RESTORATION AND MANAGEMENT PLAN FOR THE EMILY AND RICHARDSON PREYER BUCKRIDGE COASTAL RESERVE, TYRRELL COUNTY, NORTH CAROLINA

A CONCEPTUAL APPROACH

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EXECUTIVE SUMMARY

The North Carolina Coastal Reserve Program aims to preserve unique coastal ecosystems as a setting for scientific research, public education, and recreation and traditional uses. Specifically, the goals for the Emily and Richardson Preyer Buckridge Coastal Reserve, located in Tyrrell County, are to preserve and restore its rare habitats and wildlife and to provide an undisturbed link between the adjacent Alligator River and Pocosin Lakes National Wildlife Refuges. The Preyer Buckridge Reserve is an undeveloped tract of swamp forest that contains rare natural communities and wildlife species. Yet, the site's hydrology has been altered by roads and ditches from past logging, though the extent of this alteration is unclear.

Restoration and management at the Reserve is directed toward restoring the natural hydrology and the rare natural communities, protecting and improving the water quality in the Alligator River, and protecting habitat at a watershed level. Toward that end, hydrological restoration will be the primary strategy. Supplemental strategies include planting, fire management, selective herbicide application, and selective forest cutting.

Prior to implementing restoration actions, basic information is needed to decide how to implement appropriate restoration actions. While some information is available, some basic research needs exist. For example, hydrology and water quality monitoring and modeling studies are planned and basic species inventories are recommended. In addition, monitoring of natural communities and restoration actions is essential. Finally, there are several management issues that must be considered when implementing restoration actions. These include: adjacent agricultural interests, road maintenance, hunting, ecotourism, non-native species, military airspace, carbon sequestration, and land additions to the Reserve.

CHAPTER 1
INTRODUCTION AND GOALS

"*Into this wilderness it seems impossible that the hand of human industry, or the foot of human wayfaring should ever penetrate; no wholesome growth can take root in its slimy depths; a wild jungle chokes up parts of it with a reedy, rattling covert for venomous reptiles; the rest is a succession of black ponds, sweltering under black cypress boughs -- a place forbid.*" - Frances Anne Kemble writing about the Great Dismal Swamp (1838), quoted in ***Discovering North Carolina*** (1991) edited by Jack Claiborne and William Price

"*By and large, a Southern swamp is one of the safest places in the world!*" - Brooke Meanley, ***Swamps, River Bottoms & Canebrakes*** (1972)

INTRODUCTION

Euro-Americans have long considered the expansive swamps of northeastern North Carolina and southeastern Virginia to be places of grave danger - sources of illness, disease, and death. Yet, prior to Euro-American settlement, Native Americans made their living hunting, gathering, and cultivating in these places. The remote swamps of the Emily and Richardson Preyer Buckridge Coastal Reserve are part of this vast landscape that is now valued as a sanctuary of natural beauty. Indeed, many of these ecologically valuable wetlands are owned and protected by state and federal agencies. Through funding partnerships with the U.S. Fish and Wildlife Service (Coastal Wetlands Conservation Grant Program), the N.C. Natural Heritage Trust Fund, and the N.C. Clean Water Management Trust Fund, the N.C. Division of Coastal Management purchased the Buckridge Coastal Reserve in June 1999 for the important values and functions that it provides to the nationally significant Albemarle-Pamlico Sounds region - the second largest estuary in the continental United States. On July 31, 2000, the site was formally dedicated as a State Nature Preserve and was re-named the Emily and Richardson Preyer Buckridge Coastal Reserve - the largest and first inland component in the North Carolina Coastal Reserve Program.

PURPOSE AND GOALS

First and foremost, the N.C. Coastal Reserve Program aims to preserve exceptional examples of unique coastal ecosystems. In addition, the program strives to provide both settings for research that aids coastal decision-making and platforms for public education about these valuable ecosystems. Coastal Reserves also provide opportunities for the public to personally experience nature through outdoor recreation, such as hiking and wildlife watching, and traditional uses, such as hunting and fishing.

Specifically, the goals for the Preyer Buckridge Coastal Reserve are to preserve and restore its rare habitats and wildlife and to provide an undisturbed link between the adjacent Alligator River and Pocosin Lakes National Wildlife Refuges (NWR). Logically, the Coastal Reserve Program will manage the Preyer Buckridge Reserve jointly with the U.S. Fish and Wildlife Service. Management goals are to provide a setting for research in peatland habitats, to allow traditional uses such as hunting and fishing, to promote ecotourism to this and other preserved areas throughout Tyrrell County, and to provide opportunities for public education. The goal of ecosystem restoration is to restore habitat and hydrology altered by past forestry activities.

CHAPTER 2
SITE DESCRIPTION

Location

The Preyer Buckridge Coastal Reserve (hereafter Buckridge or the Reserve) is an 18,652-acre (7,548 hectares / 29.1 sq. miles / 75.5 sq. km) site located in Tyrrell County, North Carolina along the Alligator River approximately 15 miles (24 km) southeast of Columbia (***Figures 1 and 2***). Situated in the community of Gum Neck, Buckridge is bounded to the east and south by the Alligator River and to the north by the Frying Pan embayment. The western boundary of the Reserve is adjacent to agricultural land in Gum Neck.

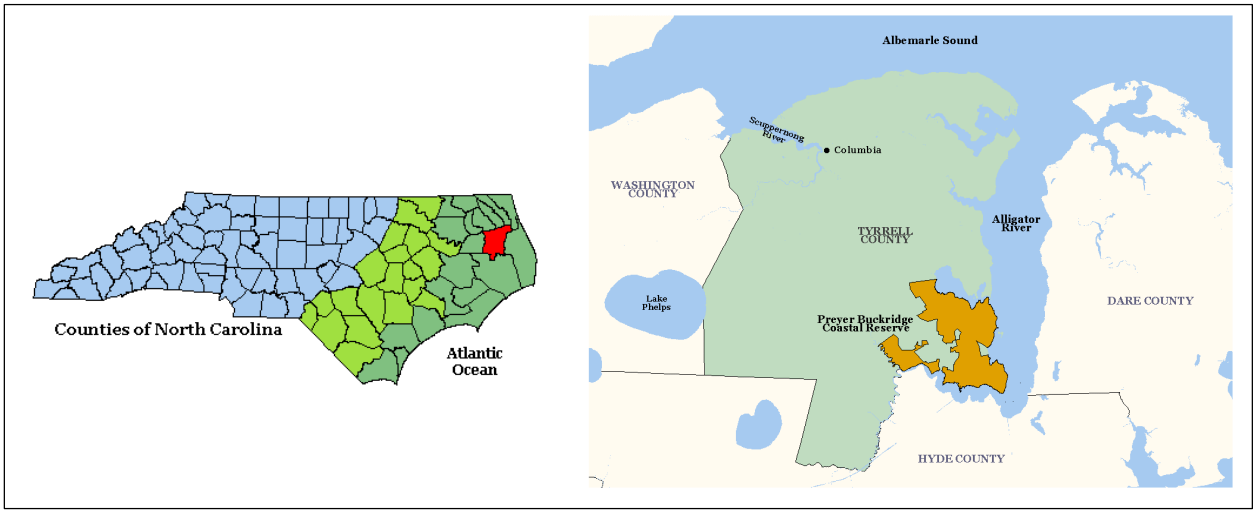

Figure 1. *Location of the Preyer Buckridge Coastal Reserve in Tyrrell County, North Carolina.*

Physiography and Geology

The Reserve is a large depressional and riverine wetland complex that lies along the Alligator River, located within the Coastal Plain Flatwoods physiographic region. This region is a flat, former sea floor that is currently above sea level (Holland Consulting Planners, 1998) and is dissected by low-gradient streams and rivers and wide, shallow sounds and bays. The Alligator River forms Tyrrell County's eastern and southern borders, while to the north lies the Albemarle Sound and to the west is Washington County (***Figure 1***). Tyrrell County's highest elevations are slightly above 15 feet in the southwest and its lowest elevations are near sea level along the Alligator River and the Albemarle Sound. In general, the county drains into the Albemarle Sound via the Scuppernong and Alligator Rivers and their tributaries (Tant et al., 1988).

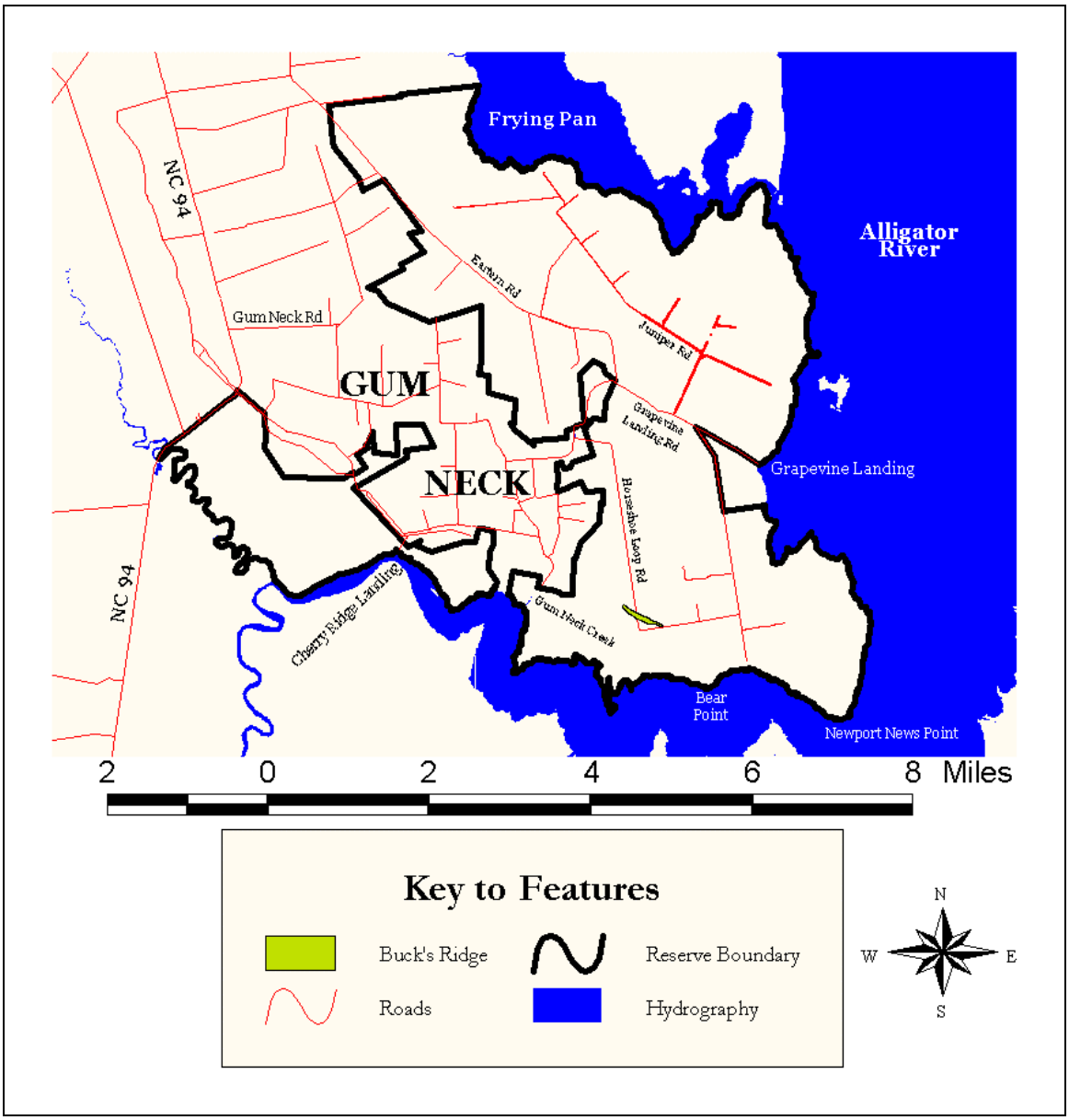

Figure 2. *Location of the Preyer Buckridge Reserve in Gum Neck, showing Buck's Ridge.*

The Alligator River region lies east of the Suffolk Scarp on the 1,266,000-acre (512,333 hectares) Albemarle-Pamlico Peninsula, comprising Tyrrell, Washington, and Hyde counties, the mainland of Dare County, and a portion of Beaufort County. The ocean covered the peninsula about 75,000 years ago prior to the most recent glacial expansion. As the ocean receded about 10,000 to 15,000 years ago, stream channels formed on the exposed sea floor (McMullan, 1984). From an analysis of peninsula soils, Daniel (1981) infers that they reflect "a branching pre-peat drainage system that flowed from the west end of the peninsula eastward to the southern end of the Alligator River." The peninsula is now characterized by widespread peat soils, decaying organic matter that is saturated for much, if not all, of the year (McMullan, 1984). Historical clay deposits indicate that there was considerable sediment transport via streams. Additionally, an open water phase likely led to sand ridges brought by storms or derived from the clay

deposits through wave action (Daniel, 1981). "Buck's Ridge," a 20-acre (8.1 hectares) island of mineral soils surrounded by the deep peats of the Reserve (***Figure 2***), is an example of this phenomenon.

Peat formation occurred as the result of blocked stream channels, frequent heavy rainfall, low drainage gradients, and fine-textured deposits that limited subsurface drainage. Under saturated conditions, anaerobic decomposition of fallen plant matter leads to peat formation (McMullan, 1984). Peat depth is not apparent from surface features, but it varies greatly. For example, peat depth at the Reserve ranges from 2-9+ feet. The soil formations that lie under the peat greatly influence the vegetative communities at the surface (Hinesley, 1999).

Climate

Tyrrell County experiences hot, humid summer weather with a July average of 78 degrees F (25.5 degrees C). Winter is cool, but rarely freezing, with a January average of 42 degrees F (5.5 degrees C). Hurricanes and tropical storms, delivering torrential rains and intense winds, are common from June to November (Tant et al., 1988). Rain occurs year-round with an annual average of 60.12 inches [range = 43.75 to 80.78 inches] (152.7 centimeters [range = 111.1 to 205.2 centimeters]) from 1985-2000 in the adjacent community of Gum Neck (Parker, 2001).

Soils

Soil information is derived from the *Soil Survey of Tyrrell County, North Carolina* (Tant et al., 1988) and has been confirmed by on-site soil samples. The soils at the Reserve are primarily mucks, or peat soils (***Figure 3***). The predominant soil types are Pungo, Dorovan, and Belhaven mucks. Although these soils are difficult to traverse, they are typically used for timber production.

Pungo muck is by far the most dominant soil type, covering approximately 75% of the Reserve. It is poorly drained with the seasonal water table at or near the surface. It is rarely flooded from the river and averages 5.5 feet thick (1.7 meters), though the underlying mucky loam may reach depths in excess of 9 feet (2.7 meters). It is highly decomposed, but there are logs, roots, and stumps throughout. At Buckridge, this soil type is dominated by Atlantic white cedar, pond pine, red maple, and sweetbay. It is associated with Dorovan and Belhaven mucks.

Dorovan muck occurs along the Alligator River, where it is frequently flooded by wind tides. It is very poorly drained and the seasonal water table is at or near the surface. It averages 8.5 feet thick (2.6 meters) and is often thicker. Baldcypress, blackgum, Atlantic white cedar, pond pine, and red maple are dominant species observed at the Reserve.

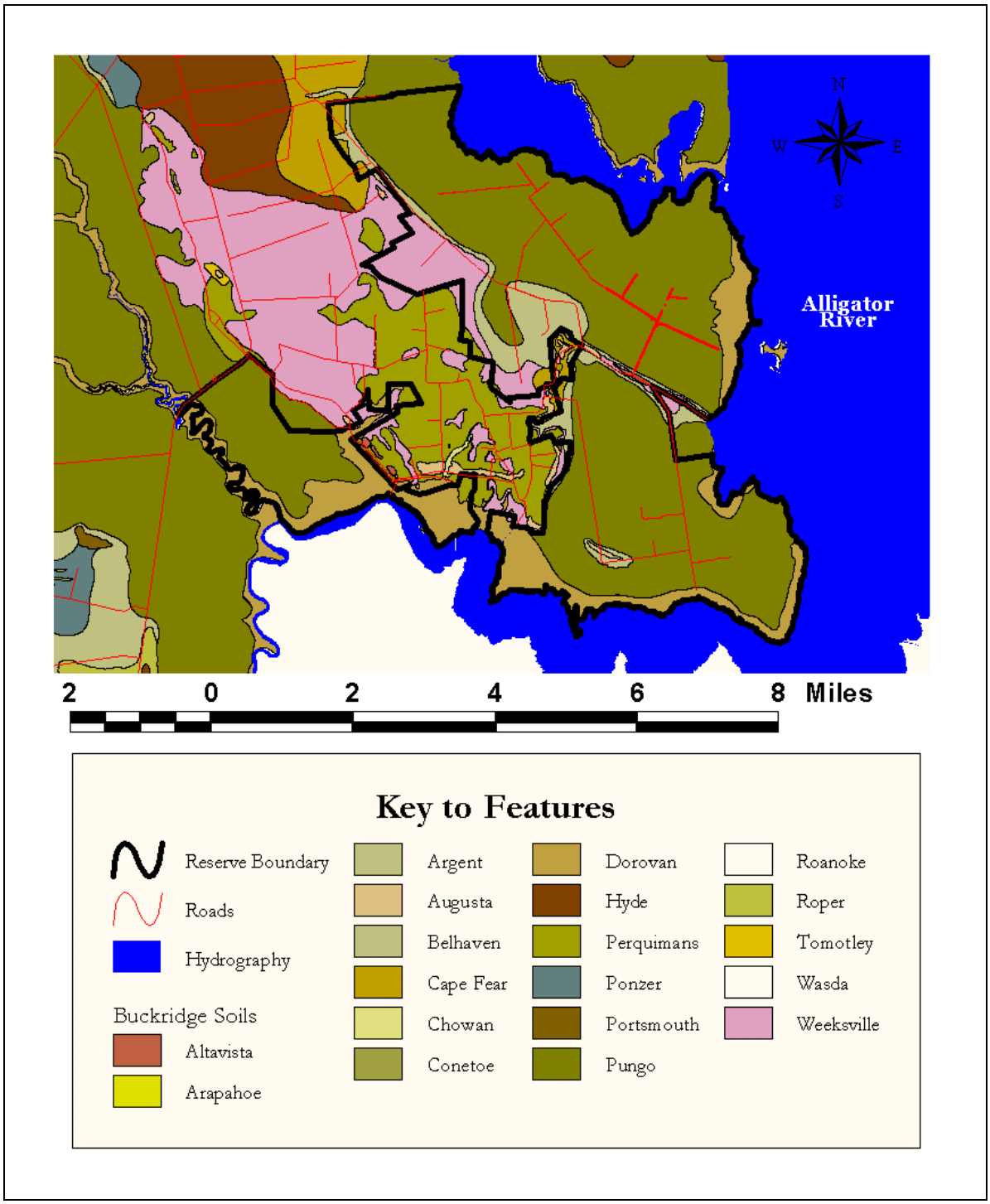

***Figure 3**. Soils at the Preyer Buckridge Reserve (Tant et al., 1988).*

Belhaven muck is rarely flooded and averages 3.5 feet thick (1 meter). It is very poorly drained and the seasonal high water table is at or near the surface. Dominant trees include red maple, Atlantic white cedar, pond pine, sweetgum, blackgum and baldcypress.

There are also small, irregular mineral soil ridges made of Augusta, a fine sandy loam. These are very rare and range from 5-20 acres (2-8 hectares). This soil is somewhat poorly drained with a seasonal high water table within 1-2 feet (0.3-0.6 meters) of the surface and is up to 5 feet thick (1.5 meters). An example at the Reserve is "Buck's Ridge," where observed dominant trees include loblolly pine, sweetgum, red maple, black cherry and water oak. It is probably the site of a contact period Native American village (Pruden, 2001).

Finally, Weeksville silt loam occupies one small portion along the northwestern edge of the Reserve where it borders agricultural land. This soil is rarely flooded from the river and averages 5 feet thick (1.5 meters). The soil is very poorly drained and the seasonal high water table is at or near the surface. It is mostly used as cropland, but sometimes it is used for timber production, as was the case at the Reserve. The dominant tree species observed at the Reserve include baldcypress, pond pine, red maple, sweetgum, and blackgum.

Hydrology

The Reserve occupies portions of two U.S. Geological Survey 14-digit hydrologic units separated by Gum Neck Creek – 03010205180010 to the east and 03010205210010 to the west (***Figure 4***). Most of the Reserve is depressional and is not flooded by the river except under extreme storm conditions; however, a narrow fringe of Dorovan soils along the Alligator River is regularly flooded by wind tides (Tant et al., 1988). Water flow dynamics at Buckridge represent a groundwater recharge/discharge system (NC DEHNR, 1997). Generally, water movement is characterized as surface and subsurface sheet flow from the mineral soils of adjacent agricultural lands towards the peat soils along the river (Daniel, 1981). Unlike neighboring pocosin wetlands that are entirely rainfall-dependent and extremely nutrient-poor, the Reserve's depressional swamp forests support larger vegetation such as Atlantic white cedar by receiving nutrients via rainfall and groundwater flow (Hinesley, 1999). Yet, sheet flow is very slow, even though soil saturation in peat soils can exceed 80%. In the upper soil horizon where the degree of peat decomposition is low, water flows consistently. Deeper in the peat soil where decomposition is more complete, however, groundwater flow may be negligible (Daniel, 1981). Thus, these depressional swamp forests are nutrient-limited.

The main influences on groundwater levels are precipitation and evapotranspiration (Daniel, 1981). Seasonal fluctuations in groundwater levels in peat soils are primarily controlled by evapotranspiration. Water levels in peat soils tend to be near the soil surface in the winter when evapotranspiration is low, while water levels drop during the summer when evapotranspiration is higher. These seasonal fluctuations, however, are significantly muted in low elevation peat soils (Daniel, 1981), like those at the Reserve. Thus, water levels at the Reserve tend to be near the soil surface for most of the year.

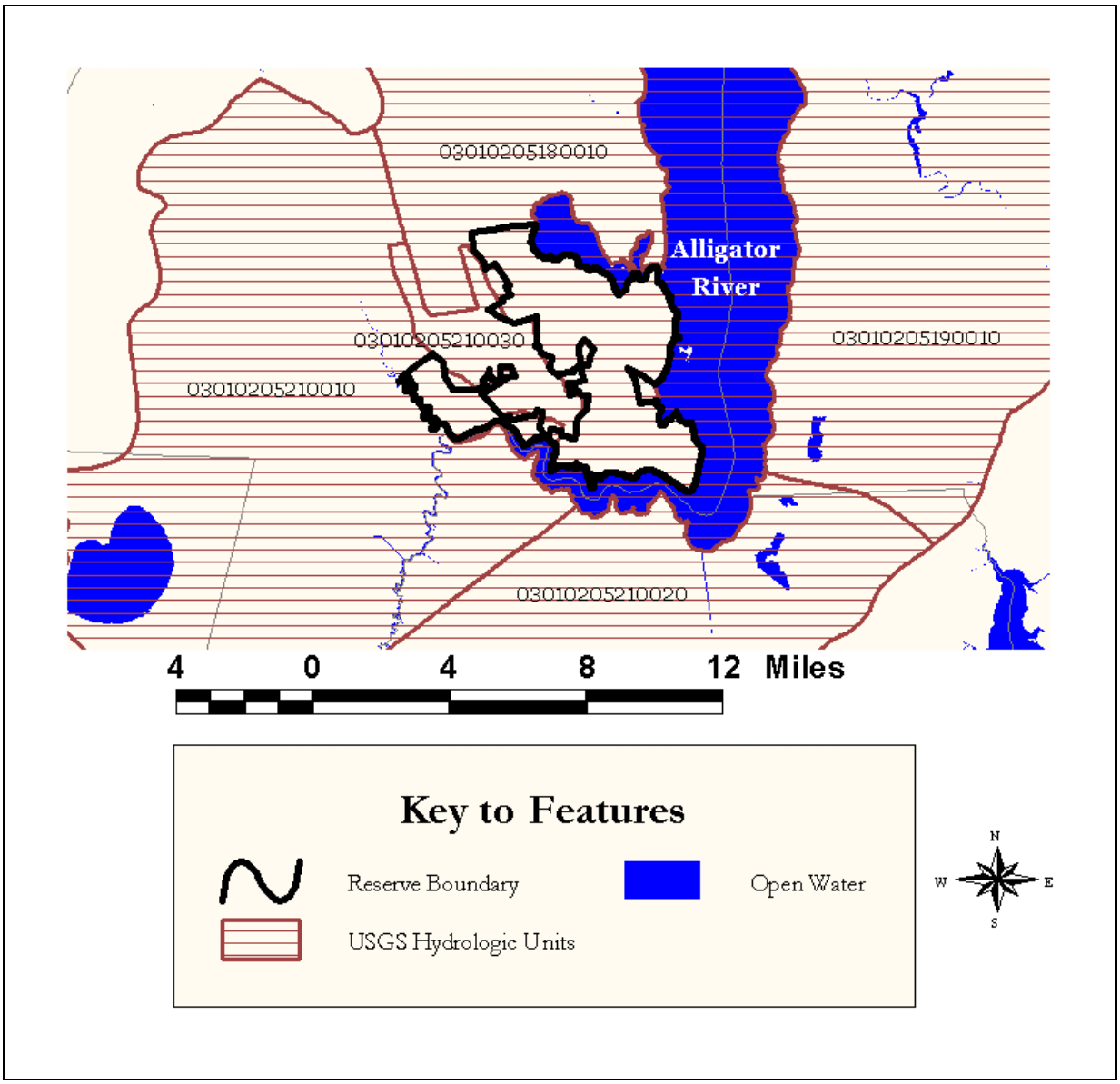

***Figure 4**. U.S. Geological Survey 14-digit hydrologic units near the Preyer Buckridge Reserve.*

In swamps, surface runoff is distributed widely over the swamp surface, slowing water flow. Daniel (1981) observed that "the most obvious feature…of undeveloped wetland watersheds is the indication that there are significant amounts of time when there is little or no flow," a characteristic exhibited by ditches in the interior of the Reserve (D. Fuss, *pers. obs.*). This slow discharge has a positive effect on water quality in adjacent water bodies, but this effect can be easily diminished when ditches alter hydrology (Daniel, 1981). Channelized wetland watersheds show higher groundwater discharge and higher storm runoff, likely due to reduced soil infiltration from drainage of peat soils (Daniel, 1981; Laderman, 1989). At their outlets to the river, the ditches at Buckridge consistently flow and exhibit stronger flow after rain events (D. Fuss, *pers. obs.*), indicating that they are influencing the hydrologic regime.

Over time, timber companies have constructed 31 miles of roads and accompanying ditches at Buckridge, with an additional 18 miles of free-standing ditches (***Figure 5***). Each road surface utilizes excavated material from the adjacent ditch. The ditches range from 3 to 10 feet deep and from 10 to 30 feet across, but the average ditch is 6 to 8 feet deep and 20 to 25 feet across (***Figure 6***). According to studies at neighboring Pocosin Lakes NWR, the probable impact of the ditches is a decline in water levels toward the ditch. In the low hydraulic conductivity of the peat, the ditches slowly drain the organic soil layer and the underlying mineral soil layer. The greatest effect on water levels is seen nearest to the ditches, with the influence reaching up to 165 feet from the ditch (Daniel, 1981).

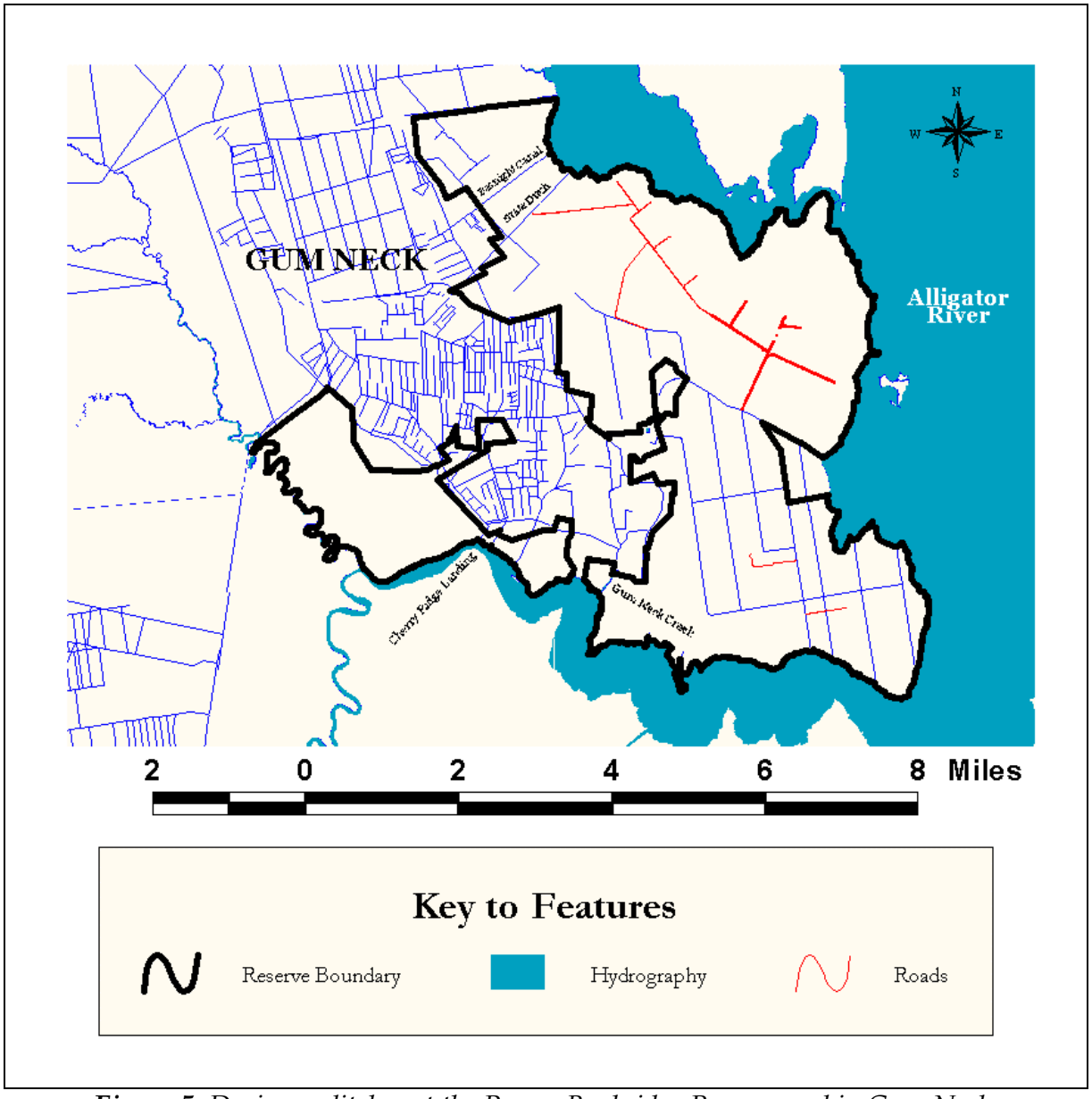

Figure 5. *Drainage ditches at the Preyer Buckridge Reserve and in Gum Neck.*

Figure 6. *A typical drainage ditch at the Preyer Buckridge Reserve.*

Field observations have revealed that the ditch system at Buckridge varies in density and capacity and divides the Reserve into several mini-watersheds (***Figure 7***). The large Basnight Canal, which flows into the Frying Pan, drains most of the northwestern portion of Buckridge. The nearby and parallel State Ditch seems to be blocked and actually flows towards the Basnight Canal, rather than towards the Frying Pan. The spur roads along the Eastern Road isolate several ditches. The ditches adjacent to the spur roads along Juniper Road are also isolated. The ditches along Juniper Road, where the main stand of Atlantic white cedar lies, drain to Grapevine Landing Road, which empties into the Alligator River. This ditch also drains a considerable portion of the land along the Horseshoe Loop Road via culvert connections to the ditch system. At some undetermined point along the Horseshoe Loop Road, a drainage divide exists. South of this drainage divide, the ditches drain southward, entering the Alligator River near Bear Point. Several small free-standing ditches in the southeastern portion of the Reserve connect directly to the Alligator River. The southwestern portion of the Reserve is not heavily ditched, but Gum Neck Creek and three large ditches (Tar Kiln Neck, Meekins Canal, and an unnamed ditch) drain surface water. In addition, a large capacity pumping station (***Figure 8***) moves water from farmland in Gum Neck through the Reserve via a canal to the Alligator River near Cherry Ridge Landing. Finally, along the Reserve boundary at N.C. Route 94, McClees Canal is now isolated from the Alligator River by the landing access, once an old Richmond Cedar Works wharf. Water flow in all Reserve ditches is dependent upon rainfall and is influenced by the water level in the Alligator River, which is subject to wind tides.

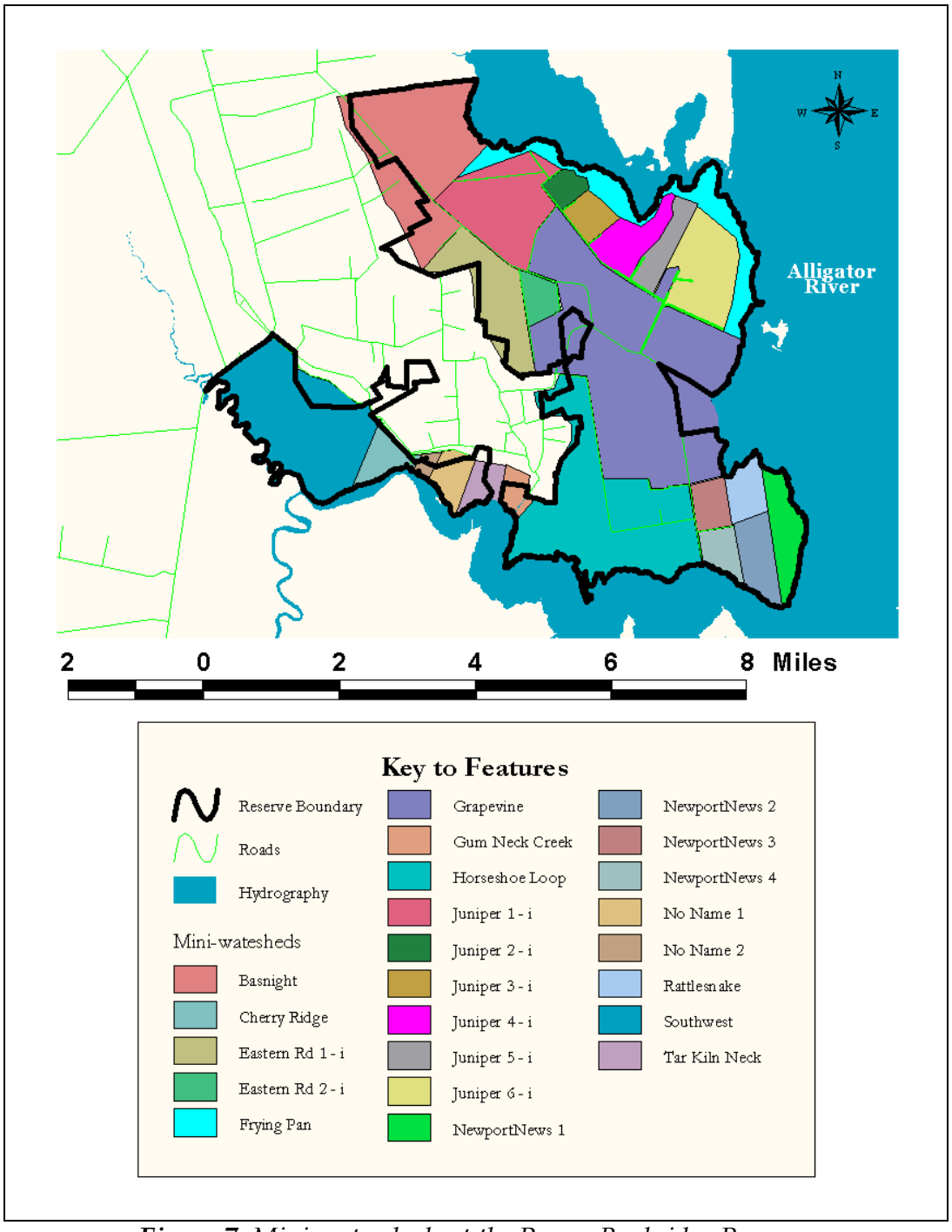

Figure 7. *Mini-watersheds at the Preyer Buckridge Reserve.*

Several other hydrologic phenomena may occur. First, roads may act as dams to surface and subsurface water flow, causing prolonged inundation on one side of the road while the other side drains to the ditch (Mylecraine and Zimmermann, 2000). This phenomenon can cause severe differences in the growth characteristics of the plant communities (Graham and Rebuck, 1958), although major differences have not been observed at Buckridge. Second, a large levee (***Figure 9***) separates the Reserve from

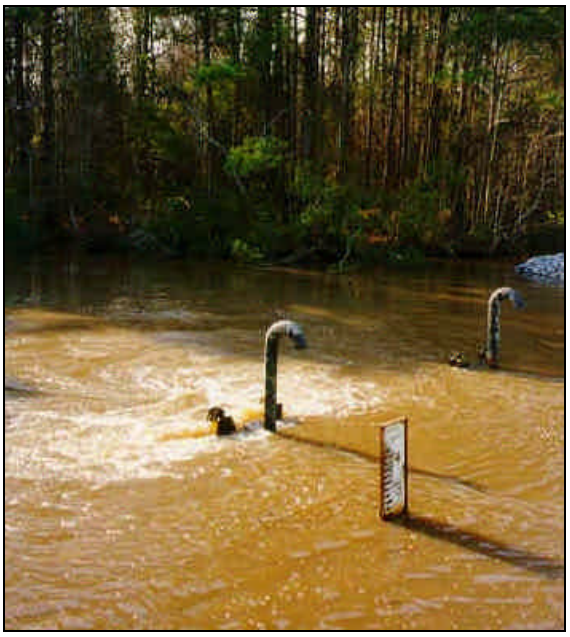

Figure 8. *Agricultural drainage is pumped through the Reserve to the Alligator River.*

adjacent farmland in the Gum Neck Drainage District and interrupts the natural surface and subsurface flow of water. This levee is 8 to 10 feet high and is designed to protect agricultural land from flooding from the Alligator River. Water from the Gum Neck Drainage District's ditch network is pumped through the levee and into the canal at Cherry Ridge Landing (***Figure 8***). Finally, during storm events, the ditches may act as a conduit for increased flooding or penetration of salt/brackish water into the Reserve's interior that would not have been possible before ditch construction. At the Alligator River National Wildlife Refuge, studies have shown that salt water enters artificially deepened freshwater creeks and lakes during storms that exhibit southwesterly winds (R. Smith, *pers. comm.*). Salt intrusion can kill vegetation; for example, storms breached dikes in New Jersey cedar swamps, resulting in tree and shrub mortality from salt exposure (N.J. Forest Service, *pers. comm.*).

Water Quality

The N.C. Environmental Management Commission designates the waters of the Alligator River and its tributaries as Outstanding Resource Waters [15A NCAC 2B .0225(e)(6)], the highest water quality designation in the state. The N.C. Division of Water Quality's *Pasquotank River Basinwide Water Quality Management Plan* shows that the Reserve falls into the 6-digit Subbasin code 03-01-51. The plan states that undisturbed forested areas, particularly nonriverine wet hardwood forests and Atlantic white cedar forests, are an ideal land cover for water quality protection. The plan identifies the importance of the Reserve to filtering the waters entering the Alligator River. It also states, however, that the upper reaches of the Alligator River have elevated levels of nitrogen and low dissolved oxygen (NC DEHNR, 1997). It should be

Figure 9. *Aerial photography with locations of levee and pump in Gum Neck Drainage District.*

noted that this statement is based upon data collected from 1982-1994 at a water quality monitoring station that was located at the mouth of the Gum Neck Drainage District's agricultural canal near Cherry Ridge Landing. It should also be noted that low levels of dissolved oxygen are often considered to be a natural characteristic of lower coastal plain blackwater stream systems like the Alligator River.

Peat soils, like those at Buckridge, store groundwater and absorb and adsorb nutrients and pollutants (Gorham, 1987), protecting the quality of ground and surface water. A study at the adjacent Pocosin Lakes NWR shows that drainage leads to the oxidation of

peat soils, resulting in a release of nutrients (e.g. nitrogen) and mercury (Hinesley and Wicker, 1997). While the wetland ecosystem at Pocosin Lakes NWR distinctly differs from that at the Reserve in the level of disturbance, degree of drainage, and vegetation cover, the study raises concern that the ditch network at the Reserve may contribute to this type of phenomenon. Spot tests in selected ditches along Juniper Road, however, indicate normal levels of pH, dissolved oxygen, nitrogen, phosphorus, and mercury for lower coastal plain blackwater stream systems. Water quality standards for Class C Waters, as stated in 15A NCAC 2B .0211, may be found in the ***Appendix***.

Vegetation

According to the N.C. Natural Heritage Program, the Preyer Buckridge Reserve is a component of the nationally significant Alligator River Wetland Mega-site, 370,000 acres of upland, wetland, and aquatic habitat, including Alligator River National Wildlife Refuge (NWR), Mattamuskeet NWR, Pocosin Lakes NWR and the Preyer Buckridge Coastal Reserve. The Reserve is a vast mosaic of wetland community types (*see* ***Appendix*** *for descriptions*), including Nonriverine Swamp Forest, Peatland Atlantic White Cedar Forest, Pond Pine Woodland, and Tidal Cypress-Gum Swamp (Schafale 1999, 1996*a*, 1996*b*). Daniel (1981) explains this community mosaic by stating that "the availability and seasonal fluctuation of water…will contribute to vegetational diversity on the peatland surface. Slightly elevated topography within the peatland that has periodic drying of the root zone will support vegetation such as pines or pond pine whereas portions of the peatland that are flooded much or all of the year will tend to support other species such as cypress and swamp [black] gum." The N.C. Natural Heritage Program has identified these community types as rare globally and within the state and has indicated that the Reserve plays an important landscape role by connecting the main Upper Alligator River Pocosin with wetlands on the west side of the lower Alligator River. These important forest communities have been ranked by rarity, based on criteria developed by The Nature Conservancy (Master, 1981):

	Global Rank	State Rank
Nonriverine Swamp Forest	**G2**	**S3**
Peatland Atlantic White Cedar Forest	**G2**	**S2**
Pond Pine Woodland	**G4**	**S4**
Tidal Cypress-Gum Swamp	**G4**	**S3**

G2 - Imperiled globally
G4 - Globally rare throughout parts of its range
S2 - Imperiled in the state
S3 - Very rare and local throughout its range in the state
S4 - Secure in the state but may be rare within its range

The canopy and understory species that may occur in these communities according to Schafale and Weakley (1991) may be found in the ***Appendix***. Additional canopy and understory species observed at the Reserve may also be found in the ***Appendix***.

According to the Division of Coastal Management's (DCM) GIS-based wetland mapping program that evaluates the type, amount, location and functional significance of wetland and potential wetland restoration sites, the Reserve (not including two additional tracts totaling 654 acres acquired in late 1999) contains the following wetland types (***Figure 10***; *see* ***Appendix*** *for descriptions*):

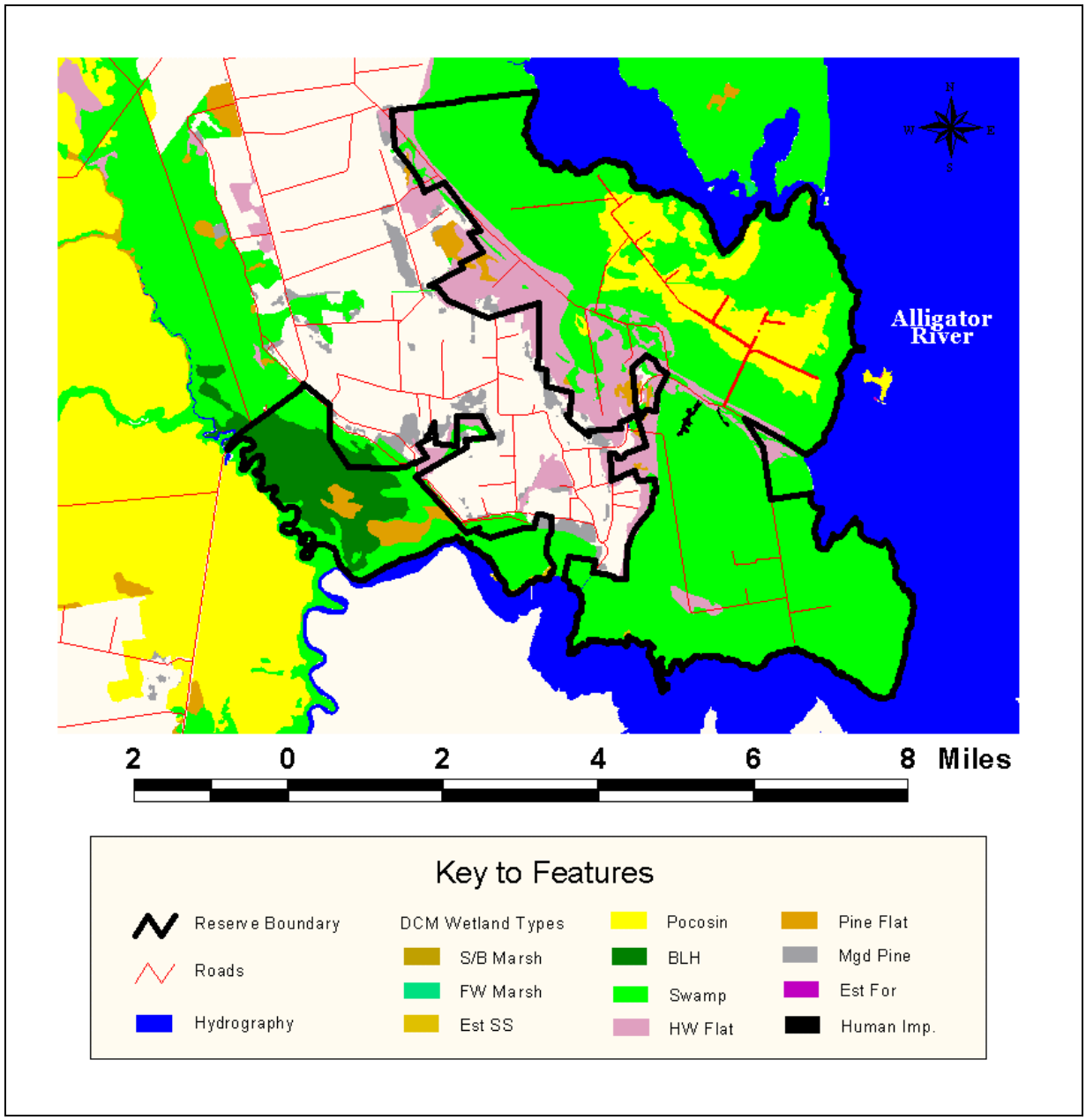

Figure 10. *DCM wetland types at the Preyer Buckridge Reserve.*

Wetland Type	Approximate Acreage
Estuarine Shrub Scrub	56
Bottomland Hardwood	892
Riverine Swamp Forest	2,013
Depressional Swamp Forest	14,633
Hardwood Flat	134
Pine Flat	369
Managed Pineland	128
TOTAL	**18,225** (231 acres not included in acquisition)

The U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) characterizes wetland types by vegetation and hydrology. This data is available for Buckridge (***Figure 11***) and a key to the data may be found in the ***Appendix***.

The legacy of past forestry activities is a mosaic of wetland community types at different ages of regeneration or maturity. There are areas of several hundred acres each that have been clearcut in the recent past, but there are vast expanses of mature swamp forest that have not been harvested since before the turn of the century. While the Reserve is no longer being logged, the portions that have been cut will require many years to reach maturity (Bell, 1997).

Peatland Atlantic White Cedar Forest is identified as a rare community type globally and within the state of North Carolina. Although much of the forest at Buckridge has been cut during recent decades (Bell, 1997), there are small, isolated mature stands of Atlantic white cedar (AWC). There is also approximately 4,000 acres of 20-year old regenerating Peatland Atlantic White Cedar Forest (Schafale, 1996*a*). A statewide inventory of AWC completed by Davis and Daniels (1997) recorded about 11,000 acres in North Carolina, but did not include the regenerating stand at Buckridge because it did not meet the minimum size requirements at the time of the study. Extrapolating from the results of that inventory, the community at Buckridge represents the most extensive contiguous example of AWC in North Carolina and more than 25% of what remains in the state. While most of the AWC at Buckridge is healthy, some small, regenerating areas have suffered mortality. There may also be areas that previously supported Peatland Atlantic White Cedar Forest, but did not regenerate after logging operations (Schafale, 1999).

Prime examples of the natural community types at Buckridge have been digitized over 1998 color infrared aerial photography (***Figure 12***). It should be noted that this data is incomplete and only shows prime examples of community types.

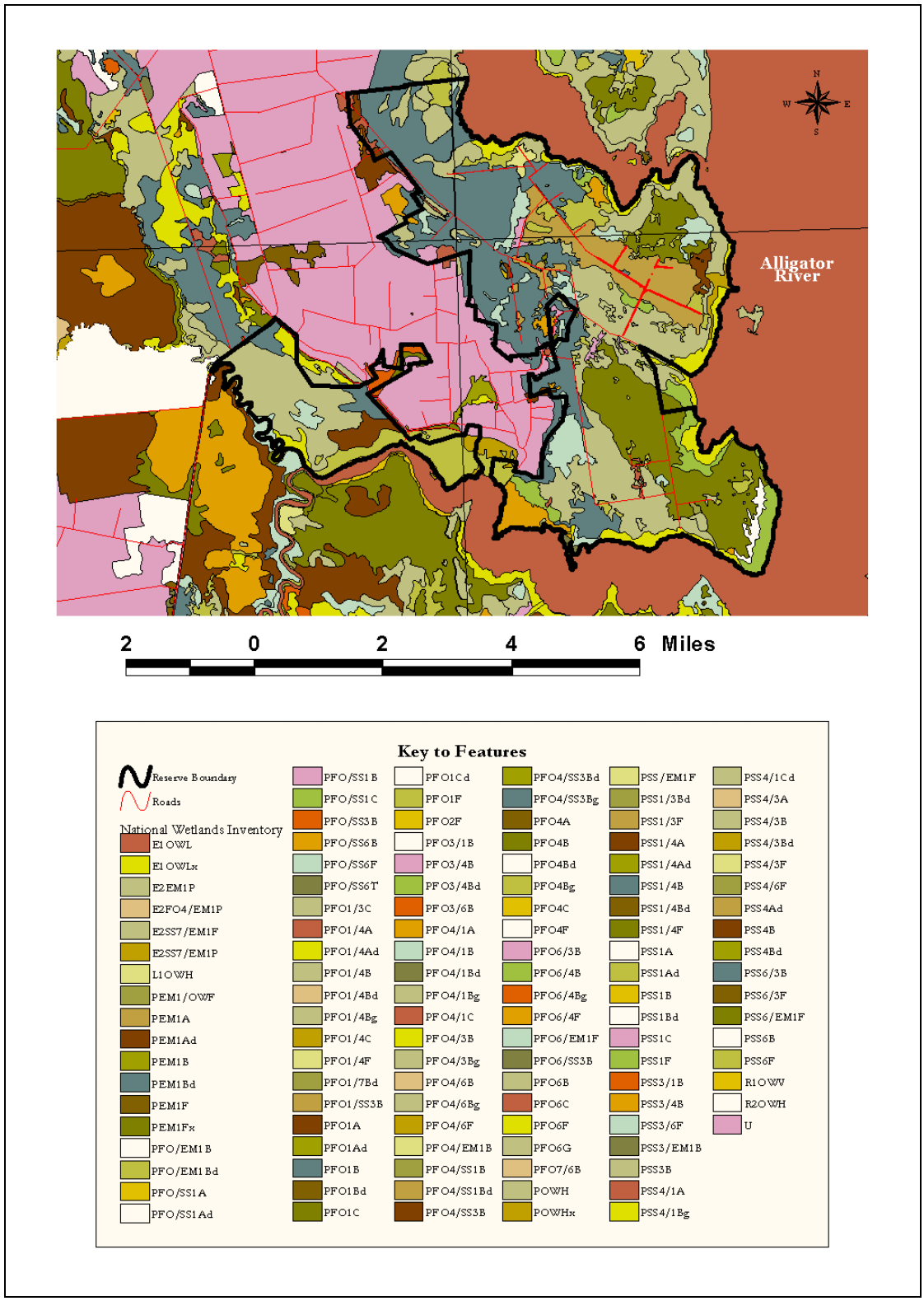

Figure 11. *National Wetlands Inventory for the Preyer Buckridge Reserve (see* ***Appendix*** *for classification key).*

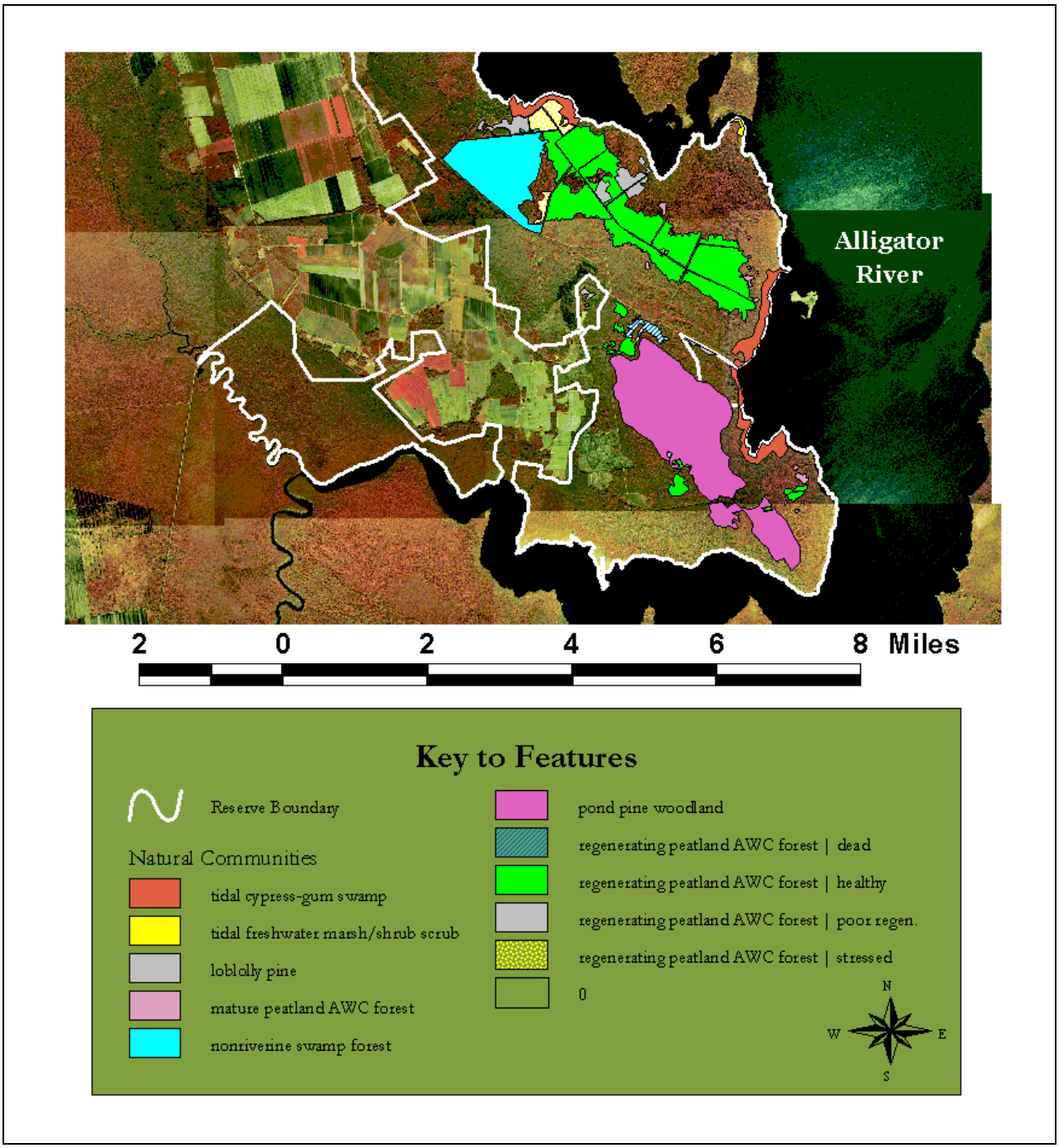

Figure 12. *Aerial photography with examples of community types at Preyer Buckridge Reserve.*

Furthermore, a vegetation change study from 1988 to 1994 has been performed for the Reserve using Landsat TM satellite imagery. Classified vegetation types for 1988 (***Figure 13***) and 1994 (***Figure 14***) were compared to yield a map of vegetation changes during this period (***Figure 15***). A 2-panel summary poster (Meyer and Fuss, 2001) presented at the Coastal Zone 2001 Conference in Cleveland, Ohio in July 2001 can be found in the ***Appendix***. The results of this study, visually compared with historical

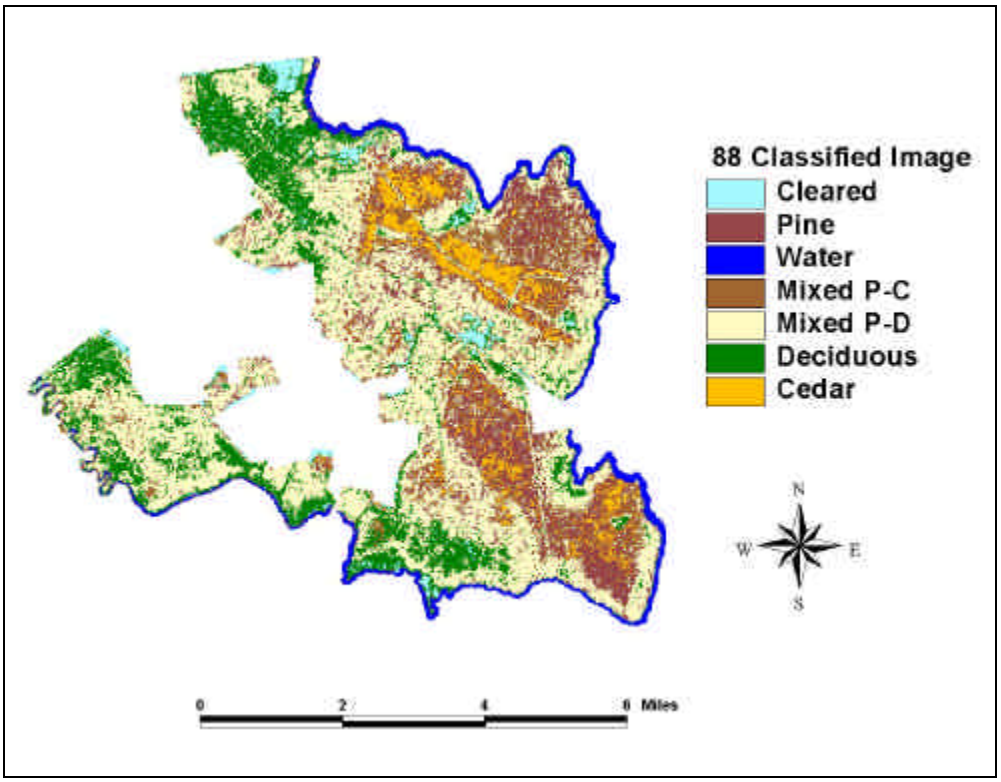

Figure 13. *Classified 1988 satellite image showing vegetation classes (Meyer and Fuss, 2001).*

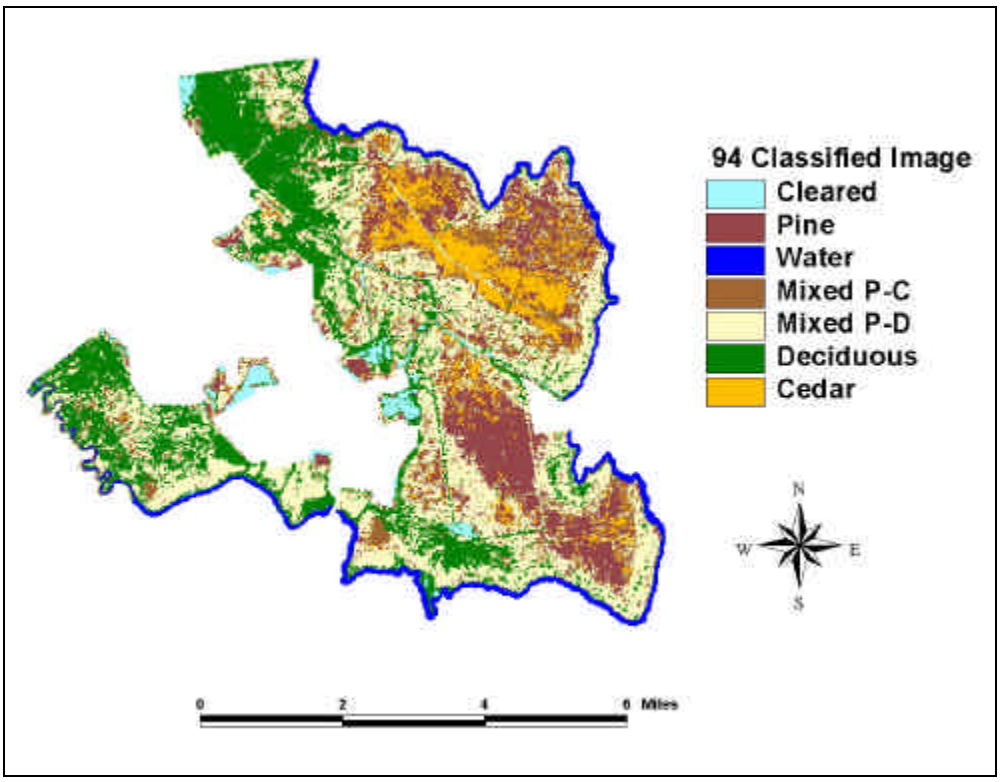

Figure 14. *Classified 1994 satellite image showing vegetation classes (Meyer and Fuss, 2001).*

maps and aerial photography, indicate that the mosaic of natural communities at Buckridge is dynamic, but is not suffering from major ecosystem shifts. Most of the changes are in transition areas from one community type to another, both of which share many of the same dominant species. Thus, Daniel's (1981) observation that "the availability and seasonal fluctuation of water…will contribute to vegetational diversity on the peatland surface" seems to hold true at Buckridge.

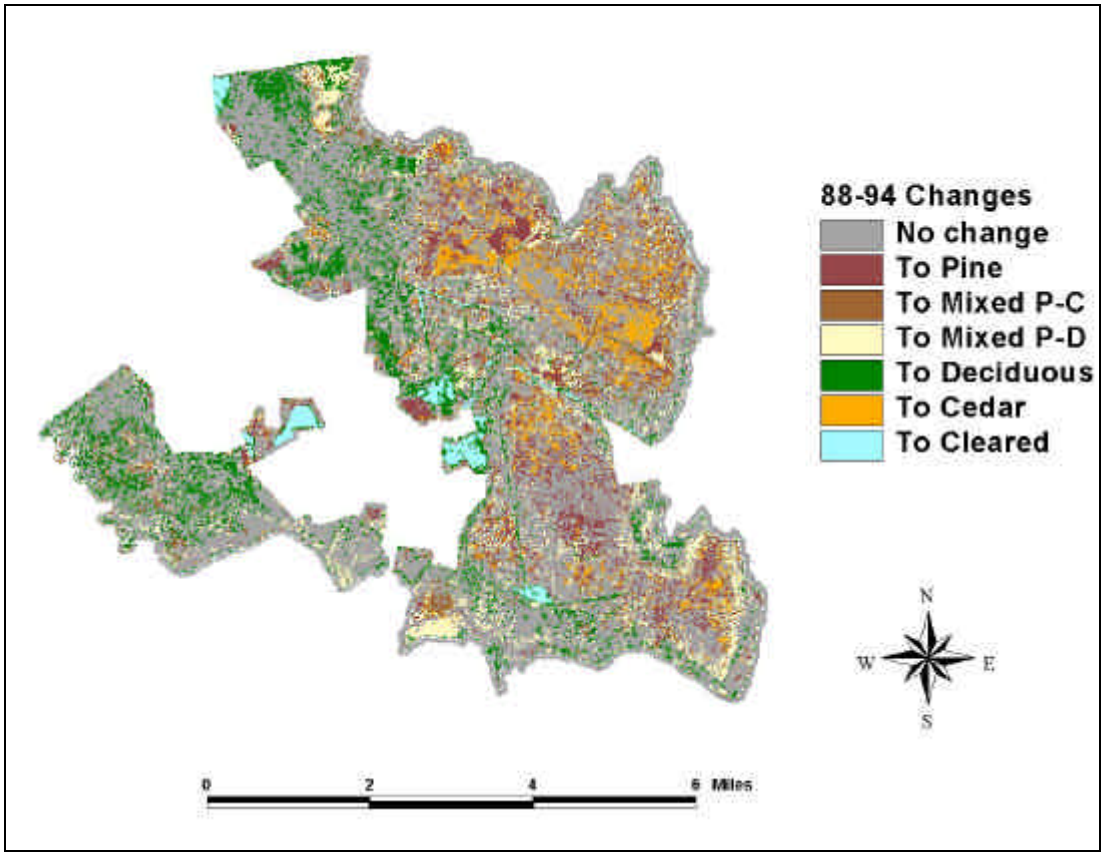

Figure 15. *Classified satellite image change map from 1988 to 1994 (Meyer and Fuss, 2001).*

Fauna

Terrestrial

Situated between the Pocosin Lakes and the Alligator River National Wildlife Refuges, Buckridge and its adjacent waters serve an important role in the landscape by providing a contiguous habitat corridor for terrestrial and aquatic species, many of which require considerable areas of suitable habitat in order to survive. The N.C. Natural Heritage Program has identified Buckridge as providing habitat for several terrestrial wildlife species listed by state and federal agencies as being rare, threatened and endangered including:

State Listed	*Federally Listed*
Red Wolf (Endangered)	Red Wolf (Endangered)
Red-cockaded Woodpecker (Endangered)	Red-cockaded Woodpecker (Endangered)
Bald Eagle (Endangered)	Bald Eagle (Threatened)
Black Bear (Significantly Rare)	

Other terrestrial species that have been observed at Buckridge or that are likely to occur there are listed in the ***Appendix***.

Neotropical Migratory Birds

Buckridge also provides important habitat for migratory birds. According to the U.S. Fish and Wildlife Service's Office of Migratory Bird Management, 32% of the Neotropical migratory bird species occurring in North Carolina are experiencing population declines. The Neotropical Migratory Bird Conservation Program cites fragmentation of breeding habitat as one of the primary factors causing the decline in Neotropical migratory birds. Throughout the eastern U.S., previously contiguous tracts of mature forest have been reduced to smaller patches or have been replaced by younger forests that differ in composition from their predecessors. In contrast, the Alligator River Wetland Mega-site, which includes the Reserve, contains vast areas of forested wetlands and supports three of the five highest priority Neotropical migrants that are dependent on southeastern forested wetlands of the coastal plain - black-throated green warbler, Swainson's warbler and prothonotary warbler (Fussell, 1994). In addition, prairie and worm-eating warblers are dependent on Atlantic white cedar forests in the Great Dismal Swamp in Virginia (Terwilliger, 1987), and they are also found in Dare County, North Carolina (Fussell et al., 1995; Peacock and Lynch, 1982). In fact, the Dare County mainland serves as a breeding ground for approximately 40 species of Neotropical migratory birds. The highest diversity of these birds occurs in mature nonriverine swamp forest, such as that found at Buckridge. Many birds also occur in the other natural community types that are found at Buckridge (Fussell et al., 1995). Therefore, it is likely that some of these Neotropical migratory bird species also occur at Buckridge. Those species likely to occur at Buckridge and those species that have been observed there may be found in the ***Appendix***.

Aquatic

The N.C. Environmental Management Commission designates the Alligator River and its tributaries as Outstanding Resource Waters [15A NCAC 2B .0225(e)(6)]. The N.C. Natural Heritage Program has identified waters adjacent to Buckridge as providing habitat for several aquatic species listed by state and federal agencies as being of special concern, threatened and endangered including:

State Listed	*Federally Listed*
Shortnose Sturgeon (Endangered)	Shortnose Sturgeon (Endangered)
American Alligator (Threatened)	
Atlantic Sturgeon (Special Concern)	

Buckridge and its adjacent waters help to provide important habitat for other aquatic species, as well. The Albemarle Sound and its tributaries are the state's most important anadromous and freshwater fish spawning areas (Epperly, 1984). In particular, the N.C. Wildlife Resources Commission designates the Alligator River and its tributaries as a major spawning area for river herring – blueback herring and alewife (NC DEHNR, 1997). The Alligator River and its tributaries also serve as a nursery area for many species, including blue crab, river herring, menhaden, catfish, white perch, silver perch, weakfish, spot, croaker, striped bass, hickory shad, American shad, and sturgeon (NC DEHNR, 1997; Epperly, 1984). Recent studies at the Alligator River National Wildlife Refuge have found river herring in the natural creeks and lakes that populate the Dare County mainland (R. Smith, *pers. comm.*).

History

It is quite certain that Croatan Indians used the area near Buck's Ridge (***Figure 2***) as a base camp for hunting, fishing, and cultivating along the Alligator River. The Croatan Indian Nation was an Algonquin tribe that had frequent interaction with the Roanoke Indian Nation. The Croatans ranged from Buxton across the Pamlico Sound to Hyde County and the Dare County mainland and controlled the Alligator River region. The Roanoke Indians controlled the Albemarle Sound. The Croatan village, Tramaskecooc, was possibly located at Buck's Ridge, a 20-acre ridge of mineral soils at the Reserve. Nearby, artifacts such as primitive wells have been located on a smaller ridge (2-3 acres). The Lost Colony Center for Science and Research (Willard, 2001) is performing archaeological research at these sites and proposes that there may be a connection between this site and the mysterious disappearance of the Lost Colony at Roanoke Island – the first English settlement in America in 1585. In any case, many Gum Neck families reportedly have Indian blood in their heritage, so there was apparently substantial interaction between Indians and Euro-Americans. Permanent human settlement persisted at Buck's Ridge into the 1900's. In the early 1960's, there were still remnants of old stock pens at the site (J. Landino, *pers. comm.*).

The Gum Neck area was settled for agriculture by Euro-Americans in the early 1700's and is one of the oldest permanent settlements in North Carolina. In the mid-late 1800's, the economic target shifted from agriculture to timber – primarily Atlantic white cedar (Angley, 1986). By the late 1800's, Richmond Cedar Works owned at least 300,000 acres of land in Tyrrell, Dare, and Hyde Counties, including the Reserve property. Richmond Cedar Works harvested Atlantic white cedar from the Reserve property during the 1880's with the use of narrow gauge railroad – a common practice in

swampy areas during that time. Around the turn of the century, a major land dispute erupted between Richmond Cedar Works and the John L. Roper Company that ultimately led both companies to erect concrete markers to define their boundaries. Some of these markers can still be found at the Reserve (***Figure 16***).

Figure 16. *Concrete marker in Gum Neck Creek erected by Richmond Cedar Works.*

According to a 1921 Richmond Cedar Works map, Grapevine Road followed the area's mineral soils (***Figure 3***) to access the Alligator River at Grapevine Landing. Gum Neck Road (then known as New Road), Frying Pan Road, and a road near the present N.C. Route 94 also existed. Basnight Canal led to the Frying Pan and drained the northwestern portion of the Reserve property. Cherry Ridge Landing, Gum Neck Landing, and Buck Ridge Landing at Bear Point were prominent features. In addition, Camp Branch Canal ran from just north of Gum Neck Landing in an area known as Swindell's Store to Buck Ridge Landing at Bear Point. This canal seems to have been the primary mode of log transport from the site to the barge landing. McClee's Canal was also a prominent feature along the western edge of the present Reserve bordered by N.C. Route 94. Though not as early as 1921, the canal eventually led to the Richmond Cedar Works wharf near the N.C. Route 94 bridge. The adjacent Gaither Tract, which was added to the Preyer Buckridge Reserve in 1999, was then owned by the Kent Timber Company. The individuals who owned the lands adjacent to the Reserve developed parcels that resemble those in existence today.

In 1952-1953, West Virginia Pulp and Paper Company (Westvaco) purchased 300,000 acres from Richmond Cedar Works in Dare, Tyrrell and Hyde counties, including Buckridge. Timber cruises to assess the Westvaco timber stock led to vegetation type maps for 1955 and 1960. During the 1950's and 1960's, many hydrological modifications were implemented. In the early 1950's, the Eastern Road (accompanied by the Western Road, the Northern Road, and the Southern Road in Tyrrell and Hyde counties) was constructed along the northwestern edge of Buckridge. Around 1962, the Gum Neck Drainage District constructed the levee system that separates agricultural land in Gum Neck from the forested land at Buckridge (***Figure 9***). Next, Westvaco

constructed the Horseshoe Loop Road in the southeastern portion of the Reserve. In addition, free-standing drainage ditches - built 660 feet apart with a backhoe - were excavated in this area as a routine practice in response to the massive flood kill during Hurricane Hazel in 1954. Westvaco reportedly lost a total of 20,000 acres of timber, some of which occurred at Buckridge near the Alligator River and the Frying Pan. One final Westvaco practice was to collect swamp loblolly pine seeds and cuttings for nursery use. Most of the loblolly pines that were used for seed collection were ultimately lost to erosion along the Alligator River, estimated at 20 feet per year during the early 1960's (J. Landino, *pers. comm.*).

In 1973, Westvaco sold its 300,000 acres, including Buckridge, to Malcolm McLean, who created First Colony Farms. Westvaco made a ten-fold profit on the sale from 1953 to 1973 ($10/acre to $100/acre). During the first year that First Colony Farms owned Buckridge, a company called Juniper, Inc., owned by former Westvaco employees Joe Landino and Vernon Gray Gibbs, cut a stand of Atlantic white cedar in the southeastern portion of the Reserve near the Horseshoe Loop Road. The timber was harvested with a "corduroy" board road and a cable skidder. The regenerating stand can be seen in aerial photography (***Figure 17***), although the road is no longer readily evident. In 1974, First Colony Farms sold the Atlantic white cedar timber rights on its 300,000 acres to MacMillan-Blodell, effectively eliminating Juniper, Inc. from the market. In 1975, MacMillan-Blodell's subsidiary, Atlantic Forest Products, began to harvest Atlantic white cedar at Buckridge. The 2,000-plus-acre pure cedar stand in the northeastern portion of the Reserve was the main target and the Juniper Road and spur roads were constructed during this harvest, which lasted into the early 1980's. During this same period, short spur roads were constructed along the Horseshoe Loop Road to access small stands of Atlantic white cedar in the southeastern portion of Buckridge. Metal skids can still be found throughout these areas and compacted soils along old skid trails are also evident. These compacted areas fill with water, while the adjacent hummocks often harbor the regenerating cedar. This pattern is readily apparent on aerial photography, though not as striking on the ground.

Aerial photography has been acquired for Buckridge for 1998 (***Figure 18***), 1993, 1974, and 1951. Available vegetation type maps date from 1955 and 1960 (Westvaco) and 1948 (Richmond Cedar Works). Finally, a Richmond Cedar Works land ownership map for Tyrrell County was made in 1921.

Archaeological Resources

According to the N.C. Department of Cultural Resources' State Historic Preservation Office, there are no confirmed sites of archaeological significance at Buckridge. Ongoing archaeological investigations by The Lost Colony Center for Science and Research, however, indicate the presence of contact period Native American and Euro-American artifacts on a ridge of mineral soils known as Buck's Ridge (***Figure 2***). This

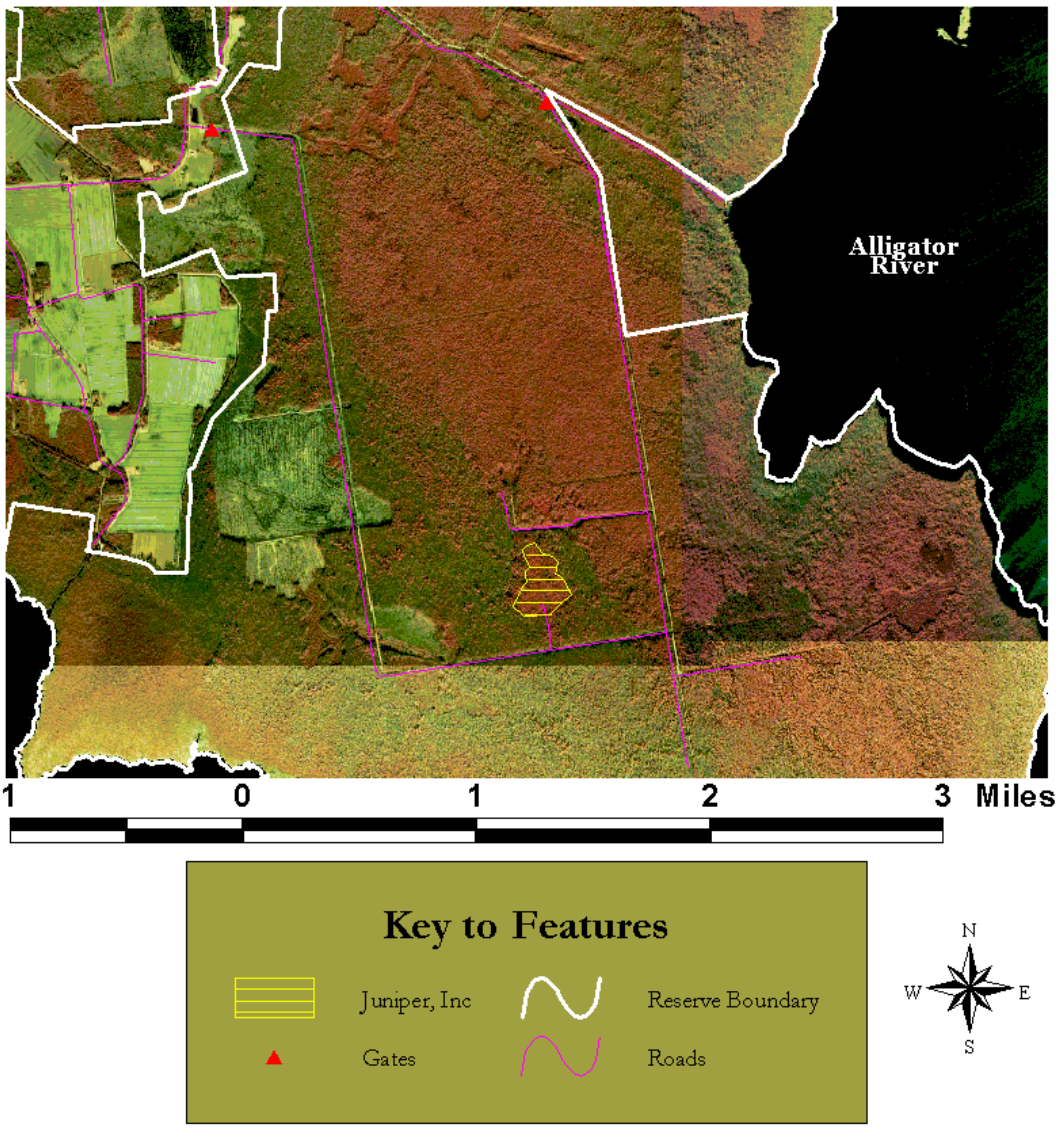

Figure 17. *Aerial photography with regenerating Atlantic white cedar tract cut by Juniper, Inc.*

20-acre area is 2-3 feet higher than the surrounding swamp and is perhaps the site of the Croatan Indian village, Tramaskecooc (Pruden, 2001), meaning "people of the white cedar forests (Heath, 1975)." Verbal reports from local citizens indicate that the village was active until around the turn of the 20th century. Furthermore, a smaller ridge (~2 acres) to the southwest of Buck's Ridge has yielded Native American artifacts, such as primitive wells. Archaeological investigations beginning in November 2001 will focus on this site.

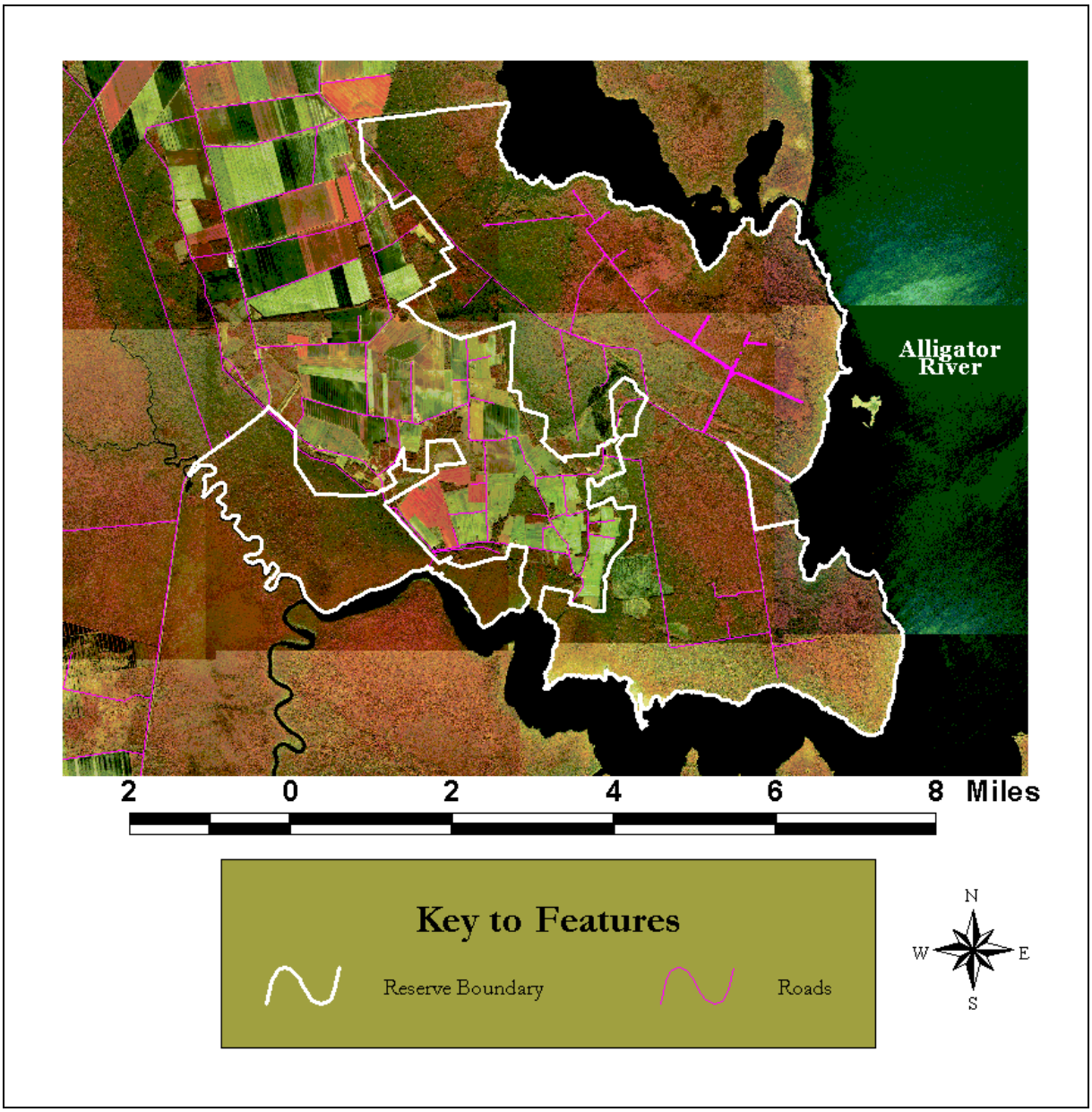

Figure 18. *1998 color infrared aerial photography of the Preyer Buckridge Reserve.*

The archaeological sites at the Reserve connect to other ancient Indian villages, such as Pomieooc at Lake Mattamuskeet, via an old trail that extended north from Lake Mattamuskeet, crossed the Alligator River, passed through the Reserve, and continued to the shore of the Albemarle Sound. A recent hypothesis proposes that the archaeological sites at the Reserve are connected to the whereabouts of The Lost Colony on Roanoke Island, the first English settlement in America in 1585 that mysteriously disappeared by 1587 (Pruden, 2001; Willard, 2001).

Infrastructure

There are no utilities at Buckridge, excepting the small office/trailer near the main entrance that has power, phone, a residential water well, and a septic system (***Figure 19***). There is also a small storage shed for equipment.

While vehicles may access portions of Buckridge along two paved roads, Gum Neck Road and N.C. Route 94, the main entrance is via Grapevine Landing Road, a paved road that gives way to a silt road maintained by the N.C. Department of Transportation. The silt portion of the road is scheduled for paving, but this is unlikely to occur for at least 10-15 years (S. Baker, *pers. comm.*). Authorized vehicular access to the Reserve's interior is solely via unpaved logging roads that are currently gated. The gates serve as a public safety precaution because there is presently no on-site supervision and the road and drainage network can be hazardous. The public may access these roads on foot.

Several water access points exist at the Reserve (***Figure 19***). There are State-maintained (Wildlife Resources Commission) boat ramps at Gum Neck Landing and Frying Pan Landing. Both areas have small docks and adequate parking for boat trailers. An unnamed landing at N.C. Route 94 where it crosses the North Fork Alligator River has an unpaved parking area and a concrete boat ramp. Finally, Grapevine Landing is equipped with a dock on the Alligator River and an unmaintained, deteriorated boat ramp.

Land Uses, Traditional Uses, and Recreation

The Emily and Richardson Preyer Buckridge Coastal Reserve was dedicated as a State Nature Preserve on July 31, 2000. The N.C. Nature Preserves Act (NCGS §113A-164) now governs the use of the Reserve. The Reserve's dedication document provides that visitor activity shall not result in significant environmental degradation. In addition, activities such as commercial silviculture and disturbance of archaeological resources are prohibited. Activities associated with ecosystem restoration and management are acceptable.

Hunting and fishing are popular traditional activities that will be accommodated at the Reserve, provided that they do not adversely affect the attainment of other project goals and objectives. Recreational fishing is open to anyone and must be carried out in compliance with the regulations of the N.C. Wildlife Resources Commission (WRC) and the N.C. Division of Marine Fisheries (DMF). A license is required for fishing in inland waters, which encompass parts of Buckridge. ***Figure 20*** highlights the jurisdictional boundaries for the DMF; the WRC's jurisdictional boundary is immediately upstream. Traditionally, commercial fishermen utilize the landings and boat ramps at the Reserve for access to the Alligator River. Commercial fishermen must have a commercial fishing license and are subject to commercial fishing regulations of the WRC and the DMF. Hunting is restricted at Buckridge. Hunting rights are currently leased to the

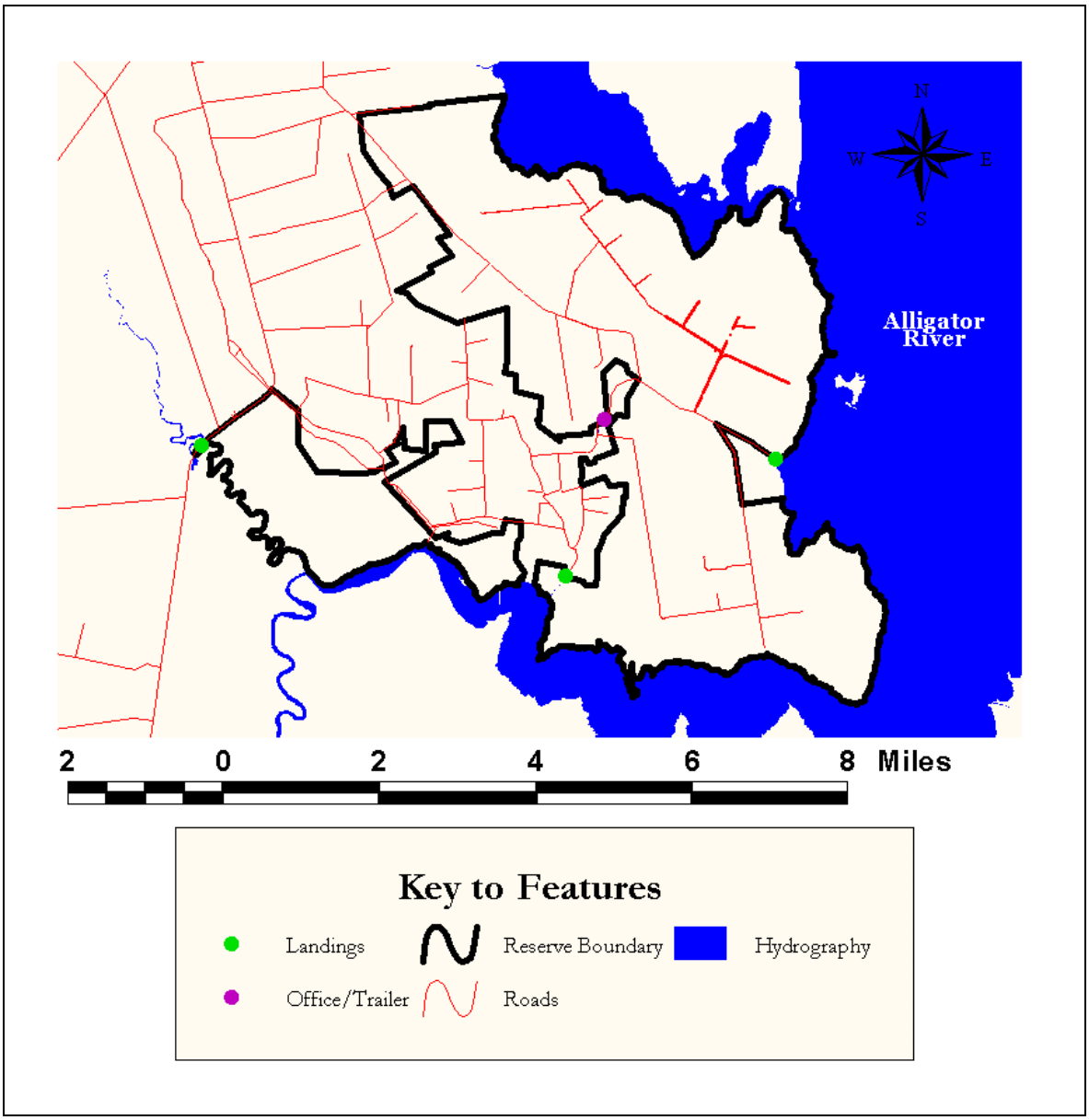

Figure 19. *Locations of the office/trailer and boat landings at the Preyer Buckridge Reserve.*

Pocosin Wildlife Management Group. Hunters must be licensed and must comply with the regulations of the WRC. In the future, the Reserve may be incorporated into the WRC's Game Lands program, subject to appropriate rules and a Memorandum of Agreement between the Coastal Reserve Program and the WRC.

Ecotourism is another activity that occurs at Buckridge. As an example, Rock Rest Adventures, a regional outdoor outfitter, guides kayak trips to Buckridge (J. Jacob, *pers. comm.*). The Northwest and Southwest Forks of the Alligator River and the main stem downstream to and along Roper Island are marked as a paddle trail with mile markers and identification signs (***Figure 21***) and are mapped in the "North Carolina Coastal Plain Paddle Trails Guide" [http://www.ncsu.edu/paddletrails/] (***Figure 22***).

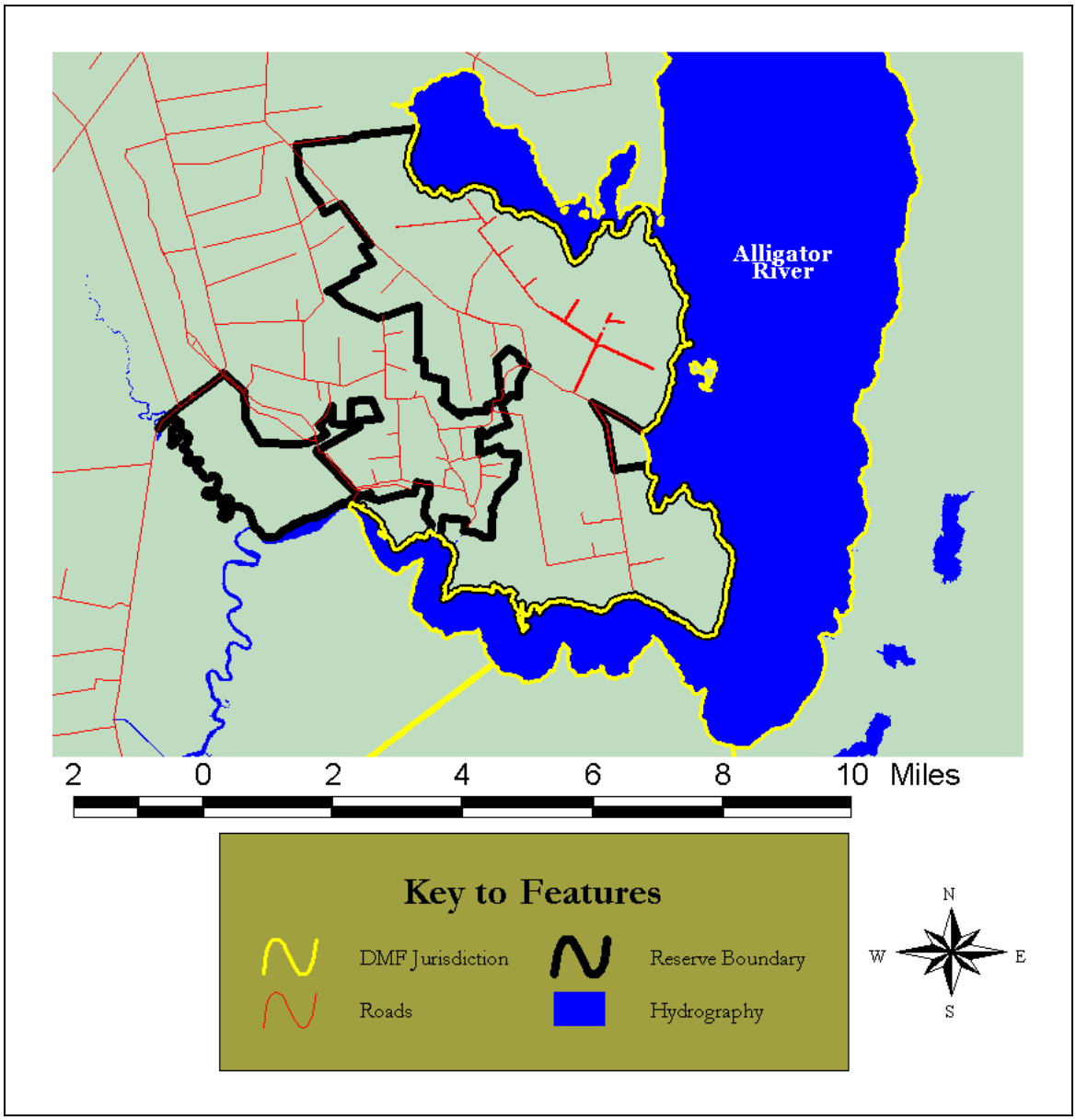

Figure 20. *Division of Marine Fisheries (DMF) jurisdictional boundary in the Alligator River.*

Future plans for minor ecotourism development (e.g. trails for hiking and paddling) will complement this and similar trails at the other preserves and refuges in the region. Lessons learned from ecotourism efforts at The Conservation Fund's Palmetto-Peartree Preserve in northeastern Tyrrell County will help to guide ecotourism planning at Buckridge (The Conservation Fund, 2000).

The Alligator River region is an important recreation destination, offering rich cultural and natural resources such as the Scuppernong River Wetlands Walk, the Columbia Theater, the Alligator River National Wildlife Refuge, the Pocosin Lakes National Wildlife Refuge, The Conservation Fund's Palmetto-Peartree Preserve, and the Preyer

Figure 21. *Paddle trail sign marking the Alligator River near the N.C. Route 94 landing.*

Buckridge Coastal Reserve. The N.C. Department of Transportation's Tyrrell County Visitor's Center in Columbia is the second-most visited rest area in the state (The Conservation Fund, 2000). Recognizing the significance of these visitors, Tyrrell County is committed to promoting ecotourism, which manifests itself in such projects as The Walter B. Jones, Sr. Center for the Sounds, the Pocosin Lakes National Wildlife Refuge headquarters and visitor's center, and the 4-H Environmental Education Conference Center. The maintenance of aesthetic quality at Buckridge is important to the success of the county's ecotourism efforts.

Socioeconomics

Tyrrell County is the least populated county in North Carolina – the 2000 census revealed that 4,149 people lived in the county. Tyrrell County is 56.5% white, 39.4% black and 3.6% Hispanic (http://www.census.gov). According to 1999 statistics of the N.C. Security Employment Commission (http://www.esc.state.nc.us/), the county's per capita income is $20,513, less than the state average of $29,468. The average annual unemployment rate during 1995-2000 ranged from 8 to 10%. The county's economy is dominated by agriculture, silviculture, and fishing (Holland Consulting Planners, 1998). Potential effects on the county's economy are significant because of its small size.

The Gum Neck community mainly subsists on agriculture, along with silviculture and fishing. The 2000 census lists Gum Neck's population at 462, with a population density of 3 persons per square mile (http://www.census.gov). The Gum Neck Drainage District collects taxes to maintain an extensive drainage network (***Figure 4***) to enable farming operations. The Drainage District also maintains a large levee (8 to 10 feet high) and pumping station (***Figures 8 & 9***) that move water via canals from the drainage network through the levee and the Reserve to the Alligator River.

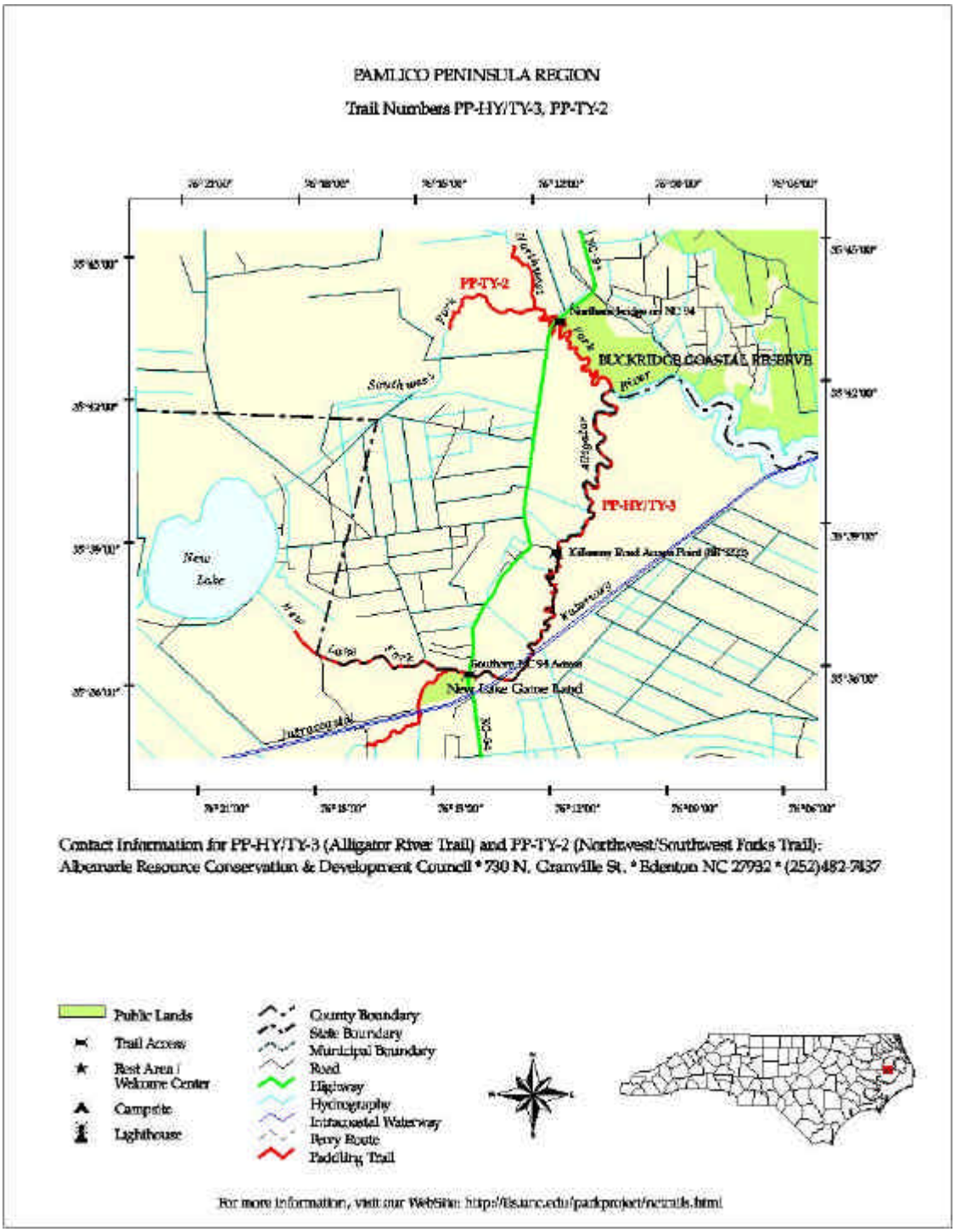

Figure 22. *The Alligator River in the "North Carolina Coastal Plain Paddle Trails Guide."*

CHAPTER 3
PROJECT OBJECTIVES AND PLAN ADMINISTRATION

RESTORATION AND MANAGEMENT OBJECTIVES

The specific objectives for restoration and management of the natural resources at the Preyer Buckridge Coastal Reserve are as follows:

1. Restore the natural hydrology and the rare natural communities, including Peatland Atlantic White Cedar Forest, Pond Pine Woodland, Nonriverine Swamp Forest, and Tidal Cypress-Gum Swamp;

2. Protect the outstanding water quality of the Alligator River and its tributaries;

3. Improve water quality in the Albemarle Sound region by preserving and restoring functioning wetlands;

4. Ensure the protection of aquatic and terrestrial habitat at a watershed level;

5. Foster environmental education partnerships with other organizations; and

6. Enhance the public's enjoyment of the Preyer Buckridge Coastal Reserve by promoting ecotourism in Tyrrell County.

FUNDING

Since 1998, the Division of Coastal Management has received a total of $6,290,745 ($5,451,291 State, $838,824 Federal) for the acquisition and restoration of the Preyer Buckridge Coastal Reserve. The U.S. Fish and Wildlife Service's Coastal Wetlands Conservation Grant Program provided the federal funds, which included ~$75,000 for restoration activities. State funds came from the N.C. Natural Heritage Trust Fund and from the N.C. Clean Water Management Trust Fund, which also allocated ~$500,000 for restoration implementation. The hunting lease fee ($10,000) paid by the Pocosin Wildlife Management Group goes directly into the State's General Fund and is not used for management activities at the Reserve.

PLAN ADMINISTRATION

Coastal Reserve staff

The plan will be administered by the following Coastal Reserve Program staff:

Coastal Reserve Program Coordinator
Coastal Reserve Research Coordinator

Coastal Reserve Education Coordinator
Coastal Reserve Preyer Buckridge Site Manager
Coastal Reserve Northern Sites Manager (when necessary)

Division staff

Additional assistance will be provided by the following Division of Coastal Management staff:

Wetlands Management Specialist
Wetlands Restoration Specialist
Policy Analyst and Land Acquisition Grant Manager
GIS Analysts

Local Advisory Committee and Restoration Advisory Group

In the near future, a Local Advisory Committee will be formed to oversee management issues at Buckridge. This committee will be composed of local representatives of federal and state agencies, local government officials, and private citizens from the community. Local Advisory Committees for Coastal Reserves typically meet twice a year.

In addition, the Preyer Buckridge Reserve Restoration Advisory Group, which consists of representatives from federal and state agencies, university researchers, and private forestry consultants, serves as a scientific advisory panel for natural resource restoration and management at the Reserve. This group was integral to the development of restoration and management strategies and to identifying research needs. The group also reviewed this document.

Both of these groups should include representatives from the U.S. Fish and Wildlife Service and the N.C. Division of Forest Resources. These agencies should review and participate in restoration and management decisions at the Preyer Buckridge Reserve.

Review of Research Proposals

Proposals for research at the Preyer Buckridge Reserve will be reviewed by the Coastal Reserve Program Coordinator and the Coastal Reserve Research Coordinator. Research projects are appropriate if they are designed to assist coastal decision-making in North Carolina or beyond. Research proposals that would result in significant environmental degradation to the natural resources at the Reserve are not appropriate.

Plan Review and Modification

The plan will be reviewed by the Coastal Reserve Program staff, the Division staff, the Local Advisory Committee, the Preyer Buckridge Restoration Advisory Group and other interested entities. Future modifications to the plan may be made by the Local Advisory Committee in conjunction with the Coastal Reserve Program staff.

LAWS AND REGULATIONS

Federal

Activities at the Preyer Buckridge Coastal Reserve will be undertaken in compliance with the following federal laws and regulations:

Clean Water Act (USC Title 33, Chapter 26)
Coastal Zone Management Act (USC Title 16, Chapter 33)
Estuary Protection Act (USC Title 16, Chapter 26)
Executive Order 11990 (Protection of Wetlands)
Rivers and Harbors Act of 1899 (USC Title 33, Chapter 12)

State

Activities at the Preyer Buckridge Coastal Reserve will be undertaken in compliance with the following state laws and regulations:

Archaeological Resources Protection Act (NCGS Article 2, Chapter 70)
Archives and History Act (NCGS Article 1, Chapter 121)
Coastal Area Management Act (NCGS Article 17, Chapter 113A)
Nature Preserves Act (NCGS Article 9A, Chapter 113A)
North Carolina Coastal Reserve Rules (15A NCAC 7O)
Prescribed Burning Act (NCGS Article 4E, Chapter 113)
State Guidelines for Areas of Environmental Concern (15A NCAC 7H)
Forest Practices Guidelines for Streamside Management Zones (15 NCAC 1I.0201)

CHAPTER 4
STRATEGIES

RESTORATION AND MANAGEMENT STRATEGIES

Hydrological Restoration

The primary restoration and management strategy is to restore hydrology that was altered by roads and ditches constructed for logging in the past. Restoration of the natural hydrologic regime, or a close approximation, will allow naturally regenerating and mature vegetative communities to persist over the long-term and will permit them to fully perform ecological functions such as removal of nutrients and pollutants, water storage, and provision of terrestrial and aquatic habitat.

Some of these ecological functions may currently be impaired by the presence of the road and drainage network. By transporting water from the site faster than a natural system, drainage ditches can have deleterious effects on swamp hydrology (Daniel, 1981) and swamp species such as Atlantic white cedar (Laderman, 1989). Similarly, roads may have adverse effects on hydrology and natural communities because they act as dams to surface and subsurface water flow, causing prolonged inundation on one side of the road (Mylecraine and Zimmermann, 2000; J. Landino, *pers. comm.*). Atlantic white cedar does not tolerate extended periods of flooding (Laderman, 1989). In addition, the ditches may serve as conduits for wind-driven tidal surges during storm events that transport either fresh or salt/brackish water into the interior of the Reserve that was not possible before ditch construction. Salt/brackish water is toxic to Atlantic white cedar and other species in freshwater wetlands.

Currently, other than observational data, there is little data with which to interpret natural hydrology or any alterations. An initial attempt to install automated water level gauges to measure groundwater levels across roads and ditches failed because black bears physically damaged the instruments. With funding from the U.S. Environmental Protection Agency's Clean Water Act Section 319 Nonpoint Source Pollution Grant Program, a 3-year hydrology monitoring and modeling study by the U.S. Geological Survey jointly with a 3-year water quality monitoring study by N.C. State University will begin simultaneously in 2002. These studies will provide information concerning the direction and rate of flow in the drainage ditches and associated water quality parameters on a seasonal and event-driven (e.g. rainstorms and wind-driven tides) basis. Ultimately, hydrologic and water quality models will be produced that will be tied to atmospheric data from a Campbell Scientific Weather Station and a network of geodetic benchmarks installed by the N.C. Geodetic Survey.

The hydrology study will install automated bi-directional water flow gauges in three primary ditch network outlets - Grapevine Landing Road, Bear Point, and Basnight

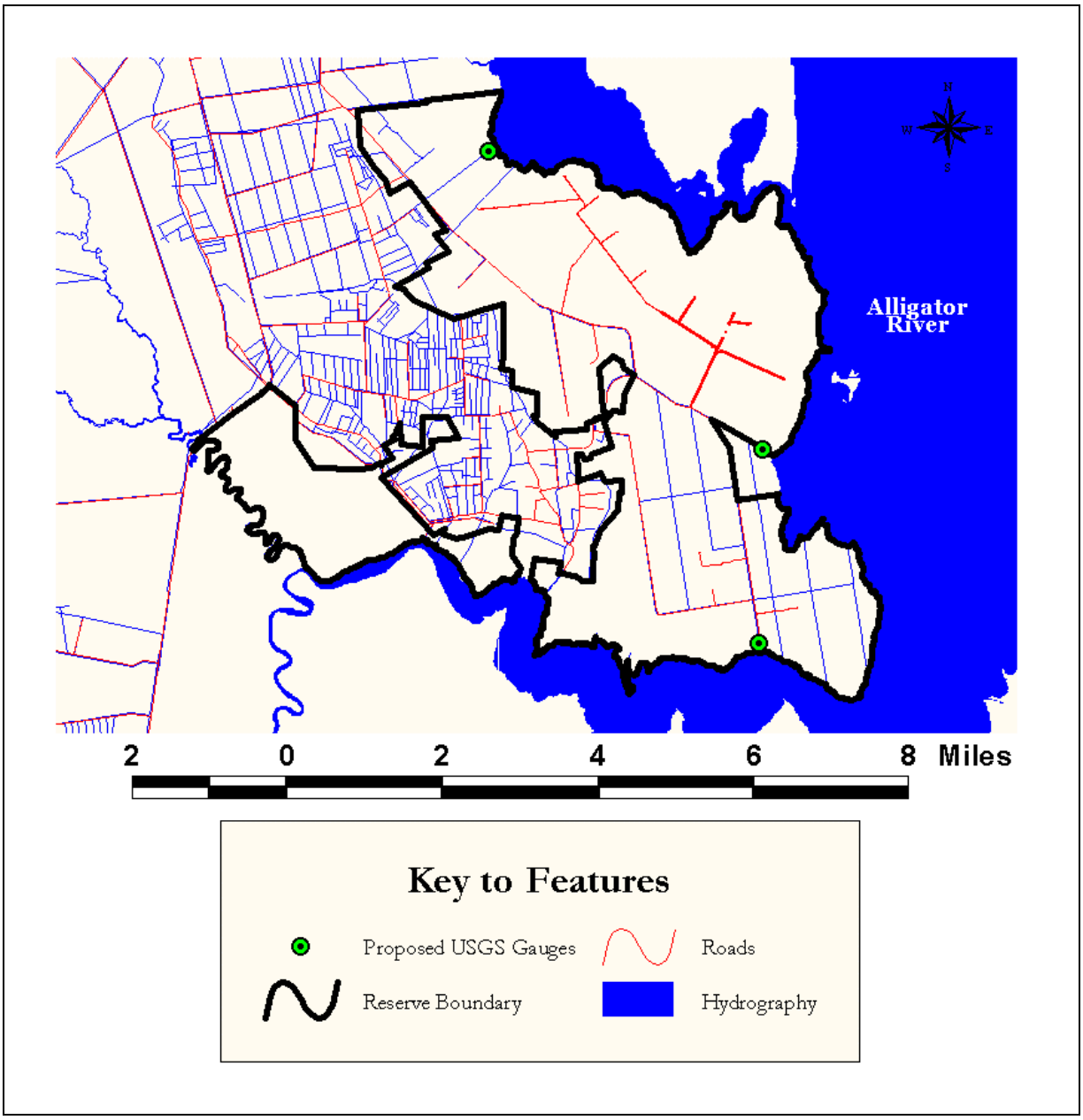

Figure 23. *Proposed locations of USGS water flow gauges at the Preyer Buckridge Reserve.*

Canal (***Figure 23***). At these locations, seasonal water quality samples will also be collected and will be analyzed at the U.S. Geological Survey laboratory in Ocala, Florida for pH, conductivity (salinity), dissolved oxygen, nitrogen, phosphorus, and mercury. In addition, one hydrology monitoring transect will be selected within a community of Peatland Atlantic White Cedar Forest. The purpose of this transect will be to discern the hydrologic effects of the road and the ditch on the surrounding natural community.

The water quality monitoring study will concentrate on ditches draining specific natural communities to detect differences, if any, among them. Automatic sampling will be triggered by a rain or wind event. Samples will be collected and analyzed for

coliform bacteria and other water quality parameters at the Duke University Marine Laboratory in Beaufort.

Guided by the results of the hydrology and water quality monitoring studies, several options may be employed to achieve hydrological restoration. First, breaching of spur roads (***Figure 24***) would re-establish hydrologic connectivity across the road barriers.

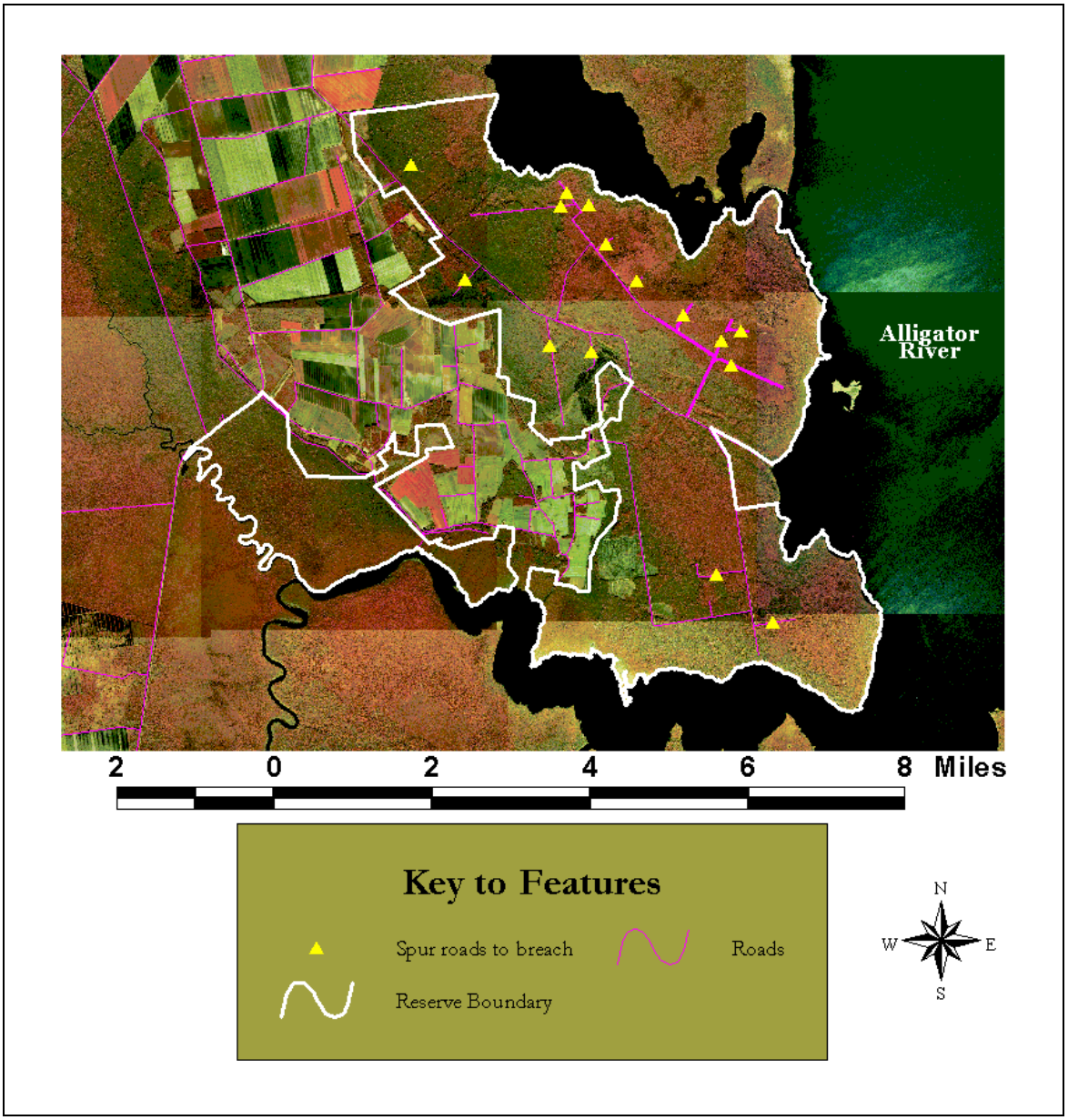

Figure 24. *Aerial photography showing spur roads that could be breached.*

This procedure could involve either: 1) complete road removal; 2) partial road removal; or 3) breaching the roads in one or more distinct locations. The Advisory Group recommends breaching each road in multiple locations and depositing the material into the adjacent ditch from which it originated. This way, if the road is deemed crucial in

the future (e.g. for wildfire control), it could be used with minimal reconstruction. The Division of Forest Resources (DFR) is responsible for control of wildfire on all land within the state and any planning related to fire control or suppression should be reviewed by the DFR's fire staff.

Second, water control structures may be installed at strategic locations in the ditches in order to approximate a natural hydrologic regime. These structures (***Figure 25***), most likely culverts with combinations of flashboard risers and fish passage structures (if needed), are appropriate if hydrology data show that water levels are lower nearer to

Figure 25. *Example of a water control structure along a drainage ditch.*

the ditches and/or that high concentrations of pollutants such as nitrogen and mercury exist. Using water control structures will allow flexible water management to achieve water levels that are essential for the maintenance and re-establishment of communities such as Peatland Atlantic White Cedar Forest. Unlike permanent ditch plugs, flashboard risers permit water levels to be raised or lowered as necessary. Associated water level gauges will allow project managers to assess the ability of water control management to achieve the project's objectives. Adjustments can be made if ideal water levels are not attained. For instance, water levels may need to be raised if ditches penetrate the sand layer lying below the peat soil, increasing groundwater recharge and reducing the water storage capacity of the site. This phenomenon has been observed at the Pocosin Lakes National Wildlife Refuge (L.E. Hinesley, *pers. comm.*). In addition, control of areas bounded by roads allows block water management, which may be important for fire management. Water control structures may also help to slow or prevent the unnatural intrusion of either salt/brackish water or unusually large quantities of fresh water during wind-driven storm surges.

Furthermore, the ditches may provide nursery or spawning habitat for anadromous fish species. If the ditches do support or are suspected to support anadromous fish species,

the Division of Coastal Management and the Coastal Reserve Program will coordinate with the National Marine Fisheries Service and the Division of Marine Fisheries to determine how restoration plans may be implemented with a minimal impact on fishery resources. Unlike permanent plugs, water control structures can be designed to accommodate anadromous fish passage. For instance, Mattamuskeet National Wildlife Refuge employs slot weirs to allow anadromous fish passage into and out of the lake. While an ongoing study at the adjacent Alligator River National Wildlife Refuge has found river herring in the natural creeks and lakes, there has been no inventory of fish usage for the Reserve's ditches. The National Marine Fisheries Service and the Division of Marine Fisheries have suggested that the ditches at Buckridge may serve as secondary habitat for anadromous fish. In such instances, water control structure design can incorporate fish-friendly technology to encourage fish passage. If anadromous fish do not use the ditches and the need for flexible water management is minimal, permanent plugs may replace water control structures as a long-term hydrological restoration option.

Third, culverts may be installed under the main access roads to restore hydrologic connectivity across the road barriers. At present, portions of the road network are difficult to pass due to wet conditions, which limits access to parts of the Reserve. Using culverts on main roads would alleviate damming of water and maintain road access for management purposes (e.g. research, fire control). Culverts could be equipped with flashboard risers to allow flexible water control management. Possible culvert locations are roadside areas where ponding occurs or where Atlantic white cedar mortality is high. Hydrologic data will aid in the determination of appropriate locations for culverts by indicating areas, if any, where water levels are higher nearer to the roads. The U.S. Natural Resources Conservation Service and the Soil and Water Conservation Service may be able to provide assistance in the design of culverts and water control structures.

Fourth, to ensure access to water control structures and other features at the Reserve, main roads may need to be improved to accommodate raised water levels. Many roads are already well above the level of the ditches, but portions of some roads are difficult to pass due to wet conditions. Simple elevation information should indicate where road improvement is necessary, or where access may be jeopardized due to raised water levels.

Fifth, some ditches, such as Basnight Canal (see ***Figure 2***), are not associated with roads. In such cases, the excavated material was deposited in a berm on one or both sides of the ditch, effectively eliminating surface flow from the ditch into the adjacent swamp. Like spur roads, berms could be entirely removed or breached in multiple locations. Weirs, level spreaders, or similar structures could be installed in the ditches to divert water from the canals through the breaches into the adjacent swamp, allowing water filtration, water storage, and aquatic habitat improvement before the water reaches the Alligator River. The hydrology study should provide adequate information with which

to gauge the outcome of breaching berms and the potential effects of storm surge on the adjacent swamp. In addition, fish passage concerns must be addressed if any structures are installed. Again, the Division of Coastal Management and the Coastal Reserve Program will coordinate with the National Marine Fisheries Service and the Division of Marine Fisheries to determine how restoration plans may be implemented with a minimal impact on fishery resources.

Hydrological restoration will be the primary restoration and management strategy at Buckridge. It addresses water quality, natural community and habitat objectives, and is one of the least invasive methods of achieving restored conditions. Guided by data from the hydrology and water quality monitoring studies, the following scenarios should be undertaken:

a) If the hydrology and water quality data show significant negative effects from the drainage ditches, then water control structures will be necessary to slow water flow from the site. Negative effects include lower water level nearer to the ditches and higher concentrations of pollutants, such as nitrogen and mercury.
b) If the hydrology data show that water is being dammed on one side of the roads (i.e. higher water level nearer to the roads), then culverts will be necessary to re-establish hydrologic connectivity.
c) If hydrology data show no significant effects from roads and ditches (i.e. no water level differences), then tree growth studies should be pursued to discern subtle effects, if any, on natural communities. No structures are recommended in this scenario.
d) If hydrology data show major inflow during storm events, then a salinity study should be performed to learn the effects of storm-driven salt intrusion on natural communities. Berm breaching may not be advisable if significant salinity problems exist.
e) Since they are not connected to the drainage network and will not be studied directly, spur roads should be breached to re-establish hydrologic connectivity across the roads. Planning for fire control and general road surface maintenance should be considered in this scenario.

Supplemental Strategies

Since it is quite probable that hydrological restoration alone will not be sufficient to restore the natural hydrology and to preserve the natural communities at Buckridge, supplemental restoration and management strategies may be needed on a case-by-case basis.

Planting

One of these strategies is to plant Atlantic white cedar and other appropriate species. Schafale (1999) suggested that some portions of Buckridge were originally Peatland Atlantic White Cedar Forest that did not regenerate after logging. Thus, candidate planting areas for restoration of Atlantic white cedar and other species may be identified. One-year old seedlings can be planted or larger transplants can be used as an alternative. Research has shown that larger Atlantic white cedar transplants survive better, particularly when exposed to weed competition and heavy deer and rabbit browse (Hughes, 1995; Hinesley et al., 1998; Hinesley et al., 2000). Research on cedar and cypress planting methods is being conducted at the Pocosin Lakes National Wildlife Refuge (Hinesley et al., 2000) and will help to guide planting at Buckridge and other areas on the Albemarle-Pamlico Peninsula. In consultation with the N.C. Division of Forest Resources' Forest Service, forestry best management practices (BMP's) would be exercised when planting. For instance, hand planting is less invasive than mechanical planting.

Due to limited funding and high cost, planting Atlantic white cedar, cypress, and other species would be on a small-scale, case-by-case basis. As an example, in February 2002, the Coastal Reserve Program plans to plant one-year old Atlantic white cedar and cypress seedlings provided free-of-charge by the U.S. Fish and Wildlife Service. Furthermore, the U.S. Fish and Wildlife Service will reimburse planting costs. About 10,000 seedlings (5,000 of each species) will be hand-planted on a 12-acre portion of a 250-acre tract that was harvested in 1997 (***Figure 26***). Currently, the small portion has few competing species and exhibits conditions conducive to growth of cedar and cypress (***Figure 27***). This planting project will demonstrate Reserve restoration activities to the public and to the local community. Successful demonstration projects tend to rally public support for the overall project objectives.

Fire Management

Another strategy is fire management, which may include prescribed burning (***Figure 28***). Fire is a natural component of peatland swamp forests and pocosins and affects the distribution and structure of many wetland plant communities (Frost, 1995; Christensen et al., 1981; Wells, 1946). Plant communities tend to regenerate quickly and diversity usually increases after fire (Christensen et al., 1981). Some species, such as pond pine, are dependent on fire for their long-term survival because fire stimulates seed germination. Likewise, some animals, such as the endangered red-cockaded woodpecker, are tied to a cycle of periodic fire to maintain their habitat.

In order to persist, Atlantic white cedar (AWC) requires a long-term cycle of disturbance, such as fire. Christensen et al. (1981) stated that AWC forests "are the product of a low frequency, relatively high intensity fire regime which is probably related to their marginally moist soil conditions." Frost (1987) observed that AWC

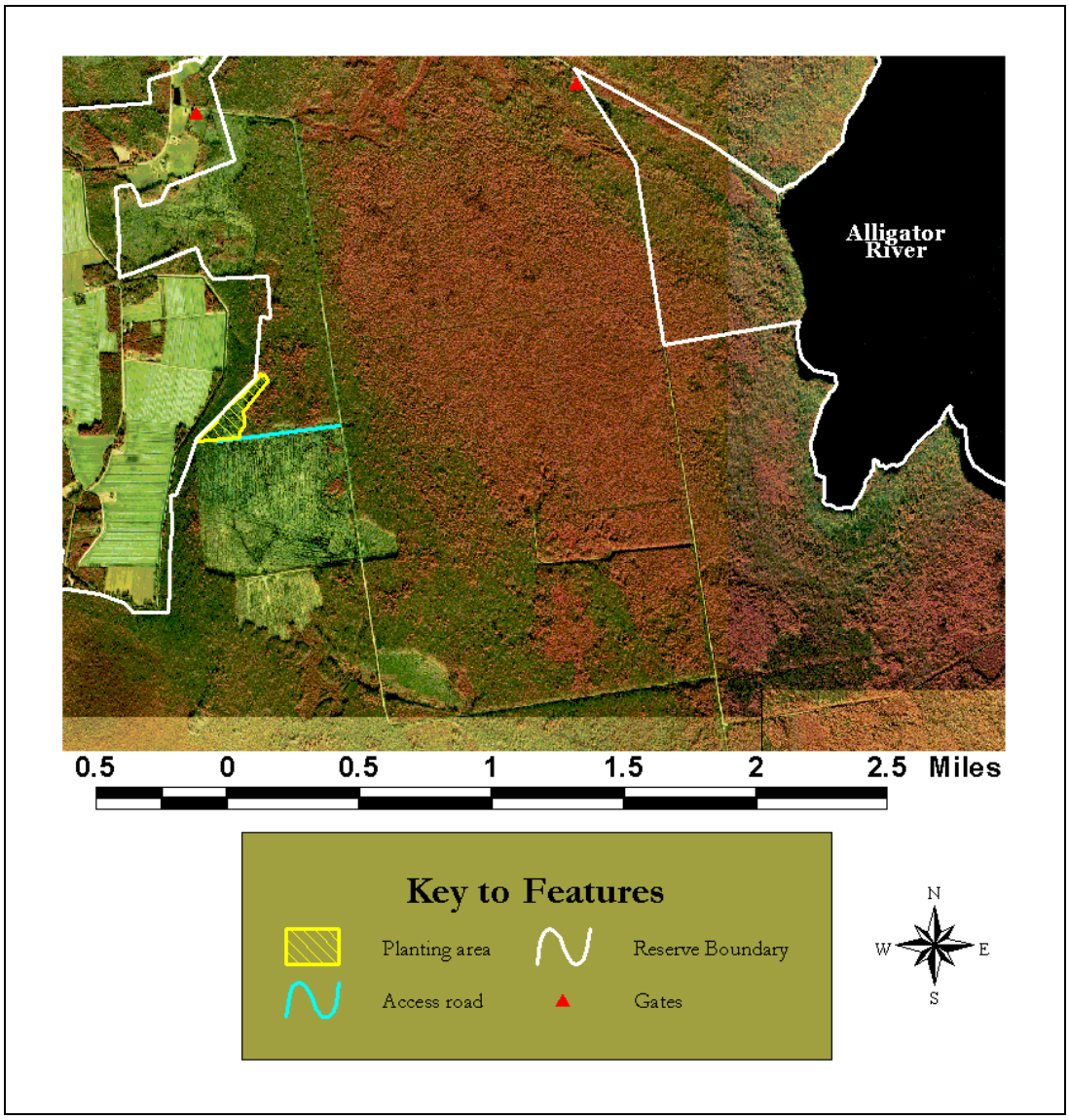

Figure 26. *Aerial photography showing the proposed planting area.*

Figure 27. *Proposed planting area showing lack of competitive growth.*

Figure 28. *Example of prescribed burning in a peatland environment.*

"requires periodic catastrophic fire, but with a medium to long fire return interval" (about 100-250 years). Extrapolating from historical maps and records, the Atlantic white cedar stands at Buckridge have not burned for at least 120 years, which is consistent with published fire cycles for AWC. Paradoxically, young and mature AWC are easily killed by fire, but moderate fire prepares the seed bed for ideal germination conditions by eliminating debris and competitive species (Korstian, 1924). Thus, fire during early regeneration can be devastating to AWC, but fire in mature forests is ultimately necessary to eliminate competitive species, prevent conversion to other forest community types, and encourage AWC regeneration and persistence (Laderman, 1989).

Many natural communities at Buckridge and their associated wildlife depend on fire as a form of disturbance. Uncontrolled fire, however, is dangerous. Peat soil is flammable and, once ignited, is difficult to extinguish. In addition, areas that burn infrequently, like Buckridge, have considerable fuel accumulation, presenting a risk of severe fire. The primary concern for fire control at Buckridge is the safety of the Gum Neck community.

Access for fire control at Buckridge is limited to the road network and the levee, where frequent wet and poor road conditions pose significant challenges for personnel and heavy equipment. Additional firebreak construction (beyond the existing road network) is not advised due to ecological impacts. We recommend that existing roads be improved and maintained as firebreaks by clearing roadside and ditch vegetation to maintain adequate road width.

At this time, prescribed fire management at Buckridge is not realistic. The Peatland Atlantic White Cedar Forest communities are well within the long fire-return intervals typical of these communities (Christensen et al., 1981; Frost, 1987). More importantly, current resources are inadequate to design and implement a prescribed fire management program. However, a wildfire response plan developed with the

assistance and input of the Division of Forest Resources (DFR) and Pocosin Lakes National Wildlife Refuge should be prepared as soon as possible. Deep organic peat soils present a significant challenge for both prescribed and wildfire planning, and should be thoroughly considered.

Once this restoration plan is implemented, prescribed fire may in fact become one of several desirable restoration tools. If so, appropriate resources to fund planning and implementation will need to be secured.

Selective Herbicide Application

Given the likelihood that Atlantic white cedar forests have been increasingly replaced by hardwood forests (Mylecraine and Zimmermann, 2000), another restoration strategy is aerial application of a selective herbicide such as Arsenal® (American Cyanamid Co., 1999, 1998) to release Atlantic white cedar from intense competitive pressure from hardwood species. Selective herbicides limit hardwoods' ability to compete with species like Atlantic white cedar. This approach has been used effectively to release AWC from competition at the jointly managed U.S. Air Force Dare County Bombing Range and Alligator River National Wildlife Refuge (Van Druten and Eagle, 2000). It is quite possible that, in addition to hydrological restoration, selective herbicide application may sometimes be necessary to prevent conversion of rare natural communities to other community types. Possible locations for this strategy include the area to be planted with AWC and cypress seedlings and portions of the regenerating AWC that may be competing with species like red maple (***Figure 29***).

Broad-scale applications of this strategy are not compatible with the management approach of the Coastal Reserve Program and pose potential water quality problems (American Cyanamid Co., 1999, 1998). Small-scale applications should be limited to the dry season, avoiding direct contact with surface waters and BMP's should be implemented to avoid impacts to water quality. In support of the research goal of the Coastal Reserve Program, it may be appropriate to investigate the effects of selective herbicide application on small, experimental plots.

Selective Forest Cutting or Thinning

Without a long-term cycle of disturbance, historically fire (Frost, 1995), Atlantic white cedar may be replaced by hardwood species such as red maple and sweet gum. Given the infrequent occurrence of wildfire at Buckridge and the difficulty of prescribed burning on peat soils, a final supplemental strategy is to introduce disturbance using selective forest cutting or thinning of hardwoods to prevent conversion of existing natural communities or to restore natural communities where they may have previously existed. This is a logical approach in light of Levy and Walker's (1979) suggestion that some nonriverine swamp forests may have originally been AWC forests that had been harvested and replaced by hardwood competitors. It has also been

Figure 29. *Aerial photography showing possible selective herbicide application areas.*

suggested that some areas of Buckridge could have previously been Peatland Atlantic White Cedar Forest, but are now Nonriverine Swamp Forest with a mix of hardwoods, AWC, and other species (Schafale, 1999). Potential areas for selective forest cutting exhibit 5-10% AWC in the canopy or subcanopy (***Figure 30***).

Given the increasing frequency of hurricanes in North Carolina, another scenario is to use selective forest cutting in areas damaged by wind during hurricanes. Historically, it is possible that hurricanes provided a source of disturbance for AWC (Laderman, 1989); however, debris from hurricane damage may impede sunlight that is necessary for seed germination. Thus, selective cutting and debris removal could prepare the seedbed for AWC germination (Korstian, 1924).

Figure 30. *Aerial photography showing possible selective cutting areas.*

Small-scale selective forest cutting may help to maintain or reestablish rare natural communities, such as Peatland Atlantic White Cedar Forest. It is also possible that the long-term persistence of Peatland Atlantic White Cedar Forest may benefit from small-scale cutting as a disturbance mechanism, particularly if prescribed burning is not feasible (Mylecraine and Zimmermann, 2000). This strategy may provide research opportunities to identify successful AWC regeneration techniques in the North Carolina coastal plain. To reduce impacts of selective cutting, forestry best management practices would be implemented to eliminate or minimize impacts on existing natural resources. For instance, shovel logging is a technique often used in forested wetlands because it reduces the effects of soil compaction typical of more conventional harvest methods. Furthermore, hand cutting is a low-impact substitute for mechanical cutting methods.

Large-scale cutting is neither compatible with the preservation goal of the Coastal Reserve Program nor with the Nature Preserves Act (NCGS §113A–164). The purpose of the Nature Preserves Act is to identify and preserve areas of natural significance for the benefit of present and future citizens of the state. The Reserve was dedicated as a State Nature Preserve on July 31, 2000.

GIS and Remote Sensing

Geographic information systems (GIS) and remote sensing techniques have been an integral part of the planning and assessment process for Buckridge. The Division of Coastal Management's GIS-based wetland mapping procedures have generated four data sets that inventory the type, amount, location, and functional significance of existing wetlands and potential wetland restoration sites for the North Carolina coastal area (Sutter, 1999; Sutter et al., 1999). These data sets identify most of the Reserve as having substantial potential wetland restoration significance (***Figure 31***). The designation of wetland restoration significance is based on the functions that the wetlands will provide once fully restored and offers further ecological evidence that Buckridge and the Alligator River system will benefit greatly from restoration efforts.

In order to inventory and assess the natural resources at Buckridge with limited staff resources on difficult terrain, GIS and remote sensing data sources were utilized extensively. Key GIS data sets include: DCM's wetland types (***Figure 10***), USGS hydrography (***Figure 5***), NRCS soils (***Figure 3***), roads (***Figure 2***), and National Wetlands Inventory (***Figure 11***). Color infrared aerial photography from 1998 (***Figure 18***) and black-and-white aerial photography from 1993, 1974 and 1951 have also been analyzed. Furthermore, Landsat TM satellite imagery from 1988 (***Figure 32***), 1994 (***Figure 33***), and 1999 (***Figure 34***) have been analyzed. In fact, a vegetation change detection study was performed using the satellite data from 1994 and 1988 (***Figures 13-15***) (Meyer and Fuss, 2001). In addition, global positioning system (GPS) data have been collected for the locations of many features of the Reserve, including roads, boat landings, and gates. Furthermore, the Reserve's boundary was digitized from a survey map. These resources, in concert with the historical vegetation maps from the timber companies, will aid planning and execution of the restoration and management strategies. A complete list of data sets available for the Preyer Buckridge Coastal Reserve is listed in the ***Appendix***.

RECOMMENDATIONS

There are a number of key recommendations for utilizing restoration and management strategies at Buckridge.

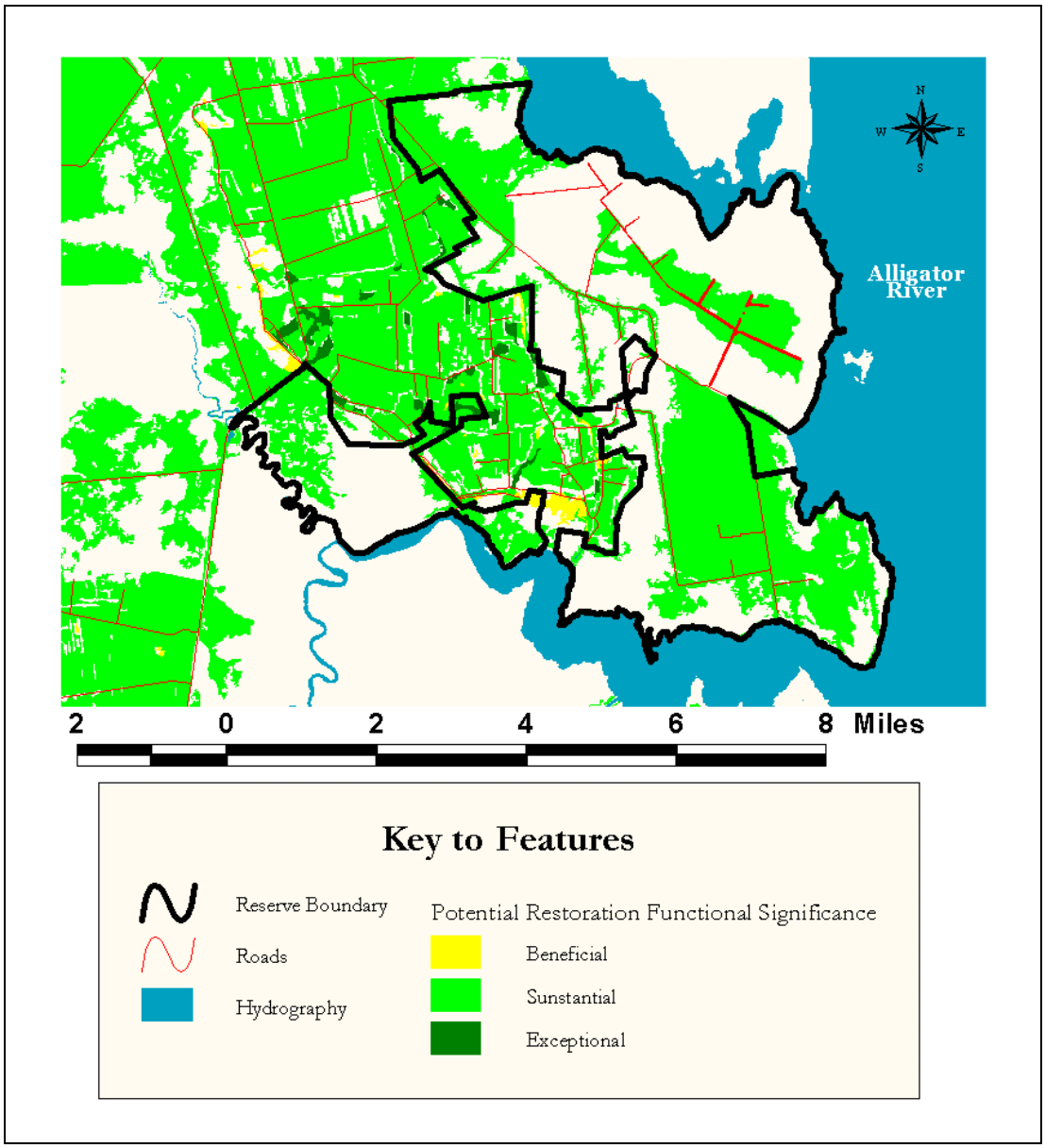

Figure 31. *Functional significance of potential wetland restoration sites at Buckridge Reserve.*

1. **Hydrological restoration should be the primary agent for restoration.** Specifically, all of the spur roads not needed for access should be breached (***Figure 24***) with consideration of fire control issues. With the help of forthcoming hydrologic and water quality data, locations for culverts and water control structures should be identified.

2. **Planting should be limited to demonstration projects** on sites that need little, if any, site preparation (***Figure 26***).

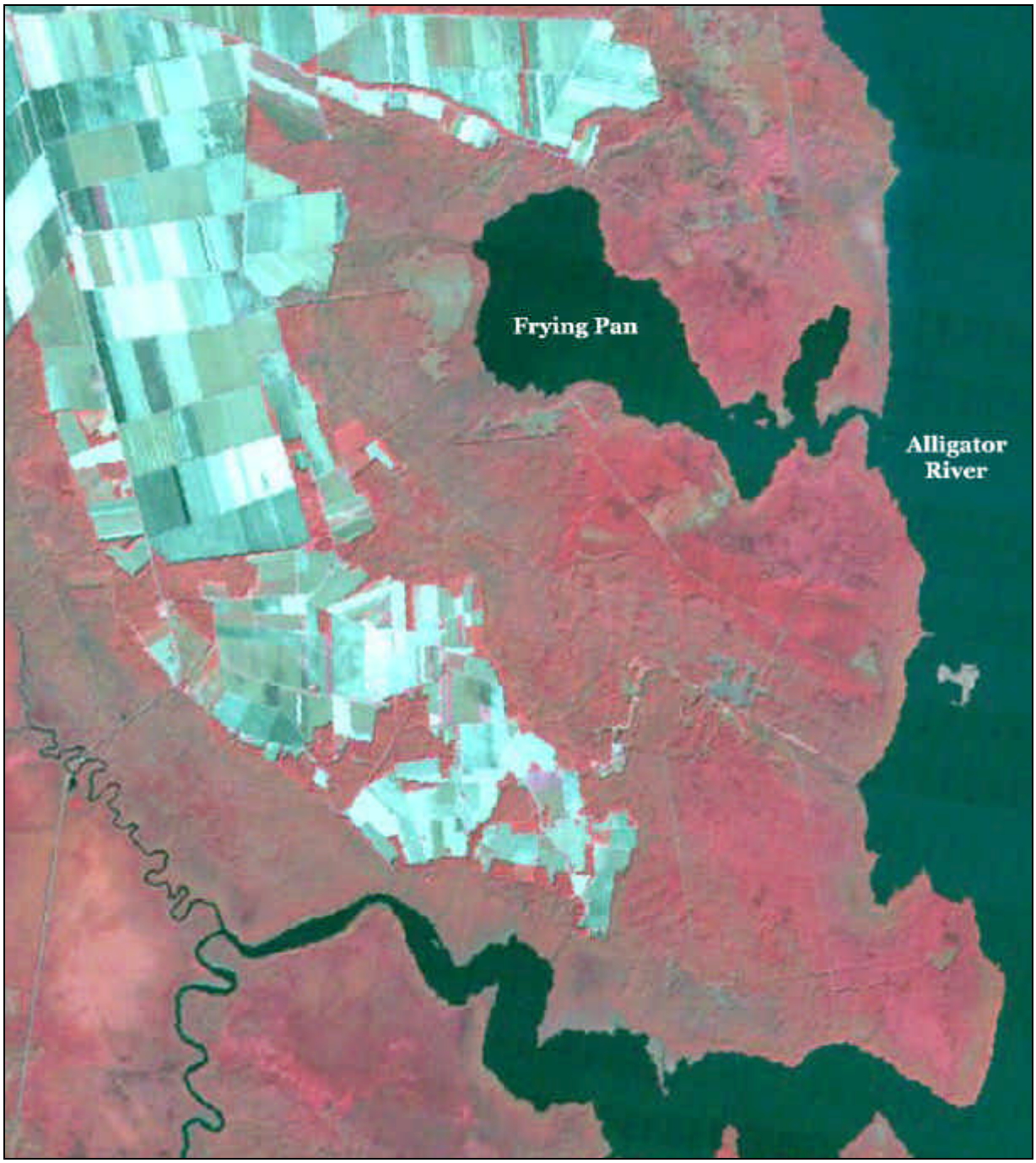

Figure 32. *Landsat TM satellite image of the Preyer Buckridge Reserve from 1988.*

3. **Fire management should initially be limited to controlling wildfires.** Ideally, wildfires will be allowed to burn to benefit the natural communities, unless they threaten the safety of Gum Neck. In addition, prescribed burning to benefit the natural communities should be considered in the future. Poor access and highly flammable peat soils, however, make prescribed burning risky.

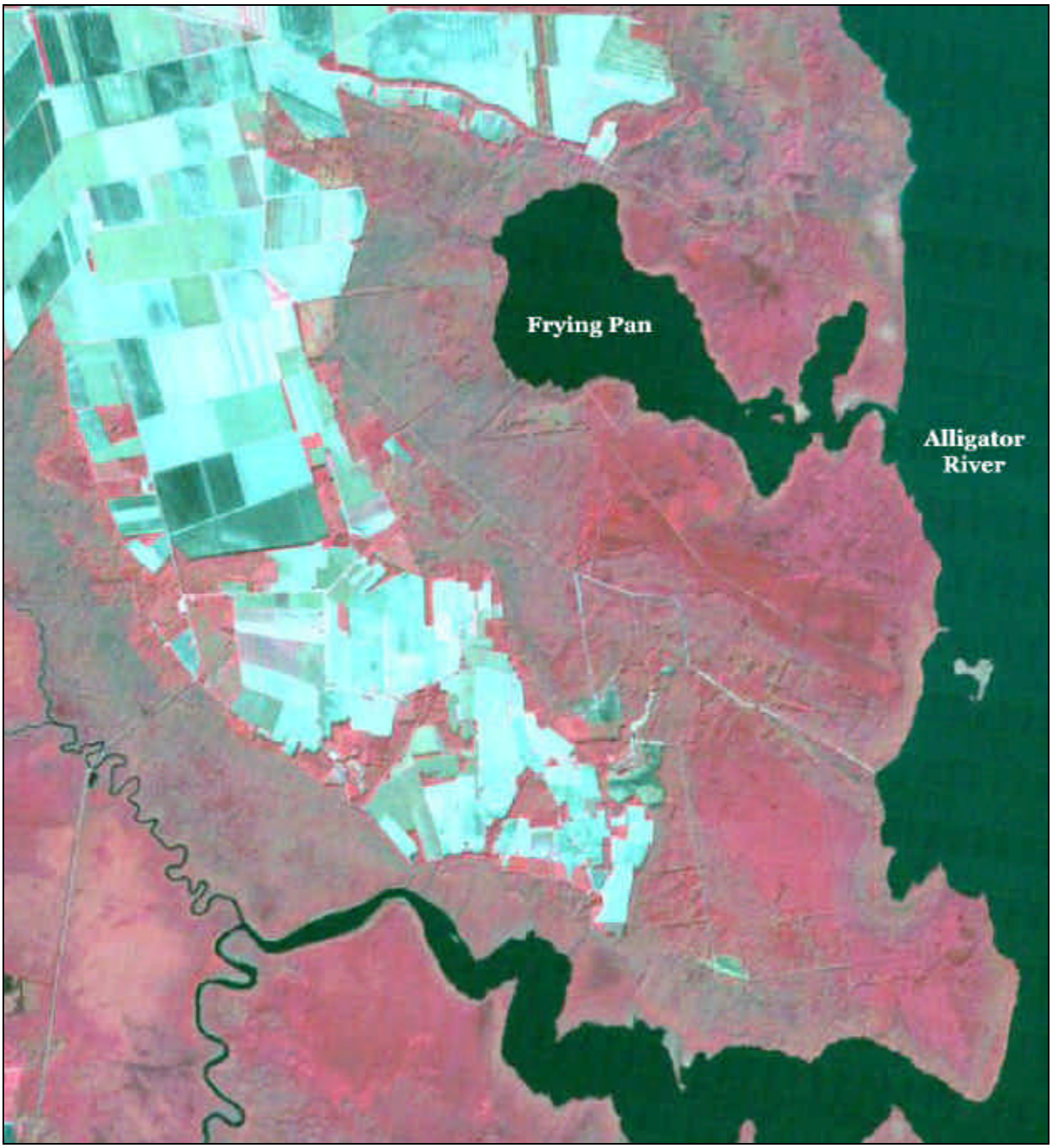

Figure 33. *Landsat TM satellite image of the Preyer Buckridge Reserve from 1994.*

4. **Selective herbicide application and selective forest cutting should be used on a case-by-case basis.** In some instances, these approaches may effectively complement hydrological restoration. However, both approaches, if used unwisely, could have unintended consequences.

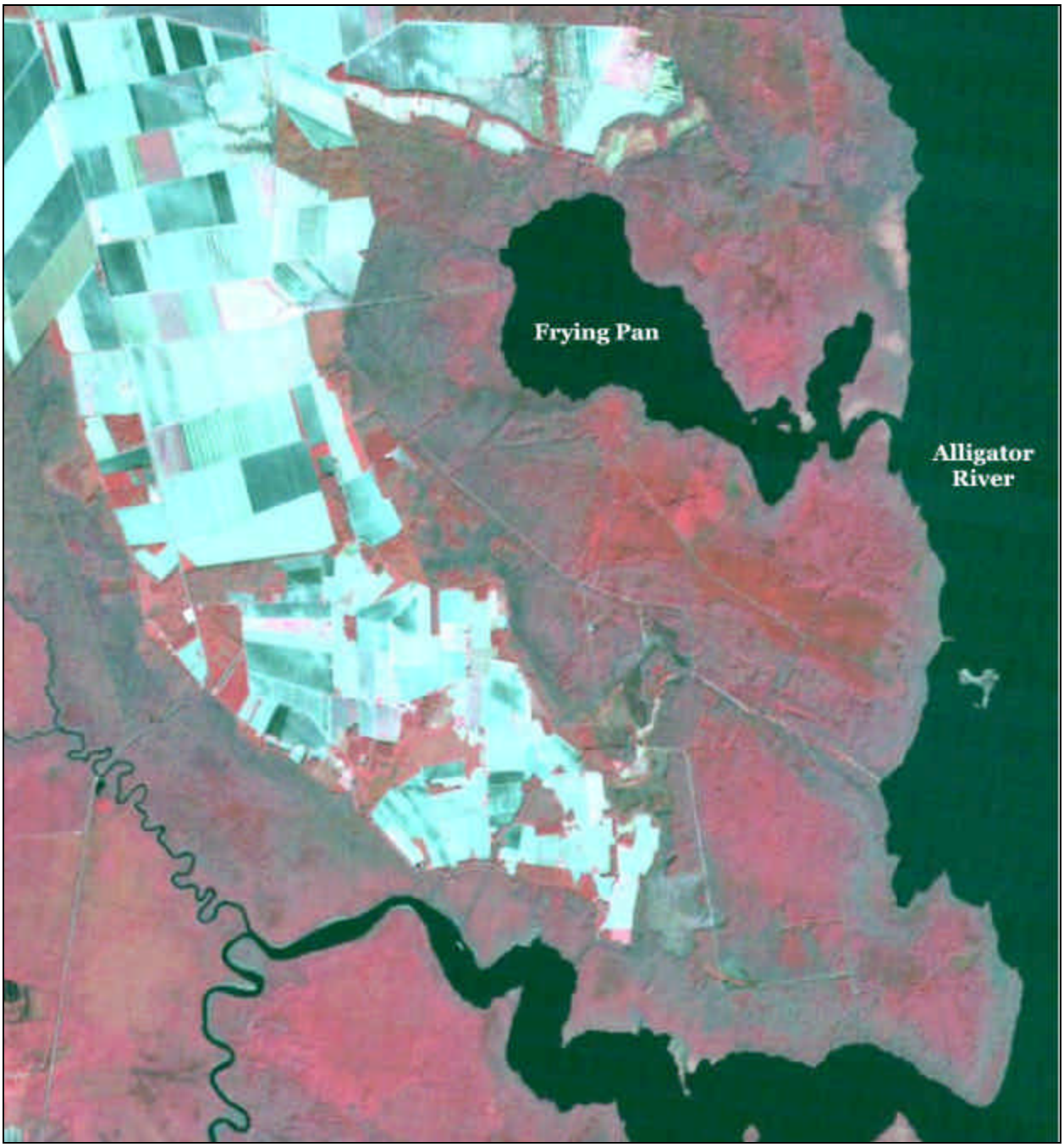

Figure 34. *Landsat TM satellite image of the Preyer Buckridge Reserve from 1999.*

5. **Restoration actions should be monitored closely and integrated with other research activities.** Monitoring should include assessment of vegetation growth, tracking of water levels, periodic assessment of wildlife, and water quality sampling. In addition, satellite imagery or aerial photography can be used to track overall forest health.

CHAPTER 5
RESEARCH AND MANAGEMENT RECOMMENDATIONS

RECOMMENDATIONS FOR RESEARCH

Hydrology

Basic information about how water moves at Buckridge is needed in order to develop the logic behind implementing proposed hydrological restoration actions. Currently, available hydrology information is limited to anecdotal observations and regional characterization of water flow. Clearly, substantial information gaps exist.

Through a U.S. Environmental Protection Agency Clean Water Act Section 319 Nonpoint Source Pollution Program Grant, a 3-year U.S. Geological Survey (USGS) hydrology study will begin to fill the information gaps in 2002. The USGS plans to install bi-directional water flow gauges in three primary ditch outlets to monitor flow dynamics (***Figure 23***). Armed with directions and magnitudes of seasonal flow regimes, USGS researchers will develop a hydrologic model and water budget for the Reserve. Additionally, the USGS plans to monitor water levels at one location within an Atlantic white cedar stand to understand the hydrologic effects of roads and ditches on groundwater levels. All of this information will aid managers in designing and installing water control structures and culverts for restoring the natural hydrology.

Future hydrologic studies should focus on water flow in small plots of specific natural communities – Peatland Atlantic White Cedar Forest, Nonriverine Swamp Forest, Pond Pine Woodland, and Tidal Cypress-Gum Swamp.

Water Quality

Like hydrology data, there is a lack of water quality data with which to evaluate possible hydrological restoration actions. Due to the undeveloped nature of the Alligator River, the sole current sampling site for water quality (the N.C. Division of Water Quality's Ambient Water Quality Monitoring Program) is at the U.S. Route 64 bridge near the river mouth, far downstream from Buckridge. This site has been sampled since 1982. From 1982 to 1994, there were three additional water quality sampling sites in the Alligator River along the Reserve's boundary – at Catfish Point (mouth of Frying Pan), Newport News Point and Cherry Ridge Landing. This data is available from the Division of Water Quality. There has been no water quality monitoring work in the drainage ditches, other than two spot checks in October 2000 which revealed normal levels of pH, dissolved oxygen, nitrogen, phosphorus, and mercury. There is a pressing need to fill water quality information gaps.

In coordination with the USGS hydrology study, researchers at N.C. State University and Duke University plan to perform a 3-year water quality monitoring study of the

ditches at Buckridge beginning in 2002. The research consists of water flow gauges that will trigger the collection of water samples during rain-driven (out) or wind-driven (out or in) flow events. These samples will be analyzed for coliform bacteria and other water quality parameters (refer to ***Appendix*** for North Carolina's water quality standards) at the Duke Marine Laboratory in Beaufort. The gauges will be located in the ditches immediately downstream from specific natural community types, such as regenerating Peatland Atlantic White Cedar Forest and mature Nonriverine Swamp Forest. Study results will help to determine water quality differences, if any, between natural community types, gauge the capability of the ditches to deliver water from the system, and compare water quality differences with developed systems along the coast. This information will also help managers in determining design and location for hydrological restoration features. If the study finds water quality problems at Buckridge, then ongoing water quality monitoring will be warranted.

Besides coliform bacteria, two water quality parameters, mercury and nitrogen, are particularly important to monitor in peat swamp situations due to their tendency to enter the water if the peat soil is oxidized through drainage. Nitrogen should be measured as total nitrogen because the acidic water in the swamp may alter its form so that it is not detected as nitrate or nitrite. The water quality standard for mercury in North Carolina is much lower than the resolution of analysis methods available in most testing laboratories. Therefore, high resolution analysis is necessary to detect mercury. Otherwise, zero detect results may be misleading.

Basic Species Inventories

Anadromous fish

Without basic information on fish usage of the drainage ditches at Buckridge, the Coastal Reserve Program cannot effectively address the National Marine Fisheries Service's concerns about potential effects of restoration activities on anadromous fishes. This plan recommends that, prior to implementing hydrological restoration, studies be undertaken to learn the extent to which anadromous fish utilize the drainage ditches for nursery or spawning habitat. Once this information is known, the Reserve can better design its hydrological restoration actions.

A survey of anadromous fish usage of natural creeks and lakes is currently underway at the Alligator River National Wildlife Refuge. The results of this study, due in March 2002, may help to evaluate the potential for anadromous fish at Buckridge. Still, a basic fish survey of the drainage ditches is needed. Possible options are: 1) to contract the Division of Marine Fisheries, the National Marine Fisheries Service, or university researchers to perform sampling with U.S. Fish and Wildlife Service funding earmarked for restoration activities at Buckridge; and 2) to submit a specific proposal to grant funding sources such as NOAA and the U.S. Fish and Wildlife Service.

Wildlife

Basic wildlife species surveys are also needed. There is a paucity of information about wildlife at the Reserve because few surveys have been performed. The U.S. Fish and Wildlife Service included Buckridge in red wolf and red-cockaded woodpecker surveys at the adjacent Pocosin Lakes National Wildlife Refuge, but the surveys yielded no occurrences of these species at the Reserve. The Wildlife Resources Commission tracks regional populations of game species such as black bear and white tailed deer, but does not calculate population estimates for small areas like the Reserve. Thus, the status, or even the presence, of game and non-game species at Buckridge is uncertain.

Basic species inventories are necessary for developing successful, long-term management strategies. Tracking the populations of wildlife species allows managers to address habitat concerns and to assess habitat restoration efforts. In addition, estimating wildlife populations will assist N.C. State University researchers in interpreting water quality data by estimating the Reserve's natural coliform bacteria load. Identifying funding mechanisms for these inventories should be a priority.

Monitor Plantings

Monitoring is essential in any restoration project in order to assess success. One key recommendation is to monitor tree plantings, such as those planned for the 12-acre cutover tract in the southern portion of the Reserve. Since other public preserved areas in the region are also planting tree seedlings, monitoring information can be exchanged to improve future plantings. For instance, planting research at Pocosin Lakes NWR has helped to alleviate problems with deer and rabbit browse. Possible monitoring parameters include: growth rate; mortality rates and causes; water levels; rainfall; and seed production.

Monitor Regeneration

Another key recommendation is to monitor areas that are naturally regenerating from past cuts, such as the Atlantic white cedar stands along Juniper Road. There are a variety of areas that were cut within the past 25 years, prior to State ownership. These areas may regenerate well, with the same species that occurred there prior to the cuts. These areas may also regenerate poorly, with either poor growth or with a species composition different than that before the cuts. In order to develop appropriate management strategies, managers need to know the dynamics of these regenerating cutover areas. This is particularly important in areas that are targeted for research or restoration, such as the regenerating Atlantic white cedar along Juniper Road. Possible monitoring parameters include: species composition of the canopy, subcanopy, and understory; growth rate; mortality rates and causes; water levels; and rainfall.

Sea Level Rise

Sea level rise is a concern in the North Carolina coastal area (Dame et al., 2000). With global estimates of sea level rise ranging from 3-10 feet (1-3 meters) over the next 100 years (Gornitz, 1995), significant threats exist to lands that border coastal waters, such as the Reserve. Since elevations at the Reserve are mostly within the range of predicted sea level rise, the Reserve must consider sea level rise in long range planning. The Reserve's border along the Alligator River already suffers a high rate of erosion, reportedly up to 20 feet per year (J. Landino, *pers. comm.*). An erosion study is appropriate to aid in decision-making about sea-level rise and erosion in the Alligator River region. This plan recommends avoiding the use of any structures to mitigate erosion. Rather, the plan recommends that restoration and management activities avoid the placement of ecological restoration structures, boardwalks, trails, or parking spaces in areas that may be affected by erosion and sea level rise.

MANAGEMENT ISSUES

Agriculture

The Reserve is adjacent to agricultural land in the Gum Neck Drainage District. The District pumps water from its ditch network through a levee and into the Alligator River. The levee separates agricultural land from the Reserve property and several small parcels of private timberland. The water pumped to Cherry Ridge Landing passes through the Reserve and affects water quality in the Alligator River. Indeed, based on sampling in the Alligator River at Cherry Ridge Landing, the *Pasquotank River Basinwide Water Quality Management Plan* (NC DEHNR, 1997) states that the Alligator River suffers from high nitrogen and low dissolved oxygen levels. While low dissolved oxygen levels are common in blackwater coastal streams, the high nitrogen levels are attributed to agricultural activities.

Since this project's objectives include the protection and improvement of water quality in the Alligator River, one possible management strategy is to divert the Drainage District's outflow into the Reserve's adjacent wetlands to enhance pollutant filtration and water storage. Obviously, the pollutant load in the agricultural outflow must be thoroughly understood to assess the possible adverse impacts on the Reserve's wetlands that may result from this strategy. If this action is deemed appropriate, coordination and agreement with the Gum Neck Drainage District would be necessary.

This option is recommended as a secondary strategy. The Gum Neck Drainage District's concern that this strategy may affect agricultural operations is a potential obstacle. Primary restoration and management strategies should focus on areas entirely within the Reserve that have historically been used for timber production.

Road Maintenance

The primary goal for road maintenance at Buckridge is to maintain access for the diversity of Reserve uses (e.g. research, recreation, fire control, etc.) without adversely affecting water quality. Stabilizing the roads by maintaining herbaceous vegetation is the chief maintenance strategy. Secondary goals are to avoid disruption of wildlife to the greatest degree feasible and to maintain firebreaks and emergency access.

The following road maintenance guidelines should be observed:

1. Seek Reserve staff approval before undertaking any major road maintenance activity (e.g. grading, disking, mowing) to coordinate with Reserve research and restoration and management goals;

2. Roads with herbaceous vegetation should remain vegetated;

3. Grading/scraping may be necessary if road sections become muddy, severely rutted, very difficult to traverse and/or devoid of herbaceous vegetation from heavy or inappropriate use. Ideally, grading should be performed during spring or early summer so that herbaceous vegetation may naturally reestablish, but it is acknowledged that equipment availability may necessitate grading at other times. In all cases, grading should be avoided prior to expected heavy road use (e.g. hunting season) or heavy rains;

4. Disking may be necessary if the roads are in extremely poor condition and grading alone is not sufficient to improve them. Ideally, disking should also be performed during spring or early summer and should be avoided prior to expected heavy road use or heavy rains;

5. Vehicles and other heavy equipment should not be used on roads that have been recently graded and/or disked;

6. Vehicles and other heavy equipment should not be used on roads during and after significant rain events for a period not to be less than 24 hours to avoid creating ruts and damaging herbaceous vegetation;

7. Seeding may be necessary if roads do not naturally re-vegetate following grading and/or disking and should be performed only at the discretion of the on-site Reserve manager;

8. Dirt may be hauled to fill large holes if an approved upland borrow site can be found at Buckridge. All borrow activities should be approved in advance by the Reserve manager;

9. To reduce fire hazards, roads should be mowed during the summer and fall seasons when the herbaceous vegetation reaches 2-3 feet high;

10. Shrubs and trees along canals of main roads should be mechanically trimmed as needed during late fall and winter to maintain access and firebreaks;

11. Avoid sediment discharge into canals during road maintenance activities (i.e. avoid piling dirt where rain will wash sediment into the canals);

12. Remove fallen trees blocking the roads as soon as is feasible;

13. Plan road maintenance activities between 10 AM and 4 PM to avoid disturbing wildlife (e.g. waterfowl); and

14. Care **must** be taken to avoid damaging sensitive elevation benchmarks installed by the N.C. Geodetic Survey. Benchmark locations will be mapped and identified with witness posts and/or other markings.

Hunting

Currently, hunting rights are leased to a private hunt club, Pocosin Wildlife Management Group. In exchange for a fee ($10,000), the club has exclusive hunting rights at the Reserve, obeys all wildlife and hunting regulations, and assumes responsibility for road maintenance according to the guidelines above. During the 2001 hunting season, an agreement was reached with the Gum Neck Hunt Club that allows them to hunt white-tailed deer on the Reserve south of Grapevine Landing Road. Pocosin Wildlife Management Group retains hunting rights on the Reserve north of Grapevine Landing Road. To coordinate research and other activities with hunting, the hunt clubs should be contacted during hunting season prior to any activities and blaze orange safety vests should be worn. In addition, as a courtesy to visitors, warning signs should be posted during hunting seasons.

The hunt clubs target black bear and white-tailed deer and generally use dogs. As established by the Wildlife Resources Commission, hunting seasons in Tyrrell County vary, but are similar, from year to year. For example, in 2001, the black bear season is November 12-17 and December 10–22. Typically, 12 bears are taken during each hunting season. Eastern deer season using guns is October 13 to January 1. On average, 50-60 deer are harvested annually. The deer harvest may increase during 2001 due to the agreement with the Gum Neck Hunt Club.

Ecotourism

When it purchased the property, the Coastal Reserve Program pledged to promote ecotourism at the Preyer Buckridge Coastal Reserve. Tyrrell County has recently

embarked upon an effort to market itself as a destination for ecotourism to encourage growth in its natural resource-based economy. Currently, the county's economy is heavily dependent on agriculture and silviculture (Holland Consulting Planners, 2000). In addition, at least 60% of the county consists of wetlands or former wetlands (Sutter, 1999). In an effort to reconcile these two factors for a positive economic outcome, considerable effort has been expended toward developing the county's economic potential for ecotourism.

In 1999, The Conservation Fund formed an Ecotourism Committee - involving community leaders and representatives from possible ecotourism destinations - to evaluate Tyrrell County's potential for ecotourism and to develop an ecotourism implementation approach for its Palmetto-Peartree Preserve in the community of Alligator in northeastern Tyrrell County. The foundation upon which the Committee's work builds is an ecotourism feasibility study (Fiori, 2000) that evaluated birding and paddling at the site based on SWOT analysis (Strengths, Weaknesses, Opportunities, Threats). The study concluded that, given adequate development and marketing for these activities, birding and paddling are potentially viable ecotourism activities at the Preserve and could provide significant benefits to Tyrrell County. The Preserve is currently being developed for birding and an implementation plan will guide future development for ecotourism (Kline et al., 2000).

Lessons from The Conservation Fund's ecotourism experience in Tyrrell County will fuel the development and marketing of the Preyer Buckridge Coastal Reserve for ecotourism. The Reserve could be marketed as a destination for ecotourists at key locations in Columbia, namely the new Walter B. Jones, Sr. Center for the Sounds, the new Pocosin Lakes National Wildlife Refuge headquarters and visitor's center, the Tyrrell County Visitor's Center, and the Columbia Theater. In fact, a Duke University graduate student study of ecotourism feasibility at the Reserve recommended that the Coastal Reserve Program partner with these organizations to promote ecotourism, particularly paddling (Auer et al., 2000).

Due to its remote location relative to other destinations such as the Palmetto-Peartree Preserve, Pocosin Lakes National Wildlife Refuge, and the Scuppernong River Wetlands Walk in Columbia, Buckridge is unlikely to attract casual visitors. Rather, the average visitor to the Reserve is likely to be actively seeking a wilderness experience. Due to its proximity to the scenic Alligator River, canoe and kayak enthusiasts will find the site attractive. As an example, Rock Rest Adventures, a regional outdoor outfitter, guides kayak trips to Buckridge (J. Jacob, *pers. comm.*). The Northwest and Southwest Forks of the Alligator River and the main river downstream to and along Roper Island are marked as a paddle trail with mile markers and identifications signs (***Figure 21***) and are mapped (***Figure 22***) in the "North Carolina Coastal Plain Paddle Trails Guide" (http://www.ncsu.edu/paddletrails/).

The Duke study (Auer et al., 2000) recommends a phased implementation for ecotourism development at Buckridge. The first phase involves simple activities. First, hiring an on-site manager as a resource to visitors is essential. Next, compiling and publishing a list of confirmed flora and fauna occurring at Buckridge and a map of the Reserve are important steps to guiding visitors. Finally, directional signs on main roads and an informational web site so that visitors can learn about and travel to the Reserve are necessary. The second phase, if Buckridge appears to be a viable ecotourism destination during and after implementation of the first phase, includes complex actions such as building partnerships with community organizations (e.g. schools, 4-H Environmental Education Conference Center) and incorporating Buckridge into local events (e.g. Scuppernong River Festival, Wings Over Water Festival). Other second phase activities are trail development and encouragement of local business support for ecotourists (e.g. camp sites, provisions, supplies).

Exotic or Non-native Species

The Reserve currently has one known exotic species, *Phragmites australis*. This plant, known as common reed, invades freshwater marsh environments. At the Reserve, common reed is currently found in ditches and roadways, where wet conditions persist. *Phragmites* is generally thought to be poor habitat for native wildlife species and can displace native plant species. It is also thought that marshes dominated by *Phragmites* do not perform the same ecological functions as natural freshwater marshes. The presence of *Phragmites* should be monitored and steps should be taken to eliminate this non-native species, if it becomes a major problem. Restoration funding should be available to perform this type of species removal.

Military Airspace

The airspace above the Reserve is military airspace (***Figure 35***) reserved for U.S. Air Force and U.S. Navy practice at the Dare County Bombing Range, which is east of the Reserve across the Alligator River. Buckridge lies along the approach route of the jet airplanes, which fly at low altitude and create tremendous noise when they pass over the Reserve. Therefore, as a courtesy, noise warnings to visitors should be posted at the entrance(s) to the Reserve. Researchers and official visitors should also be warned for their convenience. Noise is a potential obstacle for ecotourism.

In addition to noise problems, the military also restricts civilian flights over the Reserve. Civilian pilots cannot exceed 500 feet in altitude over the Reserve without express military permission on the day of the flight. This restriction must be considered when planning aerial photography or aerial flyovers for research and monitoring.

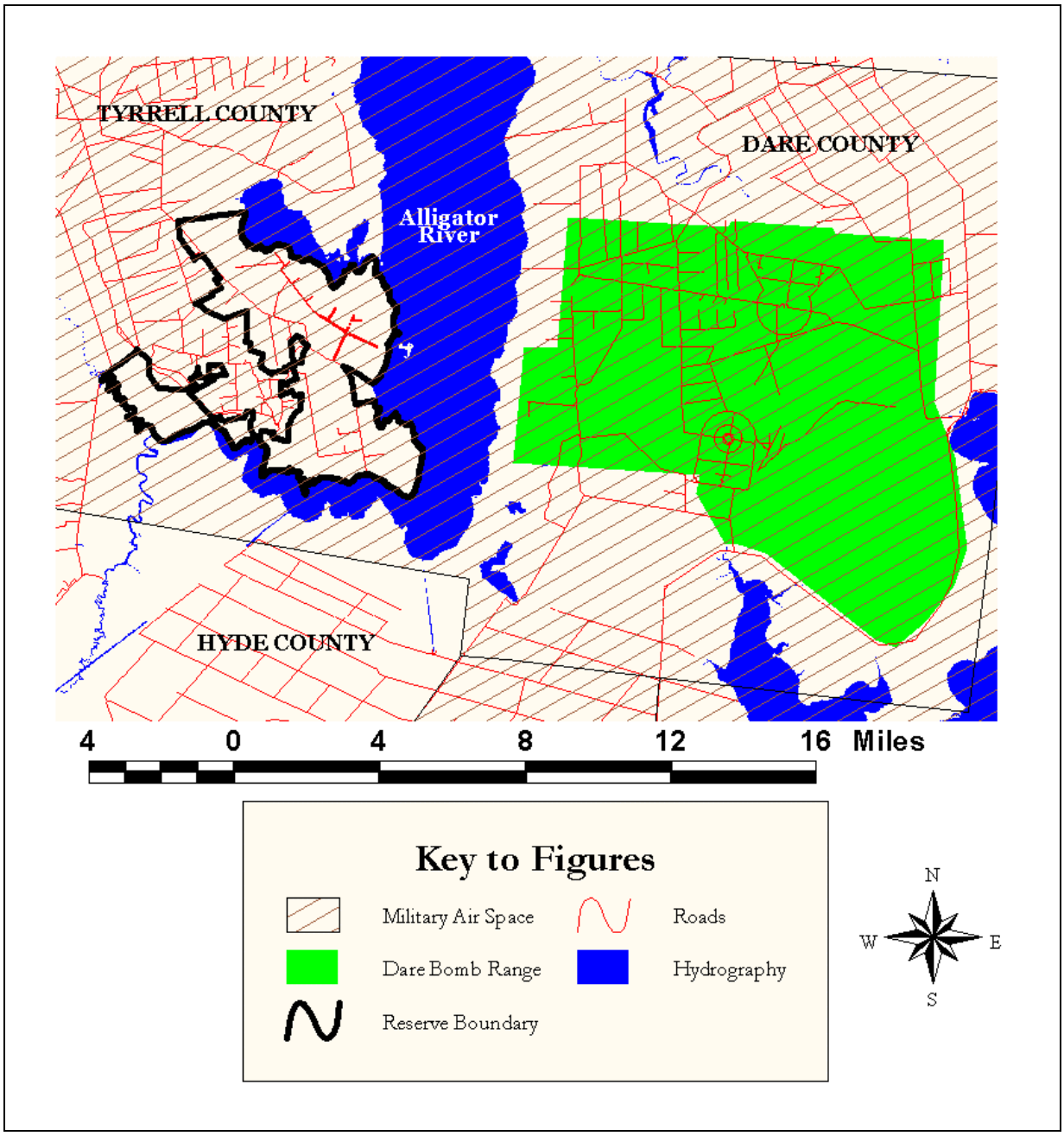

Figure 35. *Military airspace and the location of the Dare County Bombing Range.*

Carbon Sequestration

Peatlands, such as those at the Reserve, have been recognized as sinks for sequestering carbon in the soils and in the trees that grow on them. With growing international and national concern about global warming, greenhouse gas sequestration is becoming an important issue, particularly in the energy industry. Energy companies are increasingly interested in acquisition and restoration of peatlands because of their high value in carbon sequestration. For example, The Conservation Fund works with such companies to identify funds to purchase peatlands and to plant trees on them. This

arrangement represents a possible funding source for acquiring additional lands or planting trees at the Reserve. In addition, since oxidation of peat soils results in a release of carbon, it is conceivable that funding could be directed toward hydrological restoration. Carbon sequestration should be considered when additional funding needs arise at the Reserve.

RESERVE ADDITIONS

Several inholdings and adjacent properties are priorities for acquisition and addition to the Preyer Buckridge Coastal Reserve. For example, Roper Island is located across the Alligator River to the south and is formed by the Alligator River and the Atlantic Intracoastal Waterway (***Figure 36***). This undeveloped 8,274-acre tract that is currently being used for timber production is a conservation priority for the Coastal Reserve Program, the U.S. Fish and Wildlife Service and The Nature Conservancy. The Nature Conservancy is currently negotiating the purchase of a permanent conservation easement at Roper Island. The Division of Coastal Management is acquiring funds to purchase this easement, at which point Roper Island would be added to the Reserve for a total of 26,926 acres.

Several smaller inholdings in the existing Preyer Buckridge Reserve are also priorities for acquisition. Of these, the most important is the property immediately to the west of Gum Neck Creek that, if acquired, would make the Reserve continuous from the Frying Pan south and west to NC Route 94. It is currently being used for timber production.

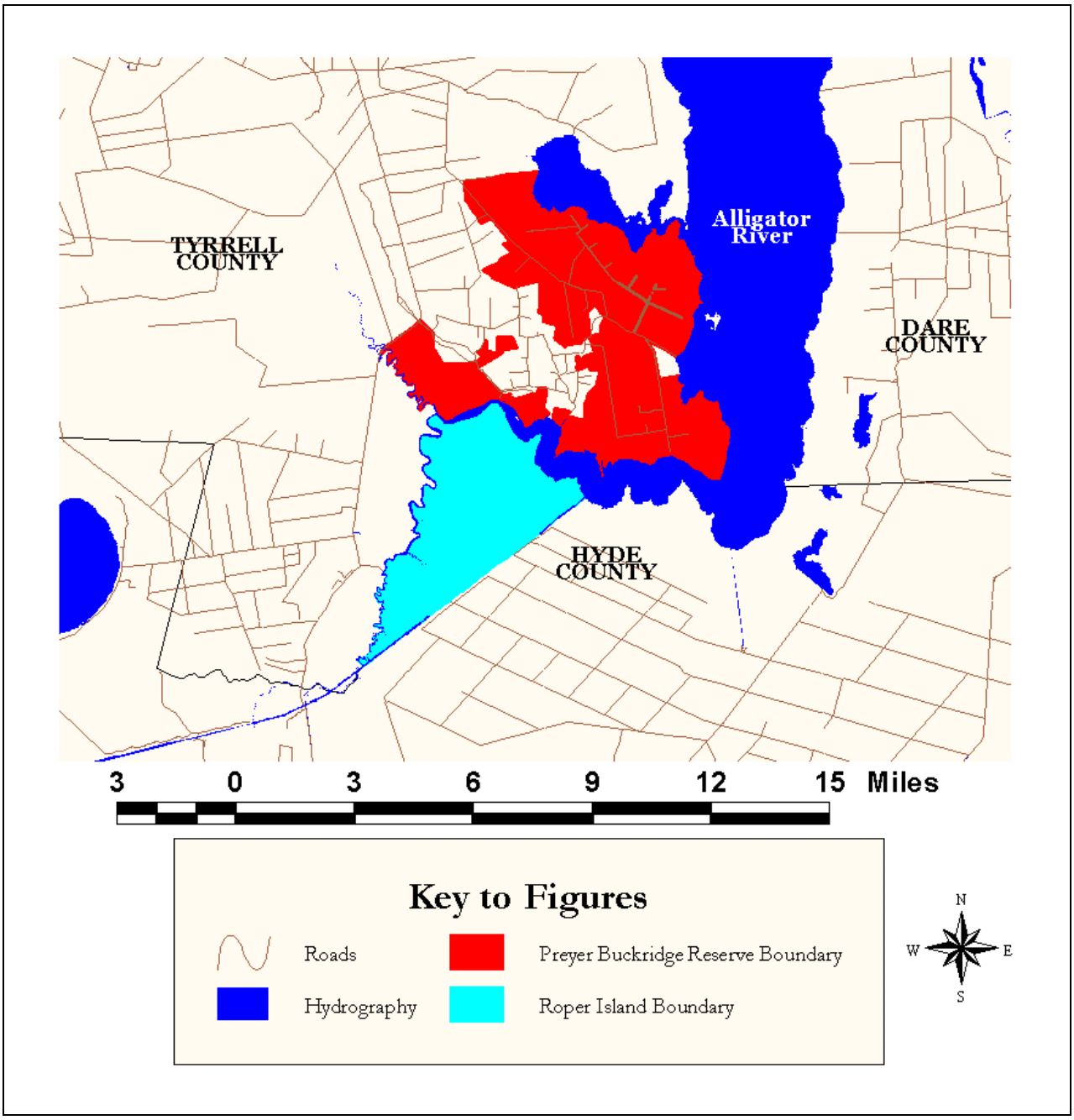

Figure 36. *Location of Roper Island relative to the Preyer Buckridge Reserve.*

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APPENDIX

SELECTED WATER QUALITY STANDARDS

From 15A NCAC 2B .0211 – Freshwater Surface Water Quality Standards for Class C Waters:

Dissolved Oxygen: for non-trout waters, not less than a daily average of 5.0 mg/l with a minimum instantaneous value of not less than 4.0 mg/l; swamp waters, lake coves or backwaters, and lake bottom waters may have lower values if caused by natural conditions.

Coliform bacteria: Fecal coliforms shall not exceed a geometric mean of 200/100 ml (MF count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100 ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over the results, the MPN 5-tube dilution technique shall be used as the reference method.

pH: pH shall be normal for the waters in the area, which generally shall range between 6.0 and 9.0 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions.

Temperature: Temperature is not to exceed 2.8 degrees C (5.04 degrees F) above the natural water temperature, and in no case to exceed 32 degrees C (89.6 degrees F) for lower piedmont and coastal plain waters.

Mercury: 0.012 ug/l (Note: **very** few water testing laboratories are capable of testing for mercury at such a low resolution).

From 15A NCAC 2B .0214 – Freshwater Surface Water Quality Standards for Class WS-II Waters

Nitrate Nitrogen: 10 mg/l

From 15A NCAC 2B .0220 – Tidal Salt Water Quality Standards for Class SC Waters

Dissolved Oxygen: not less than 5.0 mg/l, except that swamp waters, poorly flushed tidally influenced streams or embayments, or estuarine bottom waters may have lower values if caused by natural conditions.

pH: shall be normal for the waters in the area, which generally shall range between 6.9 and 8.5 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions.

Temperature: shall not be increased above the natural water temperature by more than 0.8 degrees C (1.44 degrees F) during the months of June, July, and August nor more than 2.2 degrees C (3.96 degrees F during other months and in no cases to exceed 32 degrees C 989.6 degrees F) due to the discharge of heated liquids.

Mercury: 0.025 ug/l (Note: **very** few water testing laboratories are capable of testing for mercury at such a low resolution).

COMMUNITY TYPE DESCRIPTIONS

Rare Natural Communities

The following are descriptions of rare natural communities found at Buckridge as described in Schafale and Weakley (1990):

Nonriverine Swamp Forest

Sites: Wet, very poorly drained upland flats and peat deposits with rare mineral influx from overland or tidal flooding.

Soils: Mucky mineral soils or organic soils such as Typic or Terric Medisaprists.

Hydrology: Palustrine. Seasonally or frequently saturated or shallowly flooded by high water table.

Vegetation: Canopy of varying mixtures of *Taxodium distichum, Taxodium ascendens, Nyssa biflora, Pinus taeda, Chamaecyparis thyoides, Pinus serotina, Liriodendron tulipifera,* and *Acer rubrum*. Understory of open to dense *Magnolia virginiana, Persea palustris, Cyrilla racemiflora, Lyonia lucida, Clethra alnifolia, Vaccinium* spp., and *Smilax laurifolia*. Typical herbs include *Woodwardia virginica, Woodwardia areolata, Carex* spp., and *Sphagnum* spp.

Dynamics: The origin and dynamics of these communities are not well known. They apparently were once more strongly dominated by large trees, particularly bald cypress, and had open to sparse shrub layers. Small stands of large virgin cypress in nonriverine swamp environments are known. Early logging reduced most examples to the current condition of relatively small gum and red maple, often with dense shrubs. Levy and Walker (1979) suggested that similar forests were originally Atlantic White Cedar Forests from which the cedar was cut.

Natural fires were probably rare but might have occurred in drought periods. Stand killing fires under certain circumstances may lead to development of an Atlantic White Cedar Forest community. Areas susceptible to more frequent fire probably supported pocosin communities rather than swamp. Nonriverine Swamp Forest and Atlantic White Cedar Forest may have existed in a shifting mosaic of fire-determined patches on some large peatlands; however, it seems likely that most Nonriverine Swamp Forests occurred primarily in environments which had more nutrient influx or were more permanently wet and protected from fire.

Peacock and Lynch (1982) suggest that rare flooding by wind tides, bringing some subsidy of mineral nutrients, may be responsible for the occurrence of swamp forest rather than pocosin on peatlands near the Alligator River.

Range: Outer Coastal Plain, primarily in the Embayed Region. Occasionally elsewhere in flat or shallowly depressed areas.

Associations: Grades to Pond Pine Woodland, Atlantic White Cedar Forest, or Pocosin types with decreasing flood frequency and mineral input and increasing fire. Grades to Tidal Cypress-Gum Swamp in some embayed river mouths. Less poorly drained upland areas may grade to Nonriverine Wet Hardwood Forest.

Distinguishing Features: Nonriverine Swamp Forests can be distinguished from other peatland communities by the dominance of swamp trees such as *Nyssa biflora* and *Taxodium distichum*. Disturbed examples dominated by species such as *Acer rubrum* and *Liquidambar styraciflua* may often be recognized by remnant *Taxodium*. Nonriverine Swamp Forests can be distinguished from riverine and tidal cypress-gum swamps by topographic position and source of water. They are wetted by high groundwater rather than by flowing or backed-up water. Swamps at the head of outlet streams from large peatlands are difficult to classify, and may represent intermediates.

Variation: Little information but presumably varies with peat depth, mineral influx, and amount of disturbance. Some examples have abundant pine in them, while others are more purely cypress and gum.

Comments: This community type is poorly understood. It is thought that the shrubby nature is a result of logging. The environment is in some senses intermediate between that of pocosin and that of riverine swamp forests. The sites generally have deep organic deposits. They are not regularly flooded by rivers or tides, but apparently receive some mineral input from adjacent higher lands.

Rare Plant Species: Vascular – *Listera australis*.

Pond Pine Woodland

Sites: Outer parts of domed peatlands on poorly drained interstream flats, and peat-filled Carolina bays and shallow swales. Shallow organic deposits or deeper peats with some input of mineral sediment.

Soils: Shallow Histosols or oligotrophic mineral soils with organic surface layers. Series include Croatan (Typic Medisaprist), Murville (Typic Haplaquod), Lynn Haven (Typic Haplaquod), Torhunta (Typic Humaquept), Ponzer (Terric Medisaprist), Roper (Histic Humaquept), and Pungo (Typic Medisaprist).

Hydrology: Palustrine, temporarily flooded or saturated. Water table drops to underlying mineral sediment during the dry season, allowing plants to root there. These areas may also receive some influx of water with nutrients from adjacent areas.

Vegetation: Open to nearly closed canopy of *Pinus serotina*, sometimes codominant with *Gordonia lasianthus*, and with lesser amounts of *Magnolia virginiana*, *Acer rubrum*, *Pinus taeda*, *Persea palustris*, and *Chamaecyparis thyoides*. Shrub layer tall and very dense, greater than 5 meters tall except when recently burned. Common shrubs are *Cyrilla racemiflora, Lyonia lucida, Lyonia ligustrina, Ilex coriacea, Ilex glabra, Gaylussacia frondosa, Clethra alnifolia,* and *Persea palustris. Arundinaria gigantea* is often present and may even dominate the shrub layer. *Smilax laurifolia* is usually common. Herbs are generally nearly absent under the dense woody cover, although occasional *Woodwardia virginica*, *W. areolata*, and *Sphagnum* clumps may occur.

Where Pond Pine Woodland borders Wet Pine Flatwoods or upland communities, a distinct ecotonal zone often occurs, where the more frequent fire of the uplands interacts with the wetter soils of the Pond Pine Woodland. This ecotonal zone, while too small to be classified as a separate community, often resembles a Pine Savanna, with a high diversity of herbaceous plants absent from both of the adjoining communities. This ecotone is the primary habitat for a number of rare plant species.

Dynamics: These communities are wet and nutrient poor, though less so than Low Pocosin or High Pocosin. As with other peatland communities, Pond Pine Woodlands are susceptible to fires during dry periods. Because water levels are lower, they are susceptible more of the time than the wetter pocosins. The large amount of fuel makes fires extremely intense. The dominant species sprout readily, and only a few years are apparently required for the dense shrub layer to reach its former height. *Pinus serotina* recovers by epicormic and basal sprouts as well as reproduction by seed from serotinous cones. If the pine canopy is killed, recovery of the canopy may take much longer than for the shrub layer. As in other pocosin communities, species diversity is highest right after a fire and declines gradually.

Where frequent fires have occurred over a long time period, the Pond Pine Woodland understory is dominated by *Arundianaria gigantea*, with few shrubs. This may have been the natural state for much of the large acreage of Pond Pine Woodland

that is now extremely shrubby. Frost (1989) suggests that in southeastern Virginia, Pond Pine Woodland-type sites with fire every 3-5 years would support dense, pure canebrake vegetation. With fire every 6-12 years they would alternate between canebrake and shrubby pocosin vegetation, while with less frequent fire *Pinus serotina* would dominate. Which fire regimes prevailed under natural conditions in these sites in North Carolina is uncertain. Because *Arundinaria* can recover more quickly from fire than shrubs, canebrakes, once established, might maintain themselves by promoting more frequent burning. This could only occur, however, if frequent ignition sources existed in the region.

Most Pond Pine Woodlands are thought natural but some areas are believed to have developed these communities after the logging of Nonriverine Swamp Forests. In some peatlands they may exist with Peatland Atlantic White Cedar Forest, Nonriverine Swamp Forest, and Bay Forest in a mosaic determined by disturbance history.

Range: Throughout the Coastal Plain, but most extensive in the outer parts.

Associations: Grades to High Pocosin, Bay Forest, Nonriverine Swamp Forest, Pine Savanna, or Wet Pine Flatwoods. May occasionally grade to Brackish or Tidal Freshwater Marsh, Estuarine Fringe Loblolly Pine Forest, or Tidal Cypress-Gum Swamp.

Distinguishing Features: Pond Pine Woodlands are distinguished from other peatland communities by the substantial *Pinus serotina* canopy. Mixed canopy stands are most easily classified by the predominant tree species into Pond Pine Woodland, Bay Forest, Peatland Atlantic White Cedar Forest, or Nonriverine Swamp Forest. The affinities of *Pinus taeda* dominated stands are not known. The shrub layer is generally taller than that in High Pocosin. Both the tall shrubs and the pine canopy may be absent for periods of years following severe or frequent fire, but remnant woody debris often remains to offer clues to past vegetation structure. Many sites that are called Low Pocosin or High Pocosin because of low stature of the shrubs are probably successional Pond Pine Woodland.

Variation: This is a fairly broad category, covering a range of environments and vegetation. However, no clear variants are known within it at present. Factors causing variation include depth of peat, influx of external water and mineral sediment, fire, and disturbance history. Occurrences on large peatlands, Carolina bays, and swales may be somewhat distinct from each other.

Comments: This is a widespread community type that occurs in a variety of environments. Less is known about the natural ecology and dynamics of Pond Pine Woodlands than of Low Pocosins and High Pocosins. It is unclear how much of the scientific literature on pocosins applies to them. Because of their drier location and closer association with non-peatland communities, their fire and nutrient dynamics may

be different. Because they are usually more accessible and easier to disturb, most examples have been modified more heavily than the wetter pocosin types.

Of particular interest is the role of *Arundinaria gigantea* in these communities. Hughes (1957), Biswell and Foster (1942), and some earlier writers described vast canebrakes on the wetlands of the Coastal Plain. These dense stands of *Arundinaria* usually had sparse or no tree canopy, and were maintained by frequent fire. The most common trees listed as associates in the canebrakes were *Pinus serotina*, with *Pinus taeda* and lowland hardwoods less common. Such canebrakes may represent a phase of Pond Pine Woodland occurring on sites prone to frequent fire. Alternatively, the pines may have been present because of frequent fire in sites they do not now occupy. Canebrakes have essentially disappeared from the landscape, with fire suppression and other disturbances, such as open-range livestock. It is not clear what communities have replaced them, but typical Pond Pine Woodland is one of the strongest possibilities.

Rare Plant Species: Vascular – *Hexastylis lewisii*, *Kalmia cuneata*, *Lysimachia loomisii*, *Peltandra sagittifolia*; nonvascular – *Sphagnum fitzgeraldii*.

Peatland Atlantic White Cedar Forest

Sites: Peatlands, Carolina bays, and other depressions or swales with organic deposits and without flowing or seepage water.

Soils: Deep or shallow organic soils, generally Pamlico (Terric Medisaprist), Pungo (Typic Medisaprist), or Dare (Typic Medisaprist).

Hydrology: Intermittently or seasonally saturated.

Vegetation: Canopy dominated by *Chamaecyparis thyoides*, with or without smaller amounts of other wetland trees such as *Pinus serotina*, *P. taeda*, *Acer rubrum*, *Nyssa biflora*, and *Taxodium ascendens*. Understory open to dense, of species such as *Gordonia lasianthus*, *Magnolia virginiana*, *Persea palustris*, *Lyonia lucida*, *Cyrilla racemiflora*, *Ilex glabra*, *Lyonia ligustrina*, *Gaylussacia frondosa*, and *Ilex coriacea*. Herbs are generally sparse. Typical species include *Mitchella repens*, *Woodwardia areolata*, and *Sphagnum* spp.

Dynamics: Peatland Atlantic White Cedar Forests generally exist as a mosaic with Pond Pine Woodland, Bay Forest, Nonriverine Swamp Forest, or other communities in the landscape of large peatlands. Their occurrence is determined by fire history, though hydrology and nutrient status may also be important factors. Peatland Atlantic White Cedar Forests typically occur as even-aged stands, often with a dense canopy. These stands establish after removal of previous vegetation by a crown fire or other disturbance (Buell and Cain, 1943; Korstian, 1924). Such stand establishment apparently depends on sufficient removal of competing trees and shrubs and presence of seed. Large numbers of seeds accumulate under mature stands, but they may be destroyed if the fire occurs at low water table and burns into the peat.

As even-aged stands mature, dead wood accumulates, making the community more susceptible to a stand-killing fire. In the long absence of fire, white cedar forests are believed to succeed to Bay Forest, Pond Pine Woodland, or maple-gum dominated Nonriverine Swamp Forest (Buell and Cain, 1943; Kologiski, 1977). The young cedars are, however, very susceptible to even moderate fires, and frequent fires lead to pocosin vegetation. Thus, Peatland Atlantic White Cedar Forests are dependent on a specific fire regime.

Range: Throughout the Coastal Plain, primarily in the great peatlands of the outer Coastal Plain, also prominent in the Bladen Lakes area of Carolina Bays.

Associations: Usually associated with Nonriverine Swamp Forest, Pond Pine Woodland, or other pocosin communities. May grade to Estuarine Fringe Loblolly Pine Forest, Tidal Cypress-Gum Swamp, or marsh communities along shorelines.

Distinguishing Features: Peatland Atlantic White Cedar Forests are distinguished from Streamhead Atlantic White Cedar Forest by their locations on peat domes or in depressions fed mainly by rainwater, as opposed to streamheads with flowing or seepage water. They are distinguished from all other peatland community types by the dominance of *Chamaecyparis thyoides* in the canopy. Forests with substantial *Chamaecyparis* sometimes occur along blackwater rivers. Isolated peat-filled depressions on high relict terraces may be considered to belong to this type, but if they are flooded or influenced by the river they are placed in the Bottomland Hardwoods Forest (Blackwater Subtype).

Variation: Stands vary in structure with age of the stand. There may also be differences in composition, hydrology, and dynamics between examples on large peatlands and those in Carolina bays and other depressions. Communities marginally dominated by *Chamaecyparis* mixed with other trees may include cedars of mixed age and represent a distinct variant with different dynamics.

Comments: This type was included together with the Streamhead Atlantic White Cedar Forest in the more general Atlantic White Cedar Forest type of the Second Approximation. The new distinction is parallel to the distinction between Streamhead Pocosin and Pond Pine Woodland. The two types differ in hydrology, fire dynamics, and successional trajectories. Of particular note is the importance of *Liriodendron tulipifera* in the Streamhead Atlantic White Cedar Forest.

This type differs from most natural community types included in this classification in that it occurs on sites similar to those of other types, occurring as the result of a particular fire history. It is regarded as a distinct natural community type because of its very distinctive vegetational composition and structure, and dynamics. The fire regime that creates these communities is part of the natural environment of the peatlands. With fire control and fragmentation of the large peatlands, fires suitable for creating patches of Peatland Atlantic White Cedar Forest have become extremely rare.

With the loss of natural fire regime and with widespread logging and drainage, these communities, which were once abundant, have become very rare.

Rare Plant Species: None known.

Tidal Cypress-Gum Swamp

Sites: Margins of freshwater sounds and mouths of both blackwater and brownwater rivers with regular and irregular freshwater tides.

Soils: Generally organic soils such as Dorovan (Typic Medisaprist) and Hobonny (Typic Medisaprist), occasionally mineral soils such as Masontown (Cumulic Humaquept).

Hydrology: Palustrine, regularly to irregularly flooded with freshwater lunar or wind tides. Little or no salinity in the water (0.5 ppt or less).

Vegetation: Canopy dominated by combinations of *Taxodium distichum*, *Nyssa aquatica*, and *Nyssa biflora*, sometimes with *Pinus taeda* and *Acer rubrum*. Understory species include *Acer rubrum*, *Nyssa biflora*, *Persea palustris*, *Magnolia virginiana*, *Fraxinus caroliniana*, and *Juniperus virginiana*. The shrub layer may be either open or dense. Typical species include *Myrica cerifera*, *Cyrilla racemiflora*, *Vaccinium corymbosum*, *Rosa palustris*, and sometimes *Sabal minor* or *Arundinaria gigantea*. The herb layer is usually sparse, except in canopy openings. Species include *Osmunda regalis* var. *spectabilis*, *O. cinnamomea*, *Woodwardia areolata*, *Saururus cernuus*, *Carex stricta*, and *Peltandra virginica*.

Dynamics: Tidal flooding brings seawater-derived nutrients and varying amounts of sediment into the community, probably making these communities more productive than Cypress-Gum Swamp (Blackwater Subtype).

Intrusion by salt water during major storms may cause major disturbance to the community, possibly killing most of the trees. With a long-term rise in sea level, these communities will be replaced by marsh, probably abruptly after the canopy is killed by such a disturbance.

The wet soils, long periods of flooding, and sparse herbaceous layer make these communities unlikely to carry fire.

Range: Throughout the estuarine region of the Coastal Plain.

Associations: Grades away from shore and downriver into Tidal Freshwater Marsh, Estuarine Fringe Loblolly Pine Forest, or open water. Grades upstream into blackwater or brownwater river floodplain communities.

Distinguishing Features: Tidal Cypress-Gum Swamp is distinguished from other Cypress-Gum Swamps by having tidal flooding predominating over river flooding,

rainfall, and groundwater as the main source of wetness. This may be difficult to judge in some cases. The floristic differences that correspond to this distinction are not well known. The presence of short dead-end tidal creeks may help distinguish tidal areas (J.M. Lynch, *pers. comm.*), as may the presence of Tidal Freshwater Marsh.

Cypress-Gum Swamps are distinguished from all other communities by the dominance of *Taxodium* and *Nyssa* in the canopy. Occasional heavily cut examples may become dominated by *Acer rubrum* or various understory species.

Variation: Nyssa aquatica generally occurs close to the edge of the water, while Nyssa biflora occurs further back, in areas more stagnant and dominated by organic matter. Along freshwater sounds this community may be a narrow band but on large rivers it may form extensive flats. It is likely that differences exist between these two situations due to the relative amounts of tidal and river influence and the availability of mineral sediment. Differences may also exist between regularly and irregularly flooded examples.

Comments: Tidal swamps are distinguished by flooding caused primarily by regular or irregular tides rather than seasonal river flooding. This situation modifies the water quality of both brownwater and blackwater rivers and produces a different hydrologic regime.

Rare Plant Species: Vascular – *Epidendrum conopseum*, *Heteranthera multiflora*, *Lilaeopsis carolinensis*, *Lilium* sp. 2.

Wetland Types

The following are descriptions of wetland types used in the Division of Coastal Management's GIS wetland mapping program as described in Sutter et al. (1999):

Salt/Brackish Marsh

Any salt marsh or other brackish 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), provided this shall not include hurricane or tropical storm waters. Coastal wetland plant species include: *Spartina alterniflora, Juncus roemerianus, Salicornia* spp., *Distichlis spicata, Limonium* spp., *Scirpus* spp., *Cladium jamaicense, Typha* spp., *Spartina patens,* and *Spartina cynosuroides.*

Estuarine shrub scrub

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: *Myrica* spp. and *Juniperus virginiana.*

Estuarine Forested

A forested wetland 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). Examples include pine dominated communities with *Juncus* spp. Understories or fringe swamp communities such as those which occur along the Albemarle and Pamlico Sounds.

Maritime Forest

A forested wetland community characterized by its stunted growth because of the stresses imposed by its vicinity to salt spray from the ocean. Typical vegetation includes *Quercus virginiana, Acer rubrum,* and *Nyssa biflora.*

Freshwater Marsh

Herbaceous areas which are flooded for extended periods during the growing season. Included in this are marshes within lacustrine systems, some managed impoundments, some Carolina Bays, and other nontidal marshes (i.e. marshes which do not fall into the Salt/Brackish Marsh category). Typical communities include species of sedges, millets, rushes, and grasses not specified in the coastal wetland regulations. Also included is *Arundinaria gigantean, Sagittaria* spp., *Pontederia* spp., *Peltandra* spp., *Polygonum* spp., and *Typha* spp.

Pocosin

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

Bottomland Hardwood or Riverine Swamp Forests

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 *Quercus laurifolia, Quercus nigra, Quercus michauxii, Quercus lyrata, Liquidambar styraciflua, Fraxinus pennsylvanica, Populus* spp., *Betula nigra,* and occasionally *Pinus* spp. In swamp forest systems, typical species include *Taxodium* spp., *Nyssa* spp., *Fraxinus pennsylvanica,* and *Acer rubrum.*

Depressional Swamp Forest

Very poorly drained non-riverine forested or scrub-shrub communities which are semi-permanently flooded or temporarily flooded. Typical species include *Taxodium* spp., *Nyssa* spp., *Fraxinus pennsylvanica, Acer rubrum,* and *Carya aquatica.*

Headwater Swamps

Wooded, riverine systems along first order streams. These include hardwood-dominated communities with moist soil most of the year. Channels receive their water from overland flow and rarely overflow their own banks.

Hardwood Flat

Poorly drained interstream flats not associated with rivers or estuaries. Seasonally saturated by high water table or poor drainage. Species vary greatly but often include *Liquidambar styraciflua* and *Acer rubrum.*

Pine Flat

Palustrine, seasonally saturated pine communities on hydric soils that may become quite dry for part of the year, generally on flat or nearly flat areas that are not associated with a river or stream system. Usually dominated by *Pinus taeda*. This category does not include managed pine systems.

Managed Pinelands

Seasonally saturated managed pine forests (usually *Pinus taeda*) 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 Wetland Inventory maps. These areas may or may not be jurisdictional wetlands.

Human Impacted Wetlands

Areas of human impact have physically disturbed the wetland, but the area is still a wetland. Impoundments and some cutovers are included in this category, as well as other disturbed areas such as power lines.

Drained Wetlands

Any wetland system described above that is, or has been, partially drained/ditched according to the US Fish and Wildlife Service National Inventory maps.

Cleared Wetlands

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 Wetlands

Areas for which satellite imagery indicates a lack of vegetation in 1994. These areas are likely to still be wetlands, but they have been recently cut over. Vegetation in these areas may be revegetating naturally or may be in use for silvicultural activities.

LISTS OF SPECIES OCCURRING AT THE PREYER BUCKRIDGE COASTAL RESERVE

Vegetation

According to Schafale and Weakley (1991), the species that may occur in these communities are:

Canopy	
Baldcypress	*Taxodium distichum*
Pondcypress	*Taxodium ascendens*
Black gum	*Nyssa biflora*
Loblolly pine	*Pinus taeda*
Atlantic white cedar	*Chamaecyparis thyoides*
Pond pine	*Pinus serotina*
Yellow poplar	*Liriodendron tulipifera*
Red maple	*Acer rubrum*
Loblolly bay	*Gordonia lasianthus*
Carolina ash	*Fraxinus caroliniana*

Understory and Herbs	
Sweetbay	*Magnolia virginiana*
Red bay	*Persea borbonia*
High gallberry	*Ilex coriacea*
Low gallberry	*Ilex glabra*
Swamp Cyrilla	*Cyrilla racemiflora*
Fetterbush	*Lyonia lucida*
Maleberry	*Lyonia ligustrina*
Huckleberry	*Gaylussacia frondosa*
Sweet pepperbush	*Clethra alnifolia*
Blueberry	*Vaccinium* spp.
Wax myrtle	*Myrica cerifera*
Laurel-leaf greenbrier	*Smilax laurifolia*
Giant switchcane	*Arundinaria gigantea*

Virginia chain fern	*Woodwardia virginica*
Netted chain fern	*Woodwardia areolata*
Sedges	*Carex* spp.
Sphagnum mosses	*Sphagnum* spp.
Partridge berry	*Mitchella repens*
Arrow arum	*Peltandra virginica*

Other species observed at the Reserve include:

Canopy

Sweetgum	*Liquidambar styraciflua*
Black cherry	*Prunus serotina*
Water oak	*Quercus nigra*

Understory

Black willow	*Salix nigra*
Silktree (mimosa)	*Albizia julibrissin* (non-native)
Cattail	*Typha latifolia*
Duckfoot	*Baccharus halimifolia*
Common greenbrier	*Smilax rotundifolia*
Common reed	*Phragmites australis*

Birds

Neotropical migratory bird species known to breed on the Dare County mainland are (Fussell et al., 1995):

Yellow-billed cuckoo	*Coccyzus americanus*
Black-billed cuckoo	*Coccyzus erythrophthalmus*
Common nighthawk	*Chordeiles minor*
Chuck-will's-widow	*Caprimulgus carolinensis*
Whip-poor-will	*Carprimulgus vociferus*
Chimney swift	*Chaetura pelagica*
Ruby-throated hummingbird	*Archilochus colubris*
Eastern wood-pewee	*Contopus virens*
Acadian flycatcher	*Empidonax virescens*
Great crested flycatcher	*Myiarchus crinitus*
Eastern kingbird	*Tyrannus tyrannus*
Purple martin	*Progne subis*
Tree swallow	*Tachycineta bicolor*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Barn swallow	*Hirundo rustica*
House wren	*Troglodytes aedon*
Blue-gray gnatcatcher	*Polioptila caerulea*

Wood thrush	*Hylocichla mustelina*
Gray catbird	*Dumetella carolinensis*
White-eyed vireo	*Vireo griseus*
Yellow-throated vireo	*Vireo flavifrons*
Red-eyed vireo	*Vireo olivaceus*
Northern parula	*Parula americana*
Black-throated green warbler	*Dendroica virens*
Yellow-throated warbler	*Dendroica dominica*
Prairie warbler	*Dendroica discolor*
Black-and-white warbler	*Mniotilta varia*
American redstart	*Setophaga ruticilla*
Prothonotary warbler	*Protonotaria citrea*
Worm-eating warbler	*Helmitheros vermivorus*
Swainson's warbler	*Limnothlypis swainsonii*
Ovenbird	*Seiurus arocapillus*
Louisiana waterthrush	*Seiurus motacilla*
Kentucky warbler	*Oporornis formosus*
Common yellowthroat	*Geothlypis trichas*
Hooded warbler	*Wilsonia citrina*
Yellow-breasted chat	*Icteria virens*
Summer tanager	*Piranga rubra*
Scarlet tanager	*Piranga olivacea*
Blue grosbeak	*Guiraca caerulea*
Indigo bunting	*Passerina cyanea*
Dickcissel	*Spiza Americana*
Chipping sparrow	*Spizella passerina*
Orchard oriole	*Icterus spurious*

Other

Other species observed at the Reserve include:

<u>Birds</u>

Belted kingfisher	*Megaceryle alcyon*
Osprey	*Pandion haliaetus*
Mississippi kite	*Ictinia mississippiensis*
Great Horned owl	*Bubo virginianus*
Wood Duck	*Aix sponsa*
Turkey vulture	*Cathartes a*ura
Black vulture	*Coragyps atratus*
Pileated woodpecker	*Dryocopus pileatus*
Red-headed woodpecker	*Melanerpes erythrocephalus*

Terrestrial

Bobcat	*Lynx rufus*
Eastern Cottonmouth	*Agkistrodon piscivorus*
Black rat snake	*Elaphe obsolete*
White tailed deer	*Odocoileus virginianus*

Aquatic

River otter	*Lutra canadensis*
Beaver	*Castor canadensis*
Bowfin	*Amia calva*

Other species likely to occur at Buckridge:

From McDonald and Ash (1981):

Amphibians

Southern toad	*Bufo terrestris*
Pine woods treefrog	*Hyla femoralis*
Bullfrog	*Rana catesbeiana*
Southern leopard frog	*Rana utricularia*
Pickerel frog	*Rana palustris*

Reptiles

Eastern mud turtle	*Kinosternon subruburm*
Spotted turtle	*Clemmys guttata*
Eastern box turtle	*Terrapene carolina*
Yellow-bellied turtle	*Chrysemys scripta*
Florida cooter	*Chrysemys floridana*
Eastern painted turtle	*Chrysemys picta*
Carolina anole	*Anolis carolinensis*
Plain-bellied water snake	*Nerodia erythrogaster*
Southern water snake	*Nerodia fasciata*
Eastern garter snake	*Thamnophis sirtalis*
Rough green snake	*Opheodrys aestivus*
Eastern kingsnake	*Lampropeltis getulus*
Timber rattlesnake	*Crotalus horridus*

Birds

Pied-billed grebe	*Podilymbus podiceps*
Double-crested cormorant	*Phalacrocorax auritus*
Great blue heron	*Ardea herodias*
Green heron	*Butorides striatus*
Cattle egret	*Bubulcus ibis*
Great egret	*Casmerodius albus*

Snowy egret	*Egretta thula*
Black-crowned night heron	*Nycticorax nycticorax*
Mallard	*Anas platyrhynchos*
Red-tailed hawk	*Buteo jamaicensis*
Red-shouldered hawk	*Buteo lineatus*
American kestrel	*Falco sparverius*
Common bobwhite	*Colinus virginianus*
Killdeer	*Charadrius vociferus*
Solitary sandpiper	*Tringa solitaria*
American woodcock	*Philohela minor*
Herring gull	*Larus argentatus*
Ring-billed gull	*Larus delawarensis*
Royal tern	*Sterna maxima*
Rock dove	*Columba livia*
Mourning dove	*Zenaida macroura*
Common flicker	*Calaptes auratus*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Hairy woodpecker	*Picoides villosus*
Downy woodpecker	*Picoides pubescens*
Bank swallow	*Riparia riparia*
Blue jay	*Cyanocitta cristata*
American crow	*Corvus brachyrhynchos*
Carolina chickadee	*Parus carolinensis*
Tufted titmouse	*Parus bicolor*
Carolina wren	*Thryothorus ludovicianus*
Northern mockingbird	*Mimus polyglottos*
Brown thrasher	*Toxostoma rufum*
American robin	*Turdus migratorius*
European starling	*Sturnus vulgaris*
Yellow-rumped warbler	*Dendroica coronata*
Pine warbler	*Dendroica pinus*
House sparrow	*Passer domesticus*
Eastern meadowlark	*Sturnella magna*
Red-winged blackbird	*Agelaius phoeniceus*
Common grackle	*Quiscalus quiscula*
Brown-headed cowbird	*Molothrus ater*
Northern cardinal	*Cardinalis cardinalis*

Mammals

Opossum	*Didelphis marsupialis*
Eastern cottontail	*Sylvilagus floridanus*
Swamp cottontail	*Sylvilagus palustris*
Cotton rat	*Sigmodon hispidus*
Muskrat	*Ondatra zibethicus*
Red fox	*Vulpes fulva*
Raccoon	*Procyon lotor*

From Laderman (1989):

Mammals

Southeastern shrew	*Sorex longirostris*
Dismal Swamp short-tailed shrew	*Blarina telmalestes*
Eastern mole	*Scalopus aquaticus*
Star-nosed mole	*Condylura cristata*
Red bat	*Lasiurus borealis*
Evening bat	*Nycticeius humeralis*
Gray squirrel	*Sciurus carolinensis*
Marsh rice rat	*Oryzomys palustris*
Eastern harvest mouse	*Rethrodontomys humulis*
White-footed mouse	*Peromyscus leucopus*
Cotton mouse	*Peromyscus gossypinus*
Golden mouse	*Ochrotomys nuttalli*
Hispid cotton rat	*Sigmodon hispidus*
Meadow vole	*Microtus pennsylvanicus*
Gray fox	*Urocyon cinereoargenteus*
Long-tailed weasel	*Mustela frenata*

Amphibians

Slimy salamander	*Plethodon glutinosis*
Carpenter frog	*Rana virgatipes*

Reptiles

Five-lined skink	*Eumeces inexpectatus*
Ground skink	*Scincella lateralis*

NATIONAL WETLANDS INVENTORY CLASSIFICATION KEY (Cowardin et al., 1979)

```
SYSTEM        SUBSYSTEM     CLASS                  SUBCLASS

                        |- RB=Rock Bottom          1=Bedrock
                        |                          2=Rubble
                        |
                        |- UB=Unconsolidated Bottom 1=Cobble-Gravel
                        |                          2=Sand
                        |                          3=Mud
                        |                          4=Organic
                        |
              |-- 1=SUBTIDAL----|- AB=Aquatic Bed   1=Algal
              |             |                      3=Rooted Vascular
              |             |                      5=Unknown Submergent
              |             |
              |             |
              |             |- RF=Reef             1=Coral
              |             |                      3=Worm
              |             |
              |             |- OW=Open Water/Unknown Bottom (used on older maps)
              |
M=MARINE--------|
              |
              |
              |             |- AB=Aquatic Bed      1=Algal
              |             |                      3=Rooted Vascular
              |             |                      5=Unknown Submergent
              |             |
              |             |- RF=Reef             1=Coral
              |             |                      3=Worm
              |-- 2=INTERTIDAL--|
                        |
                        |- RS=Rocky Shore          1=Bedrock
                        |                          2=Rubble
                        |
                        |- US=Unconsolidated Shore 1=Cobble-Gravel
                                                   2=Sand
                                                   3=Mud
                                                   4=Organic
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SYSTEM        SUBSYSTEM     CLASS                  SUBCLASS

                        |- RB=Rock Bottom          1=Bedrock
                        |                          2=Rubble
                        |
                        |- UB=Unconsolidated Bottom 1=Cobble-Gravel
                        |                          2=Sand
                        |                          3=Mud
                        |                          4=Organic
                        |
              |-- 1=SUBTIDAL----|- AB=Aquatic Bed   1=Algal
              |             |                      3=Rooted Vascular
              |             |                      4=Floating Vascular
              |             |                      5=Unknown Submergent
              |             |                      6=Unknown Surface
              |             |
              |             |- RF=Reef             2=Mollusc
              |             |                      3=Worm
              |             |
              |             |- OW=Open Water/Unknown Bottom (used on older maps)
              |
E=ESTUARINE-----|
              |
              |             |- AB=Aquatic Bed      1=Algal
              |             |                      3=Rooted Vascular
              |             |                      4=Floating Vascular
              |             |                      5=Unknown Submergent
              |             |                      6=Unknown Surface
              |             |
              |             |- RF=Reef             2=Mollusc
              |             |                      3=Worm
              |             |
              |             |- SB=Streambed        3=Cobble-Gravel
              |             |                      4=Sand
              |             |                      5=Mud
              |             |                      6=Organic
              |             |
              |             |- RS=Rocky Shore      1=Bedrock
              |             |                      2=Rubble
              |             |
              |-- 2=INTERTIDAL
                        --|- US=Unconsolidated Shore 1=Cobble-Gravel
                        |                          2=Sand
                        |                          3=Mud
                        |                          4=Organic
                        |
                        |- EM=Emergent             1=Persistent
                        |                          2=Nonpersistent
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                    |
                    |- SS=Scrub-Shrub              1=Broad-Leaved Deciduous
                    |                              2=Needle-Leaved Deciduous
                    |                              3=Broad-Leaved Evergreen
                    |                              4=Needle-Leaved Evergreen
                    |                              5=Dead
                    |                              6=Indeterminate Deciduous
                    |                              7=Indeterminate Evergreen
                    |
                    |- FO=Forested                 1=Broad-Leaved Deciduous
                                                   2=Needle-Leaved Deciduous
                                                   3=Broad-Leaved Evergreen
                                                   4=Needle-Leaved Evergreen
                                                   5=Dead
                                                   6=Indeterminate Deciduous
                                                   7=Indeterminate Evergreen

SYSTEM        SUBSYSTEM     CLASS                  SUBCLASS

                    |- RB=Rock Bottom              1=Bedrock
                    |                              2=Rubble
                    |
                    |- UB=Unconsolidated Bottom    1=Cobble-Gravel
                    |                              2=Sand
          |--1=TIDAL--------|                      3=Mud
          |         |                              4=Organic
          |         |
          |         |-*SB=Streambed                1=Bedrock
          |         |                              2=Rubble
          |         |                              3=Cobble-Gravel
          |--2=LOWER      |                        4=Sand
          |   PERENNIAL----|                       5=Mud
          |         |                              6=Organic
          |         |                              7=Vegetated
          |         |
          |         |- AB=Aquatic Bed              1=Algal
R=RIVERINE------|--3=UPPER      |                  2=Aquatic Moss
          |           PERENNIAL-|                  3=Rooted Vascular
          |         |                              4=Floating Vascular
          |         |                              5=Unknown Submergent
          |--4=INTERMITTENT-|                      6=Unknown Surface
          |         |
          |         |- RS=Rocky Shore              1=Bedrock
          |         |                              2=Rubble
          |         |
          |         |- US=Unconsolidated Shore     1=Cobble-Gravel
          |--5=UNKNOWN    |                        2=Sand
          |   PERENNIAL-(used on older maps) -|    3=Mud
```

```
          |                                    4=Organic
          |                                    5=Vegetated
                  |
                  |-**EM=Emergent              2=Nonpersistent
                  |
                  |- OW=Open Water/Unknown Bottom (used on older maps)
                  |
                  |-*STREAMBED is limited to TIDAL and INTERMITTENT SUBSYSTEMS
                  | and comprises the only CLASS in the INTERMITTENT SUBSYSTEM.
                  |
                  |-**EMERGENT is limited to TIDAL and LOWER
                  | PERENNIAL SUBSYSTEMS.
```

SYSTEM	SUBSYSTEM	CLASS	SUBCLASS
		|- RB=Rock Bottom	1=Bedrock
		|	2=Rubble
		|	
		|- UB=Unconsolidated Bottom	1=Cobble-Gravel
		|	2=Sand
		|	3=Mud
		|	4=Organic
		|	
	|-- 1=LIMNETIC----|- AB=Aquatic Bed		1=Algal
	|	|	2=Aquatic Moss
	|	|	3=Rooted Vascular
	|	|	4=Floating Vascular
	|	|	5=Unknown Submergent
	|	|	6=Unknown Surface
	|	|	
	|	|- OW=Open Water/Unknown Bottom (used on older maps)	
	|		
L=LACUSTRINE----|			
	|		
	|	|- RB=Rock Bottom	1=Bedrock
	|	|	2=Rubble
	|	|	
	|	|- UB=Unconsolidated Bottom	1=Cobble-Gravel
	|	|	2=Sand
	|	|	3=Mud
	|	|	4=Organic
	|	|	
	|	|- AB=Aquatic Bed	1=Algal
	|	|	2=Aquatic Moss
	|	|	3=Rooted Vascular
	|	|	4=Floating Vascular

```
        |-- 2=LITTORAL----|
                  |                                5=Unknown Submergent
                  |                                6=Unknown Surface
                  |
                  |- RS=Rocky Shore                1=Bedrock
                  |                                2=Rubble
                  |
                  |- US=Unconsolidated Shore       1=Cobble-Gravel
                  |                                2=Sand
                  |                                3=Mud
                  |                                4=Organic
                  |                                5=Vegetated
                  |
                  |- EM=Emergent                   2=Nonpersistent
                  |
                  |- OW=Open Water/Unknown Bottom (used on older maps)


SYSTEM      SUBSYSTEM     CLASS                    SUBCLASS

                  |- RB=Rock Bottom                1=Bedrock
                  |                                2=Rubble
                  |
                  |- UB=Unconsolidated Bottom      1=Cobble-Gravel
                  |                                2=Sand
                  |                                3=Mud
                  |                                4=Organic
                  |
                  |- AB=Aquatic Bed                1=Algal
                  |                                2=Aquatic Moss
                  |                                3=Rooted Vascular
                  |                                4=Floating Vascular
                  |                                5=Unknown Submergent
                  |                                6=Unknown Surface
                  |
                  |- US=Unconsolidated Shore       1=Cobble-Gravel
                  |                                2=Sand
                  |                                3=Mud
                  |                                4=Organic
                  |                                5=Vegetated
                  |
                  |- ML=Moss-Lichen                1=Moss
                  |                                2=Lichen
                  |
P=PALUSTRINE------------------------|- EM=Emergent  1=Persistent
                  |                                2=Nonpersistent
                  |
```

```
                    |- SS=Scrub-Shrub          1=Broad-Leaved Deciduous
                    |                          2=Needle-Leaved Deciduous
                    |                          3=Broad-Leaved Evergreen
                    |                          4=Needle-Leaved Evergreen
                    |                          5=Dead
                    |                          6=Indeterminate Deciduous
                    |                          7=Indeterminate Evergreen
                    |
                    |- FO=Forested             1=Broad-Leaved Deciduous
                    |                          2=Needle-Leaved Deciduous
                    |                          3=Broad-Leaved Evergreen
                    |                          4=Needle-Leaved Evergreen
                    |                          5=Dead
                    |                          6=Indeterminate Deciduous
                    |                          7=Indeterminate Evergreen
                    |
                    |- OW=Open Water/Unknown Bottom (used on older maps)


                    MODIFIERS

                    |- A=Temporarily Flooded
                    |- B=Saturated
                    |- C=Seasonally Flooded
                    |- D=Seasonally Flooded/Well Drained
                    |- E=Seasonally Flooded/Saturated
                    |- F=Semipermanently Flooded
          |--Non-Tidal--|- G=Intermittently Exposed
          |             |- H=Permanently Flooded
          |             |- J=Intermittently Flooded
          |             |- K=Artificially Flooded
          |             |- W=Intermittently Flooded/Temporary (used on older maps)
          |             |- Y=Saturated/Semipermanent/Seasonal (used on older maps)
          |             |- Z=Intermittently Exposed/Permanent (used on older maps)
          |             |- U=Unknown
WATER REGIME--|
          |             |- K=Artificially Flooded
          |             |- L=Subtidal
          |             |- M=Irregularly Exposed
          |             |- N=Regularly Flooded
          |--Tidal------|- P=Irregularly Flooded
                        |-*S=Temporary-Tidal
                        |-*R=Seasonal-Tidal
                        |-*T=Semipermanent-Tidal
                        |-*V=Permanent-Tidal
                        |- U=Unknown
                        |-*These water regimes are only used in tidally influenced, freshwater
                          systems.
```

```
                    |- 1=Hyperhaline
                    |- 2=Euhaline
          |--Coastal |- 3=Mixohaline (Brackish)
          |  Halinity-|- 4-Polyhaline
          |           |- 5=Mesohaline
          |           |- 6=Oligohaline
          |           |- 0=Fresh
          |
WATER CHEMISTRY-|
          |           |- 7=Hypersaline
          |--Inland   |- 8=Eusaline
          |  Salinity--|- 9=Mixosaline
          |           |- 0=Fresh
          |
          |
          |
          |
          |--pH Modifiers |- a=Acid
            for all         |- t=Circumneutral
            Fresh Water----|- i=Alkaline


SOIL-------------------|- g=Organic
                       |- n=Mineral


                       |- b=Beaver
                       |- d=Partially Drained/Ditched
SPECIAL MODIFIERS--|- f=Farmed
                       |- h=Diked/Impounded
                       |- r=Artificial Substrate
                       |- s=Spoil
                       |- x=Excavated

U = Uplands
```

POSTER

Change detection analysis in a forested wetland ecosystem: the Emily and Richardson Preyer Buckridge Coastal Reserve, North Carolina

Abstract

The North Carolina Coastal Reserve Program (N.C. Division of Coastal Management) aims to preserve and manage unique coastal ecosystems. In June 1999, the program acquired the Emily and Richardson Preyer Buckridge Coastal Reserve that encompasses over 18,650 acres of forested wetlands along the Alligator River in North Carolina. The Preyer Buckridge Reserve harbors black bear, American alligator, and more than one-quarter of the state's rare Atlantic white cedar. Historically, the Reserve was exploited for timber and these activities have had an unknown impact on the natural communities.

A change detection study was undertaken to document the effects of timber harvest and ecosystem dynamics. The study classified satellite images from 1988 and 1994 into distinct classes and then compared these images to determine the nature of changes that occurred. A limited accuracy assessment indicated a high level of accuracy. The study's results will help to guide future research and will ultimately lead to the implementation of appropriate restoration and management strategies to preserve the rare forested wetland communities at the Reserve.

Introduction

In an effort to improve wetland protection and management throughout North Carolina's vast coastal area, the N.C. Division of Coastal Management (DCM) employs the use of remote sensing and geographic information systems (GIS) techniques as practical alternatives that complement field-based methods. These techniques formed the basis for the development of a wetland mapping program that accurately inventories and assesses the type, amount, location, and functional significance of wetlands and wetland restoration sites without the need to physically visit all of the sites (Sutter 1999).

The Emily and Richardson Preyer Buckridge Coastal Reserve is a component of the N.C. Coastal Reserve, a program created by the N.C. General Assembly in 1989 and administered by the DCM. The Preyer Buckridge Reserve contains more than 18,650 of the program's 30,000 acres that are managed for natural resource preservation, scientific research, education, and public enjoyment.

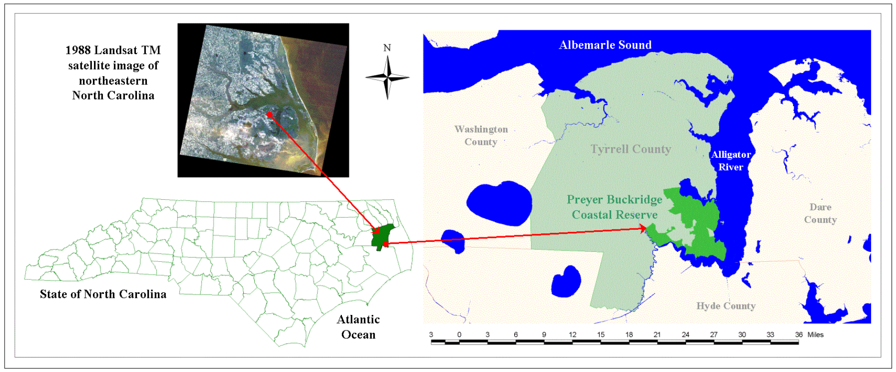


Figure 1. Location of the Preyer Buckridge Coastal Reserve along the Alligator River (Tyrrell County) in northeastern North Carolina, including 1988 Landsat TM satellite image.

Background

Acquired in June 1999, the Preyer Buckridge Reserve is located in Tyrrell County along the Alligator River near the Albemarle Sound in northeastern North Carolina (Figure 1). Using its wetland mapping data (Figure 2), the DCM determined that many wetlands at the Reserve possess exceptional functional significance. This discovery, in part, led the DCM to purchase this unique ecosystem. The Reserve provides habitat for rare, threatened, and endangered wildlife species, including black bear, American alligator, bald eagle, and many Neotropical migratory birds. The Reserve is also home to rare vegetative communities such as peatland Atlantic white cedar forest, nonriverine swamp forest, pond pine woodland, and tidal cypress-gum swamp.

The Preyer Buckridge Reserve was historically exploited for timber - primarily Atlantic white cedar - and roads and drainage ditches for logging have altered the natural hydrology. A restoration and management plan is being developed for the forested wetlands at the Reserve and a detailed assessment of the impacts to the hydrology and the natural communities is underway. However, this assessment encountered several obstacles. First, there was a lack of available information about the Reserve. Second, the Reserve is a vast, remote area and due to dense vegetation and wet conditions, access is difficult. Third, there are few staff and resources to accomplish the assessment. Therefore, remotely sensed and GIS data are essential to effective assessment and management at the Reserve.

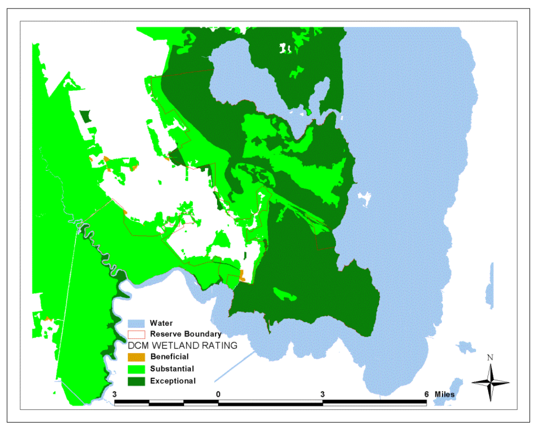
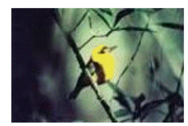


Figure 2. DCM Wetland Functional Significance Rating for the Preyer Buckridge Coastal Reserve (reserve boundary in red)

Prairie Warbler

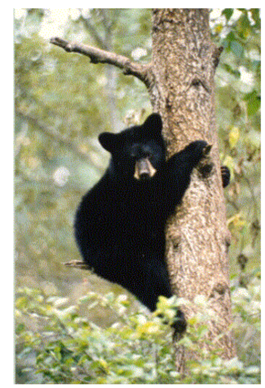


Prothonotary Warbler

Bald Eagle

Atlantic White Cedar at the Preyer Buckridge Reserve

American Alligator



Black Bear

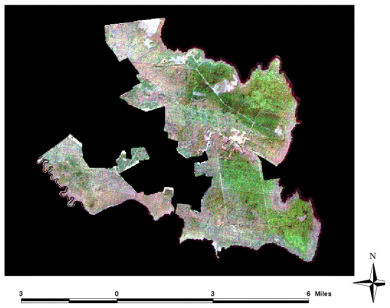
This 2-panel poster was presented by Greg Meyer and David Fuss at the Coastal Zone '01 Conference in Cleveland, Ohio, July 15-19, 2001

Classification

A vegetation change detection study for the Preyer Buckridge Reserve was undertaken to document the effects of historical timber harvest and ecosystem dynamics. Image classification was performed for 1988 and 1994 Landsat TM satellite images (Figures 3 and 4) [resolution = 25m] while color infrared photography [resolution = 1m] served as reference data. In order to minimize edge error, the Reserve's boundary was buffered by 300 feet and the satellite images were clipped to the buffered boundary using ERDAS Imagine's Mask Utility. The clipped images were classified into 7 land cover categories using a supervised classification, "maximum likelihood classifier," with a threshold value of .95 and a maximum of 6 iterations (Figures 3 and 4).

To maximize the classification accuracy, we utilized a total of 45 training sites that were geographically distributed across the image to guide the classification. Using ArcView's Spatial Analyst extension, images were transformed into grids and attributes for the land cover classes were coded systematically. For example, acreage attributes for each land cover category were calculated by n*n*N/43560, where n = pixel size and N = number of pixels per category.

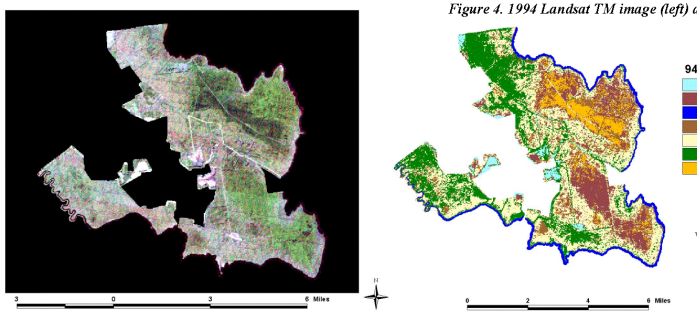
Figure 3. 1988 Landsat TM image (left) and classified Landsat TM image (below)



Type	Acreage
Cleared	579.20
Pine	3081.26
Mixed Pine-Cedar	1689.85
Mixed Pine-Decid.	9034.06
Deciduous	3726.09
Atlantic White Cedar	1178.88
Water	1044.61
Total	20333.96

Note: total exceeds Reserve acreage due to boundary buffer

Figure 4. 1994 Landsat TM image (left) and classified Landsat TM image (below)



Type	Acreage
Cleared	525.22
Pine	3198.67
Mixed Pine–Cedar	1914.63
Mixed Pine-Decid.	7132.28
Deciduous	4835.73
Atlantic White Cedar	1577.86
Water	1149.58
Total	20333.96

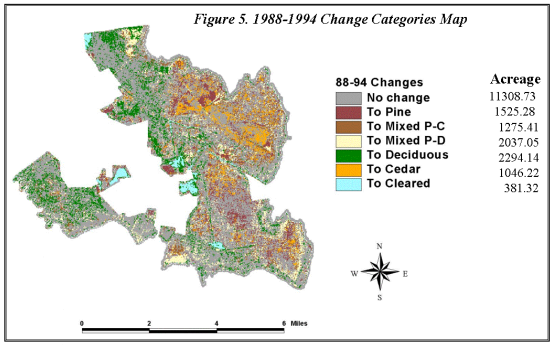
Note: total exceeds Reserve acreage due to boundary buffer

Table 1. Matrix of change detection results that tracks land cover change classes

1988 \ 1994	Cleared (1)	Pine (2)	Water (3)	Mixed Pine-Cedar (4)	Mixed Pine-Deciduous (5)	Deciduous (6)	Cedar (7)
Cleared (10)	11	12	13	14	15	16	17
Pine (20)	21	22	23	24	25	26	27
Water (30)	31	32	33	34	35	36	37
Mixed P-C (40)	41	42	43	44	45	46	47
Mixed P-D (50)	51	52	53	54	55	56	57
Deciduous (60)	61	62	63	64	65	66	67
Cedar (70)	71	72	73	74	75	76	77

No change
Changed to Cleared
Changed to Pine
Changed to Water
Changed to Mixed Pine-Cedar
Changed to Mixed Pine-Deciduous
Changed to Deciduous
Changed to Cedar

Figure 5. 1988-1994 Change Categories Map



Change Detection and Results

The change detection utilized the post classification comparison method, the most commonly used change detection method (Jensen et al. 1993). The 1988 and 1994 classified images were compared pixel by pixel using the "Add" function of ArcView's Spatial Analyst. This function provides information about the nature of change through time, resulting in a "change image map" with land cover change classes from 11 to 77 (Table 1). These classes were combined into general "from-to" change categories for emphasis (Figure 5).

Results indicate that during the 6 year study period, 57% of the Reserve remained unchanged while the Deciduous (+11.6%) and Mixed Pine-Deciduous (+10.3%) categories experienced the most change compared to the total acreage. Much of these changes can be explained by natural forest succession, such as from Mixed Pine-Deciduous to Deciduous (+6% net change of total acreage).

Accuracy Assessment

The accuracy of the change detection is primarily dependent on the accuracy of the classified images, which can be assessed by comparing the actual land cover from field observations with the classified land cover for a random sample of pixels. The accuracy of the 1994 classified image was evaluated using the DCM's field-based accuracy assessment database from 1996 (Shull 1999) and field observations from 2000. Normally, it is advisable to use numerous accuracy assessment points. We used only 11 accuracy points due to time limitations and the small number of appropriate points from the DCM's database. As a result, the Mixed Pine-Cedar category was not represented in the accuracy assessment.

The accuracy assessment yielded a 90.9% overall accuracy. The reliability of this result could be improved by using more accuracy points, by collecting observations from the same year as the satellite image, and by locating references with which to evaluate the 1988 image. Also, since the study area is small, the classification accuracy could be enhanced by using a higher resolution imagery like SPOT or IKONOS. Acknowledging the limitations of the accuracy assessment, its results and extensive field knowledge of the site lead the authors to believe that the classified images are reliably accurate.

Conclusions

Post classification may be the most useful change detection method since, unlike other methods, it provides quantified "from-to" land cover change classes. In this study, the majority of the pixels did not change, while the most significant net change was from Mixed Pine-Deciduous to Deciduous. Although the accuracy assessment could be improved, it did indicate a high overall accuracy. This change detection study indicates that the ecosystem is dynamic. Forest regeneration and natural succession seem to be primary reasons for much of the observed changes. Tracking the the changes with "from-to" land cover change classes allows resource managers to identify areas that warrant thorough field investigation. With field data, managers will be able to identify appropriate restoration and management strategies for the long-term persistence of the rare forested wetland communities at the Preyer Buckridge Coastal Reserve.

Acknowledgements

David Fuss is sponsored by the NOAA Coastal Management Fellowship Program of the NOAA Coastal Services Center and by the North Carolina Wetlands Restoration Program. Gracious thanks to Joe Knight and Jamie Halperin of The Center for Earth Observation at North Carolina State University for their technical advice and troubleshooting.

Reference

Jensen, J. R. et al. 1993. An evaluation of CoastWatch change detection protocol in South Carolina. Photogramm. Eng. Remote Sensing 59:1039-1046.

Shull, L.N. III. 1999. An accuracy assessment of GIS wetland mapping in the coastal counties of North Carolina. North Carolina Division of Coastal Management, Raleigh, North Carolina.

Sutter, L. 1999. DCM wetland mapping in coastal North Carolina. North Carolina Division of Coastal Management, Raleigh, North Carolina.

ADVISORY GROUP

The Preyer Buckridge Restoration Advisory Group consists of:

John Taggart	Coastal Reserve Program Coordinator
Barbara Blonder	Coastal Reserve Northern Sites Manager
Jim Stanfill	Division of Coastal Management Wetlands Management Specialist
Kelly Williams	Division of Coastal Management Wetlands Restoration Specialist
David Fuss	Division of Coastal Management Coastal Management Fellow
Jason Guidry	NC Wetlands Restoration Program
Scott Pohlman	NC Natural Heritage Program
Warren Boyette	NC Division of Forest Resources
Bill Pickens	NC Division of Forest Resources
K.O. Summerville	NC Division of Forest Resources (retired)
Mike Clements	Private Consultant (former site manager for Buckridge, Inc.)
Joe Landino	Landino Farms, Inc. (former forest manager for Westvaco)
Eric Hinesley	NC State University, Department of Horticultural Science
Ted Shear	NC State University, Department of Forestry
D.A. Brown	U.S. Fish and Wildlife Service, Natural Resource Planner
Bob Noffsinger	U.S. Fish and Wildlife Service, Biologist
Mike Wicker	U.S. Fish and Wildlife Service, NC Coastal Coordinator

PARTNERS

David Fuss' efforts in this project represent a partnership between the Division of Coastal Management, the National Oceanic and Atmospheric Administration's Coastal Management Fellowship Program administered by the Coastal Services Center, and the N.C. Wetlands Restoration Program.

The Division of Coastal Management and the Coastal Reserve Program have drafted a Memorandum of Understanding with the U.S. Fish and Wildlife Service's Pocosin Lakes National Wildlife Refuge outlining joint management responsibilities for the Preyer Buckridge Coastal Reserve. In addition, the N.C. Division of Forest Resources' Forest Service has agreed to provide wildfire control, if necessary. The Division of Forest Resources also provides advice concerning forest management.

Research partnerships have been established with the U.S. Geological Survey, N.C. State University, and Duke University to complete hydrology and water quality monitoring studies at the Reserve. The funding is provided by a grant from the U.S. Environmental Protection Agency's Clean Water Act Section 319 Nonpoint Source Pollution Grant Program, administered by the Division of Water Quality in North Carolina.

AVAILABLE GIS/REMOTELY SENSED DATA SETS FOR THE BUCKRIDGE COASTAL RESERVE

Military airspace
Ambient water quality sampling sites (Division of Water Quality)
Anadromous fish spawning areas
Bottom sediment sampling sites (Division of Water Quality)
Reserve boundary
Spur roads to be breached
DCM wetland functional significance
Hydrography
Roads
Natural communities
County boundaries
Land managed for conservation
Possible areas for selective cutting
Jurisdictional boundary for Division of Marine Fisheries
Gates
Groundwater discharge/recharge areas
Possible areas for selective herbicide application
USGS hydrologic units
Hurricane inundation areas
Area cut by Juniper, Inc. in 1973
Boat landings
Agricultural levee maintained by the Gum Neck Drainage District
Land use/land cover
Miniwatersheds
Natural heritage sites
National Wetlands Inventory
Outstanding resource waters
Peat depth
Proposed planting area
Possible locations for earthen plugs
Pumping station for Gum Neck Drainage District
Buck's Ridge
Closed shellfish harvesting areas
Shoreline
Significant aquatic areas
Significant natural heritage areas
Soils
Office/trailer
Proposed USGS hydrology gauges
Possible locations for water control structures
Locations of groundwater monitoring gauges damaged by black bears
DCM potential wetland restoration sites

DCM wetland types
Landsat TM 1988
Landsat TM 1994
Landsat TM 1999
Color infrared aerial photography 1998
Black and white aerial photography 1993
Black and white aerial photography 1974
Black and white aerial photography 1951