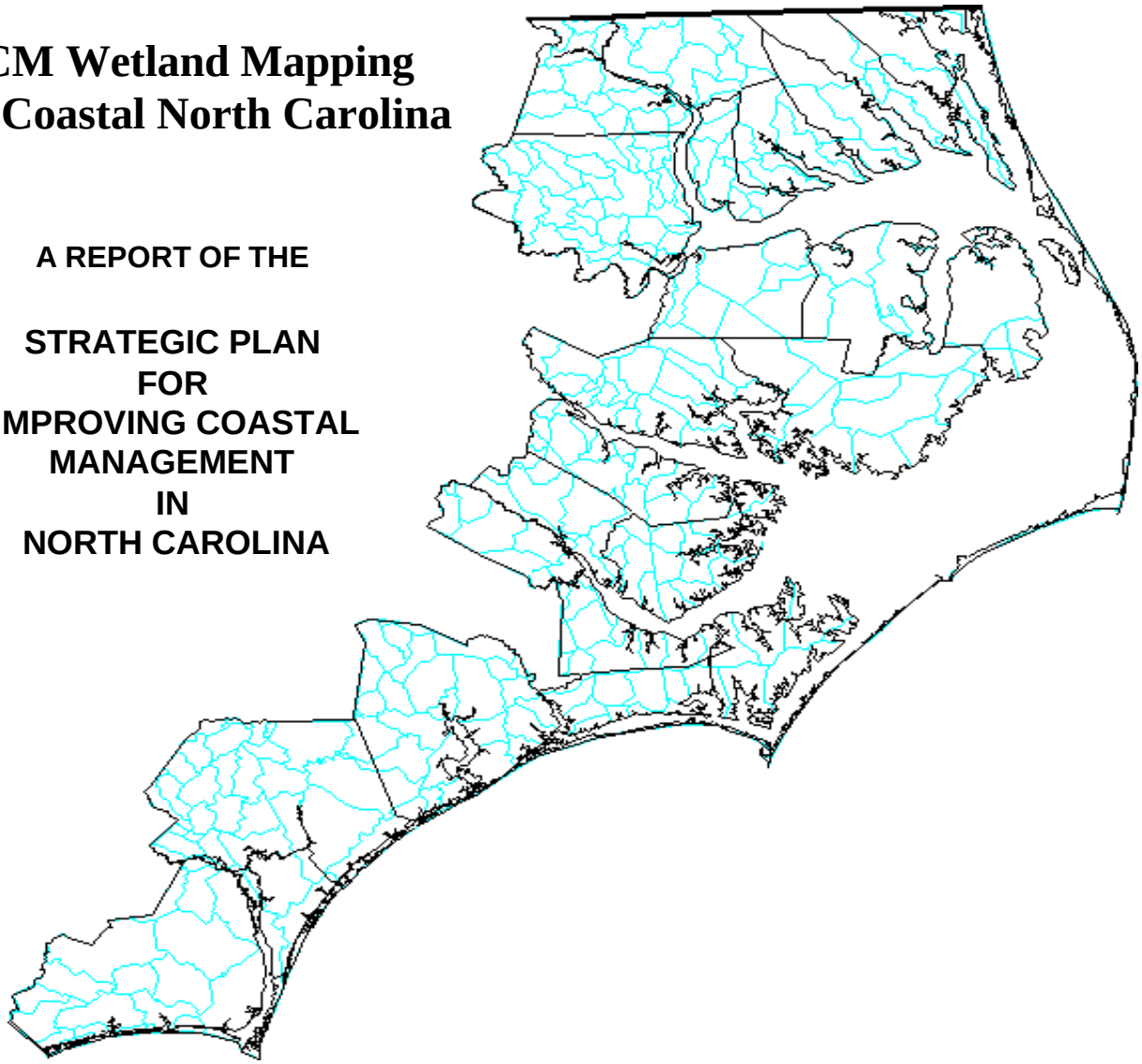
DCM Wetland Mapping In Coastal North Carolina



A REPORT OF THE

STRATEGIC PLAN FOR IMPROVING COASTAL MANAGEMENT IN NORTH CAROLINA

Performed Under The Coastal Zone Enhancement Grants Program

Division of Coastal Management
North Carolina Department of Environment and Natural Resources

May 1999

NOAA

EPA United States Environmental Protection Agency

DCM Wetland Mapping
In Coastal North Carolina

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Table of Contents

Figures and Tables

**Note: This document was originally published in May 1999. It has been reformatted and edited for the web and color figures have been added to enhance readers' understanding of the mapping procedure. Some additional text has also been added as clarification. Hardcopies of the 1999 document can be requested from DCM, but they will not include these additional figures or text. Also, this mapping procedure has been extended into the North Carolina Inner Coastal Plain counties so that a total of 37 counties have been evaluated. The text of this document focuses on the project originally confined to the 20 Coastal Counties, but the methods used for the Inner Coastal Plain were not changed.*

Introduction

Section 1

Context

The coastal area of North Carolina covers 20 counties and more than 9000 square miles of land area and about 20 percent of the state. It also includes more than 87 percent of the state's surface water. The North Carolina Coastal Management Program (NC CMP) is responsible for managing this area to meet the goals set forth in the Coastal Area Management Act (CAMA - NCGS 113A, Article 7). These goals provide a broad mandate to protect the overall environmental quality of the coastal area and to guide growth and development in a manner "consistent with the capability of the land and water for development, use, or preservation based on ecological considerations", (NCGS 113A-102(b)(2)).

Much of the North Carolina coastal area is occupied by wetlands. In many areas, wetlands comprise nearly 50 percent of the landscape. These wetlands are of great ecological importance, in part because they occupy so much of the area and are significant components of virtually all coastal ecosystems, and also because of their relationships to coastal water quality, estuarine productivity, wildlife habitat, and the overall character of the coastal area.

Estimates indicate that approximately 50 percent of the original wetlands of the coastal area have been drained and converted to other land uses (Hefner and Brown, 1985; Dahl, 1990; DEM, 1991). Although agricultural conversion, the largest historical contributor to wetlands loss, has largely stopped, wetlands continue to be lost as they are drained or filled for development. Conflicts between economic development and wetlands protection continue to be a major concern, with many coastal communities considering wetlands protection to be a major barrier to economic development.

Since wetlands are such a dominant part of the coastal landscape and are vitally important to many aspects of the area's ecology, their management and protection is a major concern of the NC CMP. Tidal wetlands, or "coastal wetlands" as they are referred to in law and administrative rules, are stringently protected by the State Dredge and Fill Act (NCGS 113-229) and the Coastal Area Management Act (CAMA) regulatory programs. Coastal wetlands are designated Areas of Environmental Concern (AECs). The management objective in AECs is "to give highest priority to the protection and management of coastal wetlands so as to safeguard and perpetuate their biological, social, economic and aesthetic values; and to coordinate and establish a management system capable of conserving and utilizing coastal wetlands as a natural resource essential to the functioning of the entire estuarine system", (15A NCAC 7H .0205).

Non-tidal freshwater wetlands, on the other hand, were not specifically protected under North Carolina law until recently. State involvement in protection of fresh water wetlands was limited to the regulatory authority given under federal laws for state agency review of federal permits, in this case §404 permits granted by the US Army Corps of Engineers. Under §401 of the Federal Water Pollution Control Act (33 USC 1341), a Water Quality Certification from the NC Division of Water Quality (DWQ) (formerly the Division of Environmental Management (DEM)) is required for a §404 permit to discharge fill material into wetlands. Section 307 of the Federal Coastal Zone Management Act (CZMA - 16 USC 1451 *et seq.*) also requires that §404 permits be consistent with the enforceable rules and policies of the NC CMP. The standards for consistency are the use standards for AECs and wetlands policies stated in the applicable local land use plan. Outside of AECs, there are no consistent standards or policies in the NC CMP regarding wetlands. A few local land use plans include policies to protect fresh water wetlands, but most do not. It was under these circumstances that the idea of a Wetland Conservation Plan came about.

Wetland Conservation Plan

The NC CMP's lack of specific protection for non-tidal wetlands was recognized in the CZMA §309 Assessment of the NC CMP performed during 1991 (DCM, 1992a). During the assessment, it was apparent that both opponents and proponents of wetlands protection felt that the current system was inadequate. Economic development interests found the §404 regulatory program to be unpredictable and inconsistent, often resulting in the loss of needed economic growth in coastal counties. Environmental interests felt that it allowed the continued loss of ecologically important wetlands. As a result, wetlands management and protection was chosen as one of the primary program areas in need of enhancement.

The North Carolina Division of Coastal Management (DCM) developed a five-year Strategy (DCM, 1992b) for improving wetlands protection and management in the coastal area using funds provided under the Coastal Zone Enhancement Grants Program established by 1990 amendments to §309 of the federal CZMA. The §309 Program is administered by the Office of Ocean and Coastal Resource Management (OCRM) in the National Oceanographic and Atmospheric Administration (NOAA), U.S. Department of Commerce. Funds provided under this Program were used for the work reported here. The work was also partially funded by a separate grant from the U.S. Environmental Protection Agency (EPA) for a Wetlands Advance Identification project in Carteret County, North Carolina.

The key element of DCM's strategy for improving wetlands protection is the development of a Wetland Conservation Plan for the North Carolina coastal area. The Plan has several components:

Wetlands Mapping & Inventory

Functional Assessment of Wetlands

Wetland Restoration Identification & Prioritization

Coordination with Wetland Regulatory Agencies

Potential Coastal Area Wetlands Policies

Local Land Use Planning

The obvious first step toward a Wetland Conservation Plan is describing the type, location and extent of the wetland resource, which will provide a factual basis for policy and decision-making. This is being accomplished by an extensive Geographic Information System-based (GIS) wetlands mapping program, which has produced GIS wetland data by wetland type for the entire coastal area of North Carolina. Using the GIS coverage, paper maps can be generated for areas within any boundaries available in GIS format. The methods and results of this mapping effort are the subject of this report.

Development of the Wetland Conservation Plan also includes an assessment of the ecological significance of all wetlands to determine which of the wetlands are the most important in maintaining the ecological integrity of the area. If there are choices and trade-offs to be made in wetlands protection, as there inevitably are in an area with as many wetlands as the North Carolina coastal area, a rational management system should address the most ecologically important natural resource areas. To identify which wetlands are most significant, a GIS-based functional assessment procedure called the North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS) has been developed that will result in a designation of each wetland polygon in the GIS coverage as being of exceptional, substantial or beneficial functional significance in the watershed in which it exists. Development and application of that procedure is described in a separate report (Sutter et al., 1998).

The remaining components of the Wetland Conservation Plan are the means by which the results of the wetland mapping and functional assessment will be used to improve wetland protection and management. Close coordination with other state and federal agencies involved in wetlands protection and management has been an important component of the entire effort. Agency representatives have been involved in development of the methods used, and the resulting maps will be provided to the agencies for use in their own planning and decision-making. Policies for protection of wetlands of varying functional significance could be proposed to the Coastal Resources Commission to serve as the basis for consistency review of §404 permit applications. Wetland maps and functional assessment results will also

be provided to local governments for use in local land use planning, and DCM will work with local governments to increase their involvement in wetlands protection.

Wetland Identification

Technical and Legal Definitions

The first step toward improving the management of wetlands is defining the location and extent of the resource. In North Carolina there are two laws that define wetlands. Section 404 of the Federal Water Pollution Control Act ("the Clean Water Act) defines wetlands as "areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted to life in saturated soil conditions." The North Carolina Coastal Area Management Act (CAMA) defines "coastal wetlands" as "any salt marsh or other marsh subject to regular or occasional flooding by tides, including wind tides (whether or not the tide waters reach the marshland areas through natural or artificial water courses), provided this shall not include hurricane or tropical storm tides." Coastal wetlands contain at least one of 10 specified species of marsh plants. The wetlands defined by these two laws, "404 wetlands" and "coastal wetlands", are the only wetlands directly regulated by state or federal agencies in North Carolina.

There are several limitations to relying on only a technical or legal definition in wetland management. Comprehensive wetland maps indicating where "404" or coastal wetlands occur or are likely to occur can be an invaluable tool as guidance for planning and policy-making purposes. While a definition of wetlands is necessary from a regulatory standpoint, a planning tool that shows the location and type of wetlands could improve wetland impact through avoidance and minimization, thus improving the ability to make planning and policy-making decisions. For example, with only a technical definition, a landowner or developer is less able to determine in advance whether wetlands are present in a given area. This makes decision-making and land use planning more difficult and time-consuming because legally, wetland delineations and determinations require on-site field visits. Wetland delineations include an on-site assessment of wetland criteria present including vegetation, soils, and hydrologic conditions that must meet certain requirements to qualify as a wetland. Wetland delineations or "jurisdictional calls" must be verified and approved by a representative from the US Army Corps of Engineers or, for coastal wetlands, a representative from the NC Division of Coastal Management.

Relying solely on a technical definition effectively limits wetland protection from land use planning where the objective is to guide development into areas best suited for it and away from ill-suited areas. Environmental considerations play a significant role in land use decision-making and are one of the major objectives of the local land use planning mandated by the NC Coastal Area Management Act. Yet, with the exception of areas obviously recognizable as wetlands, a technical definition does not provide local governments with the information needed to guide development away from ecologically important wetlands.

Wetland Mapping

Broad scale wetland mapping would alleviate many of the drawbacks associated with the use of a technical definition. By knowing where significant wetland areas exist on the landscape, land use planners can evaluate the costs and benefits of protecting them in view of other planning considerations. Developers can more easily avoid wetland areas and, therefore, the difficulties of the permit process. Policy-makers could use the maps to define policy alternatives in terms of the impact a specific policy decision may have on wetlands and other environmental factors.

However, the mapping of wetlands on a broad scale can be difficult, expensive, and time-consuming. The US Fish and Wildlife Service's National Wetland Inventory began in the 1970s and has yet to be completed. Furthermore, wetland delineations are typically approved by the Army Corps of Engineers for three years. The three-year period can be extended two more years to make a five-year period. Using the current Corps approach, to legally field delineate and map all 404 wetlands in North Carolina would require that the maps be updated and approved a minimum of once every five years. Considering the extent of wetlands in North Carolina (roughly five million acres), precise 404 boundary identification is not a viable nor affordable option at

this time. Nevertheless, the advent of computerized Geographic Information Systems (GIS) and techniques for interpretation of satellite imagery in recent years has, for the first time, made organizing and analyzing the large amounts of information necessary for broad scale, generalized wetland mapping practical.

Mapping procedures based on remotely-sensed data do have inherent limitations and inaccuracies. Even with sophisticated image interpretation, resolutions better than a minimum mapping unit of one to several acres are normally difficult to achieve. Some wetland areas can be missed entirely or mistakenly identified as other wetland types. Image interpretation relies on often subtle differences in spectral reflectance patterns, which is a much less definitive way of defining wetlands than the criteria used for on-site delineations. These accuracy limitations of mapping wetlands based on remotely-sensed data are of particular concern if the data and maps are meant to form the basis of a regulatory program. In North Carolina, wetland maps produced in this manner can be useful tools and predict the probable locations of 404 or coastal wetlands, but these generalized wetland locations cannot substitute for on-site inspections. They can, however, be a significant first step in the minimization and avoidance of wetland impacts and can fit into the currently used regulatory and planning system.

DCM's Wetland Mapping

The chief value of broad scale wetland mapping is to provide guidance for planning and policy-making purposes. The limitations of remotely sensed wetland maps from a regulatory perspective, however, do not lessen their value for the other purposes discussed above. Whether the plans are for development projects or general land use management, knowing in advance where wetlands are likely to exist with a high degree of confidence can be of great value. As users realize that, for regulatory purposes, on-site wetland delineation is still required, wetland maps based on remotely-sensed data are a useful planning tool. Having at least a close approximation of the extent and location of wetlands in various categories will provide a sound basis for wetland policy decisions. These planning and policy-making applications form the context of DCM's wetland mapping as a component of the Wetland Conservation Plan.

In application, however, the question of the relationship of mapped wetlands to jurisdictional wetlands under the §404 Program remains significant. If the primary interest in avoiding wetland impacts is to avoid the difficulties and limitations of the wetlands regulatory program, then this is a very pertinent question. DCM conducted an accuracy assessment to provide users with the various accuracies of this product. As described in the rest of this report, DCM's wetland mapping is based on an analysis of overlays of several data sets that indicate the likely presence or absence of wetland characteristics on a given site. It is highly probable that any area identified as a wetland by DCM will be functioning as a wetland and that portions or all of the area will, indeed, be a jurisdictional wetland as defined in the 1987 *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory, 1987).

A general difficulty of relating mapped wetlands to jurisdictional boundaries is that jurisdictional boundaries are the result of political decisions and are subject to change. In the past decade, the generic wetland definition upon which boundary delineation is based has changed at least three times: once with the introduction of the 1987 Manual (Environmental Laboratory, 1987); again when the 1989 Manual (Federal Interagency Committee for Wetland Delineation, 1989) was introduced; and still again with the return to the 1987 Manual. Each time the jurisdictional boundary line changed. If the proposed 1991 Manual (Environmental Protection Agency et al., 1991) had been put into effect, an even greater change in jurisdictional boundaries would have occurred. During the same period, wetlands were also delineated for other purposes using the SCS *Food Security Act Manual* (U.S.D.A. Soil Conservation Service, 1988) and the EPA *Wetland Identification and Delineation Manual* (Sipple, 1987). Continuing controversy over wetlands regulation make additional changes in the definition of jurisdictional wetlands, and thus the boundary, a constant possibility.

It is important to recognize that the wetland to upland transition is often a broad continuum and that placement of a delineated wetland boundary is subjective to some extent. Impacts to areas immediately adjacent to wetlands often have direct impact on the wetland's ability to function. In the final analysis, however, a specific boundary line somewhere along the continuum between dry land and open water is arbitrary (Mitsch and Gosselink, 1986). A regulatory program that must decide on a daily basis whether a given spot is within or beyond its jurisdiction must incorporate such an arbitrary line and specify as precisely as possible how it is to be located in the field. How closely this line relates to the presence or absence of wetland functions depends upon many factors and varies from site to site.

The objective of DCM's wetland mapping is to identify areas greater than one acre in size that are highly likely to display specific wetland characteristics and to perform wetland functions. Areas smaller than one acre cannot be reliably identified with the remotely-sensed data and interpretation techniques currently in use. (See Section 3.) If the objective of wetland management is to protect wetland functionality, then the mapped areas should be considered worthy of protection. How stringently they will be protected under the §404 or other regulatory programs is a separate, politically-determined decision. The maps may help to make those political decisions more informed.

Uses of Wetland Data & Maps

As part of the Wetlands Conservation Plan, the wetland data will be used in several ways. In combination with the results of the functional assessment, the data show the locations and relative ecological significance of wetlands in the coastal area. This information will be provided to state and federal wetland management and regulatory agencies, local governments, the Coastal Resources Commission (CRC), and the Environmental Management Commission (EMC). It will be made available to other interested parties, such as economic development councils and to the public.

Maps showing the location, extent, and functional significance of wetlands will provide a better basis for policy decisions regarding wetland protection at the state and local levels. State-level commissions and the General Assembly will have much improved information available on which to base decisions regarding the state's role in wetland management. Local governments can use the maps in land use planning and as an aid in determining which, if any, local wetland management approaches are appropriate.

Wetland regulatory agencies will be encouraged to use the maps for guidance regarding wetland location and functional importance. While the maps are not meant to substitute for field delineation and on-site inspection in making regulatory decisions, they can provide additional information for that purpose. The wetland maps will also provide valuable information for government agencies and private organizations involved in wetland acquisition and/or management. For example, they can be used to identify and prioritize wetlands for protection by acquisition or easement and for identifying areas within larger land-holdings that might be subject to more or less intensive uses.

The maps will provide useful planning tools to economic development councils and the general public. Economic development groups should find the maps useful in attracting appropriate development by locating sites where wetlands are less likely to provide barriers to development. Developers and the general public can use the maps to determine whether particular land use activities may be appropriate in a given area. While not a substitute for regulatory wetland protection or a panacea for dealing with all wetland-related problems, DCM's wetland maps are expected to make significant contributions toward improved wetland management in the North Carolina coastal area.

Wetland Mapping and Inventories

Section 2

Historic Interest

Since the early 1700s there have been numerous attempts, both in North Carolina and nationally, to inventory wetlands. This early interest was based on the potential of many wetlands to provide rich farmland, and early inventories were designed to identify suitable areas for drainage. Since the objective was an evaluation of agricultural potential, these early surveys deliberately excluded areas such as salt marshes that were immediately deemed unsuitable for agriculture (Gosselink and Baumann, 1980). These surveys indicate that even though the reasons for mapping wetlands have changed over time, interest in mapping and inventorying wetlands is not new.

In North Carolina, Col. William Byrd surveyed the area of the Great Dismal Swamp and proposed that it be drained as early as 1728 (Lilly, 1981). Wetland drainage for conversion to agriculture continued throughout the 1700s, but it was the creation of the State Literary Fund by the General Assembly in 1825 that most stimulated state involvement in wetland inventories. All swamp lands in the state were ruled to be state property and were turned over to the Literary Fund as a means of raising money for education. This resulted in intense interest in the extent, location, and agricultural potential of these wetlands. Several attempts were made to inventory state wetlands and estimate the extent of the larger swamps to which the state had laid claim (Lilly, 1981). Chief among these was the state-commissioned book on swamp lands written by Edmund Ruffin (Ruffin, 1861).

The Civil War, along with a general lack of financial success in converting swamps to agriculture, led to decreasing interest in wetland inventories in the last half of the 1800s. State reports published during the post-war period discouraged further state activity in actively draining and farming wetlands and encouraged that they simply be sold to raise revenues (Kerr, 1867; Scarborough, 1883). This lack of continued state interest, combined with efforts to attract outside capital to stimulate the state's economy and the intense climate of land speculation after the war, resulted in the remaining state-owned wetlands passing into private ownership.

At the national level, the first efforts to inventory wetlands resulted from the Federal Swampland Acts of 1849, 1850, and 1860. All lands in the public domain unfit for cultivation due to flooding were turned over to the states to be used for flood control and, where practical, for draining for agriculture. The states were to report the extent and location of these wetlands to the federal government. For the most part, these lands were quickly sold to private interests before detailed surveys were completed (Gosselink and Baumann, 1980).

Although the flooded lands had been ceded to the states primarily to avoid the federal government from bearing the costs of reclaiming them, the politically influential landowners who had acquired the wetlands put pressure on Congress and on the states to provide funds to drain them. Congress requested the USDA to inventory all wetlands east of the Rocky Mountains, resulting in the first large-scale wetland survey completed in 1906. This survey, which was based on information supplied by each county in each state, was based on either existing records or rapid estimates (Gosselink and Baumann, 1980).

In North Carolina, the same pressures led to the passage of legislation to enable groups of landowners to establish drainage districts and support area-wide drainage projects through assessments against land (Lilly, 1981). This stimulated several large drainage projects, and the revived interest in wetland drainage resulted in additional attempts to estimate the extent of reclaimable wetlands (Pratt, 1909).

The first scientific approach toward wide-scale wetland mapping occurred in 1922 when the Bureau of Agricultural Economics conducted the second national inventory of wetlands. This survey was based on data from soil survey reports, the 1920 census of drainage projects, topographic maps, and field data from the U.S. Bureau of Public Roads. The maps produced by this survey were not published, however, and most have been subsequently lost. Another

inventory of wetlands for agricultural drainage purposes was conducted by the Soil Conservation Service in 1940. Unfortunately, the 1940 inventory was not as complete or as well done as the 1922 survey (Gosselink and Baumann, 1980).

By the 1950s, enough wetland area had been drained nationally that wildlife management agencies began to become concerned over the loss of wetland habitat. In 1954 the U.S. Fish and Wildlife Service conducted the first federal wetland inventory with a purpose other than evaluation of agricultural potential. This stimulated the interest of many state wildlife management agencies to similarly inventory wetlands from a wildlife habitat perspective. In North Carolina, the work for the USFWS inventory was conducted by the Office of River Basin Studies, which plotted wetlands on aerial photographs (Office of River Basin Studies, 1954).

Based on these aerial photographs, field work was carried out in the late 1950s for the classic wetland mapping and inventory project published by the North Carolina Wildlife Resources Commission in 1962 (Wilson, 1962). The objectives of that project were to map and classify wetland areas and evaluate their potential for development of waterfowl habitat. Since waterfowl habitat management consists mostly of providing open water and food sources, some of the practices recommended, such as clearing swamps and diking bottomland hardwoods off from adjacent rivers, seem almost as destructive of other wetland functions as was drainage for agriculture. Nevertheless, the methods used for mapping wetlands were sound, and, subject to their limitations, provide useful information about the location and extent of wetlands of different types at that time.

Wilson used the aerial photograph plots produced earlier by the Office of River Basin Studies to plot wetlands of 40 acres or more on county base maps of 41 coastal plain counties. Field surveys were conducted in each county, and detailed information on soils, vegetation, water characteristics, and wildlife populations was collected for those areas with the highest potential for development of waterfowl habitat. Maps of each county showing all larger wetland areas were produced and included in the published report.

While Wilson's report is undeniably the best source of information on the location and extent of wetlands in coastal North Carolina during the 1950s, users of the information need to keep in mind its inherent limitations. The initial plotting of wetlands by the Office of River Basin Studies was performed in a relatively short period of time on black and white aerial photographs using unspecified criteria and techniques. Wilson transferred those plots to county base maps without careful geographic controls, deliberately excluding all areas less than 40 acres. In addition, since the survey was looking primarily for waterfowl habitat, open water (including inland lakes and rivers, coastal fresh water areas in Currituck Sound, and the entire area) are included in the total wetland figures. Open water is not normally defined as a wetland, especially as reviewed under §404 and CAMA. Since many wetland surveys do not include open waters, comparison of Wilson's acreage totals with those of other surveys can be extremely misleading unless the open water numbers and wetlands smaller than 40 acres are excluded.

More Recent Inventories

Because wetlands provide vital habitat for waterfowl, the U.S. Fish & Wildlife Service (USFWS) has maintained a keen interest in the protection of these ecosystems. Shaw & Fredine (1956) authored an inventory entitled *Circular 39,* which presented a simplified classification of wetlands nationwide. *Circular 39* presented 20 wetland types nationwide, divided into coastal and inland wetlands, fresh water or saline, specifically for wetlands that provided waterfowl habitat.

Recognizing the limitations of *Circular 39*, the USFWS developed a national classification (Cowardin et al. 1979) to address issues broader than waterfowl habitat. This classification was adopted by the National Wetlands Inventory (NWI) program of the USFWS. This classification scheme separates wetlands from deep-water habitats. It recognizes 5 broad wetland systems: marine, estuarine, riverine, lacustrine and palustrine. Marine wetlands are those associated with the ocean. Estuarine wetlands are salt influenced wetlands with fresh water influx and limited mixing with the ocean. Riverine wetlands are those associated with rivers and lacustrine wetlands are associated with lakes. Palustrine wetlands are the remaining freshwater wetlands (<5% salt) and comprise a substantial portion of the landscape in coastal North Carolina.

The NWI uses color infrared photography to recognize moisture and vegetative patterns on the landscape. According to Cowardin et al. (1979), this inventory meets four objectives:

-to describe ecological habitats that have certain homogenous natural attributes,

-to arrange these units in a system that will aid decisions about resource management,

-to furnish units for inventory and mapping, and

-to provide uniformity in concepts and terminology throughout the United States.

Until DCM's current effort, the NWI provided the most comprehensive inventory of wetlands in the coastal area of North Carolina. Certain limitations led to concerns among the North Carolina wetland management community about the realistic use of the NWI, even though the product clearly stated that the data should not be used for regulatory purposes. Users were encouraged to use the resource appropriately.

The method employed by the National Wetlands Inventory team is aerial photography interpretation. Interpretation of aerial photography, however, is time consuming and subject to human interpretation. It has been the experience of staff of DCM that interpretations can vary in adjacent areas, leading to discrepancies in the data. Since NWI requires extensive manual interpretation, some believed that an automated technique applying satellite data would be more cost efficient. As a result, methods emerged for using satellite imagery to identify wetlands.

A remote sensing option is the use of satellite imagery to identify patterns on the landscape and develop a classification based on vegetative reflectance signatures obtained by the satellite. As in all the methods outlined above, this method also is subject to human interpretation. Imagery also produces data in pixels, which can appear "blocky" and unnatural if not carefully controlled.

One such effort in North Carolina was a land cover classification completed for the Albemarle-Pamlico Estuarine Study, as part of the Environmental Protection Agency's National Estuarine Program. The Albemarle-Pamlico (A/P) estuarine system in North Carolina is one of the estuaries in the EPA's National Estuary Program. The lack of a current land use/land cover inventory was identified as a critical gap in the A/P Study resource database. At an A/P Study workshop held late in 1987, Landsat Thematic Mapper (TM) digital data were recommended as the most cost effective and practical source for developing an inventory for the 23,000 square mile drainage basin. The Computer Graphics Center (CGC), North Carolina State University (currently called the Center for Earth Observation), and the North Carolina Center for Geographic Information & Analysis (CGIA) were given responsibility for the development, storage and dissemination of the inventory.

The study area included a portion of Virginia and nearly one-third of North Carolina including almost the entire Tidewater region. CGC had the responsibility of analyzing the five Landsat TM scenes needed to cover the area. Digital TM data were converted to a Lambert Conformal Conic projection and classified into 18 land use/land cover classes using a supervised approach. Results of the project included image files in raster format with every pixel classified by land use/land cover category. Classification verification was performed using 1,931 one acre sample sites located on the classified TM imagery and on aerial photography. Class accuracies were 73% or greater for all Level I classes except developed areas, which had an accuracy of 46%.

Image data were converted to a format compatible with CGIA's software, filtered using a standard 5X5 mode filter, converted to vector format and integrated with CGIA's database for the A/P drainage basin. Data are georeferenced to the NC State Plane Coordinate System and stored as digital ARC/INFO coverage. Land use/land cover data are available from CGIA as map products or in digital format. Final results also include descriptions of the methodology and land use/land cover classes as well as classification error matrices for each physiographic province and for the entire study area.

There is some debate about the preferred method of identifying wetlands from remotely sensed data. Both methods outlined above have strengths and weaknesses. It is the opinion of DCM that given current products available, the NWI provides the most accurate base of wetlands in coastal North Carolina. While there is certainly error associated with that product, the work of DCM to update and improve the products with ancillary data will produce the best outcome.

As explained in Section 1, the most accurate delineation of wetlands involves on-site evaluation of the system and possibly includes studies to determine hydrology. Using standards enforced by the US Army Corps of Engineers, a wetland must be identified based on vegetative cover, soil condition and hydrology. Nearly all US Army Corps of Engineers wetland delineations are required to be conducted on-site. Rarely and only for very large-scale projects, can wetland delineation via remote sensing be allowed. These remote sensing wetland delineations must be pre-approved by the US Army Corps of Engineers on a case-by-case basis. Unfortunately, since each of these ecological characteristics must be interpreted by a human, discrepancies can develop between different interpreters. While this is the most accurate of methods known today, it is subject to human interpretation and political nuances, and can be extremely costly. It is not possible for the coastal area of North Carolina to be completely surveyed for

wetlands by on-site visits without a substantial change in philosophy of state decision makers and a significant change in resource allocation. It is clear that some means of remote sensing must be used to develop the most comprehensive data available.

DCM's methods incorporate the strengths of the NWI, the county soil surveys, and the TM Landsat imagery obtained via satellite. In addition, DCM performed extensive field verification to develop the most accurate data possible. Using GIS, DCM extracted accurate components from each of three layers and created a final wetland layer that more accurately identifies wetlands than any of the three sources. GIS allows this to be done relatively quickly, and, as new ancillary data become available, permits data updates and corrections.

The value of using GIS is that the data can be analyzed and viewed spatially, and each of the input data can be maintained. This will allow future updates to occur more efficiently. Also, with the completion of this project, wetlands can be over-layed with many other referenced layers to help decision makers in many arenas.

DCM Wetland Mapping Procedures

Section 3

Background

When developing methods for mapping, DCM quickly realized that the 9000+ square mile coastal area was too large for any exhaustive field mapping effort (see Figure 1). To efficiently map the coastal area, DCM found it necessary to use existing data compatible with Geographic Information Systems (GIS). A review of the existing data revealed that most are not applicable for one of two reasons: (1) available wetlands data are based on older photography or (2) more recent data are not classified with the intent of wetlands identification. Both of these data types, used independently, are inappropriate for use in a coastal area wetlands conservation plan. In addition, the classification schemes used in the existing methods are either too complex or not focused on wetlands.

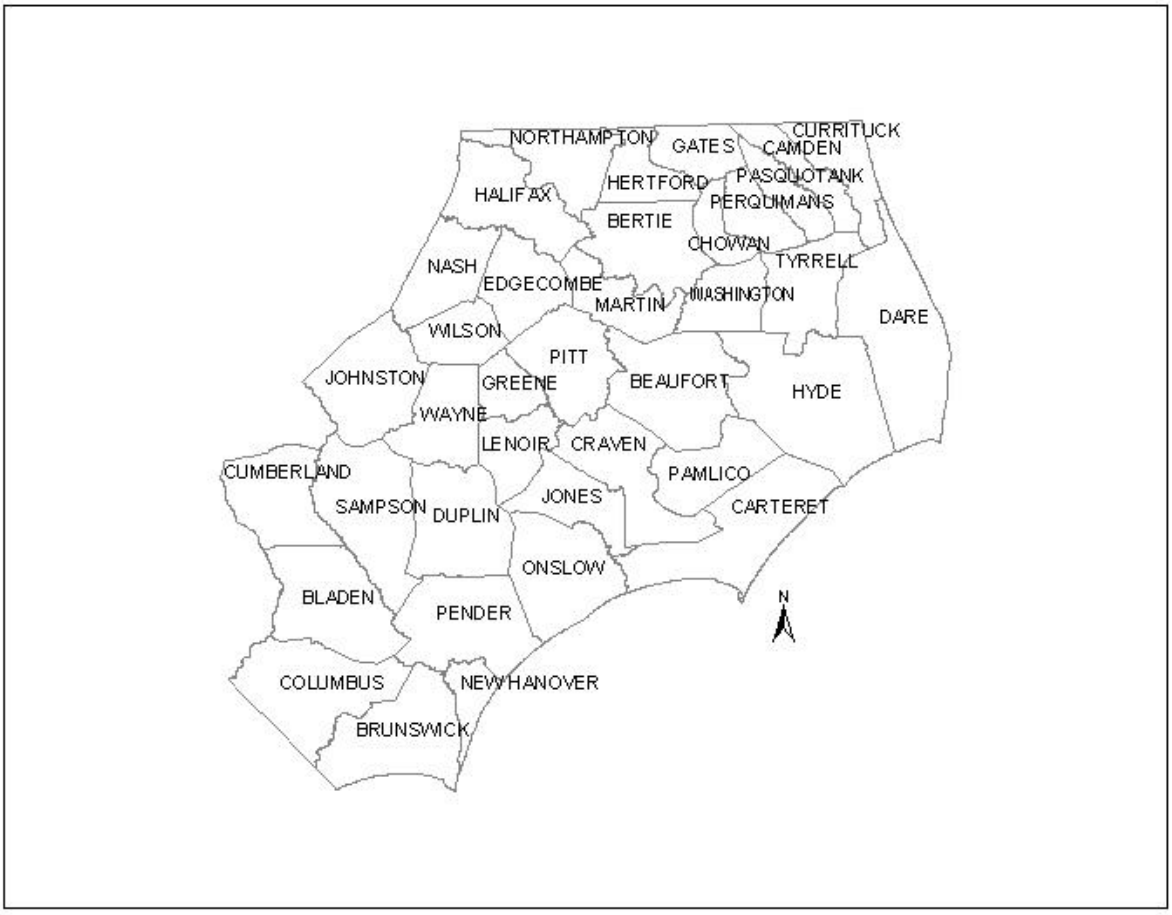

Figure. 1 Extent of Wetland Mapping for 37 Coastal Plain Counties.

Several data sets were believed to be inappropriate if used exclusively for wetlands mapping in coastal North Carolina. Each contains some information useful for mapping wetlands. DCM elected to combine three primary layers of data and extract the most pertinent information from each layer. The three primary digital

data layers selected for use were the US Fish & Wildlife National Wetlands Inventory (NWI), the County Soil Surveys, and 30 meter Thematic Mapper (TM) Satellite Imagery.

The National Wetlands Inventory (NWI) was selected because its primary purpose is to map wetlands. Unfortunately, these maps were created with photography from the early 1980s in coastal North Carolina, and many changes have occurred in the landscape during that time. In North Carolina, NWI omitted many pine dominated wetland areas. It also tended to exaggerate the boundary of linear wetlands (based on field data collected at random sites with representatives from USFWS, NC Division of Soil and Water Conservation and DCM). DCM wished to improve upon the NWI, and in particular include pine-dominated wetlands, as these areas are important to the ecology of the coastal area.

Detailed soils information from the county soil surveys were also selected for use in DCM's mapping efforts. While soils alone should not be used to identify wetlands, they can be very useful in identifying marginal areas. They are also extremely useful in helping to define the type of wetland one should expect to find in an area. Pocosins, for example, would only be expected to occur on a limited range of organic and certain sandy soil types.

Thematic Mapper (TM) Satellite Imagery was employed in the development of a mapping methodology as well. Imagery that had been classified in the late 1980s in much of coastal North Carolina to support the Albemarle-Pamlico Estuarine Study, a National Estuary Program, was used to identify developed areas, pine monocultures and other habitat types. Because this data layer was not developed as a wetlands inventory, many of the classes were not directly applicable to DCM's approach. However, the imagery was more recent than that from the soil surveys and NWI, and it provided additional habitat data not available in either of the other sources.

DCM chose to incorporate the benefits of each of these data sources into its mapping techniques. Users should be aware that the method chosen was an overlay analysis, and the final data can only be as accurate as the least accurate data used as source input.

The information provided by this mapping project will be useful to county and municipal planners in helping guide inappropriate growth away from environmentally sensitive areas. For this reason, DCM elected to pursue mapping on a county-by-county basis. In addition, a single county allowed DCM to focus methodology development to a limited geographical area to refine its methods. Carteret County was selected as a methods development laboratory because data were available for the area and because Carteret County has a large number of representative wetlands. Officials in the county were also supportive of the effort and received additional financial assistance as a result of their cooperation. Methods derived in Carteret County were then applied to the remaining coastal counties.

Source Data Descriptions

The US Fish & Wildlife Service has the responsibility of producing the National Wetlands Inventory for all wetlands in the country. For the North Carolina coastal area, these vector data were developed from 1: 58,000 scale color infrared photography taken during the winters of 1981, 1982 and 1983. Photointerpreters delineated wetland polygons on clear stabilene mylar taped over the photographs. After an initial scan of the photographs to identify questions or problem signatures, the photointerpreters reviewed areas in the field. Approximately one half to one full day of field verification was performed per 7.5 minute topographical quadrangle (Hefner and Moorhead 1991, Hefner, pers. comm.). Features were compared to USGS topographical maps for consistency. Once the 'draft' paper maps were complete, the data were reviewed by the Regional Coordinator. When approved as a final map, each 7.5 minute quadrangle was digitized. The coastal North Carolina NWI maps were digitized initially by the North Carolina Center for Geographic Information and Analysis (NCCGIA) and later by NWI Headquarters in St. Petersburg, Florida, who sub-contracted the task. Digital maps were obtained initially from 1/4" tape transfer and later from direct access to NWI via the Internet (see 'Photointerpretation Conventions for the National Wetlands Inventory', 'Cartographic Conventions for the National Wetlands Inventory', and 'Digitizing Conventions for the National Wetlands Inventory').

Digital, detailed County Soil Survey data were obtained from NCCGIA. These data are vector data based on 1:24,000 quads. County soil scientists delineated soil boundaries on aerial photographs based on slope,

topography, vegetative cover and other characteristics. A description of this process can be found in any North Carolina county soil survey. Once approved by appropriate personnel at the Natural Resource Conservation Service, the lines were recompiled onto orthophotograph quads by a qualified soil scientist. These lines were scanned or manually digitized by NCCGIA. Databases describing soil characteristics were incorporated into the coverage and then released for use.

The Landsat Thematic Mapper (TM) imagery was classified as part of the Albemarle-Pamlico Estuarine Study (APES). To provide complete coverage for the southernmost region of DCM's jurisdiction (Onslow, Pender, Brunswick and New Hanover counties), DCM contracted with NCCGIA and the NCSU Computer Graphics Center to have that area processed using the APES methods. These data provide a raster-based coverage of approximately 30 meter pixel resolution. Some of the imagery was taken at high tide, which precludes some near-water wetlands from appearing in some areas. Using Erdas Imagine®, imagery processors grouped similar spectral signatures into one of 20 classes. DCM uses these data in two formats: filtered and unfiltered. The unfiltered data were vectorized with the ArcInfo GRIDPOLY command. To remove some of the background noise in the coverage, the unfiltered data were filtered using Erdas 'scan' with a Majority filter of 5x5 pixels and then vectorized by the ArcInfo GRIDPOLY command.

Source Data Verification

Within each county, mapping was based on 1: 24,000 US Geological Survey quadrangles (7.5“ quads). As each quad was completed, it was assembled into a county-wide coverage, which was then assembled into a coastal area coverage. The initial step in the mapping process was to ensure that the base layers described previously were complete. Reviewing for errors at early stages prevented confusion and correction later in the process; therefore, the importance of the preliminary techniques cannot be over-emphasized.

The NWI data were first inspected to ensure that the coverage was complete. If parts of the quadrangle were missing, the error was investigated and corrected. Omissions may be areas of severe cloud cover on the photography or areas neglected during the digitization process. Next, the coverage was reviewed for missing label points. Any omissions were corrected based on the finalized version of the published NWI paper map. If there were omissions from this map, appropriate NWI staff were contacted for the information. At this time, labels were verified for typographical mis-entry. If not corrected, these errors would lead to confusion later in the mapping process. Once the label errors were detected and corrected, the polygons were reviewed for completion. It was not possible to verify every line in the areas of coastal North Carolina densely populated with wetlands, but the lines were reviewed for completeness. Any omissions again were submitted to NWI staff for correction.

The soils data were prepared in a similar manner to the NWI data, with questions being directed to qualified soil scientists within the NC Division of Soil and Water Conservation or the US Natural Resource Conservation Service. Prior to the steps described previously, soils were verified for completeness. It is important to note that gaps may occur if the county boundaries from two adjacent soil surveys do not adjoin. When this occurred, it was handled on a case-by-case basis.

The LandSat data do not require additional verification processes. However, it was often helpful to review this layer to ensure that the geographic boundaries match.

DCM’S Wetland Classification

DCM's wetland mapping project is an integral component of the Wetland Conservation Plan. Since the Wetland Conservation Plan is being developed to improve wetland planning and management in coastal North Carolina at local, state, and federal levels, the wetland classification system used by DCM needed to be accurate and easy to use for persons with varying levels of wetland expertise.

When the wetland mapping project began in the early 1990s, the North Carolina Natural Heritage Program had developed a very detailed classification system of all natural areas in the state. These breakdowns were based on vegetative composition, and assumed complete homogeneity at all sites (Schafale and Weakley, 1990). Although the Natural Heritage Program's classification system is very thorough, DCM chose not to use

their classification system for two reasons. First, DCM's mapping approach uses remotely sensed data which cannot provide the level of detail necessary to accurately support the Natural Heritage classification system. Second, the Natural Heritage classification system uses numerous habitat types that would result in complex maps. A product of this type would require users to have a strong technical understanding of the classification system; thus limiting the use of the maps to only those with appropriate technical training.

At the same time DCM was developing a wetlands classification scheme, the NC Division of Water Quality (then the Division of Environmental Management) also was developing a comprehensive classification for wetlands statewide. Obviously, a statewide program would encounter wetlands types elsewhere that would not apply to the coastal region. A comparison of these types can be reviewed in Table 1. DCM staff worked with staff from all of these agencies to develop a classification scheme that met the needs of its clients without introducing conflict into the existing classification schemes.

Each wetland polygon is assigned to one of DCM's classes based on all the attributes it contains from input data sources. Classification of the Cowardin types into DCM wetland types has been reviewed by personnel from the National Wetlands Inventory and the NC Department of Environment and Natural Resources Division of Soil and Water Conservation (DSWC). Further soils breakdown was reviewed by certified soil scientists at DCM and the DSWC. The classes currently recognized by DCM are salt/brackish marsh, estuarine shrub scrub, estuarine forest, maritime forest, pocosin, bottomland hardwood or riverine swamp forest, depressional swamp forest, headwater swamp, hardwood flat, pine flat and managed pineland (Table 2). NWI Cowardin classifications common to each wetland type can be seen in Table 3. Polygons that do not have criteria designating it as a wetland are considered non-wetlands.

Additional Classifications

The hydrogeomorphology of a wetland is unique in defining the wetland's function (see Brinson 1994). Because these data serve as the base for additional wetland projects, an accurate determination of this characteristic is essential. Immediately following the overlay procedure, technicians add a new item (HGM) to the wetland coverage. DCM uses three hydrogeomorphic (HGM) classifications to describe wetlands in the North Carolina coastal plain. The three HGM classes of wetlands are riverine, headwater and flat/depressional. Because DCM considers both vegetation and landscape position in its classification (discussed later), riverine, headwater and flat/depressional wetland polygons are assigned an HGM class of 'r', 'h' or 'f', respectively. Digital line graphs of hydrography are relied upon in this step of the procedure. All wetlands that are adjacent to streams or rivers are considered to be in the riverine HGM class and are designated as riverine polygons. This class should include all bottomland hardwood swamps and some swamp forests. It rarely includes any of the interfluvial wetland types. On the occasion that it does, it is a small section of a large flat from which a small stream emerges. Only the polygons adjacent to the stream are considered riverine. Headwaters are defined as linear areas adjacent to riverine areas that do not have a stream designated on the hydrography data layer. Since these are unique systems that form the transition between flatwoods and riverine wetlands, they are treated specially. Finally, polygons that exist on interfluvial divides are designated as flat/depressional wetlands. No wetlands along streams should be found in this class, unless field verification showed otherwise.

DCM recognizes that there also are wetlands that border large sounds that do not adequately “fit” into any of the r, h, or f HGM classes. These wetlands are often considered to be ‘fringe wetlands’. DCM staff are currently investigating an adequate means to address this omission and incorporate additional HGM classifications as they are defined by the scientific community.

DCM also recognizes soils as hydric or non-hydric based on List A of the US Soil Conservation Service List of Hydric Soils.

Overlay Analysis

The complete source data coverages were overlaid to create a new, integrated coverage that often approached 100,000 polygons. Each of these polygons had many characteristics assigned to it, including the Cowardin classification assigned by the NWI, the soil series provided by the detailed soil lines, the unfiltered land use/land cover code, and the filtered land use/land cover code. HGM was assigned at the same time as wetland type.

One of the uses of the TM imagery was to identify NWI wetland areas that were devoid of vegetation (e.g., classified as developed, agriculture, or other bare land or grassland). In the original overlay analysis, these areas were thought to have been converted from wetlands to other uses and therefore were given a 'cleared' modifier by DCM and considered to no longer be wetland. An analysis of the draft data upon completion of the 20 coastal counties revealed that approximately 100,000 acres of area the NWI called wetland had been assigned a 'cleared' designation by DCM. This number seemed high based on the judgment of DCM staff, and field verification at a number of representative sites confirmed that this was an over-estimation of converted wetland area. Many of the field sites visited had indeed been cut-over around the time the imagery was taken, but they were either regenerating naturally or had been planted for silvicultural activities. In addition, field visits confirmed that some marsh areas were mistaken for agriculture in the TM imagery. Based on this, and the fact that "coastal wetlands" or salt/brackish marshes have been stringently protected by regulatory programs since prior to the development of the NWI data in North Carolina, DCM removed the 'cleared' designation from all salt/brackish marshes.

Around the same time that DCM was discovering this weakness of the TM imagery, new land cover data was released for North Carolina by the state Center for Geographic Information and Analysis. These data were compiled from 30 meter resolution Thematic Mapper Satellite Imagery taken in 1994 in a manner similar to that used in the Albemarle-Pamlico Estuarine Study (APES). This represented the most recent data set available.

Based on field verification of representative sites and comparison of these new land cover data to the 1988 data from APES, DCM established a new 'cutover' modifier to its wetland classifications. The 'cleared' modifier was removed from wetland areas for which the 1988 data indicated a lack of vegetation, but which appeared to be vegetated in the 1994 data. Areas for which the 1994 data indicated a lack of vegetation were designated as 'cut-over'. Based on field verification, these areas are likely to still be wetlands. The 'cleared' modifier was only assigned to wetland areas for which both land cover data sets indicated a lack of vegetation. A similar analysis will be performed upon receipt of land cover data completed by the NOAA Coastal services Center Coastal Change Analysis Program.

The base of the map is the NWI polygon coverage. Some of the NWI polygons are omitted from the DCM maps because they are temporarily flooded but on non-hydric soils, or because recent TM imagery indicates these areas are currently bare ground. These areas are excluded because they typically would fail to meet current wetland determination criteria as defined by the 1987 UCACE Wetland Delineation Manual. Areas that NWI considers uplands, identified as pine monocultures on the imagery, and occurring on hydric soil are considered in the managed pineland wetland group on DCM maps.

Based on these characteristics, each polygon is assigned to one of DCM's classes through an automated ArcInfo model using Arc Macro Language (AML). In addition, DCM also provides a modifier to some of these polygons. If the area has been drained or ditched as determined by the NWI, it is so noted. Areas designated as wetlands at the time of the NWI photography that currently appear as bare ground on the TM imagery are designated as 'cleared' or 'cutover' on the maps. Many of the cleared areas would no longer be considered jurisdictional wetlands. Finally, spoil piles or excavated areas indicative of human activity are identified as 'human impacted' wetlands. The 'human impacted' category also contains many impoundments and some cutovers. These modifiers are useful indicators of the impacts wetlands are sustaining from human activities.

When the automated procedure was complete, an interactive session was initiated. During this session, landscape characters that are not easily described in a computer model were considered in finalizing the classification. This was especially important in distinguishing bottomland hardwood wetlands from hardwood flat wetlands. Both contain deciduous, broad leaf species of trees and can be seasonally and temporarily flooded. The hydrology of these systems, however, is completely different. All bottomland hardwood forests, for example, must be adjacent to a river where they receive seasonal floodwaters from the channel. Conversely, hardwood flats are typically located on interfluvial divides and not adjacent to any streams. Water is not introduced into hardwood flats via a channel, rather precipitation and groundwater provide the water for this system. Polygons that are adjacent to rivers or estuaries but do not have a distinct channel designated in the hydrography coverage are considered headwater swamps. The overlay analysis is depicted in Figure 2.

Field Verification

As methods were being developed, field verification was ongoing to ensure that the classification system reflected reality. Approximately 400 wetlands in and around Carteret County were visited. Sites were randomly selected within a stratification of watersheds (14 digit hydrologic units). Within each watershed, sites

were classified based on landscape position, vegetative cover and soil and hydrologic characteristics. Ongoing field verification also allowed staff the opportunity to adequately assess the classification assigned by NWI. If a particular Cowardin class was found to be systematically misidentified, the algorithm for automation was updated. While this method does not provide for a usable accuracy assessment, it allowed the most accurate methods to be developed. None of the data collected for this purpose were applied to the final accuracy assessment.

A concurrent accuracy assessment was made possible by a grant from the United States Environmental Protection Agency. The assessment provides details about the likelihood of finding a wetland where DCM indicates one should exist as well as an indication of how likely a user is to find the mapped wetland type in that location. Details of the accuracy assessment can be found in the next section.

Table 1. Cross reference of wetlands for different NC agencies.

DCM Type	DWQ Type	Natural Heritage Program Type
Salt/Brackish Marsh	Salt Marsh	Salt Marsh or Salt Flat
	Brackish Marsh	Brackish Marsh
Estuarine Shrub Scrub	Salt Shrub	Salt Shrub
Estuarine Forest	Estuarine Fringe Forest	Estuarine Fringe Loblolly Forest
Maritime Forest	none	Maritime Swamp Forest
		Maritime Shrub Swamp
Freshwater Marsh	Freshwater Marsh	Tidal Freshwater Marsh
		Maritime Wet Grassland
		Natural Lake Shoreline
		Small Depression Pond
Pocosin	Pocosin	Low Pocosin
		High Pocosin
		Pond Pine Woodland
		Peatland Atlantic White Cedar Forest
		Bay Forest
		Small Depression Pocosin
Swamp or Bottomland Hardwood	Swamp Forest	Cypress-gum swamp (blackwater)
		Cypress-gum swamp (brownwater)
		Coastal Plain Semi-permanent impoundment
		Tidal Cypress-gum Swamp
	Bottomland Hardwood Forest	Coastal Plain Bottomland Hardwood (blackwater)
		Coastal Plain Bottomland Hardwood (brownwater)
Headwater Swamp	Headwater Forest	Coastal Plain Small Stream Swamp (blackwater)
		Coastal Plain Small Stream Swamp (brownwater)
		Streamhead Pocosin
		Streamhead Atlantic White Cedar Forest
Hardwood Flat	Wet Flat	Nonriverine Wet Hardwood Forest
		Nonriverine Swamp Forest
Pine Flat	Wet Flat	Pine Savannah
		Wet Pine Flatwood
Managed Pineland	none	none

Wetland Type	ID#	General Definition	Typical Species
Salt/Brackish Marsh	1	Any salt marsh or other marsh subject to regular or occasional flooding by tides, including wind tides	*Spartina alterniflora, S. patens, S. cynosuroides; Typha* spp., *Juncus roemerianus, Salicornia* spp., *Scirpus* spp., *Distichlis spicata, Limonium* spp., *Cladium jamaicense*
Estuarine Scrub-Shrub	3	Shrub/scrub dominated community subject to flooding by tides, including wind tides.	*Myrica* spp. and *Juniperus virginiana*
Estuarine Forest	15	Forested wetlands subject to flooding by tides, including wind tides.	pine dominated communities with *Juncus* spp. understories
Maritime Forest	16	Forested wetlands with stunted growth imposed by salt spray from the ocean.	*Quercus virginiana, Acer rubrum* and *Nyssa biflora*
Freshwater Marsh	2	Herbaceous areas which are flooded for extended periods during the growing season.	sedges, millets, rushes and grasses not specified in CAMA. *Arundinaria gigantea, Sagittaria* spp., *Pontederia* spp,. *Peltandr*a spp., *Polygonum* spp.,*Typha* spp.
Pocosin	4	Evergreen shrub/scrub. Often occur on saturated, acid, nutrient poor, sandy or peaty soils.	evergreen shrubs, often mixed with pond or loblolly pines (*Pinus serotina* or *P. taeda*)
Swamp or Bottomland Hardwood	6/7	Riverine and non-riverine forested or scrub/shrub communities which are seasonally to semi-permanently flooded.	*Taxodium* spp., *Nyssa* spp., *Acer rubrum, Fraxinus pennsylvanica*, *Carya aquatica*, other hickories, oaks, gums, cottonwoods, willows, river birch, and occasionally pines
Headwater Swamp	17	Wooded systems along first order streams. Receive water from overland flow and rarely overflow their own banks	*T distichum, Nyssa biflora, Liquidambar styraciflua*, *L tulipfera, Acer rubrum, Quercus* spp., and *Pinus* spp.
Hardwood Flat	9	Poorly drained interstream flats. Seasonally saturated by high water table or poor drainage.	Varies greatly but often include *Liquidambar styraciflua* and *Acer rubrum*.
Pine Flat	10	Seasonally saturated pines on hydric soils (often quite dry for part of the year). Generally on flat or nearly flat interfluves.	*Pinus taeda*
Managed Pineland	11	Seasonally saturated, managed pine forests occurring on hydric soils.	*Pinus taeda*
Human Impacted	40	Human impacts have physically disturbed the wetland. Impoundments, some cutovers and other disturbed areas are included in this category.	Non-native, invasive species often present and prevalent
Modifiers			
Drained	21-39	Any wetland system described above which is or has been effectively drained.	See above primary class for likely historical wetland type
Cleared	41-59	Areas of hydric soils for which satellite imagery indicates a lack of vegetation in 1988 *and* 1994. Likely not a wetland today.	See above primary class for likely historical wetland type
Cutover	61-79	Areas for which satellite imagery indicates a lack of vegetation in 1994. These areas are likely to still be wetlands, however, vegetation has been removed.	See above primary class for likely historical wetland type

Table 2. Wetland Types and Descriptions Mapped by the Division of Coastal Management

Salt/Brackish Marsh
E2EM*

Freshwater Marsh

PEM*	L*EM	PAB3*	PFO5/OWHh

Estuarine Shrub-Scrub
E2SS*

Pocosin (or Pine Flat if not on pocosin soil)

PSS7*	PFO3B*	PFO3/6F*	PSS3/4B*	PSS1/3B*
PSS3B*	PFO4/1B*	PFO7/SS6B*	PSS3/4A*	PSS1/3G*
PSS4B*	PSS4*	PFO3/1B*	PFO4/6B*	PFO7/1B*
PSS6B*	PSS4Ad*	PFO7/FO4B*	PSS1/4B*	PFO3/4B*
PSS6/7*	PSS7/6B*	PFO7C*	PSS6G*	PFO7B*
PSS3/1B*	PFO7/6A*	PFO4/SS7B*	PFO3/4A*	(not PFO7Bg*)
PSS3C*	PSS4*	PFO7/6B*	PSS7/FO4B*	PFO4B*
PSS1B*	PSS1/3C*	PFO7/1C*	PSS7A*	(not PFO4Bg*)
PSS4/1B*	PSS7T*	PSS4/EM1B*		

Hardwood Flat (must be on hydric soil)

PFO/SS1A*	PSS1/4A*	PFO1/4A*	PFO6/7B*	PFO1/3A*

Pine Flat (must be on hydric soil)

PFO4/1A*	PFO4S*	PFO4/SS1A*	PFO4/SS4A*	PFO4R*
PFO4A*	PFO7A*	PFO4/3B*	PSS3A*	PFO4/3A*

Bottomland Hardwood

PFO/SS1C*	PFO4/1C*	PSS6C*	PSS3R*
PSS1/4C*	PFO7R*	PSS4C*	PSS1C*

PFO1* (not PFO1B*,PFO1/3A*,PFO1F*, PFO1/4A*, PFO1C*)

Swamp Forest

PFO6*	PFO4/SS1C*	PFO/SS6F*	PFO1C*	PFO7/6F*	PSS2G*
PFO1F*	PSS6F*	PFO3C*	PFO1/2F*	PFO1B*	PFO4C*
PFO4Bg*	PFO/SS6F*	PSS6/7T*	PFO1/4C*	PSS6T*	PSS6R*
PFO7Bg*	PFO3F*	PFO7/EM1C*	PFO/EM1F*	PFO7/6C*	PFO1B*
PFO2*	PSS1F*	PSS6/7F*	PSS/EM1C*	PFO7C*	

Estuarine Forest

E2FO4P*	PFO4/EM1B*

Maritime Forest

PFO7A*	PFO7F*

Human Impacted

PSS1A*	PSS1C* (if isolated & not riverine)

Table 3. Cowardin classifications common to each wetland type.

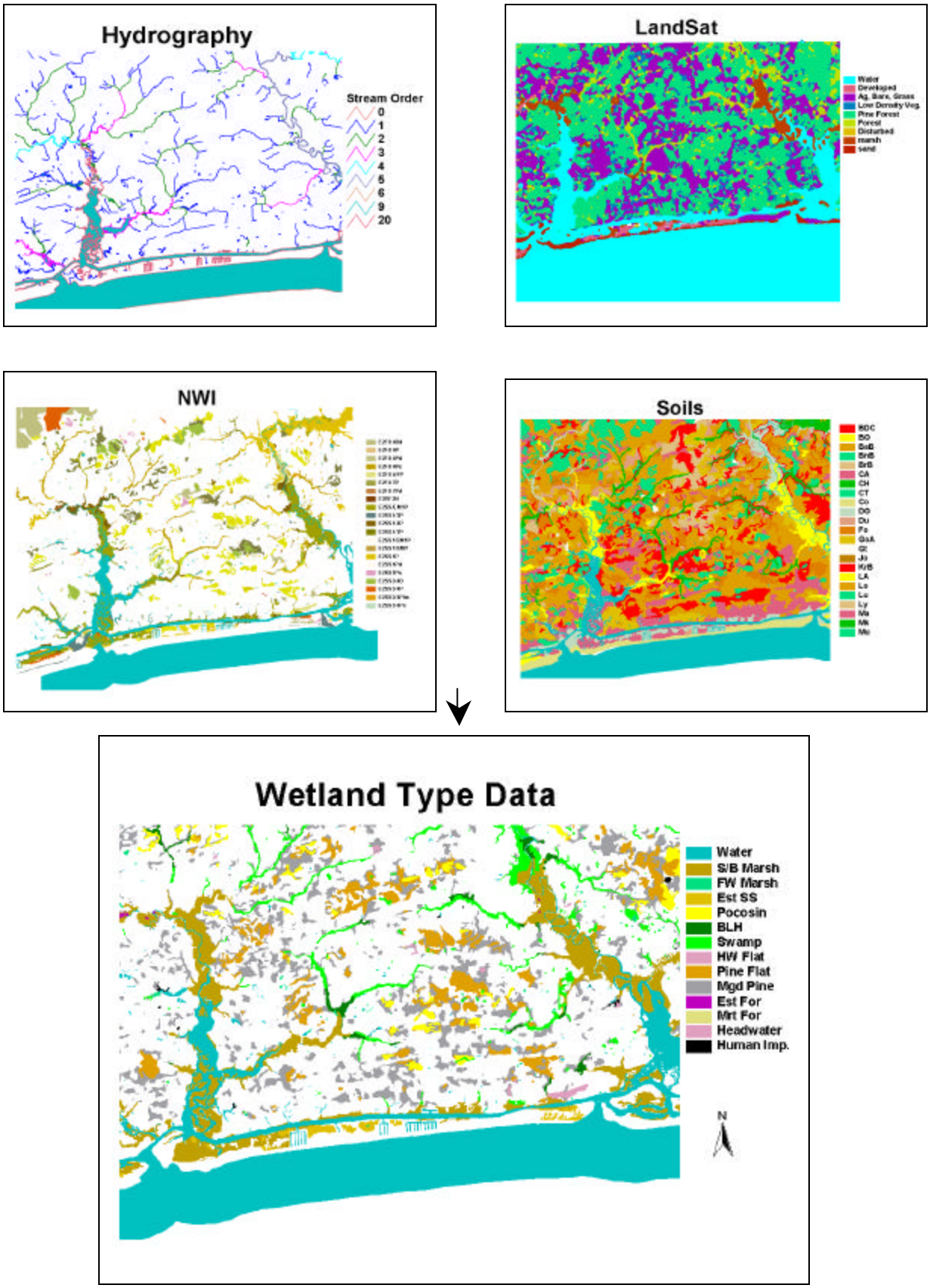

Figure 2. Overlay analysis is one step in the Wetland Type Mapping Procedure.

Results

Section 4

DCM's GIS Wetland Type Maps can be viewed on DCM's web site at www.nccoastalmanagement.net. In addition, the digital data are available from the North Carolina Center for Geographic Information and Analysis and will also be made available on DCM's website. By understanding the complexity of these ecosystems, it is DCM's intent that local governments will take an active role in wetlands conservation and protection. Several tools have been developed at DCM to assist with wetland protection and management, including wetland functional assessments, and potential wetland restoration site maps. These maps and data have been provided to local planning agencies, state wetland managers and federal wetland regulators. As stated in Section 1, these data and maps are not designed to replace an on-site jurisdictional evaluation of any wetland. They are intended to be used in a planning context and to help understand the environment in which we live.

As we continue to understand more about the role of wetlands in maintaining a healthy environment, the value of GIS wetlands data continues to grow in importance. GIS data can assist county planners in guiding development away from environmentally sensitive areas. Landowners now have the capability to look at a map and determine wetlands may exist in a given area. With this information, the public can be aware of the impact they have on natural resources, such as water quality. In addition, economic development councils can use this information to plan development in areas attractive to a particular industry. If a new business or industry wishes to locate in an area positioned such that the wetlands permitting process could be avoided, a dataset showing areas void of wetlands could be a significant tool.

As additional data become available, the DCM wetland coverage will be updated. When additional land cover data are completed for North Carolina, for example, the data will be updated to reflect changes that have occurred on the landscape since the last update. DCM has completed wetland type mapping for the 20 coastal counties and for 17 of the Inner Coastal Plain counties. It is possible that other agencies will adapt this methodology to map wetlands in other physiographic regions of the state.

DCM mapped more than 2.8 million acres (1,150,000 ha) of wetlands within the 20 coastal counties (Table 5) and more than 1.5 million acres (600,000 hectares) in the Inner Coastal Plain (Table 4). The maps confirm that there are large areas of wetlands that until recently received no additional protection under state regulations. Salt/Brackish marshes, which do enjoy additional state protection under the state Coastal Area Management Act and the Dredge and Fill Act, are only 8% of the wetlands that fall within the jurisdictional area of the North Carolina Coastal Management Program. Total wetland acreage for this mapping project is in Table 6. Wetland acreage by county can be reviewed in Appendix 2.

To better understand the accuracy of these data, DCM obtained a grant from the US Environmental Protection Agency. Based on a sample size of at least 50 sites per wetland type (selected in a stratified random sample), data indicate that the overall accuracy of the wetland data is 89%. This means that if an area is shown as a wetland in DCM data, there is only an 11% possibility that it is not actually a wetland. Conversely, upland areas identified on the map had a 73% probability of actually being an upland. In other words, any upland area on a DCM map has a 27% chance of containing a wetland (Shull 1999).

It should be noted that not all jurisdictional wetlands were captured in DCM's mapping process. DCM was more successful identifying some classes than others. This is expected because the natural system is a continuum from one community, ecosystem and landscape to another. Placing a wetland area into one of several classes means that there will be cases where there is not a clear fit. The DCM Wetland Type maps are, therefore, more accurate for some community types than for others. For example, as one might expect, there was some difficulty distinguishing headwater swamps from riverine swamp/bottomland hardwood wetlands because these habitat types often grade into one another. Determining a precise boundary between them can be difficult even in the field.

Finally, where local entities might have developed a more accurate inventory of wetlands, it is conceivable that those data could replace those developed by DCM. It is DCM's desire to distribute the most accurate information available. Since decisions might be influenced by these (or any other) data, it is hoped that all parties might work together to create a product that is most useful to all.

Table 4. Inner Coastal Plain Wetland Acreage

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	**0**
Freshwater Marsh	10,337	2,357	0	**12,694**
Estuarine Shrub Scrub	0	0	0	**0**
Pocosin	64,497	20,936	2,031	**87,464**
Bottomland Hardwood	169,242	11,505	5,039	**185,786**
Riverine Swamp Forest	454,890	15,253	7,383	**477,526**
Depressional Swamp Forest	30,471	2,716	1,188	**34,375**
Hardwood Flat	83,825	37,219	3,936	**124,980**
Pine Flat	99,631	51,063	5,485	**156,179**
Managed Pineland	424,964	n/a	n/a	**424,964**
Estuarine Forest	0	0	0	**0**
Maritime Forest	0	0	0	**0**
Headwater Swamp	11,619	1,129	693	**13,441**
Human Impacted	14,672	n/a	n/a	**14,672**
Total	1,364,148	142,178	25,755	**1,532,081**

Table 5. Wetland Acreage for 20 Coastal Counties

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	198,999	29,230	0	**228,229**
Freshwater Marsh	23,060	559	0	**23,619**
Estuarine Shrub Scrub	28,326	2,195	571	**31,092**
Pocosin	458,181	85,289	4,784	**548,254**
Bottomland Hardwood	76,602	5,067	3,471	**85,140**
Riverine Swamp Forest	483,091	12,577	107	**495,775**
Depressional Swamp Forest	192,573	59,843	4,966	**257,382**
Hardwood Flat	98,679	40,891	10,544	**150,114**
Pine Flat	223,173	64,712	11,635	**299,520**
Managed Pineland	656,633	n/a	n/a	**656,633**
Estuarine Forest	965	19	5	**989**
Maritime Forest	3,558	17	138	**3,713**
Headwater Swamp	22,236	1,590	2,341	**26,167**
Human Impacted	23,906	n/a	n/a	**23,906**
Total	2,489,982	301,989	38,562	**2,830,533**

Table 6. Coastal Plain Wetland Acreage

Wetland Type	Area (acres)				
	Unaltered	Drained	Cutover	**Total**	Percent of total
Salt/Brackish Marsh	198,999	29,230	0	**228,229**	5.2%
Freshwater Marsh	33,397	2,916	0	**36,313**	0.8%
Estuarine Shrub Scrub	28,326	2,195	571	**31,092**	0.7%
Pocosin	522,678	106,225	6,815	**635,718**	14.5%
Bottomland Hardwood	245,844	16,572	8,510	**270,926**	6.2%
Riverine Swamp Forest	937,981	27,830	7,490	**973,301**	22.3%
Depressional Swamp Forest	223,044	62,559	6,154	**291,757**	9.2%
Hardwood Flat	182,504	78,110	14,480	**275,094**	6.2%
Pine Flat	322,804	115,775	17,120	**455,699**	10.4%
Managed Pineland	1,081,597	n/a	n/a	**1,081,597**	24.7%
Estuarine Forest	965	19	5	**989**	0.03%
Maritime Forest	3,558	17	138	**3,713**	0.08%
Headwater Swamp	33,855	2,719	3,034	**39,608**	0.9%
Human Impacted	38,578	n/a	n/a	**38,578**	0.8%
Total	**3,854,130**	***444,167***	**64,317**	***4,362,614***	
Percent of Total	88.0%	9.8%	1.4%		

Note: Acreages shown are the results of the DCM wetland type mapping project. Numbers are approximate. See http://dcm2.enr.state.nc.us/Wetlands/disclaimer2.htm for more information and online displays of DCM's wetland type maps.

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Appendix 1 - Wetland Acreage by County

20 Coastal Counties

Beaufort

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	6,054	1,710	0	7,764
Freshwater Marsh	275	2	0	277
Estuarine Shrub Scrub	1,208	133	18	1,359
Pocosin	8,996	2,949	669	12,614
Bottomland Hardwood	3,828	834	312	4,974
Riverine Swamp Forest	29,333	2,723	3	32,060
Depressional Swamp Forest	8,162	5,545	630	14,337
Hardwood Flat	8,952	1,860	1,036	11,847
Pine Flat	9,822	3,368	441	13,631
Managed Pineland	84,892	n/a	n/a	84,892
Estuarine Forest	172	0	0	172
Maritime Forest	0	0	0	0
Headwater Swamp	3,280	34	174	3,488
Human Impacted	4,828	n/a	n/a	4,828
Total	169,802	19,158	3,283	192,243

Bertie

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	457	7	0	464
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	20,444	396	473	21,313
Riverine Swamp Forest	68,373	419	69	68,861
Depressional Swamp Forest	1,886	3,246	85	5,216
Hardwood Flat	2,993	1,750	154	4,898
Pine Flat	318	198	17	532
Managed Pineland	34,324	n/a	n/a	34,324
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	1,449	139	164	1,753
Human Impacted	1,673	n/a	n/a	1,673
Total	131,917	6,155	962	139,034

Brunswick

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	15,275	0	0	15,275
Freshwater Marsh	6,310	0	0	6,310
Estuarine Shrub Scrub	731	0	37	768
Pocosin	33,520	7,661	498	41,679
Bottomland Hardwood	5,549	453	401	6,403
Riverine Swamp Forest	45,984	696	1	46,681
Depressional Swamp Forest	5,195	455	482	6,132
Hardwood Flat	2,490	581	238	3,309
Pine Flat	26,639	22,299	1,049	49,986
Managed Pineland	101,541	n/a	n/a	101,541
Estuarine Forest	77	0	2	79
Maritime Forest	0	0	0	0
Headwater Swamp	1,816	2	47	1,866
Human Impacted	1,611	n/a	n/a	1,611
Total	246,738	32,147	2,755	281,640

Camden

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	Total
Salt/Brackish Marsh	1,673	0	0	1,673
Freshwater Marsh	31	6	0	37
Estuarine Shrub Scrub	92	0	0	92
Pocosin	374	0	0	374
Bottomland Hardwood	2,292	370	72	2,734
Riverine Swamp Forest	34,143	695	0	34,838
Depressional Swamp Forest	2,951	16,359	1	19,310
Hardwood Flat	6,840	3,282	1,087	11,209
Pine Flat	7,539	1,873	405	9,817
Managed Pineland	8,599	n/a	n/a	8,599
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	927	457	259	1,643
Human Impacted	95	n/a	n/a	95
Total	65,556	23,042	1,823	90,421

Carteret

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	52,607	4,730	0	57,337
Freshwater Marsh	452	357	0	809
Estuarine Shrub Scrub	6,411	337	204	6,952
Pocosin	37,054	4,233	374	41,661
Bottomland Hardwood	1,636	156	106	1,898
Riverine Swamp Forest	4,962	300	0	5,262
Depressional Swamp Forest	1,819	373	98	2,290
Hardwood Flat	7,160	276	434	7,870
Pine Flat	31,969	4,081	2,980	39,030
Managed Pineland	29,496	n/a	n/a	29,496
Estuarine Forest	166	0	0	166
Maritime Forest	148	0	46	194
Headwater Swamp	4,342	284	1,027	5,653
Human Impacted	1,650	n/a	n/a	1,650
Total	179,872	15,127	5,269	199,951

Chowan

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	35	5	0	40
Estuarine Shrub Scrub	0	0	0	0
Pocosin	1	0	0	1
Bottomland Hardwood	2,547	177	92	2,816
Riverine Swamp Forest	9,032	996	0	10,028
Depressional Swamp Forest	345	17	15	377
Hardwood Flat	1,711	765	421	2,897
Pine Flat	54	118	8	180
Managed Pineland	14,234	n/a	n/a	14,234
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	238	135	112	485
Human Impacted	481	n/a	n/a	481
Total	28,678	2,213	648	31,539

Craven

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	1,881	0	0	1,881
Freshwater Marsh	2,123	28	0	2,151
Estuarine Shrub Scrub	211	0	3	214
Pocosin	35,516	4,171	197	39,884
Bottomland Hardwood	4,865	384	129	5,378
Riverine Swamp Forest	38,283	2,347	3	40,633
Depressional Swamp Forest	7,574	5,178	362	13,114
Hardwood Flat	8,039	2,885	369	11,293
Pine Flat	24,524	7,366	801	32,691
Managed Pineland	57,686	n/a	n/a	57,686
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	3,807	371	121	4,299
Human Impacted	1,629	n/a	n/a	1,629
Total	186,138	22,730	1,985	210,853

Currituck

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	25,949	0	0	25,949
Freshwater Marsh	165	4	0	169
Estuarine Shrub Scrub	947	0	7	954
Pocosin	0	0	0	0
Bottomland Hardwood	1,897	471	190	2,558
Riverine Swamp Forest	33,806	409	16	34,231
Depressional Swamp Forest	3,199	56	176	3,431
Hardwood Flat	4,419	2,339	441	7,199
Pine Flat	1,658	2,363	356	4,377
Managed Pineland	9,743	n/a	n/a	9,743
Estuarine Forest	15	0	0	15
Maritime Forest	14	0	0	14
Headwater Swamp	224	10	33	267
Human Impacted	675	n/a	n/a	675
Total	82,711	5,652	1,219	89,582

Dare

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	25,774	3,567	0	29,341
Freshwater Marsh	2,870	0	0	2,870
Estuarine Shrub Scrub	11,625	670	153	12,448
Pocosin	84,182	27	185	84,395
Bottomland Hardwood	422	0	0	422
Riverine Swamp Forest	3,233	0	0	3,233
Depressional Swamp Forest	49,250	0	377	49,627
Hardwood Flat	1,058	0	8	1,066
Pine Flat	15,234	134	197	15,564
Managed Pineland	3,367	n/a	n/a	3,367
Estuarine Forest	213	0	0	213
Maritime Forest	3,397	17	92	3,506
Headwater Swamp	0	0	0	0
Human Impacted	1,258	n/a	n/a	1,258
Total	201,883	4,415	1,012	207,310

Gates

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	60	1	0	61
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	11	0	11
Bottomland Hardwood	4,838	79	126	5,043
Riverine Swamp Forest	27,886	490	0	28,376
Depressional Swamp Forest	525	13,111	25	13,661
Hardwood Flat	3,100	6,456	58	9,614
Pine Flat	395	24	0	419
Managed Pineland	22,480	n/a	n/a	22,480
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	319	6	24	349
Human Impacted	1,359	n/a	n/a	1,359
Total	60,962	20,178	233	81,373

Hertford

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	252	0	0	252
Estuarine Shrub Scrub	0	0	0	0
Pocosin	1	0	0	1
Bottomland Hardwood	7,422	514	64	8,000
Riverine Swamp Forest	20,022	300	0	20,322
Depressional Swamp Forest	250	11	15	276
Hardwood Flat	549	214	19	782
Pine Flat	111	7	0	118
Managed Pineland	11,181	n/a	n/a	11,181
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	620	31	16	667
Human Impacted	220	n/a	n/a	220
Total	40,628	1,077	114	41,819

Hyde

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	39,984	248	0	40,232
Freshwater Marsh	3,661	23	0	3,684
Estuarine Shrub Scrub	3,168	7	82	3,257
Pocosin	74,100	24,478	349	98,927
Bottomland Hardwood	59	0	3	62
Riverine Swamp Forest	5,833	42	0	5,875
Depressional Swamp Forest	29,119	2,373	896	32,388
Hardwood Flat	10,678	2,432	1,041	14,151
Pine Flat	17,848	3,141	698	21,687
Managed Pineland	24,606	n/a	n/a	24,606
Estuarine Forest	210	3	3	216
Maritime Forest	0	0	0	0
Headwater Swamp	513	0	11	524
Human Impacted	2,076	n/a	n/a	2,076
Total	211,855	32,747	3,083	247,685

New Hanover

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	8,193	0	0	8,193
Freshwater Marsh	2,419	0	0	2,419
Estuarine Shrub Scrub	322	0	8	330
Pocosin	6,587	2,291	615	9,493
Bottomland Hardwood	900	195	135	1,230
Riverine Swamp Forest	9,823	655	0	10,478
Depressional Swamp Forest	508	80	77	665
Hardwood Flat	893	102	36	1,031
Pine Flat	5,182	621	546	6,349
Managed Pineland	12,968	n/a	n/a	12,968
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	79	0	36	115
Human Impacted	643	n/a	n/a	643
Total	48,517	3,944	1,453	53,914

Onslow

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	9,267	2,034	0	11,301
Freshwater Marsh	348	86	0	434
Estuarine Shrub Scrub	2,379	0	37	2,416
Pocosin	30,193	4,161	369	34,723
Bottomland Hardwood	7,385	625	425	8,435
Riverine Swamp Forest	23,853	690	1	24,544
Depressional Swamp Forest	7,650	693	212	8,555
Hardwood Flat	2,607	1,268	156	4,031
Pine Flat	24,436	6,536	1,352	32,324
Managed Pineland	69,628	n/a	n/a	69,628
Estuarine Forest	78	0	0	78
Maritime Forest	0	0	0	0
Headwater Swamp	1,330	0	97	1,427
Human Impacted	1,156	n/a	n/a	1,156
Total	180,310	16,093	2,649	199,052

Pamlico

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	4,173	16,934	0	21,107
Freshwater Marsh	576	3	0	579
Estuarine Shrub Scrub	869	1,047	18	1,934
Pocosin	13,141	2,938	452	16,531
Bottomland Hardwood	1,752	41	180	1,973
Riverine Swamp Forest	6,655	785	1	7,441
Depressional Swamp Forest	5,736	102	468	6,306
Hardwood Flat	11,273	1,027	762	13,062
Pine Flat	24,280	2,595	1,241	28,116
Managed Pineland	19,611	n/a	n/a	19,611
Estuarine Forest	31	16	0	47
Maritime Forest	0	0	0	0
Headwater Swamp	933	0	25	958
Human Impacted	3,314	n/a	n/a	3,314
Total	92,344	25,488	3,147	120,979

Pasquotank

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	75	0	0	75
Freshwater Marsh	7	0	0	7
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	874	103	20	997
Riverine Swamp Forest	12,507	332	0	12,839
Depressional Swamp Forest	195	3,184	39	3,418
Hardwood Flat	3,993	7,193	1,570	12,756
Pine Flat	291	1,013	115	1,419
Managed Pineland	10,841	n/a	n/a	10,841
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	24	0	4	28
Human Impacted	89	n/a	n/a	89
Total	28,896	11,825	1,748	42,469

Pender

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	7,475	5	0	7,480
Freshwater Marsh	788	35	0	823
Estuarine Shrub Scrub	165	0	2	167
Pocosin	91,950	16,896	694	109,540
Bottomland Hardwood	6,670	64	498	7,232
Riverine Swamp Forest	53,545	50	6	53,601
Depressional Swamp Forest	9,301	144	310	9,755
Hardwood Flat	6,472	1,642	678	8,792
Pine Flat	24,907	7,445	1,236	33,588
Managed Pineland	76,781	n/a	n/a	76,781
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	1,037	114	88	1,239
Human Impacted	638	n/a	n/a	638
Total	279,729	26,395	3,512	309,636

Perquimans

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	1	0	0	1
Freshwater Marsh	108	1	0	109
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	742	53	148	943
Riverine Swamp Forest	13,826	266	0	14,092
Depressional Swamp Forest	62	50	3	115
Hardwood Flat	3,435	2,221	817	6,473
Pine Flat	156	14	3	173
Managed Pineland	25,795	n/a	n/a	25,795
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	492	6	22	520
Human Impacted	40	n/a	n/a	40
Total	44,657	2,611	993	48,261

Tyrrell

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	616	0	0	616
Freshwater Marsh	216	0	0	216
Estuarine Shrub Scrub	196	0	0	196
Pocosin	39,005	2,535	153	41,693
Bottomland Hardwood	1,397	0	0	1,397
Riverine Swamp Forest	25,916	381	4	26,301
Depressional Swamp Forest	49,866	4,331	295	54,492
Hardwood Flat	7,167	691	314	8,172
Pine Flat	6,933	783	98	7,814
Managed Pineland	22,654	n/a	n/a	22,654
Estuarine Forest	3	0	0	3
Maritime Forest	0	0	0	0
Headwater Swamp	44	0	1	45
Human Impacted	326	n/a	n/a	326
Total	154,339	8,721	865	163,925

Washington

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	1,907	0	0	1,907
Estuarine Shrub Scrub	0	0	0	0
Pocosin	3,559	12,939	229	16,727
Bottomland Hardwood	1,082	151	95	1,328
Riverine Swamp Forest	16,076	0	3	16,079
Depressional Swamp Forest	8,980	4,535	402	13,917
Hardwood Flat	4,849	3,906	906	9,661
Pine Flat	878	734	94	1,706
Managed Pineland	16,204	n/a	n/a	16,204
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	761	0	80	841
Human Impacted	145	n/a	n/a	145
Total	54,441	22,265	1,809	78,515

Inner Coastal Plain Counties

Bladen

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	2,184	927	0	3,111
Estuarine Shrub Scrub	0	0	0	0
Pocosin	21,029	3,545	67	24,641
Bottomland Hardwood	9,084	349	0	9,433
Riverine Swamp Forest	40,092	1,350	790	42,232
Depressional Swamp Forest	9,968	218	179	10,365
Hardwood Flat	20,396	3,944	502	24,842
Pine Flat	29,850	4,914	1,462	36,226
Managed Pineland	69,749	n/a	n/a	69,749
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	733	72	9	814
Human Impacted	2,643	n/a	n/a	2,643
Total	205,728	15,319	3,009	224,056

Columbus

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	789	152	0	941
Estuarine Shrub Scrub	0	0	0	0
Pocosin	5,585	3,415	1,418	10,418
Bottomland Hardwood	13,917	2,883	553	17,353
Riverine Swamp Forest	82,629	4,406	1,225	88,260
Depressional Swamp Forest	5,540	204	245	5,989
Hardwood Flat	11,707	5,381	788	17,876
Pine Flat	14,930	10,244	1,295	26,469
Managed Pineland	79,554	n/a	n/a	79,554
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	2,121	122	185	2,428
Human Impacted	850	n/a	n/a	850
Total	217,622	26,807	5,709	250,138

Cumberland

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	763	64	0	827
Estuarine Shrub Scrub	0	0	0	0
Pocosin	10,559	2,321	121	13,001
Bottomland Hardwood	5,115	75	242	5,432
Riverine Swamp Forest	14,393	812	524	15,729
Depressional Swamp Forest	3,469	128	175	3,772
Hardwood Flat	7,846	1,077	330	9,253
Pine Flat	4,721	519	197	5,437
Managed Pineland	19,920	n/a	n/a	19,920
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	886	107	70	1,063
Human Impacted	893	n/a	n/a	893
Total	68,565	5,103	1,659	75,327

Duplin

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	406	84	0	490
Estuarine Shrub Scrub	0	0	0	0
Pocosin	5,443	234	112	5,789
Bottomland Hardwood	10,071	130	285	10,486
Riverine Swamp Forest	35,674	91	592	36,357
Depressional Swamp Forest	906	91	97	1,094
Hardwood Flat	6,962	1,042	178	8,182
Pine Flat	11,978	4,367	417	16,762
Managed Pineland	39,967	n/a	n/a	39,967
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	624	77	62	763
Human Impacted	426	n/a	n/a	426
Total	112,457	6,116	1,743	120,316

Edgecombe

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	211	140	0	351
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	7,910	1,617	179	9,706
Riverine Swamp Forest	16,584	1,164	159	17,907
Depressional Swamp Forest	978	657	37	1,672
Hardwood Flat	1,566	1,838	84	3,488
Pine Flat	1,083	789	24	1,896
Managed Pineland	11,191	n/a	n/a	11,191
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	277	61	10	348
Human Impacted	310	n/a	n/a	310
Total	40,110	6,266	493	46,869

Greene

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	70	22	0	92
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	3,837	476	74	4,387
Riverine Swamp Forest	9,261	26	97	9,384
Depressional Swamp Forest	304	89	7	400
Hardwood Flat	1,069	1,906	121	3,096
Pine Flat	378	780	2	1,160
Managed Pineland	2,900	n/a	n/a	2,900
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	183	20	17	220
Human Impacted	106	n/a	n/a	106
Total	18,108	3,319	318	21,745

Halifax

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	1,508	324	0	1832
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	14,918	376	232	15,526
Riverine Swamp Forest	29,564	243	295	30,102
Depressional Swamp Forest	1,247	40	72	1,359
Hardwood Flat	2,088	196	40	2,324
Pine Flat	220	9	18	247
Managed Pineland	6,944	n/a	n/a	6,944
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	324	28	13	365
Human Impacted	776	n/a	n/a	776
Total	57,589	1,216	670	59,175

Johnston

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	485	65	0	550
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	20,147	651	414	21,212
Riverine Swamp Forest	30,829	40	360	31,229
Depressional Swamp Forest	417	0	31	448
Hardwood Flat	3,079	85	209	3,373
Pine Flat	1,277	175	60	1,512
Managed Pineland	14,023	n/a	n/a	14,023
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	245	0	14	259
Human Impacted	1,593	n/a	n/a	1,593
Total	72,095	1,016	1,088	74,199

Jones

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	302	10	0	312
Estuarine Shrub Scrub	0	0	0	0
Pocosin	21,006	11,059	309	32,374
Bottomland Hardwood	4,808	343	432	5,583
Riverine Swamp Forest	14,243	360	701	15,304
Depressional Swamp Forest	1,706	192	100	1,998
Hardwood Flat	2,983	4,387	347	7,717
Pine Flat	10,211	10,715	892	21,818
Managed Pineland	57,302	n/a	n/a	57,302
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	781	416	62	1,259
Human Impacted	84	n/a	n/a	84
Total	113,426	27,482	2,843	143,751

Lenoir

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	129	35	0	164
Estuarine Shrub Scrub	0	0	0	0
Pocosin	125	295	3	423
Bottomland Hardwood	5822	268	135	6,225
Riverine Swamp Forest	14,795	221	190	15,206
Depressional Swamp Forest	213	26	6	245
Hardwood Flat	1,892	3,073	116	5,081
Pine Flat	2,194	2,618	79	4,891
Managed Pineland	13,616	n/a	n/a	13,616
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	246	47	7	300
Human Impacted	569	n/a	n/a	569
Total	39,601	6,583	536	46,720

Martin

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	201	6	0	207
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	7,536	127	173	7,836
Riverine Swamp Forest	43,017	250	421	43,688
Depressional Swamp Forest	557	137	21	715
Hardwood Flat	1,821	1,004	23	2,848
Pine Flat	2,059	1,482	131	3,672
Managed Pineland	16,265	n/a	n/a	16,265
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	546	41	16	603
Human Impacted	117	n/a	n/a	117
Total	72,119	3,047	785	75,951

Nash

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	241	26	0	267
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	17,567	30	505	18,102
Riverine Swamp Forest	11,341	0	142	11,483
Depressional Swamp Forest	369	36	26	431
Hardwood Flat	2,313	144	137	2,594
Pine Flat	1,165	41	17	1,223
Managed Pineland	6,624	n/a	n/a	6,624
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	507	0	40	547
Human Impacted	934	n/a	n/a	934
Total	41,061	277	867	42,205

Northampton

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	1,111	180	0	1,291
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	14,479	82	166	14,727
Riverine Swamp Forest	20,328	182	112	20,622
Depressional Swamp Forest	1,083	20	51	1,154
Hardwood Flat	2,290	533	49	2,872
Pine Flat	268	1	2	271
Managed Pineland	6,066	n/a	n/a	6,066
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	1,030	0	21	1,051
Human Impacted	1,964	n/a	n/a	1,964
Total	48,619	998	401	50,018

Pitt

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	158	72	0	230
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	6,887	2,416	209	9,512
Riverine Swamp Forest	24,973	4,256	398	29,627
Depressional Swamp Forest	1,315	763	29	2,107
Hardwood Flat	3,646	10,001	434	14,081
Pine Flat	2,145	7,482	112	9,739
Managed Pineland	22,833	n/a	n/a	22,833
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	358	78	6	442
Human Impacted	886	n/a	n/a	886
Total	63,201	25,068	1,188	89,457

Sampson

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	3	4	0	7
Estuarine Shrub Scrub	0	0	0	0
Pocosin	42	66	0	108
Bottomland Hardwood	9	11	0	20
Riverine Swamp Forest	39,185	4	689	39,878
Depressional Swamp Forest	1,102	2	61	1,165
Hardwood Flat	9	12	1	22
Pine Flat	17	28	1	46
Managed Pineland	4	n/a	n/a	4
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	8	7	1	16
Human Impacted	5	n/a	n/a	5
Total	40,384	134	753	41,271

Wayne

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	585	162	0	747
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	10,681	520	406	11,607
Riverine Swamp Forest	17,204	659	347	18,210
Depressional Swamp Forest	718	113	23	854
Hardwood Flat	3,347	1,386	93	4,826
Pine Flat	1,440	2,187	60	3,687
Managed Pineland	8,870	n/a	n/a	8,870
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	508	14	25	547
Human Impacted	506	n/a	n/a	506
Total	43,859	5,041	954	49,854

Wilson

Wetland Type	Area (acres)			
	Unaltered	Drained	Cutover	**Total**
Salt/Brackish Marsh	0	0	0	0
Freshwater Marsh	125	1	0	126
Estuarine Shrub Scrub	0	0	0	0
Pocosin	0	0	0	0
Bottomland Hardwood	10,642	1,117	613	12,372
Riverine Swamp Forest	11,077	1,190	341	12,608
Depressional Swamp Forest	579	2	27	608
Hardwood Flat	4,042	331	195	4,568
Pine Flat	2,117	876	204	3,197
Managed Pineland	11,818	n/a	n/a	11,818
Estuarine Forest	0	0	0	0
Maritime Forest	0	0	0	0
Headwater Swamp	888	0	84	972
Human Impacted	1,386	n/a	n/a	1,386
Total	42,674	3,517	1,464	47,655