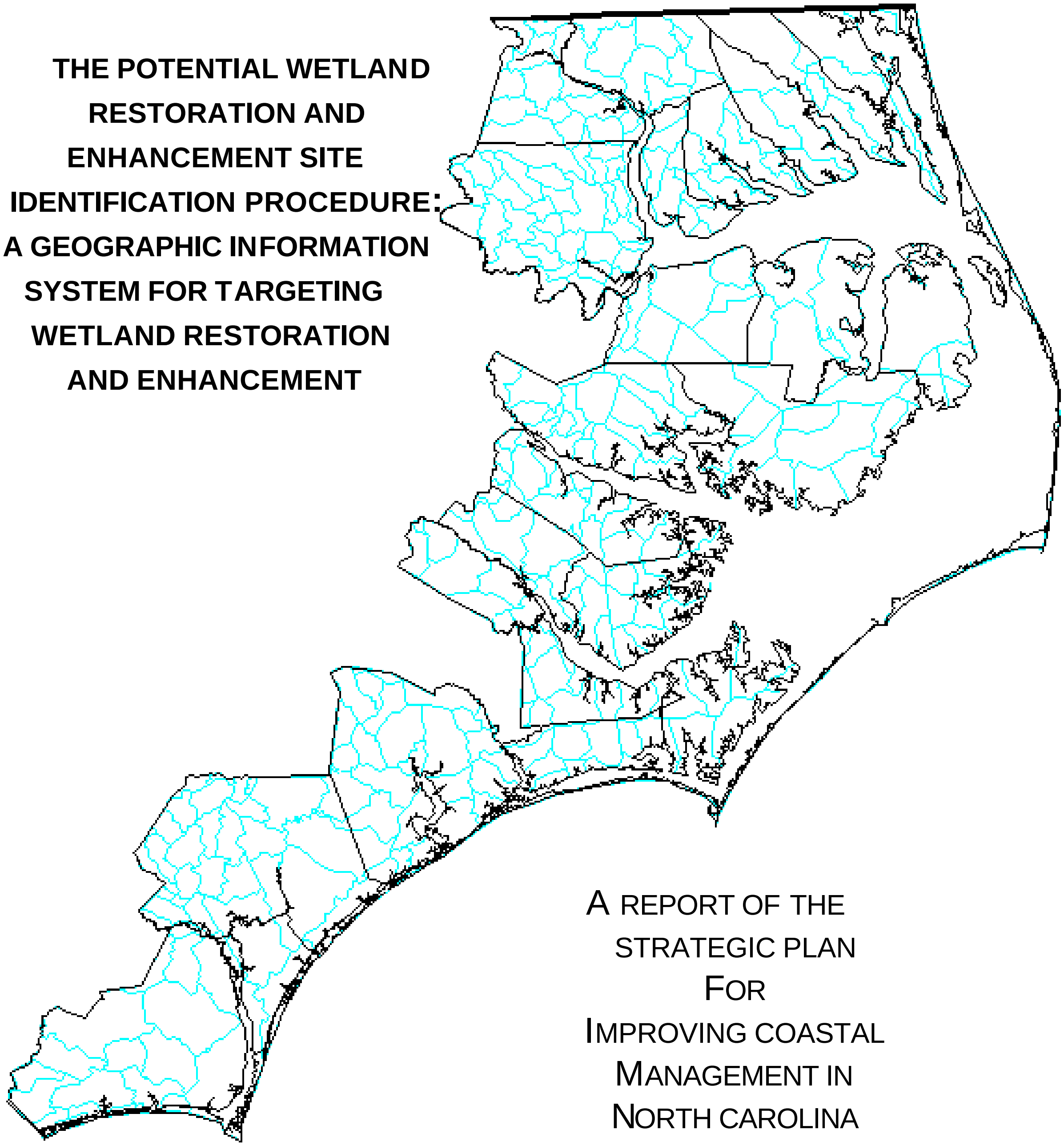
THE POTENTIAL WETLAND RESTORATION AND ENHANCEMENT SITE IDENTIFICATION PROCEDURE: A GEOGRAPHIC INFORMATION SYSTEM FOR TARGETING WETLAND RESTORATION AND ENHANCEMENT



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

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The Potential Wetland Restoration and Enhancement Site Identification Procedure: A Geographic Information System For Targeting Wetland Restoration and Enhancement

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Executive Summary

The Potential Wetland Restoration and Enhancement site identification procedure is one of four sets of Geographic Information System (GIS) data developed and used by the North Carolina Division of Coastal Management (DCM) to locate and assess wetlands and wetland restoration sites. These data can be used as planning tools for local governments, state agencies, conservation organizations and developers. The procedures used to produce the data are watershed-based and are components of DCM's Wetland Conservation Plan. The four GIS-based mapping procedures developed by DCM are:

- **Wetland Type Mapping-** a GIS that identifies the location, type, and extent of wetlands in the North Carolina Coastal Plain (DCM, 1999a). Data are available for 37 Coastal Plain counties.
- **Wetland Functional Assessment Mapping-** a model that assesses the functional significance of wetlands using the North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS), a wetland functional assessment and mapping method developed by DCM. (DCM, 1999b). NC-CREWS data are available for 37 Coastal Plain counties.
- **Potential Wetland Restoration and Enhancement Site Mapping-** a GIS identifying the location, type, and extent of potential wetland restoration and enhancement sites in the North Carolina Coastal Plain. Potential Wetland Restoration and Enhancement data are available for 37 Coastal Plain counties.
- **Restoration Functional Assessment Procedure (R-FAP)-** a functional assessment and mapping method that estimates the levels and types of functions a wetland restoration site could perform if restored.

This document will describe the Potential Wetland Restoration and Enhancement Site Mapping Procedure in detail. It will also discuss potential uses for the data as well as an accuracy assessment of the data.

A GIS that locates potential wetland restoration sites will undoubtedly prove to be an invaluable tool in locating wetland restoration and enhancement sites for watershed restoration projects, water quality and habitat improvement and protection and wetland mitigation. Like DCM's other mapping techniques, the restoration and enhancement site data are intended to be used by planners, local governments, resource agencies and permit applicants in conjunction with other planning tools to improve watershed planning, wetland conservation, and wetland restoration and enhancement. More information about DCM's GIS wetland mapping can be found at www.nccoastalmanagement.net.

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Section 1

Wetlands in Coastal North Carolina

The Outer Coastal Plain of North Carolina covers twenty counties and over 9000 square miles of land area, which is about 20 percent of the state. It also includes over 87 percent of the state's surface water. The North Carolina Division of Coastal Management (DCM) 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, which, in many areas, comprise nearly 50 percent of the landscape. These wetlands are of great ecological importance because they occupy so much area, are a significant component of virtually all coastal ecosystems, and contribute to coastal water quality, estuarine ecosystem productivity, wildlife habitat, and the overall character of the coastal area. The importance of wetlands is usually described in terms of functions and values. Wetlands typically exhibit three primary functions: water quality functions, hydrology functions, and habitat functions. The functions of wetlands are valued by society for various reasons such as floodwater storage, aesthetic value, filtering of pollutants, wildlife habitat, and shoreline protection.

It has been estimated that from one third to one half of the original wetlands of the North Carolina coastal area have been drained and converted to other land uses (Hefner and Brown, 1985; Dahl, 1990; NCDEHNR, 1991). Although agricultural conversion, the largest historical agent of wetlands loss, has mostly ceased, wetlands continue to be lost as they are drained or filled for other types of development. Conflict between economic development and wetlands protection continues to be a major concern, particularly in those coastal areas where wetlands protection can be considered to be a major barrier to their economic goals.

Increasing human alteration of the landscape continues to threaten the natural functions of our nation's wetlands. Alteration of wetlands often compromises their capacity to function and, therefore, compromises their value. Recognizing the functions of wetlands and the values of these functions to society, many natural resource agencies have placed a high priority on the protection and restoration of wetlands and riparian areas. An increasing number of state and federal agencies have developed river basin or watershed level wetland and riparian area restoration plans. Environmental organizations are involved in a wide variety of projects emphasizing wetland and riparian area restoration. Leading scientists have called for far-reaching national policies and initiatives to restore aquatic ecosystems. Described as the "acid test" of ecological theory, ecosystem restoration has also garnered support for its experimental utility.

Although many of the philosophical and technical issues surrounding ecological restoration have yet to be resolved, it is increasingly practiced and often mandated as part of environmental regulatory programs. In addition to supporting the restoration of wetlands and riparian areas for environmental and other benefits, wetland regulatory programs may require wetland replacement as compensatory mitigation in accordance with a national goal of no net loss of the nation's remaining wetlands. Unavoidable fill or discharge in wetlands is often accompanied by a regulatory requirement to compensate for the resulting losses in wetland functions. This requirement, referred to as compensatory mitigation, usually involves the restoration of former wetlands, creation of wetlands where wetlands did not previously exist, enhancement of certain functions in degraded wetlands, or preservation of highly functional wetlands and rare or endangered wetland types. Restoration of former wetlands tends to provide the greatest net gain in wetland function at the lowest cost and risk and is, therefore, the preferred method of compensatory mitigation when available (EPA, 1995).

Regulatory Context

Since wetlands are a dominant feature of the coastal landscape and are vitally important to the area's ecology, their management and protection are major concerns for DCM. Tidal salt and brackish marshes, or "coastal wetlands" as they are referred to in statutory law and administrative rules, are stringently protected by the State Dredge and Fill Act (NCGS 113-229) and the CAMA regulatory program. Coastal wetlands are designated as Areas of Environmental Concern (AECs). AECs are natural areas of importance as designated by the Coastal Resources Commission. These areas are protected under CAMA from uncontrolled development. Their importance is outlined in CAMA with the mandate "To conserve and manage 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, have not been specifically protected under North Carolina regulation until recently. Prior to the 1996 implementation of the state's wetland rules by the NC Division of Water Quality (DWQ), state regulatory agency involvement in protection of fresh water wetlands had been limited to enforcement of state water quality standards and to the regulatory authority given under federal laws for state agency review of federal §404 permits issued by the U.S. Army Corps of Engineers (USACE) under the Federal Water Pollution Control Act, also known as the Clean Water Act. Under §401 of the Clean Water Act (33 USC 1341), a 401 Water Quality Certification from the DWQ is required prior to approval of §404 permits 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 in coastal counties be consistent with the enforceable rules and policies of DCM, namely the use standards for AECs and wetlands policies stated in the applicable local land use plan. A few local land use plans include policies to protect fresh water wetlands, but most do not.

The 1996 DWQ Wetland Rules provided increased protection to freshwater wetlands where no specific protection had been provided by the state. These rules regulate fill and discharges of pollutants into wetlands based on the water quality classification, distance from a stream, and size of the impact. They also provide required ratios for compensatory mitigation including a minimum of one acre of restoration for each acre impacted when mitigation is required.

Compensatory Mitigation Success

There is no "cookbook" approach to compensatory wetland mitigation. Although there are some examples of successful mitigation projects where institutional and ecological difficulties have been overcome, compensatory mitigation has often failed to fully replace wetland functions. This failure has resulted from three primary factors. First, is a lack of commitment and resources on the part of a permit applicant. Compensatory wetland mitigation has been seen by many applicants as a cost of doing business or a hurdle to clear before getting a permit. In the past, an applicant that truly put the necessary time and money into successful wetland mitigation has been uncommon. The result has been many failed wetland mitigation sites and a net loss of wetland area and functions. Without well-funded and well-staffed enforcement programs to ensure mitigation requirements and mitigation success criteria are met, remediation of failed mitigation projects has been uncommon.

The second reason for mitigation project failure is a lack of interdisciplinary technical knowledge about wetland conditions and restoration techniques needed to design a mitigation site that results in a self-sustaining ecosystem that replaces the desired wetland functions. Wetland conditions vary widely and with seemingly infinite combinations of hydrology, vegetation, and soil characteristics, designing a mitigation project to meet certain ecological and regulatory criteria has been extremely difficult. Accurately predicting post-restoration hydrologic and soil conditions and matching appropriate plant species in a composition and spatial arrangement similar to a reference plant community is complex and remains a complicated mix of practical experience and science.

The third reason for failed mitigation projects is the site selection process. Permit applicants typically prefer to minimize mitigation costs and project delays. The mitigation site selection process has, therefore, often been guided by convenience, cost, and time rather than by the consideration of wetland functions and watershed conditions. Unfortunately, this can result in the selection of a mitigation site lacking the potential to support the wetland functions that it is designed to replace.

Wetlands Conservation Plan

The key element of DCM's effort to improve wetlands protection has been the development of a Wetlands Conservation Plan for the North Carolina coastal area. The CZMA §309 Assessment of the North Carolina Coastal Management Plan (NC CMP) performed during 1991 identified a weakness in the protection of non-tidal wetlands (DCM, 1992). The assessment revealed 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 inhibiting economic growth in coastal counties. Environmental interests found that it allowed the continued loss of ecologically important wetlands. As a result, DCM chose wetlands management and protection as one of the primary program areas in need of improvement. The Wetland Conservation Plan is one response to this need.

The Wetlands Conservation Plan includes a component designed to target wetland restoration efforts and to improve the ecological effectiveness of wetland compensatory mitigation. The Plan's components are:

- **Wetlands Mapping & Inventory**
- **Functional Assessment of Wetlands**
- **Wetland Restoration Site Identification and Functional Assessment**
- **Coordination with Regulatory Agencies**
- **Local Land Use Planning**
- **Environmental Education**

DCM developed a five-year strategy (DCM, 1992) 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 Resources Management (OCRM) in the National Oceanographic and Atmospheric Administration (NOAA), U.S. Department of Commerce. Funds provided under the §309 Program, particularly Project of Special Merit awards for fiscal years 1992 and 1993, were used to fund the Potential Wetland Restoration and Enhancement Site Identification Procedure. The work was also partially funded by the North Carolina Department of Transportation (NCDOT), as part of a pilot project associated with the future New Bern Bypass, and the U.S. Environmental Protection Agency (USEPA) as part of the Carteret County Wetland Advanced Identification (ADID) Project. The expansion of our mapping efforts into the Inner Coastal Plain of North Carolina was funded by the NC Wetlands Restoration Program (NCWRP).

Wetland Restoration and Enhancement Site Identification

Certain initial considerations shaped the approach and methods used in developing techniques for identifying potential wetland restoration and enhancement sites. These techniques needed to fit within the context and objectives of the Wetlands Conservation Plan for the North Carolina coastal area as described above. Note that the procedure described in this document is used to identify both restoration and enhancement sites. While restoration is a preferred mitigation action, wetland enhancement is an important activity that, when used appropriately, can contribute in important ways to watershed improvements.

DCM's Potential Wetland Restoration and Enhancement Site Identification Procedure requires information in a GIS format. In the North Carolina coastal area (Figure 1), these GIS data layers either already existed and were available from the North Carolina Center for Geographic Information and Analysis (CGIA) or were developed as part of the Wetland Conservation Plan. DCM was fortunate to have a relatively large amount of GIS data readily available. For use in other areas, the procedure could be modified to account for landscape differences, water quality conditions and other regional conditions. Potential restoration and enhancement sites were mapped in 37 Coastal Plain counties.

In addition to the identification of potential restoration and enhancement sites, DCM has developed a GIS based potential restoration site functional assessment model. This model is called the Restoration Functional Assessment Procedure or "R-FAP." This hierarchical model is used to prioritize potential restoration and enhancement sites for targeted watershed-based restoration and enhancement projects. A pilot project involving the search for and prioritization of potential mitigation sites for the North Carolina Department of Transportation's (NCDOT) proposed New Bern Bypass was carried out in1996. DCM was able to use GIS models and data to search a large area for sites, evaluate the impact sites, and select sites for further study that most closely matched the anticipated impact areas. After additional review of the R-FAP model to ensure it uses the most current data available, DCM will expand its use throughout the coastal counties. The R-FAP model will be described in detail in a separate document. The information here is essential for understanding the R-FAP model.

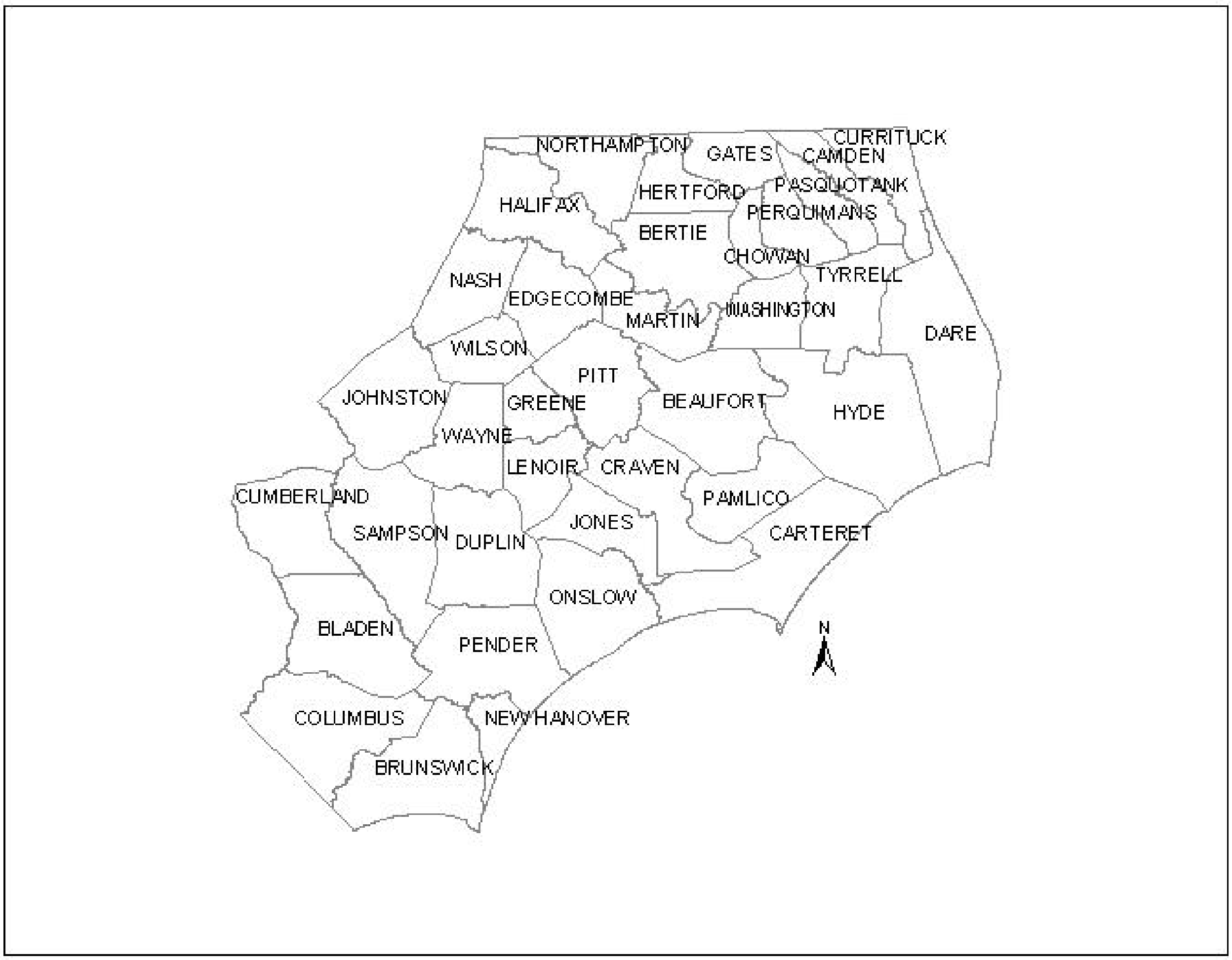

Figure 1. Extent of Potential Restoration and Enhancement Site Mapping for 37 Coastal Plain Counties.

GIS Identification of Potential Restoration Sites

Section 2

This section will describe the data and the procedures used to identify potential wetland restoration and enhancement sites. The procedure uses several GIS data layers to locate sites. Land cover and hydrology data are then used to classify sites according to their disturbance type and to differentiate between restoration and enhancement sites. Digital soil data are used to classify potential restoration and enhancement sites based on the type of wetland (*i.e.* swamp/bottomland hardwood, pocosin, marsh) they would support after restoration or enhancement has taken place.

GIS Data

The identification and mapping of potential wetland restoration and enhancement sites begins with the identification of areas with hydric soils that (1) used to possess wetland characteristics (restoration sites) or (2) are wetlands, but have been degraded or converted to a different wetland type than existed there in the past (usually identified as enhancement sites). The procedure for the identification of potential wetland restoration and enhancement sites requires the following GIS data layers:

(1) DCM Wetland Type data
(2) NRCS soil data
(3) Land use/land cover
(4) Hydrography

DCM Wetland Type Data

DCM's Wetland Type data were produced using a peer-reviewed mapping procedure developed by DCM which utilizes National Wetland Inventory (NWI) maps in digital format, LandSat imagery with land cover classifications and county boundaries, and NRCS 1:24,000 scale digital soils data to classify wetlands into wetland types. This procedure is described in *DCM Wetland Mapping in Coastal North Carolina* (DCM, 1999a). The DCM Wetland Type data are used to identify the location of existing wetlands, areas of managed pine, and impounded, flooded, drained, and other degraded wetlands. Wetlands are assigned a number corresponding to a wetland type based on their plant community type and their degree of disturbance. Non-wetlands are mapped as wetland type zero (see Appendix A). Figure 2 gives an example of DCM's Wetland Type data for the Preyer Buckridge Coastal Reserve in Tyrrell County, NC.

NRCS Soil Data

The soil data consists of detailed county soil maps that were produced by NRCS and digitized by CGIA. The primary use of the soil data is to identify areas with hydric soil (NRCS,1995). Hydric soil is the best indicator of the location of both existing and historic wetland areas. Consequently, when used with the DCM Wetland Type data (which show existing wetlands) and land use data (which show recent land use changes), the soil data layer is used to identify the location of potential wetland restoration sites. In DCM's Potential Wetland Restoration and Enhancement Site Identification Procedure, potential wetland restoration and enhancement sites can only occur on hydric soils. The properties of the soil series are used to determine the type of wetland that could be restored at each site.

Land Use/Land Cover Data

Three separate coverages are used for the land use/ land cover data layer: 1994 Coastal Change Analysis Program (C-CAP) data, 1988 filtered data from the Albemarle-Pamlico Estuarine Study (APES, 1988), and unfiltered data from the 1988 APES study interpreted by Khorram, et al. (1992). The 1994 C-CAP data were used to identify forested wetlands that had been recently cutover. The 1988 filtered APES data were used to identify cleared areas and areas with low-density vegetation. Wetland areas that were classified as cleared in 1988 and 1994 were thought to no longer support vegetation, *i.e.* have been cleared, and were mapped as potential wetland restoration sites. The 1988 unfiltered APES data were also used to identify forested areas.

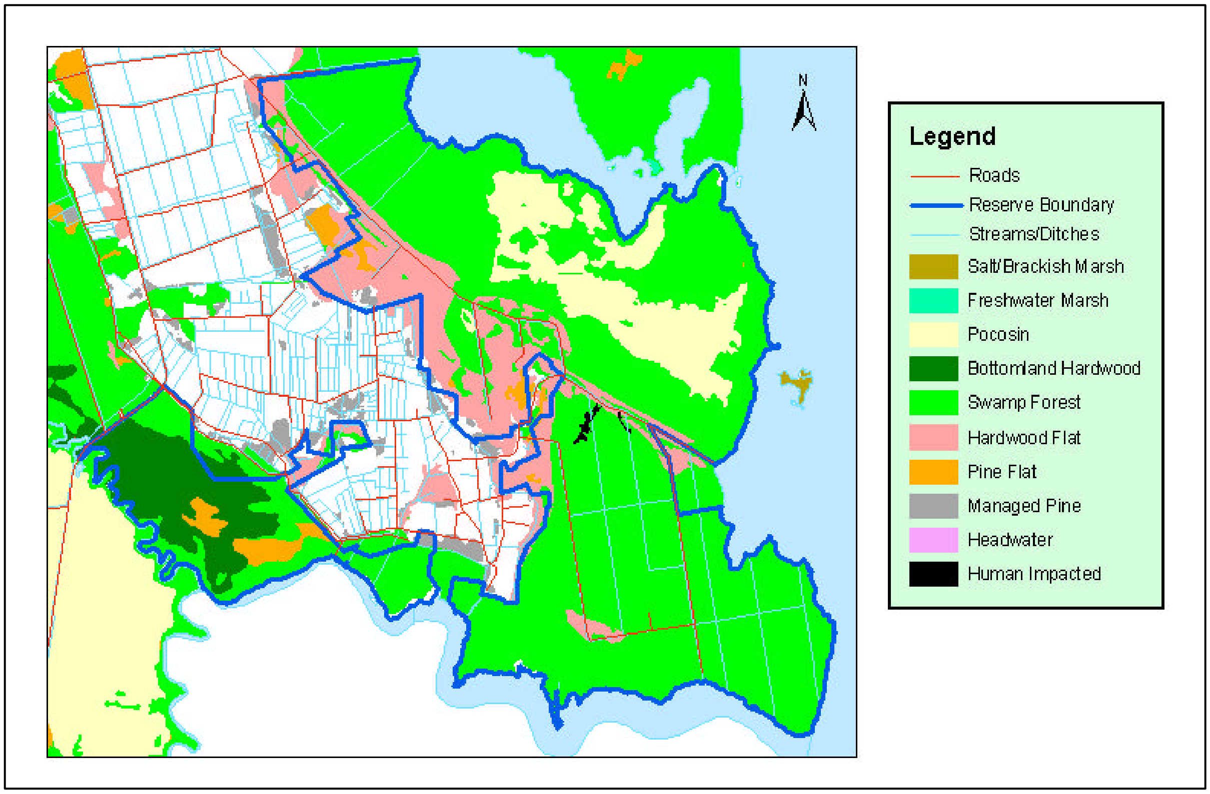

Figure 2. DCM Wetland Type data for the Buckridge Coastal Reserve

USGS Hydrography

The base hydrography coverage consisted of 1:24,000 scale US Geological Survey digital line graphs (DLGs). This coverage was manually edited to indicate whether a stream had been ditched or channelized, the origin and order of the stream (Strahler, 1957), whether it contained anadromous fish habitat, and whether it exhibited perennial or intermittent flow.

Wetland Disturbance Classes

Before sites are classified by restoration site type, they are placed into groups according to a set of criteria based on site conditions and disturbance types (Table 1). These wetland disturbance classes (WDC) or WD_Classes indicate the kinds of historical impacts to the site and whether the site is classified as restoration or enhancement. There are 9 wetland disturbance classes. Based on the soil type, each site is then classified as one of 6 restoration types that refer to the wetland type that could be restored or enhanced.

WDC 1: Restoration sites greater than 100 feet from a ditch or channelized stream, shown as agricultural land, bare grass, or low density vegetation on LandSat, are not on pocosin soils and are mapped as uplands, PEM1A, or are PSS1A or PSS1C polygons on NWI maps (Cowardin, 1979). These sites are mapped as drained and cleared.

WDC 2: Restoration sites greater than 100 feet from a ditch or channelized stream, shown as agricultural land, bare grass, or low density vegetation on LandSat, and has a “d” modifier and “Forested” class on NWI maps. These sites are mapped as drained and cleared.

WDC 3: Restoration sites greater than 100 feet from a ditch or channelized stream, shown as agricultural land, bare grass, or low density vegetation on LandSat, with a “Forested” NWI class and no NWI “d” modifier. These sites are mapped as drained and cleared.

WDC 4: Enhancement sites greater than 100 feet from a ditch or channelized stream, shown as vegetated on LandSat, and have an NWI "d" modifier. These sites are ditched/partially drained and not cleared.

WDC 5: Enhancement sites greater than 100 feet from a ditch or channelized stream, LandSat imagery shows needle leaved evergreen vegetation, sites are on hydric soils, and are uplands on NWI maps. These sites are managed pine areas.

WDC 6: Restoration or enhancement sites greater than 100 feet from a ditch or channelized stream including areas with a soil type of "water" that have an "h" modifier on NWI maps (excluding L1UB3Hh, L2EM2K3Hh, L2AB3K3h PEM2Kh, L1*, and those with K or RB classes and PFO5G (PFO5*b included)). These sites are impounded.

WDC 7: Restoration sites greater than 100 feet from a ditch or channelized stream including areas with a soil type of "water" that have an "x" or "s" modifier on NWI maps (excluding those with RB classes). These sites are excavated or filled wetlands.

WDC 8: Restoration sites less than 100 feet from a ditch or channelized stream that are forested on LandSat imagery and are uplands on NWI maps. These sites are drained and not cleared.

WDC 9: Enhancement sites less than 100 feet from a ditch or channelized stream and mapped as wetlands on NWI maps. These sites are ditched/partially drained and not cleared.

Identifying Potential Enhancement Sites

Once polygons are classified by disturbance class, the next step in the Potential Wetland Restoration and Enhancement Site Identification Procedure is to identify potential wetland enhancement areas on existing wetlands. Wetland enhancement can be carried out on wetland sites that have been degraded and no longer perform wetland functions at original levels. Areas that are currently wetlands were identified using DCM's Wetland Type maps. These areas are referred to as "DCM wetlands" in this document. There are three WDC types identified as enhancement sites.

Partially drained, ditched, or channelized DCM wetlands are considered potential enhancement sites and are identified using the DCM Wetland Type, NWI, and hydrography data layers. NWI maps identify some degraded wetlands with modifiers attached to their Cowardin Classification Codes. Areas that are thought to be drained wetlands have a "d" modifier on NWI maps. Polygons on DCM wetland type maps with an NWI "d" modifier in areas that had not been cleared were identified as potential enhancement sites that are "partially drained, not cleared" (WDC 4). Channelized streams were manually identified in the hydrography data layer. Vegetated DCM wetlands within 100 feet of channelized streams were assumed to be potential enhancement areas due to their degraded hydrologic conditions (WDC 9). WDC 9 is considered "ditched, not cleared."

Impoundments were also identified using the NWI data layer. Impoundments have an "h" modifier on NWI maps. These areas are usually considered potential wetland enhancement sites (WDC 6) although some contain areas converted to open water that no longer meet wetland jurisdictional criteria.

A fourth type of enhancement site is Managed Pine (WDC 5). Managed Pine wetlands are shown as needleleaf evergreen forests on LandSat imagery and are on hydric soils. They are mapped as uplands on NWI maps. Usually, these are wetlands that have been converted to silviculture. Accuracy assessment has shown that these areas meet 1987 Corps of Engineers Wetland Delineation Manual (Environmental Laboratory, 1987) wetland jurisdictional criteria approximately 65% of the time (DCM, 1999c.). Consequently these areas are normally considered enhancement sites though some may no longer exhibit wetland jurisdictional criteria and may be restoration sites depending on the extent of hydrologic alteration.

Table 1. Criteria used to identify potential wetland restoration and enhancement sites

GIS Data Layers				Description	Wetland Disturbance Class (WD Class)	Disturbance type	Management Goal
Soil	**Hydrography**	**Land cover**	**NWI**				
Hydric[1]	>100 feet from channelized stream/ditch	Ag./Bare Grass or low density vegetation	Upland[2]	PC[3], Ag, or developed land	1	Drained and cleared	Restoration
			"d" modifier and "FO" class	Cleared NWI area on hydric soil w/ ditches	2		
			"FO" class and no "d" modifier	Cleared NWI area on hydric soil w/o ditches	3		
		Vegetated	Wetlands with a "d" modifier	Vegetated NWI area w/ ditches	4	Ditched[4], not cleared	Enhancement
		Pine vegetation	Upland	Managed pine	5	Managed Pine	
		Not used	"h" modifier[5]	Impounded former wetlands	6	Impounded	Enhancement
			"x" or "s" modifier[6]	Excavated or filled former wetland	7	Excavated or filled	Restoration
	< 100 feet from channelized stream /ditch	Vegetated (forested)	Upland [2]	Drained wetland	8	Drained, not cleared	Restoration
		Not used	Wetland	Partially drained wetland	9	Ditched, not cleared	Enhancement

1 All potential sites are on hydric soils with the exception of WDC 6 and 7 which may have soils mapped as "water"
2 Also includes areas mapped as PSS1A and PSS1C not on pocosin soils and PEM1A
3 Prior converted
4 Ditched or partially drained. Most of these areas have retained wetland hydrology, but have lost some hydrologic functions
5 Excluding L1UB3Hh, L2EM2K3Hh, L2AB3K3h PEM2Kh, L1*, and those with K or RB classes and PFO5G (PFO5*b included)
6 Excluding those w/ RB classes

Identifying Potential Restoration Sites

Restoration is a preferred method of compensatory mitigation. DCM's GIS procedures identify potential wetland restoration sites on former wetland areas with hydric soils that have been cleared, drained, excavated, impounded, and/or filled with spoil. True potential restoration sites are no longer wetlands. Areas mapped as potential wetland restoration sites on DCM's maps have a low probability of exhibiting all three primary wetland functions needed to meet wetland jurisdictional criteria.

The first group of restoration sites is described as "drained and cleared." "Cleared" areas are identified primarily using land cover data from 1988 and 1994. Areas identified by the 1988 land cover as agricultural land, bare land, or grassland were considered cleared of natural vegetation. Areas identified as low-density vegetation in the 1988 land cover are also considered cleared if those areas were located on soils that normally support forested vegetation or had an NWI classification that was forested. Areas that are shown in the 1994 land cover as developed, agricultural land, or managed herbaceous, or upland herbaceous (*e.g.* golf courses, lawns, etc.) are also considered cleared of natural vegetation.

"Drained" areas are identified using NWI and Hydrography data layers. NWI identifies partially drained wetlands with a "d" modifier on their maps. Portions of NWI's partially drained wetlands are still considered wetlands because they are wet enough to support wetland vegetation, but some portions no longer support wetland hydrology. The USGS Hydrography data layer was manually edited to locate streams that had been ditched or channelized. A 100-foot buffer was added to the ditch/channelized stream data to capture the areas that were likely to have lost wetland hydrology- those areas closest to a ditch or channelized stream. Areas within the buffer were considered to be "drained" and to no longer support wetland hydrology.

Agricultural lands and prior converted wetlands in crop production were mapped as uplands on NWI maps. DCM identified former wetlands currently in agriculture as potential wetland restoration sites (WDC 1) by using the land cover data to identify those agricultural lands on hydric soils. Cleared areas mapped on NWI maps with a "d" modifier are in WDC 2. Cleared areas on hydric soil with no "d" modifier, are WDC 3. All areas classified as WDC 1, 2, and 3 are considered "drained and cleared."

The second group of restoration sites contains those that have been altered by humans, often severely. Excavated areas and areas filled with spoil were identified using the NWI data layer. The NWI data layer identified excavated areas as "x" and spoil areas as "s." These areas are identified as wetland restoration sites (WDC 7).

The last site type in the restoration category is WDC 8. These are areas that overlap the 100-foot buffer, are mapped as wetlands on NWI maps, and mapped as uplands on DCM wetland type maps. They are designated as "drained, not cleared" on DCM's potential wetland restoration site maps.

Restoration Types ("Rest types")

DCM classifies potential wetland restoration and enhancement sites according to the wetland plant community types that they are likely to support once they are restored or enhanced. The development of the classification scheme for potential wetland restoration and enhancement sites is based on soil taxonomy, a frequency analysis of DCM's wetland type mapping results (wetland type vs. soil mapping unit), landscape position, and best professional judgment from wetland scientists and soil scientists. Appendix B shows the wetland restoration type results for Craven, Carteret, and Jones County soils as an example. DCM identifies potential wetland restoration and enhancement sites as one of the following six "rest types":

Marsh (restoration type = 1)

Salt and brackish marshes are typically found along the margins of sounds and estuaries in low, flat, protected areas that are influenced by daily tides. Natural vegetation common to salt/brackish marshes includes species which are tolerant of frequent regular flooding and high salt concentrations such as: big cordgrass (*Spartina cynosuroides*), saltmarsh cordgrass *(Spartina alterniflora*), saltmeadow cordgrass (*Spartina patens*), sawgrass (*Cladium jamaicense*), saltgrass

(*Distichlis spicata*), and black needlerush (*Juncus roemerianus*). Marsh soils typically have a mucky surface layer that extends downward 30 to 60 inches. They are generally found on organic soils (Typic Medisaprists) that may be slightly acidic to moderately alkaline.

Estuarine Shrub/Scrub, Estuarine Forest, Estuarine / Maritime Forest (restoration type = 2)

Estuarine Shrub/Scrub and Forest sites are typically located on the landward margins above mean high tide. These areas are irregularly flooded by wind tides with salt or brackish water. Vegetation is heavily influenced by exposure to salt spray. Species include saltmeadow cordgrass, wax myrtle (*Myrica cerifera*), red cedar (*Juniperus virginiana*), eastern baccharis (*Baccharis halimifolia*), and live oak (*Quercus virginiana*). In areas where salt spray is less prevalent, vegetation such as black willow (*Salix nigra*), redbay (*Persea borbonia*), blueberry (*Vaccinium corymbosum*), wild olive (*Osmanthus americana*), yaupon (*Ilex vomitoria*), red maple (*Acer rubrum*), and loblolly pine (*Pinus taeda*) occur.

Maritime Forests are usually found on stabilized dune systems located on the sound side of barrier islands. Although these areas rarely flood, they are subjected to salt spray, wind shear, and poor soil conditions (low water, nutrient availability). Vegetation common to these dune swale communities includes: loblolly pine, red maple, live oak, laurel oak (*Quercus laurifolia*), wax myrtle, redbay, and red cedar. Soils found on all the above sites are typically mineral and have a sandy particle size prevalent throughout the limited horizontal development (e.g., Typic Psammaquents).

Swamp Forests/ Bottomland Hardwood (restoration type = 4)

Riverine swamp and bottomland hardwood forests are found in the floodplains of major rivers and streams. Depressional swamps are not associated with riverine systems and are found in more isolated depressional areas. While riverine swamps and bottomland hardwood forests experience over-bank flooding from stream and rivers, depressional swamps are frequently flooded and/or nearly permanently saturated with groundwater. Vegetation typically found in swamp and bottomland hardwood forests includes many water-tolerant hardwoods such as: Bald cypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), swamp tupelo (*Nyssa sylvatica* var. *biflora*), Willow oak (*Quercus phellos*), Overcup oak (*Q. lyrata*) and Carolina ash (*Fraxinus caroliniana*). Common herbaceous species include lizard's tail (*Saururus cernuus*) and arrowhead (*Sagittaria* sp.). Soils found in swamp and bottomland hardwood forests may be organic (Typic Medisaprists) or mineral (Cumulic Humaquepts) and the riverine systems usually contain pockets of sandy (alluvial) deposits.

Bottomland Hardwood/Headwater Forest (restoration type = 5)

Bottomland hardwood forests are associated with fluvial or riverine systems whose hydrology is primarily controlled by over-bank flooding. Vegetation commonly found in bottomland hardwood forests includes: red maple, river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), American elm (*Ulmus americana*), overcup oak (*Quercus lyrata*), willow oak (*Quercus phellos*) green ash (*Fraxinus pennsylvanica*), and swamp tupelo. Soils common to bottomland hardwood sites are typically young mineral soils (Typic Fluvaquents or Humaquepts).

Headwater forests are often found along intermittent and/or the upper end of perennial streams (first order). While headwater forests may be irregularly flooded by surface runoff, their hydrology is typically controlled by seasonally high water tables (groundwater). Species common to headwater forest include: red maple, sweetgum (*Liquidambar styraciflua*), loblolly pine, tulip poplar (*Liriodendron tulipifera*), blackgum *(Nyssa sylvatica* var. *sylvatica*), and greenbriar (*Smilax* spp). Soils typical of headwater forests often have an upper horizon with significant amounts of organic matter and an argillic clay horizon, where the clay is moving down in the horizon.

This mapping program uses the Swamp/BLH type and the BLH/Headwater type because the boundaries between riverine swamp forests and bottomland forests and between bottomland forests and headwater forests are difficult to discern using remotely sensed data, especially for potential restoration and enhancement sites.

Wet Flatwoods (restoration type = 6)

Wet flatwood forests are located on broad, flat inter-stream divides. Typical hydrology for wet flatwoods is controlled by seasonally high water tables from local groundwater input. Local rainfall may have an impact on hydrology if the area is slightly depressional. Vegetation common to wet flatwoods includes: loblolly pine, sweetgum, red maple, willow oak, water oak (*Quercus nigra*), blackgum, longleaf pine (*Pinus palustris*), horsesugar *(Symplocos tinctoria*), hollies (*Ilex* sp.), and giant switchcane (*Arundinaria gigantea*). Soils in wet flatwoods are typically mineral which contain numerous redoximorphic features (from the fluctuating water table) with a significant clay layer in the lower horizons (e.g., Typic Paleaquults).

Pocosins (restoration type = 7)
Pocosin sites are found on slightly raised areas on inter-stream divides. This restoration type also includes some Carolina Bays and bay forests due to their similar vegetation types. Broad-leaved evergreen trees and shrubs dominate pocosins and bays. One of their distinguishing features is their dense shrub vegetation. Plant species typical of pocosins include: pond pine (*Pinus serotina*), sweet bay (*Magnolia virginiana*), loblolly bay (*Gordonia lasianthus*), hollies, blueberry, fetterbush *(Lyonia lucida*), sweet pepperbush (*Clethra alnifolia*), ti-ti (*Cyrilla racemiflora*), and laurel-leaf greenbriar (*Smilax laurifolia*). Pocosin soils may either be organic or mineral. Many of the organic soils of pocosins have a deep peat layer (Typic Medisaprists) while the mineral soils typically include a water restrictive (spodic) horizon (e.g., Typic Endoaquod).

Summary of Map Design
The most practical mapping unit due to initial data format, processing requirements, and ease of editing was determined to be the USGS 7.5 minute quadrangles. Potential restoration and enhancement sites are mapped primarily by their past vegetation type or soil type and the type of disturbance and current land cover of the site. Map legends are designed to reflect both the type of wetland appropriate for restoration on the site and the disturbance type. Different colors represent different wetland restoration types as described above (marsh, swamp/BLH, pocosin, etc.) and hatched patterns represent disturbance class (drained and cleared, impounded areas, excavated areas, enhancement sites, and managed pine areas.) A sample Potential Wetland Restoration and Enhancement Site map of the Buckridge Coastal Reserve in Tyrrell County, NC is shown on Figure 3.

Field Verification of Mapping Methods
After identifying an initial group of diverse potential restoration or enhancement sites using ARC/INFO, a sample set was selected for field verification. The ideal sample size for each data combination would be 40 sample sites. With six restored wetland types and five site types yielding 30 different classes, a fully intensive sampling would have required 1200 potential restoration site visits. Time and resources simply were not available to visit that number of sites, so a comprehensive random sample was not practical. Instead the field verification methodology used was designed to maximize statistically meaningful information within these constraints.

Sample sites were visited in three coastal counties (Craven, Carteret, and Jones) to verify the mapping methods. A total of 212 potential wetland restoration sites in 17 quadrangles were sampled. To ensure an equitable distribution of wetland restoration types, a stratified random sampling technique consisting of a sequential selection process that accounted for the six different restoration types and the five disturbance classes was used. The process began with the random selection of a specific wetland restoration type (*e.g*., swamp forest). Then, restoration types were randomly selected within each disturbance class (*e.g*., NWI impounded). Sites representing each combination of restoration type and disturbance class in the quadrangle were selected. This process was completed for the restoration and disturbance class combinations until approximately 40 sites per quadrangle were selected. As expected, certain restoration and disturbance class combinations were relatively infrequent or absent in some quadrangles.

On-site verification involved completing a data sheet (Appendix C) containing various site attributes and geo-locating the site with a Global Positioning System (GPS) unit. The data sheet included a brief vegetation description and a detailed examination of the soils. Soil characterization was based on several factors: amount of organic matter, texture, depth to water table, depth to mottling, and comparison to the Munsell Soil Color charts. Hydric soils and hydrology were identified in accordance with the 1987 Corps of Engineers Wetland Delineation Manual (Environmental Laboratory, 1987) and used to determine whether each site was a jurisdictional wetland. Site analyses provided a judgment of a restoration site type, land cover, verification of the hydrography layer and, ultimately, a recommendation to classify the site as restoration, enhancement, upland, or undisturbed wetland requiring no intervention.

Sites that lacked any one of the three jurisdictional wetland parameters (hydrophytic vegetation, hydric soils or wetland hydrology) were classified as restoration sites. Enhancement sites were defined as areas that were thought to meet jurisdictional wetland criteria, but were degraded. These sites usually displayed hydric soils and/or hydrology altered as a result of ditching or conversion to pine monoculture. Non-wetlands that were not considered former jurisdictional wetlands were classified as uplands.

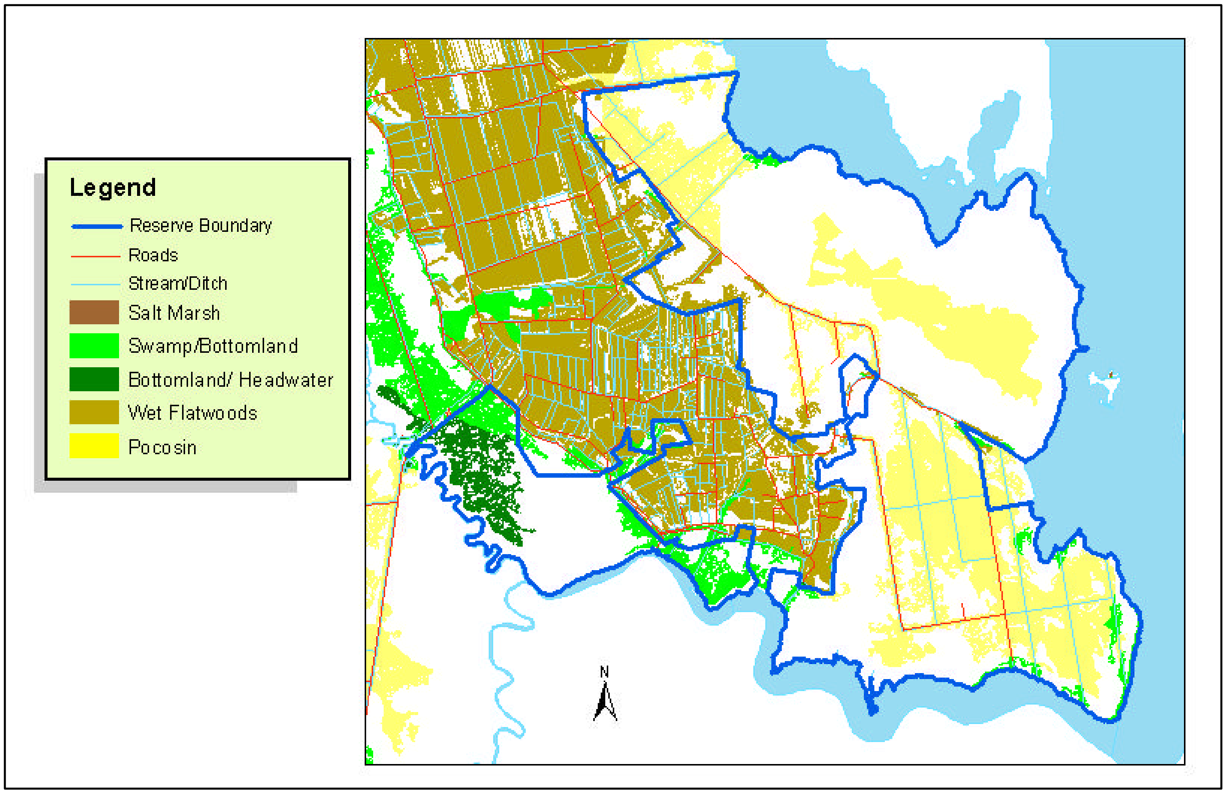

Figure 3. DCM Restoration and Enhancement Site data for Buckridge Coastal Reserve

Accuracy Assessment

Producers and users accuracies were calculated for the data with associated confidence intervals for each of the primary wetland restoration site types (Story and Congalton, 1986). Producers accuracy represents the probability that a wetland restoration site type identified on-site actually is in the wetland restoration site type class on the map. Producers accuracy covers possible errors of omission (errors leaving data out of its correct category). Users accuracy is the probability that a wetland restoration type that has been classified as such on the map is actually in that respective restoration type class on-site. Users accuracy covers possible errors of commission (errors putting data in the wrong category) (Story and Congalton, 1986).

The frequency of restoration, enhancement, and upland sites from the data set was also determined. An error matrix or contingency table for potential wetland restoration sites was created to demonstrate the accuracy of the potential restoration site maps (Table 2). The error matrix shows the union of two data sets: the field data and the map data. Confidence intervals are based on a method applicable to binomial proportions (Snedecor and Cochran, 1989). The equation included a correction for continuity at the 95% confidence limits as follows:

$$1.96(p*q/n)^{0.5} + 1/2n.$$

The correction for continuity was used primarily to widen confidence intervals for samples with a small sample size (n) and has little effect on the confidence intervals for samples with a large sample size (n) (Snedecor and Cochran, 1989).

Table 2. Error matrix for potential wetland restoration/enhancement sites.

	Mapped Data							
Field Verified Data	Rest. Type	BLH/ Hdwtr	Swamp Forest/ BLH	Wet Flat	Pocosi n	Marsh	Estuarine SS/Forest	Other	Total Mapped
	BLH/ Hdwtr	69	3	12		1		2	87
	Swamp For/ BLH	18	30	5		1		3	57
	Wet Flat	12		27	1				40
	Pocosin	1	1	6	4			2	14
	Marsh		1			9	1	3	14
	Est SS/For								
	Other								
	Total Verified	100	35	50	5	11	1	10	212

One of the primary objectives of this accuracy assessment was to determine the accuracy of the procedure in identifying disturbed wetland areas that would benefit from restoration or enhancement activities. Frequency values and confidence intervals for both producers and users accuracy are listed in Table 3. Accuracy data are expressed as: n correct / n total. Confidence interval values for the Marsh and Pocosin restoration site types were quite wide for both producers and users accuracies due to the small sample size.

Table 3. Producers and Users accuracies for five restoration types.

Wetland Types	Producers Accuracies	Users Accuracies
BLH/ Headwater	0.79±0.09	0.69±0.10
Swamp Forest	0.53±0.16	0.86±0.14
Wet Flatwood	0.68±0.16	0.54±0.15
Pocosin	0.29±0.27	0.80±0.45
Marsh	0.64±0.27	0.82±0.27

DCM determined that approximately 60% of the sample sites visited were actually potential restoration sites.

Enhancement sites were encountered 30% of the time from the sample pool. Only 10% of the sites mapped were not potential wetland restoration or enhancement sites. The cleared areas that were field verified were dominated by prior converted agricultural fields and managed pinelands. Staff visited 66 agricultural sites, all of which were classified as potential wetland restoration sites. Staff visited 51 potential sites on managed pinelands and determined that 45% of the managed pine sites were potential restoration sites, while 55% of the areas were probably enhancement sites. Of 212 samples, bottomland hardwood/headwater, swamp forests/bottomland hardwood, and wet flatwoods were the three most prevalent potential wetland restoration site types visited and comprised 87.2% of the total sample pool. We found from field verification that 1.5% of the total sample pool were upland sites. Another 8.7% of the sites visited were normally functioning wetlands where no restoration or enhancement was necessary.

There were 17 cases in which sites were reclassified from a wet flatwood type to a bottomland hardwood/headwater type (12 cases) or swamp forest/bottomland hardwood type (5 cases). This change of classification was done primarily on the basis of site morphology, soil characteristics, and drainage features including the size of the ditches and amount of flow. In each of these cases, on-site judgments regarding landscape position, hydrologic observations and antecedent weather conditions were made. The GIS procedure for identifying riverine sites was subsequently modified to improve the accuracy of differentiating these site types.

Overall results from the field verification of the mapping procedure were good. Only 10% of the sites identified as restoration or enhancement were re-classified as upland or undisturbed wetlands when field verified. Ninety percent of the sites mapped were correctly identified as restoration (60%) or enhancement (30%) sites. The procedure identified restoration sites on prior converted (PC) cropland with particular accuracy. The vast majority of error was introduced by the identification of managed pinelands that were very disturbed, but thought to have wetland hydrology. The procedure accurately predicted the correct post-restoration wetland type for two-thirds of the mapped areas.

The high level of accuracy of these data resulted in the expansion of the procedure throughout the 20 coastal counties of NC and later into 17 Inner Coastal Plain counties. Further field verification was performed in each county so that differences in landscape conditions and local factors could be taken into account. By visiting each county, DCM staff members were able to make any changes necessary to increase the accuracy of the maps. For example, in some areas, the classification of "cleared" areas was inaccurate. Noting these inaccuracies out in the field and making slight modifications to the data allowed some inaccuracies to be eliminated. An estimated 538 sites were visited during the field check phase of the expanded mapping effort in all 20 coastal counties and 17 Inner Coastal Plain counties.

Conclusions

Section 3

GIS Mapping Procedures

As with DCM's other GIS data, the restoration and enhancement site data are designed to be used as a decision support tool. The data provide an ecologically based approach to identifying wetland and riparian area restoration sites across river basins, physiographic regions and other large geographic areas. They are not meant to provide a substitute for field reconnaissance and on-site evaluations by knowledgeable restoration ecologists and wetland scientists. DCM's wetland restoration and enhancement site identification techniques do appear to be promising for directing pro-active restoration efforts, mitigation planning, alternatives analysis and siting mitigation banks.

While there are some problems and sources of error in the potential wetland restoration and enhancement site identification process, the technique successfully utilizes widely available data to identify degraded wetlands with 90% accuracy. Pre-disturbance wetland types were identified in 54-86% percent of the field-verified sites, depending on the former wetland type. Restoration sites, as opposed to enhancement sites, were identified with 60% accuracy. The vast majority of error was introduced by attempting to identify managed pinelands as potential restoration sites. The accuracy of the techniques for identifying restoration sites on prior-converted farmland was high.

Limitations of the GIS Approach

As with any GIS analysis, the quality and age of the data are key concerns in developing and refining these methods. Unresolved mapping and GIS analysis issues include the following:

- One key issue that affects GIS analyses of this type is the availability of accurate land use data. We used 1988 LandSat imagery for this study and found that 10 to 12 year old data created some problems in identifying cleared areas. For example, many of the areas that were cleared in 1988 are now managed pine plantations. Of the 40 managed pine sites visited during the accuracy assessment in 1995, just over half (21 sites) were found to be approximately 3 to 8 years old. Also, other "agricultural, bare grass" or "disturbed areas" on the LandSat imagery were actually field-verified as residential areas, city parks, or parking lots (12 sites). An updated and more accurate LandSat imagery data layer would substantially improve the accuracy of the mapping procedure.

- Inconsistencies in the digitization of the hydrography layer increased mapping error. Some aerial photo interpreters included ditches in the hydrography layer while others only included streams. Outdated and inconsistent hydrography data are a problem as many potential restoration and enhancement sites may have been missed.

- A way to accurately distinguish between riverine and non-riverine restoration sites would be a valuable addition to the procedure. As more useful data (*e.g*. digital elevation models) become available, efforts should be made to refine this component of the procedure.

- A more rigorous procedure for identifying channelized stream sections would be very useful. Gathering historical data, examination of NWI sites with an "x" modifier, aerial photographs, digital orthophotos, and refinement of hydrography layers through additional attributes may be beneficial. More accurate data on channelized streams may also prove helpful in stream restoration site searches.

- Roadway rights-of way occurring on hydric soils are often confused as forageland in the classification of satellite imagery. Erroneous identification of roadway rights-of-way as potential restoration sites could be reduced by an automated procedure that buffers primary roads approximately 150-300 feet and eliminates those polygons from consideration as candidate sites.

- Riparian areas without anthropogenic disturbance were often identified as potential restoration sites due to beaver impacts on canopy vegetation.

Implications for Riverine and Riparian Management Efforts

DCM found that riverine and riparian restoration areas are by their nature less prevalent in the landscape, smaller than non-riverine sites, more hydrologically complex to restore than other non-tidal wetland types, and are often controlled by several independent landowners whose properties are hydrologically interdependent. Given the inherent practical difficulties of performing ecologically meaningful compensatory mitigation for riparian wetlands within the permitting process time frame, better planning and creative approaches are needed. These approaches should be based on a systematic inventory and prioritization of potential riparian restoration corridors and might include:

- A strict requirement to avoid and minimize impacts to high quality riverine wetlands and riparian areas;

- Integrating efforts that provide incentives and compensation for protecting and restoring riparian areas;

- Pro-actively identifying and protecting highly functional riparian areas that are at greatest risk for conversion to developed land uses;

- Identifying high priority restoration corridors along streams with high potential habitat value and well documented water quality impairment due to non-point sources of sediment and nutrients;

- Preservation of existing riparian forest corridors which link and complement landscape level restoration planning, especially those with threatened and rare community types;

- Integrating the implementation of targeted and cost-effective urban and agricultural BMPs with ecosystem restoration based on watershed management strategies;

- Assessments of both site-specific and watershed level functions to manage and develop criteria for siting of mitigation banks;

- Proceeding with minimization and compensatory mitigation planning early in the project process through an integrated Section 404 / NEPA process; and

- Integrating wetland inventory, wetland functional assessment, potential wetland restoration site identification, and restoration site functional assessment into the planning stages of the NCDOT's Transportation Improvement Program (TIP).

In the past, compensation for impacts to riparian wetlands in North Carolina was often functionally out-of-kind (*i.e*. compensating for riparian impacts with non-riparian wetlands). Allowing the destruction of riparian wetlands in exchange for restored depressional wetlands that lack the suite of water quality, wildlife, fisheries, and other functions unique to riparian wetlands does not constitute a sound watershed management strategy. Given the formidable difficulties encountered in providing true functional replacement of wetlands and riparian areas, even when employing state of the art site location techniques, avoidance and minimization of impacts is still by far the most effective form of mitigation.

Local Coordination

Local knowledge is an extremely important resource. The NC Division of Soil and Water Conservation and NRCS District Conservationists, among others, were a valuable source of information on specific sites and landowners, soils and wetlands maps, and the shortcomings of information sources that are unique to their district during the field verification portion of the development of this mapping procedure. In addition, many NRCS District Conservationists were involved in field checking the validity of NWI maps in their districts. Significant effort, coordination, and education will be necessary to target restoration efforts in accordance with local Soil and Water Conservation District objectives. The local districts are undoubtedly the best mechanism for initial landowner contacts and coordination when targeting agricultural lands. Other agencies that can assist in this effort include local land trusts, The Nature Conservancy, Partnership for the Sounds and other non-profit organizations with roots in the community.

In reality, probably less than 10% of the areas identified as restoration areas will ultimately be available for acquisition or conservation easements. Availability is obviously a complicated matter due to land values, funding, hydrologic complications on the selected site or adjacent sites, landowner personalities and perceptions, and many other factors. Novel approaches to stakeholder involvement, education, and compensation must be developed, especially if we hope to restore substantial lengths of converted riparian wetlands and floodplains. Collective involvement of all landowners along a riparian corridor in a "blanket" conservation easement may be a promising approach. Such an approach, however, will require significant amounts of skilled negotiation and consensus building, not to mention time and resources.

Clearly, the GIS approaches presented in this report are very powerful tools for inventorying all the candidate sites that exist in a particular geographic area. But even with a complex GIS revealing a vast array of good sites, the most challenging aspects of ecological restoration are still encountered on the ground: working with landowners and successfully restoring wetlands.

Future Efforts

The Restoration Functional Assessment Procedure or RFAP described earlier was developed by DCM for use in rating the functional significance of potential restoration and enhancement sites on a watershed basis. This model, is structured like the NCCREWS model, but rather than evaluating wetlands, it evaluates potential restoration and enhancement sites. The RFAP has been used in a pilot project to identify potential mitigation sites for a future NCDOT highway project. The criteria used to perform the site search were determined using our NCCREWS wetland functional assessment model to estimate the functional impacts likely to occur during the construction of the new roadway. Several potential mitigation sites were identified during this cooperative site identification effort. DCM contacted several landowners of potential mitigation sites, but only received permission to enter a few properties. Other potential sites were eliminated because they did not provide the correct habitat type, were not of the same quality as the high quality wetlands the highway project would impact, or were not feasible restoration sites. Of the five sites chosen from this group for extra study, none of them were chosen for acquisition as mitigation sites. Reasons for this included the potential for hydrologic trespass (when altering one site's conditions affects the hydrology of another site by making it wetter or drier), landscape position, unwillingness of landowners to sell their property and other problems with site feasibility. Due to the high quality riverine wetlands this highway project would impact and the lack of appropriate mitigation available in the vicinity of the project, NCDOT decided to bridge the high quality wetlands to avoid impacts to them. This plan had not been considered "practicable" because of the extremely high cost of bridging large floodplains until joint efforts to find appropriate mitigation had essentially failed.

In this pilot project, the RFAP was used as a support tool to supplement information from other sources in a decision making process that led to a commitment by the NCDOT to provide increased avoidance and minimization of wetland impacts beyond what had been identified as "practicable." A GIS model was used to search a large area for sites, select sites that most closely matched the anticipated impact areas for further study, and determine that acceptable compensatory mitigation for those impacts was not available in the vicinity of the project. The RFAP model has a lot of potential to assist in the prioritization of potential mitigation sites throughout the NC Coastal Plain. Since the model is watershed based it will be practical to use in conjunction with the many watershed-based planning efforts that are ongoing. In addition it can be used with the NCCREWS model to identify mitigation sites that are functionally similar to impacted wetlands to provide in-kind functional replacement of wetlands.

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Appendix A

Wetland Type Definitions

Salt/Brackish Marsh (w-type 1)
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 watercourses), as long as this flooding does not include hurricane or tropical storm waters. Plant species include: smooth cordgrass; black needlerush; glasswort; salt grass; sea lavender; salt marsh bullrush; saw grass; cattail; salt meadow cordgrass; and big cordgrass. Marshes in this category are also called Coastal Marshes.

Freshwater Marsh (w-type 2)
Herbaceous areas that are flooded for extended periods during the growing season. Included are marshes within lacustrine systems, managed impoundments, some Carolina Bays, and other non-tidal marshes (i.e. marshes which do not fall into the Salt/Brackish Marsh category). Typical communities include species of sedges, millets, rushes and grasses that are not specified in the coastal wetland regulations. Also included are giant cane, arrowhead, pickerelweed, arrow arum, smartweed, and cattail.

Estuarine Shrub Scrub (w-type 3)
Any shrub/scrub dominated community subject to occasional flooding by tides, including wind tides (whether or not the tide waters reach the marshland areas through natural or artificial watercourses). Typical species include wax myrtle and eastern red cedar.

Pocosin (w-type 4)
Palustrine scrub/shrub communities (i.e. non-Estuarine Scrub/Shrub) dominated by evergreen shrubs, often mixed with pond or loblolly pines. Typically occur on saturated, acid, nutrient poor, sandy or peaty soils; usually removed from large streams; and subject to periodic burning.

Bottomland Hardwood and Riverine Swamp Forest (w-type 6, 7)
Riverine forested or occasionally scrub/shrub communities usually occurring in floodplains, that are semi-permanently to seasonally flooded. In bottomland hardwood systems, typical species include oaks (overcup, water, laurel, swamp chestnut), sweet gum, green ash, cottonwoods, willows, river birch, and occasionally pines. In swamp forest systems, typical species include cypress, black gum, water tupelo, green ash and red maple.

Depressional Swamp Forest (w-type 7)
Very poorly drained non-riverine forested or occasionally scrub/shrub communities that are semi-permanently or temporarily flooded. Typical species include cypress, black gum, water tupelo, green ash and red maple. These are distinguished from riverine swamp forests in the data by having a hydrogeomorphic (hgm) class of flat (f).

Hardwood Flat (w-type 9)
Poorly drained interstream flats not associated with rivers or estuaries. Seasonally saturated by a high water table or poor drainage. Species vary greatly but often include sweet gum and red maple.

Pine Flat (w-type 10)
Palustrine, seasonally saturated pine communities on hydric soils that may become quite dry for part of the year. Generally occur in flat or nearly flat areas that are not associated with a river or stream system. Usually dominated by loblolly pine. This category does not include managed pine systems.

Appendix A, continued

Managed Pineland (w-type 11)
Seasonally saturated, managed pine forests (usually loblolly pine) occurring on hydric soils. This wetland category may also contain non-managed pine forests occurring on hydric soils. Generally these are areas that were not shown on National Wetlands Inventory maps. These areas may or may not be jurisdictional wetlands. Since this category is based primarily on soils data and 30 meter resolution satellite imagery, it is less accurate than the other wetland categories. The primary criteria for mapping these areas are hydric soils and a satellite imagery classification of 'pine forest'.

Estuarine Forested (w-type 15)
A forested wetland community subject to occasional flooding by tides, including wind tides (whether or not the tide waters reach the these areas through natural or artificial watercourses). Examples include pine-dominated communities with rushes in the understory or fringe swamp communities such as those that occur along the Albemarle and Pamlico sounds.

Maritime Forest (w-type 16)
A forested community characterized by its stunted growth due to the stresses imposed by its proximity to salt spray from the ocean. Typical vegetation includes live oak, red maple and swamp tupelo.

Headwater Swamp (w-type 17)
Forested systems along the upper reaches of first order streams. These include hardwood-dominated communities with soil that is moist most of the year. Channels receive their water from overland flow and rarely overflow their banks.

Human Impacted Area (w-type 40)
Areas of human impact have physically disturbed the wetland, but the area is still wetland. Impoundments and some cutovers are included in this category, as well as other disturbed areas, such as power lines.

Wetland Modifier Explanation:
Drained: add 20 to w-type (e.g., drained hardwood flat = 29)
Cleared: add 40 to w-type (e.g., cleared pocosin = 44)
Cutover: add 60 to w-type (e.g., cutover pine flat = 70)
Note that these modifiers are not applicable to Managed Pine and Human Impacted wetland types.

Partially Drained Wetland (w-type 21-37)
Any wetland system described above that is, or has been, partially drained/ditched according to the US Fish & Wildlife Service's National Wetland Inventory maps.

Cleared Wetland (w-type 41-57)
Areas of hydric soils for which satellite imagery indicates a lack of vegetation in *both* 1988 *and* 1994. These areas are likely to no longer be wetlands.

Cutover Wetland (w-type 61-77)
Areas for which satellite imagery indicates a lack of vegetation in 1994. These areas are likely to still be wetlands, however, they have been recently cut over. The vegetation in cutover areas may be regenerating naturally, or the area may in use for silvicultural activities.

Appendix A, continued

HGM Descriptions

Riverine HGM Classification (r)

These wetlands are those in which hydrology is determined or heavily influenced by proximity to a perennial stream of any size or order. Overbank flow from the stream exerts considerable influence on their hydrology.

Flat/Depressional HGM Classification (f)

These wetlands are generally not in direct proximity to surface water. While they may be either isolated from or hydrologically connected to surface water, the hydrology of depressional wetlands is primarily determined by groundwater discharge, overland runoff, and precipitation.

Headwater HGM Classification (h)

These wetlands exist in the uppermost reaches of local watersheds upstream of perennial streams. Headwater systems may contain channels with intermittent flow, but the primary sources of water input are precipitation, overland runoff, and groundwater discharge rather than overbank flow from a stream.

Estuarine Wetlands (e)

This code was added to DCM's wetlands data for clarity, as these wetlands do not generally fit into the other three HGM classes. These wetlands are generally found along the margins of estuaries and sounds and sometimes exhibit tidal regimes.

Appendix B

Soil Information Table for Restoration Types. Soil types were used to classify sites into "rest types" for each county. This table shows the classifications for Carteret, Craven and Jones counties.

County	*Soil Series Name*	*Restoration Type*	*Taxonomic Subgroup*
Carteret	***Arapahoe***	***6***	***Typic Humaquept***
Carteret	***Belhaven***	***7***	***Terric Medisaprist***
Carteret	***Carteret***	***1***	***Typic Psammaquent***
Carteret	***Croatan***	***7***	***Terric Medisaprist***
Carteret	***Dare***	***7***	***Typic Medisaprist***
Carteret	***Deloss***	***2 or 6***	***Typic Umbraquult***
Carteret	***Duckston***	***2***	***Typic Psammaquent***
Carteret	***Dorovan***	***4***	***Typic Medisaprist***
Carteret	***Hobucken***	***1***	***Typic Hydraquent***
Carteret	***Lafitte***	***1***	***Typic Medisaprist***
Carteret	***Leon***	***6***	***Aeric Alaquod***
Carteret	***Masontown***	***4***	***Cumulic Humaquept***
Carteret	***Murville***	***7***	***Umbric Endoaquod***
Carteret	***Pantego***	***6***	***Umbric Paleaquult***
Carteret	***Ponzer***	***7***	***Terric Medisaprist***
Carteret	***Rains***	***6***	***Typic Paleaquult***
Carteret	***Roanoke***	***6***	***Typic Endoaquult***
Carteret	***Tomotley***	***6***	***Typic Endoaquult***
Carteret	***Torhunta***	***6***	***Typic Humaquept***
Carteret	***Wasda***	***7***	***Histic Humaquept***
Craven	***Arapahoe***	***6***	***Typic Humaquept***
Craven	***Bayboro***	***6***	***Umbric Paleaquult***
Craven	***Croatan***	***7***	***Terric Medisaprist***
Craven	***Dare***	***7***	***Typic Medisaprist***

County	*Soil Series Name*	*Restoration Type*	*Taxonomic Subgroup*
Craven	***Deloss***	***6***	***Typic Umbraquult***
Craven	***Dorovan***	***4***	***Typic Medisaprist***
Craven	***Grantham***	***6***	***Typic Paleaquult***
Craven	***Leaf***	***6***	***Typic Albaquult***
Craven	***Lafitte***	***1***	***Typic Medisaprist***
Craven	***Leon***	***6***	***Aeric Alaquod***
Craven	***Meggett***	***6***	***Typic Albaqualf***
Craven	***Masontown***	***4***	***Cumulic Humaquept***
Craven	***Murville***	***7***	***Umbric Endoaquod***
Craven	***Pantego***	***6***	***Umbric Paleaquult***
Craven	***Ponzer***	***7***	***Terric Medisaprist***
Craven	***Rains***	***6***	***Typic Paleaquult***
Craven	***Roanoke***	***6***	***Typic Endoaquult***
Craven	***Tomotley***	***6***	***Typic Endoaquult***
Craven	***Torhunta***	***6***	***Typic Humaquept***
Jones	***Bayboro***	***6***	***Umbric Paleaquult***
Jones	***Croatan***	***7***	***Terric Medisaprist***
Jones	***Grantham***	***6***	***Typic Paleaquult***
Jones	***Grifton***	***6***	***Typic Endoaquult***
Jones	***Hobonny***	***1***	***Typic Medisaprist***
Jones	***Leaf***	***6***	***Typic Albaquult***
Jones	***Leon***	***6***	***Aeric Alaquod***
Jones	***Meggett***	***6***	***Typic Albaqualf***
Jones	***Muckalee***	***4***	***Typic Fluvaquent***
Jones	***Murville***	***7***	***Umbric Endoaquod***
Jones	***Pantego***	***6***	***Umbric Palequult***
Jones	***Rains***	***6***	***Typic Paleaquult***

County	Soil Series Name	Restoration Type	Taxonomic Subgroup
Jones	***Stockade***	***6***	***Typic Umbraqualf***
Jones	***Torhunta***	***6***	***Typic Humaquept***
Jones	***Woodington***	***6***	***Typi c Paleaquult***

Appendix C

WERC AML (there are other AMLs that support this process, this one serves as an example of the routine that is run to identify potential restoration and enhancement sites)

```
&echo &on
&arg cov_name
precision double
&watch %cov_name%_watch
&sv beg_time [date -vfull]

&if [null %cov_name%] &then
&return &error \You did not enter a coverage (quad name)--\~
USAGE: &RUN WERC <coverage>
&if [exists cov_copy -cover] &then
kill cov_copy all
&if [exists hydr_copy -cover] &then
kill hydr_copy all
&if [exists dit_buf -cover] &then
kill dit_buf all
&if [exists ditches -cover] &then
kill ditches all
&if [exists str_buf -cover] &then
kill str_buf all
&if [exists streams -cover] &then
kill streams all
&if [exists %cov_name%_tmpnl -cover] &then
kill %cov_name%_tmpnl all


copy %cov_name%_cov2 cov_copy


/****** Reselect and clip nl24_nc to get quad neatlines ******
reselect %.bndry%/nl24_nc %cov_name%_tmpnl poly
res TILE-NAME = [quote [unquote [upcase %cov_name%  ]]]
~
n
n
```

```
/***************************************************************
/*Clip cama area 24k hydrography coverage to generate temporary
/*hydrography coverage
/*Note that hydrography update must be complete since this aml
/* utilizes both ditch and order items

clip /hydro/hyd24/hyd24_cm %cov_name%_tmpnl hydr_copy net
build hydr_copy lines
kill %cov_name%_tmpnl all

/***************************************************************

/*Generate a coverage that contains all ditches buffered 100'

reselect hydr_copy ditches line
res ditch = 1
[unquote '']
n
n
buffer ditches dit_buf # # 100
kill ditches all

/*Generate a coverage that contains all perennial and intermittent
/*streams and ditches with order > 1 buffered 100' (these are usually
/*channelized streams)

reselect hydr_copy streams line
res minor1 in {412,413,605,606,610}
[unquote '']
n
y
res ditch <> 1
[unquote '']
n
y
asel minor1 in {412,413,605,606,610} and ditch = 1 and order > 1
[unquote '']
n
n
buffer streams str_buf # # 100
kill streams all
kill hydr_copy all

/*add temporary and permanent items necessary for analyses if
/* they don't already exist

&severity &error &ignore
additem cov_copy.pat cov_copy.pat d_mod 2 2 b
additem cov_copy.pat cov_copy.pat ditch_buff 2 2 b
additem cov_copy.pat cov_copy.pat stream_buff 2 2 b
additem cov_copy.pat cov_copy.pat noveg 2 2 b
additem cov_copy.pat cov_copy.pat werc_type 2 2 b
```

```
additem cov_copy.pat cov_copy.pat rest_type 2 2 b
dropitem cov_copy.pat cov_copy.pat soil_type
dropitem cov_copy.pat cov_copy.pat site_type
&severity &error &fail


&terminal 9999

arcplot
disp 0

/* Add a relate to lookup table containing soils information for each
/*county.  This lookup table contains columns "resttyp" and "pocosin"
/* which indicate probable restoration site types for various soil
/* mapping orders

relate add
veg
/gis3/lori/hsoillut
INFO
co_soil
co_soil
linear
ro
~
calc cov_copy poly d_mod = 0
calc cov_copy poly ditch_buff = 0
calc cov_copy poly stream_buff = 0
calc cov_copy poly noveg = 0
calc cov_copy poly werc_type = 0
calc cov_copy poly rest_type = 0


/*Define items for ditch buffer and stream buffer
/*All polys within 100' of a stream and/or ditch are tagged
res cov_copy poly overlap dit_buf poly passthru
calculate cov_copy poly ditch_buff = 1
clearsel
res cov_copy poly overlap str_buf poly passthru
calculate cov_copy poly stream_buff = 1
clearsel


/*Define d_mod and noveg items
/* d_mod indicates NWI "d" modifier for drained / ditched wetlands
res cov_copy poly nwi-name cn 'd'
calculate cov_copy poly d_mod = 1
clearsel
/*Identify noveg areas using the APES LandSat categories
/*"Agriculture / Bare Grass" and "Disturbed Land"
res cov_copy poly grid-code in {6,12}
unsel cov_copy poly cleared = 0       /*Added 9/98, cjb
```

```
calculate cov_copy poly noveg = 1
clearsel
/*Utilize the "Low Density Vegetation" category for areas
/*which should be forested based on soils or NWI
res cov_copy poly grid-code = 7
res cov_copy poly veg//resttyp in {4,5,6,7}
calculate cov_copy poly noveg = 1
clearsel
res cov_copy poly grid-code = 7
res cov_copy poly nwi-name cn 'FO'
calculate cov_copy poly noveg = 1
clearsel

/******SITE IDENTIFICATION*************************************
/*Nine site types / data combinations are identified in an item
/* called werc_type

/*Prior Converted Sites
/*1) hydric soil + NWI upland or PEM1A, PSS1A, PSS1C + noveg
/*(Land Use/Land Cover codes 6,7,12) (soil_type 7 = Pocosin Soils)
/*Note: PSS1* sites on Histosols are not selected
res cov_copy poly nwi-name in {'PEM1A','PSS1A','PSS1C'}
aselect cov_copy poly w-type = 0
res cov_copy poly noveg = 1 and h-soil = 1
unselect cov_copy poly nwi-name in {'PSS1A','PSS1C'} and veg//pocosin = 1
calculate cov_copy poly werc_type = 1
clearsel

/*NWI wetlands - select three types of potential restoration sites
/*2) "d" modifier + hydric soils + noveg (Land Use/Land Cover
/*codes 6,7,12)
/*3) noveg + hydric soils, no "d" modifier
/*4) "d" modifier + hydric soils, not noveg
res cov_copy poly noveg = 1 and h-soil = 1
unselect cov_copy poly w-type = 0
calculate cov_copy poly werc_type = 3
clearsel
res cov_copy poly d_mod = 1 and h-soil = 1
calculate cov_copy poly werc_type = 4
res cov_copy poly noveg = 1
calculate cov_copy poly werc_type = 2
clearsel

/*Managed Pinelands
/*5) hydric soil + NWI upland + pine monoculture (Land Use/Land Cover code 8)
res cov_copy poly werc_type = 0
res cov_copy poly w-type = 11
calculate cov_copy poly werc_type = 5
clearsel

/*Impoundments
/*Polygons with NWI "h" modifier including PFO5G + SCS hydric soil or 'w'.
```

```
/*'RB','L1UB3H','L2EM2K3','L2AB3K3','PEM2K' are not
/*selected.
res cov_copy poly nwi-name cn 'h'
unselect cov_copy poly nwi-name in {'L1UB3Hh','L2EM2K3h','L2AB3K3h','PEM2Kh'}
unselect cov_copy poly nwi-name cn 'RB'
aselect cov_copy poly nwi-name = 'PFO5G'
res cov_copy poly h-soil = 1 or soil in {'w','W','water','Water'}
calculate cov_copy poly werc_type = 6
clearsel

/* Excavated areas and spoil areas
/*"x" and/or "s" NWI modifier without a rock bottom + hydric soil
res cov_copy poly nwi-name cn 'x'
aselect cov_copy poly nwi-name cn 's'
unselect cov_copy poly nwi-name cn 'RB'
res cov_copy poly h-soil = 1
calculate cov_copy poly werc_type = 7
clearsel

/*Potential Enhancement Sites
/*8) hydric soil + NWI upland or PEM1A, PSS1A, PSS1C +
/*vegetated (Land Use/Land Cover codes 9-11,14-17) + intersects
/*drainage buffer
/*9) NWI wetland intersecting drainage buffer with hydric soils
res cov_copy poly werc_type = 0
res cov_copy poly nwi-name in {'PEM1A','PSS1A','PSS1C'}
aselect cov_copy poly w-type = 0
res cov_copy poly ditch_buff = 1 and h-soil = 1
unselect cov_copy poly nwi-name in {'PSS1A','PSS1C'} and veg//pocosin = 1
res cov_copy poly lu# in {9,10,11,14,15,16,17}
calculate cov_copy poly werc_type = 8
clearsel
res cov_copy poly werc_type = 0
res cov_copy poly ditch_buff = 1 and h-soil = 1
unselect cov_copy poly w-type = 0
res cov_copy poly werc_type = 0
calculate cov_copy poly werc_type = 9
clearsel

/*Assign probable community types based on soils
/*and proximity to water bodies in item REST_TYPE
/*
/*Rest_types:
/*1) Marsh
/*2) Estuarine SS, Estuarine FO, Maritime possibly containing marsh
/*3) Same as 2 w/o possibility of marsh (NO LONGER UTILIZED)
/*4) Swamp Forest / BLH - Riverine or Depressional Mucks (e.g. Masontown
series)
/*5) BLH / Headwater - Riverine - Mineral soil
/*6) Wet Flat
/*7) Pocosin
```

```
/*Define rest_type for polys with a werc_type
res cov_copy poly werc_type > 0
res cov_copy poly veg//resttyp = 1
calculate cov_copy poly rest_type = 1
clearsel
res cov_copy poly werc_type > 0
res cov_copy poly veg//resttyp = 2
calculate cov_copy poly rest_type = 2
clearsel
res cov_copy poly werc_type > 0
res cov_copy poly veg//resttyp = 3
calculate cov_copy poly rest_type = 3
clearsel
res cov_copy poly werc_type > 0
res cov_copy poly veg//resttyp = 4
calculate cov_copy poly rest_type = 4
clearsel
/*Note that in the following steps that those sites with
/*mineral soils supporting wet flats and overlapping the
/*stream buffer are assigned a rest_type of 5 (BLH / Headwater)
res cov_copy poly werc_type > 0
res cov_copy poly veg//resttyp = 6
calculate cov_copy poly rest_type = 6
res cov_copy poly stream_buff = 1
calculate cov_copy poly rest_type = 5
clearsel
res cov_copy poly werc_type > 0
res cov_copy poly veg//resttyp = 7
calculate cov_copy poly rest_type = 7
clearsel

quit /*arcplot

/*Clean up and lose unecessary items

kill dit_buf all
kill str_buf all

dropitem cov_copy.pat cov_copy.pat d_mod
dropitem cov_copy.pat cov_copy.pat ditch_buff
dropitem cov_copy.pat cov_copy.pat stream_buff
dropitem cov_copy.pat cov_copy.pat noveg

&if [exists [entryname %cov_name%]_werc -cover] &then
kill [entryname %cov_name%]_werc all
rename cov_copy [entryname %cov_name%]_werc

relate drop
   veg
  [unquote '']

 /* add to check the rest_type and werc_type by ming, 7/18/95
```

```
          ap
          &fullscreen &off
          disp 0
          clearsel
          res [entryname %cov_name%]_werc poly werc_type > 0 and rest_type = 0
          unsel [entryname %cov_name%]_werc poly soil in {'w' 'W'}
          unsel [entryname %cov_name%]_werc poly cty = 0
          statistics [entryname %cov_name%]_werc poly soil
          max area
          end
          statistics [entryname %cov_name%]_werc poly werc_type
          max area
          end

          clearsel
          res [entryname %cov_name%]_werc poly werc_type = 0 and rest_type > 0
          unsel [entryname %cov_name%]_werc poly soil in {'w' 'W'}
          unsel [entryname %cov_name%]_werc poly cty = 0
          statistics [entryname %cov_name%]_werc poly soil
          max area
          end
          statistics [entryname %cov_name%]_werc poly rest_type
          max area
          end
          quit

&type Beginning Time:              %beg_time%
&type Ending Time:                 [date -time]

&watch &off
&echo &off
```

Appendix D

DCM restoration field data form used during accuracy assessment

Site ID #: NWI / USGS Quad: County:

Date: Checked by:
Time:
Directions to Site:

Vegetation

Provide a brief description of plant community(s) present on-site:

Is there regeneration of woody seedlings (indicate species)?

Are there any nuisance species present (e.g. Phragmites australis, Typha spp.)?

Hydrology / Soils

Is there evidence of:

scouring sedimentation rack buttressing watermarks ponding

Are there obvious sources of surface water input on or near the site? Describe briefly.

If soil coring (<3 cores) is feasible, briefly describe the following:

Depth of water table:

Depth to mottling:

Presence of hydric soil:

Hue/Value/Chroma:

General Site Attributes

Does the site appear to meet jurisdictional wetland criteria pursuant to the 1987 manual? If not, why?
_______vegetation _______soils _______hydrology

Does the actual size and shape of site match map area? Indicate any obvious discrepancies.

Indicate suspected form(s) of past disturbance (circle all that apply):

tillage   fallow / pasture   timber harvest   conversion to pine   beaver   N/A

cleared/other   impounded   ditched   filled/excavated   channelized   compaction

DCM Restoration-site Type:

Expected from map : Marsh   Marsh,Est SS/FO,Maritime   Swamp For/BLH
(circle one)

BLH/Headwater   Wet flatwood   Pocosin   other:_____________

Found, based soils/hydrology: Marsh Marsh,Est SS/FO,Maritime   Pocosin
(circle one)

BLH/Headwater   Wet flatwood   Swamp For/BLH   other:____________

Land Cover / Land Use

Expected: Ag/Silv conversion (cleared)   Managed Pinelands   Ditches only
(circle one)

Impounded   Excavated   other:________________

Found: Ag/Silv conversion (cleared)   Managed Pinelands   Ditches only
(circle one)

Impounded   Excavated   other:_______________

Hydrography (Stream vs. Ditch / Canal / Impoundment) from USGS Hydrography Data

Expected: Streams   Ditches/Canals   Side Ditches   Impoundment   None

Found: Streams   Ditches/Canals   Side Ditches   Impoundment   None

Check one of the following that would best describe a wetland constructed or modified on this site:

Restoration ____   Enhancement____   Creation____

General Observations/Explanation of Discrepancies/Comments and Suggestions: