NCDENR Division of Coastal Management
GIS Data Guidance Document

GIS Potential Restoration and Enhancement Site Mapping for the North Carolina Coastal Plain

Background

Much of the North Carolina Coastal Plain is occupied by wetlands, which, in many areas, comprise 50 percent or more of the landscape. These wetlands are of great ecological importance, in part because they occupy so much of the landscape and are a significant component of virtually all coastal ecosystems. They are also important because of their relationships to coastal water quality, estuarine productivity, wildlife habitat, and the overall character of the coastal area. Historically, 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).

Increasing human alteration of the landscape continues to threaten the natural functions of wetlands. Alteration of wetlands 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 permitting and management 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.

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. 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).

Compensatory Mitigation Success

Although there are some examples of successful mitigation projects, 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 is not typically the primary goal for any permit applicant. In the past, an applicant that 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. Also, without adequate enforcement programs to ensure mitigation requirements and mitigation success criteria are met, remediation of failed mitigation projects is uncommon.

A 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 in their hydrology, vegetation, and soil characteristics, designing a mitigation project to meet certain ecological and regulatory criteria is 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.

A third reason for failed mitigation projects is the site selection process. In the past, mitigation site selection by a permittee has 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.

Using GIS Data

DCM's GIS restoration and enhancement site identification procedure analyzes several layers of GIS data to identify degraded wetlands and areas that formerly supported wetlands. In the North Carolina coastal area these GIS data layers either already existed or were developed as part of the DCM Wetland Conservation Plan. 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

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.

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. 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 that are tolerant of frequent regular flooding and high salt concentrations.

Estuarine Shrub/Scrub or Forest, Maritime Swamp 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. Maritime Swamp 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). Soils found on these 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. Non-riverine swamps are not associated with stream systems and are found in more isolated interstream areas. While riverine swamps and bottomland hardwood forests experience over-bank flooding from stream and rivers, non-riverine 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. 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. Soils common to bottomland hardwood sites are typically young mineral soils (Typic Fluvaquents or Humaquepts). Headwater wetlands are often found along intermittent and/or the upper end of perennial streams (first order). While headwater wetlands may be irregularly flooded by surface runoff, their hydrology is typically controlled by seasonally high water tables (groundwater). 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. 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). *Because of the difficulty in discerning potential pine flat restoration sites form hardwood flat restoration sites, this mapping program includes them in the same restoration category.*

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. 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).

Counties Mapped:

Beaufort	**Craven**	**Halifax**	**New Hanover**	**Sampson**
Bertie	**Cumberland**	**Hertford**	**Northampton**	**Tyrrell**
Bladen	**Currituck**	**Hyde**	**Onslow**	**Washington**
Brunswick	**Dare**	**Johnston**	**Pamlico**	**Wayne**
Camden	**Duplin**	**Jones**	**Pasquotank**	**Wilson**
Carteret	**Edgecombe**	**Lenoir**	**Pitt**	
Chowan	**Gates**	**Martin**	**Pender**	
Columbus	**Greene**	**Nash**	**Perquimans**	

For more detailed information on these data, please see DCM's publication: *The Potential Restoration and Enhancement Site Identification Procedure: A Geographic Information System for Targeting Wetland Restoration and Enhancement* (Williams, 2002).

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

Accuracy of the Data

One of the primary objectives of the initial accuracy assessment was to determine the accuracy of the procedure itself in identifying disturbed wetland areas that would benefit from restoration or enhancement activities. 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.

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. 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.

Future Efforts

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.

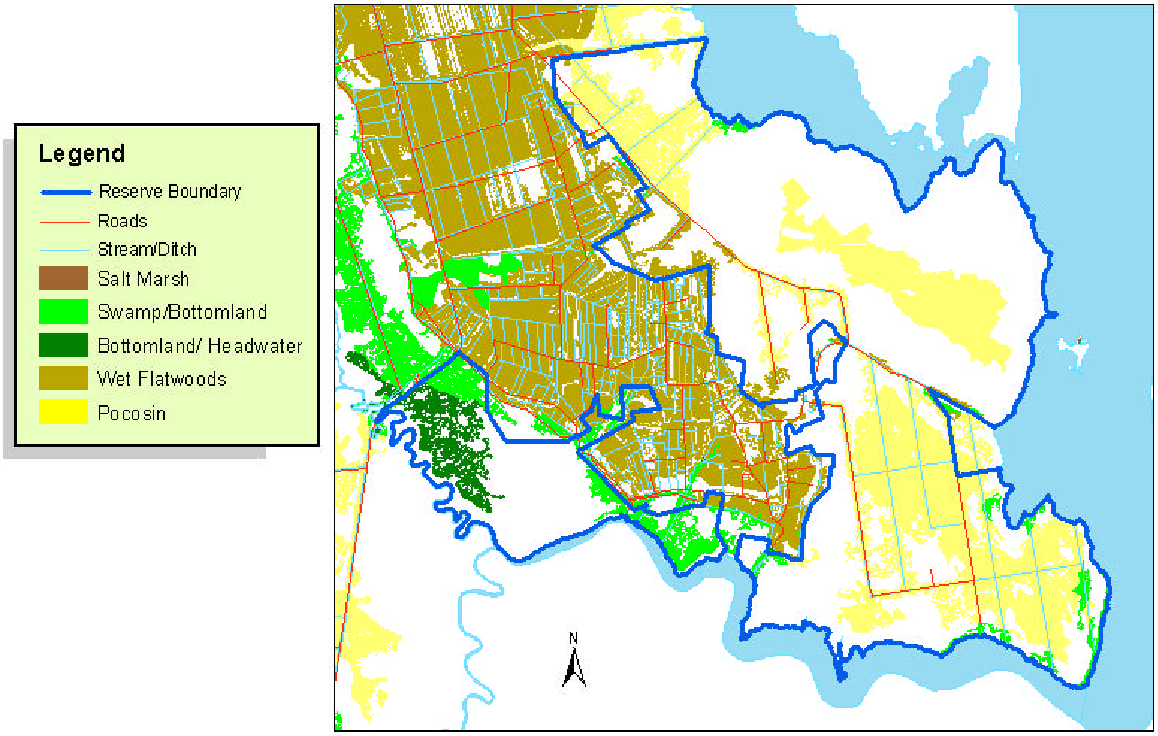

Figure 2. DCM Restoration and Enhancement Site data for Buckridge Coastal Reserve

Literature Cited

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Williams, K.B., 2002. The Potential Wetland Restoration and Enhancement Site Identification Procedure. NC Division of Coastal Management, Raleigh, NC.

For more information on DCM's GIS data or to get copies of detailed documents about these data contact DCM at 919-733-2293 or visit our website at www.nccoastalmanagement.net.