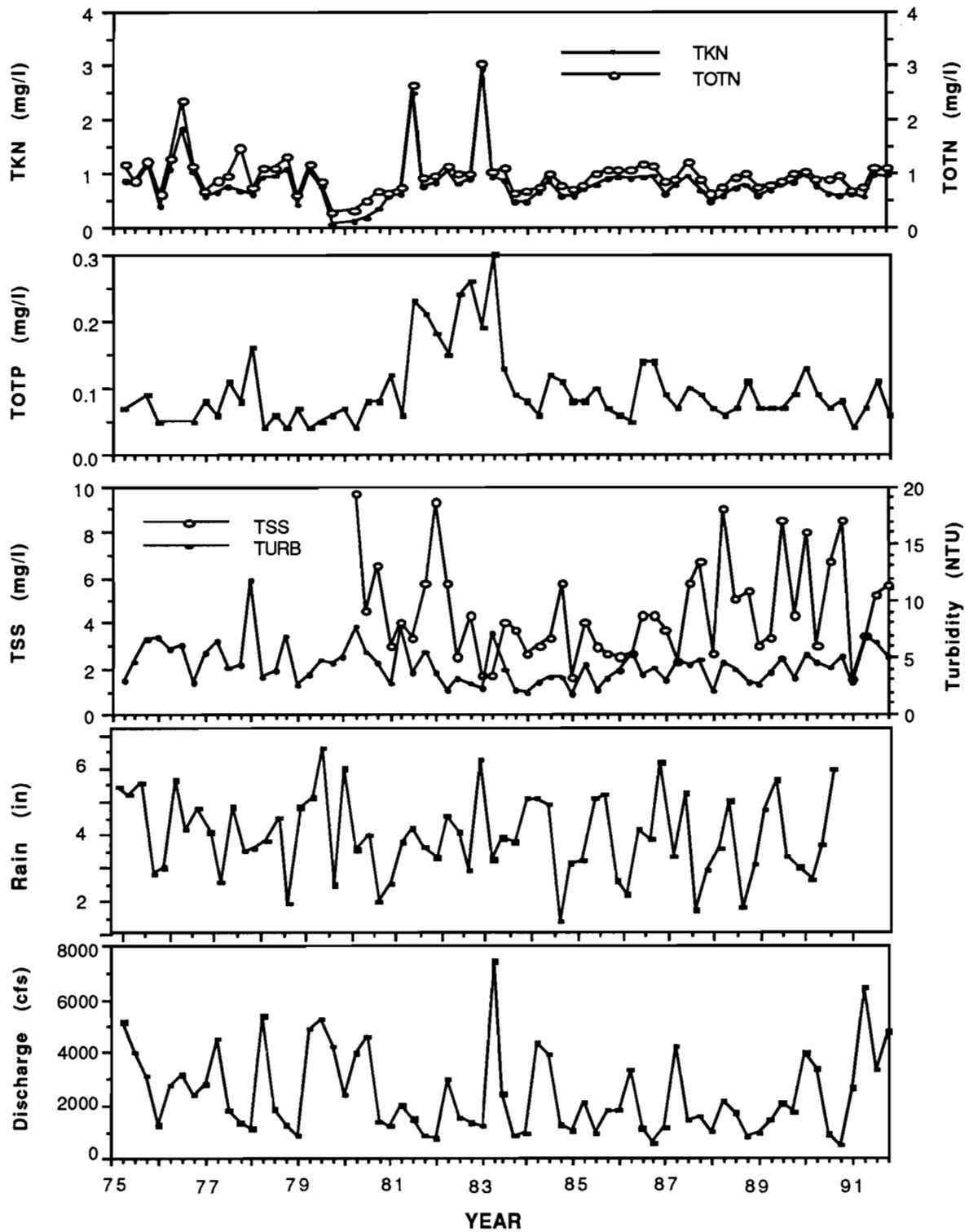
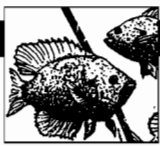


Figure 4-8. Physical and chemical characteristics of Station E-015 (Givhans Ferry State Park).

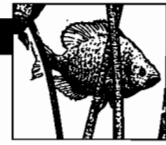


Table 4-9. Estimated loadings and flow-adjusted loads, Station E-015, Givhans Ferry State Park

Estimated load	TP (kg/yr)	TKN (kg/yr)	TSS (kg/yr)
METH. 1	161,744	1,613,466	7,099,246
METH. 2	188,400	1,380,667	8,550,415
METH. 3	200,979	1,986,901	9,929,338
Flow-adjusted load*	TP (g/m ³)	TKN (g/m ³)	TSS (g/m ³)
METH. 1	0.07	0.72	3.16
METH. 2	0.08	0.60	3.72
METH. 3	0.09	0.86	4.32

* Flow-adjusted load = total load (g/yr) / discharge (m³/yr)

SUMMARY

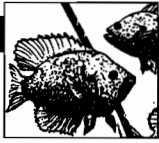
Although the analyses of historical water quality records for the years from 1975 to 1991 indicate that certain areas in the basin reflect disturbance, the overall assessment of the Edisto Basin is positive. The combined analysis of all freshwater stations showed highly significant and negative relationships of total phosphorus (TP), total suspended solids, and turbidity to stream discharge. This concurrent decrease in concentration with increase in stream volume suggests a dilution phenomenon characteristic of undisturbed, forested watersheds. The low turbidity and total suspended solid concentrations observed throughout the Basin also indicate that erosion loading during storm events is minimal.

Of the Edisto basin watersheds, 56 percent is upland and wetland forest, and only 34 percent is agricultural. According to Omernik's 1977 study of the relationship of land use to water quality, typical stream concentrations of TP and total nitrogen should have been around 0.034 mg/l phosphorus and 0.839 mg/l nitrogen. On the basis of forest cover, total nitrogen levels were slightly higher than those predicted, ranging from 0.96 mg/l in the coastal region to 1.28 mg/l in the North Fork Edisto River. As with nitrogen, TP concentrations averaging 0.16 mg/l, were much higher than the predicted values based on land use. However, the TP mean concentration of 0.09 mg/l from this study in 1991 was similar to the TP mean concentration of 0.08 mg/l observed in the Pearl River, a relatively undisturbed forested watershed in Louisiana (Gosselink and others 1990).

Overall, the watershed is maintaining acceptable water quality based on a 0.1 mg/l TP criterion derived by the USEPA (1976). The North Fork subbasin exhibited the highest TP concentration of 0.29 mg/l. All other basins had remarkably similar TP mean concentrations of 0.10 mg/l, with a range of less than 0.01 mg/l for mean values. Basin-wide, the recommended concentration was exceeded 39 percent of the time. If the excursions within the headwaters of the North Fork Edisto River are removed from the data base, the percentage decreases to 30 percent. Median values for the majority of the stations were usually below the criterion. In 1991, the mean annual phosphorus concentration for all the stations was 0.09 mg/l, exceeding the criterion only 14 percent of the year.

From 1975 to 1991 the basinwide molar N/P (nitrogen / phosphorus) ratio averaged 12.2 (with an annual range of 8.31 to 23.99). The extreme fluctuations in N/P ratios occurred prior to 1983. Since then the annual mean ratio has been between 10 and 15, indicative of a balanced ecosystem. The North Fork water quality stations exhibited the lowest N/P ratios, owing to unequal nutrient enrichment (P > N) attributed primarily to point-source discharges.

During the period from 1975 to 1991, the most consistent trends observed were declining concentrations of TP and declining BOD loads. The decreases in these constituents are concurrent with the large reductions in BOD loads and phosphorus concentrations observed nationwide (Smith and others 1982, Smith 1987). Because both municipal and industrial sources were the object of pollution control efforts during the 1970s and 1980s, it



will be interesting to see if the decreasing BOD and TP trends persist without the implementation of nonpoint-source controls.

Basin-wide, excursions of State Standards for dissolved oxygen, pH, and fecal coliform were primarily attributed to natural conditions and, therefore, were not considered violations. The exception was the North Fork Edisto River, which violated the fecal coliform standard 48 percent of the time. Upstream point-source dischargers contributed significantly to the high fecal coliform counts in this subbasin.

Although the Basin's water quality is acceptable and appears to be improving, it is important to acknowledge the disturbance reflected in certain areas (such as the North Fork) and to address this in the goal-setting and management phases of the cumulative impact assessment. In addition, certain management practices must be encouraged. Forest management practices that would maintain and improve water quality in this area include protection of existing forested corridors along streams and establishment of streamside buffer zones in developing areas. Implementation of nonpoint source controls in farming, such as no-till farming and fertilizer injection techniques would also enhance the water quality conditions.

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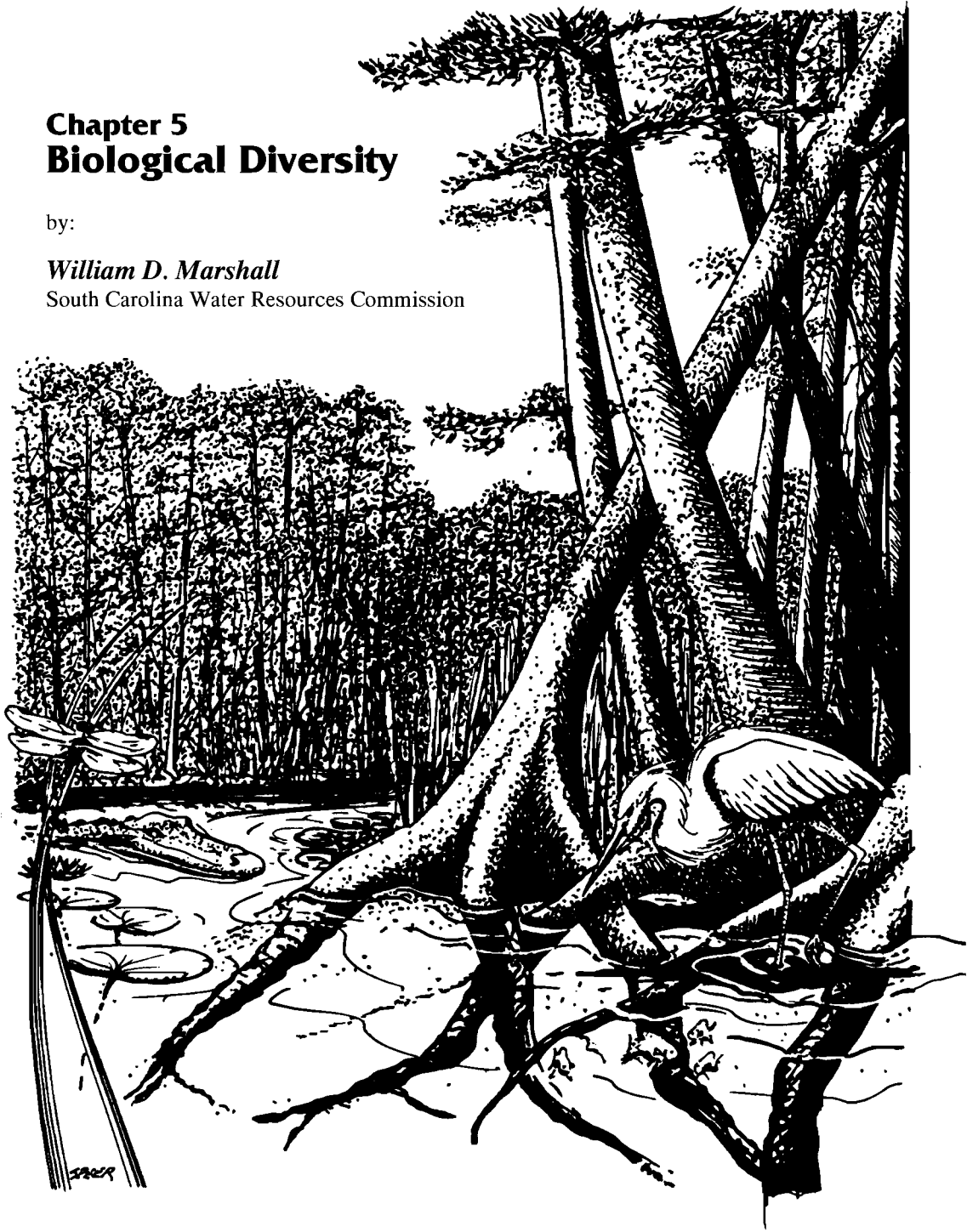
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Chapter 5 Biological Diversity

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INTRODUCTION

This study was designed to evaluate the ecological components of the landscape resource at a large scale rather than at a site-specific scale. The purpose is to assess the ecological conditions of the landscape and the changes in those conditions through time for the purpose of enabling land managers to make more informed decisions relative to conservation and development.

Biological diversity is an important indicator of ecological integrity, but it is difficult to assess at a landscape scale. The primary problems are that (1) long-term data for trend analyses are limited and interpretation can be very complex; and (2) it is difficult to devise indices that measure biological diversity over large areas (Gosselink and others 1990). Several indices of biological diversity at landscape scales were recommended by Gosselink and Lee (1989): extent and distribution of old growth stands of forest, presence of endangered and threatened species, presence of indicator species (such as top carnivores), and historical changes in species richness. These and other indicators of landscape condition were used to assess biological diversity in the Edisto River Basin. Information regarding old-growth forests, as well as relatively undisturbed natural communities, was derived from a natural-area inventory conducted by The Nature Conservancy and South Carolina Water Resources Commission. For historical changes in species richness, birds were evaluated because the U.S. Fish and Wildlife Service's Breeding-Bird Surveys were the only consistent, long-term data available. Other, and more general, information is presented to describe the relative abundance and diversity of freshwater fisheries, waterfowl, and mammals in the area.

In Chapter III of *The History of Orangeburg County, A.S.* Sally (1898) provided a description of this region of South Carolina from about 1750 to 1840. Section 1 of the chapter is called "Pioneer Life in Orangeburgh. Or, Roughing it on the Edisto." Excerpts from this book provide some description of the wildlife found in the Edisto Basin by Europeans who first settled the area.

Having cleared a piece of land, we planted, and found the soil to be exceedingly fertile in the river swamp, producing abundant crops. The country was literally infested with wild beasts, which were annoying to the inhabitants — killing stock and destroying the crops — and were so bold, daring, and ravenous, that they would come into our yards and before our doors take our sheep and poultry. Indeed, it was dangerous to venture out at night beyond the precincts of our yards unarmed. We used every device to exterminate them, and ultimately effected our object by setting traps and poisoned bait.

The forest abounded with all kinds of game, particularly deer and turkeys — the former were almost as gentle as cattle. I have seen fifty together, in a days ride in the woods. The latter were innumerable, and so very fat that I have often run them down on horseback.

— Memoirs from Tarleton Brown

Sally's historical account, originally published in 1898, describes a land with buffaloes, wild horses, beaver, wolves, and bears. His book provides an account of the techniques used for trapping wolves. He describes "the killing of the last wolf ...in this section" which reportedly occurred about 1839 or 1840. It was killed by William Robinson on the plantation of his father, Joseph Robinson, on a place called Limestone. "Bear were also plentiful in this section in the days of the pioneer, and occasionally one is to be met with today in the Edisto river swamp" (Sally 1898).

In 1992, wild turkey, reintroduced from other parts of the State, and deer continue to abound in the Edisto River Basin. Buffaloes, wild horses, and wolves no longer inhabit the region, but possibly bear and certainly beaver can be found.



METHODS

Analyzing Changes in Bird Species Richness

The Breeding-Bird Survey (BBS), jointly conducted by the U.S. Fish and Wildlife Service and the Canadian Wildlife Service, is the most comprehensive survey of non-game wildlife on the continent. Begun in 1966, the BBS now includes survey routes over the entire continent and data for more than 500 bird species (Droege 1990). These data are valuable as indicators of wildlife populations and landscape-level changes and trends. BBS routes consist of 50 stops 1/2 mile apart and are run along a standardized route, about 25 miles in length, one morning in June at the height of the breeding season. For three minutes at each stop, all birds seen or heard are recorded and counted.

Six BBS routes in or adjacent to the Edisto River Basin were analyzed for this study: Johns Island, Holly Hill, New Holland, Wagener, Walterboro, and Adams Run (see map, Figure 5-1). The routes were analyzed for species abundance and richness changes over time and for changes in species preferring either water, field and forest edge, or forest habitats. Results of these analyses were compared with changes in land use and land cover over the survey period in order to provide an indication of changes in habitat structure and floristic components that could have affected bird species richness and composition. Also, relevant information from other regional BBS data analyses, as well as information on waterfowl population trends, is presented in the "Results" section of this chapter.

The BBS data were analyzed in two ways. First, counts for each species for each route were regressed over time (linear regression) to detect significant ($P < 0.10$) trends in population changes. This follows the methods of Gosselink and others (1990) for the Pearl River Basin and is similar to the analyses performed on the BBS data for the entire continent (Droege 1990, Droege and Sauer 1990).

Second, the preferred habitat was determined for each species by using Bent (1963), Ehrlich and others (1988) and Gosselink and others (1990), and species were grouped into habitat categories. Habitat preferences were: open water, marsh, swamp, field, forest edge, forest with open canopy, forest with closed canopy, and forest in general. For analyses, these habitats were grouped into general categories of water (water + marsh + swamp), field and edge (field + forest edge), or forest (forest with open canopy + forest with closed canopy + forest in general). Then the number of species significantly increasing, decreasing, or showing no change in each of these categories was determined.

Temporal change in bird species richness by habitat was compared to change in land cover for five of the six routes. The Adams Run route was excluded because bird data were only available from 1988 to 1991. The land cover data were derived by delineating a 0.25-mile corridor on either side of each BBS route on available sources of spatial data. Where digital data were available and applicable to the BBS period of record, routes were digitized and acreage summaries were automated. Where digital data were not available, the routes were delineated on aerial photographs, general land cover classes were interpreted, and acres were tabulated manually. Data sources for each route are described in Table 5-1. The results of land cover change for each route are in Table 5-2.

For all routes, species that were counted fewer than six times over the entire survey period were eliminated. The four years of data for the Adams Run route were analyzed but are of little use in showing trends; however, they are useful for indicating species richness of the area of the Adams Run route. Although several routes had more than one observer throughout the entire survey period, all routes were treated the same in the analyses; differences in observers may, in fact, be reflected in variations in the quality of these surveys.



BREEDING BIRD SURVEY ROUTES IN THE EDISTO RIVER BASIN

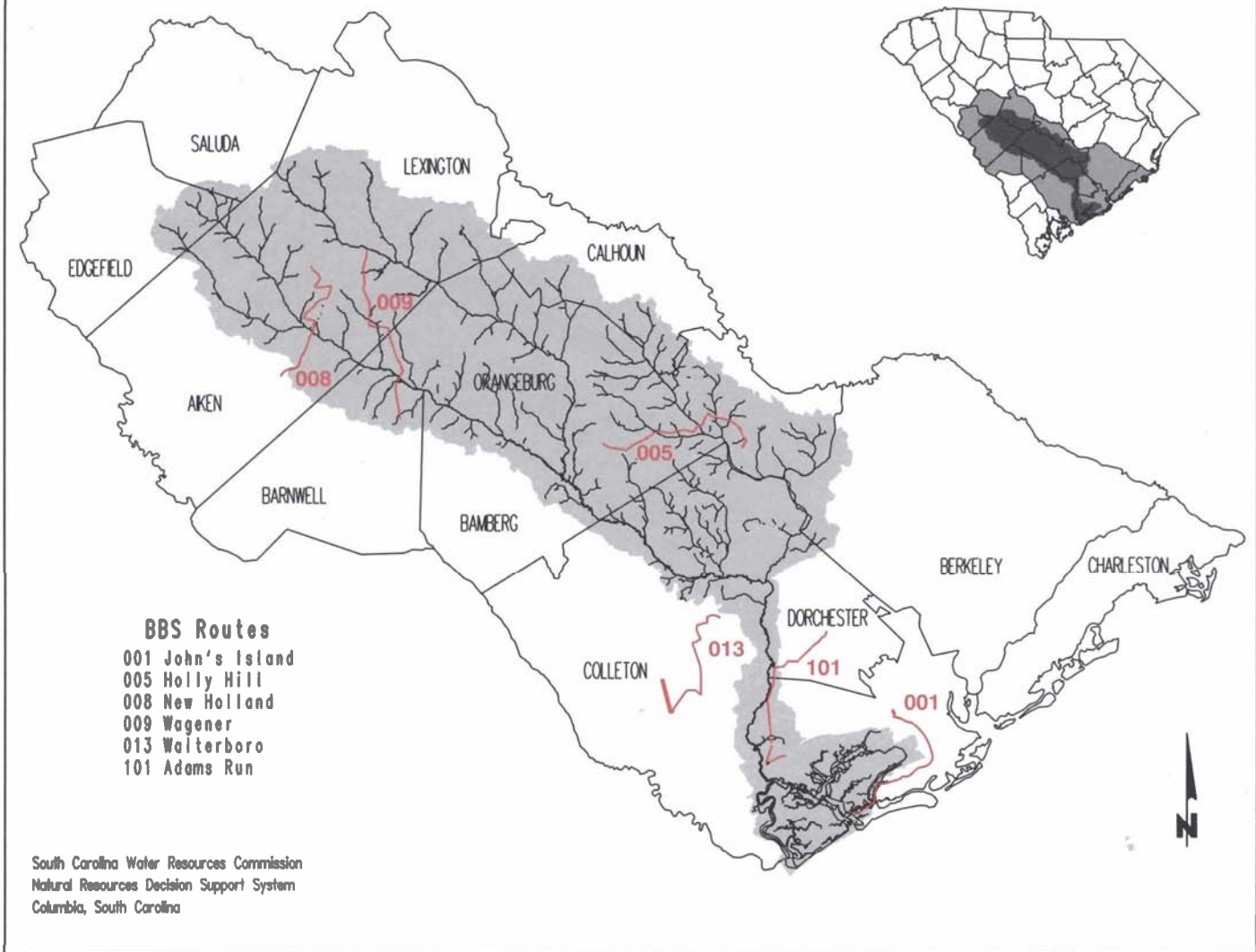


Figure 5-1. Breeding-Bird Survey routes in or adjacent to the Edisto River Basin.
 Source: U.S. Fish and Wildlife Service.



Table 5-1. Data sources for land cover change along Breeding-Bird Survey routes in the Edisto River Basin.

Route	Survey Period	Data Sources for Land Cover Change
001 - Johns Island	1966-79	<u>1966</u> - Photointerpreted from 1966 1:20,000 scale and 1:4,800 scale aerial photography. <u>1977</u> - Digitized from 1977 LUDA data.
101 - Adams Run	1988-91	<u>1989</u> - Digitized from 1989 SCWRC land use data.
005 - Holly Hill	1972-81, 86-88, 90	<u>1977</u> - Digitized from 1977 LUDA data. <u>1989</u> - Digitized from 1989 SCWRC land use data.
008 - New Holland	1967-81, 83-91	<u>1966</u> - Photointerpreted from 1966 1:20,000 scale aerial photography. <u>1989</u> - Digitized from 1989 SCWRC land use data.
009 - Wagener	1966-68, 77-81, 83-91	<u>1966-71</u> - Photointerpreted from 1966 and 1971 1:20,000 scale aerial photography. <u>1989</u> - Digitized from 1989 SCWRC land use data.
013 - Walterboro	1970-81, 86-88, 90-91	<u>1977</u> - Digitized from 1977 LUDA data. <u>1989</u> - Photointerpreted from 1989 1:40,000 scale NAPP photography (route was outside 1989 digital data coverage).



Table 5-2. Land cover change in areas of Breeding-Bird Survey routes in the Edisto River Basin.

Shown as percentage of route corridor areas (each were approximately 8,000 acres) digitized and photointerpreted from sources specified in Table 5-1.

Route	Subbasin	Land Cover	Percent of Area Early in Survey	Percent of Area Late in Survey
			<u>1966</u>	<u>1977</u>
001 - Johns Island	Edisto (main stem)	agriculture ^a	45%	66%
		forest ^b	45%	19%
		water ^c	5%	9%
			<u>1989</u>	
101 - Adams Run	Edisto (main stem)	agriculture	5%	(only 1989 source is available)
		forest	92%	
		water	<1%	
			<u>1977</u>	<u>1989</u>
005 - Holly Hill	Four Hole Swamp	agriculture	60%	57%
		forest	36%	37%
		water	—	<1%
			<u>1966</u>	<u>1989</u>
008 - New Holland	South Fork	agriculture	57%	50%
		forest	42%	47%
		water	—	<1%
			<u>1966</u>	<u>1989</u>
009 - Wagener	South Fork North Fork	agriculture	56%	41%
		forest	38%	49%
		water	—	<1%
			<u>1977</u>	<u>1989</u>
013 - Walterboro	Just west of main stem	agriculture	44%	35%
		forest	55%	64%
		water	<1%	—

^a Includes agricultural lands and grasslands.

^b includes all upland forest types and wetland forest types and associated scrub/shrub types.

^c includes all open water and nonforested wetland types



Assessing Threatened and Endangered Species, Indicators, and Other Wildlife

Additional information on native wildlife was sought in reference to the presence of threatened and endangered species, indicator species (species that indicate high ecological integrity because of habitat requirements), and historical changes in species richness of animals other than birds. Personal contacts and references from the South Carolina Wildlife and Marine Resources Department and the U.S. Fish and Wildlife Service were used to gather this information.

Natural Area Inventory

The Natural Area Inventory entailed a systematic survey for sites with relatively undisturbed, high-quality natural communities in the Edisto River Basin. This effort was conducted as a cooperative arrangement between the South Carolina Water Resources Commission and The Nature Conservancy's Southeast Regional Office. The inventory was conducted in two phases. Phase I was a detailed survey of 1:40,000-scale, color infrared photography from the National Aerial Photography Program. Phase II was an aerial survey from a small airplane and selected on-site field visits to further examine and document the sites that qualified from the photo survey. The work began in the spring of 1991 and was completed in the winter of 1993.

Phase I: Aerial Photography Survey

The first phase involved several steps. First, a list of survey features was developed that named and defined the types of high-quality natural communities and relatively undisturbed areas (survey sites) to be sought. The Nature Conservancy's Southeastern Regional Ecological Community Classification System was the primary source for defining the survey features.

Second, the selection standards for the survey features were developed. Selection and screening criteria were used to determine what kind of sites would be "candidate sites" and what kind of sites would be "qualifying sites." Based on White and Aulbach-Smith (1993), the criteria and their application are specified as follows:

The selection and screening criteria were based primarily on acreage and quality (degree of unnatural disturbance). These standards vary among the different ecological communities to allow the largest and least disturbed examples of each community to be identified, where possible. For example, communities that characteristically occur in very small, localized patches were given lower acreage standards than communities that occupy extensive areas. Furthermore, ecological communities that have suffered wholesale degradation warrant lower quality standards than communities that still have many high-quality examples.

It was decided that these standards should not be too stringent, lest qualifying sites be overlooked or rejected. At each stage of the inventory, the selection and screening process was kept liberal enough so that no site would be eliminated that would have been found to qualify if it had later been examined more closely. Because it was decided that the screening process should not be too stringent, many of the candidate sites that were carried from one stage to the next stage were eventually be found to be nonqualifying.

Acreage. A minimum acreage for selecting examples of the survey feature was defined. After a minimum acreage was selected and some surveying completed, standards were refined where necessary. For example, if an inordinate number of sites were selected, then the standards were raised. If seemingly significant sites were rejected because they did not meet the minimum acreage, then these sites were added by lowering the standards and re-examining maps and photos that had already been screened.

Quality. The degree of allowable unnatural disturbance or degradation in a survey site was described. Examples of entries under this heading are as follows: "The forest canopy should be mature, with little or no evidence of recent logging" or "When viewed on aerial photography, the forest should show no evidence of damage by grazing



livestock” or “The presence of drainage ditches does not necessarily disqualify a candidate site unless the hydrology has been significantly altered.” For some survey features, it was desirable to combine acreage standards with quality standards. For example, a candidate survey site might be defined as 100 acres of undisturbed forest with a mature canopy or 20 acres of undisturbed forest with an obviously old (overmature) canopy.

Additional Criteria. Other factors, in addition to acreage and quality, that were used to choose survey sites were described. For example, if a particular survey feature is almost always associated with certain ecological communities, then it could be decided that an occurrence of the survey feature is not likely to be viable unless it co-occurs with the other ecological communities. In such cases, the co-occurrence of the other ecological communities could be made a part of the selection and screening criteria.

Adding many factors to the selection and screening criteria was discouraged. A great number of factors (for example, the number of ecological communities, the presence of special species, and the potential for educational use) could have been used to assign relative priorities among sites; however, it was deemed that such considerations should not be part of the initial selection and screening of survey features.

The third step in phase one was to develop search images for survey sites. These search images included descriptions of how the survey features appear on maps and aerial photography. Development of the search images required field reconnaissance of reference sites, which are known high quality examples of survey features.

The fourth step involved detailing the inventory methods for applying the selection standards and search images to identify survey sites. Detailing the inventory methods involved the following: gathering and reviewing available information (studying background material, contacting persons and agencies, and reviewing literature) and examining maps and aerial photographs.

Finally, the inventory was conducted by the methods described above. Survey sites were identified and documented on maps, photos, and survey site screening forms.

Phase II: Aerial Reconnaissance and Field Verification

The aerial reconnaissance was conducted for the following purposes: (1) to screen previously selected survey sites in the study area for potential significance; (2) to determine if these sites were still intact; and (3) to find additional sites not previously determined with map and aerial photograph interpretation. Each additional survey site that was discovered during aerial reconnaissance was documented in the same manner as the sites from phase one.

The photo survey and aerial reconnaissance did not finish screening every site to resolve its significance; therefore, the sites were categorized as follows:

- *Qualifying Survey Site* — meets selection criteria.
- *Candidate Survey Site* — significance is yet to be determined. The site’s potential significance and probability of qualifying was listed as:
High Potential, Medium Potential, or Low Potential.
- *Nonqualifying Survey Site* — does not meet selection standards.

Field verification began after the aerial reconnaissance and documentation of survey sites were completed. Initially, a subset of potential and qualifying sites was selected for field verification. This subset (1) gave preference to sites that had the highest potential significance for which there is no known existing information and (2) represented the range of community types and covered the geographic extent of the study area. On-site field verification was conducted to collect and record information for the selected survey sites to verify their community components, quality, and condition. The Nature Conservancy’s Southeastern Regional Ecological Community Classification was used to name natural communities. Standard Heritage site and element occurrence data forms were prepared for each site visited. In addition, the information gathered was entered into the South Carolina Heritage data base.



RESULTS

Changes in Bird Species Richness

Trends in Population Change

Ninety-eight species of birds were seen six or more times on at least one survey route in the Edisto Basin. Appendix II shows trends for each individual species on each route. Increasing or decreasing trends at both 0.10 and 0.05 significance levels are given. Very few species show consistency in the direction or strength of change. Many species (Cattle Egret, Yellow-Billed Cuckoo, Downy Woodpecker) show a highly significant ($P < 0.05$) change for one route but no significant change on any other route. Others (American Crow, Orchard Oriole, Carolina Wren) show significant increases and decreases on different routes. Of the 98 species analyzed, 24 species have populations that appear to be increasing, 37 species have populations that appear to be decreasing, and 37 species have populations that appear to be stable or unchanged.

A few species do show consistent population trends over most of the routes where they were found. On the basis of the BBS data, the following 10 species seem to be experiencing definite population declines in the Edisto Basin:

Little Blue Heron	Northern Bobwhite	Blue Jay
Red-winged Blackbird	Eastern Meadowlark	Rufous-sided Towhee
Northern Cardinal	Painted Bunting	Northern Parula
Common Yellowthroat		

Each of these 10 species is declining statewide or throughout their continental range (Droege and Sauer 1990) and should be monitored closely in the future (see "Regional Trends for Breeding Birds," below). Interestingly these declining species represent all three categories of habitat preference: water, forest, and field/forest edge. Barn Swallow, American Robin, and Eastern Bluebird are the three species apparently experiencing general population increases. These species all utilize the field/forest edge interface. The Barn Swallow has benefited from improved nesting sites available under road overpasses (Cely 1992).

Trends for Birds Relative to Habitats

Table 5-3 summarizes results of the regression analysis at each route for all birds, and for categories of birds based on habitat preferences. Route 1 (Johns Island), being adjacent to the coast, had by far the most water species (15). Of these, one, the Laughing Gull, increased in numbers while four — the Ring-billed Gull, Great Blue Heron, Little Blue Heron, and Marsh Wren — decreased. The herons and the Marsh Wren all utilize vegetated marshes for nesting and feeding habitat, while the gulls are more closely tied to open waters. Land cover changes, however, do not show a corresponding decrease in marsh habitat at the Johns Island route. Only one of these species, the Little Blue Heron, is known to be in decline statewide (Cely 1992) and throughout its range (Droege and Sauer 1990).

Routes 8 (New Holland) and 9 (Wagener) were the only routes where more species were significantly increasing than decreasing. Both routes had more forest species showing significant increases than decreases. The other four routes all showed many more forest species decreasing than increasing. These findings for forest species correspond with the land cover changes along the New Holland and the Wagener routes, as both showed increases in forest cover over the survey period.

The Johns Island route showed the greatest losses, with 51.6 percent of the forest species decreasing in population. Several species preferring forest with closed canopy or forest in general, such as Red-eyed Vireo, Summer Tanager, and Carolina Chickadee, were responsible for this. Corresponding to the decline in forest species, the Johns Island route also showed the greatest losses in forest cover (from 45 to 19 percent). For Route 13 (Walterboro), the data showed that 28.6 percent of the forest species decreased significantly; however, the change in land cover showed increases in forest land. Interestingly, the Johns Island and Walterboro routes do not show increases in field/forest edge species (Table 5-3); rather a substantial percentage of these species are decreasing in population. In particular, Blue Jay,



Red-winged Blackbird, Eastern Meadowlark, Orchard Oriole, and Painted Bunting are all decreasing significantly at these sites.

Johns Island and Walterboro are the only routes to have more bird species decreasing than increasing in all three categories. Overall, the population of 42.4 percent of the bird species found at Johns Island and 31.4 percent at Walterboro are decreasing significantly. This may indicate that the most serious habitat alteration has been occurring in the area of these two routes. The major forest cover losses that occurred at the Johns Island route support this hypothesis. At Walterboro, land cover changes and habitat alterations were not simply structural changes (such as forest to field) but rather changes in forest species composition from mixed upland forest types to a monoculture of loblolly pine forest. 1989 NAPP photography of this area shows that most of the forest cover along the route is planted pine.

Regional Trends for Breeding Birds

Droege and Sauer (1990) reported continental trends since 1966 for 88 of the same 98 species analyzed in the Edisto Basin; 50 percent of these species showed increasing populations and 50 percent showed decreasing populations. Comparing results from both the Edisto Basin and the continental analyses, only 38 species showed a consistent direction of population change for both areas; of these, 25 species showed decreases in populations and 13 showed increases.

A statewide analysis of the BBS data for South Carolina (includes 22 BBS routes) from 1966 through 1989 showed declines for most of the bird species found to be declining in the Edisto Basin (previously noted as species "experiencing definite population declines in the Edisto Basin"). The exception was the Common Yellowthroat; this bird is decreasing in numbers statewide, but the trends are not statistically significant at this time (Cely 1992). Three species in decline statewide but showing relative stability in the Edisto Basin are Prairie Warbler, Loggerhead Shrike, and Woodthrush. The limited sample size from the Edisto Basin may explain the inconsistency for these three species. Declining species in the Edisto Basin that are of statewide concern and should be given special attention in the future are: Little Blue Heron, Eastern Meadowlark, Northern Parula, Northern Bobwhite, Common Yellowthroat, and Painted Bunting (Cely 1992).

Cely (1992) identified bird species (with their preferred habitats) found in the Edisto Basin and known to be in decline throughout much of their breeding range:

Field Species —	Loggerhead Shrike, Bobwhite, Meadowlark, Barn Owl.
Forest Edge/Shrub Species —	Prairie Warbler, Painted Bunting.
Forest Species —	Wood Thrush, Swainson's Warbler.
Longleaf Pine Species —	Red-cockaded Woodpecker, Bachman's Sparrow.
Maritime Forest Species —	Ground Dove, Yellow-throated Warbler.
Beach/Dune Species —	Wilson's Plover, Least Tern, Piping Plover.



Table 5-3. Summary of numbers of birds regressed over time.

Species Summary	Routes					
	R1 Johns Island	R101 Adams Run	R5 Holly Hill	R8 New Holland	R9 Wagener	R13 Walter- boro
Total no. species	66	48	68	72	76	70
No. species increased*	2	1	10	17	15	7
% species increased	3	2.1	14.7	23.6	19.7	10
No. species decreased*	28	5	13	8	11	22
% species decreased	42.4	10.4	19.1	11.1	14.5	31.4
No. species showing no trend	37	42	45	47	50	41
% species showing no trend	56.1	87.5	66.2	65.3	65.8	58.6
<u>Categorized by Habitat</u>						
Total no. water species	15	0	4	1	3	5
% of total that are water species	22.7	0	5.9	1.4	3.9	7.1
No. water species increased	1	0	0	0	0	1
% water species increased	6.7	0	0	0	0	20
No. water species decreased	4	0	1	0	1	1
% water species decreased	26.7	0	25	0	33.3	1.4
No. water species showing no trend	10	0	3	1	2	3
% water species showing no trend	66.7	0	75	100	66.7	60
Total no. forest species	31	36	40	43	45	42
% of total that are forest species	47	75	58.8	59.7	59.2	60
No. forest species increased	0	0	4	9	11	5
% forest species increased	0	0	10	20.9	24.4	11.9
No. forest species decreased	16	5	7	1	5	12
% forest species decreased	51.6	13.9	17.5	2.3	11.1	28.6
No. forest species showing no trend	15	31	29	33	29	25
% forest species showing no trend	48.4	86.1	72.5	76.7	64.4	59.5
Total no. field / forest edge species	21	12	24	28	28	23
% of total that are field species	31.8	25	35.3	38.9	36.8	32.9
No. field species increased	1	1	6	8	4	1
% field species increased	4.8	8.3	25	28.6	14.3	4.3
No. field species decreased	8	0	5	7	5	9
% field species decreased	38.1	0	20.8	25	17.9	39.1
No. field species showing no trend	12	11	13	13	19	13
% field species showing no trend	57.1	91.7	54.2	46.4	67.9	56.5

* All numbers given are for species showing a trend significant at $P < 0.10$.

Water species = water + marsh + swamp preferences.

Forest species = forest in general + forest with open canopy + forest with closed canopy preferences.

Field/Forest Edge species = field + forest edge preferences.



The Neotropical Migratory Landbird Conservation Program, also known as the Partners in Flight Program, has compiled data on neotropical migrant bird populations for the southeastern United States in an attempt to prioritize species for protection. Three species which are in apparent decline in the Edisto Basin are also on the priority list of the Partners in Flight Program. These priority species include the Painted Bunting, Common Yellowthroat, and the Northern Parula; species experiencing significant widespread population declines.

Waterfowl

Information provided by Strange (1990) for midwinter surveys of waterfowl of the Atlantic Flyway indicate that populations of ducks have decreased dramatically since 1964. The steepest declines were in the late 1960s and early 1970s, and populations seem to have leveled out somewhat since that time. The midwinter surveys indicate that South Carolina has experienced a greater decline than the Flyway. South Carolina has had a 60 percent decrease in ducks since 1964, while the Flyway has experienced less than a 40 percent decrease in ducks. The surveys indicate a much more unfavorable comparison for geese. South Carolina's goose populations have decreased more than 90 percent since 1964, while populations of the Flyway have increased more than 60 percent.

Strange provided harvest records for the State's waterfowl management areas and these data indicate that the impoundment systems in the coastal areas of the Edisto Basin, specifically in the vicinity of Bear Island Wildlife Management Area, provide very favorable habitat for waterfowl. Harvest trends at Bear Island are similar to overall trends for waterfowl management areas throughout the State. However, the average annual harvest (birds per gun per day) at Bear Island has been consistently higher than the rest of the state since 1969 (beginning of record). As mentioned above, Bear Island is part of the region known as the ACE Basin, an area identified as one of the highest priorities for protection under the North American Waterfowl Management Plan and has been classified as a nationally significant wildlife ecosystem by the U.S. Fish and Wildlife Service.

In other portions of the Basin, waterfowl use is considered moderate in the marshes and bottomlands along the Edisto River from the coast up through Orangeburg County (winter populations are estimated at roughly 100 to 200 ducks per 1000 acres in these areas) as compared to high waterfowl use (greater than 200 ducks per 1,000 acres) attributed to the wetland impoundments of the ACE Basin (USDA 1982).

Changes in Other Wildlife Species Richness

Anadromous Fish

Anadromous fish species known to spawn in the Edisto River include the American Shad, Hickory Shad, Blueback Herring, Striped Bass, Atlantic Sturgeon, and Shortnosed Sturgeon. A survey conducted by the U.S. Fish and Wildlife Service reports that the recent status of each of these species in the Edisto River, except for the American Shad and Shortnosed Sturgeon, was judged to be stable (Rulifson and others 1982). The Shortnosed Sturgeon is an endangered species, and census and harvest data have indicated declines in American Shad. The shad fishery of the Edisto has traditionally been important to residents of the region. Ulrich and others (undated) stated that the recreational shad fishery for South Carolina centers on the Edisto River in the Jacksonboro area. Reports on commercial catches for Shad in the Edisto date back to 1880.

There have been a few efforts to assess the Shad fishery of the Edisto River. Major declines in commercial landings have been noted, but few comparable sources of data provide estimates of catch per unit of effort (CPUE). A summary of American Shad landed in South Carolina shows a decrease of approximately 85 percent over the period from 1896 to 1977 (Ulrich and others undated). On the Edisto River historical catches of Shad are reported as follows:

- 30,000 were estimated for 1880 and 28,273 in 1899 (from Walburg 1956);
- 11,011 in 1955 - about 1,500 of these by recreational fishermen (Walburg 1956);
- 14,259 in 1971 - 2,582 from creel census and 11,677 reported at fish houses (Wade 1971);
- 4,132 in 1975 - limited to creel census (Crochet 1975).



The Edisto Shad fishery was reported to extend from Willtown Bluff to Branchville in 1978, but Shad are known to ascend the river as far as Orangeburg on the North Fork and Norway on the South Fork (Ulrich and others undated). Unpublished data from a 1938 study by L.E. Cable indicated that the major Shad spawning grounds were between Westbank Landing and Givhans Ferry. Similarly, Wade reported in 1971 that 92 percent of the spawning activity of the American Shad on the Edisto River occurred between Westbank Landing and Jellico Landing just south of Givhans Ferry State Park. Another 7 percent occurred between Jellico Landing and Givhans Ferry.

Generally, the U.S. Fish and Wildlife Service biologists at the Orangeburg National Fish Hatchery believe that there has been a steady decline in the population of anadromous fish species that use the Edisto River. They believe that the species that do enter, do not venture or spawn as far inland as in the past.

Freshwater Fish

The South Carolina Wildlife and Marine Resources Department (SCWMRD) has sampled the Edisto River for freshwater fish species at more than 160 locations. However, at this time, none of the sampling has been repeated at these locations and changes in species composition and abundance cannot be assessed. Sampling was conducted in 1989 and 1990 using rotenone and electrofishing methods. A total of 71 species of fish were collected. Spotted Sucker was the most abundant species. Other dominant species (by weight) included Bowfin, Creek Chubsucker, Largemouth Bass, Common Carp, Longnose Gar, Striped Mullet, and American Eel. Redbreast Sunfish, an important recreational species, contributed 6 percent to the total biomass of the rotenone sampling.

A 1989 to 1990 creel census for the Edisto River to determine the user and harvest characteristics of the sport fishery was conducted by SCWMRD. These data indicate that the Redbreast Sunfish is by far the most sought species in terms of the percentage of fishermen and hours of directed effort (65 percent of total directed effort). Redbreast was the dominant species harvested in terms of numbers (45 percent) and pounds (32 percent) of fish caught. Results indicated that Flat Bullhead and Channel Catfish followed the Redbreast in being sought after and in total catch. The catch per unit of effort was much greater for the Bullhead and Catfish. Census results show that the Edisto freshwater sport fishery may be characterized as a winter Bullhead and Catfish fishery and a late spring - early summer redbreast fishery with low fishing pressure in the late summer and autumn.

Other Wildlife

There are very few wildlife species for which long-term data are available on species composition and population levels other than for birds. However, the Basin does support a diversity of wildlife populations that seem to be maintained at healthy levels. Large game animals that are sought after by hunters include the white-tailed deer, which is widely distributed, and the eastern wild turkey.

The bottomlands of the Edisto River, particularly along the main stem, are believed to support a high population density of deer (greater than 5 deer per 100 acres) relative to the rest of the state. Portions of Calhoun, Orangeburg, Dorchester, and Charleston Counties support medium densities of deer (3 to 5 deer per 100 acres). Turkey populations in the Basin are believed to be increasing along the Edisto River in Bamberg and Orangeburg Counties and in Four Hole Swamp (USDA 1982). SCWMRD staff members believe that previous declines in the turkey populations were probably brought about by illegal hunting activities and, to a lesser degree, habitat degradation (Bauman 1992). Restocking efforts begun in Bamberg and surrounding counties in 1981 have proven highly successful.

Presence of Indicator Species

Indicator species can be defined as top carnivores or species with large ranges whose presence or absence is an index of landscape integrity (Gosselink and Lee 1989). Species that could possibly serve as "indicators" of landscape integrity in this region are the Red Wolf, Black Bear, and Eastern Cougar. A recent occurrence of the Black Bear in Aiken County is recorded in the South Carolina Heritage data base; however, the State's wildlife biologists believe all of these have been extirpated from the Edisto River Basin. "Extirpated" means that the species is completely gone from a specific portion of its former range. Other species suggested as



indicators of landscape ecological integrity include raptors. Carnivores with smaller range requirements may also serve as indicators of ecological integrity.

Generally, there are no time series data available for population changes for indicator species; however, there is some knowledge of apparent trends in the population of raptors. The population of American Bald Eagle, for example, is known to be increasing in the lower basin at the coast. This region, known as the ACE Basin (coastal region of the Ashepoo-Combahee-Edisto Basin) presently supports 40 percent of South Carolina's nesting eagles, representing the most important Southern Bald Eagle nesting region in the State. It is estimated that there are 24 active nesting territories in this region. Raptors known to occur in the Basin are listed in Table 5-4. Populations for most of the raptors found in the Edisto River Basin are believed to be either increasing or stable within the region.

Bobcats and River Otters are known to inhabit the Edisto Basin and seem to have stable populations. These animals have smaller range requirements than the wolves, bears, and cougars but their presence may indicate good ecological conditions in the areas where they are found.

Presence of Threatened and Endangered Species

The U.S. Fish and Wildlife Service defines endangered species as those in danger of extinction throughout all or a significant portion of their range. Threatened species are those likely to become endangered within the foreseeable future. Table 5-5 shows the listed threatened or endangered animal species that are native to the Edisto River Basin.

The Florida Manatee is a periodic summer visitor to the coastal waters in the Basin. The Edisto Basin is within the historical range of the Bachman's Warbler, Eskimo Curlew, and Ivory-billed Woodpecker, but there are no records of occurrence for these species in the region. Bald Eagles, as mentioned above, are nesting in increasing numbers in the coastal areas of the Basin. The Red-cockaded Woodpecker is known to be nesting in several locations within the Basin. Wood Storks are known to be nesting near the Edisto River and American Swallow-tailed Kites have been seen carrying nesting materials near Cottageville, so they are probably nesting as well. The Peregrine Falcon is a fall and winter visitor to the coast.

Figure 5-2 is a map of the distribution of sensitive species and communities found in the Edisto Basin and associated counties derived from the South Carolina Heritage data base. This data base includes the known locations of threatened and endangered species. Several species listed in Table 5-5 are not shown in Figure 5-2 because exact locations are not known or have not been recorded in the Heritage data base. The distribution and density of the sensitive features shown in Figure 5-2 reflect the gaps that are common for biological data. In this case, the location is known for many more sensitive features around the heavily developed areas outside of the Basin. Much less is known of what exists in the remote areas within the Basin — areas where a greater density of sensitive species and communities would be expected.

As mentioned above wolves, bears, and cougars, which once inhabited this region, are believed to have been extirpated. Of these, only the Eastern Cougar is listed as endangered by the State of South Carolina; however, this species is known to exist only in southern Florida.

Several species are believed to have been extirpated from the region of the Edisto Basin. Some of these species are likely to be extinct. Others appear on the national list of threatened or endangered species; still others maintain stable populations in other regions of the United States. These extirpated species include the following:

- Ivory-billed Woodpecker (extirpated, possibly extinct);
- Eskimo Curlew (extirpated, possibly extinct);
- Bachman's Warbler (extirpated, possibly extinct);
- Whooping Crane (extirpated);
- Bison (extirpated from area before end of 18th century);
- Elk (extirpated from area before end of 18th century);
- Eastern cougar (extirpated from area);
- American Black Bear (extirpated from area);
- Red Wolf (extirpated from area in early to middle 19th century);
- Gopher Tortoise (extirpated from area, now found in South Carolina only in Jasper and Hampton Counties);
- Eastern indigo snake (extirpated from area, may occur in Hampton and Jasper Counties, South Carolina).



Table 5-4. Raptors known to frequent the Edisto River Basin.

Species	Occurrence ^a & (Residency)	Population Trend ^b
Bald Eagle (<i>Haliaeetus leucocephalus</i>) -	U&L (resident of Edisto estuary)	I
Golden Eagle (<i>Aquila chrysaetos</i>) -	R (winter visitor)	I
American Swallow-tailed Kite (<i>Elanoides forficatus</i>) -	U (breeder)	S
Mississippi Kite (<i>Ictinia mississippiensis</i>) -	L (breeder)	I
Cooper's Hawk (<i>Accipiter cooperii</i>) -	FC (winter visitor)	I
“ “	R to U (breeder)	
Sharp-shinned Hawk (<i>Accipiter striatus</i>) -	FC (migrant & winter visitor)	S
Red-tailed Hawk (<i>Buteo jamaicensis</i>) -	C (resident)	S
Red-shouldered Hawk (<i>Buteo lineatus</i>) -	FC (resident)	S
Broad-winged Hawk (<i>Buteo platypterus</i>) -	CS (breeder)	S
Northern Harrier / Marsh hawk (<i>Circus cyaneus</i>) -	FC&L (winter visitor)	D
American Kestrel / Sparrow hawk (<i>Falco sparverius</i>) -	FC (winter visitor)	U
“ “	U (breeder)	
Merlin / Pigeon Hawk (<i>Falco columbarius</i>) -	U (winter visitor)	U
American Peregrine Falcon (<i>Falco peregrinus anatum</i>)	U (winter visitor)	I
Osprey (<i>Pandion haliaetus</i>) -	L (breeder)	I
Great Horned Owl (<i>Bubo virginianus</i>) -	FC (resident)	S
Barred Owl (<i>Strix varia</i>) -	C (resident)	S
Barn Owl (<i>Tyto alba</i>) -	U&L (resident)	D
Eastern Screech Owl (<i>Otus asio</i>) -	C (resident)	S
Turkey Vulture (<i>Cathartes aura</i>) -	C (resident)	S
Black Vulture (<i>Coragyps atratus</i>)	C (resident)	S

^a Occurrence: Irregular Occurrence — species is not recorded annually; Regular Occurrence — reported at least once a year (adapted from Post and Gauthreaux 1989, and Cely 1992).

Species of irregular occurrence: CS = Casual, 2-6 records exist

Species of regular occurrence:

R = Rare, 1-6 individuals per season

U = Uncommon, 1-6 individuals per day per locality

L = Localized distribution; could be common or fairly common in appropriate location

FC = Fairly Common - more widespread than localized, 7-20 individuals per day per locality

C = Common, 21-50 individuals per day per locality

^b Population Trends: S = Stable, U = Unknown, I = Increasing, D = Decreasing

Table 5-5. Threatened and endangered species of the Edisto River Basin.^a

<u>Species</u>	<u>State Status</u>	<u>Federal Status</u> ^b
Mammals		
Eastern Cougar (<i>Felis concolor cougar</i>)	LE	LE
Florida Manatee (<i>Trichechus manatus</i>)	LE	LE
Rafinesque's Big-eared Bat (<i>Plecotus rafinesquii</i>)	LE	
Birds		
Bachman's Warbler (<i>Vermivora bachmanii</i>)	LE	LE
Eskimo Curlew (<i>Numenius borealis</i>)	LE	LE
Ivory-billed Woodpecker (<i>Campephilus principalis</i>)	LE	LE
Southern Bald Eagle (<i>Haliaeetus leucocephalus</i>)	LE	LE
Red-cockaded Woodpecker (<i>Picoides borealis</i>)	LE	LE
American Peregrine Falcon (<i>Falco peregrinus anatum</i>)	LE	LE
Wood Stork (<i>Mycteria americana</i>)	LE	LE
American Swallow-tailed Kite (<i>Elanoides forficatus</i>)	LE	
Piping Plover (<i>Charadrius melodus</i>)	LT	LT
Common Ground Dove (<i>Columbiana passerina</i>)	LT	
Glossy Ibis (<i>Plegadis falcinellus</i>)	LT	
Least Tern (<i>Sterna antillarum</i>)	LT	
Wilson's Plover (<i>Charadrius wilsonia</i>)	LT	
Fish and Reptiles		
Shortnose Sturgeon (<i>Acipenser brevirostrum</i>)	LE	LE
Loggerhead Turtle (<i>Caretta caretta</i>)	LT	LT
Gopher Tortoise (<i>Gopherus polyphemus</i>)	LE	
Flatwoods Salamander (<i>Ambystoma cingulatum</i>)	LE	
Eastern Indigo Snake (<i>Drymarchon corais couperi</i>)	LE	LT

^a Known to have occurred in the Edisto Basin, or occurrence is strongly suggested by geographic range.

^b LE = listed endangered, LT = listed threatened.



SENSITIVE SPECIES AND COMMUNITIES IN THE EDISTO RIVER BASIN

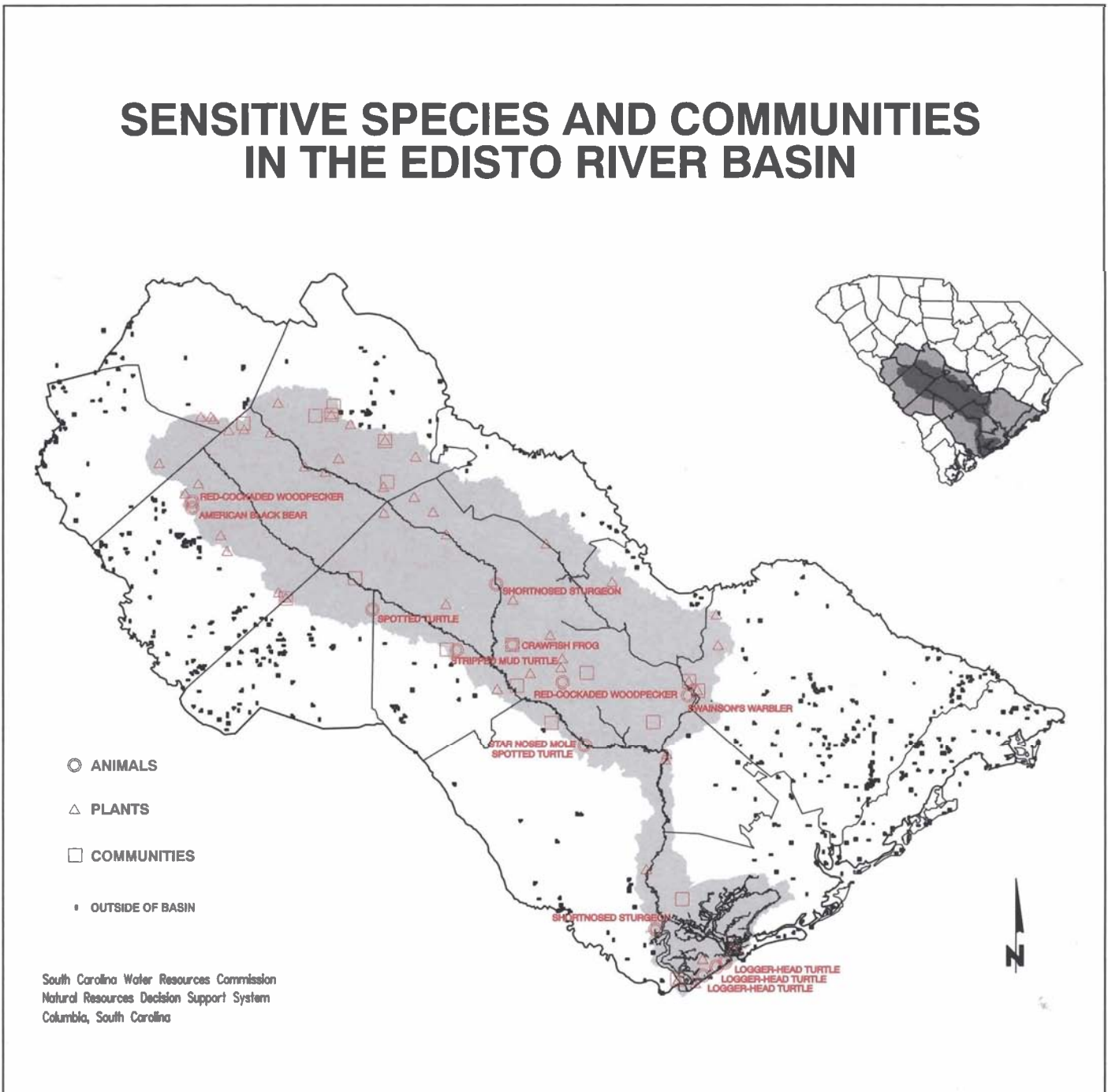


Figure 5-2. Locations of sensitive species and communities in the Edisto River Basin and outside the basin in associated counties. Source: Nongame and Heritage Trust Section of the South Carolina Wildlife and Marine Resources Department.



Natural Areas

The Natural Area Inventory was a systematic survey for sites with relatively undisturbed, high quality natural communities. Aerial photo examination, aerial reconnaissance, and selected on-the-ground field verification identified and assessed more than 400 sites within the Edisto River Basin. Working through the selection and screening criteria (see “Methods”) resulted in the identification of 301 qualifying and candidate sites. Figure 5-3 shows a map of these sites identified in the Natural Area Inventory. One hundred and forty-nine sites were found to be qualifying natural areas, and 152 sites were candidates (60 candidate sites had high potential for qualifying, 19 had medium potential, and 73 had low potential). Many other sites were found to be nonqualifying. The sites were categorized according to the complex of communities found on the sites. Nine community complexes were determined for the 94 natural communities believed to exist in the Edisto River Basin (upland and wetland communities were included but aquatic communities were excluded). Figures 5-4 through 5-7 show the sites by natural community type for each subbasin. Table 5-6 and Appendix III list community groups and specific natural communities of the Basin and summarize findings of the Natural Area Inventory.

In rather large areas of the Edisto Basin, few qualifying sites were found. The flat interstream areas were generally devoid of natural areas. Little remained intact except for an occasional wet depression or drainageway that had escaped recent disturbance. Ninety-five percent of the qualifying sites and 85 percent of the sites with high potential were wetland communities.

Most of the sites for high quality natural areas in the Edisto Basin were found in the coastal region; the inland areas had very few sites. Over 50 percent of the Edisto Basin’s qualifying sites were found in the coastal region of the Edisto (main stem) subbasin, primarily estuarine wetlands. Twenty-eight qualifying sites were found in the upper portions of the main stem; most were bottomland hardwood and Carolina bay communities. The North Fork had 11 qualifying sites and the South Fork had 10. Most of these were palustrine wetland communities associated with the streams. Only six qualifying sites were found in Four Hole Swamp — all were bottomland hardwood communities. Two of the sites in Four Hole Swamp were the largest of the qualifying natural areas; one was about 5,000 acres and the other, 7,000 acres.

It was rare to find a portion of the landscape where a sizable block of high-quality natural area encompassed both lowlands and uplands. There were many intact areas in wet lowlands, and a few areas on the ruggedly dissected uplands. Usually the uplands were cleared (or once were cleared and are now in pines) to the edge of the swampy bottomland. There was only one area where a large block of intact bottomland adjoined a large block of intact upland; this was northwest of Pringletown where several hundreds of acres of unfarmed upland borders Four Hole Swamp and supports significant flatwoods. Other than this site, there are no large potential preserves that span the full local range of natural diversity from the drainage divides to the streamside.

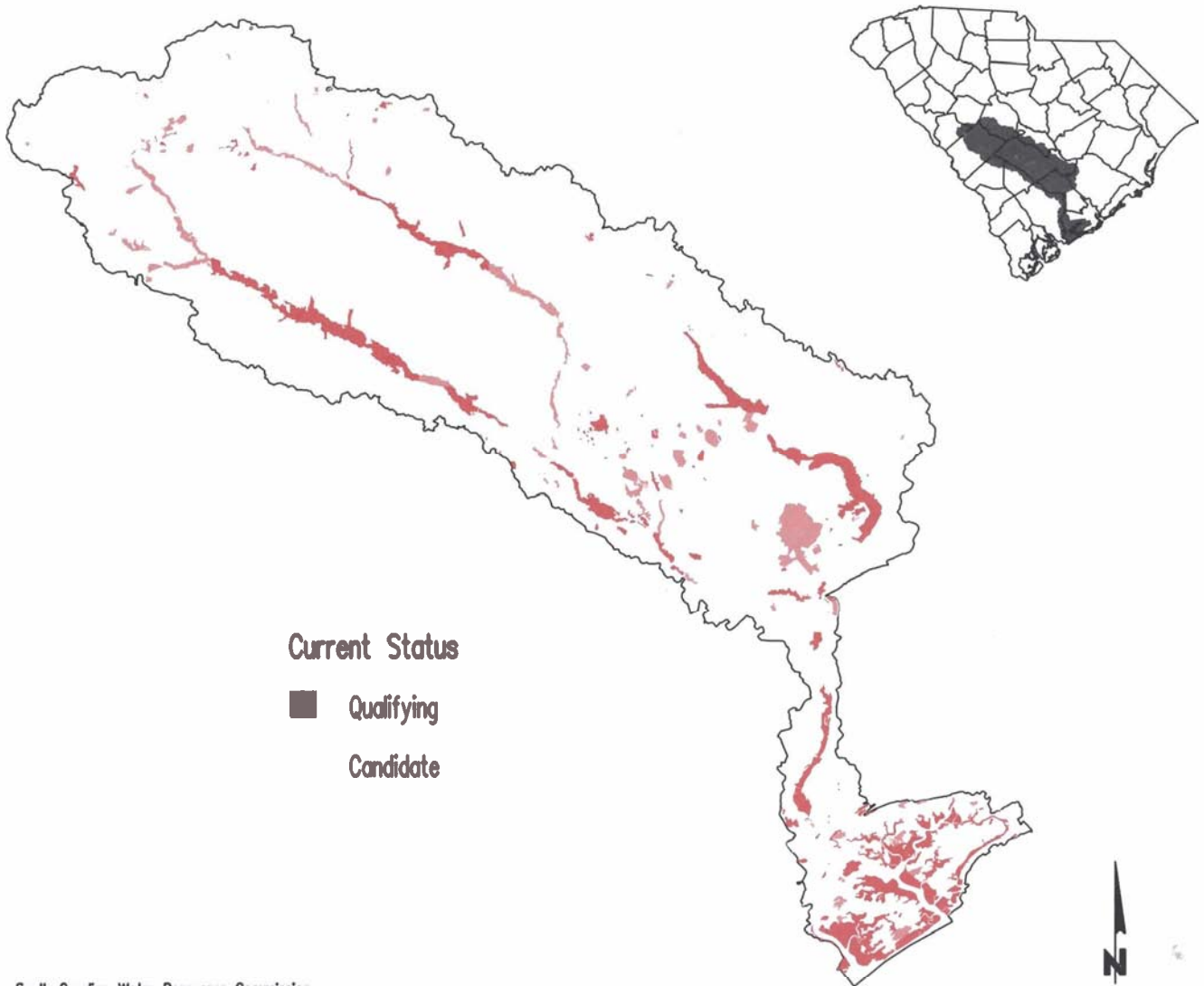
The Basin has extensive tracts of bottomland forest and swamp along the length of the Edisto River and its tributaries. Much of the forest is mature (40 to 80 years old). Few stands of old trees were identified in the survey. The condition of most of the forest is the result of a long history of timbering disturbances; much of the cutting was selective in the past, but now it is predominantly clearcutting.

On the uplands, few high-quality xeric and subxeric pine forests were found owing to a long history of fire suppression.

During the survey, no thorough examination was given to the aquatic habitats of the streams other than to look at the water and the aquatic plants. The overall impression was that the Edisto and its tributaries generally had good water quality. Black Creek, a tributary of the North Fork Edisto River in Lexington County, in particular seemed to have a unique aquatic habitat with very clear water and an abundance and diversity of aquatic macrophytes.



EDISTO RIVER BASIN NATURAL AREA INVENTORY



South Carolina Water Resources Commission
Natural Resources Decision Support System
Columbia, South Carolina

Figure 5-3. Locations of natural areas found in the Edisto River Basin, 1992.

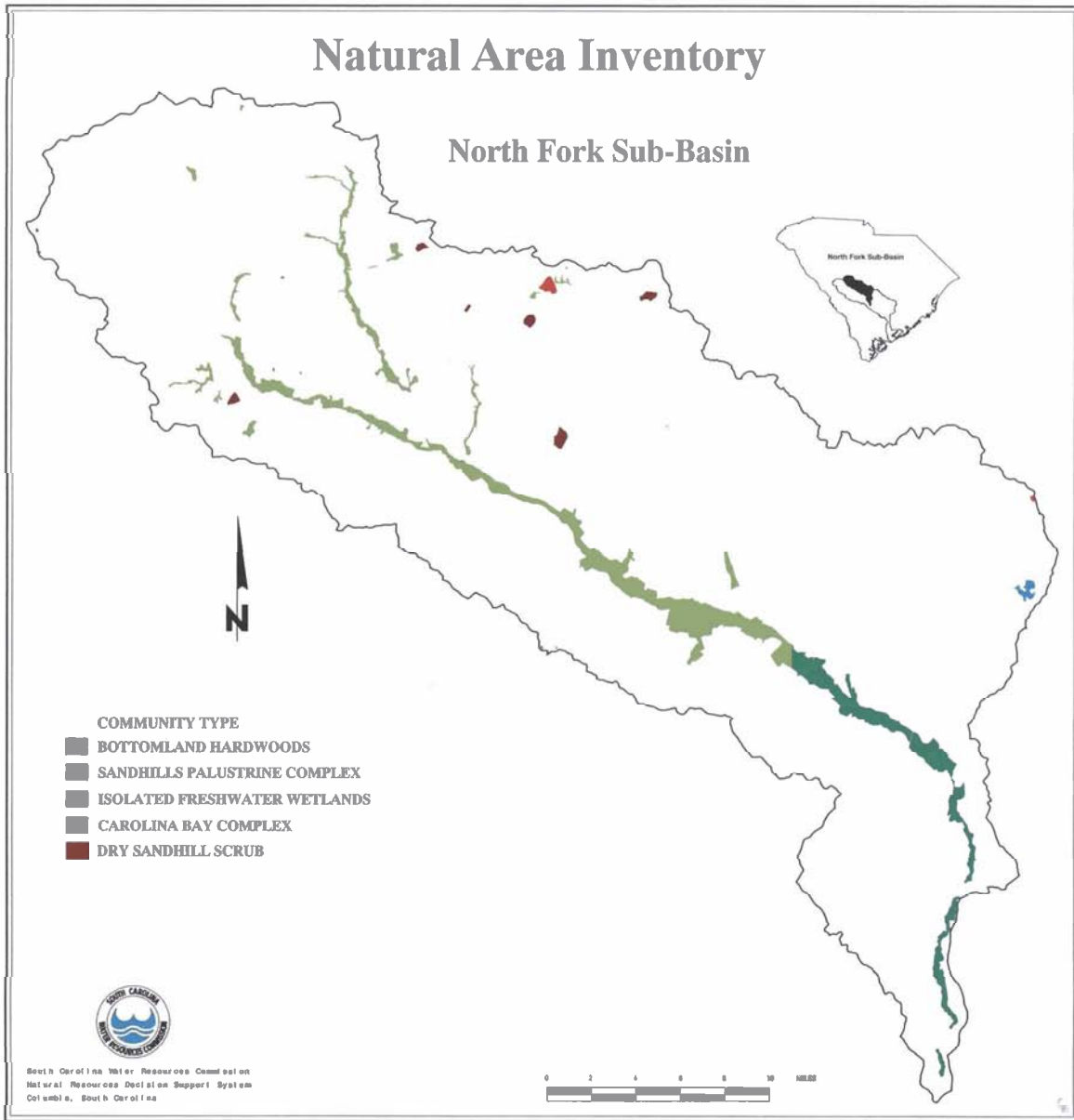


Figure 5-4. Locations of natural areas, by community type, found in the North Fork subbasin of the Edisto River Basin, 1992.



Natural Area Inventory

South Fork Sub-Basin

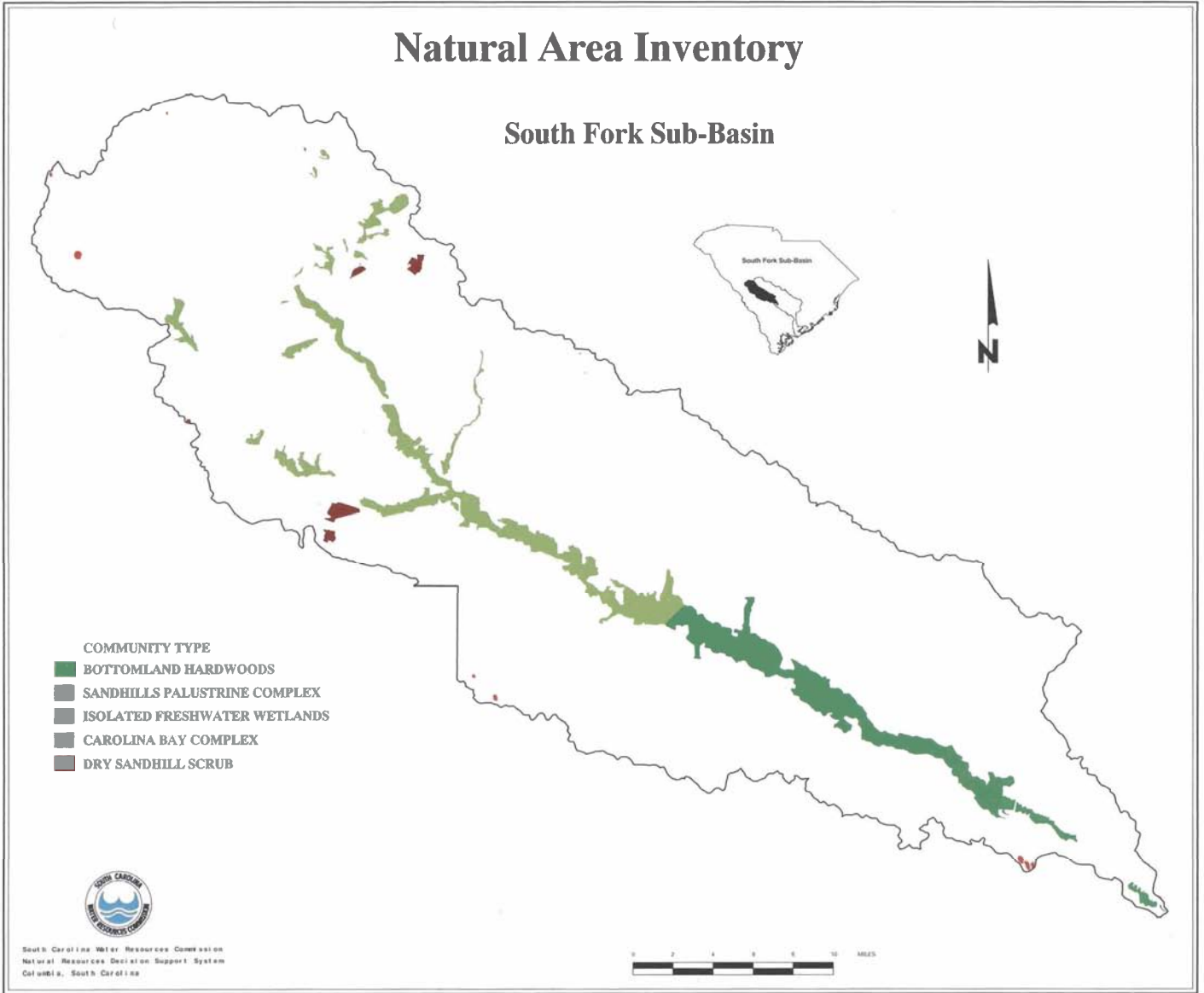


Figure 5-5. Locations of natural areas, by community type, found in the South Fork subbasin of the Edisto River Basin, 1992.

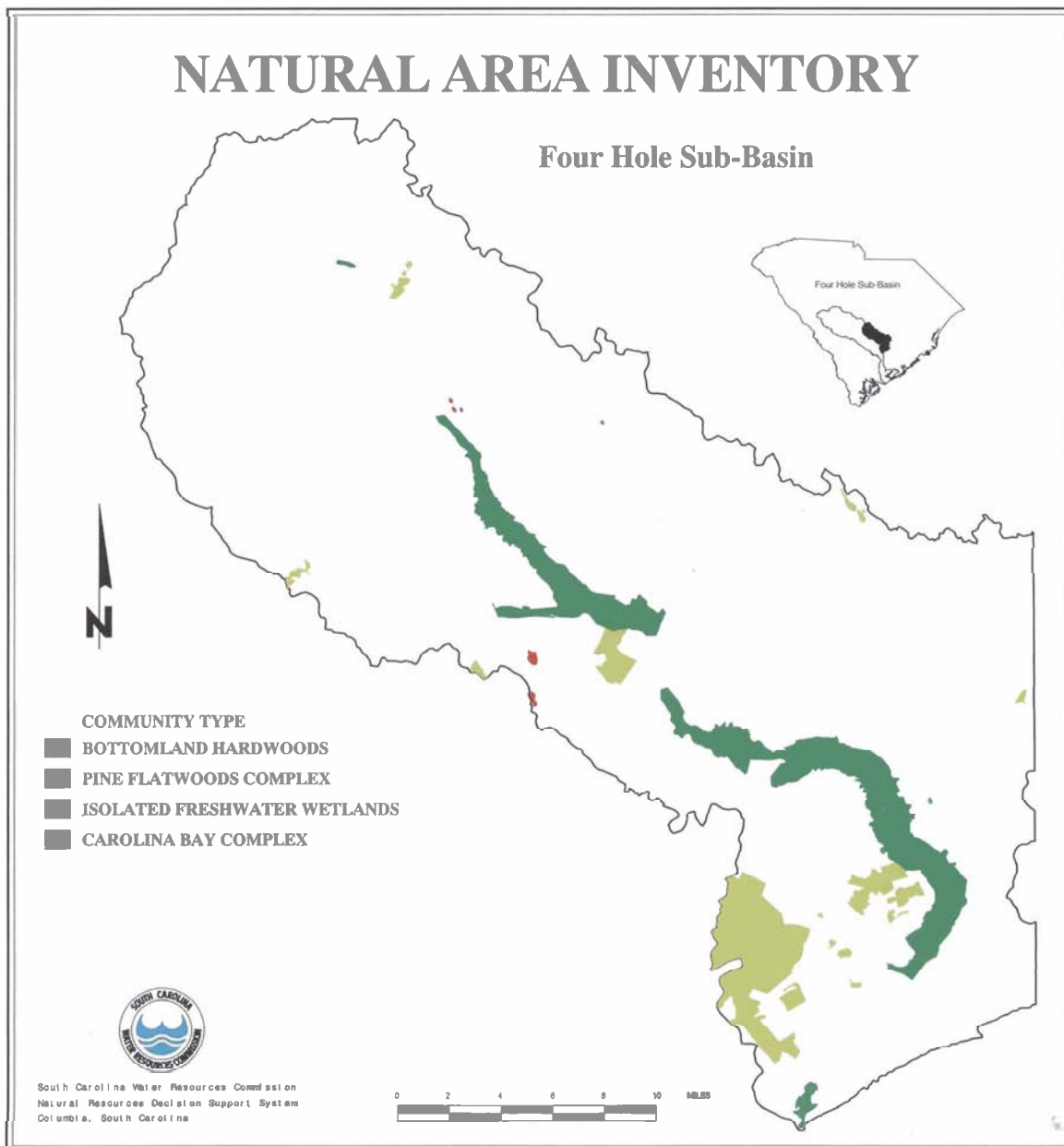


Figure 5-6. Locations of natural areas, by community type, found in the Four Hole Swamp subbasin of the Edisto River Basin, 1992.

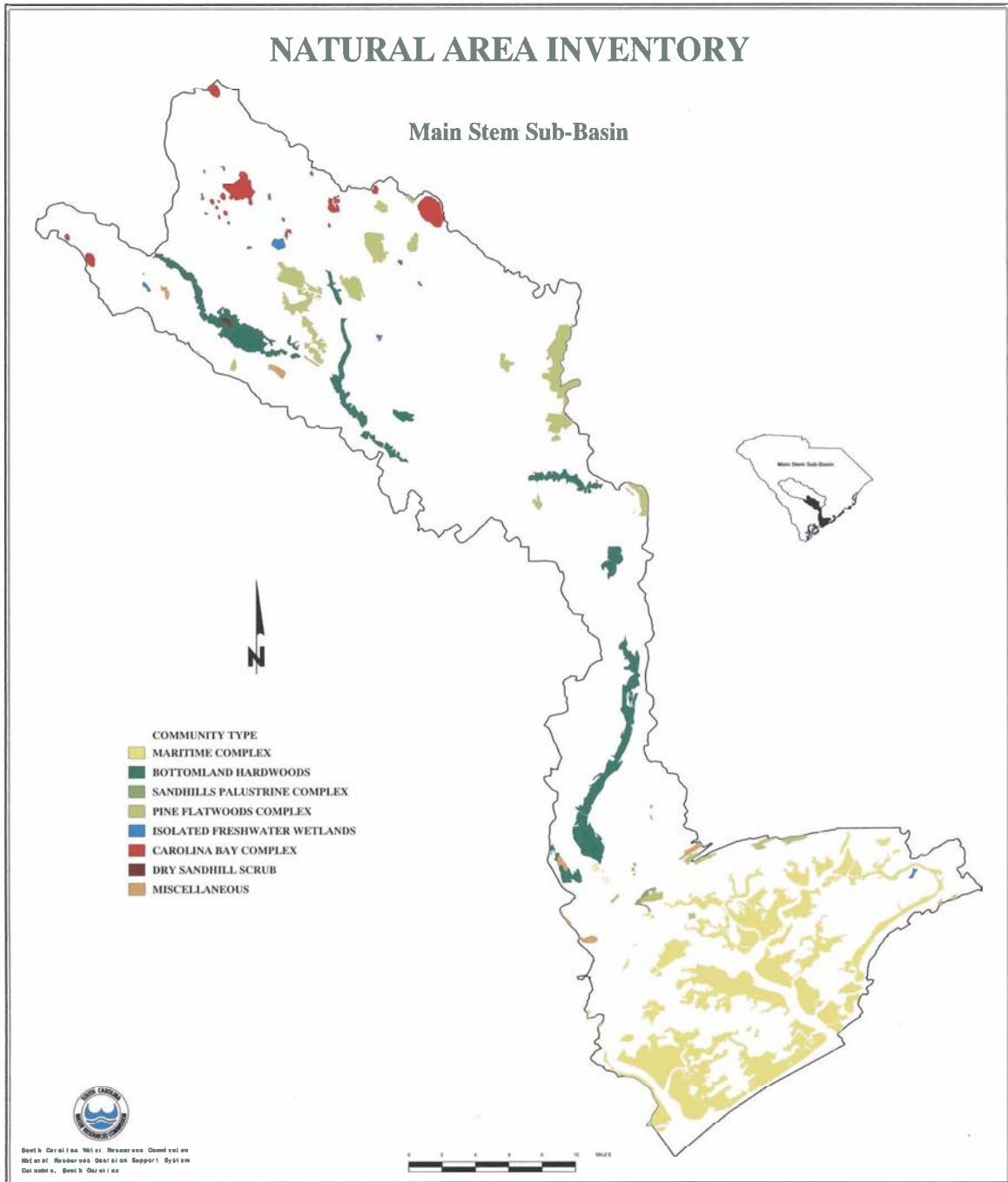


Figure 5-7. Locations of natural areas, by community type, found in the main stem subbasin of the Edisto River Basin, 1992.



Table 5-6. Qualifying and candidate sites of the Natural Area Inventory by community complexes, frequency, and total acreage.

<u>Community Complex</u>	<u>Frequency</u>	<u>Acreage</u>
Bottomland Hardwoods	41	61,166
Carolina Bay Complex	39	4,992
Dry Sandhill Scrub	13	2,202
Isolated Freshwater Wetlands	17	1,064
Maritime Complex	89	47,393
Miscellaneous	15	1,322
Pine Flatwoods Complex	43	26,057
<u>Sandhills Palustrine Complex</u>	<u>44</u>	<u>31,850</u>
Total	301	176,045

Significant Discoveries

The following review is not comprehensive but mentions the most notable finds of the survey.

Bottomland hardwoods and swamp forests — The Edisto (both forks, Four Hole Swamp, and the main stem) has thousands of acres of bottomland forests that appear to be relatively undisturbed and in good condition. Most of it probably is not exceptional in terms of its age and degree of past disturbance, but some stretches of river and swamp appear to have exceptional forests. As seen from the air, some sites have many giant old bald cypresses. These big cypress trees are probably hollow culls, so they may have been passed over when the stands were logged long ago. If this is so, then the forest surrounding the big cypresses is probably second-growth.

Most of the natural areas in forested bottomlands are adjacent to the streams; however, one site on the St. George SW Quadrangle stands out because it is a greater distance from the riparian zone. It was an obvious choice on the NAPP photos, and when the area was field checked it stood out as a high-quality site.

There are not many tracts of obviously old forest; perhaps they are very scarce. Some extensive old forests may exist, perhaps in parts of Four Hole Swamp, but this should be confirmed through on-site visits or consultations with people. Much of the bottomland forest and swamp appears basically uniform, and the forests seen on the ground are not especially old; consequently, most of the similar looking forest is similarly mature rather than old.

Longleaf pine savannas and flatwoods — Several sites seemed to have high potential as natural areas. One of the most promising in appearance on NAPP photography was just behind the Harleyville High School; later it was learned that it had been clearcut within the past several months. It also had heavy invasion by young trees, but it might be recoverable over the long term. All examples of such communities should not be dismissed simply because no sites could be found in good condition. Another site seen from the air was intact longleaf pine managed with fire.

Atlantic white cedar swamps — There are extensive white cedar (*Chamaecyparis*) swamps in the Black Creek and South Fork Edisto drainage (southern Lexington County). Some of them extend for more than a mile and cover more than 100 acres.

Granitic flatrocks — Three flatrocks were found at the extreme northwest end of the survey region. These Piedmont communities are actually outside the Edisto drainage but are in the quadrangle-based survey region, which extends beyond the Edisto watershed.

Hitchcock Woods — This is a large, old, outstanding forest in the sandhills in Aiken County just outside of the Edisto drainage. It has been protected for decades. Hitchcock Woods was not visited on the ground but was flown over. Nothing else in the sandhills compared with it. Such an outstanding natural area helped to put into perspective the many marginal areas that were encountered in the survey.

Streamhead and Streamside pocosins — Many pocosins are found along both forks



of the Edisto and in small tributary valleys. The streamhead pocosins are found at the very headwaters of small sandhill streams on seepage slopes. However, other large pocosins are found that stretch for a mile or more on slightly elevated flats in floodplains of streams in the sandhills; they contain loblolly bay (*Gordonia lasianthus*) and are floristically similar to bay forests (which are not associated with rivers but rather peatland interstream flats); therefore, these areas are tentatively called streamside pocosins. The differences between these pocosins is unclear but the community is locally common in the sandhills.

Inland Maritime Shrub Swamps — This was another new community discovered in the estuarine areas. It occurs between salt or brackish marshes and uplands or on slightly elevated areas within brackish marshes. This community is dominated by red bay (*Persea palustris*), wax myrtle (*Myrica cerifera*), and marsh cordgrass (*Spartina bakeri*).

Pond cypress ponds — Many of these are found in Carolina bays, particularly in bays south of Orangeburg. Many appear to be in good condition. They are beautiful and exhibit quite a diversity in structure (dwarfed, open stands; tall, dense, productive stands; open, grassy areas). These areas have potential for much preservation work and scientific study.

Depression meadows — Many depression meadows are found near the coast, including two on the Adams Run Quadrangle that were particularly unique owing to their size. Many of the depressions are round and less than an acre, but some are linear and several acres. These are not always apparent on the NAPP photos but are easy to spot from a plane. There are many more depression meadows than originally anticipated. Another intriguing type of depressional wetland was found in the study area. The largest one (a few acres) is dominated by *Xyris* (a graminoid known as yellow-eyed grass) and quite a variety of true grasses.

Other isolated wetlands — The most distinctive of this group are known as “high ponds.” These probably are the same as any Carolina bay except that they are in the very headwaters, they are small, and they often are herb-dominated. There are few high ponds, and most have suffered from direct disturbances or degradation from surrounding farming practices. Heritage Trust had previously inventoried high ponds. Several found in this survey appear to be high-quality sites. A few sites are distinct from typical Carolina bays and high ponds because they consist of irregularly shaped depressions or clusters of depressions. The most interesting looking site that seems well qualified for preservation is south of Denmark.

Old cypress stands — Several stands of old cypress were found; one stand has 300-year-old bald cypresses. These are located along the Edisto River in the fresh tidewater areas.

Coastal islands — Otter Island and several of its neighboring islands are outstanding complexes of maritime communities.

Recent Land Conversion

When this survey was conducted (1992) there was less destruction of survey sites than was anticipated, since the NAPP photos were taken in 1989. For the most part, the potential natural areas had survived this 3 year period. A reason for the high survival rate could be that most of the destructible areas were destroyed years ago. Sites that had survived until 1992 were likely already deliberately protected or it had not been economically feasible to exploit them.

Suburban sprawl (mobile homes) was claiming some sandhills sites, especially near Columbia; similar sprawl was occurring near Charleston from expensive homesites.

Some survey sites have suffered severe damage (such as clearing) or minor intrusions (such as a new homesite). However, these disturbances have not always eliminated an entire survey site. Furthermore, recent disturbance was not necessarily evidence that a high-quality natural area had been damaged, because most of the survey sites turned out not to meet final qualification standards. Consequently, most of the recent disturbances have been to areas that were not especially significant even before the most recent disturbance.

One of the greatest causes of recent logging was Hurricane Hugo. Many of the potential sites suffered heavy blowdown followed by salvage logging. In many instances it appeared that people opted to clearcut areas that were wind damaged rather than limiting their activities to salvaging windthrows. Almost all of the forested survey sites south of Lake Marion were either wiped out by post-hurricane logging or were so badly broken over by the storm that they no longer met the survey standards. Other areas with much wind damage



included Four Hole Swamp and other bottomland areas on the Sandridge, Wadboo Swamp, Holly Hill, Harleyville, Ridgeville and Pringletown Quadrangles. The extreme southeast part of the survey region (Wadmalaw Island and Johns Island) also received much wind damage. If a site was salvage logged, it was judged nonqualifying. If the site looked good on the photos and was not salvage logged, it was assessed as high potential or qualifying.

One of the most significant land conversions was not necessarily a new one: impoundment of headwater streams. The many small, deep, springfed valleys in the sandhills are ideal sites for ponds and small lakes. It was rare to find a headwaters stream that had no dam, and most have several dams. According to a fisheries biologist at the South Carolina Wildlife Department this was having a big impact on the aquatic animals that depend on this habitat.

Areas logged years ago recovered fairly well. Areas clearcut in recent years were removed from consideration as potential natural areas due to the extent of damage, particularly soil disturbance in wetland areas, done by the equipment that is now used. Where feasible, clearcut areas are often being converted to planted pine forest.

DISCUSSION AND CONCLUSIONS

There is a lack of data to support an analysis of trends in species richness and composition for the Edisto Basin. The only long-term, systematic data available are for birds — the Breeding-Bird Surveys (BBS). The BBS data are available for six routes at intermittent periods of time since 1966 and represent birds that may be seen or heard from a road in early June. These data show trends for many species that coincide with changes in land use and land cover. Other very limited data for fisheries and waterfowl are available and provide some informative facts for a better perspective of the Basin. Indicators of biological diversity show that much has been lost in the Basin since European settlement; however, substantial remnants of high-quality habitat and many rare or sensitive species remain.

Changes Affecting Bird Species

Analysis of the Breeding-Bird Surveys suggests that the habitat structure of the Edisto River Basin, based on avian habitat preferences, is undergoing change. However, there does not appear to be consistent change from forest to field or vice-versa. In some areas, forest-dwelling species are increasing, while in other areas they are decreasing. The same trend exists for the field-dwelling species, although fewer field species appear to be increasing than decreasing. This variability was similarly found by Gosselink and others (1990) in the Pearl River Basin. These patterns may indicate that some land is being allowed to grow into forest while other land is being cleared.

Analysis of land-use data and vegetation cover showed a fair degree of correlation with bird trends. The Wagener and New Holland routes had more significant increases in the populations of forest species than the other routes; this was consistent with increased forest along these routes. The Johns Island route showed the greatest losses in forest species and these losses corresponded with the greatest losses in forest cover. The Walterboro route had a large number of forest species that decreased significantly; however, the ratio of forest to cleared land along the route appeared to be about the same at the beginning and at the end of the survey period (1970 to 1991). Declines in forest species at Walterboro may be related to the conversion of land from natural forest to the monoculture pine plantation forests that currently dominate land cover along this route. These findings are consistent with opinions of biologists at the South Carolina Wildlife and Marine Resources Department who believe that the greatest threats to bird diversity in the Edisto region are the loss of longleaf pine forests; loss of hedgerows and edges from small agricultural fields; replacement of natural forests with pine plantations; and short timber rotations and excessive clearcutting in bottomlands (Cely 1992). Studies in Louisiana and Florida found bird species abundance and diversity to be significantly less in stands of even-aged pine monoculture forest compared to natural forest stands (Harris and others 1974, Noble and Hamilton 1975).

Wagener and New Holland were the only routes where more species were significantly increasing rather than decreasing; elsewhere the overall numbers of species declined.



Johns Island and Walterboro showed the greatest losses in the numbers of species, with more losses than increases for each of the three categories of habitat preference. No species had plummeting populations or appeared threatened with local extinction. However, those listed previously (in "Results") as experiencing definite population declines should be paid extra attention. As additional years of BBS data are collected, general trends will become even more evident. A reasonable strategy may be to perform regression analyses and look for trends on all data every five years.

Nearly half (43 percent) of the bird species examined in the Edisto Basin BBS analysis are neotropical migrants, meaning they breed in North America but migrate to regions south of the United States in the winter. Populations for many of these species have experienced continued declines, and in some cases severe declines, throughout North America since the late 1940s (Finch 1991). Two factors are believed to be causing population declines for neotropical migrants: forest fragmentation on their breeding grounds in North America; and deforestation of their wintering habitats in Central and South America (Finch 1991). Overall, the neotropical migrant species analyzed in Edisto Basin show no consistent pattern or direction of change. These migrant species were evenly distributed among three broad groupings — those with populations that appear to be increasing, decreasing, or remaining relatively unchanged. Four of the 10 species that show definite population declines in the Edisto Basin are neotropical migrants.

The analysis of bird trends affected by land use changes discussed in this section represents possible explanations for changing trends in bird species richness; however, many factors may be affecting these changes. Note that the bird data analyzed for the Edisto Basin are limited. A greater number of survey routes (a larger sample) is needed to make definitive statements relating bird trends with land cover change. One problem with the BBS data for the Edisto Basin is years of missing data. For example, the Wagener route has an 8-year gap in data. Because populations tend to show wide year-to-year fluctuations, such a gap weakens the ability to analyze general trends. Those routes with the longest unbroken data sets are therefore the most reliable. The inevitable year-to-year variation may be due to factors such as weather or breeding status of the birds (Droege 1990).

A further problem with BBS data arises with flocking and colonial birds (Droege 1990). Some of the species showing the most variation in this analysis (White Ibis, Little Blue Heron, Turkey Vulture) tend to occur in groups, and if a group is not near a survey point, no birds will be counted there. Additional years of data will significantly help in deciphering fluctuations in trends for these species. Also, the BBS data represent birds that may be seen or heard from a road in the spring; birds that prefer forest-interior habitats were not sampled as effectively as those that prefer edges.

Birds are just one class of organisms sensitive to changes in land use and habitat quality. They do not reflect all aspects of ecological change. Ideally, other measures of species abundance and diversity, for other vertebrates, invertebrates, and plants, should be used in land management decisions. However, more species populations are decreasing than increasing at four of the six BBS routes analyzed. Two routes are showing declines for 30 to 40 percent of the species over the last 20 years, which is markedly different compared to the average of 14 percent among the other four routes. The population declines in these two areas may indicate ecological instability, specifically in the Edisto (main stem) and Four Hole Swamp subbasins (the lower half of the Basin).

Indicator Species and Threatened and Endangered Species

The large, wide-ranging mammals native to the Edisto River Basin — bears, cougars, and wolves — have been extirpated. There was recently a documented sighting of a bear in Aiken County, but no viable population exists in the Basin. This sighting may indicate that habitat within the Edisto Basin is capable of supporting the Black Bear. Stable populations of medium-sized carnivores with smaller range requirements, such as bobcats and river otters, are found in the Edisto Basin, and the apparent trends of increasing and stable populations for most of the raptors in the Basin are evidence that the region provides stable food web support for these top-level carnivores.

The presence of nationally threatened and endangered species in the Edisto River Basin can be a positive sign of ecological integrity — showing that certain areas serve as a



refuge for sensitive or specialized species. The few Red-cockaded Woodpeckers found in the Basin require mature pine forest for nesting habitat. Generally, these birds have declined due to the loss of mature pine stands resulting in part from more intensive planted-pine forest management with shorter rotations for harvests. Populations of the Southern Bald Eagle in the ACE Basin survived the effects of widespread chlorinated pesticide use during the 1950s and 1960s. Biologists believe that the remote character and extensive system of tidal impoundments in this area protected the eagle nesting and feeding habitats from disturbance and contamination. The Loggerhead Turtle has continued to nest on the Basin's coastal beaches because of their relatively undeveloped character. The Shortnosed Sturgeon, which is believed to be a very sensitive species — unable to adapt well if its habitat is destroyed or polluted, has maintained a spawning population in the Edisto River. During spring floods, Shortnosed Sturgeon are believed to swim as far upstream as Orangeburg to spawn among the roots and tree trunks of swamps and oxbow lakes. This suggests that the aquatic habitat of the Edisto River is relatively intact and uncontaminated.

Natural Areas in the Landscape

The Natural Area Inventory revealed that the relatively undisturbed, high quality natural communities that remained in the Edisto River Basin were almost all wetlands, and the major portion of these were found in the coastal region. Most of the Edisto landscape has a long history of intensive land management for agriculture and forest products; therefore, very few upland communities of any size remained intact.

Much of the Basin's bottomland forests were mature (40 to 80 years old), but not old. Very few areas of old forest were found in the Basin, with the exception of a few old cypress stands in the main stem and one in Four Hole Swamp subbasin. Most of the natural areas in bottomlands were found along the streams. Intensive land use activities, particularly agriculture and pine plantations, have encroached on much of the bottomlands in the Basin and narrowed their natural extent. Despite these activities the largest natural areas of the Edisto Basin were found in the wetland communities of the bottomlands. Most of these areas were part of the Basin's larger forest patches, the cores of which were primarily forested wetland. Owing to the wide extent of intensively managed uplands, these wetland natural areas are likely to be very critical for maintaining wildlife diversity throughout much of the Edisto Basin.

Forest stands with older, larger trees are thought to support more wildlife species than those with younger and smaller trees (O'Neil and others 1991). The reasons for this are increased surface area of bole, branches, and foliage; increased production of leaves, twigs, branches, fruits, and seeds; and increased probability of decay leading to cavities and, further, to cavities of different sizes. Because much of the upland forests were intensely managed planted pine, the overall age of the Basin's forests was relatively young. Most (over 70 percent) of the Basin's older forest stands (stands greater than 80 years old) were bottomland hardwoods, according to the U.S. Forest Service (1991) Forest Survey data for the Edisto Basin. These stands, however, amounted to only about 4 percent of all the forestland in the Basin (about 32,000 acres). Twenty-four percent of all forestland in the Basin had mature stands (stands from 40 to 80 years old). More than half (54 percent) of these mature stands were bottomland hardwoods. These data promote the relative importance of the Basin's bottomland hardwood forests, particularly the associated natural areas, for the maintenance of species diversity in the Edisto Basin.

The greatest number and diversity of qualifying sites was concentrated in the main stem subbasin, which spans the most ecologically diverse portion of the Basin. The main stem had nearly 80 percent of the qualifying sites, sites that represented flatwoods, Carolina bays, bottomland hardwoods, a full array of intertidal wetlands, and barrier island communities. Far fewer qualifying sites and fewer community types were found in the more inland subbasins.



Ecological Integrity Based on Indicators of Biological Diversity

Several indices of biotic diversity that can be used to assess the ecological integrity of a region like the Edisto River Basin were suggested by Gosselink and Lee (1989), and have been addressed in this chapter. Indices of biotic diversity have included the extent and distribution of old-growth stands of forest, and in this study, high-quality natural areas; the presence of threatened and endangered species; the presence of indicator species (such as top carnivores); and historical changes in species richness, in this study primarily for birds. Ecological integrity, as it relates to the quality of an area for biota (animals and plants), also depends upon the structure of the landscape; that is, the mix and pattern of land uses and land cover types affecting the quality of natural habitats of the region.

The structure of the landscape, in terms of the remaining natural cover — its distribution and pattern — is important for maintaining populations of indigenous wildlife species. Discussion of landscape structural characteristics is therefore brought forward from Chapter 2 which addresses land use and land cover in the Edisto River Basin. Reductions in area of forest and natural cover lead to reductions in the number of species. Forest pattern — the sizes of forest patches and the connections between patches in a landscape — is considered a key index in the “island” (or isolation) affect of biogeography (Gosselink and Lee 1989). As a forested landscape becomes fragmented, species richness often increases due to the invasion of alien and opportunistic species; but this usually occurs to the detriment of native species that require large forest reserves. To support favorable habitats for many indigenous species, large interconnected forest patches should be maintained in a landscape.

This discussion emphasizes “forests” because it is in reference, generally, to rapidly diminishing natural forested landscapes. However, it is important to note that maintenance of a variety of natural habitats, particularly unique or rare natural communities, is also necessary to support many native species. Pine savannas and flatwoods, shrub pocosins, and a variety of marshlands, meadows, and grasslands are natural habitats of the Edisto Basin and should also be maintained in the landscape. Conserving landscape ecological integrity involves maintaining and restoring a mix of natural communities in a regional pattern that can support viable indigenous plant and animal populations in the context of traditional land uses. Hunter (1990) suggests that the interspersed or juxtaposition of different ecosystems and forest stands of varying sizes, ages, and species compositions will provide the greatest biological diversity in a forested landscape; and because some of the most threatened species require very large forested habitats, further forest fragmentation should be avoided.

In summary, based on the indices of biotic diversity and the landscape structural characteristics that relate to maintenance and support of wildlife species, the Edisto River Basin could be judged to have a moderate level of ecological integrity. No native far-ranging animals, such as bears or cougars, still inhabit the Basin; but bobcats and otters are resident, and most of the region’s raptor populations are stable or increasing. The Breeding-Bird Surveys indicate that several species of birds have declining populations and that the total number of species is declining in several areas. In terms of landscape structure, the Edisto River Basin is mostly forested, about 56 percent, with an additional 6 percent in nonforested wetlands. The remaining areas are primarily agricultural with very little urban or built-up land. Most of the Basin’s stream-edge habitats, or riparian zones, are intact with natural vegetative cover on 75 to 85 percent of these areas. Healthy riparian ecosystems are key components in maintaining the wildlife diversity of forested landscapes (Hunter 1990).

About 70 percent of the Basin’s total forest is in large patches (patches greater than 50,000 acres). These forest patches tend to be linear and extend through most of the landscape via the bottomlands of the streams connecting most of the upland and wetland forests into a continuous, irregular, and dendritic (branching) pattern of forested corridors. Large forest patches distributed in an irregular linear pattern often do not provide an abundance of isolated interior-forest habitat that is required by a number of sensitive species (O’Neil and others 1991). In addition, many roads and utility corridors crisscross the forest patches creating more fragmentation than is demonstrated by the patch analysis (presented in Chapter 2). Nevertheless, the Basin’s forest pattern of extensive regional connectivity and interspersed of different habitat types is probably very supportive of many indigenous wildlife species, though isolated interior-forest habitats are rare.



As discussed in Chapter 2, where maintaining biological diversity is a goal, silviculture practices must enrich forest structure (Sharitz and others 1992). At the scale of individual forest stands, important features of forest structure include the presence of native herbaceous and shrub plants, complex vertical structure in the forest canopy, some large living trees, standing dead snags, and large downed woody debris (Van Lear 1991, Seymour and Hunter 1992). Pine plantations, which represent one-third of the Basin's forests, typically lack the multilayered canopy, diverse tree sizes, abundant snags and fallen trees, and the high species diversity that exists in natural communities (Van Lear 1991). After canopy closure, dense pine plantations may furnish little for wildlife other than escape or thermal cover (Thill 1990). Plantation forests, however, can be established and maintained in ways that will improve their diversity. They can support a variety of plant and animal species depending upon how the stands are managed. Different management schemes for harvesting, site preparation, planting, and intermediate stand treatments will each have different effects on the quality of wildlife habitats in pine plantation stands.

The landscape scale, as suggested by Hunter (1990), remains the level at which the fate of wildlife species is ultimately determined and the interspersed of various types of forest habitats and ecosystems will provide the greatest biological diversity in a forested landscape. Thill (1990) recommends that the habitats which are lacking in the pine plantations may best be provided through retention and management of native riparian forests or upland hardwoods interspersed within the plantations. In the Edisto Basin landscape, some pine plantation stands are quite extensive but generally they remain interspersed with other types of habitats — primarily upland and wetland forests and agricultural lands. Therefore, existing habitat conditions at the landscape scale are probably favorable for most species with the exception of those requiring isolated forest interiors and old forest habitats, as noted previously.

As discussed in Chapter 2, the hydric soils analysis indicates that a great potential exists throughout the Basin for restoration of many sights to native wetland forest communities. The restoration of such sights is one option for providing increased dispersion of habitats within and adjacent to the existing plantations. Also discussed in Chapter 2 was the age structure of the Basin's forests. On balance, the forests are relatively young in age and, therefore, provide limited habitat for species that require late successional forests. Longer rotations for timber harvests, particularly in the non-plantation forests, could balance the forest age distribution and enhance the potential for increased biological diversity in the landscape of the Edisto Basin. Forest management principles that enhance biological diversity in forest stands and in forested landscapes that support intensive silvicultural activities — landscapes such as the Edisto River Basin — are discussed by Hunter (1990), Thill (1990), Seymour and Hunter (1992), Sharitz and others (1992), and Van Lear (1991).



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APPENDIX I

Hydric soils* used to assess changes in native wetland vegetation of the Edisto River Basin.

Source: U.S. Soil Conservation Service, County Hydric Soils Lists.

Argent loam	Bayboro sandy clay loam	Bayboro loam
Bayboro clay loam	Beaches	Bethera clay loam
Bethera loam	Bibb sandy loam	Bibb loamy sand
Bladen fine sandy loam	Bohicket association	Brookman clay loam
Byars loam	Cape Fear loam	Capers silty clay loam
Capers association	Chastain association	Chastain soils
Chenneby silty clay loam	Chenneby soils	Coxville fine sandy loam
Coxville loam	Coxville sandy loam	Daleville silt loam
Dasher mucky peat	Dawhoo-Rutlege loamy fine sand	Dunbar sandy loam
Dunbar fine sandy loam	Elloree loamy fine sand	Elloree loamy sand
Enoree soils	Grady loam	Grady loam, thin surface
Grady sandy loam	Grifton fine sandy loam	Handsboro muck
Haplaquents, loamy	Hobcaw fine sandy loam	Johnston sandy loam
Johnston soils	Johnston mucky loam	Leaf clay loam, thin surface
Leaf loamy sand, sandy substratum	Leon sand	Leon fine sand
Levy mucky silty clay loam	Lumbee loamy sand	Lumbee fine sandy loam
Lumbee sandy loam	Lynn Haven loamy sand	Lynn Haven fine sand
McCull loam	McCull sandy loam	Meggett loam
Meggett clay loam	Mixed wet alluvial land	Mixed alluvial land
Mouzon fine sandy loam	Myatt sandy loam	Myatt loam
Myatt loamy sand	Nakina fine sandy loam	Ogeechee loamy fine sand
Ogeechee sandy loam	Ogeechee fine sandy loam	Okenee loam
Osier loamy fine sand	Osier loamy sand	Osier fine sand
Paleaquults, sandy	Pamlico muck	Pantego sandy loam
Pantego fine sandy loam	Paxville fine sandy loam	Pelham loamy sand
Pelham sand	Pickney loamy fine sand	Pickney loamy sand
Plummer loamy sand	Plummer loamy fine sand	Plummer-Rutlege loamy sand
Portsmouth fine sandy loam	Portsmouth loam	Portsmouth sandy loam
Pungo muck	Rains fine sandy loam	Rains loamy sand
Rains sandy loam	Rembert loam	Rutlege loamy sand
Rutlege loamy fine sand	Rutlege-Pamlico complex	Santee clay loam
Santee loam	St. Johns fine sand	Stono fine sandy loam
Swamp	Tawcaw association	Tidal marsh, soft
Tidal marsh, firm	Torhunta-Osier association	Wadmalaw fine sandy loam
Wadmalaw variant loamy sand	Wehadkee silt loam	Williman loamy fine sand
Williman sand	Yonges loamy fine sand	

* This list was derived from 1989 Hydric Soils Lists for the 12 counties of the Edisto Basin and includes only the soil "map unit names" determined to have a "hydric soil component" for the "whole map unit."



APPENDIX II

Bird species, preferred habitat, and results of regression over time for six Breeding-Bird Survey routes, Edisto River Basin, South Carolina.

AOU No.	SPECIES	HABITAT	R1	R101	R5	R8	R9	R13
540	RING-BILLED GULL	W	-					
580	LAUGHING GULL	W	+					
650	ROYAL TERN	W	NS					
1260	BROWN PELICAN	W	NS					
1440	WOOD DUCK	W			NS	NS		
1840	WHITE IBIS	W/FE	NS		NS			NS
1860	GLOSSY IBIS	W	NS					
1880	WOOD STORK	W/FE	NS					+
1940	GREAT BLUE HERON	W	_*					NS
1960	GREAT EGRET	W	NS		NS		NS	NS
1970	SNOWY EGRET	W	NS					
1990	TRICOLORED HERON	W	NS					-
2000	LITTLE BLUE HERON	W	-		-		_*	NS
2001	CATTLE EGRET	FD/W	NS	NS	NS	_*	NS	NS
2010	GREEN-BACKED HERON	W	NS		+*	-	NS	
2110	CLAPPER RAIL	M	NS					
2730	KILLDEER	FD/M			NS	NS	NS	+
2890	NORTHERN BOBWHITE	FD	NS	NS	_*	NS	_*	_*
3131	ROCK DOVE	FD	NS		+		NS	NS
3160	MOURNING DOVE	FE/FD	NS	NS	NS	NS	NS	NS
3200	COMMON GROUND DOVE	FE/FD	_*					
3250	TURKEY VULTURE	FE/FD		NS	NS	NS	NS	NS
3260	BLACK VULTURE	F/FOC		NS	_*		NS	_*
3370	RED-TAILED HAWK	FE/FD				NS	NS	NS
3390	RED-SHOULDERED HAWK	S/F			_*			NS
3680	BARRED OWL	FCC		NS	NS			NS
3870	YELLOW-BILLED CUCKOO	FCC	NS	NS	_*	NS	NS	NS
3930	HAIRY WOODPECKER	F	-		NS		NS	NS
3940	DOWNY WOODPECKER	F		NS	NS	NS	NS	+*
4050	PILEATED WOODPECKER	FCC	NS	NS	NS	NS	NS	NS
4060	RED-HEADED WOODPECKER	FOC			NS	NS	_*	NS
4090	RED-BELLIED WOODPECKER	FOC	_*	NS	NS	NS	-	NS
4120	YELLOW-SHAFTED FLICKER	FE/FD	NS	+	NS	NS	NS	-
4160	CHUCK-WILL'S WIDOW	FCC	NS		NS	+*	NS	-
4170	WHIP-POOR-WILL	FOC					+	
4200	COMMON NIGHTHAWK	FOC/FE	NS			NS	NS	-
4230	CHIMNEY SWIFT	F	NS	-	NS	NS	NS	-
4280	RUBY-THROATED HUMMINGBIRD	FOC	_*	NS	NS	NS	NS	NS
4440	EASTERN KINGBIRD	FE/FD	-		NS	+*	+*	NS
4520	GREAT-CRESTED FLYCATCHER	FOC	-	NS	+	NS	NS	NS
4560	EASTERN PHOEBE	FE/F				NS	NS	
4610	EASTERN WOOD-PEWEE	FOC		NS	NS	+*	+*	NS
4650	ACADIAN FLYCATCHER	FCC		NS	NS	NS	NS	NS
4740	HORNED LARK	FD				NS		
4770	BLUE JAY	F/FE	_*	NS	_*	NS	_*	_*
4880	AMERICAN CROW	F/FE	_*	NS	NS	+*	NS	NS
4900	FISH CROW	F/FE	NS	NS	NS	NS	+	NS
4930	EUROPEAN STARLING	FOC/F/FE	NS		NS	_*	_*	NS
4950	BROWN-HEADED COWBIRD	FOC/FE/FE	NS	NS	NS	+*	+	NS
4980	RED-WINGED BLACKBIRD	FD/FOC/S	_*		_*	-	_*	_*
5010	EASTERN MEADOWLARK	FD	_*		_*	_*	NS	_*
5060	ORCHARD ORIOLE	FOC/FE	_*	NS	+*	NS	NS	-
5110	COMMON GRACKLE	FOC/FE/FE	NS	NS	NS	+*	_*	_*



AOU No.	SPECIES	HABITAT	R1	R101	R5	R8	R9	R13
5130	BOAT-TAILED GRACKLE	FD/M	NS					
5290	AMERICAN GOLDFINCH	FD/FOC				NS	NS	
5500	SEASIDE SPARROW	M	NS					
5600	CHIPPING SPARROW	FD/FE/FOC	NS	NS	NS	+	NS	
5630	FIELD SPARROW	FD			-	+	NS	-*
5750	BACHMAN'S SPARROW	FD		NS		+	+	
5870	RUFOUS-SIDED TOWHEE	FOC/FE	-*	-	NS	-	NS	NS
5930	NORTHERN CARDINAL	FE/FOC/FC	-*	NS	-*	NS	NS	-*
5970	BLUE GROSBEAK	FD/FE			NS	+	NS	NS
5980	INDIGO BUNTING	FD/FE	-*	NS	NS	NS	NS	NS
6010	PAINTED BUNTING	FD/FE	-*		-		-	-*
6100	SUMMER TANAGER	F	-*	NS	NS	NS	+	+
6110	PURPLE MARTIN	FOC/FD	-*		NS	NS	-	NS
6130	BARN SWALLOW	FD/FE	NS		+	+	+	
6140	TREE SWALLOW	FD/FE	+					
6170	NORTHERN ROUGH-WINGED SWALLOW		FD				NS	NS
6220	LOGGERHEAD SHRIKE	FE/FD	NS		NS	NS	NS	NS
6240	RED-EYED VIREO	FCC	-*	NS	NS	NS	NS	-
6280	YELLOW-THROATED VIREO	FOC		NS		NS	NS	NS
6310	WHITE-EYED VIREO	FOC	NS	NS	NS	NS	NS	+
6360	BLACK-AND-WHITE WARBLER	FCC				NS		
6370	PROTHONOTARY WARBLER	F/S			NS	NS	NS	NS
6480	NORTHERN PARULA	FOC	NS	-	-*	NS		-*
6630	YELLOW-THROATED WARBLER	FE	NS	NS	NS	NS	NS	-*
6710	PINE WARBLER	FOC	NS	NS	NS	NS	+	+
6730	PRAIRIE WARBLER	FOC/FE				NS	NS	NS
6760	LOUISIANA WATERTHRUSH	F					NS	
6770	KENTUCKY WARBLER	FOC		NS		NS	NS	NS
6810	COMMON YELLOWTHROAT	FOC/FE/M	-	NS	-*	NS	NS	-*
6830	YELLOW-BREASTED CHAT	FOC/FD	NS	NS	NS	+	NS	NS
6840	HOODED WARBLER	FOC		-	NS	NS	NS	+
6882	HOUSE SPARROW	FD/FE	+		+	-*	-*	-
7030	NORTHERN MOCKINGBIRD	FE	-*	NS	NS	-*	NS	NS
7040	GRAY CATBIRD	FOC		NS		NS	NS	
7050	BROWN THRASHER	F	-*	NS	NS	NS	NS	-
7180	CAROLINA WREN	F	-*	NS	+	+	+	NS
7250	MARSH WREN	M	-*					
7270	WHITE-BREASTED NUTHATCH	F				NS		NS
7290	BROWN-HEADED NUTHATCH	F		NS	NS	NS	NS	NS
7310	EASTERN TUFTED TITMOUSE	F	NS	NS	NS	+	+	NS
7360	CAROLINA CHICKAGEE	F	-*	NS	NS	NS	+	NS
7510	BLUE-GRAY GNATCATCHER	F	NS	-*	NS	+	+	NS
7550	WOOD THRUSH	F	NS	NS	-*	NS	NS	-*
7610	AMERICAN ROBIN	FOC/FE/FD			+	+	+	
7660	EASTERN BLUEBRID	FE		NS	+	+	+	+

APPENDIX II: PREFERRED HABITAT CODES:

W = WATER;
 F = FOREST IN GENERAL;
 FE = FOREST EDGE;
 FCC = FOREST WITH CLOSED CANOPY;

M = MARSH;
 FD = FIELD;
 FOC = FOREST WITH OPEN CANOPY;
 S = SWAMP

NS=NO SIGNIFICANT TREND

- = POPULATION DECREASING, P<0.10

+ = POPULATION INCREASING, P<0.10

-* = POPULATION DECREASING, P<0.05

+* = POPULATION INCREASING, P<0.05



APPENDIX III

Community groups of the Edisto River Basin, communities found during the Natural Area Inventory, and communities probably present in the Basin.

Sandhills Palustrine Complex

- ** Atlantic White Cedar Swamp Forest
- ** Coastal Plain Small Stream Swamp Forest
- ** Streamside Pocosin / Bay Forest
- ** Streamhead Pocosin

Sandhill and Coastal Plain Scrub

- ** Southeastern Coastal Plain Xeric Sandhill
- ** Southeastern Coastal Plain Turkey Oak Barrens
- ** Southeastern Coastal Plain Subxeric Pine-Scrub Oak Sandhill
- ** Atlantic Coastal Plain Mesic Longleaf Pine Forest ^{a, b}
- ** Longleaf Pine Seep
- ** Coastal Plain Seepage Shrub Slope ^a
- ** Streamhead Pocosin
- ** Small Depression Pocosin ^a
- ** Coastal Plain Hillside Herbaceous Seepage Bog ^a
- ** Atlantic Coastal Plain Depression Meadow
- ?? Pond Pine Seep ^a
- ?? Slash Pine Seep ^c

Pine Flatwoods Complex

- ** Atlantic Coastal Plain Mesic Longleaf Pine Forest ^{a, b}
- ** Wet Longleaf Pine Flatwoods
- ** Wet Longleaf Pine - Slash Pine Flatwoods ^{b, c}
- ** Longleaf Pine Savanna
- ** Pond Cypress Savanna
- ** Atlantic Coastal Plain Depression Meadow
- ** Swamp Tupelo Pond Forest
- ** Pond Cypress Pond Forest
- ** Pond Pine Woodland
- ** Pond Pine Seep ^{a, b}
- ** Streamhead Pocosin
- ** Non-Riverine Wet Hardwood Forest
- ** Non-Riverine Swamp Forest
- ** Coastal Plain Small Stream Swamp Forest
- ** Slash Pine Flatwoods ^c

Isolated Freshwater Wetlands

- ** Atlantic Coastal Plain Depression Meadow
- ** Non-Riverine Swamp Forest
- ** Non-Riverine Wet Hardwood Forest
- ** Coastal Plain Small Depression Pond Complex
- ** Pond Cypress Pond Forest
- ** Swamp Tupelo Pond Forest
- ?? Pond Cypress Dome and Swamp Forest
- ** Pond Pine Woodland
- ** Low Pocosin ^c
- ** High Pocosin
- ** Bay Forest



- Coastal Plain Hillside Herbaceous Seepage Bog ^a
- Limesink Pond Complex ^a
- Small Depression Pocosin ^a
- Interior Freshwater Marsh ^c
- ** Natural Impoundment Pond

Bottomland Forests

- ?? Bald Cypress Swamp
- ** Bald Cypress - Water Tupelo Swamp
- ** Bald Cypress - Swamp Black Gum Swamp
- ?? Tupelo Swamp
- ** Bald Cypress - Hardwood Forest
- ** Overcup Oak - Water Hickory Bottomland Forest
- ** Willow Oak Forest
- ** Sweetgum - Mixed Bottomland Oak Forest
- ** Sycamore - Sweetgum - American Elm Bottomland Forest
- ** Swamp Chestnut Oak - Cherrybark Oak Bottomland Forest
- ** Black Willow Riverfront Forest
- ?? River Birch - Sycamore Riverfront Forest
- ** Eastern Cottonwood - Willow Riverfront Forest
- ** Coastal Plain River Edge Shrub Wetland
- ** Riverside Shoal and Stream Bar Complex
- ** Coastal Plain Small Stream Swamp Forest
- ** Beech - Magnolia Forest
- Forested Canebrake ^a
- Lowland Pine - Oak Forest ^{a, c}
- Deciduous Forested Coastal Plain Seep ^a
- Wet Marl Forest ^a
- Flood Plain Pool ^a
- ** Coastal Plain Lakeshore Complex
- Interior Freshwater Marsh ^c

Upland Forests - Miscellaneous

- ** Interior Upland Dry-Mesic Oak-Hickory Forest
- Coastal Plain Calcareous Mesic Forest ^a
- ** Southern Mixed Hardwood Forest
- ** Spruce Pine - Mixed Hardwood Forest
- ** Beech - Magnolia Forest
- Upland Slash Pine Forest ^c
- Interior Calcareous Oak-Hickory Forest ^c
- Coastal Plain Limestone Sinkhole Pit ^a
- ** Atlantic/Gulf Coastal Plain Marl/Shell Bluff
- Piedmont/Coastal Plain Heath Bluff ^a
- Coastal Plain Acidic Cliff ^a
- Wet Acidic Cliff ^{a, c}

Maritime Complex

- ** South Atlantic Inland Maritime Forest
- ** South Atlantic Barrier Island Forest
- ?? Barrier Island Depression Forest
- ** Temperate Shell Midden Woodland
- ?? Barrier Island Dune Scrub Woodland
- Palm - Live Oak Hammock ^c
- ** Maritime Dune Shrub Thicket
- ** Atlantic Maritime Dry Grassland
- ** Atlantic Dune Grassland
- Estuarine Fringe Loblolly Pine Forest ^c



- ** Maritime Shrub Swamp
- ** Maritime Wet Grassland
- ** Barrier Island Pond Complex
- ** Salt Shrub Thicket
- ** Salt Marsh
- ** Brackish Marsh
- ** Salt Flat
- ** Estuarine Intertidal Mud Flat
- ** Estuarine Intertidal Sand Flat
- ** Tidal Pool
- ** Mollusk Reef
- ?? Seagrass Bed
- ?? Intertidal Algal Bed
- ?? Submergent Algal Bed
- ?? Subtropical Sponge Bed
- ?? Subtropical Worm Reef

Tidal Freshwater Complex

- ** Freshwater Tidal Bald Cypress - Tupelo Swamp
- ** Tidal River Edge Shrub Wetland
- ** Tidal Freshwater Marsh
- ** Estuarine Intertidal Mud Flat
- ** Estuarine Intertidal Sand Flat

Carolina Bay Complex

- ** Non-Riverine Swamp Forest
- ** Atlantic Coastal Plain Depression Meadow
- ** Pond Cypress Pond Forest
- ** Pond Cypress Savannah
- ** Bay Forest
- ?? Pocosin
- ** Pond Pine Woodland
- ** Natural Impoundment Pond

** = Found; ?? = Probably present; a = Difficult search image;
 b = Possibly extirpated; c = Probably not present in the basin.

Assessing Change in the Edisto River Basin

Total copies:	1500
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Cost per copy:	7.32
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