Chapter 2: Currituck Banks Component

2.1: Environmental Setting

The Currituck Banks component of the NCNERR is the northern most component and is the only component located in the Virginian biogeographic province. Currituck Banks encompasses 960 acres (3.9 km^2) in the northeastern corner of North Carolina's northern Outer Banks in Currituck County. The Reserve property lies just north of the unincorporated village of Corolla, ten miles (16 km) south of the Virginia border. The nearest population center is Elizabeth City, N.C., approximately 20 miles (~32 km) to the west. The Nature Conservancy and U.S. Fish and Wildlife Service properties bound Currituck Banks to the north, the Atlantic Ocean to the east, the Currituck Sound to the west, and private subdivisions to the south (Figure 2.1). Currituck Banks is located in the Pasquotank River Basin. Currituck Banks was one of the three original NERRS components dedicated by NOAA and DCM in 1985 (Masonboro was added in 1991). Currituck Banks is accessible by foot traffic and boat however no boat ramp or dock is available within the Reserve boundaries. The northern portion of the Reserve is accessible only by four-wheel drive along the beach corridor after N.C. 12 terminates at the beach access ramp. Two walking trails exist at the southern portion of the property just off state route N.C. 12 where public parking and handicap access is available.

2.2: Historical Uses

A: Native American Usage

Before the European settlement of northeastern North Carolina, the area now known as Currituck County was home to the Poteskeet Indian Tribe. Although the Poteskeet's main village was located on the mainland, they used the northern Outer Banks, including the area now within the Reserve, as hunting and fishing grounds. Oyster shell middens and pottery fragments found at several locations in the northern Outer Banks are evidence that the Poteskeet used this area (Gale 1982). As English colonists began to settle in the area, documents dictate several nonviolent disputes over territory with the Poteskeet. By 1730, the Poteskeet had mostly disappeared from the Currituck area (Gale 1982).

B: Colonial Uses

In 1584, the English made their first attempt at settlement in the New World on Roanoke Island, approximately 42 miles (67.5 km^2) to the south. Despite the failure of this first colonization attempt, the English made a permanent settlement in southeastern Virginia. From there, the English began spreading to the south and settling in Currituck by the late seventeenth century. Like the Native Americans, the English also lived on the mainland. They used the banks for feeding livestock, fishing and hunting (Gale 1982).

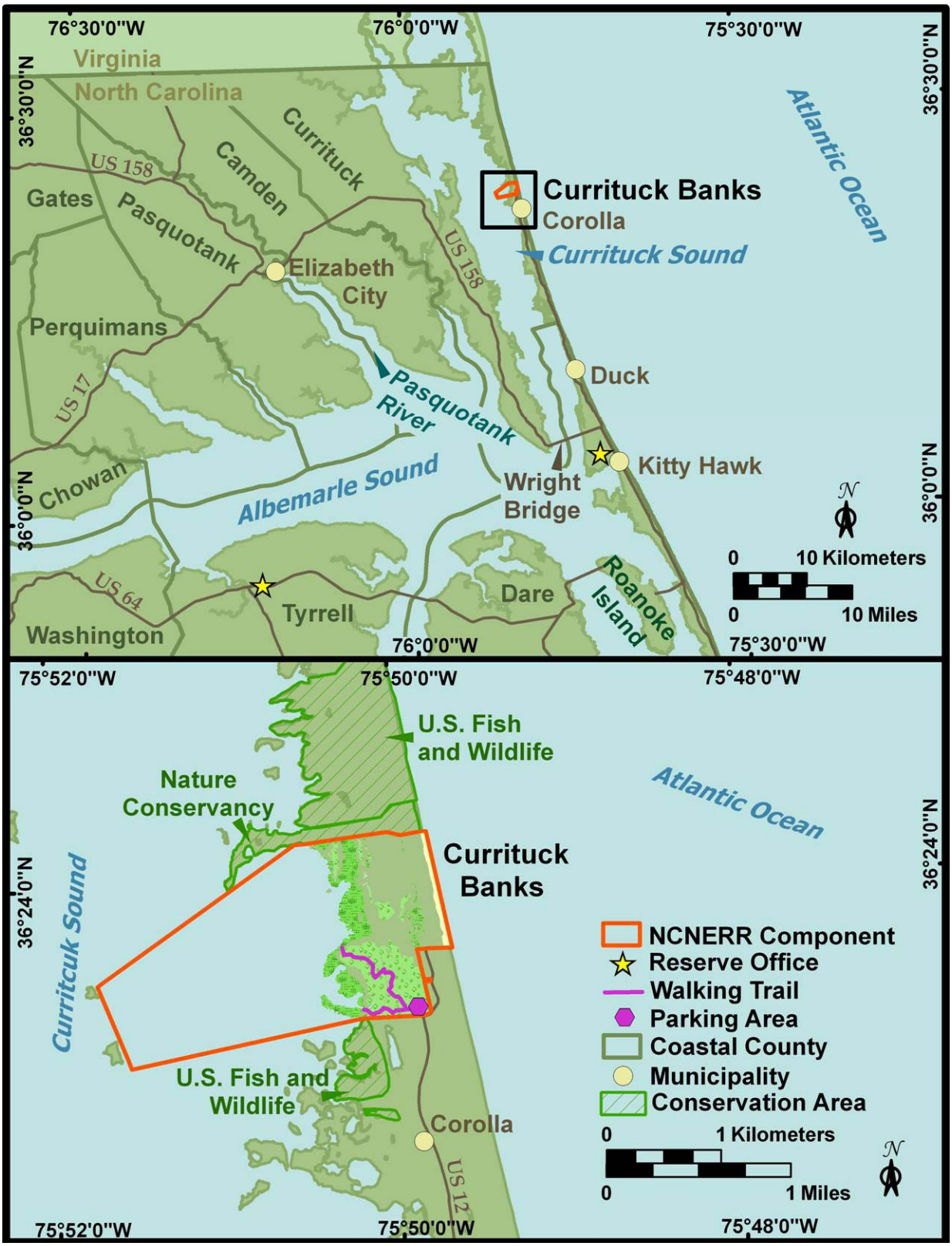

Figure 2.1: Currituck Banks location. The bottom panel shows a close-up of the Currituck Banks Reserve Component.

C: Waterfowl Hunting

Many ocean inlets existed throughout the history of the northern Outer Banks, however, by 1828, New Currituck Inlet, the last of the inlets, closed. This caused a transformation in the Currituck Sound from a high salinity estuarine environment to a low salinity estuarine environment (see Section 2.4). Along with this change, shellfish beds began to vanish; increased growth of SAV began and brought with it an increase in waterfowl to the area. Because of this increase in waterfowl, the area became known throughout the nation as a prime waterfowl hunting ground. This began the development of many hunt clubs in the area. The first of these hunt clubs was the Currituck Hunting Club in 1857. Most of these clubs were made up of wealthy nonresidents. The clubs assembled large tracts of land to preserve waterfowl feeding areas and to ensure a continuous bounty of geese, ducks and migratory game birds. (Gale 1982). During the Civil War and the years after, many people visited Currituck and enjoyed dinners of ducks and geese killed in Currituck Sound (Bates 1985). Around 1870, inquiries began coming in for available waterfowl to be shipped to large northern cities and the commerce was welcomed (Bates 1985). By the mid 1900s due to hunting pressure and declines in the SAV, the populations of migratory birds declined dramatically in Currituck sound, and the use of the area as a hunting ground also decreased.

D: Life Saving Stations and Lighthouses

During the 1800s many ships wrecked along the North Carolina coast. The federal government launched a two-part program to build lighthouses with powerful lights close enough to give ships continued guidance and to assist sailors by providing life saving services. This forerunner to the Coast Guard, called the U.S. Life Saving Service, was established in 1874 (Mobley 1994). Life saving stations were constructed and the U. S. Light House Board began erecting lighthouses to help mariners navigate the treacherous waters off the Outer Banks. The region near Currituck Banks had both a life saving station and a lighthouse (Mobley 1994). In 1873, construction began on the Currituck Beach Lighthouse. The lighthouse was completed and lit on December 1, 1875. In 1874 the Jones Hill Life Saving Station was constructed just east of the Currituck Beach Lighthouse site. This station was later renamed the Currituck Beach Life Saving Station as Jones Hill was renamed to Corolla in 1895 when a U. S. Post Office was erected. In 1915 the Life-Saving Service was merged with the Revenue Cutter Service to form the U.S. Coast Guard. Throughout the early part of the 20th century, modern Coast Guard Stations slowly replaced the life saving stations. The Light House Board was transformed into the U.S. Light House Service in 1910 and eventually also merged with the U.S. Coast Guard in 1939.

E: War Uses

The area of the outer banks where Currituck Banks is located was not as heavily used during war time as other areas of the coast. However, during the Revolutionary War, Civil War, and World War II, the area did see some military action. During the Revolutionary War, the Carolina coast was vital to the colonist. The large British ships could not navigate the small shifting sands of the North Carolina inlets. Local mariners could, allowing much needed supplies for the Confederate war effort to be brought in through North Carolina ports. During

the Civil War the North Carolina ports again became critical supply routes for the Confederacy. Most of this activity occurred farther south (see Chapter 3-5) but some skirmishes did occur in the Northern Outer Banks region. Roanoke Island was a Confederate stronghold that was taken by the Union army after a fierce battle in 1862. Union forces held Roanoke Island, and most of the Outer Banks, for the rest of the Civil War (Campbell 2005). During World War II, the U.S. Coast Guard used the area near Currituck Banks as a training ground. Several hundred sailors were brought to the Corolla area. Barracks were built near the lighthouse and former life saving station. The waters offshore of Currituck Banks were used by German U-boats. During the war, residents were instructed to keep their house lights off and windows closed to prevent the U-boat captains from using them as a point of reference.

2.3: Climate

The weather of Currituck Banks is typical of a maritime climate on the Outer Banks where the ocean has a strong moderating effect on temperature compared to the mainland areas. Climatologically, Currituck Banks is classified as Subtropical with humid, warm summers and mild winters. Currituck Banks is 15 miles (24 km) north of the U.S. Army Corps of Engineers Field Research Facility in Duck, North Carolina, where atmospheric and oceanic data are collected (Figure 2.1). The average annual temperature for the region is 62 °F (17 °C). January is typically the coldest month with average daily temperatures (average of day and night) of 44 °F (7 °C) and July is normally the warmest month with average daily temperatures of 80 °F (27 °C). Because of the orientation of the Currituck Banks coastline, direct hurricane impacts are much less than the other more southern Reserve components. Nor'Easters tend to be more important at Currituck Banks because by the time the storms reach the northern Outer Banks they have had time to develop and strengthen. Several tropical systems have impacted the region since record keeping began. Table 2.1 lists the tropical systems that have passed within 65 nautical miles of Currituck Banks since 1955.

Currituck Banks precipitation data was inferred from the climate data available from NOAA for Norfolk, Virginia and Elizabeth City, N.C. The average annual precipitation for Currituck Banks based on data from 1971-2000 is 46.98 inches (119.3 cm). The wettest month is September and the driest month is October (Figure 2.2). The wettest year on record since 1871 occurred in 1889 with over 70 inches (177.8 cm). The driest year on record since 1871 occurred in 1986 with 26.5 inches (67.3 cm) of precipitation (Table 2.2).

Table 2.1: Tropical storms passing within 65nm of Currituck Banks since 1955

Storm	Date	Name	Wind (kts)	Minimum Pressure (mb)	Classification
1	Aug 1955	Connie	70	965	Category 1 hurricane
2	Sept 1955	Ione	65	960	Category 1 hurricane
3	Sept 1956	Flossy	35		Extratropical
4	July 1959	Cindy	35		Tropical storm
5	July 1960	Brenda	50		Tropical storm
6	Sept 1960	Donna	90		Category 2 hurricane
7	Sept 1961	Not Named	35		Tropical storm
8	Sept 1964	Cleo	40		Tropical storm
9	Sept 1964	Dora	50	998	Tropical storm
10	Oct 1964	Isbell	40	1000	Extratropical
11	June 1965	Not Named	30		Extratropical
12	Sept 1967	Doria	55	990	Tropical storm
13	June 1968	Abby	25		Tropical depression
14	Aug 1969	Camille	30		Tropical depression
15	May 1970	Alma	25	1003	Extratropical
16	Aug 1970	Not Named	30	1011	Tropical depression
17	Aug 1971	Doria	55	989	Tropical storm
18	Oct 1971	Ginger	30		Tropical depression
19	June 1972	Agnes	45		Tropical storm
20	July 1979	Bob	20	1011	Tropical depression
21	July 1981	Bret	50	1000	Tropical storm
22	Aug 1981	Dennis	60	997	Tropical storm
23	June 1982	Subtropical 1	60	992	Subtropical storm
24	Sept 1983	Dean	55	1009	Tropical storm
25	Sept 1984	Diana	50	1000	Tropical storm
26	Aug 1985	Danny	25	1012	Extratropical
27	Sept 1985	Gloria	90	942	Category 2 hurricane
28	Aug 1986	Charley	70	987	Category 1 hurricane
29	Sept 1992	Danielle	55	1001	Tropical storm
30	June 1995	Allison	40	992	Extratropical
31	June 1996	Arthur	35	1005	Tropical storm
32	Oct 1996	Josephine	45	986	Extratropical
33	July 1997	Danny	40	1000	Tropical storm
34	Aug 1998	Bonnie	75	985	Category 1 hurricane
35	Sept 1998	Earl	50	998	Extratropical
36	Sept 1999	Floyd	70	967	Category 1 hurricane
37	Sept 2000	Helene	40	1008	Tropical storm
38	June 2001	Allison	25	1006	Subtropical depression
39	Oct 2002	Kyle	40	1009	Tropical storm
40	Aug 2004	Bonnie	25	1008	Tropical depression
41	Aug 2004	Charley	60	1000	Tropical storm
Data from the NOAA – Coastal Services Center					

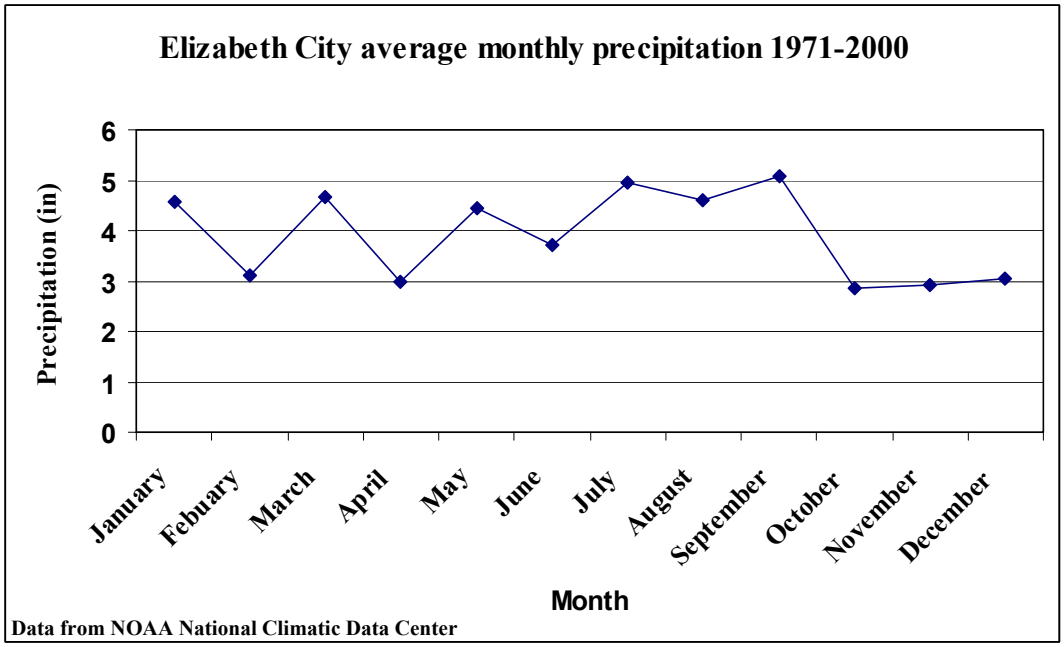

Figure 2.2: Elizabeth City average monthly precipitation 1971-2000.

Table 2.2: Top ten highest and lowest annual precipitation amounts for Norfolk, VA recorded 1892 – 2004

Top 10 highest precipitation amounts 1871 – 2004		
Rank	Precipitation (in)	Date
1	70.72	1889
2	69.14	1877
3	64.96	1979
4	63.25	1871
5	61.76	2003
6	59.70	1937
7	57.90	1893
8	57.78	1958
9	57.71	1964
10	57.67	1882
Top 10 lowest precipitation amounts 1871 – 2004		
Rank	Precipitation (in)	Date
1	26.48	1986
2	26.67	1965
3	26.91	1930
4	30.36	1921
5	30.90	1918
6	32.00	1931
7	32.21	1923
8	32.36	1976
9	32.89	1919
10	33.36	2001
Data from NOAA National Climatic Data Center		

2.4: Geological Processes

Currituck Banks is part of a barrier spit that extends 30 miles (48 km) from Virginia Beach, VA. The geomorphic attributes of this area include gentle to moderate slope, coarse to medium grain sediments, high profile islands, low frequency of high waves, slowly eroding coastlines, and generally wide lagoons and wide islands (Kochel et al. 1985). At current time, this spit is continuous and the sound behind the barrier, Currituck Sound, is predominately fresh in nature. However, through geologic time, inlets have formed and closed within the barrier spit. During an open inlet period, Currituck Sound is mostly marine in nature and very similar to the sounds bordering the other Reserves. However, during closed inlet periods, as is currently the case, Currituck Sound is uniquely fresh in nature. The inlet cycle is governed by litoral sediment supply moving from North to South along the spit, by storm processes and sea level.

The sediments that comprise the barrier spit are very similar to those that make up the rest of the Carolina Outer Banks. They consist of both Recent (less than ~11,550 years old) and Pleistocene (~1.8 million to ~11,550 years before present) sediments. The Pleistocene sediments represent ancient sand shoals that have been pushed landward by oceanic processes. The recent sediments represent terrigenous material that has been transported from upland areas by rivers and wind.

The entire barrier spit that Currituck Banks is a part of is still moving landward. Evidence to support this is found in the exposed peat layers on the beach front that are residuals from ancient maritime forests which were once located on the back of the island. As the island has moved landward these areas are transposed to the beach front where tidal action exposes the ancient tree roots and peat layers.

2.5: Hydrology and Water Quality

A: Ocean Side

a: Hydrology

The nearest tide gauge to Currituck Banks is located at the U.S. Army Corps Field Research Station in Duck, N.C. (Figure 2.1). This tide gauge is maintained through the NOAA - Center for Operational Oceanographic Products and Services. Based on data from this location, tides on the ocean side of Currituck Banks are mesotidal and average 3.2 feet (0.6m) a day and are diurnal in nature. The general flow offshore is from north to south due to the Labrador Current (Figure 1.3). The cool Labrador Current keeps the area around Currituck Banks a few degrees cooler than water south of Cape Hatteras, which is influenced by the warm water Gulf Stream. The near shore currents move sediment on and off the beach. This process is enhanced during coastal storms.

b: Water Quality

Ocean side water quality is monitored by the North Carolina Department of Environmental Health Shellfish Sanitation and Recreational Water Quality Section. They monitor for enterococcus bacteria (an indicator organism whose presence is correlated with that

of others that can cause illness in humans) to determine if swimming advisories should be posted at several locations in and around Currituck Banks. Limits for enterococcus are based on the level of use a particular beach receives. A Tier 1 area is defined as receiving daily use during swimming season (April – September). Tier 1 beaches shall not exceed either: (1) A geometric mean of 35 enterococci per 100 ml of water, that includes a minimum of at least five samples collected within 30 days; or (2) A single sample of 104 enterococci per 100 ml of water. There are two Tier 1 sampling locations, Site N1 located directly adjacent to Currituck Banks and Site N2 located just south of the Reserve on the beach across from the lighthouse in Corolla (Figure 2.3).

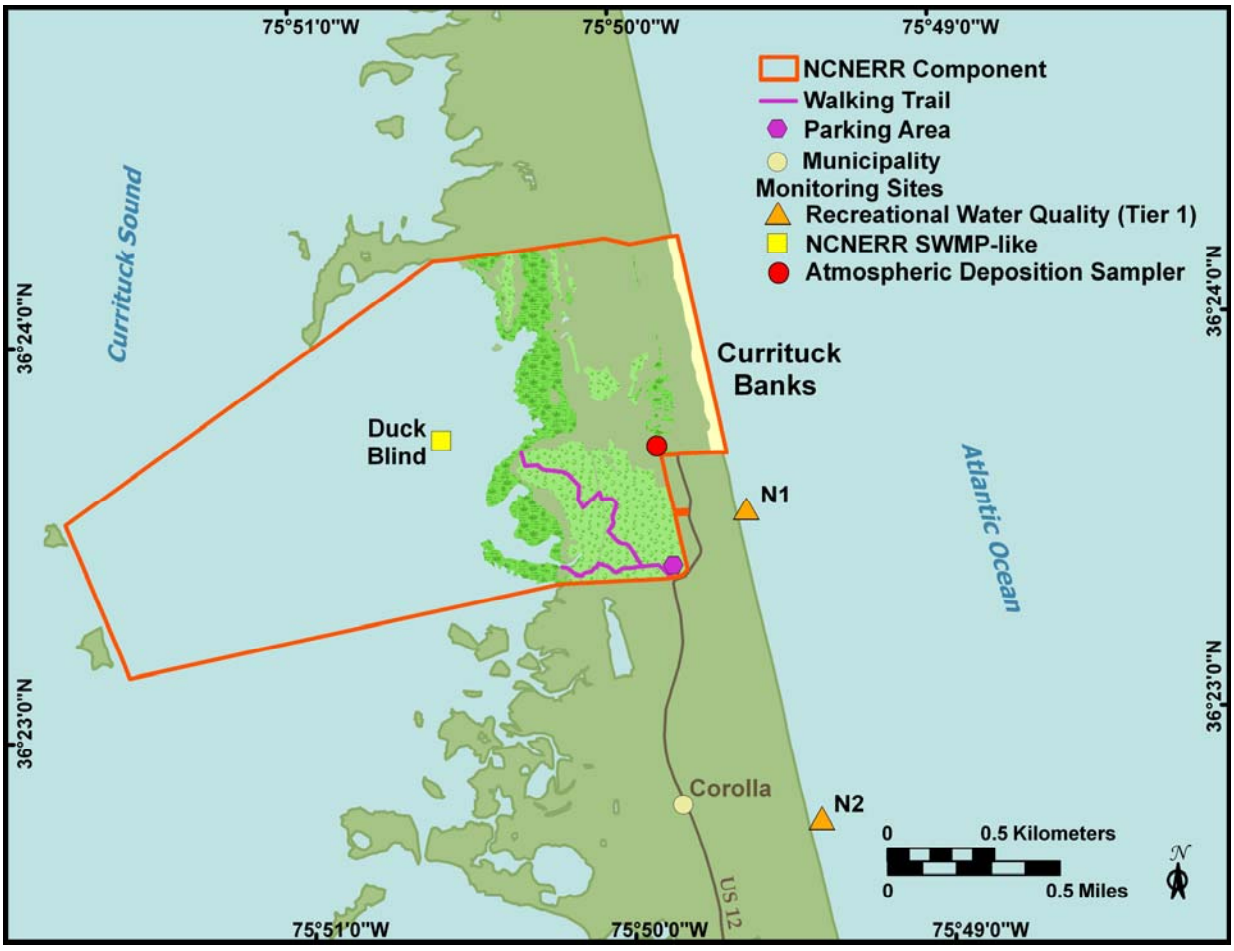

Figure 2.3: Water quality monitoring locations at Currituck Banks.

Based on data from these locations, the water quality along the ocean side of Currituck Banks is generally good in nature. Enterococci levels are usually very low (less than 25) however, single sample values are occasionally very high (Figure 2.4). These high values are of concern because they violate the state standard for Tier 1 beaches, and represent a potential risk to public health. As the population continues to increase and the development in the northern Outer Banks continues (see Section 2.10), the water quality on the ocean side of Currituck Banks could get worse. This is an important issue for the municipalities along the North Carolina northern Outer Banks because the primary source of income in these areas is tourism. Tourists would be

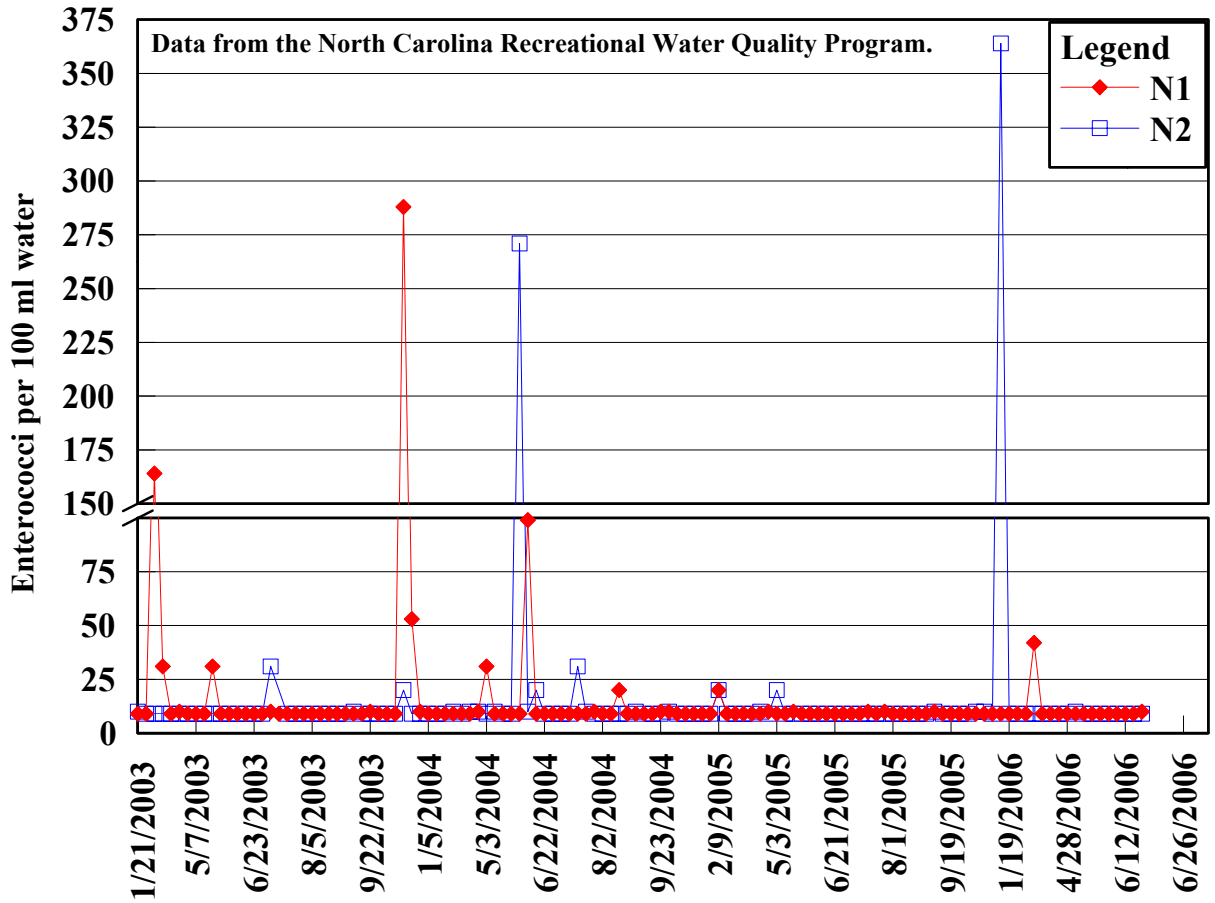

Figure 2.4: Enteroccoci data from the Tier 1 locations near Currituck Banks.

discouraged from visiting the area if there are continual swimming advisories and beach closures associated with fecal contamination.

B: Sound Side

a: Hydrology

The sound side of Currituck Banks is located within the Pasquotank River Basin (Figure 2.5). Tidal influence on the sound side is almost completely muted by the long distance between Currituck Banks and the nearest inlet, Oregon Inlet, which is located about 45 miles (72 km) away. Currituck Sound is approximately 35 miles (56 km) long, varies from 4 to 15 miles (6.5 to 24 km) wide, and is extremely shallow averaging 5 ft (1.5 m), and supports large amounts of SAV. Water movement in Currituck Sound is driven primarily by wind. This means that the water levels in Currituck Sound can change dramatically and rapidly in response to changes in the wind pattern. North winds tend to blow water out of the sound and southerly winds tend to force water into the sound. Because of this relationship between wind direction and water level, water levels tend to be highest in summer when winds predominately blow from the south-

southwest, and tend to be lowest in the winter when winds predominately blow from the north-northeast (Caldwell 2001).

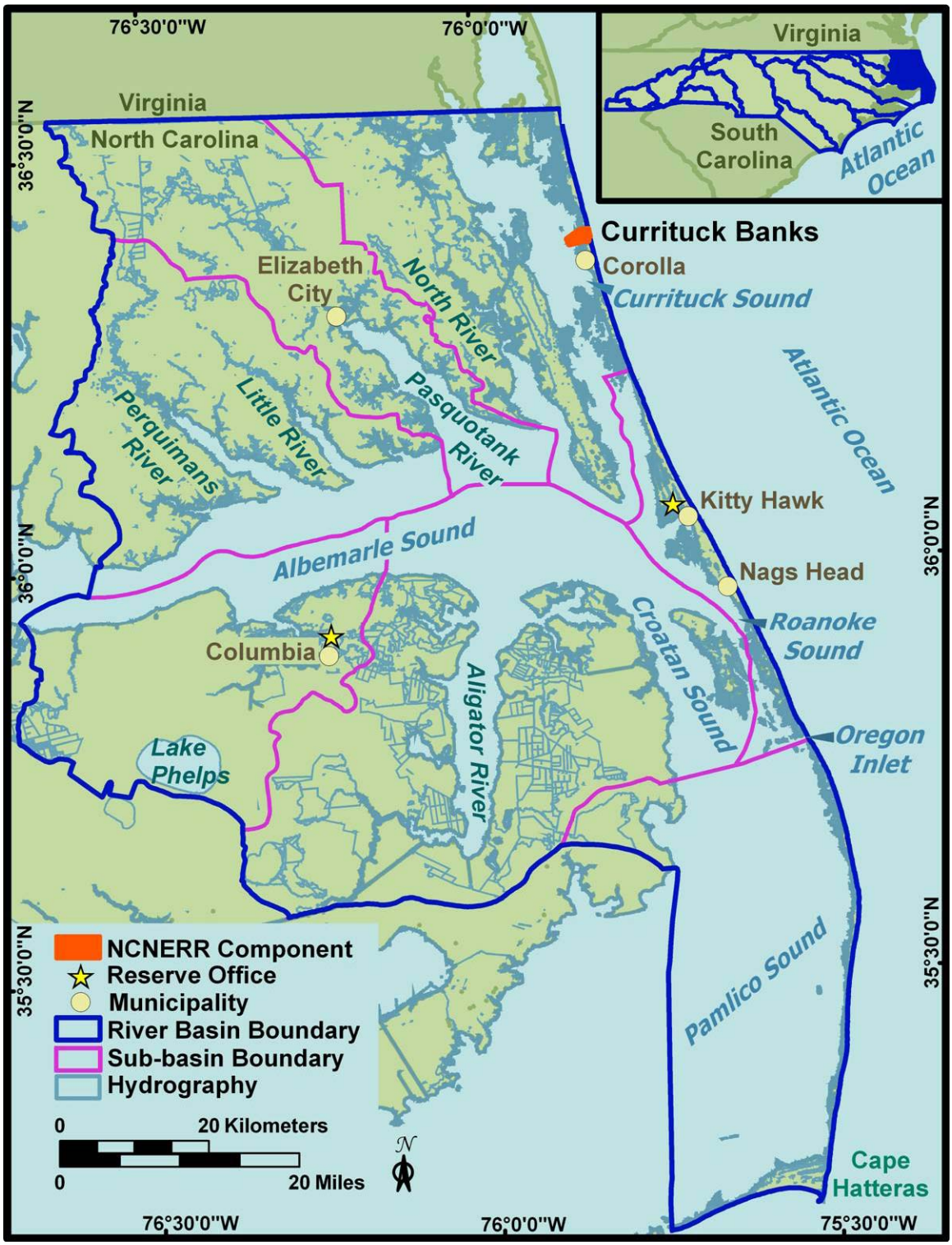

Figure 2.5: Pasquotank River Basin map.

Salinity levels in the sound vary from essentially 0 up to 20 ppt, but average around 3.5 ppt (Caldwell 2001). Salinity shows a seasonal signal with higher values observed in the sound during summer due to the influx of marine waters from the sounds to the south. Currituck Sound empties into the larger Albemarle Sound at Kitty Hawk and is connected to the Chesapeake Bay through two canals in southern Virginia. These Chesapeake Bay canals are a source for high salinity water for the upper Currituck Sound during strong north wind events (Bales and Skrobialowski 1994). Currituck Sound is generally well mixed due to its shallow nature and can completely ice over during hard winters.

b: Water Quality

Water quality in Currituck Sound is heavily dependent upon the above hydrology. This is important as the spatial coverage of the SAV in the sound has been decreasing in recent years. The leading suspected cause for this decline is decreased water quality (Caldwell 2001). SAV issues are one of the focus areas for NCNERR in the Northern region. As such, understanding the water quality within Currituck Sound is a high priority issue. To address this issue, NCNERR as part of a larger group has been monitoring water quality within Currituck Sound since 2006. Two SWMP-like water quality monitoring stations were established. One is located on the channel guide of the Wright Memorial Bridge connecting Kitty Hawk with the mainland (Figure 2.1) and the other is located within the boundaries of Currituck Banks on a duck blind (Figure 2.3). Both were equipped with instruments made by Yellow Springs Instruments that measure: dissolved oxygen, pH, temperature, conductivity, salinity and turbidity. The Wright Bridge instrument is deployed at about 3.5 ft (~1 m) depth and in the middle of the sound. The Duck Blind location instrument is deployed at about 1 ft (~0.3 m) and very close to the eastern shore of Currituck Sound. This arrangement provides NCNERR coverage of both the central deeper mainstem portion of Currituck Sound (Wright Bridge location) and the shallow litoral areas. In addition to the physical-chemical data, water samples have been collected from the two stations once a month and analyzed for nutrients, total suspended solids, secchi depth and Chlorophyll *a*. These data coupled with that from the other project team members will be used to construct a hydrologic model for Currituck Sound. The model will then be used to predict how the Sound will respond to various potential future scenarios.

The monthly averaged physical-chemical data from the two SWMP-like sampling stations in Currituck Sound is presented in Figure 2.6. The data from the two stations demonstrate how the salinity levels in the sound fluctuate especially at the mouth (Wright Bridge location). Salinity is highest at the Wright Bridge location in summer. The highest salinity levels at the Duck Blind location also occurred in summer, but overall salinity was much lower at the Duck Blind location (2-5 ppt) compared to the Wright Bridge location (4-15 ppt). The salinity levels at the Duck Blind are lower than those at the mouth of Currituck Sound due to two factors. First the Duck Blind location is much farther away from the nearest ocean inlet, thus it is farther away from the primary source of salty water, the ocean. Second, it is closer to the land, making it more impacted by stormwater runoff. Both these factors make the sound waters at the Duck Blind location fresher than the water at the Wright Bridge.

Turbidity also shows extreme variations between months. Turbidity at the Wright Bridge location was highest in the winter months. Winter is also the time of year when the strongest winds occur in the region. This data suggest that the turbidity in the system is mainly caused by resuspended sediments. There is no apparent seasonal turbidity signal at the Duck Blind

location. This is most likely because the seasonal signal is obscured by pulses of turbidity associated with both runoff events caused by rain, and by wind. The shallow nature of the Duck Blind location also means that lower energy is required to disturb the bottom. All of these factors help explain the more frequent turbidity spikes at the Duck Blind location.

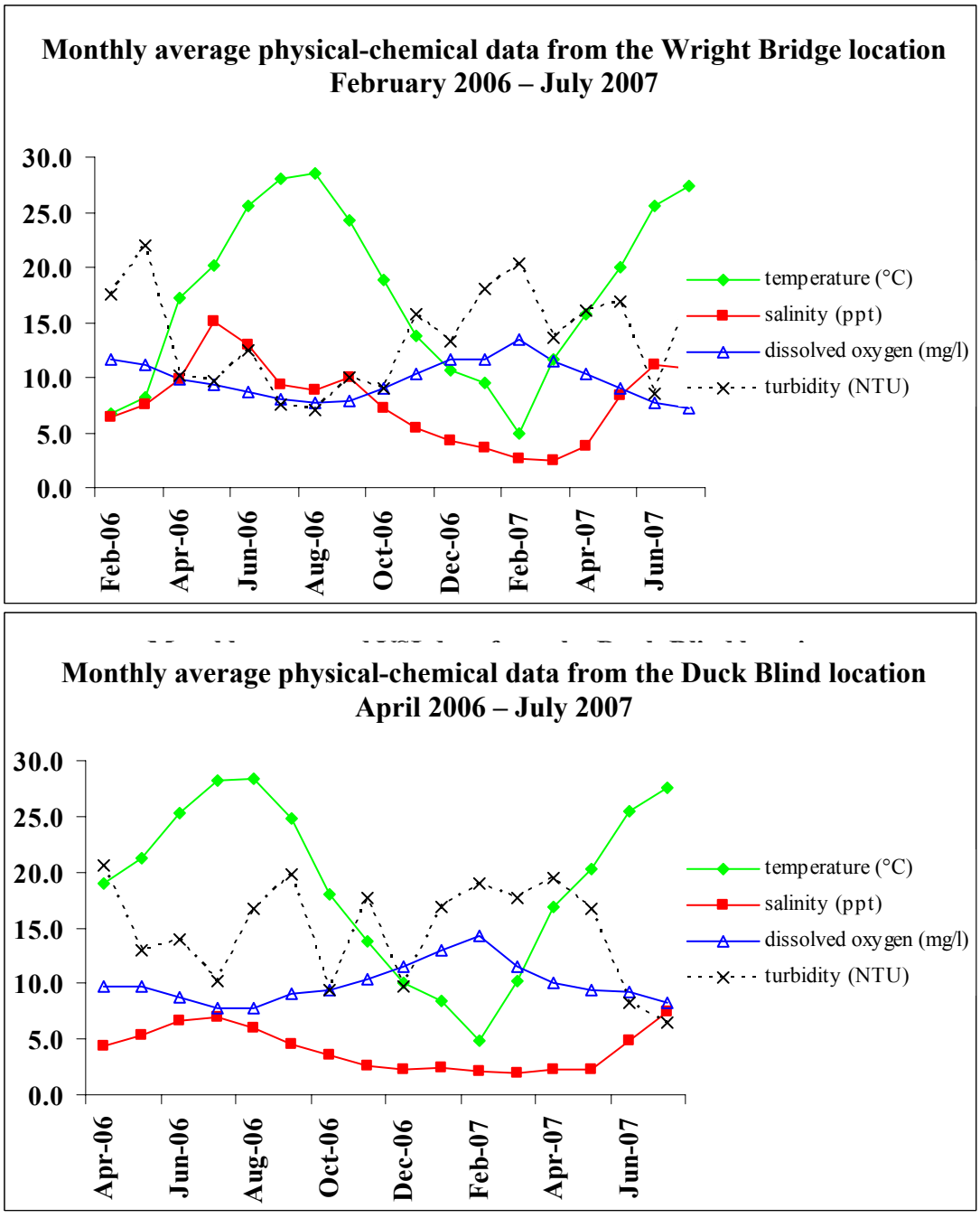

Figure 2.6: Monthly averaged physical-chemical data from the NCNERR SWMP-like Currituck Sound water quality stations.

Turbidity levels are extremely important because they impact how much light penetrates the water column. Suitability of habitats for SAV are determined by light and parameters that modify light such as epiphytes, total suspended solids, chlorophyll and nutrient concentrations (Koch 2001). Thus, high turbidity values are not favorable for SAV growth and recovery. Turbidity is just one factor that affects water column light penetration. Secchi depth is a measurement that quantifies all the factors that affect light penetration and provides an estimate for the lowest depth at which photosynthetic plants can grow. Secchi depths for the southern end of the sound near the Wright Bridge (Figure 2.1) range from 1.2 to 3.2 ft (0.375 to 1 m) and average 2.25 ft (0.68 m). Secchi depths at the Duck Blind (Figure 2.3) range from 1.2 to 2 ft (0.375 to 0.625 m) and average 1.6 ft (0.5 m). Both these depths are shallower than the average depth for Currituck Sound which is 5 ft (1.5 m). Thus, there are many areas of the sound that are not capable of supporting SAV because of the lack of light. See Section 2.11 for maps showing where SAV is currently found within Currituck Sound.

The nutrient (NO_3^-, NH_4^+, PO_4^{-3}) and Chlorophyll *a* data from the two SWMP-like stations is presented in Figure 2.7. These data suggest that nutrient levels in the sound are usually quite low. Occasional pulses of nutrients do occur as seen in February and May 2007 (Figure 2.7). Higher nutrient pulses were observed at the Duck Blind location, which is closer to land, compared to the main stem Wright Bridge location. This suggests that the main nutrient sources for Currituck Sound are runoff from adjacent land and not the waters of the Albemarle Sound. The data in Figure 2.7 also show that the Chlorophyll *a* levels did not respond to the nutrient pulses. Three possibilities may be occurring in the sound to explain this. The sound's productivity may be primarily due to the SAV and thus the phytoplankton would not be expected to respond to nutrient pulses, the sound may be light limited, or the productivity spike associated with the nutrient additions may occur at a different location than where the water quality monitors are located. Future research needs to examine this question, and help explain how the system responds to nutrient pulses.

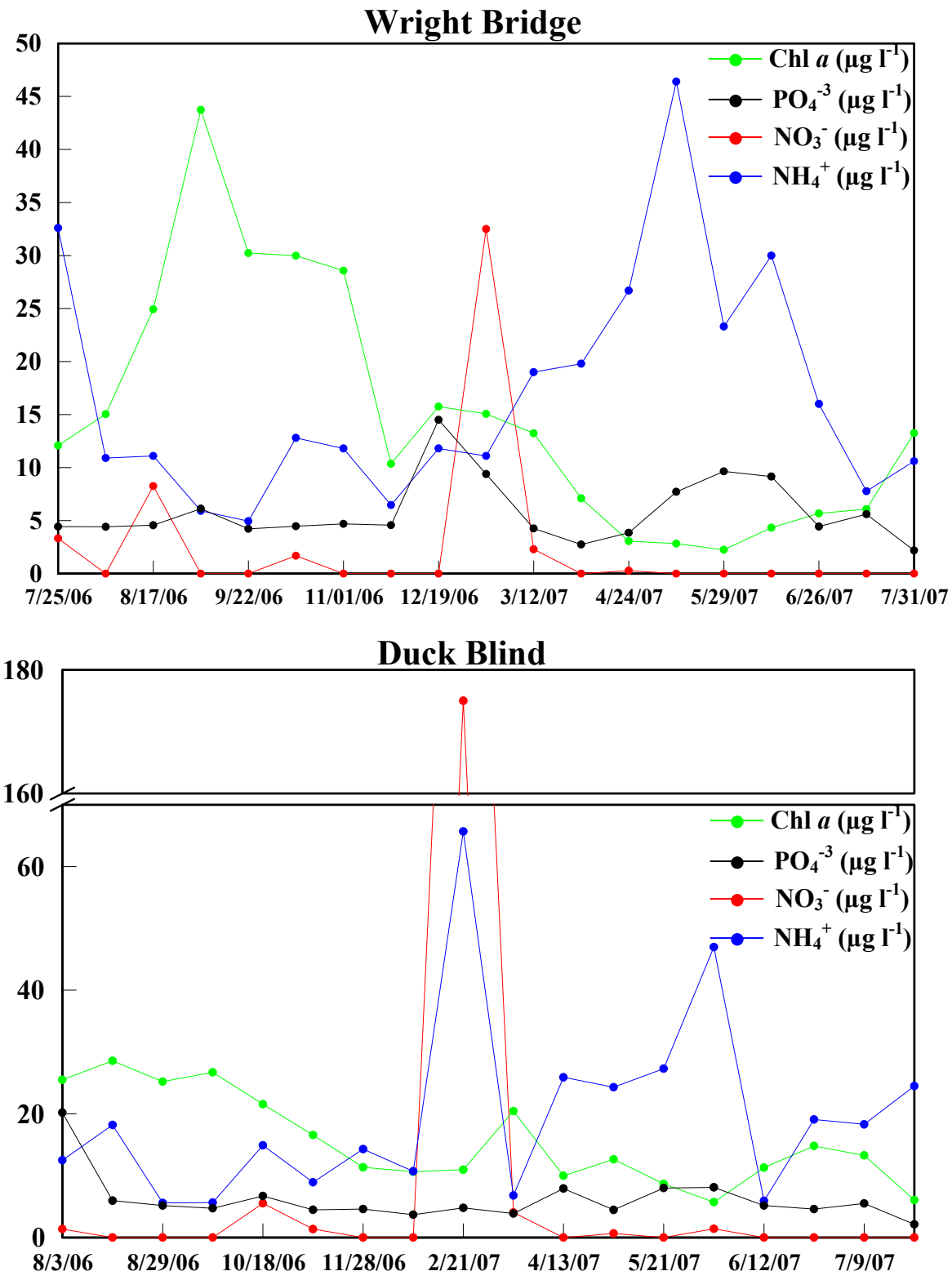

Figure 2.7: Nutrient and Chlorophyll a data from the NCNERR SWMP-like Currituck Sound water quality stations.

2.6: Habitat Types

A primary objective of SWMP Phase 3 is to evaluate changes over time in estuarine habitats and coastal land cover. To accomplish this, the types and locations of habitats within the Reserve must be periodically quantified. The habitat types of Currituck Banks were initially characterized in 1994. This effort used a very general classification system that only broke habitats down into very broad categories. These habitat types included the open water of Currituck Sound, irregularly exposed flats, marshes, maritime shrub thicket and forest, ponds, dunes and beaches (Table 2.3). Figure 2.8 shows the resultant map from this effort.

Table 2.3: Currituck Banks 1994 habitat classifications

Habitat	Description
Shallow waters of Currituck Sound	Open Oligohaline water with areas of aquatic vegetation, including sago pondweed, widgeon grass and Eurasian water milfoil.
Irregularly exposed mud flats	Open mud or sand flats exposed during irregular low wind tides.
Marshes	Mosaic of brackish, transitional and freshwater marshes. Vegetation includes black needlerush, giant cordgrsss, cattails, sedges and rushes.
Maritime shrub thicket	Upland areas with shrubs that include wax myrtle, bayberry, youpon.
Maritime evergreen forest	Upland areas with mixed mature forest, with live oaks and loblolly pines dominant.
Dunes	Upland areas stabilized by grasses such as sea oats, American beach grass and beach panic grass.
Interdune ponds	Seasonal or permanent open water in depressions within upland.
Beaches	Gently sloping, open intertidal sandy beaches.

However, this assessment provided only minimal information regarding habitat types and function. To more accurately and methodologically account for the various habitat types within the Reserve components, in 2005 NCNERR participated as a pilot Reserve for the NERRS habitat and land use classification system. This effort categorized the habitats within the Reserves using a much improved classification system (Appendix 4).

The updated habitat map for Currituck Banks is presented at the subclass level in Figure 2.9. Areal statistics for habitat occurrence were calculated from the digital classification data and are provided as acreage and the percentage of total acres mapped for each habitat subclass (Table 2.4). Subtidal areas were not included in this assessment. Visual observations were made during field surveys to document predominant plant species for each habitat subclass. These data provide a baseline framework for conducting more in-depth inventories of vegetation composition and conditions. Habitat subclasses at Currituck Banks are described in the following paragraphs, with representative photographs presented in Appendix 4.

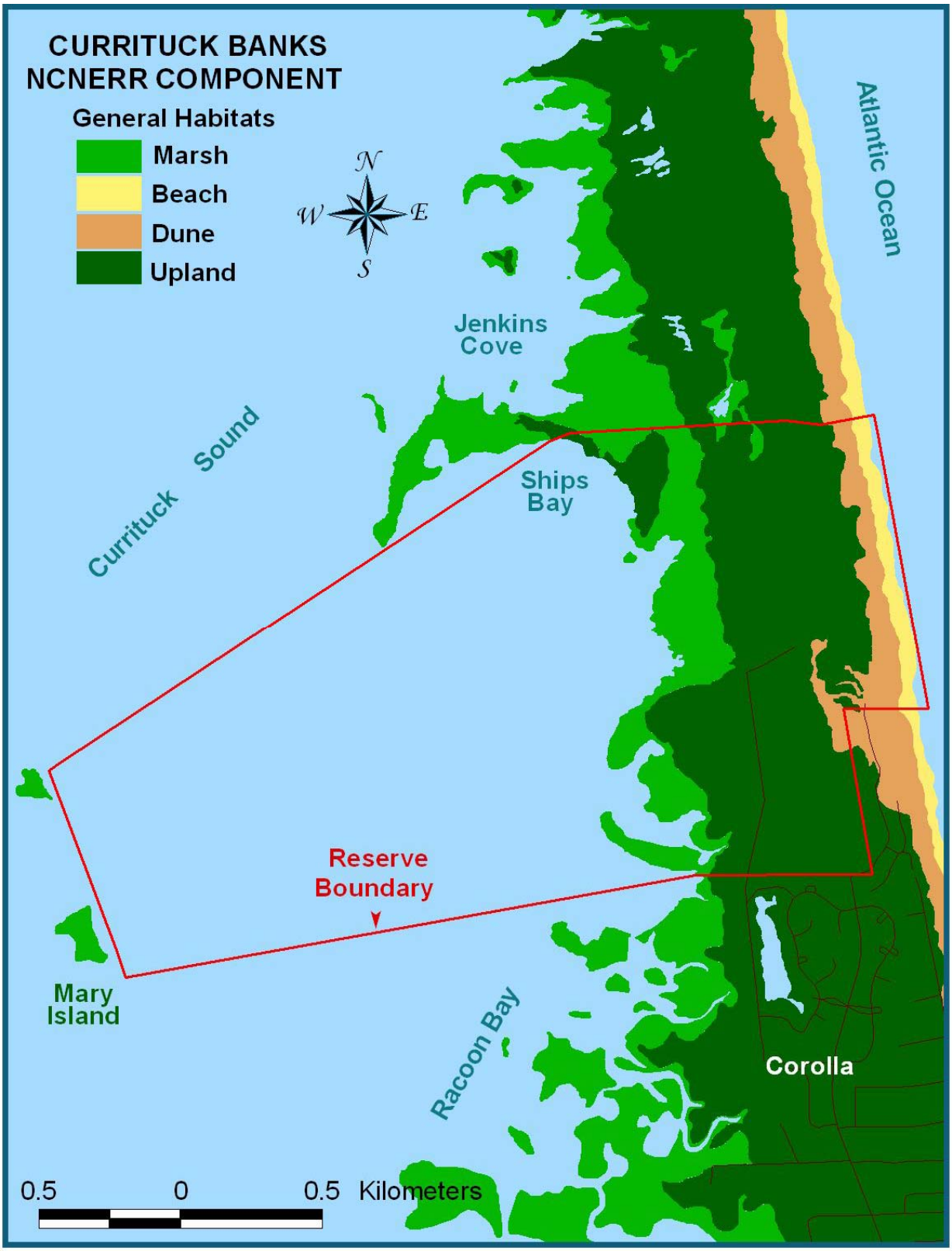

Figure 2.8: Habitat map from 1994 for Currituck Banks.

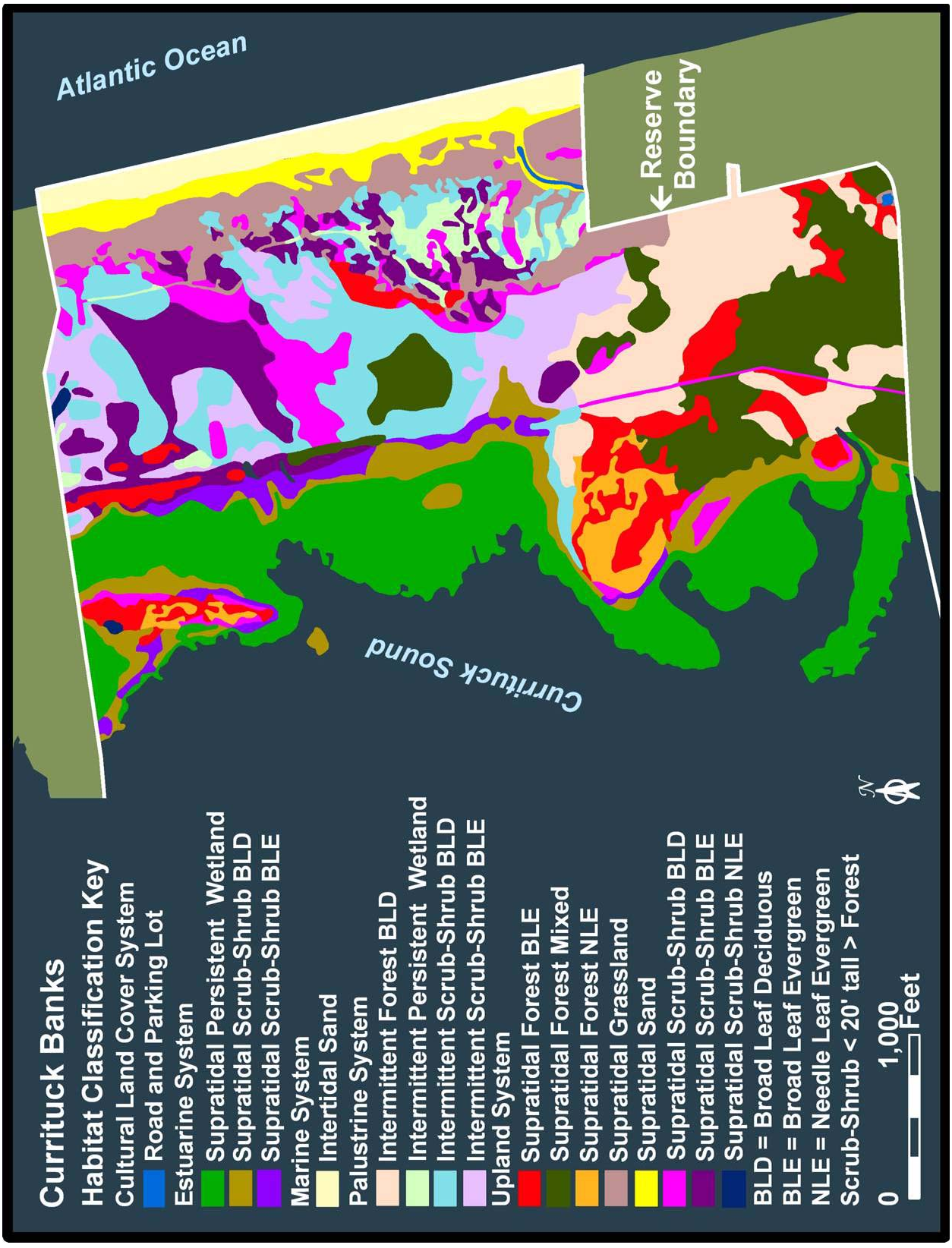

Figure 2.9: Currituck Banks 2004 habitat classification presented at the subclass level.

Table 2.4: Currituck Banks 2004 habitat classifications areal statistics

Habitat Subclass	Area (Acres)	% of Total
Estuarine Supratidal Persistant Wetland	55.06	17.32
Upland Supratidal Forest Mixed	35.08	11.04
Palustrine Intermittent Scrub-Shrub Broad Leaf Deciduous	32.58	10.25
Palustrine Intermittent Forest Broad Leaf Deciduous	29.91	9.41
Upland Supratidal Grassland	25.19	7.93
Upland Supratidal Scrub-shrub Broad Leaf Evergreen	23.71	7.46
Upland Supratidal Forest Broad Leaf Evergreen	20.71	6.52
Palustrine Intermittent Scrub-Shrub Broad Leaf Evergreen	19.75	6.21
Upland Supratidal Scrub-shrub Broad Leaf Deciduous	18.03	5.67
Marine Intertidal Sand	14.05	4.42
Estuarine Supratidal Scrub-Shrub Broad Leaf Deciduous	12.52	3.94
Upland Supratidal Sand	9.98	3.14
Upland Supratidal Forest Needle Leaf Evergreen	6.91	2.17
Palustrine Intermittent Persistant Wetland	6.74	2.12
Estuarine Supratidal Scrub-Shrub Broad Leaf Evergreen	6.68	2.10
Upland Supratidal Scrub-shrub Needle Leaf Evergreen	0.52	0.16
Paved Road	0.28	0.09
Sand Parking Lot	0.11	0.03
Total Mapped Habitat Area	**317.81***	**100.00**
* Subtidal areas not included		

- The largest subclass within the Currituck Banks Component was Estuarine Supratidal Persistant Wetland, comprising 55 acres and 17% of the total non-aquatic habitat area. This habitat, located along Currituck Sound, is irregularly flooded by brackish water during wind-driven high tides. These areas are expanses of Giant Cordgrass (*Spartina cynosuroides*), with stands of Black Needle Rush (*Juncus roemerianus*) and Cattail (*Typha* sp.).

- The second most common habitat was Upland Supratidal Forest Mixed, which covered 35 acres and 11% of the total area. Stands of this subclass were found in the south and center portions of the Reserve. Vegetation consists of a mix of Loblolly Pines (*Pinus taeda*) and broad leaf trees, including Live Oak (*Quercus virginiana)*, Yaupon (*Ilex vomitoria*), Wax Myrtle (*Morella cerifera* or *Myrica cerifera*) and Laurel Oak (*Quercus laurifolia*).

- Palustrine Intermittent Broad Leaf Deciduous communities of Scrub-Shrub (33 acres, 10% of total) and Forest (30 acres, 9% of total) were the next most prevalent habitats. Vegetation was designated Scrub-Shrub or forest when, respectively, less or greater than 20’ in height. These areas were found in depressions in the middle of the

Reserve, between the dune ridge to the east and marshes along Currituck Sound to the west. Species include Red Maple (*Acer rubrum),* Carolina Willow (*Salix caroliniana*), Willow Oak (*Quercus phellos*), Persimmon *(Diospyros viginiana*) and Black Gum (*Nyssa sylvatica*).

- Upland Supratidal Grassland (25 acres, 8% of the total mapped habitat) was located adjacent to the Atlantic Ocean beach. This area has greater than 30% vegetative cover, with a mixed community of perennial beach grasses such as Salt Meadow Hay (*Spartina patens)*, Sea Oats (*Uniola paniculata*), Inland Saltgrass (*Distichlis spicata*) and various species of *Panicum.*

- Two subclasses of Upland Supratidal Broad Leaf Evergreen each represented approximately 7% of the habitat area. Scrub-shrub (24 acres) and Forest (21 acres) are, respectively less or greater than 20 ft in height. These are mixed communities that include Live Oak (*Quercus virginiana*), Yaupon (*Ilex vomitoria*), Wax Myrtle (*Morella cerifera* or *Myrica cerifera*), and Laurel Oak (*Quercus laurifolia*). The Eastern Red Cedar (*Juniperus virginiana*), a needle leaf evergreen, is also present, though not dominant.

- Total habitat area included two subclasses with 6% each. Palustrine Intermittent Scrub-Shrub Broad Leaf Evergreen included 20 acres of mixed Sweet Bay (*Magnolia viginiana*), Red Bay (*Persea boarbonia*), Wax Myrtle (*Myrica cerifera*) and Dahoon Holly (*Ilex cassine*). Upland Supratidal Scrub-shrub Broad Leaf Deciduous consisted of 18 acres of Marsh Elder (*Iva frutescens*), Grounsel Tree (*Baccharis halimifolia*) and Northern Bay Berry (*Myrica pensylvanica*).

- Subclasses with 3 – 4 % each of the total area include 14 acres of Marine Intertidal Sand beach along the Atlantic Ocean, 12 acres of Estuarine Supratidal Scrub-Shrub Broad Leaf Deciduous containing mostly Sea Ox-eye (*Borrichia frutescens*) and Glasswort (*Salicornia spp.*) and 10 acres of Upland Supratidal Sand, commonly known as "sand dunes", adjacent to the beach. These areas are open, with $\leq$ 30% vegetative cover.

- Three subclasses each covered approximately 7 acres and 2% of the mapped habitat area. The Upland Supratidal Forest Needle Leaf Evergreen is composed primarily of Loblolly Pines (*Pinus taeda*) with a small unique stand of Longleaf Pine (*Pinus palustris*) at the north western boundary of the Reserve. Palustrine Intermittent Persistant Wetland, predominantly Salt Meadow Cordgrass *(Sparina patens),* exists in depressions in the south eastern portion of the Reserve. Estuarine Supratidal Scrub-Shrub Broad Leaf Evergreen habitat, found along the eastern edge of the Currituck Sound marsh, includes Sweet Bay (*Magnolia viginiana*), Red Bay (*Persea boarbonia*), Wax Myrtle (*Myrica cerifera*) and Dahoon Holly (*Ilex cassine*).

- Subclasses with less than 1% of the total area each were Upland Supratidal Scrub-Shrub Needle Leaf Evergreen with 0.5 acres of short ($\leq$ 20 ft) Loblolly Pines (*Pinus taeda*) and Eastern Red Cedar (*Juniperus virginiana*), as well as the Paved Road (0.3

acres) and Sand Parking Lot (0.1 acres) of the visitor access site at the south eastern border of the Reserve.

2.7: Plants

The plant communities present within the Currituck Banks Reserve are consistent with those found in other areas of North Carolina's northern Outer Banks. The dominant terrestrial plant species for each habitat subclass are listed in the preceding section. For a full species list refer to Appendix 5. Also found within the Currituck Banks boundary are large beds of submerged aquatic vegetation (See section 2.11 for a spatial coverage map). These communities provide good habitat for a variety of aquatic animals, which in turn attract and support migratory waterfowl.

The maritime forest community found within Currituck Banks is an extremely rare habitat. There are very few places within the North Carolina coastal area that still contain undisturbed maritime forest. These slow growing communities provide important habitat for many types of animals. Maritime forests contain unique assemblages of flora and fauna (Grand and Vernia 2002). The leaf litter produced by the forest is also an important soil building material. As the leaf litter accumulates on the forest floor over time peat is formed. This peat layer provides a nutrient rich environment that supports many other plant species. The North Carolina Natural Heritage Program list several plant species as significantly rare in Currituck County and one, the Carolina Grasswort (*Lilaeopsis carolinensis*), as threatened (Table 2.5)

The water areas within the Reserve contain large beds of SAV. The plants found within the Reserve mirror those found for all of Currituck Sound. Section 2.11 details efforts to map and identify SAV species within Currituck Sound.

2.8: Animals

Currituck Banks is home to a variety of animals. Since the Reserve is located just north of the transition between the Carolinian and Virginian biogeographic province, it potentially can support the fauna from both provinces. The well developed maritime forest of Currituck Banks provides habitat for many mainland species that otherwise would not be capable of surviving in the Currituck Banks area. The beach and marsh areas of Currituck Banks provide valuable wetland habitat that supports a myriad of species. Unfortunately, there has not been much work conducted in Currituck Banks relative to the fauna and the list below represents a very small percentage of the species that are present. The lack of comprehensive animal data for Currituck Banks is a gap that needs to be addressed with future research and monitoring. The North Carolina Natural Heritage Program lists several animal species as significantly rare or threatened in Currituck County (Table 2.5).

Table 2.5: Species of special concern in and near Currituck Banks

State Status Codes: E = Endangered, T = Threatened, SC = Special Concern, SR = Significantly Rare, L = range limited to North Carolina and adjacent states.

Federal Status Codes: E = Endangered, T = Threatened, FSC = Federal Special Concern.

Major Group	Scientific Name	Common Name	State Status	Federal Status
Vascular Plant	*Amaranthus pumilus*	Seabeach Amaranth	T	T
Vascular Plant	*Carex hormathodes*	A Sedge	SR-P	None
Vascular Plant	*Cladium mariscoides*	Twig-rush	SR-O	None
Vascular Plant	*Cyperus dentatus*	Toothed Flatsedge	SR-P	None
Vascular Plant	*Eleocharis montevidensis*	Sand Spikerush	SR-P	None
Vascular Plant	*Eleocharis rostellata*	Beaked Spikerush	SR-O	None
Vascular Plant	*Hudsonia tomentosa*	Sand Heather	SR-P	None
Vascular Plant	*Isoetes riparia*	Riverbank Quillwort	SR-P	None
Vascular Plant	*Leptochloa fascicularis var. maritima*	Long-awned Spangletop	SR-O	None
Vascular Plant	*Lilaeopsis carolinensis*	Carolina Grasswort	T	None
Vascular Plant	*Limosella australis*	Awl-leaf Mudwort	SR-P	None
Vascular Plant	*Ludwigia alata*	Winged Seedbox	SR-P	None
Vascular Plant	*Ludwigia brevipes*	Long Beach Seedbox	SR-T	None
Vascular Plant	*Myriophyllum pinnatum*	Cutleaf Water-milfoil	SR-T	None
Vascular Plant	*Ranunculus hederaceus*	Ivy Buttercup	SR-D	None
Vascular Plant	*Sagittaria weatherbiana*	Grassleaf Arrowhead	SR-T	FSC
Vascular Plant	*Torreyochloa pallida*	Pale Mannagrass	SR-P	None
Vascular Plant	*Trillium pusillum var. virginianum*	Virginia Least Trillium	E	FSC
Vascular Plant	*Vaccinium macrocarpon*	Cranberry	SR-P	None
Invertebrate Animal	*Euphyes dukesi*	Dukes' Skipper	SR	None
Invertebrate Animal	*Papilio cresphontes*	Giant Swallowtail	SR	None
Invertebrate Animal	*Poanes aaroni*	Aaron's Skipper	SR	None
Invertebrate Animal	*Satyrium favonius ontario*	Northern Oak Hairstreak	SR	None
Animal Assemblage	*Colonial Wading Bird Colony*	None	None	None
Animal Assemblage	*Gull-Tern-Skimmer Colony*	Colonial Waterbirds Nesting Site	None	None
Bird	*Charadrius melodus*	Piping Plover	T	T
Bird	*Coturnicops noveboracensis*	Yellow Rail	SR	None
Bird	*Egretta caerulea*	Little Blue Heron	SC	None
Bird	*Egretta thula*	Snowy Egret	SC	None
Bird	*Egretta tricolor*	Tricolored Heron	SC	None
Bird	*Haliaeetus leucocephalus*	Bald Eagle	T	T
Bird	*Laterallus jamaicensis*	Black Rail	SR	FSC
Bird	*Picoides borealis*	Red-cockaded Woodpecker	E	E
Bird	*Plegadis falcinellus*	Glossy Ibis	SC	None
Bird	*Sternula antillarum*	Least Tern	SC	None
Reptile	*Crotalus horridus*	Timber Rattlesnake	SC	None
Reptile	*Dermochelys coriacea*	Leatherback	E	E
Reptile	*Caretta caretta*	Loggerhead	T	T
Reptile	*Lampropeltis getula sticticeps*	Outer Banks Kingsnake	SC	None
Reptile	*Nerodia sipedon williamengelsi*	Carolina Water Snake	SC	None
Mammal	*Peromyscus leucopus easti*	Pungo White-footed Mouse	SC	None
Mammal	*Condylura cristata pop. 1*	Star-nosed Mole - Coastal Plain Population	SC	None
Mammal	*Trichechus manatus*	West Indian Manatee	E	E

Data from the North Carolina Natural Heritage Program

A: Invertebrates and Zooplankton

There is not much data available regarding the invertebrates and zooplankton found within the Reserve. The Natural Heritage Program lists four butterfly species, Dukes' Skipper (*Euphyes dukesi*), Giant Swallowtail (*Papilio cresphontes*), Aaron's Skipper (*Poanes aaron*) and the Northern Oak Hairstreak (*Satyrium favonius ontario*) as having special concern (Table 2.5).

Unfortunately, there has not been any monitoring to determine if these species are found in the Reserve. The soundside nearshore sediments support a myriad of benthic invertebrate animals including mussels, insect larvae, and crustaceans. These animals are an important food source for migratory waterfowl and fish.

B: Fishes

The oligohaline waters of Currituck Sound support many types of fresh and saltwater fish. A commercially important fishery for Striped Bass (*Morone saxatilis*) is present. Other important sportfish include Largemouth Bass *(Micropterus salmoides)*, Flounder (*Paralichthys dentalus*), Speckled Trout (*Cynoscion nebulosus*), and Red Drum (*Sciaenops ocellatus*). The sound supports several Sunfish species (*Lepomis sp.*), Crappie (*Pomoxis nigromaculatus* and *Pomoxis annularis*), Perch (*Perca flavescens* and *Morone Americana*) and several species of Catfish [Channel Catfish (*Ictalurus punctatus*), White Catfish (*Ameiurus catus*), Blue Catfish (*Ictalurus furcatus*), Bullhead Catfish (*Ameiurus sp.*)]. The American Eel, (*Anguilla rostrata*) can also be found in Currituck Sound. Juvenile eel, called elvers, are an important component in the diet of many predatory fish such as the Striped and Largemouth Bass.

C: Reptiles and Amphibians

The habitats of Currituck Banks support many types of reptiles and amphibians. Table 2.5 list five as having special or threatened status. Two of these are marine turtles, the Leatherback (*Dermochelys coriacea*) and Loggerhead (*Caretta caretta*). While turtles generally nest south of Currituck Banks, occasionally the ocean areas of Currituck Banks are used for nesting. The waters of Currituck Sound support many species of freshwater turtle. This makes Currituck Banks the only NCNERR component that supports both aquatic freshwater and marine turtles. The remaining species on the Natural Heriatage list are snake species, the Timber Rattlesnake (*Crotalus horridus*), the Outer Banks Kingsnake (*Lampropeltis getula sticticeps*), and the Carolina Water Snake (*Nerodia insularum*). In addition, many other snake species utilize the habitats at Currituck Banks. Some of the more common include the Black Racer (*Coluber constrictor*), Eastern Gater Snake (*Thamnophis sirtalis*), and Eastern Hognose Snake (*Heterodon platyrhinos*) and Rat Snake (*Elaphe obsoleta*). Green Anoles (*Anolis carolinensis*) and Six-lined Racerunners (*Cnemidophorus sexlineatus*) have also been observed in the Reserve.

The amphibians found in Currituck Banks are very similar to those found in other areas of North Carolina. The presence of the maritime forest habitat means that many mainland species not normally found in barrier island systems are present. Common frogs and toads found in Currituck Banks include the Eastern Spadefoot (*Scaphiopus holbrookii*), Southern Toad (*Bufo terrestris*), Green Treefrog (*Hyla cinerea*), Spring Peeper (*Pseudacris crucifer*), and Southern Leopard Frog (*Rana utricularia*). Salamander species are also probably present in the Reserve, but at current time there is no information available to verify this assumption.

D: Birds

Currituck Banks provides habitat to a great many species of birds. Migratory waterfowl including many types of Ducks and Geese utilize the sound waters within the Reserve for feeding. The marsh habitats of Currituck Sound support Belted Kingfishers (*Megaceryle*

alcyon), Herons and Egrets (*Egretta sp.* and *Ardea sp.*), and Ducks. The maritime forest support many species of songbirds including Sparrows, Warblers, Finches, and Wrens. The ocean and dune areas of the Reserve support colonial nesting birds such as Plovers, and other shorebirds like Brown Pelicans (*Pelecanus occidentalis*), Gulls, Terns and Sandpipers (*Calidris sp.*). The Reserve is also home to several species of raptor including the Osprey (*Pandion haliaetus*), Bald Eagle (*Haliaeetus leucocephalus*), Red-tailed Hawk (*Buteo jamaicensis*), Great Horned Owl (*Bubo virginianus*) and Barred Owl (*Strix varia*). The endangered Red-Cockaded Woodpecker (*Picoides borealis*) has also been observed in the Reserve but, at present, there are not any active nesting trees.

E: Mammals

Currituck Banks is home to many mammal species. Three are listed in Table 2.5 as having special or threatened status: the Pungo White-footed Mouse (*Peromyscus leucopus easti*), the Star-nosed Mole (*Condylura cristata*), and the West Indian Manatee (*Trichechus manatus*). Only the first two are potentially found in the Reserve. The Manatee is listed only because occasionally one strays from the warm waters of Florida to more northern waters. No manatees have ever been documented within the boundaries of Currituck Banks.

The Reserve is home to many other common mammals including White Tail Deer (*Odocoileus virginianus*), Grey Squirrel (*Sciurus carolinensis*), Raccoon (*Procyon lotor*), River Otter (*Lontra Canadensis*), Eastern Cottontail Rabbit (*Sylvilagus floridanus*), Marsh Rabbit (Sylvilagus palustris) and Possum (*Didelphis virginiana*). Feral horses and pigs are also found in Currituck Banks (see section 2.9).

2.9: Invasive Species

Invasive species are a growing concern for the Currituck Banks Reserve. Several have been documented within the Reserve boundary. Common Reed (*Phragmites australis*) is a nonnative invasive marsh grass growing in Currituck Banks marshes (Figure 2.10). Phragmites tends to grow into a monoculture and crowds out native marsh plants. The habitat value of Phragmites is considered much lower than a native marsh and waterfowl usage is reduced (Roman et al. 1984). Phragmites also tends to alter the soil biochemistry making it unsuitable for native plants (Windham and Lathrop 1999). Phragmites is a rapid grower and can be highly resistant to management techniques. See section 2.11 for information regarding a current research project at Currituck Banks that is studying the effect of Phragmites removal.

Figure 2.10: Phragmites australis (Common Reed) at Currituck Banks.

Figure 2.11: Feral horse at Currituck Banks.

Currituck Banks and the adjacent Nature Conservancy and Fish and Wildlife properties are home to a feral herd of horses (Figure 2.11). These horses are managed by the Corolla Wild Horse Fund. The Fund has an advisory board made up of the landowners impacted by the horses as well as other stakeholders. The goal of the Fund is to manage the horses for a safe carrying capacity and minimal environmental degradation. A recent population assessment determined that the herd was too large and above the carrying capacity for the resources in the region. Corrective efforts are being explored by the Fund. The impact of the horses on Currituck Banks is largely unknown. This is a gap that needs to be addressed by future research. It is thought that the horses spend most of their time north of the Reserve property. But there have not been any tracking studies to quantify this observation. The need for research into the impact of the horses is further justified by the fact that the areas north of the Reserve are continuing to be developed. This will squeeze the horses into a smaller more fragmented habitat, potentially making the areas within the Reserve more appealing. This could jeopardize the habitats at Currituck Banks because the land and plant species are not appropriate horse habitat.

Feral pigs are also found on Currituck Banks and the lands to the north (Figure 2.12). Historically, the pig use was limited to the marshes at the northern end of the Reserve. However, recently the pigs have started rooting within the maritime forest and interdunal areas. This activity could cause extensive tree damage as the shallow roots of the trees are damaged during the pig foraging activities. The pig hoofs as well are not adapted to the soils of the region and tend to sink in and break up plant roots. Both these activities could lead to tree/shrub loss and increased erosion. Hunting for feral pigs is allowed from September through March, although not enough pigs are taken to affect population numbers. Similar to the horses above, as the area north of Currituck Banks is developed the pigs' use of the Reserve is likely to increase. Thus, research into the ecological effects of the pigs is needed for this Reserve.

Figure 2.12: Feral Pig.

2.10: Stressors

The Currituck Banks Reserve is exposed to a variety of stressors, both natural and anthropogenic (man-made). Natural stressors include hurricanes and Nor'Easters, inlet migration/closure, sea level rise, salinity fluctuations and sedimentation. Anthropogenic

stressors include altered land use, pollution, nutrient loading, and habitat disruption. Some key anthropogenic stressors are discussed in detail below.

A: Altered Land Use

The type of land cover present is a critical issue because how the land is used and the type of cover on it has large impacts on its ability to sequester nutrients and pollution rather than convey them to surface waters. Natural land covers with vegetative cover such as forest and marsh have large buffering capacities. They tend to trap nutrients and sediment prior to them entering surface waters. Developed land tends to have very little capacity to absorb nutrients and pollution. This is because developed land has increased impervious surfaces such as roofs, roads, and parking lots. These surfaces do not let water infiltrate the ground and high percentages of impervious surfaces have been correlated with degraded water and sediment quality (Holland et al. 2004, Mallin et al. 2000b). Consequently, runoff from these surfaces usually picks up whatever contaminants and nutrients are on them and rapidly moves these materials to surface waters (Mallin et al. 2000b, Mallin et al. 2001).

To assess the amount of change within the Currituck Banks watershed, land cover types were evaluated for the two most recent years that data were available, 1991 and 1997. Land cover information was obtained for coastal North Carolina from NOAA's Coastal Change Analysis Program. Figure 2.13 shows the land use classifications from 1991 and 1997 for the Currituck Banks watershed (United States Geological Survey - Hydrologic Cataloging Unit 030310205). See Appendix 4 for detailed methodology. This delineation covers all the areas of the Pasquotank River Basin as shown in Figure 2.5 except for the Pamlico Sound sub-basin south of Roanoke Island. Equivalent land cover data is not available for the Virginia portion (15%) of the Currituck Banks watershed. The major land cover types were water (31%), Palustrine Forested Wetland (22%), and cultivated (18%).

For clarity the changes that occurred between 1991 and 1997 have been grouped into three categories: 1) decreased vegetation cover (of any type), 2) increased vegetation cover (of any type), and 3) a change from one type of non-vegetated cover to another (neither an increase or decrease of vegetation). The decrease in vegetation cover category includes all areas where the Land Cover changed between 1991 and 1997 to a class that characterizes conditions with generally less plant cover or biomass. Examples of this category are a transition from Forested to Grassland or Scrub-shrub to Low Density Development. The increase in vegetation cover category was assigned to all areas where the Land Cover changed to a class that represents generally greater plant cover or biomass. Examples of this category are succession of grassland to Scrub-Shrub and Scrub-Shrub to Forested. The change in non-vegetated cover category designates all areas that had different non-vegetated land cover classes in 1991 and 1997. Examples included water to unconsolidated shore, unconsolidated shore to bare land and bare land to low-density developed. Figure 2.14 and Table 2.6 show the changes between 1991 and 1997 associated with these three groups.

Changes that occurred between 1991 and 1997 affected 7% of the total land area within the watershed. The difference between vegetation losses and gains were essentially even. The increase in vegetated conditions was mainly associated with succession of Grassland to Scrub/Shrub and Evergreen Forest. The majority of decreased vegetative cover was Evergreen Forest reduced to Grassland and Scrub/Shrub with the largest tract in the northern center area of the watershed. Only 0.6% of the total vegetated land areas were lost to low and high density

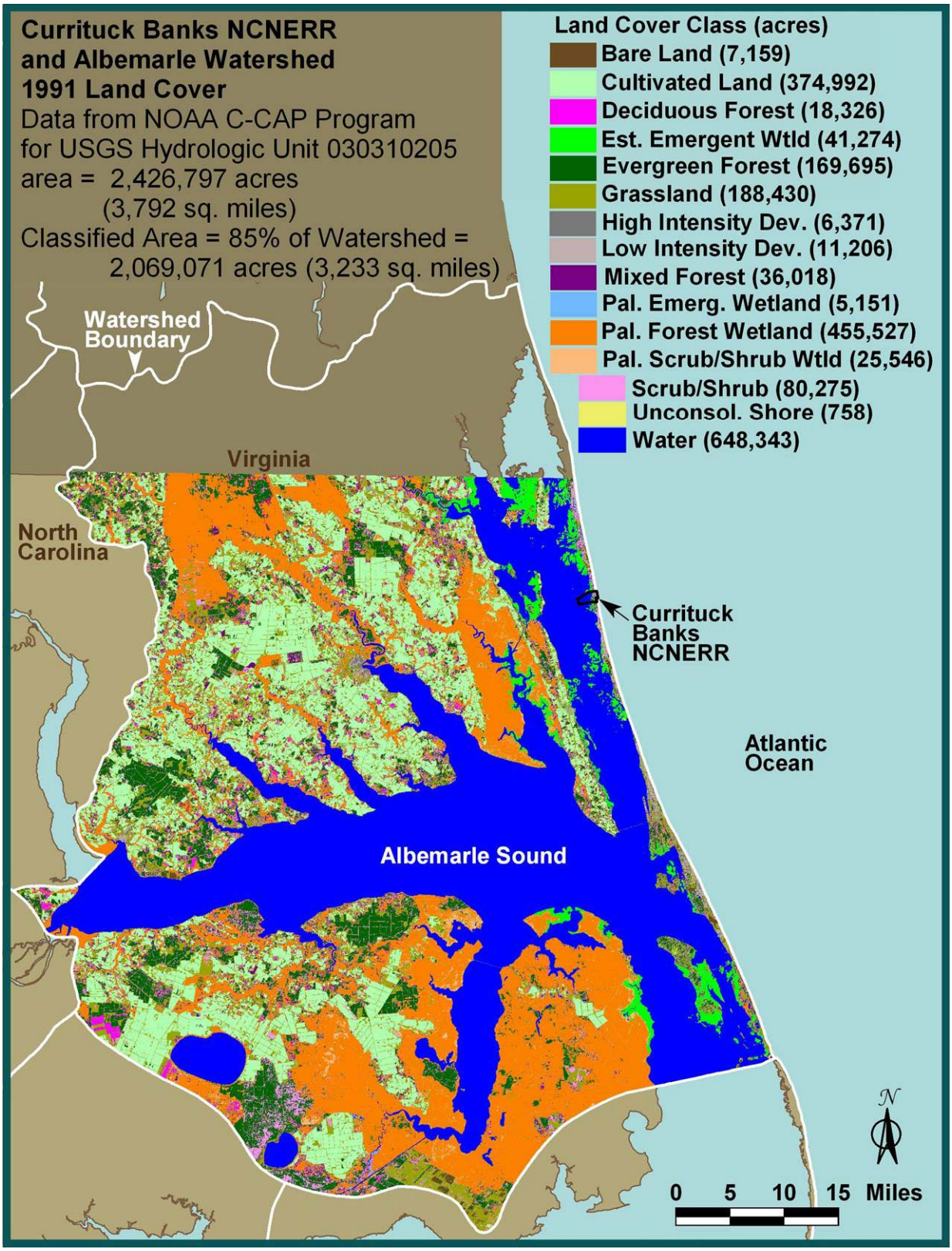

Figure 2.13a: Land use classification from 1991 in the Currituck Banks watershed.

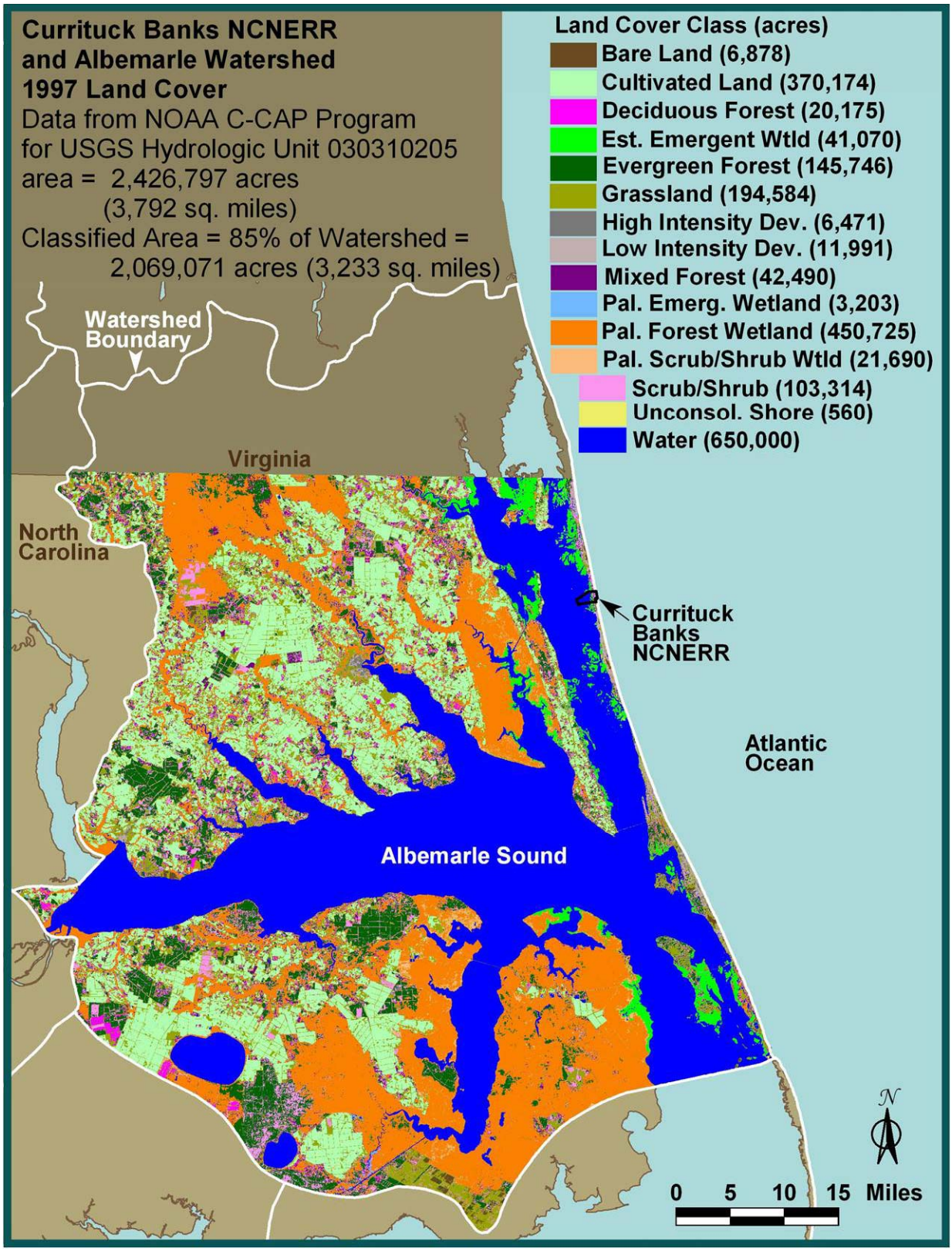

Figure 2.13b: Land use classification from 1997 in the Currituck Banks watershed.

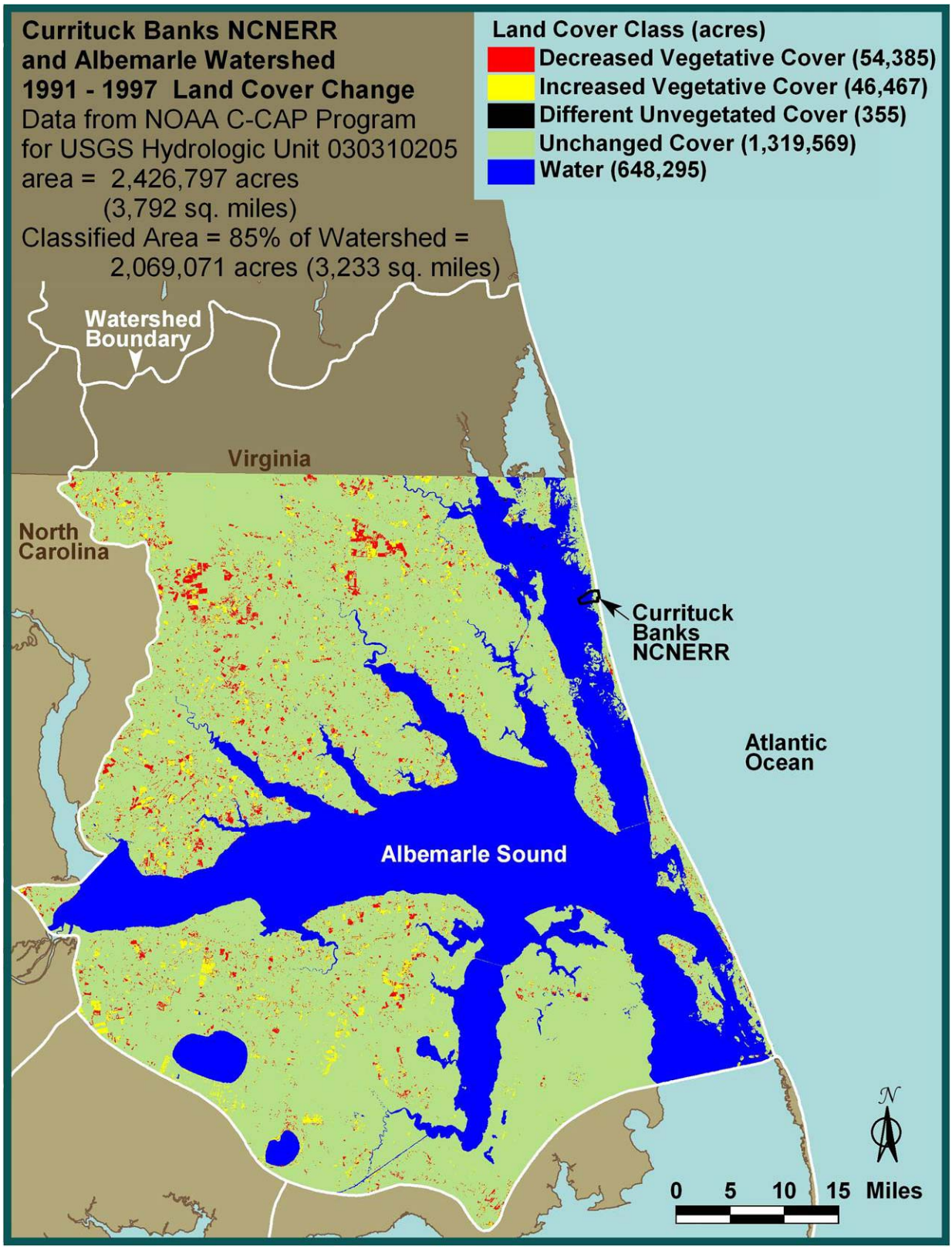

Figure 2.14: Changed land cover from 1991 to 1997 in the Currituck Banks watershed.

development. This suggests that not much buffering capacity was lost in the watershed between 1991 and 1997. Since 1997, development has continued at a rapid pace. These changes are not captured in the analysis here. When the latest land-cover data is released from NOAA, this effort will be repeated. It is anticipated that a large loss of vegetative cover has occurred since 1997.

Table 2.6: Change in land cover from 1991 to 1997 in the Currituck Banks watershed

Category	Acres	% of total
Total mapped area	2,069,071	n/a
Water area	648,295	31.3
Total land area	1,420,776	68.7
Decrease in vegetative cover	54,385	3.8
Increase in vegetative cover	46,467	3.3
Change from one unvegetative cover to another	355	0.02
Unchanged land cover	1,319,569	92.9
Net loss of vegetation = 0.6%		
Percent of land area with changed cover types = 7%		

B: Pollution/eutrophication

Eutrophication leads to excessive phytoplankton production. This can lead to a multitude of water quality problems including hypoxia, decreased light penetration, altered community composition, loss of seagrass beds, and decreased fish and shellfish populations. Recovery from eutrophication can take long periods of time even if the causes of the eutrophication are immediately halted (Nixon 1995; Paerl et al. 1998; Mallin et al. 2000a; Niemi et al. 2004). In Currituck Banks eutrophication has historically not been a big issue. This was mainly because there was not much human presence in the area. As noted in the water quality section, stormwater runoff has become an important source of pollution in the region in recent years. This fact is observable in the ocean side enterococci numbers that occasionally violate the state standards. Loss of SAV in Currituck Sound has also been blamed on reduced water quality (Davis and Brinson 1989), with parameters such as total suspended solids, chlorophyll and nutrient concentrations affecting light availability and suitability of habitat for SAV (Koch 2001). These issues have direct impacts on Currituck Banks. Traditional uses such as swimming and fishing are not possible when the beach is closed due to bacterial contamination. Loss of SAV has caused dramatic changes in the fauna of Currituck Sound including decreased fish and waterfowl.

These trends are expected to worsen in the future as well due to development pressure. Two expected projects have tremendous potential to enhance the rate of development in the region over the next decade. A mid-island bridge is planned that will connect Corolla to the mainland. This would enhance access to the area, making development much more likely. Extending Highway N.C. 12 north through the Reserve toward the Virginia border has also been proposed. This would directly impact the Reserve by separating the Reserve into two halves. Both these projects pave the way for future development around Currituck Banks, thus increasing the potential for more water quality impacts.

C: Public Use

Most visitors using Currituck Banks do so in an appropriate manner. Walking and hunting are the two most common activities within Currituck Banks. The Reserve is typically accessed via the boardwalk and hiking trails. Hunters are asked to use the northern portion of the Reserve, to maintain a safe distance between themselves and other users of the Reserve. These types of activities have a very low impact on the overall health of Currituck Banks.

Unfortunately, the Reserve also receives several types of inappropriate use. These usually occur after hours when staff is not present. The parking lot at the head of the walking trails and boardwalk is heavily utilized. Litter and vandalism are common occurrences. Bike racks and portable rest room facilities that were originally provided at the parking lot had to be removed because of severe abuse. Off road vehicles access the northern portions of the Outer Banks through the beach corridor of Currituck Banks. This impact can disrupt dune communities including sand stabilizing plants, nesting shorebirds and sea turtles. The vehicle traffic is also a major source of hydrocarbon pollution. Vehicle traffic is highest during summer.

2.11: Research Activities

The information in this section is in a rapid state of flux. Research projects are constantly being initiated, executed and completed. As a result, this section will rapidly become dated. Despite this complication, it is still beneficial to describe the current body of research in this manner. The past projects represent a large foundation which future projects can utilize as planning guides. The projects currently being conducted are designed to address current high priority coastal management issues. Thus, in addition to the actual research results, these projects will provide future interested parties with awareness into what the high priority issues were for the Reserve at this time. The needed research represents current knowledge gaps that need to be addressed. While future projects may address some of these, the underlying issues such as eutrophication and sea level rise will still be valid.

A: Research Facilities

The office facilities for the Currituck Banks are located in the town of Kitty Hawk, approximately 35 miles south of the site. There are no laboratory facilities located at this office, although space is available for minimal sample processing. Computer equipment and internet access are available allowing all types of data entry and analysis. Staff and volunteers of NCNERR are able to use the laboratory facilities of the University of North Carolina - Coastal Studies Institute located in Nags Head, N.C. These labs, located about eight miles south of the Kitty Hawk office, are fully equipped and provide the capability to conduct many types of research activities.

In addition to the Coastal Studies Institute, several entities in the Currituck region assist NCNERR with research and stewardship activities. They do this by providing space, logistical support and technical expertise. The U.S. Army Corps of Engineers has a field research station located midway between Currituck Banks and the Kitty Hawk office in Duck, N.C. This facility provides NCNERR with valuable climatic data and access to an oceanic pier if needed. In addition, meeting rooms at this facility are available to NCNERR if needed. The North Carolina

Wildlife Resources Commission Environment Education Center in Corolla, N.C. has also partnered with NCNERR provided boats and staff time in support of projects within Currituck Banks.

B: Historical Research Activities

Since its dedication, not much research has occurred within the boundaries of Currituck Banks. The remoteness of the Reserve is the primary reason for this. There have been a few studies conducted within the northern Outer Banks and the Currituck Sound. These are documented in Appendix 6, the bibliography of work conducted within NCNERR. Topics of these efforts include the sand supply and inlet dynamics for the Currituck spit (Inman and Dolan 1989; Leithold et al. 1991), the salinity of Currituck Sound (Caldwell 2001), wave and climate models (Goldsmith 1977), the sediment characteristics of Currituck County and Sound (Soil Conservation Service 1984), habitat use of feral horses (Rheinhardt and Rheinhardt 1997) and waterfowl and American coot abundance in relation to submersed macrophytic vegetation (Wicker and Endres 1995). Researchers from NOAA's Center for Coastal Environmental Health and Biomolecular Research in Charleston, SC recently completed a project at Currituck Banks examining the sediments in the Reserve using an EPA-Environmental Monitoring and Assessment Program style sampling design. The results of this project showed that the overall condition of the sediments within the Reserve was good and contaminant loads were relatively low (Cooksey and Hyland 2007). The lack of work to date is a problem and informational gap that NCNERR needs to address. This work has already started in earnest. The next section details current research projects going on within Currituck Banks.

C: Current Research Activities

Research projects currently underway at Currituck Banks will help fill the informational gap identified in the previous section. Several projects currently ongoing have sample sites directly within the Reserve boundaries. These projects are designed to examine the impact of atmospheric deposition of nutrients, the impacts to and recovery of native marsh species after removal of *Phragmites australis* via mowing and herbicide application, the amount of SAV coverage in Currituck Sound, and the potential for a toxin producing cyanobacteria to become dominant in Currituck Sound waters. All of these projects will provide critically important information that previously was not available for Currituck Banks.

The atmospheric deposition work is a part of a larger study examining the eutrophication potential of increased atmospheric deposition of nutrients to North Carolina estuaries and sounds. This is extremely important as prior work has shown that atmospheric sources can contribute upwards of 50% of the new nitrogen to coastal oceanic waters (Paerl and Fogel 1994). This work is being conducted in partnership with the U.S. Fish and Wildlife Service, the University of North Carolina – Institute of Marine Science and North Carolina State University. As part of this project NCNERR has been collecting weekly rain water samples from within Currituck Banks (see Figure 2.3). This project has shown that the wet precipitation is a significant source of nutrients for the Reserve, and that the phytoplankton in the region are stimulated by pulses of nutrients. These results clearly show that the area around Currituck Banks is susceptible to eutrophic changes.

The *Phragmites* removal project is a dual purpose experiment. Initially it was a stewardship project solely aimed at removing the Phragmites from Currituck Banks. However through collaboration between the research and stewardship sectors, the project was augmented to also allow NCNERR to monitor the recovery of native marsh species after the *Phragmites australis* was removed. The *Phragmites* stand at Currituck Banks has been growing concentrically over the past two decades. As a result, there are several age classes of the *Phragmites* present (Figure 2.15). Other studies have shown a reduction in biodiversity as many native species are replaced by the more cosmopolitan *Phragmites* species (Chambers et al. 1999). Thus, a long term monitoring program was designed to sample locations within each of these age classes annually. The results of this study will allow NCNERR to make better management decisions regarding *Phragmites* removal.

A visitor use survey was conducted in the summer of 2007. This project was conducted by both NCNERR staff and researchers from UNCW. Data analysis is currently being conducted. This project will allow site managers for Currituck Banks to better understand the public use that the Reserve receives. This will allow more efficient management of the Reserve to maximize public benefit without negatively impacting the natural community.

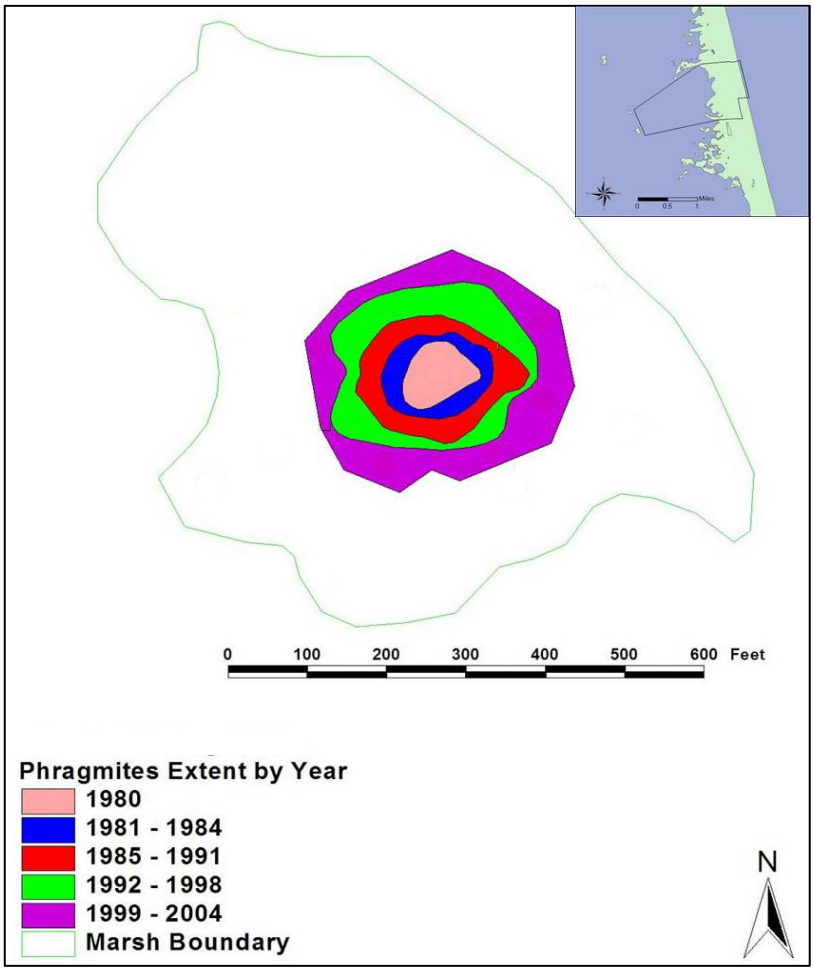

Figure 2.15: Currituck Banks Phragmites australis extent by year. The insert shows the location of the stand in Currituck Banks.

Elizabeth City State University in partnership with United States Fish and Wildlife Service (regions 4 and 5), Virginia Institute of Marine Science, North Carolina Department of Environment and Natural Resources, and the Albemarle-Pamlico National Estuary Program are conducting a study of SAV habitats in Currituck Sound in order to update earlier surveys conducted by Carraway and Priddy (1983), Davis and Brinson (1989), and Ferguson et al. (1989). They are using color aerial photography to digitize locations of SAV. Field verifications have shown the dominant SAV species in the region include Widgeongrass (*Ruppia maritime*), Pondweed (*Potamogeton perfoliatus*), Wild Celery (*Vallisneria Americana*),

and Eurasian water-milfoil (*Myriophyllum spicatum*) (Davis and Brinson 1989). Elizabeth City State University has produced a GIS spatial database and maps. These maps (Figure 2.16) provide a baseline against which future changes in SAV spatial coverage can be judged.

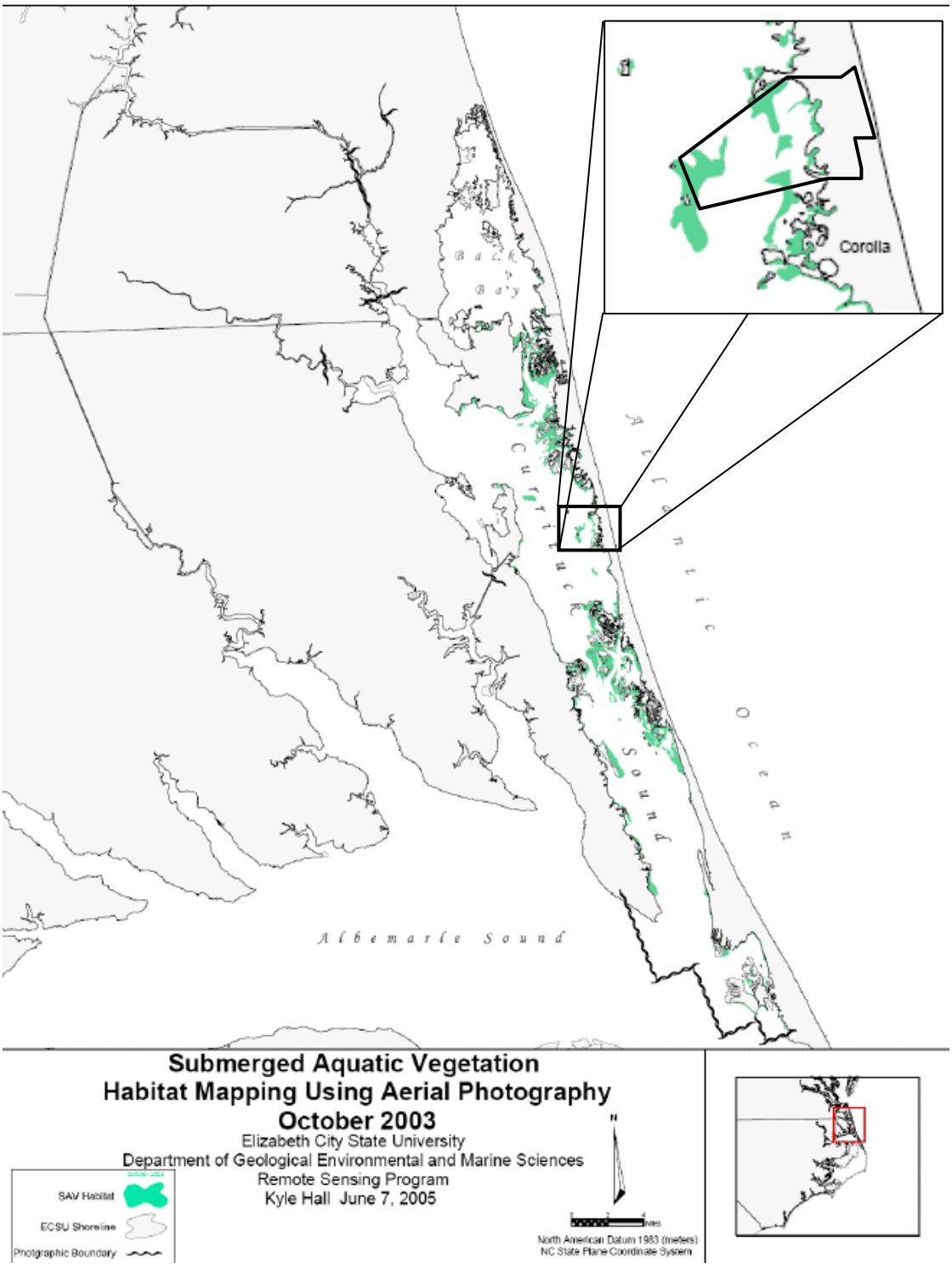

Figure 2.16: Submerged aquatic vegetation spatial coverage in Currituck Sound. Insert shows a close up of the area around Currituck Banks.

This will be a critical factor as work continues to restore the SAV in Currituck Sound.

A GRF project is also currently occurring within Currituck Banks. This is the first time a GRF has worked within the Currituck Banks component of NCNERR. The project is designed to examine the potential for Cylindrospermopsis raciborskii to become problematic within Currituck Sound. This cyanobacteria is a toxin producing cell and can lead to detrimental effects upon both fauna and humans. This research will help inform management schemes designed to protect Currituck Sound. It also will provide NCNERR valuable information regarding the community composition of the phytoplankton within the Reserve.

2.12: Future Research Needs

The above projects are providing valuable information for Currituck Banks, but much work remains to be done. Research into the effect of the feral populations of horses and pigs needs to be completed. The U.S. Fish and Wildlife Service would be an ideal partner to complete this work because they face the same management issues on their property north of Currituck Banks. The North Carolina Wildlife Resources Commission could also be brought in as a partner to help educate the public about the impacts of the horses.

The mapping efforts that have been conducted within Currituck Banks and its associated watershed need to be repeated. Specifics of interest to NCNERR are the loss of vegetative cover within the watershed, the conversion of upland Reserve habitats to marsh, the spatial coverage of SAV within Currituck Sound, and documentation of any new invasive species. Only by repeating these mapping efforts will changes be able to be quantified.

Partnership with the N.C. Wildlife Resources Commission is a great possibility with their Education Center in such close proximity. The N.C. Wildlife Resources Commission emphasizes education on wildlife in the surrounding area. With their expertise, it would be of interest to gather detailed data on wildlife in and around Currituck Banks. An initial idea has been offered from N.C. Wildlife Resources Commission to conduct amphibian research and counts, information which the Reserve lacks. Since amphibians are considered keystone species, this information would be invaluable as a predictor for climate change in the Currituck Banks area. Documenting the wildlife would also allow fauna invasive species to be documented.

Continuing SWMP-like monitoring of water quality in Currituck Sound is a high priority research need. The oligohaline back barrier sound system is a unique habitat not found anywhere else in the State. This, coupled with the expected development pressure, and the large group of data users including researchers, state managers, and the general public, makes documenting the changes in water quality within Currituck Sound paramount. Potential partners to help with this project include the Albemarle Pamlico National Estuary Program, Elizabeth City State University and the University of North Carolina - Coastal Studies Institute, and the N.C. Division of Water Quality.

Marsh elevation studies also need to be conducted within Currituck Banks. One of the big issues for the mainland side of Currituck Sound is sea level rise. Much of the area is very low relief and quite susceptible to sea level rise. Since there is not any development within the Reserve and natural processes are allowed to occur, the data from Currituck Banks could serve as the ideal control to compare other areas against. Ideal partners to assist with this project include the United States Geological Survey, and NOAA – National Centers for Coastal Ocean Science.