Department of Defense
Legacy Resource Management Program

PROJECT NUMBER 05-252

Reintroduction of Prescribed Fire in Coastal Plain Ecosystems to Reduce Wildland Fire Risk

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September 2006

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EXECUTIVE SUMMARY

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OBJECTIVE: The goal of this project was to develop maps of the original vegetation and original fire regimes of the four USAF and USMC sites and the Alligator River NWR. The resulting maps can provide a background for decisions around restoration and land management. The intent was to produce the best approximation of the natural vegetation that existed at time of first European settlement. This is the vegetation that dominated the landscape prior to 1600 and for some 6,000 years before. Understanding original vegetation is essential to restoring habitats and managing lands for perpetuation of rare species, natural vegetation communities and forest types, and for the full range of animal and plant species that depend upon them for habitat. Nearly all-original vegetation of the natural areas was in some way structured by fire. About 65% of rare native plants and animals in the South are in some way dependent upon fire to create or maintain their habitat. Since the site contains many of these fire dependent species, the GIS layers can serve as base maps for guidance in protecting endangered species and wildlife habitats. They can also serve as a guide to managing and restoring examples of the longleaf pine ecosystem, canebrakes, pocosins, white cedar forests, swamps and the diversity of other natural vegetation communities and wildlife habitats originally present. A new mapping method using landscape fire ecology was used to reconstruct presettlement fire frequency and pre-settlement vegetation for each site. This involved field sampling of the best remnant vegetation on each of the soil series shown on the portions of the three counties in which the examined lands occur; compilation of historical information relating to vegetation; characterizing fire effects in each kind of vegetation on each soil series; mapping regional and local fire compartments; and identification of fire-frequency indicator species and fire-frequency indicator plant communities. Soil series and areas delimited on aerial photos were used to put boundaries on vegetation types. Data collected from several hundred plots during previous work at other sites in the mid-Atlantic region were used in interpreting vegetation. Descriptions were prepared of the original vegetation types of the natural area as they occurred on each soil series. The presettlement vegetation method used here is expected to have application throughout the South and in other landscapes where frequent fire was an important determinant of vegetation in presettlement times. Forestry staff at the four sites has begun a program of management for natural forest types, and for restoring natural processes such as fire. Using the maps as guides for habitat restoration, the cooperating agencies should be able to establish management policies that will meet national defense, wildlife, recreation and other management objectives while restoring natural fire regimes and maintaining examples of the full range of rich natural communities that the area first encompassed the region.

INTRODUCTION

In the southeastern U.S. it is possible to reconstruct original vegetation and natural fire regimes, even where human land use practices have radically transformed upland vegetation. This is feasible even without witness tree records from early surveys, because of the pervasiveness of fire in the presettlement southeastern landscape and the predictability of fire in shaping vegetation. Given topography, modern soil maps, natural vegetation remnants, and any available historical background, a close approximation of original forest and other vegetation types can be obtained (Frost 1998, 2000).

The landscapes now occupied by the four map sets is complex, in soils, topography and geomorphology, but has lost some of the associated complex natural vegetation and species diversity as the result of disturbance and twentieth century fire suppression. Still there are enough historic materials, remnant native species and natural plant community fragments on the sites, as well as information from natural vegetation on similar soils elsewhere in the region, to adequately reconstruct original vegetation.

In a long-disturbed landscape, reconstructing historic vegetation requires synthesis of every shred of available physical, vegetational and historic information. It also requires interpretation of the role of fire using methods related to landscape fire ecology. The overall region of which the sites are a part originally experienced fire frequencies as high as 1-3 years on upland sand ridges and in some marshes. On the other hand, at Cherry Point despite frequent fire on the most fire-exposed uplands of the landscape, steep slopes, protected from fire by water at the slope toe, provided habitat for fire refugial species such as beech. Reduced fire effects in the vicinity of such steep bluffs near the Neuse River, permitted the coexistence of frequent fire types like longleaf pine/wiregrass on uplands, in close proximity with less fire tolerant hardwoods such as pignut hickory (*Carya glabra*) on partially fire-protected parts of the landscape, and even beech and magnolia (*Magnolia tripetala*) on the most fire sheltered slope toes. The objectives of this study were:

1. Determine the community types and species composition of original vegetation types and their soil, topographic and fire relations,
2. Reconstruct the generalized presettlement fire regimes for the natural area,
3. Create a pre-settlement natural vegetation map at the resolution of the soil series, and
4. Recommend prescribed fire intervals of natural plant communities that contribute to range sustainability and ecosystem management.

The resulting fire frequency and presettlement vegetation maps were prepared as GIS layers to serve as reference conditions for use in planning and in restoration and management of natural forest communities and wildlife habitats. The maps can also be used to help delimit habitat for endangered and threatened animals and plants. The project also constitutes a demonstration of the landscape fire ecology method for reconstruction of presettlement vegetation and fire frequency regime, and illustrates the applicability of this new method for public lands, natural areas and preserves throughout the southeastern U.S.

CHAPTER 1

PRESETTLEMENT VEGETATION OF MAINLAND DARE COUNTY

The county falls into three disjunct regions of land separated by bodies of water: the Outer Banks, Roanoke Island, and the mainland. The maps of original vegetation and fire frequency cover only mainland Dare County. The Dare mainland demonstrates a set of wetland fire-mosaic communities distributed across a remarkable landscape-scale fire frequency gradient. All of the mainland lies barely above sea level (0 to 8 feet) and consists of Holocene and recent sediments and peat. Older soils, including the Baymeade and Leon sands at Mann's Harbor, suggest that these are Pleistocene remnants in a mostly Holocene and recent landscape (Riggs et al. 1992). The wide gap between the mainland and Roanoke Island created by the shallow waters of Roanoke Sound appears to be a recent development. Before closure of all three northern inlets from the sea from Albemarle and Currituck Sounds in historical times, there would have been little hydrologic necessity for the water channels on either side of Roanoke Island. These channels, Roanoke Sound and Croatan Sound, now serve as outlets for the northern sounds. While one of the earliest maps shows a channel labeled the "Thorofare", some historical maps show nearly continuous marshes between the mainland and the southern end of Roanoke Island (Cumming 1966). It may be that Roanoke Island and the mainland comprised a continuous fire compartment shortly before time of settlement.

SEA LEVEL RISE AND VEGETATION CHANGES

Vegetation of mainland Dare appears to have been profoundly affected by sea level rise over the past several centuries. Neglecting any acceleration related to human caused global warming, world sea level is believed to be rising at a rate of about 10 cm (4 inches) per century. This is the amount contributed to the world ocean by melting glaciers. In the mid Atlantic area, however, near the mouth of the Chesapeake Bay, measurements from 1940 to 1970 recorded the highest rate of land subsidence on the east coast, about 0.21 cm per year or 21 cm (8.4 inches) per century (Hicks 1972). This would give a maximum rate of land submergence (land subsidence + sea level rise) in the area of about 30 cm (12 inches) per century. Dramatic effects on the low-lying Dare mainland include loss of land area, fragmentation and isolation of islands such as Durant's Island and flooding of low-lying areas. Elimination of fire or reduction in fire frequency occurs as islands are carved off from the large fire compartment on the mainland, creating firebreaks. As sea level rises, the water table in the Dare mainland interior rises and large areas of mineral soil, once supporting upland fire communities like longleaf pine (frequent fire areas) and hardwood flats (fire sheltered areas) have been converted to wetter soil types, and the most low lying are being mantled with peat. Soils with shallow histic epipedons are trending toward true peat soils. Today there are only 767 acres of well-drained or moderately well-drained soils remaining on the entire peninsula.

Known historical inlet openings and closings from Currituck Sound in Virginia south to Oregon Inlet. Inlet dates have been mentioned by various authors, especially Powell (1968) and for the first 250 years were mostly determined by their appearance and disappearance on the series of 17 historical maps listed below. Beginning in the 1800's some more specific dates are known, as follows:.

(Old) Currituck Inlet – opened pre-1657, appears on the Comberford map of 1657 as Choratuck Inlet (Cummings 1966). The site of the inlet was chosen to be the boundary between Virginia and North Carolina (Byrd 1728). It was shoaling up at the time of the 1728 survey and finally closed in the 1730s (Stick 1958).

Musketo Inlet, south of Currituck Inlet, opened prior to 1657 and closed in the 1670s (Stick 1958) Appears on the Ogilby map of 1671 (Cummings 1966).

New Currituck Inlet – South of old Currituck Inlet, opened in the 1730's (Stick 1958), closed permanently in a storm in 1828 (Ruffin 1861). This inlet, opposite Church's Island in Currituck Sound, was the last remaining outlet to the sea north of Oregon Inlet.

Crow Inlet – a short-lived inlet, opened and closed in the 1790's (Stick 1958).

Caffey's (Providence) Inlet – another short-lived inlet north of Duck, opened in 1790's, closed in early 1800s (Stick 1958)

Trinity Harbor Inlet – south of Duck, opened pre-1585 – this was the inlet used by the Roanoke colonists – closed before the 1657 Comberford map).

Roanoke Inlet (also called Old Inlet, New Inlet and View Passage). South of Nags Head and east of Roanoke Island, opened before the 1657 map, closed between 1780 and 1810.

Gun (also Gunt) Inlet – opposite mainland Dare, through Bodie Island near the southern end of Roanoke Island, is shown on the Moseley map so opened pre-1733, closed in the 1770's (Stick 1958).

Port Lane Inlet – through Bodie Island, shown on the earliest map, opened pre-1585, closed before 1657 (Stick 1958)

Hatorask Inlet (Port Fernando, Hatoras, Hatorasck) – Bodie Island, opened pre-1585, closed by time of the Comberford map,1657.

Oregon Inlet – south of Bodie Island, opened 1846, now the northernmost inlet.

Chickinacommock (or New) Inlet – opened in the 1730s, appears on the Moseley map (1733) south of Pea Island, opposite Stumpy Point, closed in the 1930s.

Only once in the 421 years (2006-1585) since first English settlement has the eastern shoreline of mainland Dare been less salty than at present. That was a period of only 16 years between the 1828 closing of New Currituck Inlet and the opening of Oregon Inlet in 1846. For the other 405 years the whole northern half of the mainland has been exposed to brackish waters of at least 1/3 the strength of seawater. For the past 70 years, the banks from Oregon Inlet north to the Chesapeake Bay have been stabilized against new inlet formation by construction of the coastal barrier dune line beginning in the 1930s, and the waters of Currituck and lower Albemarle Sound have been constrained largely to the oligohaline range (<0.5% salinity), disturbed only by the occasional northward pulse of brackish water from Pamlico Sound during hurricanes.

Historical Inlets and effects of salinity changes on vegetation of mainland Dare. The interpretation of historical changes in shorelines and water bodies rest on an extraordinary series of historical maps on which such changes can be traced since 1585. All but the Wimble maps below were part of a series of large, facsimile reprints (Cumming 1966). Seventeen historical maps used for interpretation included:

Year	Map
1590	White MS
1606	Mercator-Hondius
1657	Comberford
1672	Ogilby
1730	H. Moll
1733	Wimble
1733	Moseley – the first map with reasonable accuracy and detail
1738	Wimble
1770	Collet
1775	Mouzon
1808	Price-Strother – produced by two surveyors working in the study area, best detail to date
1833	Mac Ray-Brazier
1861	Bachman
1861	Colton
1865	U.S. Coast Survey
1882	Kerr-Cain
1896	Post Route – a modern map with extensive roads and other details.

At time of settlement, the lower Albemarle Sound and all of Currituck Sound were strongly brackish. The freshwater cypress-gum swamps and oligohaline marshes around Currituck Sound have been replacing brackish marsh since closure of the last inlet to the sound in 1828. To the south, the Pamlico Sound today is brackish as far inland as Pamlico county where salinities from Bay River all around the eastern shoreline runs 1.1-1.3% salinity as measured with an optical salinometer (Legrand et al. 1992). This is 35 miles inland from the nearest outlet to the sea. In the past, before 1828, therefore, salinities should have been at least this high in the Currituck Sound and around Durant's Island to the mouth of the Alligator River which is less than 20 miles from some of the historical inlets.

Durant's Island, however, would not have been expected to have as high a fire frequency in its eastern marshes as the adjacent mainland despite salt influence. The earliest maps show that the island has always had a gap from during historical times, separated from the mainland by the narrow channel at Haulover Point. Contrary to what might be expected with rising sea level, this gap between Durant's Island and Haulover Point (the point at the land's end west of Mashoes) has been narrowing rather than widening (see the change between 1932 and modern aerial photos). The narrowing has been accomplished by eastward migration of a sand spit, part of the nearly continuous sand berm thrown up and maintained by wave action and northeast storms. In striking contrast, Durant's Island's separation from mainland Dare on its southwestern end appears to be much more recent. Several of the earliest maps show the eastern lobe of Durant's Island joined with or almost touching the land at Briery Hall just north of the present settlement of East Lake. The Collet map of 1770 shows a short line, suggesting a bridge, connecting the southwestern tip of Durant's Island with the northern mainland shoreline of Briery Hall. The body of water called East Lake at time of discovery appears to have once been an inland freshwater to oligohaline lake, perhaps only separated from the mainland by rising sea level just before or during the era of discovery. Sometime prior to that event, East Lake had established a drain to the Albemarle Sound via the little channel at Haulover Point.

Subsequent historical maps show rapid widening of the gap between the southeastern end of Durant's Island and Briery Hall, with no visible change in width of the channel at Haulover point. This appears to result from a rapidly retreating shoreline along the southwest end of Durant's Island. This shoreline is the only one exposed to the prevailing southwest winds and the shore is battered daily by waves generated along a long fetch to the southwest. In contrast, the south and east shorelines are protected by land and the north shore along the Albemarle is only affected by northwest and uncommon north and northeast winds. The gap has now widened to over 4000 feet and in historical times East Lake has become a bay of the Alligator River.

Decreasing salinity may have favored tidal cypress gum swamp along some of the shorelines of Durant's island since closure of New Currituck Inlet in 1828 but not at the expense of marsh. Comparison of photos taken in 1932 and 1982 indicate that marshes are expanding with rising sea level.

Even though Durant's Island was likely connected with the mainland at its western tip shortly before settlement, only a little increase in fire frequency should have been expected. This connection was in the fire-sheltered western margin where only a rare (100-300 year) fire might have carried in on strong south winds, enough to maintain white cedar stands. Since the only natural source of fire now would be rare lightning ignitions on the island itself, little regeneration of white cedar could be expected since breaking of this connection. Some dark signatures on 1982 color infrared photos suggest small remnants of (likely post-logging) white cedar in the interior.

Sea Level Rise and Soil Changes

Table 1 shows soils in relation to high water table on mainland Dare. Soils were mapped between 1974 and 1986 or 20-32 years ago and the table reflects soil taxonomy as of that time. As mentioned, the past rate of land submergence in the Albemarle-Pamlico region has been estimated at around a foot per century (8 inches land subsidence + 4 inches global sea level rise), not taking into account the accelerating rate of rise suggested by recent investigations into global warming. Given only the past rate of 12 inches per century, sea level and the Dare mainland water table should have risen 2.4 to 3.84 inches (6 to 10 cm) just since the soils were mapped. In my experience, low-lying soils on the peninsula, such as the Cape Fear are wetter here than in more stable inland locations. North of the community of East Lake, along Wood Duck and Briery Hall roads, the Cape Fear lies practically at sea level and is semipermanently flooded with pools of ankle-deep water, whereas in mainland situations, as in Cape Fear soils in the counties on the north side of the Albemarle Sound, the soil is a dark mineral soil, only flooded in times of high rainfall. In the flooded Dare County sites the Cape Fear is accumulating a wet organic layer, lacking in the inland sites. Where not already accomplished, the Cape Fear and Hyde soils are in rapid transition to organic soils such as the Roper muck.

Similarly, all the soils of mainland Dare are experiencing rising water tables and have been doing so since colonial times. The first settlers began arriving on the periphery of the Dare mainland around 1750, some 250 years ago. Given a past rate of 12 inches per century, that would be about 30 inches (76 cm) of sea level rise and rise in water table. This would be about 48 inches (1.2 meters) since the first appearance of Europeans with the Roanoke voyages in the 1580's .

As water table has risen, Dare soils have undergone transformation to the next wetter soil types. Except for the wettest and driest soils this change is continuing even as we discuss them. With exception of only a few localities where the highest ridges of the former mineral soil landscape project above the peat blanket, such as at Manns Harbor, Mashoes, East Lake and Stumpy Point, most of mainland Dare has already been submerged. Decade by decade, the last of the Holocene and eroded Pleistocene mineral surface is disappearing under the organic cover.

SOIL TEXTURE AND MOISTURE GRADIENTS UNDERLYING VEGETATION OF MAINLAND DARE

HIGHER AND DRIER → LOWER AND WETTER

SOIL SERIES AND SOIL DRAINAGE CLASS:

TEXTURE	(ED = Excessively drained, WD = Well drained, MWD = moderately well drained, PD = Poorly drained, VPD = Very poorly drained)							
	ED	WD	MWD	SPD	PD	VPD	VPD	VPD-saline
SAND	Fripp (Typic Quartzi-psamments)	Baymeade (Arenic Hapludults)	Ousley (Aquic (Quartzi-psamments)		Leon (Aeric Haplaquods)	Icaria (Typic Umbraquults)		
LOAMY SAND			Johns (Aquic Hapludults)	Johns				
LOAM/CLAY (Umbraquults)						**Cape Fear** (13) (Typic Umbraquults)		
LOAM/CLAY LOAM (Umbraquults)						**Hyde** (13) (Umbric Endoaqualfs)		
LOAM/LOAM (Humaquepts)						**Roper** (18) (Histic Humaquepts)		
MUCK (Terric Medisaprists)						Ponzer (24) (Terric Medisaprists)	Belhaven (38) (Terric Medisaprists)	
MUCK (Typic Medisaprists)							Pungo (65) (dysic Typic Medisaprists)	
BRACKISH SOILS								
MARSH MUCK/SAND								Currituck(40) (euic Typic Medisaprists)
MARSH MUCK/SAND, SILT or CLAY								Hobonny (72) (euic Typic Medisaprists)

Table 1. Soil catenae of mainland Dare County arranged according to soil texture, drainage class and salinity. With exception of the Fripp series, which occur on low sand berms subject to salt spray along the Albemarle Sound, soils to the left in the table are found in higher and drier landscape positions. Numbers in parentheses indicate average depth of organic matter (in the form of either mucky peat or a black organic epipedon). The three primary determinants of vegetation on the mainland were (in declining importance) soil moisture→fire frequency→soil texture. **The three histic soils in boldface have probably developed from much drier soils with agricultural potential in colonial times:** with as more than two feet of sea level rise in combination with land subsidence over the 250 years since first settlements on the mainland, low soils of the uplands have become mantled with peat and peatlands have become deeper. Today there are only 767 acres of well-drained or moderately well-drained soils remaining on the entire peninsula).

Despite perhaps a meter of sea level rise, mainland Dare may have lost a relatively small percent of its acreage. As sea level rises, two counteracting forces govern the net rate of land loss. Most of northern and eastern mainland Dare is bordered by platform marsh. The rhizomes of marsh grasses hold the platform together. With deepening water, the marsh platforms are undermined and the platform edges flex up and down with wave action. Portions of the platform break off, mostly during storms, and the shoreline recedes (Riggs, 2006 pers. comm.).

At the same time, annual growth of marsh graminoids stabilizes the marsh surface. The dense grass stem matrix traps dust and water-borne sediments and continues to produce new rhizome mat above the old, in equilibrium with the opposing effects of drying and sea level rise so that the marsh platform builds vertically, maintaining the surface at equilibrium with sea level. Similarly, in the fresh ground water interior, woody peat formation maintains a surface in equilibrium with the opposing forces of subaeric decomposition and anaerobic preservation of organic matter.

Marshes in the region have been recorded to recede at a maximum of 18.3 feet per year while the average is 3.2 feet (Riggs, pers. comm.). Wind tides, in cooperation with lunar tides, are the main drivers of shoreline erosion. With any increase in rate of sea level rise, more breaches in the barrier island chain can be expected. Since the Outer Banks dampen the effects of lunar tides in the sounds, more inlets would lead to higher lunar tides within the sounds, resulting in a greater rate of shoreline erosion (Riggs, pers. comm.).

Swamp forest shorelines, such as that along the Alligator River, erode after flooding because few species, even those such as red maple and swamp black gum, cannot tolerate more than intermittent flooding. Saltwater intrusion adds another stressor, speeding the process (see Figure 1).

Figure 1. Alligator River, looking southeast. Evidence of sea level rise abounds around the margins of the sounds. Dead baldcypress are found here along the receding shoreline of the Alligator River near the US 64 bridge near the mouth of the Alligator River. Upstream, toward the headwaters of the Albemarle Sound, living baldcypress can be found in water permanently flooded to a depth of two or three feet, a situation in

which they could never become established today. Since baldcypress typically germinate on wet mud and cannot become established in standing water, the bases of trees indicate maximum sea level at time of establishment. Several medium sized cypress that I cored at various points around the shorelines had become established 100-300 years ago, but were now growing in water up to 30 inches deep. Recent mortality of trees such as those in the photo may be due to increasing exposure to salinity, especially during pulses of salt water pushed north into the Albemarle and Currituck sounds from Oregon Inlet and the Pamlico Sound during hurricanes and other storms.

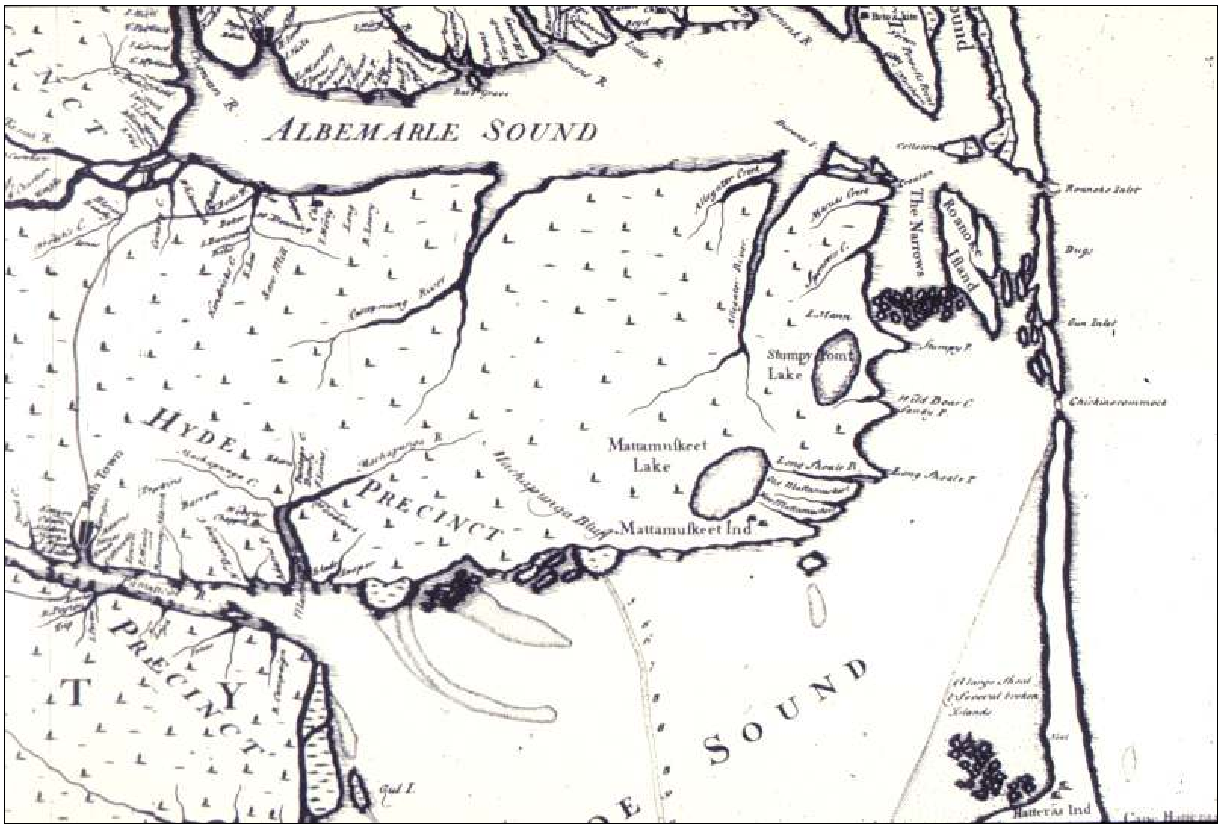

Figure 2. The Moseley map of 1733 is the first historical map to show mainland Dare in much detail. Stumpy Point Lake, is shown as an inland lake, not yet connected to the sound. A zone of marshes nearly connect mainland Dare to Roanoke Island and may have formed a fire bridge between the two bodies at some time shortly before settlement. This would have contributed to maintenance of the remnants of longleaf pine found there. Durant's Island is shown already disconnected from the mainland at its eastern tip 273 years ago but the southwestern end appears to nearly touch the mainland. Note that Roanoke Inlet provided an outlet to the sea for the waters of Albemarle Sound and Currituck Sound, obviating a need for much water flow north/south around Roanoke Island, which today is the only way that waters from the north can drain to the sea. Note Alligator Creek and Alligator River, sometimes referred to as "the two Alligators" in historical deeds.

Figure 3. The Price-Strother map of 1808 shows a narrow connection forming between Stumpy Point Lake and Stumpy Point Bay. This gap has widened until today the former lake is merely the western half of the bay. The high ground along Manns Harbor and Mashoes is called Croatan. This map best shows the former connection of Roanoke Island with the mainland. With exception of a narrow channel, the marshes between the Dare mainland and Roanoke Island form almost a complete bridge. The map also shows a ditch or canal leading from the head of Long Shoal River to a tract of 5000 acres in the vicinity of the present Air Force bombing range. The tract is apparently mislabeled I.G.B. but should have been J.G.B for John Gray Blount who obtained the land as part of a 100,000 acre grant he entered in 1795. The ditch, which was probably dug by slaves for access to the inland tract, can still be made out on aerial photos.

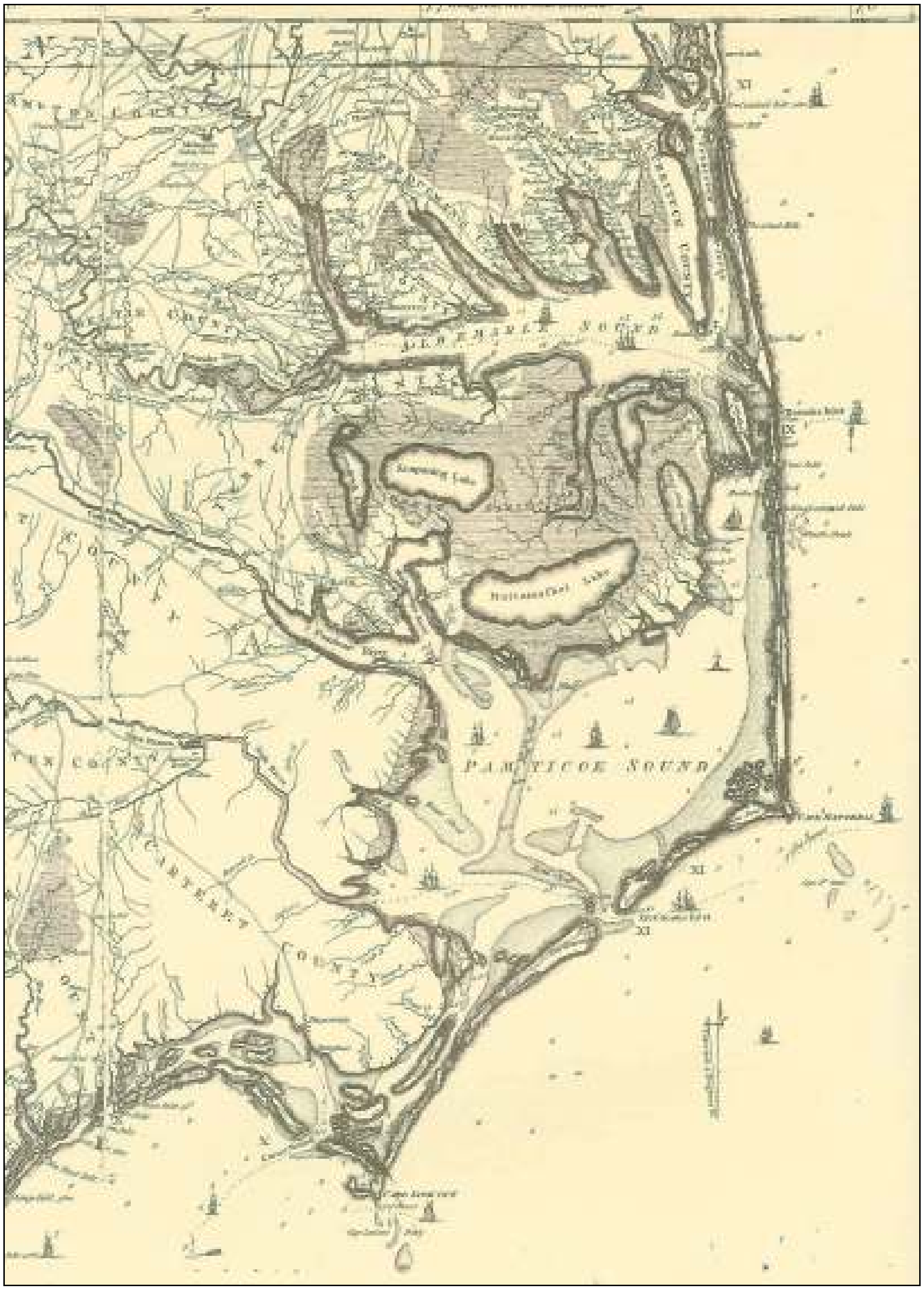

Figure 4. The Mouzon map of 1755, while accurately representing the Alligator River, greatly exaggerates the size of the inland lakes, including Stumpy Point Lake and East Lake. The marshes between the Dare mainland and Roanoke Island are still present but a connection has opened between Stumpy Point Lake and the Pamlico Sound. Note that Durant's Island all but touches the point at Briery Hall and the earlier Price-Strother map above shows a line, apparently a small bridge, connecting the two.

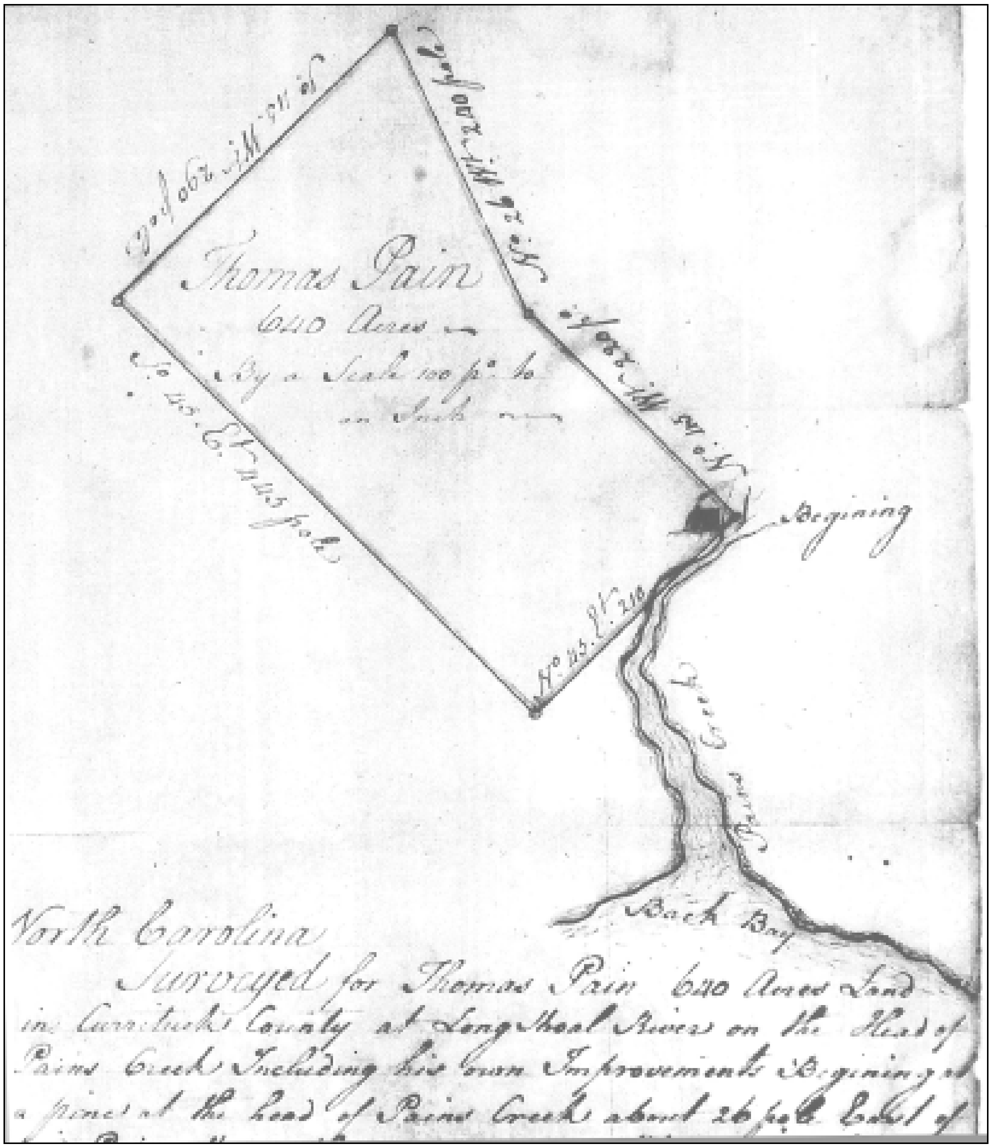

Figure 5. 1765 land grant survey for Thomas Pain, the first settler on Pains Bay, southeastern Dare County just north of Long Shoal River. The house is shown at the edge of Pain's Creek near its head, a site now buried under brackish marsh peat. On modern soil maps most of the rest of the land is now Belhaven and Pungo mucks. The portion of interest for agriculture was a pine ridge, described in the deed that occupied the area shown as Hyde (HyA) soils on the soil map below. Beyond the pine ridge the land was described as "the Desart", a term that seemed to mean open, treeless land. Given the estimated fire frequency of around 3 years in the vicinity, the expected vegetation types on the surrounding organic soils would have been canebrake and pyrophytic (fire-maintained) low pocosin with only sparse pond pine.

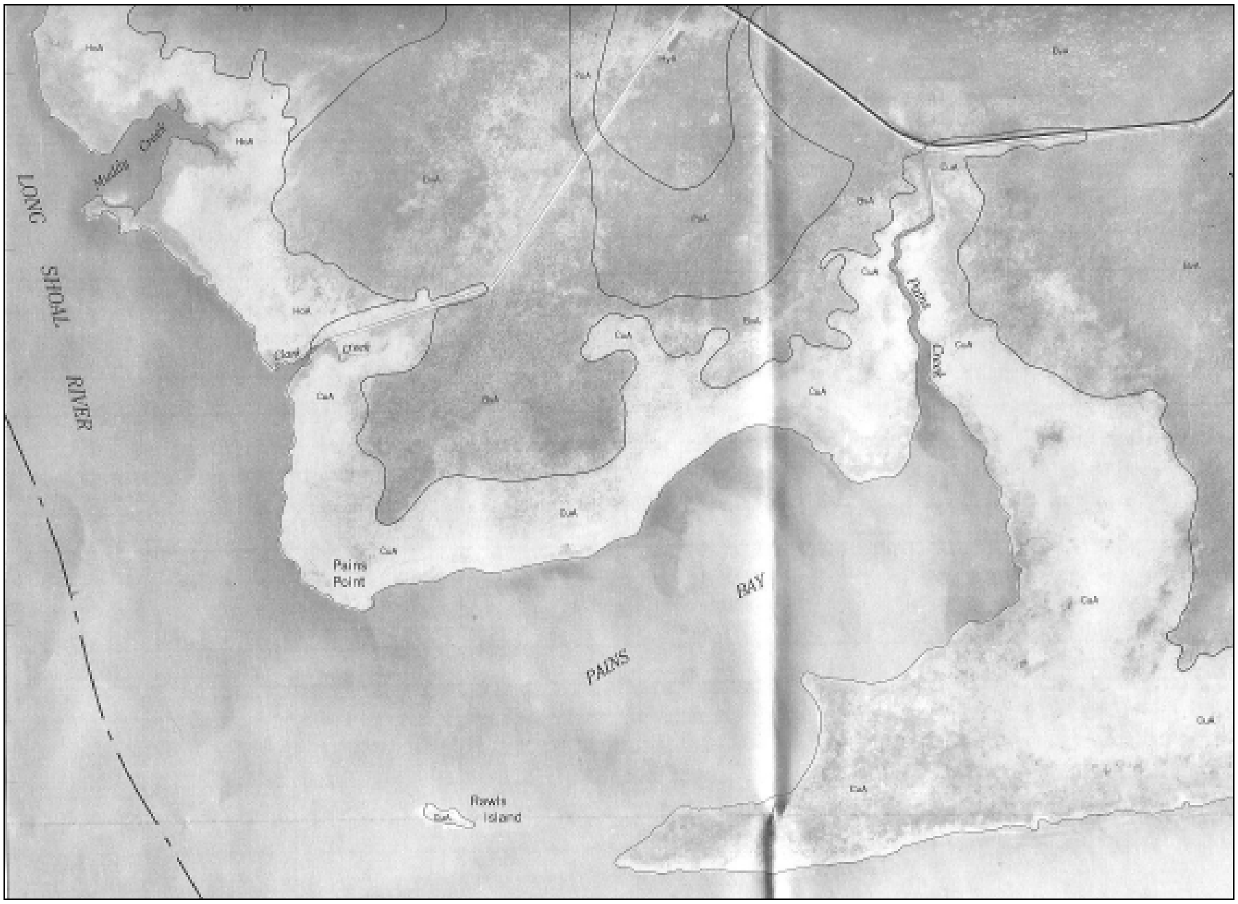

Figure 6. Thomas Pain's house was located on the west side of Pains Creek at the point of its last bend before reaching the straight, channelized stretch leading to US 264 (black line at upper right). The house site is now buried under Currituck salt marsh peat. Aerial photo for soil map taken around 1975 (Tant, pers. comm.). Note how the US 264 ditches along the sides of the road have led to salt water intrusion to the right, killing pond pine forest and creating a finger of new brackish marsh labeled Cu (Currituck) along the road (see also Figure 7 below).

During the last 35 years, the ditch-facilitated oligohaline marshes appear to have expanded into thousands of acres of former pond pine canebrake and pocosin. Pines deteriorate quickly after being killed. New inroads seem to occur in pulses, likely associated with mortality of freshwater trees after large amounts of saltwater input during hurricanes. The only slightly deteriorated trees in Figure 7 below suggest that they were killed as a group following one of the recent hurricanes.

Figure 7. Salt-killed pond pine forest on the east side of US 264, 100 meters north of the Pains Creek ditch which facilitates the salt water intrusion. This is a common phenomenon along many of the ditches along the east side of mainland Dare. Beneath the trees is a layer of sawgrass, wax myrtle, cattails and *Andropogon glomeratus*, the tall reddish grass in the foreground along the roadside ditch.

For the past 40 years, scientific opinion has held that world sea level has been rising at about 4 inches per century. In addition, in the Albemarle Sound region there has been an estimated 8 inches of land subsidence per century giving a net amount of land submergence of around 12 inches. From the time of settlement along the Stumpy Point (1754) and the Pain's Bay shoreline (Pain's house, 1765), 241 years would give approximately 74 centimeters (29 inches) of land submergence. This is confirmed circumstantially by the location of Pain's house, originally in the woods near the head of Pain's Creek, a site now buried under some depth of brackish marsh peat (Figures 5 and 6).

Given that the mineral soil would have been more than 2 feet higher above sea level than at present, this may have been occupied by longleaf pine or a mixture of longleaf and pond pine at time of settlement. There are remnant longleaf pines only a few miles to the south along the margins of the Hyde County shoreline. The soil series was mapped prior to 1986 as Hyde (Umbric Endoaqualfs). Two hundred and fifty years ago, before salt marsh invaded Pain's house site, sea level was some 30 inches lower than at present so this ridge should have been a terrestrial mineral soil such as the Johns (Aquic Hapludults). As such, given the fire-exposed nature of the site, the original forest was likely longleaf pine or a mixed pine savanna with longleaf, loblolly and pond pine. The Hyde loam has a seasonal high water table of 0-1.5 feet below the soil surface. Subtracting the estimated 29 inches of land submergence would give the original pine ridge a mineral soil with a seasonal high water table of 2.5-4.0 feet. This would be equivalent to a good agricultural soil as dry as the Goldsboro fine sandy loam (2-3 ft), Foreston loamy fine sand (2.5-3.5 ft) or Craven silt loam (2-3 feet).

Figure 8. The former pine ridge farmed by Thomas Pain in 1765. While loblolly pine and pond pine are still present, the soil has had 241 years of increasing wetness and now has accumulated enough organic content in its umbric epipedon to provide habitat for canebrake.

Formation of Dare County. The history of counties in which Mainland Dare was located (State Library of North Carolina, Raleigh comes from a printed summary with six maps and dates of county formation. See also Formation of North Carolina Counties (Corbitt 1987):
Albemarle – 1664 to 1668
Currituck – 1668 from part of Albemarle county-1729
Tyrell – 1729-1870
Dare – 1870 (mainland portion) from Tyrell

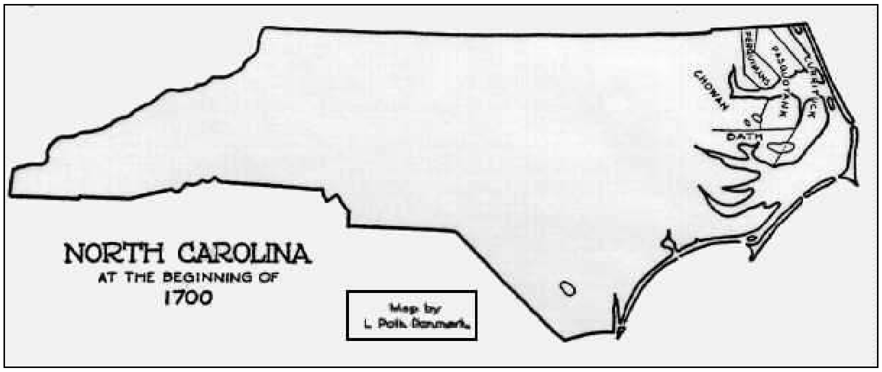

Figure 9. NORTH CAROLINA at the beginning of 1700

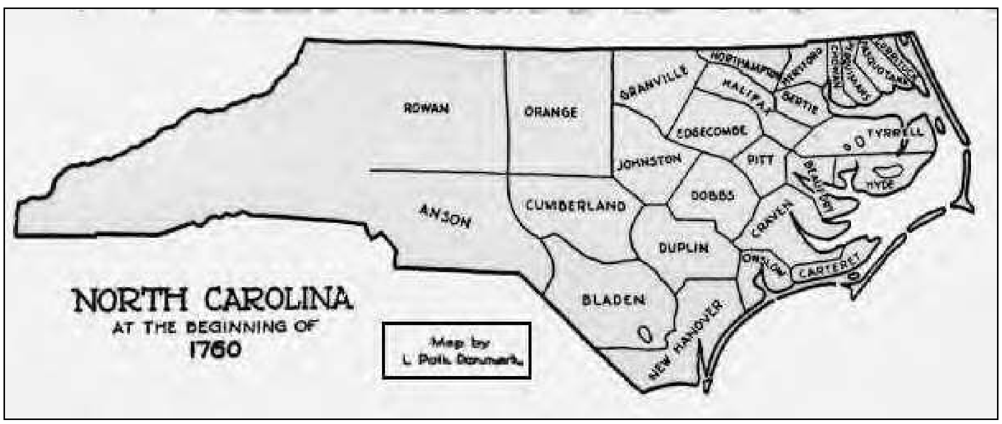

Figure 10. NORTH CAROLINA at the beginning of 1760
N.C. Div. of Archives and History

Early settlement on the Dare Mainland

1713 — Durant's Island was granted to Capt. Cornelius Jones, 1280 acres (survey map lost). Despite being called an island on the grant, early survey maps suggest that it may have still been connected at its southwestern end to the mainland at what is now Briery Hall Point. 95 years later the Price-Strother map (1808) shows only a small gap with a bridge at that point. No tree species were listed in the deed description.

1727 — John Mann, two tracts of 160 and 616 acres granted at "Croatan", now Manns Harbor (survey maps lost). The deed for the 160 acre tract mentioned only a pine at the mouth of Mashoes Creek with the
first line running up the creek. The 616 a tract also mentioned only a pine at the starting point. The pine could have been longleaf, loblolly or pond pine.

mid-1700s — George Caroon, land granted on Durants Creek near Mashoes. The name appears as Carron on the Collet map of 1770 and Mouzon map of 1775 and seems to indicate all of the lands in and around Mashoes (also called historically "Live Oak Hammock").

1743 — 300 acres on "Stumpy Point Bay" to Richard William Silvester (Sylvester), "on the Lake and Sound". What is now Stumpy Point Bay was then still a freshwater lake. The Price-Strother map of 1808, 65 years later still shows it as a lake but with a narrow mouth to the sound. Later maps show it progressively opening into a bay. The trees, listed consecutively, on the Sylvester deed are " cypress, maple, gum, cypress, cypress, gum, gum, then 'along the Swampy Bay and Sound' to a gum."

1748 and 1749 — Three tracts of 160, 360 and 600 acres (all survey maps lost) to Benjamin Cowell in the vicinity of East Lake and Briery Hall on the east side of the "Great Alligator River" (there is also a Little Alligator River on the Tyrell side) near the present route of US 64. The 160-acre tract on the south side of South Lake and "above Briery Hall" has only three trees, "Sweet Gum, gum and Gum". The later two may be swamp black gum. Given its dimensions and location above Briery Hall", this tract seems to fit the land on the northeast corner of the Briery Hall peninsula with Broad Creek its eastern boundary. Broad Creek was the first southern arm of South Lake (the lower limb of East Lake), which at the time may well have been a freshwater lake, opening only to the north into the Albemarle Sound at Haulover Point. In 1808, s mentioned above, the Price-Strother map seems to show a gap with a small bridge crossing to Durants Island.
The tract of 360 acres, called "the Mulberry or Buck Ridge" was also on the south side of South Lake. The deed mentions consecutively: "Sweet Gum, pine, poplar, sweet gum, pine, 'an Oak', water oak, Sycamore, Sycamore, Beech and then along the course of the "Lake Swamp" shoreline back to the beginning.
The 600 acre Dutchman's Ridge tract deed description of 1748 mentions only the four corner trees: **hickory** (probably Carya glabra in this fire sheltered location), pine, pine and gum.
Of the four pieces of high ground existing along the river at that time, Briery Hall, Lake Neighborhood, East Lake, and the high ground along Milltail Creek, the highest, and the only land likely to be referred to as a ridge was the land at East Lake.

1754 — Thomas Sanderson 100 acres on Stumpy Point Lake

1765 — Thomas Pain, 640 acres at the head of Pain's Bay, north of Long Shoal River.

1778-1795 — Samuel Jackson patent for 150 acres on Milltail Creek (entered in 1778, not issued until 1795).

1795 — Samuel Jackson entered (filed for a land grant) and was issued the adjoining 2000-acre tract to his earlier grant of 150 acres on Milltail Creek. Jackson may have gotten wind of the land rush being fueled by Blount and his associated Philadelphia land speculators and filed for this land before Blount got to it. A letter from his surveyor to John Gray Blount commented that he had neglected his opportunities in Dare County.

1795 — John Gray Blount filed a patent for 100,000 acres or most of the still unoccupied lands of mainland Dare. Survey began at three pines at head of Long Shoal River at a corner with lands owned by John Hall. The deed description mentions boundaries extending northwest to the Great Alligator River, then along the river north to Briery Hall Point above what is now the community of East Lake, then east along the margins of South River (South Lake) and the arms of East Lake to the Thorofare between the eastern end of Durant's Island and the mainland. It then continued east and south along the margins of the Croatan sounds south to Long Shoal Point. This outrageous land grab, if read literally, included much of the lands previously granted to others above, but presumably was understood to be a blanket grant for all the remaining unoccupied land on mainland Dare. Part of this enormous tract had a common border with the 2000-acre tract obtained by Thomas Sanderson (above). The 100,000 acre patent included within its boundaries 22,633 acres previously granted to Blount and the same instrument mentioned conveyance of 9,600 acres of it to George Pollock (probably another speculator), the lands being on the northeast corner of Samuel Jackson's 2000 acre tract mentioned above. .

Mainland Dare is essentially a huge peninsula 47 km (29 miles) long, bounded by Roanoke Sound on the east, Albemarle Sound on the north and the Alligator River on the west. Alligators may still be found in small tributaries like Milltail Creek, the present northern limit for the species. The peninsula is connected to Hyde County at its southern end. Fire vegetation comprises virtually all of the plant cover of this large peninsula. The sole exceptions are a region of oak flats in the vicinity of East Lake in the northwestern quarter and a narrow zone of tidal cypress-gum swamp immediately bordering the Alligator River along its whole length. The entire landscape also comprises essentially a single fire compartment. On the northern end, Durant's Island appears to have only recently been separated by sea level rise from the pocosin to the south and may be still within range of ignition by firebrands carried by convection during pocosin fires. Within the mainland fire compartment, however, vegetation is conspicuously zoned from frequent-fire types like marsh and canebrake on the east, to long fire-return interval types like Atlantic white cedar on the west.

As opposed to stable upland landscapes elsewhere on the Coastal Plain, interpretation of presettlement vegetation in the tidal zone has to take into consideration sea level rise. Restoration of historical natural conditions cannot be tied to specific geographic locations since the soils that supported the original vegetation has been transformed into the next wetter soil. Restoration targets can be suggested, however, just by describing the natural vegetation of each soil series as it occurred in the original landscape. In most cases the fire relations of each location have changed little.

PRESETTLEMENT FIRE FREQUENCY OF MAINLAND DARE

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Fire Frequency Class	Mean Fire Interval (years)	Estimated Historic Range of Variation (90% of Fires) (years)	ACRES	PERCENT
A	2	1-4	1,192	0.6
B	3	1-6	28,727	14.7
C	4	2-10	63,468	32.5
D	6	3-20	12,484	6.4
E	9	4-50 depending upon vegetation type and location in the landscape	21,993	11.3
F	25	10-100 depending upon vegetation type and location in the landscape	35,116	18.0
G	90	35-300+ depending on landscape position along the fire frequency gradient	26,357	13.5
H	None	Nonflammable, tidal cypress-tupelo swamp	4,712	2.4
Water			1,239	0.6
TOTAL			195,288	100

Table 2. Original fire regimes of the Dare county mainland. Summary is from the accompanying GIS map See Appendix 1, Methods for a summary of methods used for determining presettlement fire regimes and presettlement vegetation.

A Landscape-scale Fire Frequency Gradient

Oddly enough, the pronounced east-west fire frequency gradient seems to have been set up entirely by salinity. The brackish water along the eastern margin maintains Juncus marshes which form a continuous, wide shoreline band stretching some 80 km (50 miles), all the way from the Albemarle Sound, down the length of mainland Dare, south along the border of Hyde County to the Pamlico Sound. This 50-mile fire corridor was augmented by flammable canebrake in the next vegetation band immediately to the west. The beginning of salt-intolerant canebrake may mark the western limit of storm overwash. On the west side, in contrast, non-pyrophytic cypress-gum swamp fringes the fresh waters of the Alligator River in a narrow band. The frequent-fire marsh and cane communities of the eastern side and this river swamp on the west comprise the extremes of a cross-peninsula fire frequency gradient. For a cross-section of this gradient see Figure 6.4. Vegetation components of the fire frequency gradient from east to west were as follows. Salt marsh was composed of several distinct communities, of which black needle-rush (*Juncus roemerianus*) was dominant. Just inland from the marshes was the canebrake zone, originally up to a kilometer or more wide. In the marsh-canebrake transition there were islands of loblolly pine marsh, apparently in places where mineral soil approached the surface, or pockets of pond pine with a marshy or pocosin understory. Inland, canebrake graded first into low pocosin, then medium and high pocosin. Next to the west, pocosin graded into a large-scale patch mosaic of wooded wetland types. The individual components of the pyrophytic patch mosaic were tall pocosin, pond pine forest, *Nyssa biflora* forest, *Taxodium ascendens*, bay forest and Atlantic white cedar. Figure 3.9 in Chapter 3 is a black and white version of a color infrared aerial photo showing a virgin patch mosaic composed of the above elements. Finally, the patch mosaic was bounded on the west by a relatively narrow band of cypress-gum swamp, only 100-300 meters wide, along the Alligator River.

Following is an annotated checklist of presettlement vegetation types of mainland Dare and Roanoke Island. The descriptions are based on landscape fire ecology (Chapter 6) and presettlement vegetation methods (Chapter 7). Field investigations included 1/10 ha plots in several of the major vegetation types, along with extensive exploration by land and by boat. Tree cores were used to determine fire dates of some of the stands in the virgin patch mosaic depicted in Chapters 3 and 6 (Figures 3.9 and 6.4). Historical documentation of mainland vegetation was sparse, but recollections were used from some local residents as well as 19^{th} and early 20^{th} century observations by Ashe (1894), Pinchot and Ashe (1897), Anon (1907), Hale (1883) and Sargent (1884). Study of canebrake-pocosin-pond pine dynamics was aided by several wildfires in different kinds of vegetation, including a fire in 1982 that rejuvenated a large canebrake along the east side of highway 264 just south of its juncture with US 64.

Table 3. PRESETTLEMENT VEGETATION OF MAINLAND DARE

Symbols represent the dominant vegetation types in descriptions which follow.

1. **Estuarine Fringe Beaches, Sand Berms and Low Dunes, Sparsely Vegetated** Đ

2. **Dry-mesic Longleaf Pine Forest and Savanna** □

3. **Mesic Mixed Pine Woodland** (loblolly, pond pine, longleaf at some sites, some hardwoods) Ɵ

4. **Wet-mesic Longleaf Pine Savanna** ☼

5. **Maritime Pine-Live Oak Forest** (loblolly pine, live oak) ◙

6 **Oak-Loblolly Pine Flats** ♠ (mineral soil, fire-sheltered) (water oak, laurel oak, willow oak, swamp chestnut oak, sweetgum, loblolly pine)

7. **Pine-Gum flats** ▲ (moist mineral soil, fire-exposed)

8. **Pond Pine Savanna** (on mineral soils with occasional longleaf and loblolly) ◊

9. **Canebrakes** (canebrake-pocosin mosaic with canebrake dominant) ○

10. **Pond Pine Pocosin** (pocosin-pond pine forest-canebrake mosaic; pocosin dominant) ◘

11. **Patterned low pocosin** ф

12. **Peatland Long Fire Interval Pyromosaic** ► (mosaic elements are pond pine forest, pond pine pocosin, swamp black gum, baldcypress, pond cypress and Atlantic white cedar)

13. **Peatland Very Long Fire Interval Pyromosaic - Atlantic White Cedar dominant** ♥

14. **Tidal Cypress-Gum Swamp** ■

MARITIME DUNES, SWALES AND MARSHES

15. **Pine Marsh and Estuarine Scrub** Д

16. **Oligohaline Marsh** Ø

17. **Oligohaline to Brackish Marsh** (combined, salinity< 1.5%) **Ω**

18. **Brackish and Salt Marsh θ** >1.5% salinity (toward PA Sound)

19. **Water:** Aquatic communities of lakes, streams and sounds**.**

Table 3. Summary of vegetation types of mainland Dare County. The symbols are used in the descriptions below to represent different vegetation types that may occur on the same soil series.

PRESETTLEMENT VEGETATION SUMMARY – MAINLAND DARE:

Vegetation Type	ACRES	%
Estuarine Fringe Beaches, Sand Berms and Low Dunes, Sparsely Vegetated	130	0.07
Dry-Mesic Longleaf Pine/Wiregrass Savanna	197	0.10
Mesic Mixed Pine Savanna and Pyrophytic Hardwood Woodland	347	0.18
Wet-mesic Longleaf Pine Savanna	161	0.08
Maritime Pine-Live Oak Forest	223	0.11
Oak-Loblolly Pine Flats	11,977	6.13
Pine-Gum Flats	9,756	5.00
Pond Pine Savanna and Forest	160	0.08
Canebrake (canebrake-pocosin mosaic, canebrake dominant)	33,823	17.32
Pond Pine Pocosin (pocosin-pond pine forest-canebrake mosaic, pocosin dominant)	38,445	19.69
Patterned Low Pocosin	18,560	9.50
Peatland Long Fire Interval Pyromosaic	31,349	16.05
Peatland Very Long Fire Interval Mosaic – Atlantic White Cedar Dominant	26,681	13.66
Tidal Cypress-Gum Swamp	3,726	1.91
Pine Marsh and Estuarine Scrub	6,812	3.49
Oligohaline Marsh	288	0.14
Oligohaline to Brackish Marsh	5,387	2.76
Brackish and Salt Marsh	6,023	3.08
Water (interior)	1,247	0.64
TOTAL	195,291	100

Table 4. Number of acres in each presettlement vegetation type at mainland Dare County. Summary from GIS map.

LIST OF PRESETTLEMENT VEGETATION TYPES OF MAINLAND DARE. Format below begins with name of the presettlement vegetation type. In some cases, such as canebrake, these may not strictly agree with modern vegetation classifications that were developed for existing vegetation. Type is followed by the soil series (one or more) on which the vegetation type is found, followed by the soil taxonomy. When there are more than one series the driest is listed first. Symbols that follow the soil classification refer to the vegetation types found on that series with the most important listed first. See Table 4 above for the complete list of symbols and vegetation types. Community types are the principal vegetation types found.

1. Estuarine Fringe Beaches, Sand Berms and Low Dunes, Sparsely Vegetated Đ
Soils:
FrD Fripp fine sand – uncoated Typic Quartzipsamments, ED, >6 Đ ◙
Unclassified recent sands Đ
Community types:
Spartina patens
Iva frutescens/mixed oligohaline marsh and low dune graminoids and forbs
Quercus virginiana-Pinus taeda/Ilex vomitoria-Smilax spp.

This type is found almost exclusively along the northwestern and northern shorelines of Durant's Island and the mainland to Mashoes, and the northeastern shores of the mainland south to Redstone Point at Manns Harbor. The white sand component, easily visible on aerial photos, consists of narrow beaches and sand berms, mostly 1-3 feet high. Wave action, particularly during northeast storms and with northwest winds following cold front passage, is likely responsible for the frequent fresh deposits of sand and salt spray which prevent the berms and low dunes from ever becoming completely vegetated. When stable for a few years the low sand patches are colonized by saltmeadow cordgrass (*Spartina patens*) which then becomes colonized by marsh elder (Iva frutescens) and a few other salt-tolerants graminoids and forbs such as seaside goldenrod (*Solidago sempervirens*). Older low dunes a little back from the shoreline have patches of yaupon (*Ilex vomitoria*). See Maritime Pine-Live Oak Forest below for further description of wooded communities.

2. Dry-Mesic Longleaf Pine Savanna ☐
Soils:
BaC (ByB) Baymeade fine sand - loamy, siliceous, Arenic Hapludults, WD, 4-5 ☐ ◙
Community type:
Pinus palustris/dry-mesic savanna herbs

This type occurred only at Manns Harbor (likely) and on a single pedon forming the dryer part of Sandy Ridge just south of Sawyer Lake). No example of natural vegetation on the Baymeade sand remains today. Every square meter of the uplands at Manns Harbor have been farmed or otherwise completely altered in the 279 years since John Mann was granted two tracts of 160 and 616 acres granted at "Croatan", now Manns Harbor in 1727. At Sandy Ridge (near the site of Buffalo City), the site was heavily used during the WWI timber boom and later planted in slash pine that is now mature. There is no natural vegetation on the drier part other than some loblolly pine, pond pine and a few woody shrubs that have reinvaded.

Longleaf Pine. An early engraving of one of the drawings of John White, made during the 16th century Roanoke voyages, shows a dancing Indian brandishing a pine branch with long needles and a thick stem resembling longleaf pine (Harriot 1590). There have been 421 years of human land use and rising sea level since the founding of the Lost Colony (1585-1587). Widely scattered single longleaf pine stems in the now loblolly pine-dominated woods of Roanoke Island suggest that much of the interior of Roanoke Island was likely covered in longleaf. These would have been mixed with pond pine and loblolly on the wetter fringes and interior sloughs. Loblolly pine likely dominated the marsh/mineral soil upland transitions as it does today. Besides the scattered trees, the only remnants in the vicinity today are, a small stand of less than an acre of longleaf pine on the Fort Raleigh National Historic Site at Manteo just off US 64, scattered patches in Nags Head Woods and in the old forested sand dunes on the southeast side of Colington Island. The original herb layer dominants are unknown, the site having been long fire suppressed and covered with a deep accumulation of pine needle litter. Besides a few clumps of *Andropogon*, practically the only herbs I found in a study plot at the Lost Colony site were a few specimens of *Cnidoscolus stimulosus*, which is rarely absent from the Baymeade soil. As a fire compartment, Roanoke Island is too small to expect a high fire frequency from lightning ignitions. The presence of longleaf pine there is strongly indicative of either the use of fire by the Indians or a former marsh connection with the mainland and the Nags Head/Colington Island portions of the Outer Banks.. Both causes appear to be likely.

On the mainland, Little's Atlas of U.S. Trees (1971) shows a single occurrence of longleaf in central Dare County. According to staff of the Alligator River National Wildlife Refuge, longleaf pine was completely extirpated from mainland Dare before establishment of the refuge (Nofsinger pers. comm.). The former location is Sandy Ridge, an isolated lens of Baymeade and Ousley sand in the west central part of the peninsula, surrounded by kilometers of organic soils. Before settlement the species probably also occurred at Mann's Harbor, the only other place on the mainland where suitable soils appear, and a few stems may have been found in mixed pine stands on the higher soils near East Lake. Never extensive on mainland Dare in historical times, not a single longleaf is known to remain. Only a few centuries earlier, however, when sea levels may have been a few meters lower, and before the extensive peat mantling that is accompanying sea level rise, longleaf pine may have been a prominent species on mineral soils of the peninsula.

Besides the longleaf just across the former marshes from Manns Harbor, I found in Hyde County to the south a remnant stand of longleaf on an island in the brackish marshes of the Swanquarter National Wildlife Refuge and there are a few mature trees in the woods that can be seen from the bridge where US 264 crosses the IntraCoastal Waterway. The small stand of pines on the ridge on Thomas Pain’s 1765 grant at Pains Bay (probably mixed longleaf-loblolly-pond pine) is another likely site in the series of stepping stones connecting the longleaf pine of the barrier island/Roanoke Island remnants with those of the rest of the coastal plain. Historically we appear to be experiencing the final stages of extirpation of longleaf pine from mainland Dare and Hyde counties as rising sea level blankets the remaining mineral soils with peat.

3. Mesic Mixed Pine Woodland (loblolly, pond pine, longleaf at some sites, some hardwoods) **ϴ**

Soils:

OuB Ousley fine sand - uncoated Aquic Quartzipsamments (this applies only to the single pedon of Ousley with BaC on Sandy Ridge, the rest is maritime forest at Mashoes), MWD, 1.5-3

JoA Johns loamy sand - fine-loamy over sandy, siliceous Aquic Hapludults, MWD, 1.5-3 (this excludes the two pedons of Johns at East Lake – they are pine-hardwood flats)

The single pedon of HyA Hyde soil at Pains Bay mentioned above is in this class)

Community type:

Pinus serotina-Pinus taeda-Pinus palustris/Chasmanthium laxum-mixed mesic savanna graminoids and forbs

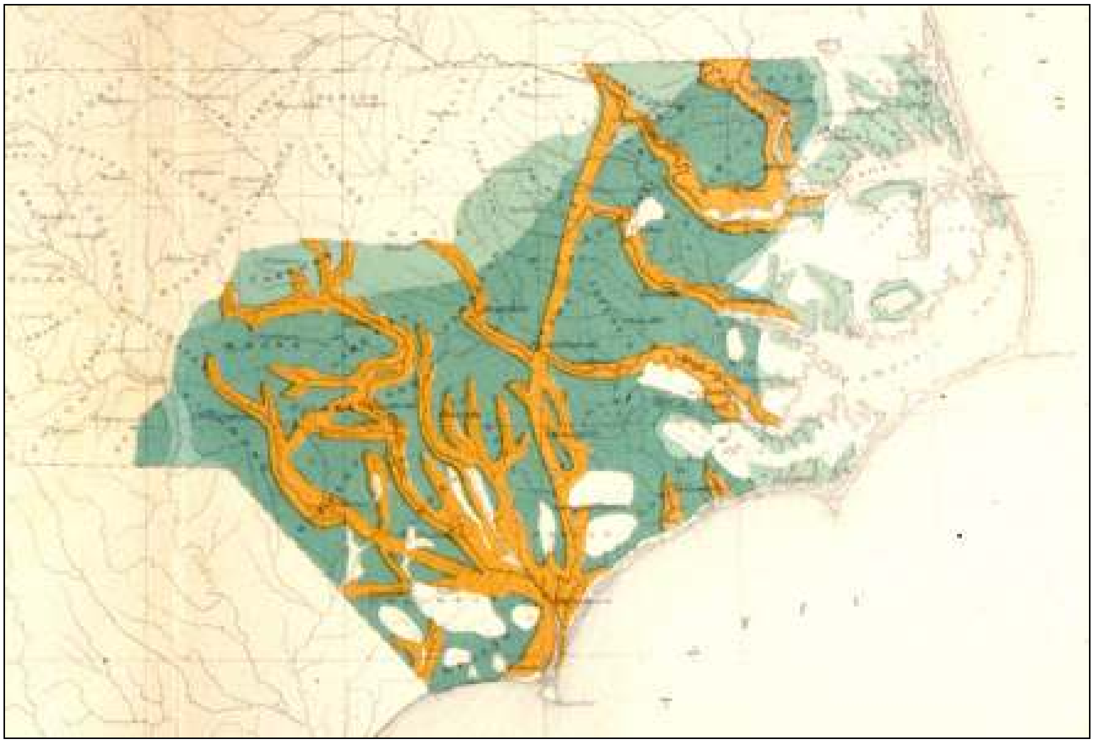

Figure 11. Map of longleaf pine in North Carolina in 1880 (Sargent (1884). The orange bands are areas where all commercial pine timber had been removed along navigable rivers and railroads. The long line running from near the Virginia border south to Wilmington was the route of the Weldon and Wilmington Railroad – the longest in the world at time of its construction in 1848. The light green area on the western margin was the Piedmont transition region where longleaf was mixed with shortleaf pine. The similarly colored region in the eastern part of the state was where there were stands and patches of longleaf mixed with pond pine and loblolly. The white areas lacked significant amounts of commercial pine species and included large expanses of peatland with pocosin, canebrake, Atlantic white cedar and swamp black gum. Note the longleaf in the Currituck peninsula, described also by Ashe 1894, of which not a single tree remains today and at Roanoke Island and Lake Mattamuskeet. Either Sargent did not know of or the map scale did not permit showing the scattered longleaf in Nags Head Woods and on Colington Island or the small stepping stone population at Swanquarter. Today there are only a few remnant trees on Roanoke Island and near Mattamuskeet near the Intracoastal Waterway.

Natural mixed pine savanna occurs where frequent fire coincides with moist mineral soils, especially in the peripheral zones transitional to wetlands. No examples survive today as the three sites where appropriate soils occur, Manns Harbor, Sandy Ridge and the Pains Bay pine ridge have been heavily used in the past. The closest approximation of this vegetation type is represented by the Ousley sand at Sandy Ridge where it forms a band around the small central patch of Baymeade sand with the planted slash pine. The Ousley sand, with fire completely excluded since the heyday of Buffalo City has a canopy dominated by sweetgum, supplemented with stems of loblolly and pond pine, water oak, and swamp black gum. There is a subcanopy of red bay (*Persea palustris*) and red maple and a light shrub layer of wax myrtle. The only herb of any consequence, *Chasmanthium laxum* with 25-50% cover, was the likely ground cover dominant in the original woodland.

4. Wet-mesic Longleaf Pine Savanna ☼
Soils:
Ln Leon fine sand – sand, siliceous Aeric Haplaquods, PD, 0-1☼ ⌂
Community type:
Pinus palustris/species-rich wet savanna

There are sizeable areas of moist Leon sand on Roanoke Island and small areas at Mann's Harbor, but with exception of single longleaf trees here and there on Roanoke, I was not able to find any remnant community, especially one that had been maintained with fire. The associated herb layer under the original fire regime can only be guessed at by comparing that of burned examples elsewhere. All of the Leon sand at Mann's harbor, the only mainland site with longleaf soils other than those mentioned above, has been domesticated since colonial times and no trace of undisturbed natural vegetation remains.

5. Maritime Pine-Live Oak Forest (loblolly pine, live oak, yaupon, Smilax) ◙
Soils:
OuB Ousley fine sand - uncoated Aquic Quartzipsamments, MWD, 1.5-3 ◙. This category covers all Ousley soils except for the single pedon with BaC at Sandy Ridge. There is also the single, long, curving pedon of HyA Hyde soil forming the north rim of Stumpy Point Bay that is in this class.
FrD Fripp fine sand – uncoated Typic Quartzipsamments, ED, >6 Đ ◙
Community types:
Quercus virginiana-Pinus taeda/Chasmanthium laxum.
Quercus virginiana/Ilex vomitoria
Pinus taeda/Smilax spp.

Most of the Ousley soil is at Mashoes, that was called Live Oak Hammock on the Mouzon map of 1775. Maritime forest, a very minor type on mainland Dare, contains live oak, loblolly pine and a few yaupon (*Ilex vomitoria*) on wooded dunes of Fripp and Ousley sands (the wooded versions of the Newhan and Corolla dune sands). These deposits occur primarily along the northern fringe of the Albemarle Sound, where waves associated with northeast storms have thrown up sand berms and low dunes. In counties south of Dare there are remnant examples of maritime sites having longleaf pine and live oak (Plot CA01 on Brown's Island in Carteret County). Some longleaf may have extended up to Mashoes when sea level was lower. Live oak may have been a component of the loblolly pine fringes along the shoreline at Mashoes and Mann's Harbor, and around the fringes of Roanoke Island and Wanchese.

6. Oak-Loblolly Pine Flats, fire sheltered ♠ (water oak, laurel oak, willow oak, swamp chestnut oak, tulip poplar, sycamore, pignut hickory, beech, sweetgum and loblolly pine)
Soils:
JoA Johns loamy sand - fine-loamy over sandy, siliceous Aquic Hapludults, MWD, 1.5-3 (this excludes the Johns at its very fire exposed Mann's Harbor locations where the vegetation was pyrophytic Mesic Mixed Pine Woodland and savanna)
HyA Hyde loam - fine-silty, mixed Typic Umbraquults, VPD, 0-1 (15" black loam = Umbric epipedon to 15" thick over clay loam) (almost the same as Cape Fear but slightly better internal drainage).
CaA Cape Fear loam – clayey, mixed, Typic Umbraquults, VPD, 0-1 (16" black loam/dark gray clay loam. Umbric epipedon 0-16", argillic 16-45", no mention of mottles)

Community types.
Mixed mesophytic oaks and *Pinus taeda*
Mesic mixed hardwoods (*Carya glabra, Quercus michauxii, Quercus nigra, Quercus laurifolia, Liriodendron tulipifera, Liquidambar styraciflua, Platanus occidentalis, Fagus grandiflora)-Pinus taeda*

These types occurred some 260 years ago at time of settlement, before the land was altered by clearing of all the drier sites and by displacement of mesophytic species by swamp species on the lower sites following some 31 inches (79 cm) of sea level and water table rise.

The first land grant surveys in virgin forests of the Briery Hall peninsula (just north of East Lake community) and the high ground in the vicinity of East Lake found "oak" water oak, hickory, sweetgum, poplar, "pine" and sycamore on flats of dry mineral soils that are now classified as Hyde and Cape Fear (see dates and grantees in "Early Settlement" section above). Given the fire-sheltered nature of the lands near the Alligator River, the hickory referred to was probably pignut (*Carya glabra*) and the upland pine most likely loblolly. In this mesic, fire-sheltered type, loblolly pine aggressively captures any sizeable opening and fire frequency would not have been sufficient to maintain pond pine. Shade-intolerant loblolly pine may have been maintained as a component by light gaps created by hurricane blowdowns. Remnant swamp chestnut oak (*Quercus michauxii*) was reported recently from woods near the edge of a loblolly pine plantation on the Air Force bombing range (Andrew Bailey, pers. comm.). The uplands on the Johns soils, the driest on the western side of the peninsula, were settled shortly before 1748 and were all cleared for agriculture and used for many years. Today, wet forests of swamp black gum, loblolly pine, and pond pine dominate the former mineral soil flats north of US 64.

No good remnants of oak flats were found anywhere else in mainland Dare but extensive stands were to have been expected on some of the mesic, fine-textured mineral soils. This is especially true of the portions of the Hyde and Cape Fear loams where they occupy those sites most sheltered from fire toward the Alligator River on the west side of the peninsula.

Given the past rate of land submergence in the area, of 12 inches per century, water table should have risen by about 31 inches over the 257 years since the first land grants at East Lake and Briery Hall (2006-1749). Soils such as the Hyde and Cape Fear would have been at least as dry as the Johns (1.5 to 3 feet above seasonal high water table) and the Johns has developed from some even drier soils in the past such as Goldsboro, Foreston or even Baymeade, which have similar textures. The area called Dutchman's Ridge truly would have been a low sand ridge, distinctly drier than the surrounding hardwood flats.

More of the former hardwood flats occur to the south from US 64 as a series of large mineral soil lenses of Hyde and Cape Fear soils "islands" surrounded by Atlantic white cedar and other long fire interval patch mosaic stands on wet mucky soils. "Beach" Land Landing (Powell 1968) is an old place name on upper Milltail Creek on the south side of the creek near the head of navigation. In historical times there never was a beach at this landing, the creek being bordered by the Pungo muck, the present depth of which could not have been accounted for by historic sea level rise. There were found, however, just a short distance inland from the shoreline, two isolated bodies of mineral soil that before sea level rise would have been dry enough and sufficiently fire sheltered to support beech. The name "Beach Land" Landing suggests actual "beech land", perhaps just misspelled long ago. For an analogous community see the isolated patches of mineral soil with old growth beech in the west central portion of the Great Dismal Swamp. These soils lie also in an area once surrounded with very long fire interval Atlantic white cedar.

Today there is ankle deep water much of the time in the spaces between the pond pines and swamp black gum now found on trees on the Cape Fear soils near Briery Hall. These soils likely have been transformed by rising water tables from the Johns or other dry mineral soils since the Colonial Era.

Logging History. Islands of these formerly upland soils, now delimited as Hyde and Cape Fear as they were mapped during the period 1974-1982 on the Dare County soil survey (Tant 1992), would have been important for supporting the temporary light rail lines set up for logging the interior white cedar, pine and hardwoods. (see Map 1 presettlement vegetation)

Shortly after the Civil War, when vast tracts of southern lands were bought by carpetbagging corporations from the north, Buffalo Timber of New York purchased more than 100,000 acres on the Dare mainland (Degregory 1994). Buffalo City appears on the 1896 Post Route map (Cumming 1966), with a road coming in 2 miles from East Lake. Logging operations apparently had commenced some years before 1889 when the first post office was opened (Degregory 1994). By 1919, near the end of WWI, about 3000 people were reported living there, including 200-300 Russian workers (Hackney n.d.). Buffalo Timber's primary concern was juniper (Fred Sawyer in Tate 2000), which since Colonial times was always the most valuable commercial timber (Frost 1987). When the accessible virgin juniper was gone by around 1907 the company closed and that year, the Dare County Lumber Co. bought the forest and re-invigorated the town, cutting loblolly and pond pine that had been passed over by Buffalo Timber.

Pine logging was winding down around 1928 and a third company, Duvall Brothers, operated a mill for shingles and other products from second growth white cedar for 10-12 years from the 1930s (Tate 2000), up until around World War II. Other small operations kept mills going until 1950 when there were fewer than 100 residents left (Hackney n.d.) and most left when the sawmill finally closed for good. See Tate 2000 and Appendix 3 for accounts of life in Buffalo City. With exception of a few of the most inaccessible pockets (see the 300 year old cypress stand in Figure 16) of the Dare peninsula appears t have been logged during the 50 year period between around 1870 and 1928. The declining operations up until 1950 likely were fueled by stands that regenerated from the late 19th century clearcuts and small patches previously considered not worth cutting.

7. PINE-GUM flats, fire exposed ▲

Soils:

HyA Hyde loam - fine-silty, mixed Typic Umbraquults, VPD, 0-1 (15" black loam = Umbric epipedon to 15" thick over clay loam) (almost the same as Cape Fear but slightly better internal drainage). Some white cedar on Hyde soils.

CaA Cape Fear loam – clayey, mixed, Typic Umbraquults, VPD, 0-1 (16" black loam/dark gray clay loam. Umbric epipedon 0-16", argillic 16-45", no mention of mottles)

Community types

Mixed mesophytic pine-gum-white cedar (*Pinus taeda, Pinus serotina, Nyssa biflora, Liquidambar styraciflua, Chamaecyparis thyoides*)

On the same soils as the oak-pine flats above, this type occurs in more fire exposed situations where fires sweeping through the canebrakes and other flammable types to the east are only occasionally are able to carry into the flats to the west. These are natural mixed species stands with composition depending upon local wetness and fire frequency position in the landscape. Mixture components include loblolly pine, pond pine, white cedar, swamp black gum and red maple as dominants with occasional stems or pockets of cypress (wetter pockets and sloughs) and sweetgum (drier lenses). Understories may be open or dense consisting of species such as red bay, red maple and sweet bay with pockets of gallberry (*Ilex glabra*),inkberry (*Ilex coriacea*), fetterbush (*Lyonia lucida*) or any of the common pocosin shrubs. The herb layer is typically depauperate, consisting typically of ferns (*Woodwardia areolata, Woodwardia virginica, Osmunda cinnamomea*) and sphagnum with a scattering of other swamp graminoids and forbs.

Figure 12. Pine-Gum Flats with swamp black gum forest on Hyde loam with remnant stems of Atlantic white cedar, pond pine and loblolly pine. Note sphagnum in depressions. This location west of Sandy Ridge was easily accessible from Buffalo City and this stand, about 60 years old, is probably third growth from that era of logging. It was likely logged in the first round of logging around 1880, if not before, and again around WWII, giving rise to the current stand. Given 60 years of sea level rise we can expect around 7 inches (18 cm) water table rise since these stands germinated or 27 inches (69 cm) in the 228 years since Samuel Jackson's 1778 patent for 150 acres nearby on Milltail Creek. With a water table over 2 feet lower, the original stand should have consisted of mesic oak-hickory-loblolly pine, very different from that present. With continued sea level rise this site is poised for transformation into habitat for Atlantic white cedar as peat spreads over the surface.

8. WET POND PINE SAVANNA ◊
Soils:
IcA Icaria loamy fine sand - fine-loamy over sandy, siliceous Typic Umbraquults, VPD, 0-1
Community types:
Pinus serotina/diverse wet savanna graminoids and forbs ◊
Pinus serotina-Pinus palustris-Pinus taeda/diverse wet savanna graminoids and forbs ◊ ☼

This was a frequent fire type of moist mineral soils of series such as the Icaria, transitional between pine uplands and wetter types. Fire at about 2-4 years intervals was required to maintain an open community with a sparse to medium canopy of pond pine over a species rich grassy understory. Always a rare type in Dare County, this community was found only at Mann's Harbor, now long vanished after centuries of land use.

9. CANEBRAKE -canebrake-pocosin mosaic; canebrake dominant ○
Soils:
RpA Roper muck (RoA in Hyde county) - fine-silty, mixed, acid Histic Humaquepts, VPD, 0-1 (15" black sapric material = Histic epipedon to 15" thick/mucky silt loam)(Roper soils were previously included as a mucky phase of the Hyde series. However, Hyde soils have an umbric epipedon and do not allow a histic epipedon. No mention of mottles).
(area deleted) GuA GullRock muck - Coarse-silty, mixed, semiactive, **nonacid,** thermic Histic Humaquepts, VPD, 0-1 (Hyde Co. 13" black & reddish brown muck = Histic epipedon to 13" thick/dark brown loamy vfs. Iron accum below 13")
ScA Scuppernong muck (Hyde county only) - Loamy, mixed, dysic, thermic Terric Haplosaprists, VPD, 0-1 (9" Histic epipedon, continuing up to 28 total" dark reddish brown /28-45" mucky silt loam/ sand). In comparison to ScA, Belhaven soils lack the silty mineral horizon below the organic layers. Ponzer soils have organic layers that are in hues of 7.5YR, 10YR, and 2.5Y and also lack the silty mineral horizon below the organic layers. ScA has 16-51 inches org/massive silty substrate.
PoA Ponzer muck (PnA in Hyde county) - loamy, mixed, dysic Terric Medisaprists, VPD, 0-1 (muck to 35")
BvA Belhaven muck (BmA in Hyde county) - loamy, mixed, dysic Terric Medisaprists, VPD, 0-1 (muck to 50")
PuA Pungo muck - dysic Typic Medisaprists, VPD, 0-1 (to 72" muck over gray clay. There is a 10" reddish brown Histic epipedon over very finely decomposed sapric)
Community types:
Canebrake (*Arundinaria gigantea*), trees largely lacking ○
Pinus serotina/Arundinaria gigantea
Pinus serotina-Pinus palustris-Pinus taeda/Arundinari gigantea/wet savanna graminoids and forbs (see Pond Pine savanna above)
Liquidambar styraciflua/Arundinaria gigantea
Pinus taeda/Arundinaria gigantea.
Chamaecyparis thyoides.

Where most frequently burned, canebrakes have scattered individual trees and small patches of pond pine, interspersed with large areas having almost nothing but cane. Occasional stems of other species such as poison sumac (*Rhus vernix*) and dewberry (*Rubus hispida*) may be found, and scattered herbs may occur in the most frequently burned stands, especially where transitional to sandy uplands. Pond pine-canebrake dynamics are complicated. A fairly dense pond pine forest with cane understory may be maintained through a number of light fires, but a hot fire can create a patch of nearly pure canebrake. Wind events may be sufficient to drive fire into pond pine crowns. The combination of lethal understory fires interspersed with light understory fires likely accounts for much of the patchiness in these communities. Cane is replaced with pond pine pocosin when mean fire frequency is reduced to the 13-25 year fire-return interval (Table 5 below), and with a mosaic of pond pine forest, *Nyssa biflora* forest, red maple forest, bay forest and pond cypress forest when the frequency is even lower (see Frost 1995, Table 2).

PRESETTLEMENT DISTRIBUTION OF PEATLAND VEGETATION OF THE SOUTHEASTERN U.S. ALONG MASTER GRADIENTS OF FIRE FREQUENCY AND DEPTH OF ORGANIC SOIL

CELLS 1-32: MODERATELY FERTILE SITES

FIRE FREQUENCY

ORGANIC MATTER DEPTH	1-3 YEARS	4-6 YRS	7-12 YRS	13-25 YRS	26-50 YRS	51-100 YRS	100-300 YRS	NEVER BURNED
Seasonally wet mineral soils ROW 1	Species-rich wet prairie with graminoids and grass-leaved forbs CELL 1	Species-rich wet prairie, with dwarf shrubs CELL 2	ANGL, ARGI, CLJA, ILGL, CYRA, CLMO, tree saplings CELL 3	Small ACRU, NYBI, LIST, PISE, PITA, PIEL, TAAS CELL 4	Dense ACRU, NYBI, TAAS, LIST, PISE, PITA, PIEL/ ARGI, Shrubs CELL 5	PITA, PIEL, TAAS, QUMI, PISE, ACRU, LIST/ sparse ARGI, ferns CELL 6	TADI, FRPE, LIST, ACRU, NYBI, QUMI other bottomland oaks/mesophytic herbs CELL 7	TADI, NYBI, FRPE, LIST, ACRU, bottom land oaks CELL 8
Soils with thin organic layers, 10-30 cm thick ROW 2	Wet prairie and bog graminoids and forbs, patches of ARGI, ANGL CELL 9	Dense canebrake CELL 10	Alternating canebrake and pocosin CELL 11	PISE, ACRU, PITA, PIEL, TAAS, LIST/ ARGI CELL 12	PISE, PITA, PIEL, TAAS, LIST, NYBI/ PEPA, MAVI CELL 13	PISE forest, PITA, PIEL, TAAS, bottomland hardwoods, bay forest CELL 14	TADI, NYBI, FRPE, LIST, PITA/ ACRU, FRCA/ Carex, swamp herbs CELL 15	TADI, NYAQ, NYBI/ ACRU, FRCA, ULAM/ swamp shrubs, herbs CELL 16
Shallow histosols, 30-100 cm thick ROW 3	Open bog with dwarf shrubs, graminoids, pitcher plants, short cane, mosses CELL 17	Dense canebrake CELL 18	Alternating canebrake and pocosin CELL 19	PISE/ canebrake, alternating with PISE-ACRU tall pocosin CELL 20	Patch mosaic: PISE forest, ACRU forest, CHTH forest, bay forest with PEPA, MAVI CELL 21	Patch mosaic: CHTH forest, TADI/ACRU forest, PISE forest, NYBI forest, bay for. CELL 22	Extensive CHTH forest and patch mosaic as in Cell 22 CELL 23	TADI in wet swamps, cycling ACRU forest in peatlands (hypothetical) CELL 24
Deep histosols, peat deeper than 1 m ROW 4	Open bog with low shrubs, pitcher plants, grasses and sedges CELL 25	Canebrake or Low pocosin with ANGL, and bog herbs CELL 26	Alternating canebrake and pocosin, or medium to tall pocosin CELL 27	Tall pocosin with PISE, GOLA, ACRU; PISE forest, bay forest, CHTH patch mosaic CELL 28	Patch mosaic of types seen in Cell 22 CELL 29	Extensive CHTH forests and patch mosaic of types seen in cell 22 CELL 30	Extensive old growth CHTH forests and patch mosaic of types in cell 22 CELL 31	TADI in wet swamps, cycling ACRU forest in peatlands (hypothetical) CELL 32

SPECIES ACRONYMS: **ACRU**: Acer rubrum (red maple), **ANGL**: Andropogon glomeratus, **ARGI**: Arundinaria gigantea (cane), **CHTH**: Chamaecyparis thyoides (Atlantic white cedar), **CLJA**: Cladium jamaicense (sawgrass), **CLMO** Cliftonia monophylla (black titi), **CYRA**: Cyrilla racemiflora (titi), **FRCA**: Fraxinus caroliniana (water ash), **FRPE**: Fraxinus pennsylvanica red ash), **GOLA**: Gordonia lasianthus (loblolly bay), **ILGL**: Ilex glabra (gallberry), **LIST**: Liquidambar styraciflua (sweet gum), **MAVI**: Magnolia virginiana (sweet bay), **MYCE**: Myrica cerifera (wax myrtle), **NYAQ**: Nyssa aquatica (tupelo or water gum), **NYBI**: Nyssa biflora (swamp black gum), **PEPA**: Persea palustris (red bay), **PIEL**: Pinus elliottii (slash pine), **PITA**: Pinus taeda (loblolly pine), **TAAS**: Taxodium ascendens (pond cypress), **TADI**: Taxodium distichum (baldcypress).

TABLE 5. Cells show common dominants for each combination of fire frequency and organic matter depth. Note the range of the niche for canebrake in cells 9 through 12, 17 through 20 and 26-27. See Frost (1995) for further cell descriptions.

Small patches of white cedar sometimes can be found in canebrake-dominant areas such as the headwaters of Callaghan Creek south of Mann's Harbor. These small patches appear to occupy sloughs too wet for canebrake, which doesn't tolerate standing water. The wet places may occur in poorly defined creek drains or as pockets created when fire burns out small depressions in dry peat.

Judging by remnant canebrakes that have been regenerated from time to time by wildfires, there appears to have been a vast canebrake along the east side of the county in a broad zone bordered on the east by brackish marsh and pine marsh, and on the west by pocosin. This estuarine margin canebrake, which may have been the largest in the South, ran from near Mashoes and Durant's Island, down the length of the east side of Dare and Hyde Counties (see Maps 1 and 2). Most of this zone is succeeding to pocosin pond pine forest but the occasional fire still regenerates sections of canebrake. My plot DA05, sampled in 1984, documents a canebrake along US64 that was regenerated from pocosin in a wildfire about two years before round 1981-1982.

Cane appears unable to tolerate either standing water or salinity and canebrake never occurs as a marsh type. Even where it occurs within a hundred meters of marsh or brackish waters, there is always a zone of buffer vegetation between canebrake and marsh. In Dare County this buffer community is usually some variant of Pine Marsh and Estuarine Scrub (when burned frequently) or a swampy version of pond pine/high pocosin. The occasional overwash of brackish water during storms probably helps maintain this zone free of cane. Place names are often useful indicators of past vegetation. Reed was the name used for cane in the Colonial Period, and Reeds Point between Mashoes and Mann's Harbor may indicate a place where canebrake came close enough to be seen from the water.

Figure 13. Pond pine canebrake a few weeks after a spring fire. Cane is already knee high and will be head high by the end of the growing season. Soil is a Terric Medisaprist about 1 meter thick over a fine textured mineral soil (Pamlico County, NC).

Figure 14. Fire patterns in canebrake on the east side of the Roanoke Marshes. White area to right is sunlight reflected off the waters of Roanoke Sound. The light areas along the shoreline are brackish marshes, also illuminated by the unusual glare of the sun, which happened to be reflected into the camera at this angle. The blackened areas east of U.S. 264 represent a fire in former pond pine canebrake that had started to succeed to pocosin shrubs. Fire plow lines that extinguished the fire faintly outline the burned area. This fire, driven by winds from northwest to southeast (likely on post-cold front winds), can be seen to cross the streaky patterns from an earlier fire through former canebrake, that was driven from southwest to northeast on the prevailing winds. That fire was superimposed on an earlier fire, represented by fainter streaks in older vegetation in the reddish are to the lower right. National Wetlands Inventory color infrared aerial photo 367402 taken April 24, 1982.

Figure 15. The same US 264 canebrake site in Figure 14 above, taken in 2005 after about 24 years without fire. Note the adventive red maple in foreground that was not there when the site was visited in 1984. While stems of cane are common in the interior, the site is well on its way in the transition from pond pine/canebrake to pond pine pocosin and pond pine forest. Once the hardwood and pocosin shrub root systems are established they may persist though future burns and be hard to eliminate.

10. Pond Pine Pocosin (pocosin-pond pine forest-canebrake mosaic; pocosin dominant) ◘
Soils:
RpA Roper muck (RoA in Hyde county) - fine-silty, mixed, acid Histic Humaquepts, VPD, 0-1
ScA Scuppernong muck (Hyde county only) - loamy, dysic, thermic Terric Haplosaprists, VPD, 0-1
PoA Ponzer muck (PnA in Hyde county) - loamy, mixed, dysic Terric Medisaprists, VPD, 0-1 (muck to 35")
BvA Belhaven muck (BmA in Hyde county) - loamy, mixed, dysic Terric Medisaprists, VPD, 0-1 (muck to 50")
PuA Pungo muck - dysic Typic Medisaprists, VPD, 0-1 (to 72" muck over gray clay.

Community types:
Ombrotrophic low pocosin (see Patterned Low Pocosin below
Pyrophytic low pocosin
Medium pocosin
High pocosin

Pocosin vegetation typically consists of various percentages of about ten species: *Ilex glabra, Ilex coriacea, Cyrilla racemiflora, Vaccinium corymbosum, Magnolia virginiana, Persea palustris, Lyonia lucida, Woodwardia virginica, Smilax laurifolia* and *Pinus palustris.*

Of the portions of the original landscape that were true pocosin, the majority were kept in much lower stature that the pocosin of today. Pocosin of low stature may result from a limiting nutrient (potassium) in the case of ombrotrophic low pocosin or from frequent fire in pyrophytic low pocosin. The two kinds of low pocosin allow more sunlight to reach the ground and may have a substantial component of herbs such as sedges and pitcher plants.

Anthropogenic fertilization of the coastal environment. Critical plant nutrients such as nitrogen, phosphorus, potassium, sulfur and calcium may be limiting for shrub and tree growth, the lack of any one of which may produce woody vegetation of low stature, different species composition or more open landscapes. Internal combustion engines fix nitrogen and production of nitrogen from automobile exhausts results in several pounds of nitrogen deposition per acre. Sulfur from Midwest factory smokestacks similarly deposits pounds of sulfur per acre. Deflation of agricultural fields across the country during spring plowing on windy days results in addition of calcium, phosphorus and potassium. Atmospheric deposition of the combined nutrients may have released nutrient-limited vegetation resulting in faster growth rates and taller, denser vegetation than that found in the original landscape (Vitousek, pers. comm.).

Of nearly as great an extent as canebrake, pocosin comprised the next vegetation band just inland. There is, however, probably much more pocosin now than in the original peatlands. Pocosin has increased on its eastern margins at the expense of canebrake because of reduction in fire frequency, and on its western edges at the expense of pond pine forest and white cedar because of logging and fire exclusion. While there appears to be no true ombrotrophic low pocosin in the county, with possible exception of the bog at Stumpy Point (see Patterned Low Pocosin below), in the original situation fire frequency was high enough that some of the area on the eastern side and on the deeper mucks would have been maintained as pyrophytic low pocosin. Such frequent fie pocosins tend to be knee high to waist high most of the time and have a very even surface. With increasing time since fire taller species such as *Magnolia, Persea* and *Gordonia* as well as individual stems of the taller shrubs such as *Cyrilla* tend to grow up and produce a more irregular upper surface.

Modern pocosin remnants are mostly high pocosin. With lower fire frequency and higher fertility, pocosin grades into pond pine forest and Bay Forest. In its presettlement condition the whole peatland peninsula may have been somewhat more fertile than the ombrotrophic peat domes of the Croatan National Forest or the interior of Pamlico County because of the likelihood of aerosol input of nutrients from the sea. The membranes of airborne droplets or bubbles foam picked up by the wind from ocean whitecaps have been shown to be higher in certain cations such as calcium and magnesium than that of seawater. When deposited along coastal areas the effect should be to increase pH and fertility. This phenomenon along with high fire frequency may explain why the eastern band of vegetation was canebrake instead of pyrophytic low pocosin.

From the center of mainland Dare, tall pocosin quickly grades into the peatland forest mosaic of white cedar, pond pine forest, red maple forest, swamp black gum forest and pond cypress forest-see Medium to Long Fire Interval Patch Mosaic below

11. PATTERNED LOW POCOSIN ɸ
Soils:
BvA Belhaven muck (BmA in Hyde county) - loamy, mixed, dysic Terric Medisaprists, VPD, 0-1 (muck to 50")
PuA Pungo muck - dysic Typic Medisaprists, VPD, 0-1 (to 72" muck over gray clay. There is a 10" reddish brown Histic epipedon over very finely decomposed sapric)
Community types:
Mixed low pocosin and bog shrubs, graminoids and forbs

Low Pocosin shrubs-*Chamaedaphne (Cassandra) calyculata*

In the vicinity of Stumpy Point Bay two large overlapping ovals of vegetation are conspicuous on color infrared aerial photos. In my doctoral thesis I speculated that these were half marsh, half low pocosin, with the low stature perhaps maintained in part by extreme wetness. While both of these features will be likely added to Stumpy Point Bay as sea level continues to rise, recent LIDAR topography with a 1 ft contour interval shows that the Stumpy Point low pocosin is a peat dome, elevated 5 to 8 feet above sea level. A number of interesting species like *Chamaedaphne (Cassandra) calyculata* var. *angustifolia* are abundant.

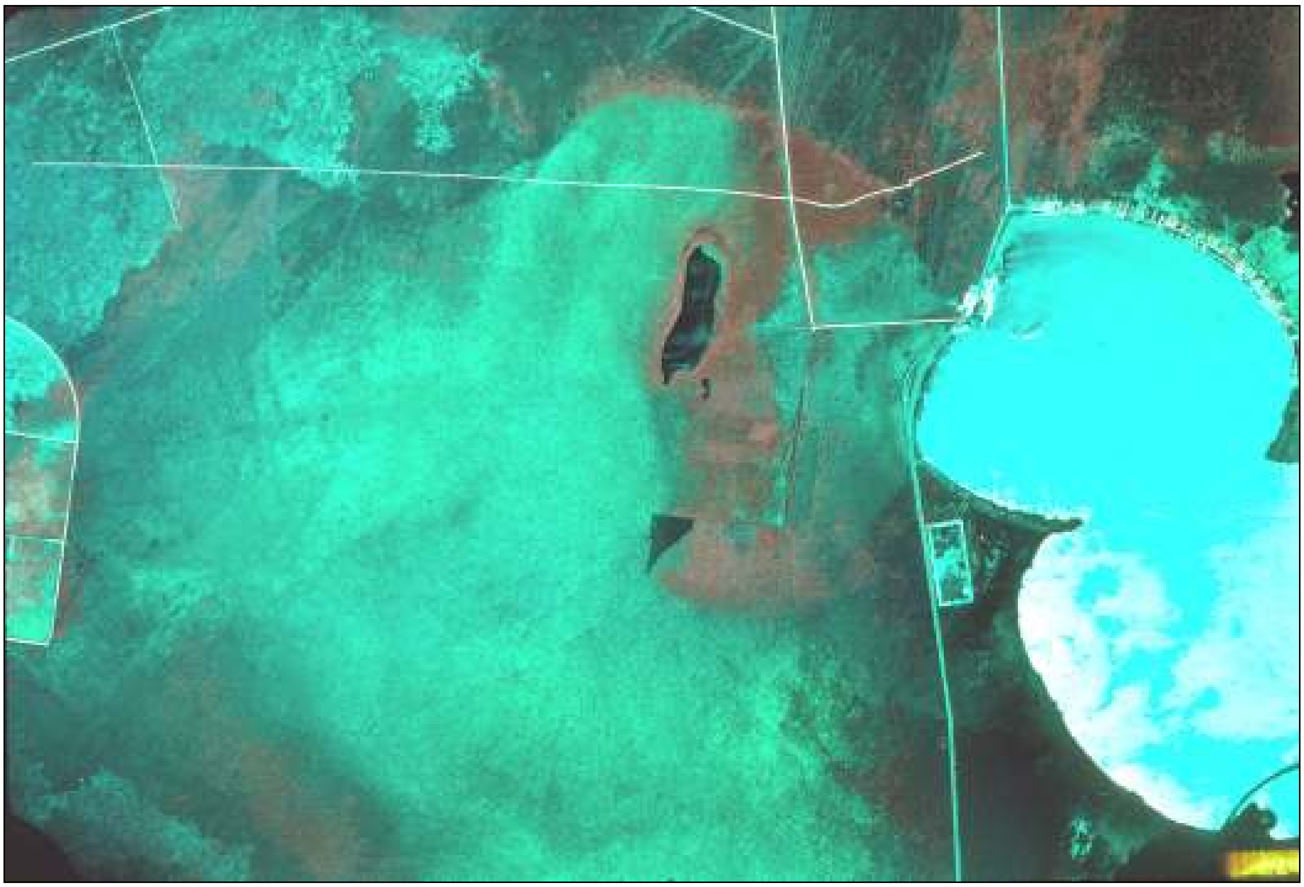

Figure 16. Stumpy Point Patterned Low Pocosin is a color infrared photo of the bog taken for the circa 1982 National Wetlands Inventory. This low pocosin may be a unique vegetation type. I know of no other like it in the southeast, rather than pocosin, it more resembles the pattern bogs of the Great Lakes region. If you look closely at the CIR you will see a fairly regular pattern of dark dots (trees or clumps of Cyrilla or other tall pocosin shrubs), along with dark streaks. In northern pattern bogs such streaks are aligned with the direction of flow. On the northwest side the streaks seem to drain into Back Lake. To the south of Back Lake there is a center from which streaks radiate in all directions but mostly into Long Shoal River, some toward its low lying headwaters to the southwest (1-2 feet above msl) and others toward its embayed portion to the south and southeast.

The bog's flat center (more of a peat mesa than a dome) runs about 5 feet above sea level (see LIDAR topography with 1 foot contour intervals on the presettlement fire frequency map). It is bounded on the north and northwest by a peat ridge up to 3 feet higher (there are some 8 foot contours) and falls away to lower peat on all the other sides. Since this bog (neglecting the peat rim along its northwest side) is the highest surface in the whole peninsula it might be expected to be a nutrient limited ombrotrophic system, similar to Sheep Ridge Low Pocosin in the Croatan. The limiting nutrient at Sheep Ridge is phosphorus (Walbridge 1987).

The bog has a long history. It was first obtained (for nothing except for a small entry fee and survey costs) by a land speculator (John Gray Blount on September 7, 1795) as part of a 100,000-acre tract applied for during the swampland craze of the 1790's. It covered much of the Dare mainland peninsula, excluding some of the small areas of high ground such as that at Manns Harbor and the Stumpy Point lake rim that had been settled in the preceding 50 years. It also excluded some swamp tracts along the Alligator River and Mill Creek that had been bought by other speculators before Blount could get to them.

The prominent east-west ditch, running between Back Lake (sometimes called Lake Worth after the Lake Worth community nearby) the dark, somewhat rectangular lake that runs north/south) and the western shore of Stumpy Point Lake was put in some time prior to 1932 in an apparent attempt to drain the lake and the bog. Besides it and highway 264 which existed at time of the photo, there are no other roads or ditches on the 1932 aerial. On the CIR, there is a shadow around Back Lake, suggesting a slightly larger size before the partial draining of the lake.

To the south, another ditch had been put in by John Gray Blount around 1795 running from the headwaters of Long Shoal River, extending northwest toward the far headwaters of Whipping Creek at the Air Force bombing range, but it seems unlikely that it had much effect on drainage of the bog since it lies in a low natural pocosin drain.

A light, mottled pattern to the north of the Air Force target represents canebrake rejuvenated by the fire around 1980. The same canebrake shows on the 1932 aerial photography, 50 years earlier, with a remarkably similar pattern suggesting some unknown set of factors contributing to stability of canebrake/pocosin boundaries. The circa 1980 fire, moving on a south-southwest wind, seems to have burned the bog uniformly leaving few streaks, while on the north side where it exited the bog, the fire left prominent streaks in the downwind pocosin.

There has been some loss of low pocosin to the expanding brackish marsh on the west side of hwy 264. Besides effects of rising sea level, marsh expansion has been facilitated somewhat by the ditches (you can see it extending along the upper ditch margins, but maybe more importantly by salt input during storm surge, perhaps facilitated only slightly by the ditches. Since this marsh lies near sea level it is likely inundated with salt water during hurricane storm surges. Marsh expansion likely happens as a result of saltwater pulses in conjunction with sea level rise. There also has been some loss of low pocosin in the vicinity of Back Lake and around the grid of small ditches put in sometime after 1932 to the east and southeast of Back Lake. The red color in the color infrared is taller pocosin that has appeared in the disturbed areas. Finally, there may have been some loss of bog to taller pocosin around the periphery with reduction in fire frequency. There is much more canebrake visible on the 1932 photos (cane requires a mean fire interval at least as frequent as 8-10 years for maintenance as a pure type) and there is a corresponding increase in pocosin (which replaces cane with reduction in fire frequency).

12. PEATLAND LONG FIRE INTERVAL PYROMOSAIC (multiple species patch dominants mostly 25-125 year fire intervals) ►

Soils:

RpA (Dare county), RoA (Hyde county) Roper muck, ScA Scuppernong muck (Hyde county), PoA (Dare county), PnA (Hyde county) Ponzer muck, BvA (Dare county), BmA (Hyde county) Bellhaven muck, PuA Pungo muck

Community types (patch dominants):

(All may have various subcanopy and shrub species but rarely forming substantial layers beneath the closed canopy unless disturbed by storms.

Chamaecyparis thyoides
Pinus serotina
Nyssa biflora
Acer rubrum
Taxodium distichum
Taxodium ascendens/Acer rubrum
Bay forest (Magnolia virginiana-Persea palustris)

13. PEATLAND VERY LONG FIRE INTERVAL PYROMOSAIC (Atlantic White Cedar dominant) ♥

Soils:

RpA (Dare co.), RoA (Hyde co.) Roper muck, ScA Scuppernong muck (Hyde co.), PoA (Dare co.), PnA (Hyde co.) Ponzer muck, BvA (Dare co.), BmA (Hyde co.) Bellhaven muck, PuA Pungo muck

Community types (patch dominants):

Chamaecyparis thyoides ♥
Taxodium ascendens/Acer rubrum ♥
Mixed Taxodium-Chamaecyparis-Nyssa biflora-Acer rubrum

This type represents the more fire sheltered areas where old growth Atlantic white cedar would have been dominant. The mosaic also includes patches of pond cypress and red maple in old peat burnouts and mixed species stands resulting from old-age mortality of white cedar and access to the canopy by understory stems of species such as swamp black gum and red maple after hurricane disturbance of nearly monospecific post-fire white cedar. The fire interval is 50 to >300 years.

Atlantic White Cedar. Remnants of huge stands of old-growth white cedar on the Alligator River side are indicators of a much lower fire frequency, in the 100-300 year range. The stands along the Alligator River originally rivaled those of the Dismal Swamp--the largest known stand in the range of the species. The total amount of white cedar in the greater Dare-Hyde-Tyrell-Beaufort-Washington peninsula likely exceeded that of the Dismal Swamp at time of discovery in 1585.

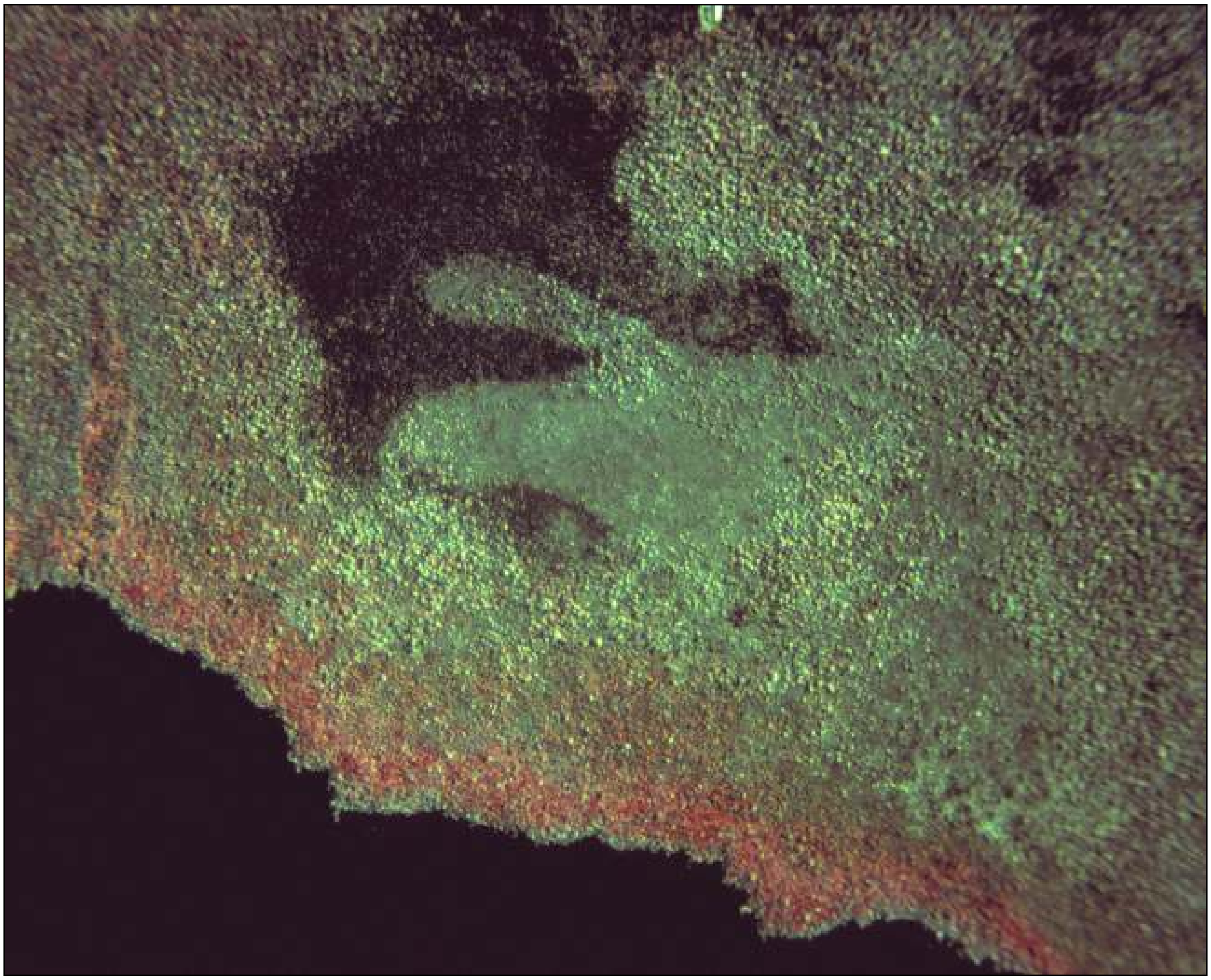

Figure 17. Aerial color infrared photograph of overlapping fire patterns in the white cedar/pond cypress/*Nyssa biflora* fire mosaic that comprised the original vegetation of almost the whole of the western half of the peninsula. Judging from age of the interior cypress (330 years at time of sampling in 1984) and the fact that the post-fire white cedar stand would have been too young to be of interest during the logging days of Buffalo City, this appears to be a virgin patch mosaic. At about a square mile in size this may be the largest remnant of virgin Atlantic white cedar peatland patch mosaic in existence.

14. TIDAL CYPRESS-GUM SWAMP ■
Soils:
ScA Scuppernong muck (Hyde co.), PoA (Dare co.), PnA (Hyde co.) Ponzer muck, BvA (Dare co.), BmA (Hyde county) Bellhaven muck, PuA Pungo muck
Community types:
Taxodium distichum/Nyssa aquatica/diverse tidal swamp shrubs, graminoids and forbs
Taxodium distichum/Nyssa biflora-Acer rubrum/diverse tidal swamp shrubs, graminoids and forbs

Swamp forest. Along the margins of the Alligator River, Milltail Creek, Whipping Creek and a few other fire-protected locations, true cypress-gum forest may be found. In presettlement times, the extent of well-developed swamp forest was limited because of the absence of significant firebreaks over much of the Dare peninsula. In places, within 100 meters of the Alligator River shoreline, tidal cypress-gum swamp is invaded by white cedar and other fire-regenerated communities of the pyrophytic patch mosaic. In the absence of landscape-scale fire, cypress-gum swamp forest can be expected to expand and take over the habitat formerly occupied by fire-dependent white cedar.

Pond Cypress. Small patches of small but old cypress remain in the patch mosaic of fire communities near the Alligator River. These appear to have originated in pockets where peat burnouts during times of low water table later pooled shallow water. The trees have ascendent foliage with appressed leaflets, more characteristic of pond cypress than baldcypress. Trees up to 330 years old were cored in Plot DA01 (located in the light colored area in the upper right of Figure 17.

Swamp black gum (Nyssa biflora). This species occurs as an element of the Alligator River interior patch mosaic as well as one of the dominant species in true swamp forest along the river.

15. PINE MARSH AND ESTUARINE SCRUB Д
Soils:
CuA Currituck mucky peat – sandy, mixed, euic Terric Medisaprists, VPD, +1-1 **Ω**
HoA Hobonny muck - euic Typic Medisaprists, VPD, +1-0 (Croatan marshes)
LfA Longshoal mucky peat - Euic, thermic Typic Haplosaprists, VPD, 0 (OM >51 inches
RpA (Dare co.), RoA (Hyde co.) Roper muck, ScA Scuppernong muck (Hyde co.), PoA (Dare co.), PnA (Hyde co.) Ponzer muck, BvA (Dare co.), BmA (Hyde co.) Bellhaven muck, PuA Pungo muck

Community types:
Pinus serotina/Myrica cerifera/Cladium jamaicense-mixed brackish marsh graminoids and forbs
Pinus serotina-Pinus taeda/Myrica cerifera/Cladium jamaicense-mixed brackish marsh graminoids and forbs
Pinus taeda/Myrica cerifera/Cladium jamaicense-Osmunda regalis-mixed brackish marsh graminoids and forbs
Pinus serotina/tall pocosin shrubs
With variation in species composition related to variation in salinity, these woody scrub communities are transitional between marsh and inland types. Along the fresh to oligohaline waters of the Alligator River they are transitional to interior cypress gum swamps. Around the northeastern tip of the mainland and south to Peter Mashoe's Creek they are transitional to pond pine pocosin. Along the eastern shores from Mann's Harbor south to Long Shoal River they are transitional between increasingly brackish marshes and the interior canebrakes, often with a band or patches of pond pine forest or pond pine/high pocosin between the canebrake and the estuarine scrub. Where mineral soils lenses approach the surface beneath shallow peat, such as on the north side of Long Shoal River, there are pockets of estuarine fringe loblolly pine forest in this zone. While too narrow to appear on the vegetation map in some places, this type occurs almost continuously down the eastern shoreline, interrupted only by the high mineral shoreline at Red Stone (Redstone) Point. This eroding shoreline would have been a high bank in Colonial times when sea level was 2-3 feet lower. Named during that era, and appearing on the U.S. Coast Survey map of 1885, the red color caused by the oxidizing iron content in the Spodic layer would have been a beacon for fishermen in small boats on the sounds (Riggs pers. comm..)

Loblolly pine swamp. Not a previously recognized forest type, loblolly pine swamp nevertheless occurs as nearly pure stands as an oligohaline swamp type on saturated muck and wet mineral soils at sea level. Its persistence in these stressful sites in place of other species appears to be related to its remarkable combination of tolerance to the triple stressors of standing water, salinity and occasional fire. Typical stands may be seen along the fringes of Durant's Island, which, since losing its connection to the mainland in the last few centuries, is now isolated from fire. Live oak cannot tolerate as much wetness and baldcypress seems to be less tolerant of salinity. On more saline sites loblolly is replaced simply by marsh and estuarine shrubs and graminoids, and on freshwater muck soils by typical tidal cypress-gum swamp.

16. OLIGOHALINE MARSH Ø
Soils:
DoA Dorovan muck – dysic Typic Medisaprists, VPD, +1-0.5 **Ø ■ ♥**
HoA Hobonny muck - euic Typic Medisaprists, VPD, +1-0 **Ø Д ► ◘ ○**
BvA Belhaven muck (BmA in Hyde county) - loamy, mixed, dysic Terric Medisaprists, VPD, 0-1 (muck to 50") **Ø ■ ►**
PuA Pungo muck - dysic Typic Medisaprists, VPD, 0-1 (muck to 72") **Ø ■ ►**
Community types:
Juncus roemerianus
Juncus roemerianus-Distichlis spicata
Spartina cynosuroides-mixed tall marsh
Spartina patens-Distichlis spicata
Cladium mariscus var. jamaicense

17. OLIGOHALINE TO BRACKISH MARSH Ω
Soils:
HoA Hobonny muck - euic Typic Medisaprists, VPD, +1-0 **Ø Д ► ◘ ○**
BvA Belhaven muck (BmA in Hyde county) - loamy, mixed, dysic Terric Medisaprists, VPD, 0-1 (muck to 50") **Ø ■ ►**
PuA Pungo muck - dysic Typic Medisaprists, VPD, 0-1 (muck to 72") **Ø ■ ►**
Community types:
Juncus roemerianus
Juncus roemerianus-Distichlis spicata
Spartina cynosuroides-mixed tall marsh
Spartina patens-Distichlis spicata
Spartina alterniflora
Cladium mariscus var. jamaicense
Mixed Eleocharis-Spartina alterniflora brackish mud flats
Myrica cerifera-Cladium mariscus var. jamaicense-Osmunda regalis

18. BRACKISH AND SALT MARSH θ >1.5% salinity (toward PA Sound)
Soils:
CuA Currituck mucky peat – sandy, mixed, euic Terric Medisaprists, VPD, +1-1 **θ Ω Д**
ScA Scuppernong muck (Hyde) - Loamy, mixed, dysic, thermic Terric Haplosaprists, VPD, 0-1 (28-45") **θ Ω Д**
BvA Belhaven muck (BmA in Hyde county) - loamy, mixed, dysic Terric Medisaprists, VPD, 0-1 (muck to 50") **θ Ω Д**
LfA Longshoal mucky peat - Euic, thermic Typic Haplosaprists, VPD, 0 (OM >51 inches) **θ Ω Д**
PuA Pungo muck - dysic Typic Medisaprists, VPD, 0-1 (muck to 72") **θ Ω Д**
Spartina alterniflora
Juncus roemerianus-Distichlis spicata
Cladium mariscus var. jamaicense (headwaters)
Mixed Eleocharis-Spartina alterniflora brackish mud flats

Marshes. While marsh is invading interior peat soils such as the Pungo and Belhaven with rising sea level, the two common marsh soils are the Hobonny, a deep, brackish muck and Currituck, a soil with a thin layer of marsh peat underlain by sand. The two series are distinguished by organic matter depth, not by salinity, so both may be found over a considerable salinity range. The marshes on the east side of the mainland are generally brackish, about 1/3 to 1/2 the strength of seawater (based on perhaps 20 salinometer readings I took in various points along the shoreline marshes). The high salinity that could ordinarily be expected this close to the outlet to the sea at Oregon Inlet fluctuates and is moderated by mixing with fresh water which, interacting with the tidal pulse, moves slowly southward from the Albemarle Sound. Marshes on the north side of mainland Dare, along the Albemarle Sound, are oligohaline and on the west there is so little salinity in the Alligator River that swamp forest comes right down to the water's edge along most of its length.

Comparing aerial photographs for the 50 years between 1932 and 1982, marshes have expanded at the expense of inland vegetation on organic soils all around the peninsula, from the outlet of Swan Creek near the head of the Alligator River around to Long Shoal River on the southeast.

19. Water: Aquatic communities of lakes, streams and sounds**.**

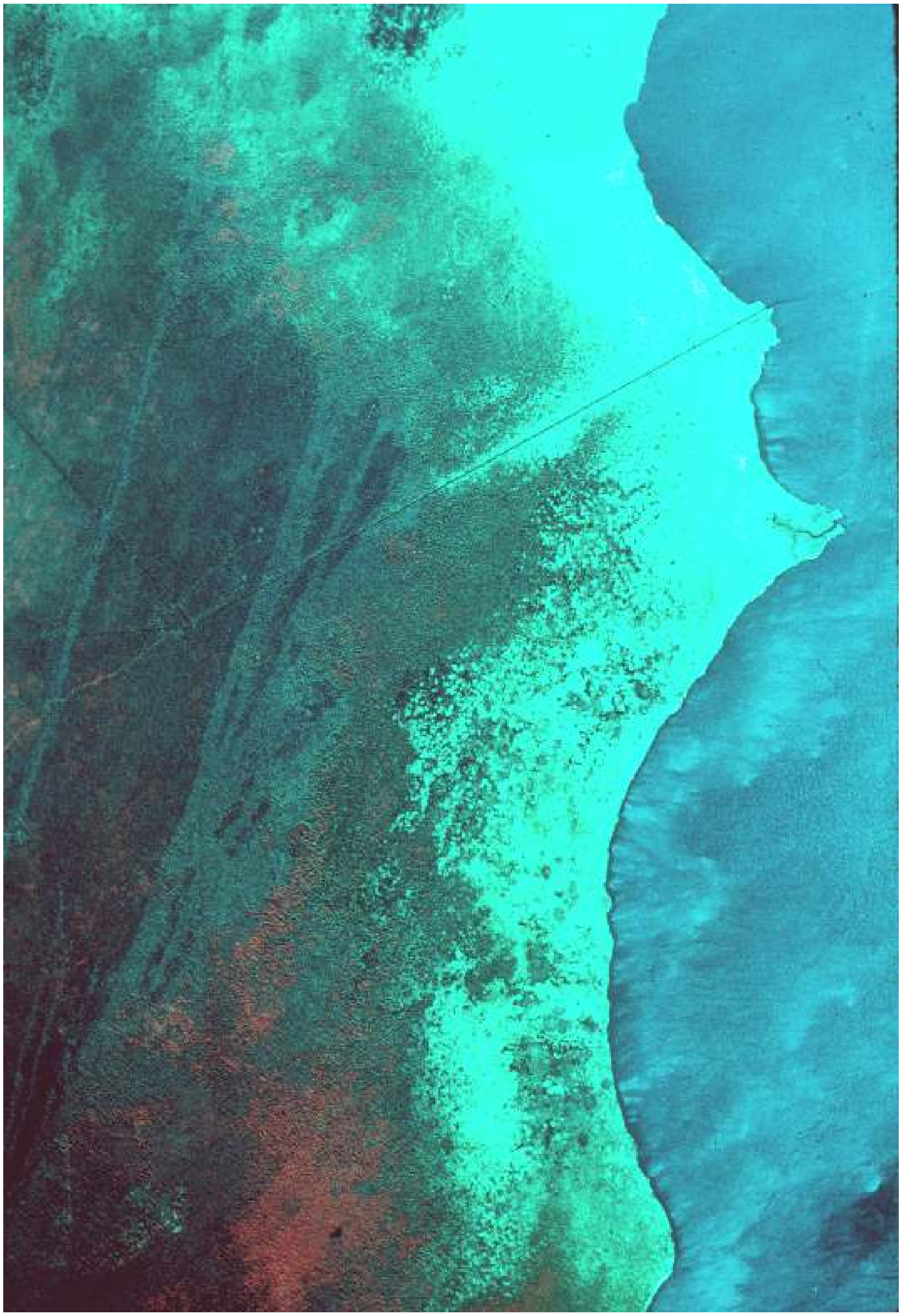

Figure 18. The Croatan Sound Marshes. Just south of what were called the Roanoke Marshes, between Roanoke Island and the mainland, marshes here are represented by light colors bordering the Croatan Sound on the right. Just inland, in the upper half of the photo, there is a light grayish zone of vegetation having a scattered canopy of loblolly pine and pond pine, and with considerable shrub cover but with marsh persisting as patches and grassy understory as evidenced by the light color. Next inland, on the dark left hand side of the photo is the beginning of the canebrake zone, this portion of which was reinvigorated by a fire around 1980, shortly before the 1982 photo. In and around the reddish area in lower center is an older

canebrake. The reddish signature is sclerophyllous evergreen shrubs associated with natural patches of pond pine mentioned above and some beginning replacement of canebrake by pocosin shrubs under fire suppression.

CHAPTER 2

MCAS CHERRY POINT

PRESETTLEMENT FIRE FREQUENCY OF CHERRY POINT

Early in the twentieth century, H.H. Brimley published an article describing the lands around Lake Ellis Simon and Little Lake on the south side of what is now US 70 just upwind from Cherry Point and one of the sources for fire. The story, serialized in four parts in Forest and Stream, was mostly about hunting and life in camp at what is now Camp Bryan on Lake Ellis Simon (Brimley 1910). Brimley was a competent naturalist and his daily accounts and the accompanying photographs help to reconstruct local vegetation and make inferences about fire frequency.

Brimley usually took the train from Raleigh to "the little way station" on what is now the Seaboard Coast Line, northwest of Havelock, where someone would pick him up. This line, originally the Atlantic Railroad, is one of the oldest in the state. Emmons (1860) mentions that it crossed savanna lands to the west along the way to Havelock in the Dover Swamp in 1852. From the railroad stop it was about 6 miles southwest to camp, and Brimley commented on the "open pocosin" along the way. This would have been on the last half of the drive that follows deepening organic soils beginning with Rains, Pantego, Torhunta and Croatan, until arriving at the eastern lakeshore. On several days he went along the south shore to a favorite hunting area in low pocosin on the Croatan series (Terric Medisaprists). The height of pocosin vegetation there in 1910 can be calculated from a photo of Brimley on a short ladder which he said put him 5 ft above the ground. Assuming that he was 6 ft tall, and measuring his height in relation to the amount of ladder exposed above the pocosin, gives a height of around 3 feet for the pocosin shrubs. This is a good description of pyrophytic low pocosin, kept low by frequent fire and the photo shows an even height to the upper surface of the pocosin vegetation typical of recent or frequent fire. Pocosin shrubs in the same area today are tall, often 10-12 feet. The change implies a high fire frequency in the original landscape just upwind from Cherry Point.

Of the low pocosin Brimley stated "The pocosins spoken of above are large stretches of low, open country, more or less swampy, with a thick growth of low gallberry bushes well and strongly laced together with bamboo brier (greenbrier or smilax)." He described the pond pine cover as only "scattering small pines". "These are the light, or low pocosins, but others show a much higher growth, often over a man's head, and they are then practically impenetrable to anything but game or dogs. There is a saying here that a deer leaps over the obstructions in a pocosin, a bear plows through them, but it is hell on men and dogs--and the saying falls rather short of the real truth." The stature of the low pocosin can be further inferred from his descriptions of deer "...loping easily and comfortably over the low bushes and tangle of tough vines....I saw a second buck covering the gallberry bushes in long, graceful leaps."

Near Little Lake, Brimley found pocosin vegetation down to near the lake edge in places, and black gum forest in others. While attempting to stalk bear, he came upon a small patch of dead canebrake in a wooded area near the lake shore: "...as that had been the driest season on record, the ground was pretty dry, and the reed brakes had all been killed out by the high water of the previous year. These dead and prostrate reeds made the noisiest going imaginable. They lay on the ground in all directions, were very dry, as brittle as glass, and it was practically impossible to move among them with any degree of quiet." The soils around Little Lake are mostly the black Torhunta and Croatan, both potential soils for canebrake and its presence indicates a fire frequency between 2-8 years (Frost 1995).

The most fire-exposed portions of Cherry Point are the flats dominated by Rains soils on the south side of the airfield. This upland is downwind not only from fires moving with the prevailing winds from the Croatan National Forest to the southwest but also from fires moving along a 20 mile or more long fire path from the dry longleaf pine lands running along NC 24 to the south. Based on multiple pathways for fire and Brimley's descriptions, this flat was assigned the highest fire frequency class of 1-3 years. Although long fire suppressed in the recent past, a few pitcher plants of *Sarracenia flava* were found on this flat. S. flava or "trumpets" is a fire frequency indicator species for the 1-3 year fire return interval, supporting this interpretation.

All the rest of Cherry Point was assigned to lower fire intervals. Slocum Creek and Hancock Creek, both originating on the flats near U.S. 70 constitute substantial firebreaks for any fires moving from the west (on cold front winds) or the east (on sea breezes). Over their short courses both creeks cut down to sea level and estuarine waters form wide lakes at their lower ends. The steep side slopes, and small tributary ravines create habitat for hardwoods including fire refugial species.

Fire Frequency Class	Mean Fire Interval (years)	Estimated Historic Range of Variation (90% of Fires) (years)	ACRES	PERCENT
A	1.5	1-3	4,468	38.2
B	2	1-4	4,056	34.7
C	3	1-6	1,236	10.6
D	4	2-9	313	2.7
E	5	2-20	71	0.6
F	7	4-100 depending upon location in the landscape	1,015	8.7
G	variable	complex patterns in small, fire exposed and fire sheltered drains and depressions	469	4.0
Water			61	0.5
TOTAL			11,689	100

Table 6. Original fire regimes of Cherry Point.

Comment on fire frequency mapping methods. Cherry Point is a good landscape for demonstrating one of the steps in making a map of original fire frequency. Having established from landscape position, fire routes, fire frequency indicator species and historical notes that the upland flat of Rains soils mentioned above had the highest fire frequency, we next look for the other extreme of the fire frequency gradient-the most fire sheltered. That was found in the beech communities on the north facing or otherwise isolated stands near the Neuse River. Thin-barked, fire refugial species such as beech and *Magnolia tripetala* indicate essentially fire free communities. Having determined the extremes, the fire frequency gradient is artificially chopped into the seven frequency classes used in the map. The middle fire frequency ranges are assigned by drawing lines between fire frequency class, considering firebreaks (such as the internal creeks), fire filters such as upland depressions or less flammable vegetation types, and bottlenecks, such as uplands where two stream heads approach each other, leaving only a narrow route for fire flow. Actual drawing of the fire frequency boundaries involves additional factors such as slope, fire compartment size, sources of fire flow and prevailing winds during fire season.

PRESETTLEMENT VEGETATION OF CHERRY POINT

Table 7 below lists the original vegetation of Cherry Point. Soil series descriptions include the soil mapping symbol, soil texture, soil taxonomy, NRCS drainage classes (ED - excessively drained, WD –well drained, SPD – somewhat poorly drained, PD – poorly drained, VPD – very poorly drained), and depth to seasonal high water table in feet. A plus sign, e.g. +1, means that there is a foot of water standing on the surface at time of seasonal high water table. Each soil series is followed by one or more symbols for vegetation types occurring on that series, with the symbol for the most abundant type shown first

1. Xeric and Dry-Mesic Longleaf Pine/Wiregrass and Longleaf pine/Turkey Oak ☐
KuB Kureb sand – uncoated Spodic Quartzipsamments, ED, >6 ☐ ◙
TaB Tarboro sand – mixed Typic Udipsamments, SED, >6 ☐ ◙

2. Mesic Longleaf Pine/Wiregrass Savanna Θ
NoA, NoB, NuB Norfolk loamy fine sand – fine-loamy Typic Paleudults, WD, 4-6 Θ (NuB = urban)
GoA, GuA – Goldsboro loamy fine sand – fine-loamy, siliceous Aquic Paleudults, MWD, 2-3 Θ, (GuA = urban)
CrB Craven silt loam – clayey, mixed Aquic Hapludults, MWD, 2-3 Θ ★
On Onslow loamy sand – fine-loamy, siliceous Spodic Paleudults, MWD, 1.5-3 Θ Ө
CnB Conetoe loamy sand – loamy, mixed Arenic Hapludults, WD, >6 Θ ◙

3. Mesic Mixed Pine Savanna and Pyrophytic Hardwood Woodland Ө various combinations of loblolly, longleaf, pond pine, some hardwoods, especially on more fire-sheltered sites)
AuB Autryville fine sand – loamy, siliceous Arenic Paleudults, WD, >5 ☐★
Le Lenoir silt loam – clayey, mixed Aeric Paleaquults, SPD, 1-2 **Ө**

5. Maritime Pine-Live Oak Forest ◙ (Loblolly Pine, Live Oak and other hardwoods including white oak, tulip poplar and hickory, an occasional longleaf in the more fire-exposed locations):
Se Seabrook loamy sand – mixed Aquic Udipsamments, MWD, 2-4 ☐ ◙ Ө★
Ag Augusta fine sandy loam – fine-loamy, mixed Aeric Ochraquults, SPD, 1-2 ◙ Ө★

6. Mixed Mesic Hardwood Slopes (with some loblolly pine) ●
SuD Suffolk loamy sand – fine-loamy, siliceous Typic Hapludults, WD, >6 ●

7. Wet-mesic Longleaf Pine/Wiregrass Savanna ☼
Ly, Lc Lynchburg fine sandy loam – fine-loamy, siliceous Aeric Paleaquults, SPD, 0.5-1.5 ☼ Θ Ө (Lc=urban)
Ln Leon fine sand – sand, siliceous Aeric Haplaquods, PD, 0-1☼ (Lu=urban)

8. Pond Pine Savanna & Forest ◊
La Leaf silt loam – clayey, mixed Typic Albaquults, PD, 0.5-1.5

9 Canebrake (Pond Pine/Canebrake, Mixed Longleaf-Pond Pine/Canebrake, Hardwood/Canebrake**)** ○
Torhunta fine sandy loam – coarse-loamy, siliceous, acid Typic Humaquepts, VPD, 0-1 ○ ⌂ ◘ (Tc = urban) (Pond pine canebrake, Mixed Longleaf-Pond Pine/Canebrake (none on gov't property)

10. Pond Pine/Pyrophytic Low Pocosin ◘
Pantego fine sand loam – fine-loamy, siliceous Umbric Paleaquults, VPD, 0-1.5 ◘ ○

11. Small Stream Swamp and Pyrophytic Wetland Mosaic Structured by Fire and Beaver ♦
(mosaic elements include swamp black gum, baldcypress, bottomland hardwood forest, hardwood/canebrake, pond pine/canebrake, pocosin, beaver ponds and freshwater marsh created by beaver).
MM Masontown-Muckalee:
Masontown mucky fine sandy loam – siliceous, nonacid Cumulic Humaquepts, VPD, +1-0.5
Muckalee loam, sandy loam – coarse-loamy, siliceous, nonacid Typic Fluvaquents, PD, 0.5-1.5♦Ba Bayboro mucky loam – clayey, mixed Umbric Paleaquults, VPD, +1-1 ♦

12. Pine Marsh and Estuarine Scrub Д (loblolly pine, red cedar, pond pine/Wax Myrtle and Pyrophytic Low Pocosin: loblolly pine, pond pine/mixed pocosin shrubs and oligohaline marsh graminoids and forbs
Se Seabrook loamy sand – mixed Aquic Udipsamments, MWD, 2-4 Д
Only on the two islands of Se soils near the mouth of Hancock Creek.

13. Oligohaline to brackish marsh Ω θ
LF Lafitte muck – euic Typic Medisaprists, VPD, 0-0.5 **Ω**

Table 7. Presettlement vegetation of Cherry Point.

PRESETTLEMENT VEGETATION SUMMARY – CHERRY POINT:

Vegetation Type	ACRES	%
Xeric and Dry-Mesic Longleaf Pine/Wiregrass Savanna	17	0.1
Mesic Longleaf Pine/Wiregrass Savanna	4,503	38.5
Wet-mesic Longleaf Pine/Wiregrass Savanna	657	5.6
Wet Mixed Pine Savanna and Forest	1,693	14.0
Mesic Mixed Pine Savanna and Pyrophytic Hardwood Woodland	899	7.7
Maritime Pine-Live Oak Forest	173	1.5
Mixed Mesic Hardwood Slopes	953	8.2
Canebrake	60	0.5
Pond Pine/ Pyrophytic Low Pocosin	19	0.2
Small Stream Swamp and Pyrophytic Wetland Mosaic Structured by Fire and Beaver	461	3.9
Pine Marsh and Estuarine Scrub	13	0.1
Oligohaline to Brackish Marsh	55	0.5
Udorthents	2,179	18.6
Water and Aquatic Communities (interior)	61	0.5
TOTAL	11,689	100

Table 8. Number of acres in each presettlement vegetation type at MCAS Cherry Point.

1. Xeric and Dry-Mesic Longleaf Pine/Wiregrass and Longleaf pine/Turkey Oak ☐
soils:
TaB Tarboro sand – mixed Typic Udipsamments, SED, >6 ☐ ◙
Community types:
Pinus palustris/Quercus laevis/Aristida stricta
Pinus palustris Pinus taeda-Quercus falcata-Quercus stellata-Quercus virginiana
Only a tiny amount of this dry type is found on Cherry Point and it occurs in a partially fire sheltered situation on the west side of Hancock Creek.

2. Mesic Longleaf Pine/Wiregrass Savanna Θ
soils:
NoA, NoB, NuB Norfolk loamy fine sand – fine-loamy Typic Paleudults, WD, 4-6 Θ (NuB = urban)
GoA, GuA – Goldsboro loamy fine sand – fine-loamy, siliceous Aquic Paleudults, MWD, 2-3 Θ, (GuA = urban)
CrB Craven silt loam – clayey, mixed Aquic Hapludults, MWD, 2-3 Θ ★
On Onslow loamy sand – fine-loamy, siliceous Spodic Paleudults, MWD, 1.5-3 Θ Ɵ
CnB Conetoe loamy sand – loamy, mixed Arenic Hapludults, WD, >6 Θ ◙
Community types:
Pinus palustris/wiregrass-diverse graminoids and forbs of frequently burned mesic savannas
This group of soils makes up the largest part of land area of the base. Portions are highly fire exposed and would have burned as frequently as 3 years while others are partially fire sheltered. The original savannas would have had high species diversity. Frequently burned examples on the nearby Croatan N.F. have up to 80 species per 1/10 hectare (about ¼ are) in my study plots After several decades of fire suppression most sites on Cherry Point have developed dense woody understory to the exclusion of much of the ground layer diversity.

3. Mesic Mixed Pine Savanna and Pyrophytic Hardwood Woodland Ɵ various combinations of loblolly, longleaf, pond pine, some hardwoods, especially on more fire-sheltered sites)
soils:
AuB Autryville fine sand – loamy, siliceous Arenic Paleudults, WD, >5 ☐★
Le Lenoir silt loam – clayey, mixed Aeric Paleaquults, SPD, 1-2 **Ɵ**
Community types:
Pinus palustris-Pinus taeda-Pinus serotina/wiregrass-diverse graminoids and forbs of mixed pine savannas
Pinus palustris-Carya glabra-Quercus stellata-Quercus alba-Quercus stellata/diverse pine-hardwwod woodland graminids and forbs.

5. Maritime Pine-Live Oak Forest ◙ (Loblolly Pine, Live Oak and other hardwoods including white oak, tulip poplar and hickory, an occasional longleaf in the more fire-exposed locations):
soils:
Se Seabrook loamy sand – mixed Aquic Udipsamments, MWD, 2-4 ☐ ◙ Ɵ★
Ag Augusta fine sandy loam – fine-loamy, mixed Aeric Ochraquults, SPD, 1-2 ◙ Ɵ★
Community types:
Quercus virginiana-Quercus alba/mesophytic shrubs and subcanopy trees.

6. Mixed Mesic Hardwood Slopes (with some loblolly pine) ●
soils:
SuD Suffolk loamy sand – fine-loamy, siliceous Typic Hapludults, WD, >6 ●

Beech is found on the steep slopes on soils like the Suffolk series on north-facing slopes and other situations in deeply-cut small stream drainages truncated by the Neuse River estuary. These are the most fire-sheltered habitats in the Outer Coastal Plain, and contain a number of other fire-refugial species like *Magnolia tripetlala*, *Aesculus pavia* and *Storax grandifolia*.

Community types:

Fagus grandifolia-Carya glabra-Quercus alba-Liriodendron tulipifera/Ostrya virginiana/Thelypteris hexagonoptera-diverse mesophytic forest graminoids and forbs

Fagus grandifolia-Carya glabra/Magnolia tripetala/diverse mesophytic forest graminoids and forbs

Fagus grandifolia-Quercus rubra

Figure 19. Old growth beech on a fire sheltered flat near the Neuse River.

7. Wet-mesic Longleaf Pine/Wiregrass Savanna ☼

soils:

Ly, Lc Lynchburg fine sandy loam – fine-loamy, siliceous Aeric Paleaquults, SPD, 0.5-1.5 ☼ Θ Θ (Lc=urban)

Ln Leon fine sand – sand, siliceous Aeric Haplaquods, PD, 0-1☼ (Lu=urban)

Community types:

Pinus palustris/Aristida stricta-diverse graminoids and forbs of wet-mesic longleaf pine savannas.

8. Wet Mixed Pine Savanna and Forest (longleaf and pond pine, an occasional loblolly) ⌂

soils:

Ra, Rc Rains fine sandy loam - fine-loamy, siliceous Typic Paleaquults, PD, 0-1 ⌂ ◊ ☼ (Rc = urban)

Ap Arapahoe fine sandy loam - coarse-loamy, mixed, nonacid Typic Humaquepts, VPD, 0-1 ⌂ ◊ ☼

Community types:
Pinus palustris-Pinus serotina-Pinus taeda
Pinus palustris/diverse wet savanna graminoids and forbs

Figure 20. The best stand of longleaf pine remaining on Cherry Point. On the moist Rains series, this stand under past fire suppression had grown up in dense shrubs with loss of much of the herb layer vegetation. Recent restoration activities by Cherry Point forestry staff, including reintroduction of fire, promises to reinvigorate the understory which includes remnants of wiregrass and other species of the original herb layer.

9. Pond Pine Savanna & Forest ◊
soils:
La Leaf silt loam – clayey, mixed Typic Albaquults, PD, 0.5-1.5
Community types:
Pinus serotina/diverse wet savanna graminoids and forbs

10. Canebrake (Pond Pine/Canebrake, Mixed Longleaf-Pond Pine/Canebrake, Hardwood/Canebrake**)** ○
soils:

To Torhunta fine sandy loam – coarse-loamy, siliceous, acid Typic Humaquepts, VPD, 0-1 ○ ⌂ ◘ (Tc = urban) (Pond pine canebrake, Mixed Longleaf-Pond Pine/Canebrake (none on gov't property?)

Community types:
Pinus serotina/Arundinaria gigantea
Pinus serotina-Pinus palustris/Arundinaria gigantea

Figure 21. Once abundant on the Torhunta soils canebrake has largely vanished from Cherry Point under the past history of fire exclusion. Fire reinvigorates cane where it passes through wetlands such as this small pond cypress slough.

11. Pond Pine/Pyrophytic Low Pocosin ◘
soils:
Pa Pantego fine sand loam – fine-loamy, siliceous Umbric Paleaquults, VPD, 0-1.5 ◘ ○
Community types:
Pinus serotina/Ilex glabra, Ilex coriacea, Cyrilla racemiflora, Vaccinium corymbosum, Magnolia virginiana, Persea palustris, Lyonia lucida, Woodwardia virginica, Smilax laurifolia and

12. Small Stream Swamp and Pyrophytic Wetland Mosaic Structured by Fire and Beaver ♦ (mosaic elements include swamp black gum, baldcypress, bottomland hardwood forest, hardwood/canebrake, pond pine/canebrake, pocosin, beaver ponds and freshwater marsh created by beaver).
soils:
MM Masontown-Muckalee:
Masontown mucky fine sandy loam – siliceous, nonacid Cumulic Humaquepts, VPD, +1-0.5

Muckalee loam, sandy loam – coarse-loamy, siliceous, nonacid Typic Fluvaquents, PD, 0.5-1.5♦Ba Bayboro mucky loam – clayey, mixed Umbric Paleaquults, VPD, +1-1 ♦

Community types:
Taxodium distichum/Nyssa biflora-Liquidambar styraciflua/Carex spp.-diverse small stream swap graminoids and forbs

13. Pine Marsh and Estuarine Scrub Д (loblolly pine, red cedar, pond pine/Wax Myrtle and Pyrophytic Low Pocosin: loblolly pine, pond pine/mixed pocosin shrubs and oligohaline marsh graminoids and forbs
soils:
Se Seabrook loamy sand – mixed Aquic Udipsamments, MWD, 2-4 Д
Only on the two islands of Se soils near the mouth of Hancock Creek.
Community types:
Pinus taeda/Myrica cerifera-mixed oligohaline marsh graminoids and forbs.

14. Oligohaline to brackish marsh Ω θ
soils:
LF Lafitte muck – euic Typic Medisaprists, VPD, 0-0.5 **Ω**
Community types:
Typha angustifolia
Juncus roemerianus
Scirpus americanus
Mixed submersed, emergent and floating graminoids and forbs of oligohaline marsh/tidal swamp transitions

CHERRY POINT PLACE NAMES
Anderson Creek – arises just east of northwestern boundary of Cherry Point, drains E iinto Slocum Creek near its mouth.
Cahoogue Creek – arise SE of Cherry Point near SR 306, drains NW into Hancock Creek
Cedar Creek – arises between US 70 and the southwestern boundary of Cherry Point, drains E into Slocum Creek.
Cherry Point Landing (peninsula E of mouth of Hancock Creek)
Daniels Branch – arises in the Croatan Nat'l Forest, drains E, crossing US 70 at Pine Grove and drains into Tucker Creek
Dolls Gut (into Hancock Cr)
East Prong of Slocum Creek – arises S of Havelock, drains N across US 70 into Slocum Creek.
Goodwin Creek – arises at US 70, drains SE into Daniels Branch.
Hancock Creek – Forms part of the eastern boundary of Cherry Point, drains N into Neuse River.
Hunters Branch
Miry Branch – a very short tributary flowing W into Sandy Run
Reeds Gut (into Hancock Cr)
Sandy Run – arises just NE of US 70, forms part of eastern boundary of Cherry Point and then drains N into Tucker Creek
Shop Branch (into Hancock Cr)
Southwest Prong of Slocum Creek – arises SW of Havelock, drains NE across US70 into Slocum Creek
Slocum Creek – the major estuarine creek. Drains N into Neuse River estuary.
Reeds Gut (into Hancock Cr)
Tucker Creek largest estuarine branch of Slocum Creek, drains NE into Slocum.

CHAPTER 3

PINEY ISLAND

PRESETTLEMENT FIRE FREQUENCY OF PINEY ISLAND

Piney Island is an eroding peninsula in the process of separation from the mainland that was its primary source of ignition for marsh burning. To the south was a large area of canebrake and low pocosin now largely transformed to agriculture by Open Grounds Farms. Once the northern terminus of a 300 square mile fire compartment extending without a significant firebreak south to the Croatan National Forest and beyond, Piney Island was the final destination for landscape scale fires originating from as far away as 30 or 40 miles to the southwest. Lying directly downwind along the prevailing winds from this vast fire landscape, the original fire frequency would be expected to have run in the 1-3 fire frequency class. This is corroborated by descriptions of annual fires on Open Grounds during the mid-1800's (Emmons 1860, Ruffin 1861).

On Piney Island, given the continuity of marsh fuels, there are only minor variations in elevation and landscape position to influence fire frequency. Lowered fire frequency is related to two situations on the island, however. First is the reduction expected in small peninsulas and lobes of marsh with bays and inlets extending inland enough so that for fire to reach the shoreline downwind of the bay or inlet, it would have to flank or even back into them to burn everything on a typical southwest wind. For an example, see the little southwesterly-curving peninsula along the shoreline west of the northernmost (east/west) access road. In the second situation there are extensive peripheral areas with less than 1-foot elevation, flooded with brackish water by diurnal and wind tides. Vegetation in these flats is composed of poorly flammable species such as saltmarsh cordgrass (*Spartina alterniflora*) with interspersed patches of nonflammable low marsh species such as Salicornia and Aster tenuifolius. Consequently, such areas are delimited on the fire frequency map in fire frequency classes B, C or D depending upon the degree of limitation to access by fire.

Effects of sea level rise. Most of the island is underlain by the Lafitte muck, a brackish organic soil up to 2 meters deep. There has been perhaps a meter of land submergence in the historical period, the combined result of sea level rise and land subsidence in the Albemarle Embayment, of which the Pamlico Sound and Piney Island are a part. Even given that much sea level rise, however, there has not been enough change for there have been anything other than the same marsh peat and pond pine islands during the historical period. The original vegetation would be expected to be the same as at present. Brackish marsh generally keeps pace with rising sea level by production of addition mass of marsh grass rhizomes, which make up a large part of the bulk of soils like the Lafitte, and by trapping of fine sediment by the dense stems. The surface of the marsh should look little different today than 300 years ago. The principal change would occur as loss of marsh area by wave action around the periphery.

Impending separation of Piney Island from the mainland. Modern fire frequency, even without human interference, is likely lower than in the presettlement situation because of ongoing constriction of the neck of land connecting Piney Island to the mainland. LIDAR topography with 1-foot contour intervals is subtle enough to pick up a number so holes and small ponds developing in the vicinity of the neck. The ponded areas are also visible and appear to be smaller on aerial photos used for making soil maps in 1975, 31 years ago. An increase in size would be expected with the four inches of sea level rise/land subsidence during that time. They occur mostly in the neck connecting the Piney Island peninsula to the mainland, suggesting that the neck is breaking up and will make Piney Island truly an island in the near future.

Fire frequency in Open Grounds on the south side of Piney Island. Two writers investigated peatlands in the region in the 1850s. In April 1852, Ebenezer Emmons came to investigate commercial possibilities of the Open Grounds wetlands for the Board of Education (Emmons 1860). According to his estimate there were 2 million acres of "swamp lands" in NC, of which the State owned 1.5 million, not counting marshes. The Legislature had decreed that these lands should be exploited or sold and the monies used to support the school system.

In his investigation of the Open Grounds peninsula Emmons seems to have had a poor opinion of the Carteret County peatlands: "It is rare indeed, that we can justly say of this or that piece of land, that it is good for nothing. These remarks are applicable to the tract which we propose now to consider."

He arrived at the Open Grounds prairie in April 1852, noting along the road from Beaufort, longleaf pine, loblolly, water oak, baldcypress and black gum. "The great tract in Carteret, generally known as the open prairie, is a marsh or swamp [he seemed not to have been familiar with the term pocosin, and, because of the nearly annual fires Open Grounds seems to have been closer to what Ashe called "grassy pocosins", more a wet prairie or bog than a shrubland], mostly destitute of trees; and hence, the area which is exposed to view is more than ten miles in length and breadth. But the entire tract, has an area of more than two hundred square miles. In this tract, there is a continuity of swamp, ranging somewhat in condition, depth of mud, and solidity of surface, but it is all swamp in reality. It furnishes a growth of coarse grasses [likely dwarf *Arundinaria*, which, in a few places, still formed dense stands less than a meter tall during my field work in the early 1980s, and *Andropogon glomeratus*] over its whole surface, or that part which is open to the sun. A piney ridge that has a sandy soil with moderately large, long-leaved pines surrounds this tract. But the immediate border is so thickly overgrown with briers, reeds [*Arundinaria*], bamboos [*Smilax laurifolia*], and other ugly bushes, that it is at the expense of a man's coat, pantaloons and shirt, if he forces his way through them. This outside hedge is twenty rods wide in many places, and even wider in others. Since improvements, however, on a small scale have been undertaken by means of ditching, the access to the open grounds is easy and safe." "The prairie was filled with water and the facilities for getting over it were only clumps of grassy knowles that stood above the water. It was soft and yielding to the foot every where else, and was easily penetrated to a depth of between five or ten feet."

Emmons was one of the first to describe radial drainage, noting that the peatlands were higher in the center and that is why all streams flow outward. His soil analysis found only 52.7% organic matter in the open ground peat, so he concluded it could be drained and farmed. A test section was ditched to provide drainage and there was a test planting of corn, beans and potatoes in June. As a consequence, he was also one of the first to describe peat subsidence after drainage. A drainage ditch 4 ft deep had been run in a mile and he reported that: "....the ground has settled about 18 inches over an area of about half a square mile."

The noted Virginia agriculturist Edmund Ruffin examined the same area four years later, visiting Open Grounds on July 3, 1856: "Until recently, it has been generally saturated with water, and in wet seasons mostly so covered, that in walking on any part, every step on the spongy surface would sink deep, and every foot-print made would be immediately filled with water." "Nearly the whole of this great savanna, except some pine-covered ground in narrow strips on the margins, is destitute of trees, and nearly so of bushes, and of any shrubs of as much as two feet high" (Ruffin 1861). A square mile block had been ditched in 1855, apparently an expansion of the test drainage initiated by Emmons, draining into Ward's Creek. The weather had been very dry and Ruffin remarked that: "If fire had been then applied, I am confident that the whole upper layer of soil, for some inches at least, would have been burnt off." "...after the ditching and before much drying of the land had yet been caused, a fire that burnt over the dead or dry growth also burnt up much of the banks of the shallower ditches, and in some cases spread some ten feet off, consuming from four to eight inches depth of the original soil."

Ruffin found the surface covered with Sphagnum. In the 1930s, Dr. Lewis Anderson found the surface similarly covered with Sphagnum and the fire-following moss *Funaria hygrometrica*. This species commonly appears in abundance on wet soils the year after a fire, and, according to Dr. Anderson, fire frequency was still every two or three years in the 1930s (Anderson, pers. comm.).

Ruffin saw "...not one grazing animal on all the immense savanna. I did not notice a single tuft of any apparently good grass. Yet there is enough growth of some other kinds to render the whole surface one impassable thicket, *if the fires could be kept off for but two successive summers*. The present living plants, except their roots, are all the growth of the present season, produced since the last fires killed everything above ground."

Frequency Class	Mean Fire Interval (years)	Estimated Historic Range of Variation (90% of Fires) (years)	ACRES	PERCENT
B	2	1-4	6981	58.4
C	3	1-6	3437	28.7
D	4	2-9	1526	12.8
Water			10	0.1
TOTAL			11,954	100

Table 9. Original fire regimes of Piney Island.

Ruffin's complaint that "if the fires could be kept off but two successive summers" implies annual fires in the 1850s, and the site had burned the year before his visit. The absence of even pond pine, which thrives on the peripheral portions of this tract now, may be due to the combination of extreme fire frequency and the seasonal standing water that Emmons and Ruffin both commented upon. Plant species he reported included some small ericad, and other dwarf shrubs, *Smilax laurifolia*, "the bunched-topped (or wet-land) broom grass" (*Andropogon glomeratus*), *Sarracenia flava*, "and some of the kindred pitcher plant" (*Sarracenia purpurea*?), "and other flowers and weeds of wet and sour savanna lands." *Sarracenia flava* is a frequent-fire indicator species, now disappeared from much of its former range. As Ruffin viewed the area in 1856: "The whole broad surface of the "Open Ground" presents a singular and remarkable scene of desolation and solitude. There was no appearance that any human being had gone as far into the ground as the remoter ditches, since they had been finished."
This was the annually burned landscape that fed fire northwards to Piney Island.

PRESETTLEMENT VEGETATION - PINEY ISLAND

Of the following vegetation types shown on the map of Piney Island and surroundings only two, Brackish Marsh and Pine Marsh and Estuarine Scrub occur on the Piney Island military lands.

Estuarine Fringe Beaches, Sand Berms and Low Dunes, Sparsely Vegetated
Be beaches

Mesic Mixed Pine Savanna: (Pond pine, longleaf and loblolly) **ϴ**
Se Seabrook loamy sand – mixed Aquic Udipsamments, MWD, 2-4 **ϴ** ☐ ◙

Wet-mesic Longleaf Pine/Wiregrass Savanna: (sometimes mixed with pond pine)
Ln Leon fine sand – sand, siliceous Aeric Haplaquods, PD, 0-1☼ ⌂ ○

Pond Pine Savanna & Forest (with occasional longleaf pine): ◊
Tm Tomotley fine sandy loam – fine-loamy, mixed Typic Ochraquults, PD, 0-1 ◊

Canebrake (canebrake-pocosin mosaic with canebrake dominant)
Ws Wasda muck - fine-loamy, mixed, acid Histic Humaquepts, VPD, +0.5-1, ○ ◘ ◊

Pond Pine/Pocosin: Pond pine/wax myrtle and Pyrophytic Low Pocosin ◘
Ap* Arapahoe fine sandy loam - coarse-loamy, mixed, nonacid Typic Humaquepts, VPD, 0-1 ◘ ⌂ ◊
De* Deloss fine sand loam – fine-loamy, mixed Typic Umbraquults, VPD, 0-1 ◘ ○ ⌂ ◊

Pine Marsh and Estuarine Scrub (Pond Pine/Wax Myrtle and Pyrophytic Low Pocosin: loblolly pine, pond pine/mixed pocosin shrubs and oligohaline marsh graminoids and forbs.
Dm Deloss mucky loam – fine-loamy, mixed Typic Umbraquults, VPD, 0-1 ◘
DA Dare muck – dysic Typic Medisaprists, VPD, +0.5-1◘ **Ω**

Brackish Marsh
LF Lafitte muck

Oligohaline to Brackish Marsh:
HB Hobucken muck - coarse-loamy, mixed, nonacid Typic Hydraquents, VPD, +1-1 **θ**

Table 10. Presettlement vegetation of Piney Island and vicinity.

PRESETTLEMENT VEGETATION SUMMARY – PINEY ISLAND:

Vegetation Type	ACRES	%
Pine Marsh and Estuarine Scrub	322	2.66
Brackish Marsh	11,750	97.30
Water (ponds and other internal areas)	5	0.04
TOTAL	12,077	100

Table 11. Number of acres in each presettlement vegetation type at Piney Island.

Brackish Marsh
soils:
LF Lafitte muck – euic Typic Medisaprists, VPD, 0-0.5 Ω
Community types:
Spartina alterniflora (wet margins)
Juncus roemerianus

Juncus roemerianus/Distichlis spicata
Low marsh (*Salicornia spp., Eleocharis sp., Aster tenuifolius, Aster subulatus*)

Many other marsh species were seen along shorelines and in disturbed areas.

Figure 22. A medium elevation phase of brackish marsh at Piney Island, 1-2 feet above sea level. Patch dominants are most often black needle rush (*Juncus roemerianus*), needle rush/saltgrass (*Distichlis spicata*) or threesquare (*Scirpus americanus*). Closer to the water and more frequently inundated, low marsh is more open and has greater species diversity.

Pine Marsh and Estuarine Scrub
soils:
DA Dare muck – dysic Typic Medisaprists (muck), VPD, +0.5-1◘
Community type:
Pinus serotina/Myrica cerifera/Osmunda regalis-mixed oligohaline and brackish marsh graminoids and forbs.

Pond pine islands. Two rapidly shrinking islands of pond pine persist on patches of what is mapped as Dare soil. This mucky peat differs from the Lafitte marsh soil principally in its freshwater origin and its composition which includes woody fibers derived from decomposing trees and shrubs that are lacking in marsh vegetation. The islands are shrinking as the salt front moves inland with lateral erosion of the marsh shorelines. Recent decline in pond pine after fires is less a result of fire than of soil water salinity reaching lethal levels for pine. A reading of 1.1% salinity taken by optical salinometer from surface water within the pond pine stand on September 26, 2005 is extremely high, approximately 1/3 the strength of seawater. I have never before seen pond pine in salinity situations that high.

Figure 23. One of the two "piney islands" on soils mapped as Dare muck in south central Piney Island. Besides the few remaining old pond pines, vegetation in the photo is dominated by wax myrtle (*Myrica cerifera*), royal fern (*Osmunda regalis*) and switchgrass (*Panicum virgatum*). Surface water in this area was measured at 1.1% salinity, likely high enough to prevent any future reproduction of pond pine which is on its way out as sea level rises.

The few remaining living pond pines comprised the only canopy. There was no subcanopy but there were patches of tall shrubs dominated by wax myrtle along with silverling (*Baccharis halimifolia*), marsh elder (*Iva frutescens*) and red bay (*Persea palustris*).

CHAPTER 4

ATLANTIC FIELD

PRESETTLEMENT FIRE FREQUENCY OF ATLANTIC FIELD

Lying on the northeast and therefore downwind side of Open Grounds peninsula in northeastern Carteret County, Atlantic Field would be expected have nearly the same fire frequency. As mentioned in the discussion under Piney Island, Open Grounds is documented as having experienced nearly annual fire in the mid 1800s. The landscape of Atlantic Field and its immediate vicinity is flat, undissected and lacks anything that could be construed as a firebreak or fire filter. Nelson Bay to the south excludes fire on southeast winds and constrains fire approach to routes along the prevailing winds to the south-southwest and fires borne on post cold front winds from the west and northwest. The bay creates a very slight fire shadow in the vicinity of Atlantic Field (see fire frequency class B on the GIS fire frequency map). The fire frequency range of 1-4 years gives an estimated mean interval of around 2 years. Presence of a number of fire frequency indicator species for that class including butterworts (*Pinguicula*) and trumpets (*Sarracenia flava*) support this estimate.

Fire Frequency Class	Mean Fire Interval (years)	Estimated Historic Range of Variation (90% of Fires) (years)	ACRES	PERCENT
A	1.5	1-3	321	21.5
B	2	1-4	1,110	74.4
C	3	1-6	23	1.5
Water			38	2.6
TOTAL			1,492	100

Table 12. Original fire regimes of Atlantic Field.

PRESETTLEMENT VEGETATION - ATLANTIC FIELD

Table 13 lists the original vegetation of Atlantic Field. Soil series descriptions include the soil mapping symbol, soil texture, soil taxonomy, NRCS drainage classes (ED - excessively drained, WD –well drained, SPD – somewhat poorly drained, PD – poorly drained, VPD – very poorly drained), and depth to seasonal high water table in feet. A plus sign, e.g. +1, means that there is a foot of water standing on the surface at time of seasonal high water table. Each soil series is followed by one or more symbols for vegetation types occurring on that series, with the symbol for the most abundant type shown first

1. Xeric and Dry-Mesic Longleaf Pine/Wiregrass Savanna ☐
KuB Kureb sand – uncoated Spodic Quartzipsamments, ED, >6 ☐ ◙

2. Dry-Mesic Longleaf Pine/Wiregrass Savanna ☐
ByB Baymeade fine sand - loamy, siliceous, Arenic Hapludults, WD, 4-5 ☐ ◙
CnB Conetoe loamy sand – loamy, mixed Arenic Hapludults, WD, >6 ☐ ◙

3. Mesic Longleaf Pine/Wiregrass Savanna ☼
Mn, Mc Mandarin sand - sandy, siliceous Typic Haplohumods, SPD, 1.5-3.5 (Mc = urban) ☼ ◙

4. Wet-mesic Longleaf Pine/Wiregrass Savanna ☼
Ln Leon fine sand – sand, siliceous Aeric Haplaquods, PD, 0-1☼ (Lu=urban)

5. Maritime Pine-Live Oak Forest (Longleaf Pine, Loblolly Pine, Live Oak) ◙
Ag Augusta fine sandy loam – fine-loamy, mixed Aeric Ochraquults, SPD, 1-2 ◙

6. Pond Pine/Pyrophytic Low Pocosin ◘
Mu Murville mucky loamy fine sand – sandy, siliceous Typic Haplaquods, VPD, 0-1 ◘

7. Small Stream Swamp/Brackish Marsh Transition ♦
BH Belhaven muck - loamy, mixed, dysic Terric Medisaprists, VPD, 0-1 ♦

8. Brackish Marsh Ω
LF Lafitte muck – euic Typic Medisaprists, VPD, 0-0.5 **Ω**

9, Brackish and Salt Marsh
CH Carteret loamy fine sand – mixed Typic Psammaquents, VPD, +3-1 **θ**
(CH is Carteret high phase, CL is low phase)

Table 13. Presettlement vegetation of Atlantic Field and vicinity. Of the nine vegetation types mapped, only numbers 3, 4, 6 and 8 occur on the airfield property.

PRESETTLEMENT VEGETATION SUMMARY – ATLANTIC FIELD:

Vegetation Type	ACRES	%
Mesic Longleaf Pine/Wiregrass Savanna	38	2.5
Wet-mesic Longleaf Pine/Wiregrass Savanna	449	30.1
Pond Pine/ Pyrophytic Low Pocosin	603	40.5
Brackish Marsh	176	11.8
Udorthents	188	12.6
Water (interior)	38	2.5
TOTAL	1492	100

Table 14. Number of acres in each presettlement vegetation type at Atlantic Field. Descriptions are for only the vegetation types actually found on the property

3. Mesic Longleaf Pine/Wiregrass Savanna
soils:
Mn, Mc Mandarin sand - sandy, siliceous Typic Haplohumods, SPD, 1.5-3.5 ☼ (Mc = urban or disturbed)
Community types:
Pinus palustris/wiregrass

4. Wet-mesic Longleaf Pine/Wiregrass Savanna
soils:
Ln, Lu Leon fine sand – sand, siliceous Aeric Haplaquods, PD, 0-1☼ ⌂ (Lu = urban or disturbed)
Community types:
Pinus palustris/wiregrass-diverse graminoids and forbs of wet-mesic longleaf pine savannas.

Figure 24. Butterwort (*Pinguicula caerulea*) at Atlantic Field. This is a fire frequency indicator species for the 1-4 year fire frequency class. A fire-dependent genus, butterworts disappear under fire suppression because they are easily shaded out by shrubs. Along with several other fire frequency indicator species, their presence indicates that Atlantic Field was in the highest fire frequency class in the original landscape.

6. Pond Pine/Pyrophytic Low Pocosin
soils:
Mu Murville mucky loamy fine sand – sandy, siliceous Typic Haplaquods, VPD, 0-1 ◘
Community types:
Pinus serotina/Ilex glabra, Ilex coriacea, Cyrilla racemiflora, Vaccinium corymbosum, Magnolia virginiana, Persea palustris, Lyonia lucida, Woodwardia virginica, Smilax laurifolia and

8. Brackish Marsh θ
soils:
LF Lafitte muck – euic Typic Medisaprists, VPD, 0-0.5 **Ω**
Community types:
Spartina alterniflora (wet margins)
Juncus roemerianus
Juncus roemerianus/Distichlis spicata

With exception of fire suppression in recent decades and past removal of most of the longleaf pine on Leon soils immediately around the runways (likely to reduce hazard to aircraft), there has been little impact on natural vegetation. The site is largely a mosaic of two soils and vegetation types: Wet-mesic Longleaf Pine/Wiregrass Savanna on the Leon sand lenses, interspersed in a matrix of former Pond Pine/Pyrophytic Low Pocosin on the shallow, acid organics of the Murville muck. There are a few ridges of slightly higher Mandarin sand to the north and south of the field. Fire has been excluded from these areas away from the runways long enough that the former open longleaf pine savannas have been overrun with shrubs and a deep pine needle litter and duff layer has accumulated. In many areas the combination of shrubs and litter have been enough to smother most of the herb layer, with only a few species and a few hummocks of wiregrass persisting. On the ridge of Mandarin sand parallel to SR 1387 on its north side only five herb species could be found, one of which was wiregrass.

Under the original fire frequency of 1-4 years most of the pocosins would have been maintained at less than a meter in height by frequent fire. Today most have grown up to tall pocosin in the absence of fire.

In the northern third of the property, north of state road 1387, the savanna-pocosin mosaic gives way after 100-300 meters to a narrow zone of estuarine fringe loblolly pine forest (not mapped) and estuarine scrub along the southern margin of a large brackish marsh. The marsh, mapped Lafitte muck, had salinity of 1.3% on the date of visit in September 2005. This is in the brackish range at about 1/3 the strength of seawater.

See the Natural Heritage report on Atlantic Field for a complete listing of plant species present and discussion of the rare plants found in the wet savannas and low pocosins.

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APPENDIX.

BACKGROUND:

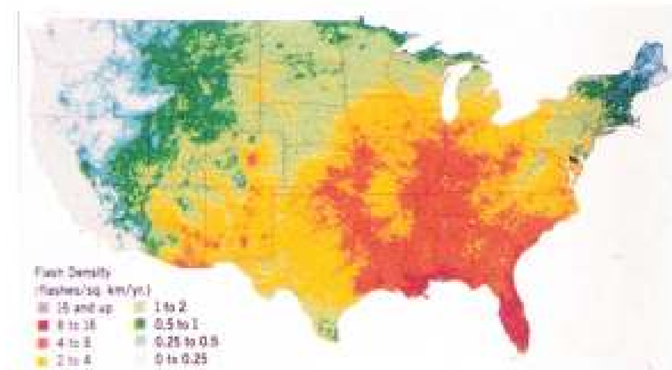

Figure 1. Lightning strike density of the four study areas have pixels in the range of about 4 strikes per square kilometer per year. This would be expected to have provided a high ignition frequency even without the use of fire by Native Americans.

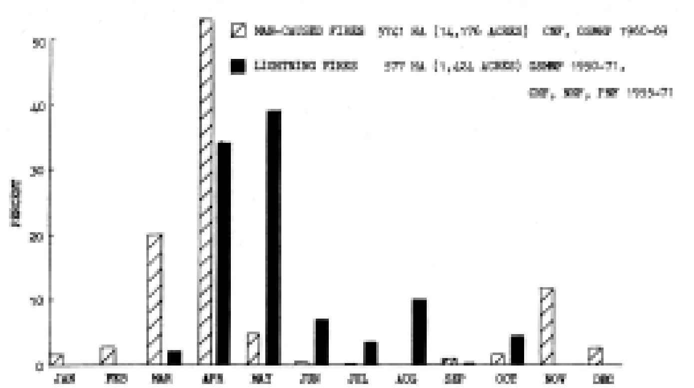

FIG. 2. Incidence of wildfires in the Appalachians of Tennessee and North Carolina

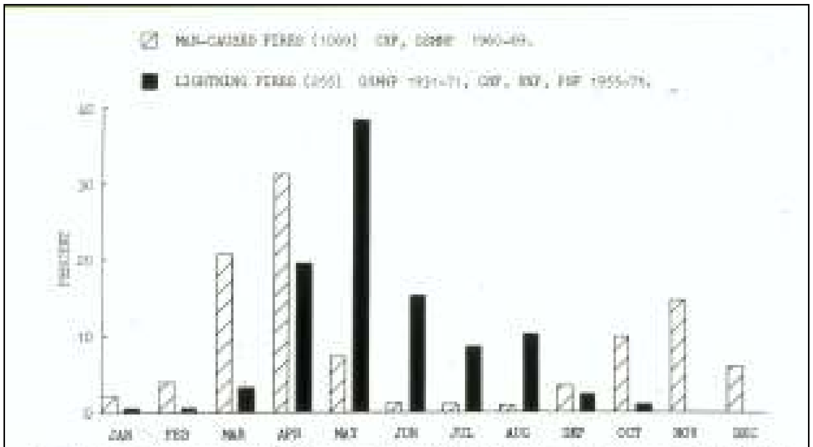

Fig. 1. Area burned by wildfires in the Appalachians of Tennessee and North Carolina.

Figures from Barden and Woods 1973, show the history of wildfires in the Southern Appalachians compiled from USFS records. Peak fire season, the time when lightning ignitions are most frequent and also the time when fires travel farthest, is around May in the mountains. In south Florida the peak occurs around February-March, and on the mid-Atlantic coastal plain it occurs in March and early April. This corresponds not to peak lightning strike density but to the time when there is the largest amount of dry, winter-dead fine fuel available to carry fire. In presettlement times a second fire season was related to annual fall burning carried out by Native Americans.

The study region is the most complex in the coastal region of the Carolinas, with vegetation ranging from the highest to the lowest fire frequency classes (see the individual maps for the four sites), including some in the highest fire frequency band of the southern U.S. where the original fire frequency, primarily based on lightning on the coastal plain, with some supplemental effect by Native American burning, averaged as high as 1-3 years (Figure 16 below).

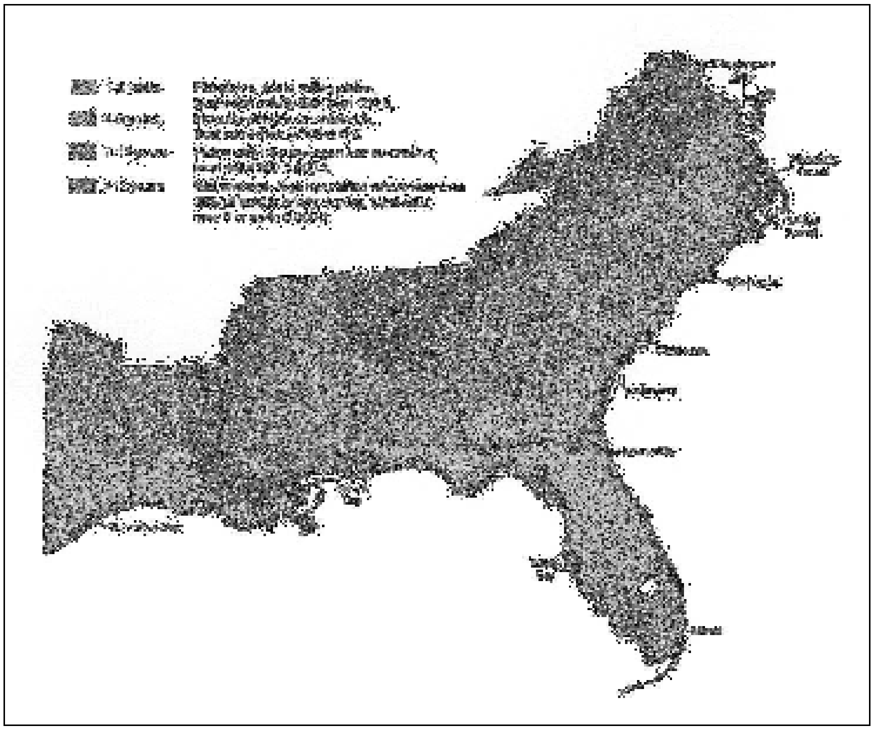

Figure 4. Presettlement fire regimes of the southeastern United States. Derived from regional fire compartment size, topography, historical records, climate, vegetation remnants and soils. Frequencies are only for the most fire-exposed parts of the landscape. Each region also contains variously fire-protected areas with lower incidences of fire (Frost 1995).

METHODS – MAPPING HISTORICAL FIRE FREQUENCY

Assumptions and assertions: The following principles are based on work elsewhere (Frost 1993, 1995, 1998 and 2000).

1. Under presettlement fire regimes, fire played a role in structuring all natural vegetation of the coastal plain, piedmont and mountains, except those vegetation types that are restricted to natural fire refugia like steep fire-sheltered slopes, islands and peninsulas.
2. Elimination of fire from a pyrophytic landscape initiates succession and replacement of pyrophytic species by non-pyrophytic species and communities.
3. Elimination of fire from a pyrophytic landscape initiates transformation of vegetation structure from one or two layers to multi-storied woody vegetation.
4. Lightning associated with growing-season convection storms drove the fire regime for the Coastal Plain. Native American influence predominated in areas where lightning ignitions were low (Pyne 1982); in portions of the landscape such as floodplain islands that are naturally isolated from fires on uplands (Harper 1911), or in more dissected topographic regions where lightning ignitions were high but fire compartments were small.
5. Landscape factors, such as fire compartment size, control fire frequency.
6. Landscape factors, such as landscape position, slope, aspect and soils, control fire intensity through effects on both vegetation and fire behavior.
7. Frequent fire vegetation and nonpyrophytic vegetation do not abut each other without some interaction. In the natural landscape there are fire-tension zones ranging in width from a few meters to several miles. Many rare species and important vegetation types, such as mixed pine savanna or pyrophytic woodland, were found only in such zones.

TABLE 1. Physical and Biological Components of Landscape Fire Ecology. Characteristics that affect fire frequency, fire intensity and fire effects on vegetation.

PHYSICAL

___Fire compartment size.
___Corridors and windows for fire flow between fire compartments.
___Orientation of fire compartments and corridors to the prevailing winds during fire season.
___Fire shadows.
___Distance from nearest firebreaks.
___Fire filters—landscape and vegetation features that temporarily reduce fire intensity or rate of spread.
___Soil texture. In flat landscapes, soil texture can control fire frequency and fire effects through its influence on vegetation. There can be found 'islands' of mesophytic communities on moist clay soils in a sea of pyrophytic vegetation.
___Depth to water table (especially outer Coastal Plain and upland flats of the middle and inner Coastal Plain and Piedmont).
___Slope & aspect.
___The soil series. While delimited by humans, and subject to frequent errors in mapping, soil series represent real noda of complex environmental variables in the multidimensional soilscape. The soil series, being much more enduring than vegetation, is the most useful mapping unit for putting boundaries on presettlement vegetation.
___Ignition source, lightning versus Indians.
___Land surface form (Hammond 1964).

BIOTIC (Vegetation)

___Pyrogenicity, the physical and chemical influence of vegetation on fire behavior, mediated by ignitability and fire-carrying capacity of living and dead vegetation, and also by litter decomposition rates.
___Fuel structure of live fuels, standing dead fuels, and litter.

Landscape-scale fire frequency gradients. In general, flat landscapes can be expected to have large fire compartments and a correspondingly high fire frequency. On the Coastal Plain, however, I have seen several situations where, within a single fire compartment, vegetation changed along a fire frequency gradient. In some cases this gradient was long attenuated, extending from a frequent-fire area, to an area with lower frequency, to an area with 100 year fire-return interval or no fire at all. These occur primarily in peatlands or areas in Florida where fire flow is obstructed by numerous small lime sinks deep enough to hold water during fire season.

Evaluating Firebreaks
Factors listed below are considered when evaluating streams, swamps and steep slopes as potential firebreaks or as fire filters (factors that slow down the rate of spread, increasing the probability for fire to go out with rain events or night time humidity).

Firebreak factors are evaluated under the assumption of conditions of an average uncontrolled wildfire in presettlement vegetation—warm, dry, conditions with light to medium winds such as occur frequently during spring fire season. Severe burning conditions are not considered since effects of all but the largest firebreaks as well as of fire filters and fire compartment size become irrelevant.

Quality of channel:
Width of standing water in channel (ft).
Topographic factors:
Depth to which channel incised below floodplain or slope toes.
Channelized or ditched?
Incised more deeply as the result of anthropogenic erosion?
Quality of floodplain:
Continuity:
___Channels, ponds & oxbows increase fire filter effect? (1-5)
___Wet microtopography create a fire filter effect?
___Present or past impoundment effects?
Quality of floodplain litter fuels:
___Continuity of fuel (1 continuous-4 almost too patchy to carry, 5 absent or won't carry)
___Fuel types
___Depth of litter fuels (cm)
___Structure of litter fuels
___Longevity of litter fuels (1-5) before flood removal or decomposition to non-fuel
Quality of shrub layer fuels:
___Fuel species
___Fuel species dense enough to carry fire? (1-3)(1 unlikely, 2 likely under moderate burning conditions, 3 would carry fires under typical wildfire conditions).
___Likely fire intensity based on fuel density under presettlement fire regimes (1-5)(1 barely competent to carry fire, 3 moderate intensity fires such as those in bottomland canebrakes hot enough to carry cleanly but without enough intensity to kill canopy trees, 5 high intensity canebrake or pocosin fires with potential to produce 40 ft flame lengths).
Quality of side slopes:
___Elevation from floodplain to top of slopes (feet)
___Slope percent.
___Potential transport of firebrands/glowing leaf parts across firebreak? (1-5 with 1 lowest)

Continuity of firebreak (are there fire channels or places where fire could cross an otherwise good firebreak?

TABLE 2. KINDS OF EVIDENCE FOR PRESETTLEMENT FIRE FREQUENCY AND PRESETTLEMENT VEGETATION

Asterisks indicate degree of usefulness, with four being most valuable.

LANDSCAPE AND ENVIRONMENTAL FACTORS:

****	Original fire compartment size.
***	Presence of fire barriers and fire filters: landscape factors, which resist flow of fire between compartments (steep slopes, water bodies, and certain vegetation and soil types).
***	Soil maps and observations of fire behavior on different soil types.
**	Lightning ignition records.
*	Records of size of area burned by wildfires.

HISTORICAL EVIDENCE:

****	Early survey plats with witness trees, verbal descriptions of vegetation, and vegetation sometimes sketched on survey plats.
****	Historical records mentioning fire frequency indicator species and indicator vegetation types.
**	Historical references to fire or fire frequency.
**	Historical references to use of fire by Indians.
**	Vegetation on old photos and aerial photos.
*	Palynology and varved lake sediments.

EVIDENCE FROM REMNANT NATURAL VEGETATION

****	Observations of vegetation structure, by layer, under known fire regimes.
****	Fire scar dating.
***	Studies of vegetation response to fire exclusion (on each soil series).
***	Vegetation response to reintroduction of fire (on each soil series).
****	Presence of remnant fire frequency indicator species.
***	Presence of remnant fire frequency indicator communities.
****	Presence of fire-refugial species with individuals old enough to predate fire suppression.

TABLE 3. FIELD METHODS (for each soil series)	
1.	Verify soil taxonomy in the field and correlate soil with vegetation types.
2.	Assemble complete species list by vegetation layer (canopy, subcanopy,
	shrub layer, herb layer). Make cover estimates by layer to gauge degree of
	woody succession. Record existing community type and make preliminary
	estimate of presettlement community type.
3.	Examine vegetation change along local soil, moisture and fire frequency
4.	gradients.
5.	Determine recent fire history from fire char, fire scar cores, shrub stem age
	classes.
6.	Determine extent of human disturbance history, including any evidence of
7.	turpentining, logging, grazing and fire suppression.
8.	Determine fire compartment size.
9.	Assign first estimate of presettlement fire return interval.
10.	Determine number and effectiveness of natural firebreaks.
	Collect any local and regional records of original vegetation.
11.	Assemble any historic and recent vegetation records and studies from other
	parts of the southeastern landscape that may apply.
12.	Record any fire-frequency indicator species, either extant or in the historical
	record and map them onto the specific soil series on which they are or were
13.	found.
14.	Assign tentative estimates of recent fire frequency and revise original fire
15.	frequency estimate.
	Assign tentative estimates of presettlement vegetation type and species
	dominants.
	Determine variation, if any, by slope and aspect.
	Determine range of variation in vegetation between pedons of the same soil
	series within the study area.

A complete list of all species present on each soil pedon examined was compiled; unknown specimens were pressed for herbarium identification. Cover values were obtained for each stratum. The following ten cover classes, defined by the North Carolina Vegetation Survey (Peet et al. 1998), were used for plots on Fort Stewart:

COVER SCALE			
10	95-100 %	5	5-10
9	75-95	4	2-5
8	50-75	3	1-2
7	25-50	2	0-1
6	10-25	1	Trace (as with one seedling, no appreciable cover)

Cover area for each species, by layer, was estimated for an area of about 100 meters square and then adjusted while wandering through the plot. The species lists and cover values are roughly equivalent to those that would be obtained from 1/10 hectare plots.

Synthesis and Mapping

After obtaining soil photomaps and assembling the historical data, the method consists of the following major steps. Plant taxonomy generally follows Kartesz (1994). Following are some guidelines for this stage of mapping.

1. Approximating presettlement community types.
a). Sample remnant natural vegetation on each soil series in the area under study, according to the scheme in Table 23 above. This should include burned examples if fire is believed to have played a role in presettlement vegetation. If some series have no natural remnants, then sample remnants on the same soils in any nearby counties for which they are available.
b). Watch for fire frequency indicator species (such as pitcher plants, wiregrass (*Aristida beyrichiana*), wet savanna species, and fire-frequency indicator communities (like canebrake, *Pinus glabra* or magnolia forest), both in the field, in herbarium records, and in the historical record. Each site for these indicators can be assigned a fire frequency, based on the known range of fire frequency tolerance or intolerance for each species. Adjust these figures slightly upward or downward depending upon soil type and topographic situation and degree of fire shelter or fire exposure for each specific occurrence.
c). Build species lists and make cover estimates by layer (canopy, subcanopy, shrubs, herbs, vines) for all communities on each soil series, under natural fire regimes, and under fire suppression. Learn to recognize the degree of fire suppression for each.
d). Record evidence of successional changes resulting from fire exclusion, reduction in fire frequency or change in season of burn.

2. First approximation vegetation map. Decide upon appropriate mapping units like hardwood hammock, pine savanna, or canebrake, and assign vegetation types to each slope class of each soil series. Group related soils with similar vegetation and assign a color to each group on GIS.

3. First approximation presettlement fire frequency map. Using a copy of the soil series base map, plot all known existing or historical fire indicator species and communities. This should begin to yield a picture of the regional pattern of fire regimes. Where data are scarce, it is useful to reconstruct fire frequency over the larger region that includes the study area. Since there will then be many more examples found, the information can be extrapolated to portions of the study area where information is lacking. Threading contours along lines of equal fire frequency will produce something like a topographic map, only the isopleths will represent different fire-return intervals, or different levels of fire effects, rather than elevation. Alternatively, fire frequency can be mapped by fire compartment.

4. Second approximation vegetation map. Compare the first map of vegetation with the first fire frequency map. At this point some adjustments can be made and areas needing more fieldwork will become obvious. Return to the field to resolve any apparent discrepancies, such as frequent-fire vegetation types and non-pyrophytic vegetation that occur in immediate proximity (this may not be an error—there may just be a locally steep fire-frequency gradient). Pyrophytic wetlands usually require further work because they may have more than one vegetation type on the same soil series. The effects of local natural firebreaks may need to be investigated.

5. Readjust the vegetation map, using the new field data.

6. Refine the fire frequency map, using any new fire frequency data and the adjusted vegetation map.

7. Return to the historical record for discussions or information that may be better interpreted now, after the questions are better known.

8. Refine both the presettlement vegetation and fire frequency maps, using any new insights from the historical record. At this point there will probably be more field questions to answer. There may be more iterations of steps 5, 6, 7 and 8 before a final map is arrived at.

APPENDIX
DARE MAINLAND PLACE NAMES
from 1:24,000 topo maps and historical sources

√ = place known to be on mainland Dare. Other names from nearby areas are included for orientation on history survey plats.
^ = place known to be outside mainland Dare.
* = name appears in earliest records of settlement.
NE - capital letters are abbreviations for general locations on mainland Dare (NE = Northeast).
See the text for names of historic inlets on the banks opposite the eastern shoreline of the Dare peninsula

Towns, Creeks, Rivers and unusual, locatable PLACE NAMES:

Back Lake (Lake Worth) SE – A small blackwater lake, isolated in the peatlands W of Stumpy Point Bay , to the west of a small community called Lake Worth on Stumpy Point Bay.

Bay Point NW – A point of land on the Alligator River between Cypress Point and Laurel Point.

Beach (originally likely Beech) Land Landing (Central) – land on the S side of Milltail creek near the head of navigation. There never was a beach at this landing, the creek being bordered by the deep Pungo muck. There were just a short distance from the shoreline, however, two isolated bodies of mineral soil that, before sea level rise, would have been dry enough and sufficiently fire sheltered to support some beech.

Boat Bay W central – a lobe of Milltail Lake, extending to the SE.

Boranges Point N – Divides East Lake form South Lake.

*Briery Hall Point NW – A point of land on the Dare mainland opposite Lake Point on Durant Island. Divides South Lake from Alligator River

*Briery Hall. Named prior to 1748, a tract of land referred to on an adjacent tract granted to Benjamin Cowell deed of 6/28/1748.

*Broad Creek NW – a short oligohaline marsh creek and narrow bay. Arises in the Briery Hall peninsula and flows NE into South Lake near its confluence with East Lake.

*Buck Ridge (and Mulberry Ridge) S of the South Lake arm of East Lake (water body) and N of East Lake community, see Benjamin Cowell deed of 6/20/1769.

Buffalo City – former community on "high" ground on N side of Milltail Creek. Settled 1888, Named for former sawmill, Buffalo City Mills.

Callaghan Creek E central – Arises E of US 264 just S of Manns Harbor and flows NE into Croatan Sound just S of the mouth of Spencer Creek. See George Caroon on Durants Creek that may be an early name for one of these small marsh tributaries)

*Caroon Point NE – Extreme NE point on Mainland Dare, at S end of Mashoes. Named for an early settler George Caroon who bought land on Durant's Creek.

Clark Creek SE – tiny salt marsh creek on N side of Long Shoal River, just upstream from Pain's Point.

*Croatan – the name of the dry land at Manns Harbor as shown on early survey maps.

Croatan Sound E central – The strait between Mainland Dare and Roanoke Island, connecting the Albemarle Sound with Pamlico Sound.

^Catfish Point W – Point on N side of mouth of the Frying Pan in east-central Tyrell County.

Cypress Point W – Point on extreme W mainland Dare, near midpoint of Alligator River.

Davis Pond NE – A small, brackish lake between Reeds Point and Peter Mashoes Creek. The pond is surrounded by marsh and may have been a bay before being barricaded by a sand berm created by winds from northeast storms.

*Deep Bay NW – A short arm of South Lake, just W of Briery Hall Point.

Deep Creek (S central) – A short arm of Long Shoal River arising on the NE side of US 264 and draining SW into Long Shoal River.
Deep Creek NW – on W side of South River W of Alligator River See plat 4 where the word "Lake" is also inserted under South River.
Deer Creek N central – A short, southward-extending arm of South Lake, just W of the confluence of Hookers Gut and Northeast Prong.
Drain Point SE – Point of land on N side of Stumpy Point Bay at its confluence with Pamlico Sound.
*Durant Island NE – On NE end of mainland Dare between the Alligator River and Albemarle Sound. Name may also be spelled Durrance on some old docs.
*Durants Creek (no loc) – on shuck (no plat or deed book info avail) for George Caroon (340 a + see Caroon Point above).
*East Lake N – bay between Durant Island and mainland Dare.
East Lake NW – Small community along US 64.
East Lake Landing NW – Boat landing on the Alligator River just N of the US 64 bridge.
Fleetwood Point NE – Point on E side of Manns Harbor, E of intersection of US 64 and 264. Before they were eroded away by late 19th and early 20th century sea level rise, the marshes at this point once extended so close to Roanoke Island that voices could be heard on the other side (pers. comm, Harry Mann).
Gar Gut NE – a tiny marsh creek on the S side of Peter Mashoes Creek.
Halfway Point W central – a point on Milltail Creek about half way from its origin and mouth.
*Haulover Point N – Extreme northern point of Mainland Dare. Just E of the E tip of Durant Island.
Hooker Gut N – The S arm of South Lake, arising just N of US 64 and draining NW.
Kazer Point SE – A point of land representing the former rim of Stumpy Point Lake, now eroding away with rising sea level.
Lake Neighborhood NW – Small community between East Lake community and South Lake. Only one or two houses and a church remain.
Lake Point NW – The southernmost point of Durant Island, at the confluence of East Lake and South Lake.
Lake Worth SE – a community on the W shore of Stumpy Point Bay.
*Laurel pocosin NW – from Benjamin Cowell's survey 1753 (near Laurel Point?)
*Laurel Point NW – A point of land on the Alligator River between Bay Point and the US 64 bridge.
Long Point N – A point of marsh at the confluence of the northern and southern arms of East Lake.
*Long Shoal River SE – Forms a portion of the SE boundary of Dare County. Arises at the Dare County Bombing Range (which is on the divide between Long Shoal River and Whipping Creek) and flows SSE into the Pamlico Sound.
*Long Shoal Point SE – A point of land on the S side of Parched Corn Bay, forming the extreme SE point of land in mainland Dare county (not contiguous with Long Shoal River).
Long Stretch (central) – The narrow upper portion of Milltail Creek.
Manns Harbor NE – Small community on the Croatan Sound. At 3-6 feet above sea level this location represents the largest area of mineral soil on mainland Dare available to early settlers.
Mashoes NE – Small community in extreme NE mainland Dare near Caroom Point. John White's map of 1585 shows an Indian village called Mashawatoc somewhere in this vicinity (Powell 1968).
Mill Creek – name of Milltail Creek on
Milltail Creek W central – arises just N of the Dare County Bombing Range near the very center of mainland Dare, flows NW in to Milltail Lake and W into the Alligator River.
*Mulberry Ridge (and Buck Ridge) S of the Lake (N of East Lake community) See Cowell deed of 6/20/1769.
Muddy Creek S – Sort salt marsh arm of Long Shoal River on E side near its mouth.
Ned Bees Point N – Point of land on the N side of Durant Island, between Tom Mann Creek and the Albemarle Sound.
Northeast Prong N – An arm of South Lake, arising N of US 64 and draining SW to its confluence with Hooker Gut.

Old Point SE – Point of land in Pamlico Sound due E of town of Stumpy Point.
*Pains Bay SE – Last bay on Pamlico Sound at extreme SE corner of mainland Dare, just E of the mouth of Long Shoal River. Surveyed for Thomas Pain in 1765. Labeled Back Bay on the land grant survey plat.
*Pains Point SE – point marking the boundary between the Long Shoal River and Pains Bay.
Parched Corn Bay SE – bay on Pamlico Sound just N of Pains Bay. Origin unknown: the name suggests that there may have been land there dry enough for corn to have been planted by Indians or early settlers.
Parched Corn Point SE – divides Parched Corn Bay from Sandy Bay to the N.
Peter Mashoes Creek NE – A small bay between Croon Point and Reeds Point.
*Poplar Ridge Point SW – A point on the Alligator River N of the mouth of Whipping Creek. Soils there are deep mucks but the name suggests that there may have been a low ridge of mineral soil that has now eroded away with rising sea level.
Poster Gut NE – A small brackish marsh creek on the south side of Mashoes Marsh.
Raccoon Pont W central – a small point on the W side of Milltail Creek Lake.
Rawls Island SE – tiny marsh island in Pamlico Sound at the mouth of Pains Bay. Marks the extreme S point of mainland Dare.
*Redstone Point NE – Point N of Manns Harbor at site of old US 64 bridge. Name apparently refers to the reddish color of a low cliff of Pleistocene soils. Iron minerals in the subsoils of the Aquods and Ultisols of the eroding shoreline along Manns Harbor would account for the color. The cliff would have been more prominent in Colonial times before rising sea level inundated some three feet of its original elevation.
*Reeds Point NE – Point of land between Caroon Point and Redstone Point, opposite Northwest Point on extreme NE Roanoke island. The name may refer to the original zone of canebrake (called reeds, not cane, in colonial times), visible behind the shoreline marshes when seen from the water.
Roanoke Marshes – long stretch of brackish marshes along the Croatan Sound, S of Mann's Harbor.
Sandy Bay SE – Bay on Pamlico Sound S of Stumpy Point Bay and N of Parched Corn Bay.
Sandy Point SE – A point of land just south of Wild Boar Point and Stumpy Point Bay.
Sandy Ridge NW central – A narrow, NE/SW extending ridge of Baymeade and Ousley sands surrounded by wet soils with organic epipedons. The "ridge" is only 2-3 feet above sea level and 1-2 feet above the surrounding swamp.
Sawyer Creek NW central – Arises S of US 64 and flows SW into Milltail Creek.
Sawyer Lake NW central – A small lake forming the origin of Sawyer Creek.
Sound Point NW – The westernmost point on Durant Island. Marks the boundary between the mouth of the Alligator River and the Albemarle Sound.
*South Lake (South River) – an arm of East Lake originating in N central mainland Dare, draining NW across US 64and emptying into the Alligator River near its mouth on the Albemarle Sound.
*South River name used on plat 4 for South Lake, also "the South Fork of the lake".
Spence Creek NE – A small brackish marsh creek just N of Peter Mashoes Creek.
Spencer Creek NE – a brackish marsh creek arising on the S side of US 64/264 W of Manns Harbor and flowing SE into Croatan Sound.
Swan Creek SW – Arises in Hyde county and flows NW into the Alligator River just N of the Dare county line.
Stumpy Point SE – Fishing community on the N side of Stumpy Point Bay.
*Stumpy Point SW – Point of land on the Alligator River between Poplar Ridge Point and Cypress Point
*Stumpy Point Bay SE – Bay on S side of community of Stumpy Point and east side of US 264 S of the confluence of Croatan Sound and Pamlico Sound. On the Moseley map of 1733 it is shown as a lake with a narrow connection to the Pamlico Sound. Looking at the series of early maps of the region, the change from an isolated lake, to a bay with a widening connection to the sound, to the bay with a mouth about 2 miles wide today, can be traced.
The Frying Pan N – A small bay between Haulover Point and East Lake (check shape on historical maps).

^The Frying Pan W – Bay in central Tyrell County on W side of Alligator River.

Tom Mann Creek N – A small Bay of the Albemarle Sound on the N side of Durant Island. The name suggests that, like the expansion of Stumpy Point Lake into Stumpy Point Bay, shoreline erosion associated with rising sea level has flooded the original creek.

*Whipping Creek SW – Drains the SW corner of the Dare County Bombing Range near the head of Long Shoal River and flows NW, S and W into the Alligator River.

Whipping Creek Lake SE – a small lake, oriented north/south, on the southward-dipping portion of Whipping Creek.

Wild Boar Point S – Point of land on S side of Stumpy Point Bay at its confluence with Pamlico Sound.

APPENDIX. Article on logging history at Buffalo City

THE VIRGINIAN-PILOT
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DATE: Sunday, October 2, 1994 TAG: 9409300159
SECTION: CAROLINA COAST PAGE: 16 EDITION: FINAL
TYPE: Cover Story
SOURCE: BY LANE DEGREGORY, STAFF WRITER
DATELINE: ALLIGATOR RIVER NATIONAL WILDLIFE REFUGE LENGTH: Long : 251 lines

BUFFALO CITY ONCE IT WAS DARE'S COUNTY'S LARGEST SETTLEMENT. IT WAS A THRIVING CENTER FOR LOGGING. WHEN THE FOREST GREW THIN, PROHIBITION BEGAN AND THE LOGGERS TURNED TO PRODUCING MOONSHINE. BUT LIQUOR BECAME LEGAL. THE CITY FELL ON HARD TIMES. NOW IT IS BEING RECLAIMED BY THE SWAMP.

ABOUT 60 FEET from the main dirt road, faint, sandy tracks fade into a pine and sweet gum forest. Joe Hassell slows his trek through the waist-high weeds, then squints and scans the undergrowth. He's trying to find his family home. Moist and marshy - blanketed thick with decaying leaves and pine needles - the forest floor offers few clues. Town streets have composted into nothingness. Houses and hotels have long since crumbled and rotted away. Hassell works his way toward the roof of a former barn, or stables. An inch-thick copperhead slithers out.

Nature has reclaimed what once was Dare County's largest community. Memories are all that remain of Buffalo City. ``It's kind of weird, really, walking around in here again and seeing it all gone," Hassell said after escaping the snake. The 63-year-old retired engineer now lives in Manns Harbor and owns a commercial cleaning company. He spent his first 13 years in Buffalo City.
``It makes me feel funny that there's nothing left at all. Nothing to show my grandchildren," Hassell said of the empty forest. ``At least nothing they would get out of the car to see.
``This is downtown," he explained, pointing into twisting vines and 40-foot trees. Even the train tracks which carried seven locomotive engines down Main Street have broken and become overgrown. Only a few rusty rails remain.

There is little evidence of the once-lively logging town. But just 75 years ago, more than 3,000 people lived in Buffalo City. Shortly after the Civil War, Buffalo Timber Co. of New York purchased more than 100,000 acres on the Dare County mainland. About 19 miles west of Manteo, off what is now U.S. 64, company officials carved a path through the swampy forest stretching two miles south of the current East Lake Community Center.

There, in the wilderness, local black laborers and more than 200 Russian immigrants constructed a logging town. Buffalo City was born. Located on the north bank of Milltail Creek, the town was owned and operated by New Yorkers. Some Albemarle-area families moved there for jobs, and stayed. At least half of the workers were immigrants shipped by steamboat from up North.
The forest, back then, was filled with ancient trees. Juniper was the most profitable wood. Some trunks were more than six feet thick.

The operation became the largest logging industry in northeastern North Carolina.

On Oct. 11, 1889, Buffalo City's first post office opened. National Archives records show Charles A. Whallou distributed the mail. The post office closed in 1903.
``That Buffalo company logged the whole place clean out and left," said Hubert Ambrose, 73, who lived in Buffalo City from 1926 until 1939. He, too, now lives in Manns Harbor.
``Some of the people stayed and farmed on Sandy Ridge, nearby. Others went back North, I guess," Ambrose said. ``I didn't get there until it was already going again. My father worked on the railway line. Later, he and Mama ran the main hotel."

In 1907, Dare Lumber Co. bought the forest and re-established the booming log town in the middle of nowhere. The post office reopened Feb. 29, 1908. It kept the name Buffalo City, although the new town was called Daresville. Hassell and other later-day inhabitants, however, still refer to their hometown as Buffalo. When I was a kid, seemed like sawdust filled everything," said Hassell, whose father and grandfather worked for Dare Lumber Co. in the 1920s and early '30s. ``They planked the outsides off trees and laid those down as streets. Filled in on top with sawdust. You had to, the ground was so soft. There's a lot of tricky walking through the swampy stuff. You're liable to slip into a 10-foot hole if you don't watch your step."

The town was laid out along three ``pole roads" running perpendicular to Buffalo City Road - the 10-foot-wide dirt stretch between East Lake and Milltail Creek. A fourth log-lined road curved around the community's north end to the pulp mill. That's where Hassell lived. ``Roads were about 150 feet long, if that, and lined with double-planked houses on both sides," he said. ``Houses were made from the lumber they couldn't sell, just slapped up so the folks'd have something to live in. When the boards dried, they had cracks all across the walls. Only heat was from a stove. We used the same one for cooking and heating. Fed it all day long with wood.

``We had outdoor wells for water, no electricity, and used outhouses. Oil lamps gave us light. Most folks rode horses. Granddaddy had one of the only cars in town, an old Model T. During the Second World War, when they rationed gas, he ran that thing on whisky and kerosene. It'd keep on chugging 10 minutes after you shut it off," Hassell said. ``For play, us kids used to climb this 50-foot pile of sawdust behind my house. Called it `Sawdust Mountain,' 'cause it was the tallest thing any of us'd ever seen." Small garden plots yielded fresh vegetables. Pigs, cows and chickens provided fresh meat. Pike, bass and ``humongous" catfish swam all through the creek.
A railroad cut through the center of Buffalo City and ran along 100 miles of track. The locomotive engines were shipped in on barges. From logging camps deep in the woods, mules dragged timber through the forest to the railroad. Then freight cars carried 100,000 feet of pine a day to loading docks at Milltail Creek. At a huge transfer station spanning the waterway, workers dropped the logs onto barges. Boats transported the lumber - including about 50,000 feet of juniper weekly - to Elizabeth City mills.

Workers made about 50 cents a day. ``They paid you in plug money. Made it out of aluminum in 5-cent to 5-dollar pieces. And it only worked in town," Ambrose said. ``There was no way in or out of there except by boat. Didn't need money for anywhere else, really. All the supplies were brought back by the barges." Lumber company officials owned most of the houses - and the country store, sawmill and hotel. So workers' wages went right back to the people who paid them.
``They'd give you a piece of brass with a hole in it to wear on your key ring. Called it a check. Said `Dare Lumber Co. (NU)5' on the side. That was your voucher at the community store. You had to buy groceries there, so that came out of your pay. Sometimes, at the end of a week of work, you'd wind up owing them money," Ambrose said. ``The company store really owned you."
Although there was only one store, the town was split into two sections, Ambrose said. Black, Russian, Japanese and other immigrant workers lived in white-washed houses and had a separate hotel and church. White workers lived closer to the center of town, in homes painted red.

One school on Main Street served all of the children until 1926, when a cigarette caught it on fire. Then, classes were held in the church. By the 1930s, Hassell and about a dozen other Buffalo City youth were hiking two miles to East Lake school.

``You'd sink to your thighs in muck along the way. But we always had clean clothes for school," Hassell said. ``Someone would drop them off for you at the beginning of the week and leave them in your locker: a wooden box nailed to the wall. Then you'd change before class - and for the long hike home." About 30 children attended the one-room school in the current East Lake Community Center. A single teacher taught 10 grade levels. Pupils were promoted by moving closer to the front of the room.

``There were no doors or nothing. But no one stole. And everyone behaved," said Hassell. ``Buffalo City didn't have police, a mayor or elected officials. But it had rules."
In the center of town, Hassell said, a wooden stockade awaited violators of the community's rigid moral standards. Once, as a boy, Hassell said he watched a man get locked in the stockade and ``whipped by a cat-o'-nine-tails." The crime was cussing in front of a child. ``That was a Saturday afternoon thing, watching people get punished," Hassell said. ``They'd whip 'em 'til the blood ran down their backs. Leave them locked in there for up to two days. Make a 250-pound logger cry."
Hassell said he never saw a woman whipped, although one was driven out of Buffalo City.
``Men were stopping by her place afternoons," he said. ``The wrong husband dropped by on his way home from the mill. All the women chased that lady out of town, running behind her shaking sticks."

More uplifting entertainment could be found at town square dances on Saturday nights; street dances where fiddlers, banjo players and jew's-harp musicians entertained; or along the waterfront where showboats sometimes docked for weekend performances - and men came from miles around to drink the homemade moonshine.

Buffalo City's logging industry continued to strive through the 1920s. When prohibition went into effect in 1920, the town had more than 2,000 residents. When the stock market crashed in 1929, the town barely noticed. Moonshine made on the Dare County mainland was sold in speakeasies from New York to Chicago. ``More whisky was made in Buffalo City than anywhere else in the country during the 1930s and early '40s," Hassell said. Ambrose agreed. ``There weren't no Depression in Buffalo City. I remember that Black Friday, hearing about it," he said. ``But as long as bootlegging went on, there weren't no Depression.
``Logging started dropping off just about the time the government made liquor illegal. Men were hunting deer, keeping bees and shipping geese and duck up North. But they had to do more to make money," said Ambrose. ``They made barrels and barrels of moonshine." Almost every family had its own still, said Hassell, whose grandfather and father shipped some of the largest loads of liquor from Buffalo City's creekfront landing. Clear, strong moonshine was distilled from corn, sugar and other materials - mashed into a pulp and filtered through copper tubing and charcoal beds. ``Granddaddy'd pour that stuff onto the ground and strike a match into it," Hassell said. ``If it didn't burn blue, it weren't no good."
The moonshine was made deep in the woods, near former logging camps, transported on mules and by barges - same as the lumber. It was stored in 5-gallon glass jugs sealed with corks and wax. Bottles had to be air tight for transportation. Women watched the woods and roads for revenuers.
``There was a 30-foot boat carried that whiskey to Elizabeth City, then brought back all the sugar it could hold," Hassell explained. ``If they got caught by revenuers, everybody in the community had put their name in for 100 pounds of sugar. That way, no one would get found out."
Moonshine jugs were tied on ropes and dragged beneath Milltail Creek's surface, behind barges. About 20 jugs tied together were called a raft. Barges carried two to three rafts per trip, making one or two trips per week. If law enforcement officials showed up, loggers would cut the ropes. Liquor sank to the cypress swamp's dark bottom. ``There are still rafts of them, I know, down there," Hassell said. ``If you could find just a few of those jugs, they'd still be good. You could retire." In the 1930s, Ambrose said, each jug fetched about $6 cash.

``I never could figure out why it took Daddy and them three days to get to Elizabeth City and only one to get back," Hassell said. ``Then, I found out they were moonshining. ``It was the best liquor in the world, sold in 80 to 110 proof," Hassell said. ``If you didn't make whiskey back then, you starved to death. Instead, a lot of moonshiners ended up getting rich." Some, however, also got caught. Revenuers eventually got wise to the liquor-making loggers. At least three town men were tried, convicted, and sent to federal prison. Liquor became legal again in 1933.

Although most good timber had long since been felled, Buffalo City's sawmill continued processing shingles, posts to prop up mines and other special orders through the 1940s.
Cholera, typhoid, smallpox, the flu and an increasing lack of work caused the population to drop below 100 by 1950. The sawmill closed a few years later. Richmond Cedar Works purchased the land, but soon sold it to a farming company. Prulean Farms - a subsidiary of McLean Farms and Prudential Life Insurance Co. - owned a 5,100-acre agricultural operation through the 1970s.
Few artifacts survived the decades of decay. But a 1980 Exxon map depicts ``Buffalo City" as if it were a destination on the dead-end dirt road. Today, only two privately owned hunt camps remain standing.

In 1984, the U.S. Fish and Wildlife Service acquired the 118,000-acre area as a tax donation from Prudential. Alligator River National Wildlife Refuge now encompasses the forest and former logging community. Last week, two hiking trails and more than 15 miles of marked canoe/kayak trails opened along Milltail Road beside and in the wide cypress swamp. Bayberry bushes dipped into the coffee-colored water. Lilies bloomed from murky depths. And a few rotten pilings - almost overgrown with lichens and sphagnum moss - are all that are left of the huge railway transfer station. Buffalo City is nowhere to be found. Even broken bottles and boards from crumbled buildings are difficult to discern in the decaying debris. The forest has completely reclaimed the former logging town. ``I'd like for the public to be able to come out and see what was Buffalo City," Hassell said sadly. ``But I guess it's too late. Everything is already gone.
``I'm glad the government got this land, though," he said. ``I'm glad this forest won't be clear-cut no more. I'm tired of seeing all those big trees go. And I know I won't live long enough to see them all grow up again."