

Chapter 4: Masonboro Island Component

4.1: Environmental Setting

Masonboro Island is the largest NCNERR component and was designated in 1991. It is located in New Hanover County between the barrier island towns of Wrightsville Beach and Carolina Beach (Figure 4.1). It is bounded by Masonboro Inlet to the north, the Atlantic Ocean to the east, Carolina Beach Inlet to the south, and Masonboro and Myrtle Grove Sounds (part of the Atlantic Intracoastal Waterway) to the west. The city of Wilmington lies approximately five miles to the northwest. Masonboro Island is the largest undisturbed barrier island along the southern part of North Carolina. It is located within the Carolinian biogeographic province. It is approximately 8.4 miles long and encompasses 5,046 acres (20.4 km²) of subtidal soft bottoms, tidal flats, hard surfaces, salt marshes, shrub thicket, maritime forest, dredge spoil areas, grasslands, ocean beach and sand dunes. Masonboro Island is only accessible by boat. Similar to the Rachel Carson Reserve, private operators provide fee based ferry service to the Reserve property. Most visitors gain access to the Reserve on the sound side of the northern and southern ends of the island where there are large sandy beaches. Most other landings on the sound side within the middle portion of the island are only accessible at or near high tide.

4.2: Historical Uses

A: Pre-colonial Uses

Prior to English settlement, the area around Masonboro Island was likely used as a hunting ground by Native American Indians. The Eastern U.S. coast including North Carolina was inhabited by Algonkian speaking tribes. However, it is unlikely that Masonboro was permanently inhabited due to the influence of storms and the low relief of the island (Anglely 1983).

B: Colonial Uses

There is a very strong possibility that the stretch of beach now known as Masonboro Island was the first portion of the entire American coastline to be seen and described by a European explorer. This initial sighting may well have occurred in March of 1524 when the Italian voyager Giovanni Verrazzano, on an expedition sponsored by Francis I of France, came within view of what is generally believed to have been the lower coastline of present day North Carolina, several miles above the Cape Fear River. During the colonial period Masonboro Island was generally known as Cabbage Inlet Sound, taking its name from the inlet which existed at that time. Cabbage Inlet was located south of today's Masonboro Inlet, just below the mouth of Purviance (now Whiskey) Creek on the opposite side of the sound (Figure 4.1). The mainland shore of Masonboro and Myrtle Grove sounds was sparsely settled during the second quarter of the eighteenth century.

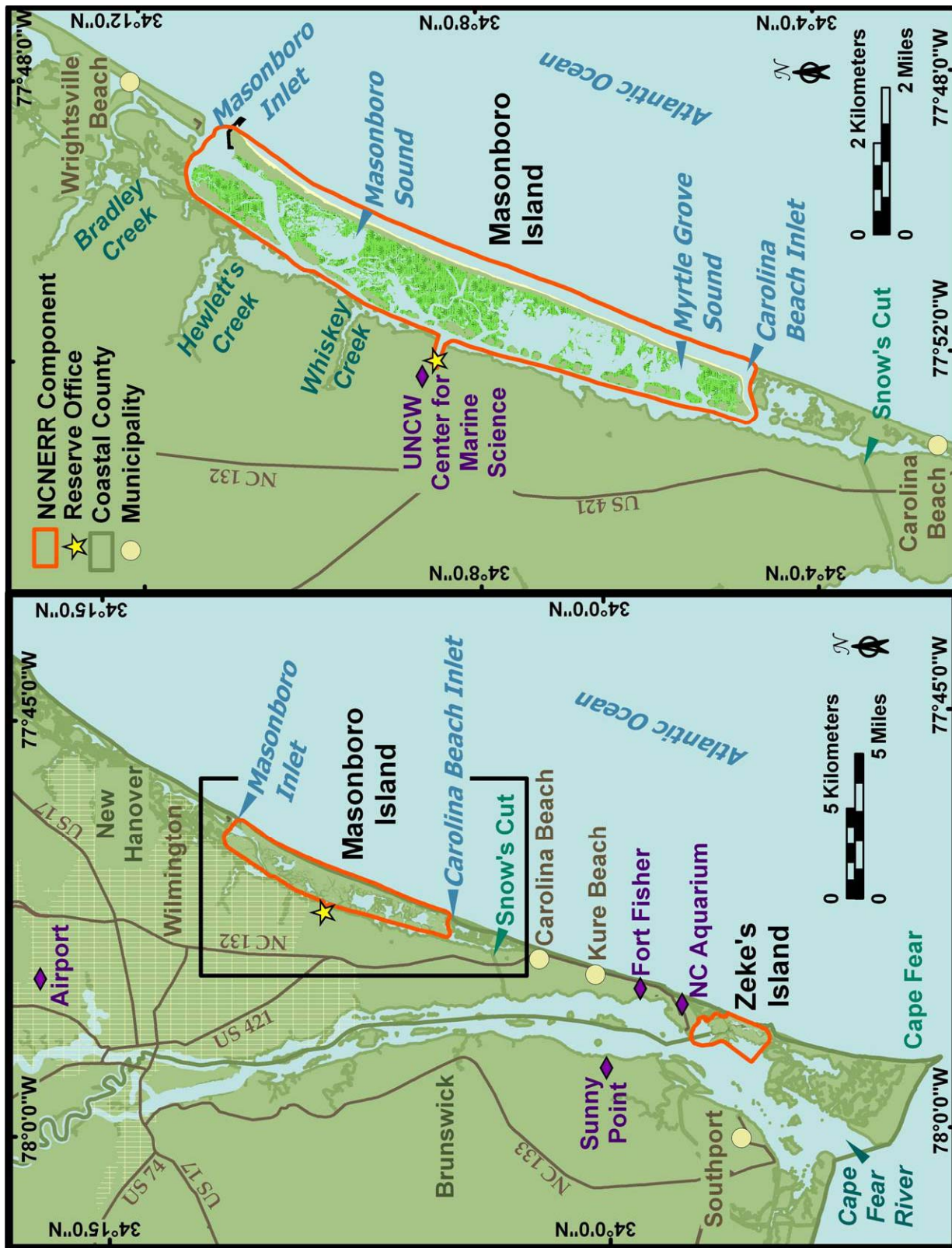


Figure 4.1: Masonboro Island location. The top panel shows a close up of Masonboro Island.

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Some of these settlers, generally those of modest means, established permanent residences along the sound, gaining their livelihoods through farming and fishing. Other, more affluent, landowners purchased property on the sound for purposes of speculation or for the establishment of summer homes (Anglely 1983).

C: Civil War Uses

Confederate troops were stationed at various points along the mainland shore of Myrtle Grove and Masonboro sounds during the course of the Civil War. Locations include the vicinity of Camp Davis, on the north bank of Hewlett's Creek, and at the state salt works near the mouth of Purviance (Whiskey) Creek (Figure 4.1). Masonboro contained at least seven salt works which operated throughout the war years (Williams and McEachern 1973). These salt works were destroyed by Union forces around 1864.

D: Post Civil War Uses

During the late nineteenth and early twentieth centuries, the mainland side of Masonboro and Myrtle Grove Sounds was settled by farmers, craftsmen, and fishermen. In the fall, mullet were taken in large quantities along the ocean side of the island. Mullet was the most abundant food fish from North Carolina southward and the most important saltwater fish for the post civil war times (Smith 1907). Other important fisheries included flounders, shrimp, clams, and oysters obtained from adjacent sound waters.

4.3: Climate

As part of the SWMP, a weather station has been maintained on a dredge spoil island within the Masonboro Island Reserve since 1994. However, more comprehensive historic climate data may be inferred from the Wilmington area which has a data record going back to 1871.

The nearest National Weather Service network reporting weather station to the Masonboro Island area is located at the Wilmington International Airport (Figure 4.1). Based on National Weather Service data, annual mean temperature for Wilmington from 1871 to 2004 was 62.7 °F (17.1 °C). The coolest temperatures occur in January, with an average daily temperature of 44.8 °F (7.1 °C), and the warmest average daily temperatures, 80.1 °F (26.7 °C), occur in July (Figure 4.2).

During the spring and summer seasons, winds are predominately from the southwest. Fall winds change to northeasterly, while winter winds are primarily from the north. Extratropical storms, known as "nor'easters", generally occur from October to May and are characterized by strong northeast winds which may blow continuously for three or more days (Moorefield 1978).

National Climatic Data Center records indicate the wettest year from 1933-2004 for Wilmington was 1999 with 72.06 inches (183.03 cm) of rainfall. Hurricane Floyd passed through the Wilmington area on September 15, 1999, and September had record rainfall amounts of 23.41 inches (59.46 cm). Average annual rainfall for Wilmington from 1900-2000 was 51.38 inches (130.5 cm). Historically, September is the wettest month and April is the driest month for

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the Wilmington area. National Climatic Data Center records indicate the driest year from 1933-2004 for the Wilmington area was 1968 with 37.77 inches (95.94 cm) of rainfall (Table 4.1).

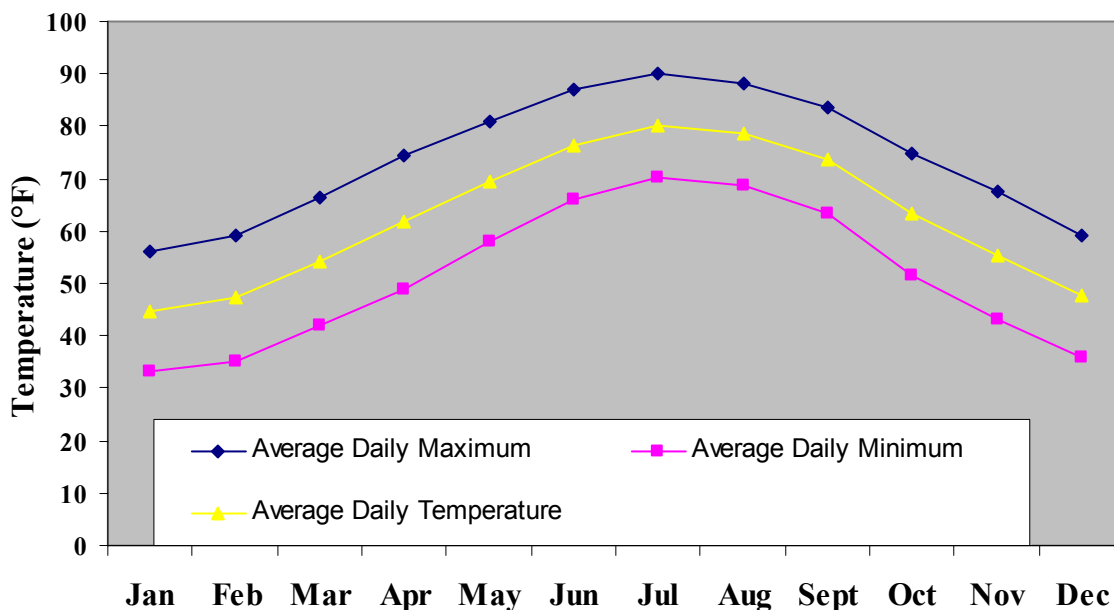


Figure 4.2: Average, minimum and maximum daily temperatures 1871 – 2004 by month for Wilmington, NC. Figure from NOAA-National Climatic Data Center.

Table 4.1: Top ten highest and lowest annual precipitation amounts for Wilmington, N.C. recorded 1933 – 2004

Top 10 highest precipitation amounts 1933 - 2004		
Rank	Precipitation (in)	Date
1	72.06	1999
2	72.05	1946
3	69.95	1947
4	66.65	1989
5	66.2	1992
6	65.63	1966
7	65.11	1995
8	64.42	1996
9	64.2	1998
10	63.95	1945
Top 10 lowest precipitation amounts 1933 - 2004		
Rank	Precipitation (in)	Date
1	37.77	1968
2	37.98	2001
3	39.06	1941
4	40.89	1954
5	42.16	1967
6	43.18	1933
7	43.7	1978
8	43.89	1956
9	44.02	1985
10	44.38	1981

Data from NOAA-National Climatic Data Center

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Table 4.2 shows the named tropical systems that have passed within 65 nm of Masonboro Island of the past 50 years. Notable storms include Bertha and Fran in 1996 which caused extensive damage to the Wilmington area. In 1999 Hurricane Floyd passed directly over Masonboro Island before moving North. The rainfall associated with Floyd led to extensive flood damage in the coastal plain region of North Carolina. More recently, Hurricane Ophelia passed just offshore in September of 2005 bringing large amounts of beach front erosion and large amounts of rainfall. Nor'Easters do not get named like tropical systems, but are usually denoted by the month or significant calendar event and year in which they occur (*i.e.* the Halloween storm of 1991). Several Nor'Easters have also impacted the region since 1956.

Table 4.2: Tropical storms passing within 65nm of Masonboro Island since 1956

Storm	Date	Name	Wind (kts)	Minimum Pressure (mb)	Classification
1	September 1956	Flossy	35		Extratropical
2	September 1958	Helene	115	938	Category 4 hurricane
3	July 1960	Brenda	50		Tropical storm
4	September 1960	Donna	95	958	Category 2 hurricane
5	September 1961	Not Named	35		Tropical depression
6	August 1962	Alma	45	1002	Tropical storm
7	September 1964	Dora	45		Tropical storm
8	June 1966	Alma	40	997	Tropical storm
9	June 1968	Abby	25		Tropical depression
10	October 1968	Gladys	75		Category 1 hurricane
11	August 1970	Not Named	30	1013	Tropical depression
12	August 1971	Doria	50	998	Tropical storm
13	October 1971	Ginger	65	984	Category 1 hurricane
14	June 1972	Agnes	40	988	Tropical storm
15	June 1975	Amy	30	1006	Tropical depression
16	October 1975	Hallie	45	1002	Tropical storm
17	September 1977	Clara	25	1011	Tropical depression
18	August 1981	Dennis	55	998	Tropical storm
19	June 1982	Subtropical 1	60	992	Subtropical storm
20	September 1984	Diana	115	949	Category 4 hurricane
21	November 1985	Kate	45	996	Tropical storm
22	August 1987	Arlene	10	1016	Tropical low
23	June 1995	Allison	40	995	Extratropical
24	June 1996	Arthur	40	1005	Tropical storm
25	July 1996	Bertha	90	974	Category 2 hurricane
26	September 1996	Fran	100	954	Category 3 hurricane
27	October 1996	Josephine	45	988	Extratropical
28	August 1998	Bonnie	100	962	Category 3 hurricane
29	September 1998	Earl	50	995	Extratropical
30	September 1999	Floyd	90	950	Category 2 hurricane
31	October 1999	Irene	80	976	Category 1 hurricane
32	June 2001	Allison	25	1006	Subtropical depression
33	October 2002	Kyle	35	1011	Tropical storm
34	August 2004	Bonnie	25	1008	Tropical depression
35	August 2004	Charley	65	988	Category 1 hurricane
36	September 2005	Ophelia	75	979	Category 1 hurricane

Data from the NOAA – Coastal Services Center

Snow and sleet are rare for this area due to the warming effect of the ocean in winter, but do occasionally occur.

4.4: Geological Processes

Masonboro Island is part of a barrier island complex formed offshore with the time frame being speculative (Atkinson et al. 1998). The genesis of the original island is thought to have occurred by mainland beach detachment (Hosier and Cleary 1977a and 1977b). According to Hoyt (1967) separation of the barrier island from the mainland occurred during the last 5,000 years when the Holocene sea rise slowed down. Dune ridges formed along a seashore that was some distance seaward of the present coast. The rising sea then isolated the dune ridges from the mainland forming barrier islands that were then translated landward under the influence of rising sea level. Island “migration” is still occurring as evidenced by formed sound-side peat and shell deposits being exposed on the ocean beaches of many extant barrier islands (Godfrey and Godfrey 1976).

The Masonboro Island component consists of Recent (less than ~11,550 years old) and Pleistocene (~1.8 million to ~11,550 years before present) sediments that are part of the Pamlico Terrace located on the eastern edge of the North Carolina coastal plain (Atkinson et al. 1998). The upland areas include 500+ acres of natural grasslands, dunes and woody vegetated areas and 166 acres of dredge material islands (Atkinson, et. al. 1998). The remaining 4300+ acres are estuarine areas including marshes and tidal flats (Atkinson et al. 1998).

The soils of Masonboro are classified as Entisols (Atkinson et al. 1998). The grassland areas along the ocean side of Masonboro as well as the dredge spoil islands are underlain by well drained Newhan series (Soil Conservation Service 1977). The dredge spoil islands within Masonboro Island Reserve were created in the late 1920s, when materials from the waterway construction were placed over portions of the marsh and tidal flats (Cleary and Hosier 1995). The substrate for shrub thicket and maritime forest is associated with poorly drained Duckston series, while the marshes and tidal flats are associated with the Carteret series (Soil Conservation Service 1977).

4.5: Hydrology and Water Quality

A: Ocean Side

a: Hydrology

The waters surrounding Masonboro Island are categorized as marine waters of the outer open coast or estuarine waters of the inner back bay (NOAA 1984). The mean tidal range of the open ocean at Masonboro Inlet is 3.8 ft (1.1 m) with spring tides averaging 4.5 ft (1.4 m) and average wave height is 2.7 ft (0.8 m) (Cleary and Hosier 1995). The hydrology around Masonboro Island has been significantly altered by humans. The stabilization of Masonboro Inlet, the creation of Carolina Beach Inlet, as well as the opening of Snow’s Cut between the Intracoastal Waterway and the Cape Fear River has impacted sediment transport and hydrology of areas surrounding Masonboro Island.

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The north end of the island is bounded by Masonboro Inlet, which has migrated over 4,000 feet (1219 m) since 1909 (Seabergh and Thomas 2002). Masonboro Inlet appears on historical charts from 1733, documenting the opening of the inlet in the in the early 1700s two kilometers north of its present location (Cleary and Marden 2001). Fifteen years after the completion of the Atlantic Intracoastal Waterway in 1932, the inlet's channel was artificially relocated at the southern end of a barrier spit extending northward from Masonboro Island (Cleary and Marden 2001). In 1950, a navigation project was proposed, calling for a 14 ft (4.3 m) by 400 ft (122 m) channel across the ebb-tidal delta, dual jetties and a series of access channels to the Intracoastal Waterway (Cleary and Marden 2001). In June 1966, the northern weir jetty was completed after difficulties were encountered trying to maintain the channel by dredging alone (Cleary and Marden 2001). The south jetty was completed in 1981 after several attempts to relocate the inlet away from the north jetty (Cleary and Marden 2001).

Inlet modifications have substantial impacts on the adjacent barrier islands (Cleary and Marden 2001). The Masonboro Island shoreline south of the jetty has built up as much as 295 ft (90 m), while the remainder of the island has retreated as much as 426 ft (130 m) over the past 20 years (Cleary and Marden 2001). Historic charts show the presence of Sugarloaf Inlet near the vicinity of Carolina Beach Inlet in 1882, and though the exact date is unknown, it is presumed that this inlet closed prior to 1900 (Cleary and Hosier 1995). After the closure of Sugarloaf Inlet and prior to 1952, Masonboro Island did not exist as a separate island, but was connected to present-day Carolina Beach (itself having been separated from the mainland in the 1930s by Snow's Cut). The artificial opening of Carolina Beach Inlet in 1952 for the private interests of local fishing enthusiasts afforded easier ocean access for boaters in the lower Cape Fear River region and consequently improved water quality in Myrtle Grove Sound (Jarrett 2000).

Masonboro Island also experiences overwash in the low relief and narrow section of the barrier island. Dunes on Masonboro are generally less than 13 ft (4 m) in elevation and the most of the dunes are located on the northern portion of the island (Cleary and Hosier 1995). A few isolated dunes once rose above 20 ft (6 m) and are visible on older topographic maps (Cleary and Hosier 1995), however the series of storms in the late 1990s dramatically decreased the height of most of the dunes on Masonboro.

Erosion occurring on Masonboro Island within the past several decades can be attributed to reduced sediment supply from inlet alterations by man and frequent storm events (Cleary and Hosier 1995). U.S. Army Corps of Engineers studies indicate that the barrier spit was relatively stable before the opening of Carolina Beach Inlet and the construction of Masonboro Inlet jetties (Cleary and Marden 2001). After the opening of Carolina Beach Inlet, Masonboro Island and Carolina Beach both began to rapidly erode (Cleary and Marden 2001). The increased ability for the ebb tidal delta of Carolina Beach Inlet to retain sediments has adversely affected Masonboro Island (Cleary and Marden 2001).

Both inlets are federally maintained navigational channels. The north jetty at Masonboro Inlet is designed to allow sediment from the predominant southbound littoral current to enter the inlet, where it is retained in a deposition basin. The south jetty effectively prevents almost all north bound littoral sand transport from Masonboro Island from entering the inlet (Jarrett 2000). Sediments from Masonboro Inlet are periodically extracted and used to renourish both Masonboro Island and Wrightsville Beach. According to the sediment budget analysis conducted in 1982 (used to inform current renourishment activities), the estimated amount of sand bypassing needed to offset project induced erosion is 125,000 cubic yards/year (95,569

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m³/year) to Masonboro Island (Jarret 2000). Sediments extracted from Carolina Beach Inlet are used to renourish Carolina Beach only. The southern third of the island does not receive beach nourishment and has suffered a sediment deficit of approximately 3.2 million cubic yards (2,446,575 m³) for the period 1969 to 1999 and remains in a sediment starved condition. While the area immediately south of the southern jetty at Masonboro Inlet is stable, the main portion of the island has experienced a net deficit in the supply of littoral material since 1969 (Jarrett 2000).

b: Water Quality

Ocean-side water quality monitoring is conducted by two entities, the Coastal Ocean Research and Monitoring Program (www.comrp.org) and the Department of Environmental Health Shellfish Sanitation and Recreational Water Quality Section. The Coastal Ocean Research and Monitoring Program is a collaborative program of NOAA, the University of North Carolina Wilmington, North Carolina State University and the University of South Carolina. This program monitors near shore ocean conditions and water quality parameters near Masonboro Island (Figure 4.3). These monitoring stations provide valuable data which can be used to infer conditions in the region offshore of Masonboro Island.

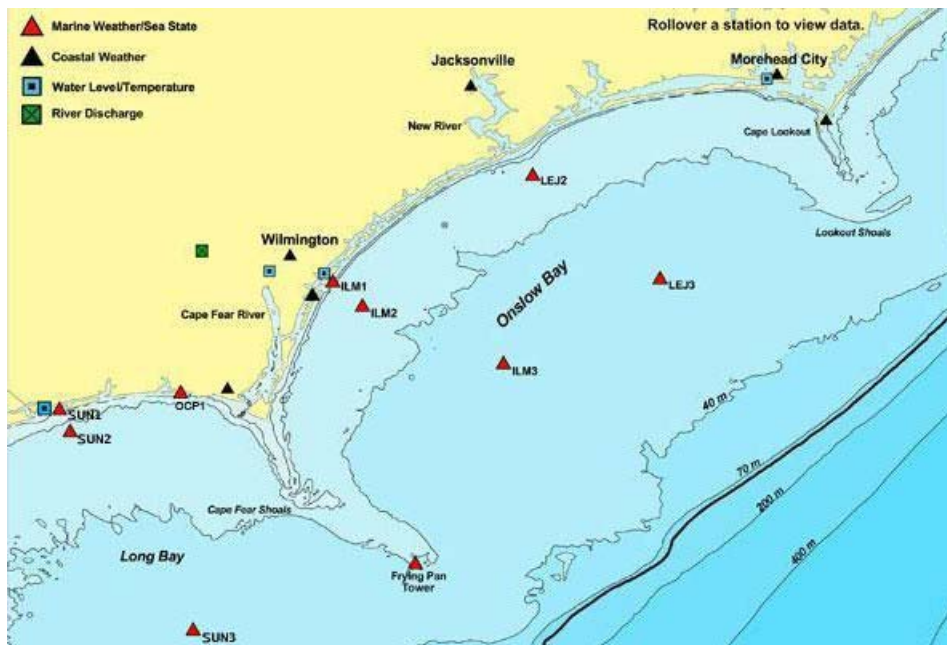


Figure 4.3: Coastal Ocean Research and Monitoring Program sampling stations near Masonboro Island.

Based on data from the Coastal Ocean Research and Monitoring Program, the areas of Onslow and Long Bay have good water quality. The area around the mouth of the Cape Fear River has occasional water quality declines associated with runoff events but these typically dissipate once the runoff event subsides.

The N.C. Department of Environmental Health Shellfish Sanitation and Recreational Water Quality Section monitors 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 Masonboro Island. Limits for

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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. A Tier 2 area is defined as receiving on average three days



Figure 4.4: Water quality monitoring locations at Masonboro Island.

of use per week during swimming season. The enterococcus level in a Tier 2 swimming area shall not exceed a single sample of 276 enterococci per 100 ml of water.

There are no beach side (Tier 1) sites on Masonboro Island. Compared to other area beaches, Masonboro is not as accessible to the general public and the island is not developed. These factors combine to limit the pollution sources and usership of the Island thus preventing it from qualifying for sampling by the water quality section. However, there are two Tier 1 sites near Masonboro located at Carolina Beach (Site S-21) and Wrightsville Beach (Site S-22A) (Figure 4.4) that provide information regarding the ocean-side water quality for Masonboro Island. Based on the data available for these locations, the water quality on the ocean-side of Masonboro Island is good relative to fecal bacteria. The average enterococcus bacteria concentration for Site S-21 (2003-2006) was 11.3 enterococci per 100 ml water and Site S-22A (2003-2006) was 12.4 enterococci per 100 ml water.

B: Sound Side

a: Hydrology

Masonboro and Myrtle Grove Sounds are included in the Cape Fear River Basin by the North Carolina Division of Water Quality (Figure 4.5). In reality, the only real connection between the Sounds and the Cape Fear River is the artificially created Snow's Cut (Figure 4.1). The estuarine waters of Masonboro and Myrtle Grove Sounds have restricted access to the ocean through Masonboro Inlet, Carolina Beach Inlet and occasional overwash. Considerable freshwater influx occurs through mainland tidal creeks, surface runoff, ground water seepage (from the island and mainland), and direct precipitation (NOAA 1984). The hydrology in the sounds is dominated by the tidal exchange through Masonboro and Carolina Beach Inlet, but tidal flushing is not complete, particularly at the midpoint region between the inlets (Zullo 1984). Two major tidal creeks, Hewletts and Whiskey, drain into the Intracoastal Waterway adjacent of the northern portions of Masonboro Island component (Figure 4.4). Field observations in the vicinity of Snow's Cut indicate variably located tide lines separating the higher salinity oceanic waters from the darker, tannin stained, low salinity riverine waters. Although the waters of the Cape Fear do not significantly influence the Masonboro Island Estuary (United States Army Corps of Engineers 1980), the southern portion of Masonboro and the adjacent marshes are affected by a small amount of water that comes through Snow's Cut that does not pass through Carolina Beach Inlet.

b: Water Quality

The absence of development on Masonboro Island coupled with tidal flushing result in generally very good to excellent water quality in Masonboro Sound. However, low to moderate levels of bacteria are contributed from sewage spills, septic tank effluents and surface runoff from portions of New Hanover County that drain into the sound via mainland creeks. The water quality parameters for Hewletts and Whiskey Creeks were monitored as part of the New Hanover County Tidal Creeks Program, facilitated through the University of North Carolina Wilmington's Center for Marine Science, Aquatic Ecology Laboratory until 2007 when this project was completed. Hewletts Creek has seen repeated sewer spills, including incidents in 1992, 1993, and 1994 which resulted in over 650,000 gallons (2,460,517 L) of effluent entering the creek.

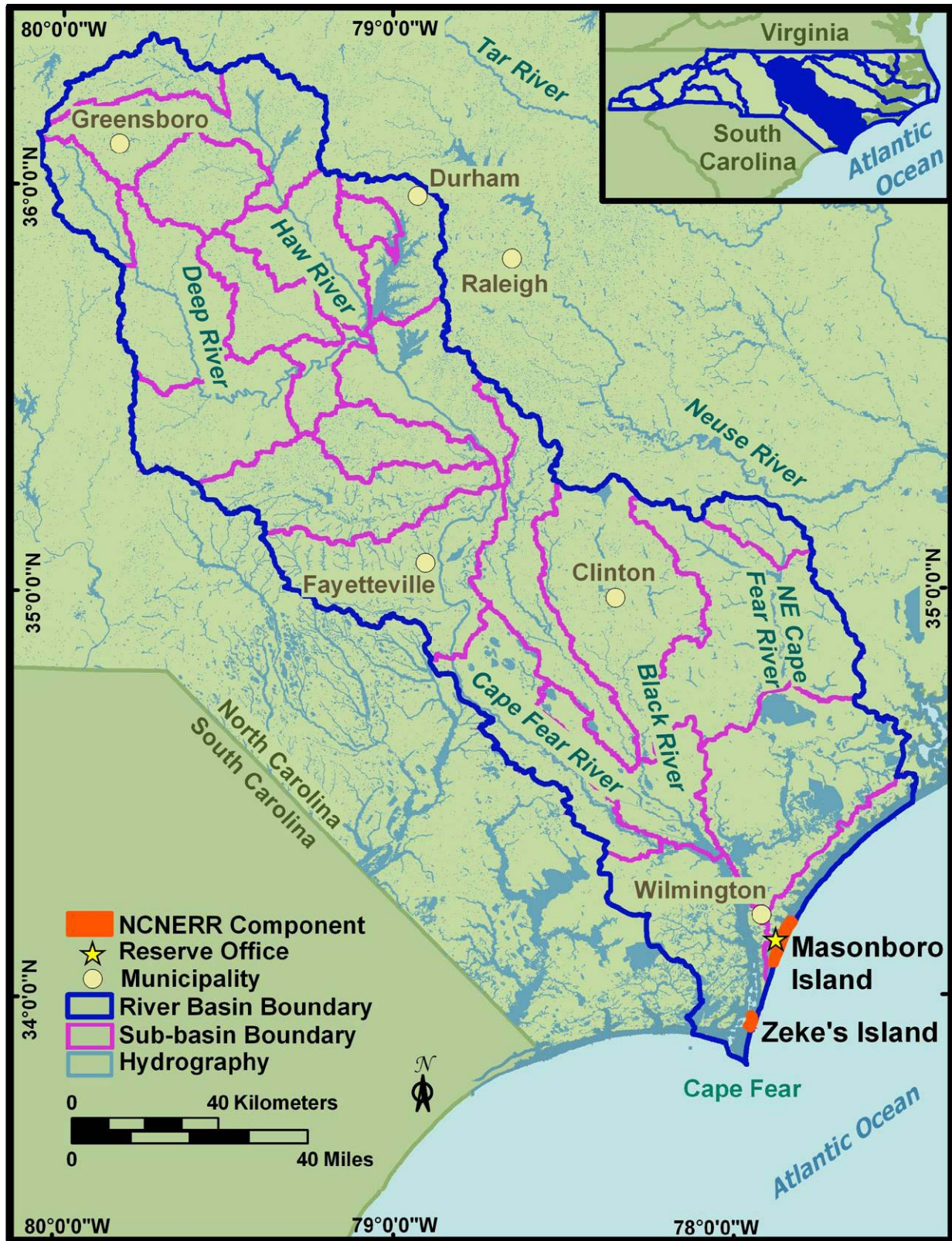


Figure 4.5: Cape Fear River Basin map.

More recently, spills in 2004, 2005, and 2006 introduced more than 4 million gallons (15,141,647 L) of raw sewage into Hewletts (McGrath 2006). These events resulted in algal bloom events on the creek and incidents of hypoxia. The latter led to fish kills and some duck mortality (Mallin et al. 2006). Fecal coliform bacteria concentrations (within the water column and sediment), nutrient concentrations, and algal blooms were also dramatically increased following the sewage spill (Mallin et al. 2006). Regulatory agencies banned swimming in the Intracoastal Waterway for two weeks following the sewage spill and banned swimming within Hewletts Creek for the remainder of the summer (Mallin et al. 2006). Hewletts Creek and surrounding areas of the waterway were closed to shellfish harvesting after the sewage spill as well (Mallin et al. 2006). Tropical storm Ernesto resulted in 18,000 gallons (68,137 L) of sewage being spilled into the creek (Gannon 2006a and 2006b). Despite such incidents, the creek has no persistent dissolved oxygen, turbidity, or algal bloom problems (Mallin et al. 2006). However, some sections of Hewletts Creek will be added to the North Carolina 303(d) list of impaired waters (North Carolina Division of Water Quality 2005).

The water quality stations in Whiskey Creek monitored as part of the New Hanover Tidal Creeks Program were considered good quality, violating the North Carolina State Standards in less than 10% of all samples for dissolved oxygen, turbidity and chlorophyll *a* concentrations for the 2004-2005 monitoring period (Mallin et al. 2006). The station at the mouth of Whiskey Creek experienced high levels of nutrient concentrations during 2004-2005. This site had the highest levels of phosphate, ammonium and nitrate compared to all other creek mouth stations sampled as part of the New Hanover County Tidal Creeks Program (Mallin et al. 2006). Whiskey Creek is currently closed to shellfish harvesting and will also be added to the state's 303(d) list of impaired waters (North Carolina Division of Water Quality 2005).

The North Carolina Department of Natural Resources, Division of Water Quality produces a Basinwide Water Quality Plan for each river basin in North Carolina. The Cape Fear River Basinwide Plan lists the waters of Masonboro Sound as part of the 03-06-24 Subbasin. Within the portion of this subbasin near Masonboro Island, one station is monitored for macroinvertebrates (BB299), and one station is monitored for ambient water quality (BA730). The macroinvertebrate station was located within Hewletts Creek (Figure 4.4) and was sampled in 2003. It was found to be "supporting" for aquatic life, with the result listed as "moderate stress" with possible stressors of fecal coliform bacteria (North Carolina Division of Water Quality 2005). The ambient monitoring station was located within Masonboro Sound north of Carolina Beach Inlet (Figure 4.4). This site was found to be "supporting" for both aquatic life and recreational use, but "impaired" and conditionally approved for shellfish harvesting. All waters within this subbasin are listed as "impaired" for the fish consumption category because of fish consumption advice that applies to the entire basin (North Carolina Division of Water Quality 2005). All waters within this basin are listed as "supporting" for the water supply category. Masonboro Sound is considered an Outstanding Water Resource Area by the North Carolina Division of Water Quality. Segments of Masonboro Sound on the mainland side, near tidal creeks and marinas are listed as "impaired" for shellfish harvesting and are classified as prohibited or conditionally approved open (North Carolina Division of Water Quality 2005).

Recreational water quality testing is conducted at three sites in and around Masonboro Island by the North Carolina Department of Environmental Health Recreational Water Quality Program (Figure 4.4). Site S46A is located off the southern end of Masonboro, near Carolina Beach Inlet. Site S47A is within the Intracoastal Waterway across from Whiskey Creek and near the NCNERR Research Creek monitoring area. Site S48 is located in an area called Masonboro

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Channel, between the northern end of Masonboro and the most northern dredge spoil island within the Reserve component. Based on the data available on the Recreational Water Quality Program there were no swimming advisories for site S46A and S48. Site S47A had one swimming advisory in September 2004. The average enterococcus bacteria concentrations for Sites S46A (2004-2006), S47A (2004-2006) and S48 (2003-2006) were 13.14, 28.30, and 20.38 enterococci per 100 ml water respectively. Sites S46A and S47A experienced the highest concentrations during this monitoring period in September 2004; S46A=137 enterococci, S47A=782 enterococci per 100 ml water. These high values were obtained after nearly two inches of rain had fallen the prior two days (precipitation data from NCNERR SWMP). The highest value at site S48, 75 enterococci per 100 ml, also occurred during September 2004. Only 4% of samples for this period had concentrations over 20 enterococci per 100 ml. This is not surprising given that S46A and S48 are in close proximity to inlets and that the waters near S47A often have swift currents with tidal cycles. Thus, pollutants in the area are rapidly flushed and high concentrations of pollutants are probable for only short durations after periods of heavy rain.

Staff of NCNERR maintains two SWMP stations on Masonboro Island. The locations of these sampling locations are shown in Figure 4.4. The Research Creek site has been in continuous operation since 1994, Loosin Creek since 2002. Both stations are equipped with continuously monitored water quality instruments made by Yellow Springs Instruments that measure: dissolved oxygen, pH, temperature, conductivity and turbidity. The Research Creek site is equipped with satellite telemetry that beams the data in near real time to the internet through NOAA's Centralized Data Management Office. These locations have also been sampled monthly for nutrient (NH_4^+ , NO_3^- and PO_4^{3-}) and chlorophyll *a* concentrations since 2002. The water quality within Masonboro Island is typically good. The criteria for a "good" rating are that N.C. State standards are not exceeded in more than 10% of all samples (see (North Carolina Division of Water Quality 2004) for a full list of state water quality standards). A "fair" rating has samples exceeding N.C. State standards in 11-25% of measurements, and a "poor" rating has samples exceeding the N.C. State standard more than 25% of the time. Table 4.3 provides the high, low and average for the measured water quality parameters at Masonboro Island.

Table 4.3: SWMP water quality data from
Masonboro Island 2002-2006

Parameter	Loosin Creek data	Research Creek Data
	Range, Average	Range, Average
Dissolved O ₂ (%)	5.2 – 196.9, 95	0.6 – 211.5, 90.4
pH	6.3 – 9.2, 8.1	7.1 – 10.8, 8.0
Conductivity(mS/cm)	23.68 – 55.69, 47.93	16.53 – 54.67, 42.64
Salinity (psu)	14.3 – 37, 31.2	9.6 – 36.1, 27.4
Turbidity (NTU)	0 – 1000, 26	0 – 1000, 32
NH_4^+ (mg/l)	BDL – 0.63	BDL – 3.3
NO_3^- (mg/l)	BDL – 0.15	BDL – 0.29
PO_4^{3-} (mg/l)	BDL – 0.16	BDL – 0.049
Chlorophyll <i>a</i> (µg/l)	BDL – 9.29	BDL – 107.56
BDL = Below Detection Limit		

Table 4.3 shows that nutrient concentration levels around Masonboro Island are usually very low. This is consistent with the lack of development and scarce sources of pollution on the island. Salinity is usually quite high validating the argument that the waters around Masonboro

Island are hydrological separate from major fresh water sources. Salinity from Loosin Creek is on average higher than that from Research Creek. This is consistent with Research Creek being farther away from the oceanic inlet than Loosin Creek. Chlorophyll *a* levels from both sampling stations are typical for the region. The Chlorophyll *a* levels were much higher in Research Creek compared to Loosin Creek. Although we currently do not have any flow data for the two sampling locations, the geomorphology of the creeks suggest that Loosin Creek has higher flow rates compared to Research Creek. Loosin Creek is within 1 mile (1.6 km) of the inlet and is located in a wide mouthed open tidal creek. Consequently, flow at Loosin Creek is likely quite high. Research Creek is located much farther from the inlet (~ 3 miles (4.8 km)) and is in a very narrow sheltered tidal creek with a sand bar constricted mouth. Consequently, flow at Research Creek is likely much slower than that at Loosin Creek. The lower flow gives algae more time to assimilate nutrients and grow before being flushed out of the area accounting for the higher Chlorophyll *a* values. Figure 4.6 shows the average annual temperature, salinity, dissolved oxygen, and turbidity measured at the Masonboro SWMP stations. Combining flow measurements with the water quality data is a research need for the Masonboro component.

The only parameter that shows any major deviation at both stations since 1994 is turbidity. Turbidity ranged from 15 to 55 NTU at Research Creek, and from 10 to 50 NTU at Loosin Creek. Turbidity was the highest at Research Creek and lowest at Loosin Creek during 2004. The year with the highest turbidity at Loosin Creek occurred in 2006. Two tropical systems impacted the area in 2004, tropical storm Bonnie, and hurricane Charley both in late summer (Table 4.2). In addition, there were strong winds and heavy rain in the Wilmington area during August 2004 as a result of Tropical Storm Gaston near Charleston, SC. The wind and rain from these storms were most likely major contributing factors for the high turbidity average at Research Creek during 2004. The fact that Research Creek and Loosin Creek responded differently during this time fame supports the idea that they are in very different hydrologic environments. The rapid tidal flushing that occurs at Loosin Creek, due to its proximity to the inlet, likely reduced the effect of the tropical systems on turbidity values during 2004 compared to Research Creek.

Figure 4.7 shows the average nutrient (NO_3^- , NH_4^+ , PO_4^{3-}) concentrations and Chlorophyll *a* values for the two SWMP stations found at Masonboro Island. Both stations show a large increase (over $500 \mu\text{g l}^{-1}$) in ammonium (NH_4^+) concentrations in August through December 2002. NH_4^+ concentrations throughout the rest of the time period become episodically elevated especially in late summer but never approach the high values seen in fall 2002. Nitrate (NO_3^-) levels were usually low ($< 50 \mu\text{g l}^{-1}$), but did increase at both stations during November 2002 and August 2004. Since these peaks occurred at both stations at the same time, it suggests a single large scale causative agent as opposed to separate local scale events. Phosphate (PO_4^{3-}) levels were extremely low throughout the entire dataset. Overall dissolved inorganic nitrogen (NH_4^+ and NO_3^-) to Phosphorus levels for both stations was 30. Compared to the Redfield ratio 16 (Redfield 1958), our data suggest the waters around Masonboro Island are enriched in nitrogen. Chlorophyll *a* levels were similar for both stations. Maximum Chlorophyll *a* values were typically observed in late summer at both stations. The late summer Chlorophyll *a* maximum is most likely due to the increased availability of NH_4^+ during this time and also to the increased temperatures. Chlorophyll *a* values were usually lowest during winter. There was one unusual Chlorophyll *a* peak at Research Creek in February 2003. This peak occurred about 1 month after a large nutrient pulse containing NH_4^+ , NO_3^- and PO_4^{3-} (Figure 4.7). Chlorophyll levels at the Masonboro SWMP stations are correlated with both dissolved inorganic nitrogen

(NO_3^- and NH_4^+ combined) and PO_4^{3-} ($p < 0.05$). Thus, the large pulse of nutrients that occurred in fall 2002 likely caused the observed Chlorophyll *a* peak in February 2003.

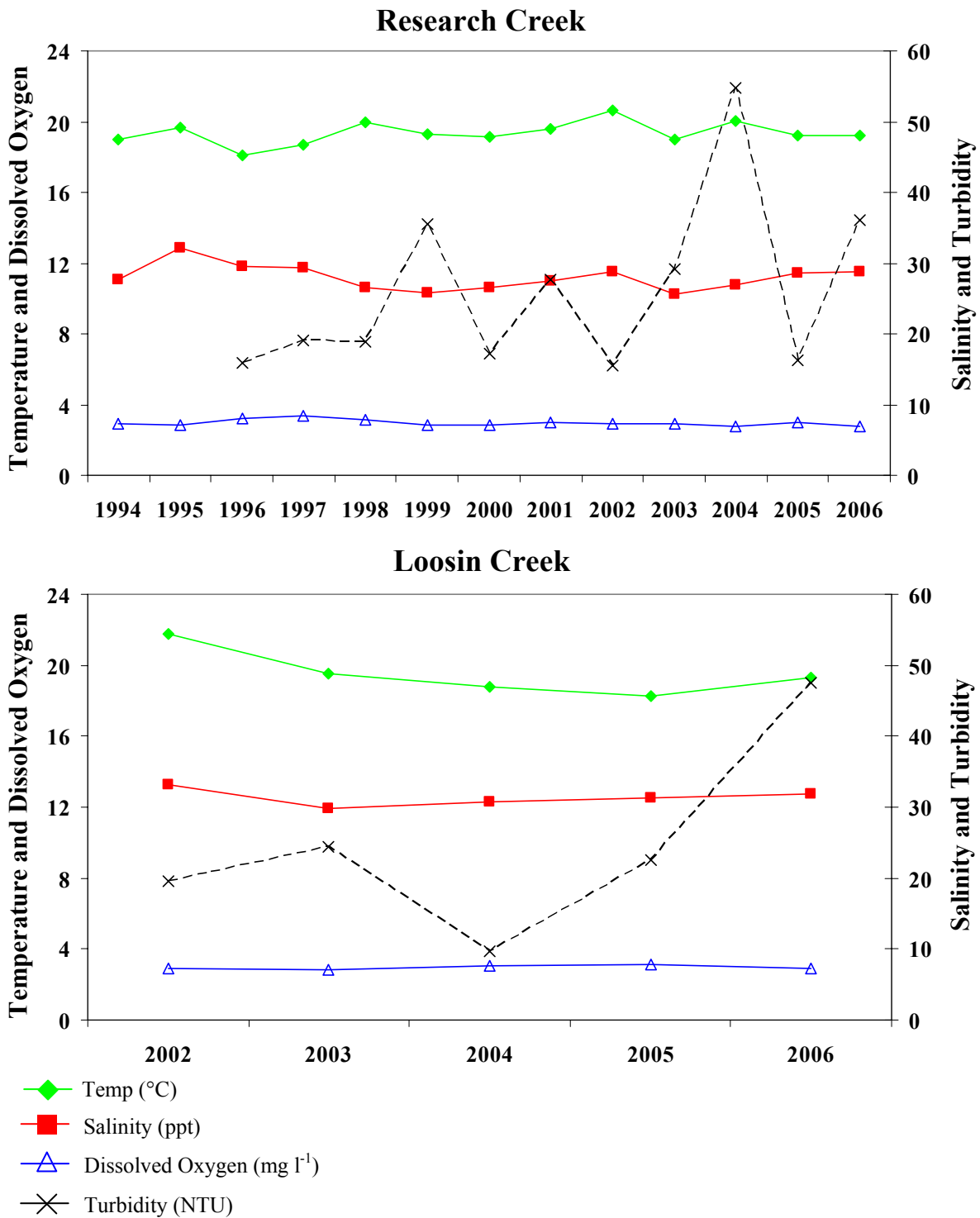


Figure 4.6: Yearly averaged physical-chemical SWMP data from Masonboro Island.

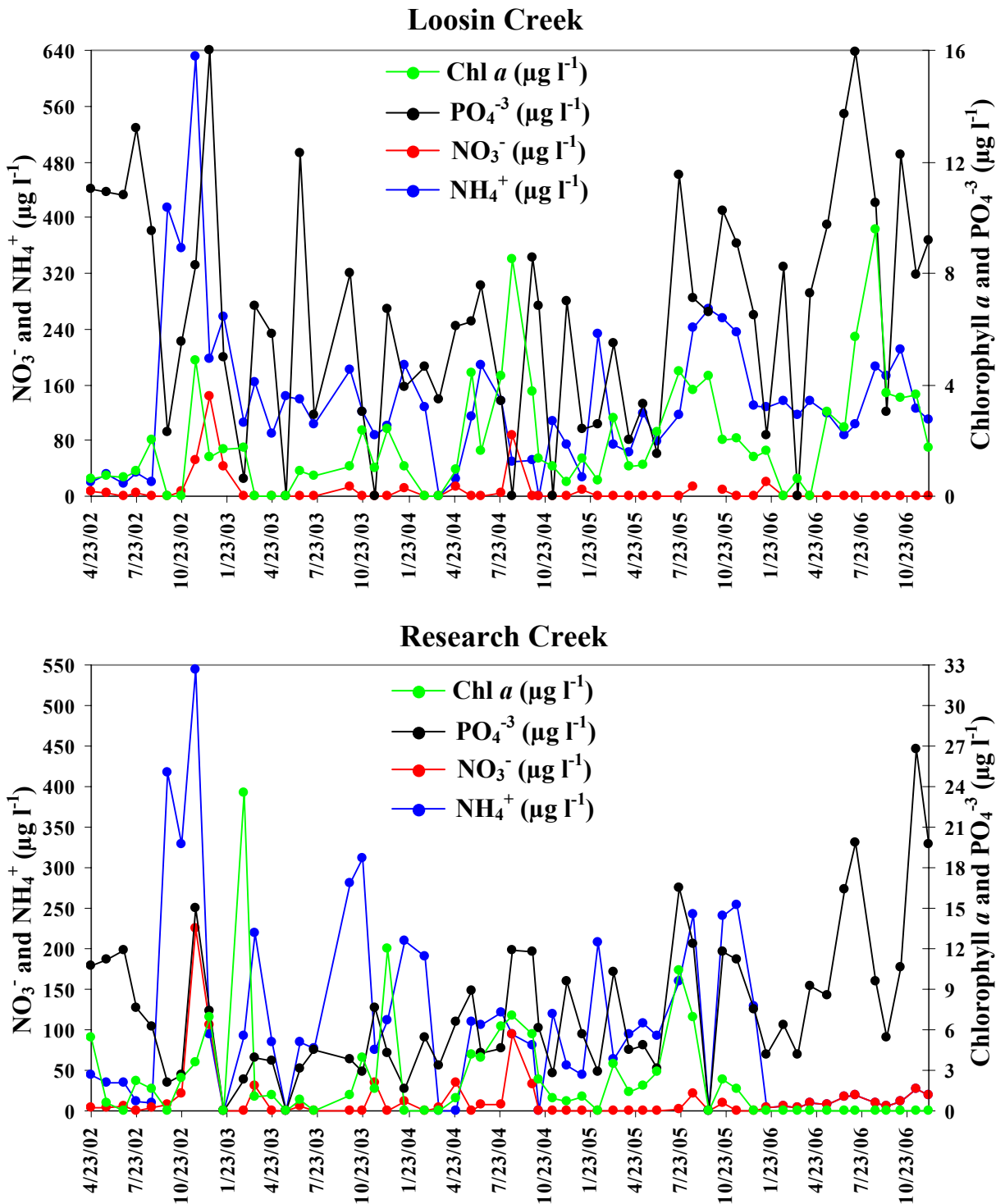


Figure 4.7: Monthly nutrient and Chlorophyll *a* data for Loosin Creek and Research Creek SWMP stations.

4.6: 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 Masonboro Island 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 subtidal soft bottoms, tidal flats, hard surfaces, salt marshes, shrub thicket, maritime forest, dredge spoil areas, grasslands, ocean beach and sand dunes (Table 4.4). Figure 4.8 shows the resultant map from this effort. However, this assessment provided only minimal information regarding habitat types

Table 4.4: Masonboro Island 1994 habitat classifications

Habitat	Description
Subtidal softbottom	Open sand or mud flats that never get exposed at low tide.
Tidal creeks	Open water feeder creeks through the marshes and across tidal flats.
Submerged aquatic plant beds	Subtidal areas that are primary habitat for bay scallops and associated species.
Intertidal mud and sand flats	Open sand or mud flats that are submerged at high tide and exposed at low tide.
Salt marshes	Low and high fringing areas that are persistently wet.
Rock jetty	Allocated on the north end of the island.
Maritime shrub thicket	Shrub areas on the upland island areas.
Evergreen maritime forest	Forested areas in the central portion of the island.
Dredge material areas	Areas along the waterway ranging in successional communities from open sand to herb dominated to woody vegetation.
Dunes	Upland areas stabilized by grasses, natural barrier to waves.
Ocean beach	Intertidal areas of sandy beach stretching the length of the island.

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 the Masonboro Island component is presented at the subclass level in Figure 4.9. 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 4.5). 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 Masonboro Island are described in the following paragraphs, with representative photographs presented in Appendix 4.

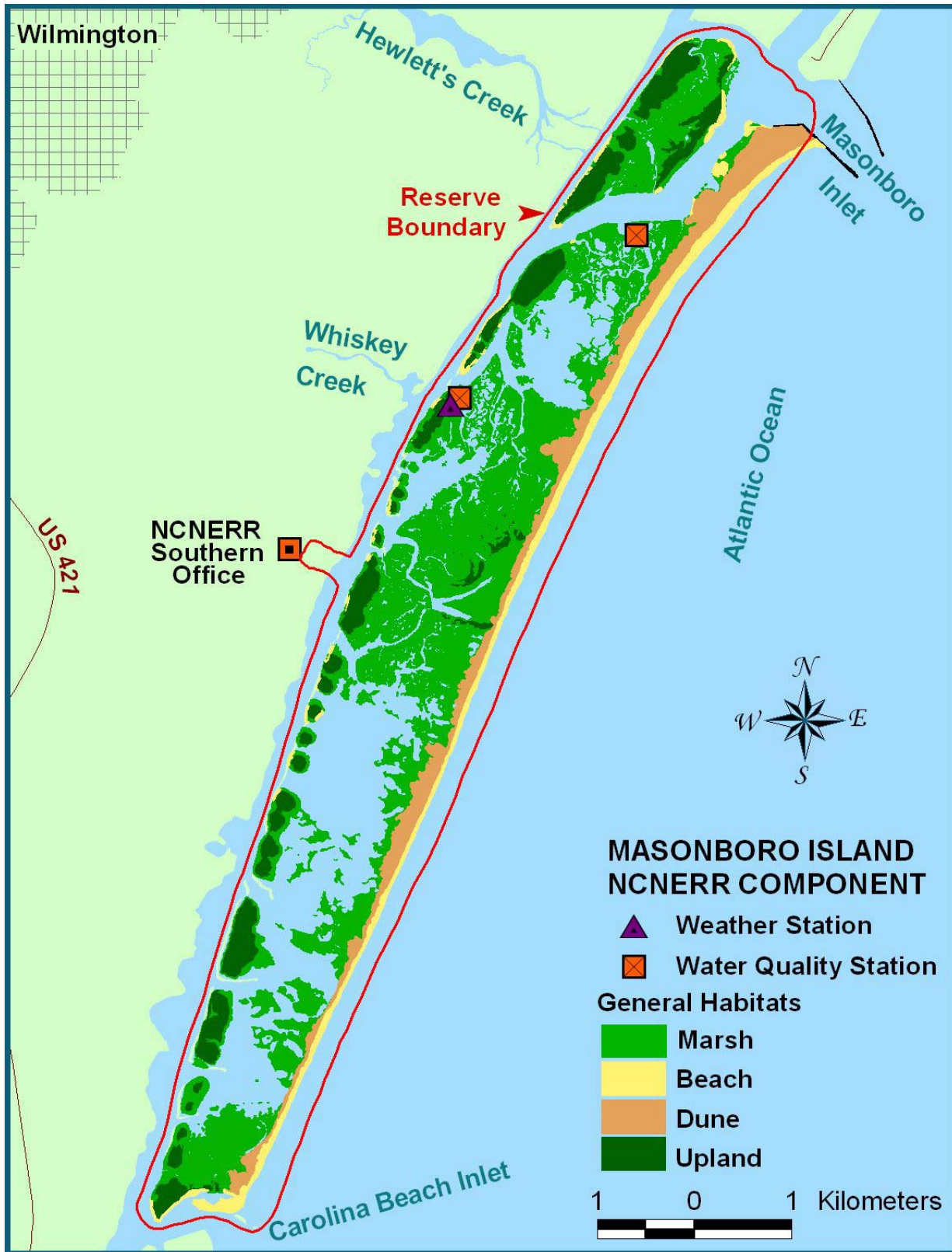


Figure 4.8: Habitat map from 1994 for Masonboro Island.

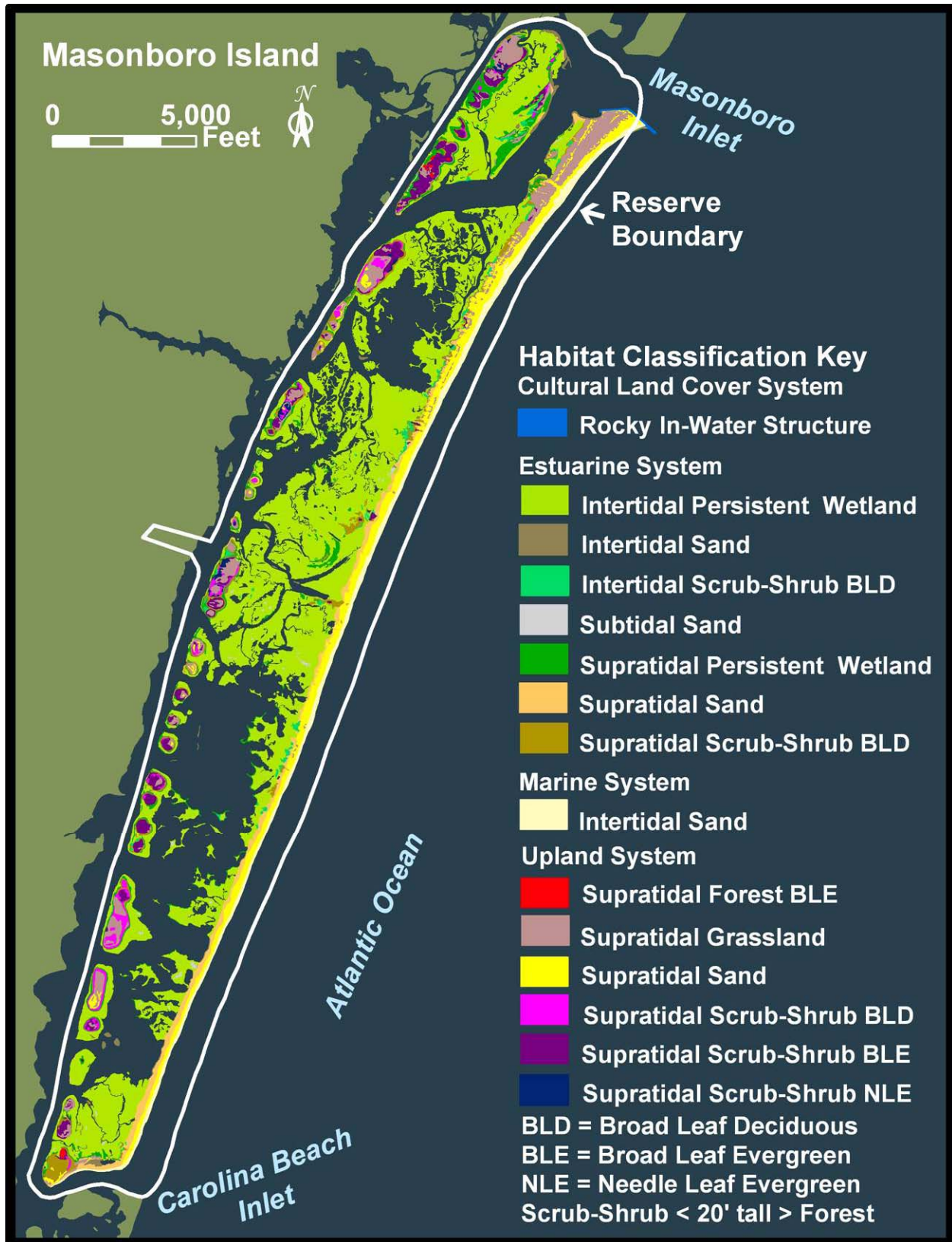


Figure 4.9: Masonboro Island 2004 habitat classification presented at the subclass level.

Table 4.5: Masonboro Island 2004 habitat classifications areal statistics

Habitat Subclass	Area (Acres)	% of Total
Estuarine Intertidal Persistent Wetland	1510.58	58.43
Upland Supratidal Sand	202.39	7.83
Upland Supratidal Grassland	197.49	7.64
Marine Intertidal Sand	133.44	5.16
Estuarine Supratidal Scrub-Shrub Broad Leaf Deciduous	122.45	4.74
Upland Supratidal Scrub-Shrub Broad Leaf Evergreen	108.51	4.20
Estuarine Supratidal Persistent Wetland	105.16	4.07
Estuarine Supratidal Sand	97.63	3.78
Estuarine Intertidal Scrub-Shrub Broad Leaf Deciduous	46.70	1.81
Estuarine Intertidal Sand	36.89	1.43
Upland Supratidal Scrub-Shrub Needle Leaf Evergreen	11.63	0.45
Estuarine Subtidal Sand	7.68	0.30
Upland Forest Broad Leaf Evergreen	3.17	0.12
CLC Rocky in Water Structure	1.67	0.06
Total Mapped Habitat Area	2,585.38*	100
* Subtidal areas not included		

- The most dominant habitat subclass within the Masonboro Island Component was Estuarine Intertidal Persistent Wetland, comprising over 58% and over 1500 acres of total habitat. This subclass, commonly known as the salt marsh was located extensively along the sound side edges of Masonboro Island as well as between the island and dredge spoil island areas. The dominant plant species is Smooth Cordgrass (*Spartina alterniflora*).
- The second largest subclass was Upland Supratidal Sand, with 202 acres and 8% of total habitat. The majority was located adjacent to the supratidal areas of open beach along the eastern shore of Masonboro Island. This subclass, commonly known as “Sand Dunes”, includes Sea Oats (*Uniola paniculata*) and other grass species. These are open areas, with \leq 30% vegetative cover.
- Upland Grassland, covering 200 acres and 8% of total habitat, was found in the interior portions of northern and southern Masonboro Island and on the dredge spoil islands to the west. These grassland areas are inhabited by a mixed community of perennial beach grasses such as Salt Meadow Hay (*Spartina patens*), Sea Oats (*Uniola paniculata*), Inland Saltgrass (*Distichlis spicata*) and several species of *Panicum*.

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- The fourth largest subclass was Marine Intertidal Sand, 133 acres (5% of total habitat) of beach along eastern Masonboro Island. This is the largest amount of Atlantic Ocean beach within the NCNERR components.
- The following subclasses made up between 3 - 5% of total habitat and covered between 90-125 acres each (listed in decreasing order): Estuarine Supratidal Scrub-Shrub Broad Leaf Deciduous containing Sea Ox-eye (*Borrchia frutescens*); Upland Supratidal Scrub-Shrub Broad Leaf Evergreen hosting a mix of Yaupon (*Ilex vomitoria*), Wax Myrtle (*Morella cerifera* or *Myrica cerifera*), and Laurel Oak (*Quercus laurifolia*); Estuarine Supratidal Persistent Wetland with salt meadow hay (*Spartina patens*), Inland Saltgrass (*Distichlis spicata*), and Black Needle Rush (*Juncus roemarianus*), and the Estuarine Supratidal Sand subclass.
- Estuarine Intertidal Scrub-Shrub Broad Leaf Deciduous and Estuarine Intertidal Sand subclasses both made up between 1 - 2% of total habitat coverage and were represented by 47 and 37 acres, respectively. The Estuarine Intertidal Scrub-Shrub Broad Leaf Deciduous subclass was dominated by Sea Ox-eye (*Borrchia frutescens*).
- The following habitats comprised less than 1% of total habitat and covered less than 12 acres (listed in decreasing order): Upland Supratidal Scrub-Shrub Needle Leaf Evergreen containing Eastern Red Cedar (*Juniperus virginiana*); Estuarine Subtidal Sand; Upland Forested Broad Leaf Evergreen dominated by Live Oak (*Quercus virginiana*), and CLC Rocky in Water Structure of the jetty at Masonboro Inlet.

4.7: Plants

The plant communities present within the Masonboro Island area are consistent with those of other barrier islands found in this part of the country. The dominant plant species for each habitat subclass are listed in the preceding section. A full species list for NCNERR is presented at Appendix 5. The Natural Heritage Program has recognized two plant species within the Masonboro plant community as significant (Table 4.6). Seabeach Amaranth (*Amaranthus pumilus*) is listed as a threatened species on both the federal and state level and is found on the foredune areas of the marine intertidal sand areas. Dune Bluecurls (*Trichostema sp*) is considered a significantly rare species on the state level, with a range limited to North Carolina and adjacent states. However, it should be noted that no Dune Bluecurls are currently found on Masonboro Island.

Submerged aquatic vegetation at Masonboro primarily consists of localized algal colonies. Seagrass beds are extremely sparse in Masonboro and Myrtle Grove Sounds. Studies have been conducted into the taxonomy, distribution and ecology of marine algae (Freeman 1989; Kapraun 1977; Kapraun and Zechman 1982; Laws et al. 1999) and introduced species (Kapraun and Searles 1990). Freeman (1989) used surveys of benthic microalgal biomass and taxonomy to indicate significance of benthic diatoms in Masonboro Sound. Distribution was found to be largely influenced by wind and temperature. Freeman also looked at consumer studies on the use of benthic microalgal biomass by the hard clam (*Mercenaria mercenaria*). Lab studies showed clams were more likely to assimilate settled microalgae than suspended microalgae. Kapraun's work (1977) is a descriptive paper of the nine species of *Polysiphonia*

that occur on the N.C. coast including keys, descriptions, and illustrations from field specimens taken from Masonboro and Zeke's Islands. Growth, reproductive periods, and local spatial distributions are also noted. Kapraun and Searles (1990) present the initial documentation of the introduced benthic algae species, *Polysiphonia* (Ceramiales, Rhodophyta) in North Carolina. Specimens were collected from Masonboro Sound.

4.8: Animals

Long stretches of undisturbed beach like those found on Masonboro serve as nesting grounds for sea turtles (Webster and Gouveia 1988; Schwartz 1989; Webster and Cook 2005; Hawkes et al. 2005), shorebirds, colonial water birds, and Diamond-backed Terrapins (*Malaclemys terrapin centrata*). Numerous mudflats act as staging areas where migratory birds forage, rest and prepare for the next leg of their journey (Webster 2005). Beaches, dunes, maritime forests, and freshwater ponds offer critical foraging habitats for birds, mammals, insects, and crustaceans. The nutrient rich estuarine waters of Masonboro Sound and marsh surrounding the island are important nursery grounds for local fisheries such as Spot (*Leiostomus xanthurus*), Mullet (*Mugil cephalus*), Flounder (*Paralichthys dentatus* and *Paralichthys lethostigma*), Pompano (*Trachinotus carolinus*), Menhaden (*Brevoortia tyrannus*), and Bluefish (*Pomatomus saltatrix*). Bottlenose Dolphins (*Tursiops truncatus*) are frequently spotted in the waters surrounding the islands and in rare instances there have been West Indian Manatee (*Trichechus manatus*) sightings. A full species list for NCNERR is included as Appendix 5.

A: Invertebrates and Zooplankton

Over 250 species of macroinvertebrates have been documented on the Masonboro Island Reserve (NOAA 1984). The habitats of Masonboro support significant populations of insects, copepods, urchins, tunicates, worms, mollusks, crab and shrimp. A literature review revealed few published studies for these fauna within the Reserve. Research includes crustacean morphology (Andon 1993), description of a new copepod species (Fiers 1996) and distribution of Grass Shrimp (*Palaemonetes spp.*) (Townsend 1991). Andon (1993) used electronmicroscopy to examine the ultrastructure of the cuticle and associated tissues of the lamellar gills in the Sand Fiddler and the Grass Shrimp at all stages of the molt cycle to identify morphological and physiological adaptations of the gill structure used to cope with molting. Animals were collected from Masonboro. Fiers (1996) described a new copepod species (*Robertsonia glomerata*), found in a marsh at Masonboro. Townsend's (1991) experimental work on the depth distribution of Grass Shrimp in Masonboro tidal creeks and Maryland indicates that Grass Shrimp prefer shallow water depths.

B: Fishes

The waters around Masonboro Island are an ideal setting for detailed ichthyological studies. The estuarine waters serve as important nursery grounds for species such as Spot (*Leiostomus xanthurus*), Mullet (*Mugil cephalus*), Flounder (*Paralichthys dentatus* and *Paralichthys lethostigma*), Pompano (*Trachinotus carolinus*), Menhaden (*Brevoortia tyrannus*), and Bluefish (*Pomatomus saltatrix*). The most recent survey documents 155 species of fish in

the Masonboro Island vicinity (Ross and Bichy 2002). Prior work with fish can be primarily categorized as feeding behavior and trophic interactions (Cline 1992; Johnson 1994; Ogburn 1984; Pereira 1983; Perry 1982; Posey et al. 1993; Troutman 1982; Trudeau 1992) and habitat selection and utilization (Hancock 1999; Innes 1992; Necaie et al. 2005; Needham 1982; Stanley 1981; Stanley 1982; Thompson 1996). Feeding behavior was primarily studied via stomach content analysis. Cline (1992) described percent composition by number and volume of food items found in Spot and Pinfish from a Masonboro tidal creek. Johnson (1994) analyzed stomach contents of Pompano from specimens collected in the surf zone of a recently renourished area, a stretch of beach about 0.5 miles (~0.75 km) south of the renourished site, and a “natural” area about 5 miles (8 km) south of the renourished site. Percent frequency of occurrence, volume and prey diversity were determined. Ogburn (1984) described food habits, some population biology, length-weight relationship, and size at maturity for Sheepshead (*Archosargus probatocephalus*). Pereira (1983) examined the feeding habits of three Sparids from the Masonboro Inlet jetty. Food items were expressed as percent occurrence and quantified volumetrically. Perry (1982) reported the percent frequency of occurrence of stomach contents of *Fundulus heteroclitus* and *F. majalis*. Posey et al. (1993) used caging experiments with a combination of nutrient additions, fish exclusions and inclusions, and uncaged control plots to examine ecology of benthic invertebrates (top down vs. bottom up control). Troutman (1982) wrote about food habits of *Tautoga onitis* including observations on feeding periodicity, relative and seasonal abundance, and length frequency distributions. Trudeau (1992) studied Pinfish (*Lagodon rhomboids*) diet using stomach content analysis and found that fish in silty habitats ate more of the same food items than those taken from a sandy habitat.

Several studies have focused on factors that affect nekton habitat selection and utilization. Hancock (1999) described the relationship between marsh patch size and nekton distribution. Innes (1992) presented evidence of segregation by depth for fishes in North Carolina and Chesapeake Bay. Lindquist et al. (1985) reported on the composition of fish on Masonboro Inlet jetties. Necaie et al. (2005) utilized caged studies of juvenile Summer Flounder and results suggested that basic abiotic conditions, at the levels and durations that occurred within the study, have little impact on growth, but may influence survival. Needham (1982) described fish species composition in a Masonboro tidal creek. Stanley (1981) used line transect sampling to census fish populations at Masonboro jetties. Stanley (1982) described species, relative abundance, diversity and seasonal composition of reef fishes for north and south jetties of Masonboro Inlet. Thompson (1996) used block nets to sample fish in oyster bed habitats and adjacent soft bottom habitats and compared species abundance and diversity between the two habitats.

C: Reptiles and Amphibians

The majority of the island’s reptiles and amphibians are found in the upland habitats and include several species of lizards, snakes, frogs, and toads. The Diamond-back Terrapin is also occasionally found in the salt marshes. Masonboro Island is an important nesting beach for both Green (*Chelonia mydas*) and Loggerhead (*Caretta caretta*) sea turtles, which have been the focus of several research efforts. The first comprehensive picture of the relative density and distribution of Loggerhead Sea turtle nesting efforts in North Carolina was developed using aerial surveys in 1980 and 1981 (Crouse 1984). Masonboro Island was continuously monitored for nesting activities from 1985 through 1989, and again in 1990, 1991, 1994 and 1999-2002.

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From 2002 until recently, the island was the only beach in N.C. not monitored. A collaborative effort between the stewardship sector of NCNERR and researchers from UNCW resumed monitoring during the 2006 nesting season. It is hoped that this effort will continue. Current and potential partners in this project include the N.C. Wildlife Resources Commission, UNCW Department of Biological Sciences, and The Pleasure Island Sea Turtle Project. The results of the turtle nest monitoring efforts have shown a slow increase in nest numbers since 1985.

The effects of nest temperature on hatchling emergence and sex determination have been studied during past monitoring (Gouveia 1988; Gouveia and Webster 1988; Neville and Webster 1988; Webster and Gouveia 1988). Studies on Masonboro Island revealed that the critical period for sex determination occurs during the latter part of the middle trimester, specifically around days 33 through 37 in a typical 60 day nest. Hentosh (1995) investigated the effects of beach nourishment that took place in 1986 and 1994 on nesting behavior. The results showed that loggerheads avoid the impact areas while nourishment activities are in progress and throughout the remainder of the nesting season. The frequency of nests and false crawls on impacted areas was found to return to normal after one year.

D: Birds

Masonboro Island provides habitat to over 250 species of birds including threatened, significantly rare, or species of special concern such as the Piping Plover (*Charadrius melodus*), Brown Pelican (*Pelecanus occidentalis*) and Black Skimmer (*Rhynchops niger*) (Table 4.6). Previous research includes population surveys and habitat utilization (Davis 1972; Everhart 1978; Kinsey 1992; Parnell et al. 1986; Smith 1988) and behavior (Warr 1991). Davis (1972) concluded man made islands at Masonboro are utilized by most species of waterway birds. Everhart (1978) compared natural and dredged material nesting site habitats of Gull-billed Terns (*Sterna nilotica*), Common Terns (*Sterna hirundo*) and Black Skimmers. Kinsey (1992) documented heavy use of intertidal habitats by birds at all seasons. The study found 55 species and nine orders and lists species by seasons, site, and habitat. Parnell et al. (1986) updated previous surveys of colonial waterbird habitats and nesting populations in North Carolina estuaries in 1983 looking at all four NERR components. Smith (1988) compared Masonboro Island and Carolina Beach ocean front beaches for bird use and found that low levels of human activity didn't seem to influence the behavior or presence/absence of birds, while high levels of human activity did influence bird activity. Warr (1991) observed foraging behavior of American Oystercatchers (*Haematopus palliatus*) for a full year in several habitats. Detailed observations include foraging rate, success rate, handling time and foraging technique. Current bird management activities on Masonboro include demarcation of colonial shorebird nesting areas in conjunction with Audubon and surveys of bird breeding success with both Audubon and the N.C. Wildlife Resources Commission.

E: Mammals

The Atlantic Bottlenose Dolphin (*Tursiops truncatus*) is the primary marine mammal of the Masonboro Island component and sightings are frequent both on the ocean and sound sides of the island. Terrestrial and wetland species include the Marsh Rabbit (*Sylvilagus palustris*), Cotton Rat (*Sigmodon hispidus*), Raccoon (*Procyon lotor*), River Otter (*Lontra Canadensis*) and Mink (*Mustela vison*). Little work has been done on the mammals of Masonboro. Past studies

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include habitat and dietary relationships of Marsh Rabbits (Markham 1989) and comparing the abundance of terrestrial mammals at varying habitats using traps (Colwell 1983; Pyles 1973; Walls 1968). Dominant species caught were Rice Rats (*Oryzomys palustris*), and House Mice (*Mus musculus*) (Pyles 1973; Walls 1968). Marsh Rabbits were the most abundant large mammals collected and one Eastern Cottontail Rabbit (*Sylvilagus floridanus*) was observed (Walls 1968).

Table 4.6: Species of special concern in and near Masonboro Island

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 Plants	<i>Amaranthus pumilus</i>	Seabeach Amaranth	T	T
Vascular Plants	<i>Trichostema sp</i>	Dune Bluecurls	SR-L	FSC
Bird	<i>Charadrius melodus</i>	Piping Plover	T	T
Bird	<i>Charadrius wilsonia</i>	Wilson's Plover	SR	-
Bird	<i>Egretta caerulea</i>	Little Blue Heron	SC	-
Bird	<i>Egretta thula</i>	Snowy Egret	SC	-
Bird	<i>Egretta tricolor</i>	Tricolored Heron	SC	-
Bird	<i>Pelecanus occidentalis</i>	Brown Pelican	SR	-
Bird	<i>Rynchops niger</i>	Black Skimmer	SC	-
Bird	<i>Sterna antillarum</i>	Least Tern	SC	-
Bird	<i>Sterna hirundo</i>	Common Tern	SC	-
Bird	<i>Haematopus palliatus</i>	American Oyster Catcher	SR	-
Bird	<i>Catoptrophorus semipalmatus</i>	Willet	SR	-
Reptile	<i>Caretta caretta</i>	Loggerhead	T	T
Reptile	<i>Chelonia mydas</i>	Green Turtle	T	T
Reptile	<i>Crotalus adamanteus</i>	Carolina Diamondback Terrapin	SC	-
Fish	<i>Evorthodus lyricus</i>	Lyre Goby	SR	-
Mammal	<i>Trichechus manatus</i>	West Indian Manatee	E	E

Data from the North Carolina Natural Heritage Program

4.9: Invasive Species

Masonboro Island has few invasive species. Beach Vitex (*Vitex rotundifolia*) has been found and removed from one location. In the future, this species will likely become more problematic. It has become established on several islands to the south and has demonstrated an ability to rapidly invade native communities. Common Reed (*Phragmites australis*) is found on some of the dredge spoil islands lining the Intracoastal Waterway on the backside of Masonboro Island. Red Foxes (*Vulpes vulpes*) (Figure 4.10) are not native to North Carolina, but were introduced in colonial times for the purpose of sport hunting. Red



Figure 4.10: Red Fox.

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Foxes have had a significant negative impact on colonial nesting bird and sea turtle nests on Masonboro Island and surrounding areas. Research reports a large and continuous population on nonnative red foxes throughout the eastern U.S., with increasing populations which have negative impacts on native species (Kamler and Ballard 2002). Nutria (*Myocastor coypus*) is also a potential threat likely to invade the Reserve in the near future. These rodents have been sighted in coastal habitats near Masonboro.

4.10: Stressors

The Masonboro Island Reserve component is exposed to a variety of stressors, both natural and anthropogenic (man-made). Natural stressors include hurricanes, sea level rise, and drought. Anthropogenic stressors include altered land use, pollution, nutrient loading, and habitat disruption. Some of the key 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, stormwater runs off these surfaces picking up whatever contaminants and nutrients are on them and rapidly moves these materials to surface waters (Mallin et al. 2000b; Mallin et al. 2001).

New Hanover County's estimated population growth from 1990-2000 was 36.6 % (North Carolina Department of Environment and Natural Resources 2005). The growth trend for this area is expected to continue with a forecasted population increase of 31.4 % for 2000-2020 (North Carolina Department of Environment and Natural Resources 2005). To assess the amount of change within the Masonboro Island 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 4.11 shows the land cover maps for 1991 and 1997 for the Masonboro Island watershed (United States Geological Survey - Hydrologic Cataloging Unit 03030001). It should be noted that the United States Geological Survey includes Masonboro Island in the New River watershed. This is in contrast to the State of North Carolina designation which places Masonboro Island in the Cape Fear watershed (as presented in the Hydrology and Water Quality section). The NERRS habitat mapping protocol calls for United States Geological Survey delineations, thus they were used in this analysis. See Appendix 4 for detailed methodology. The State of North Carolina includes the New River watershed as a sub-basin of the White Oak River Basin (See Chapter 3, Section 3.5, Figure 3.2).

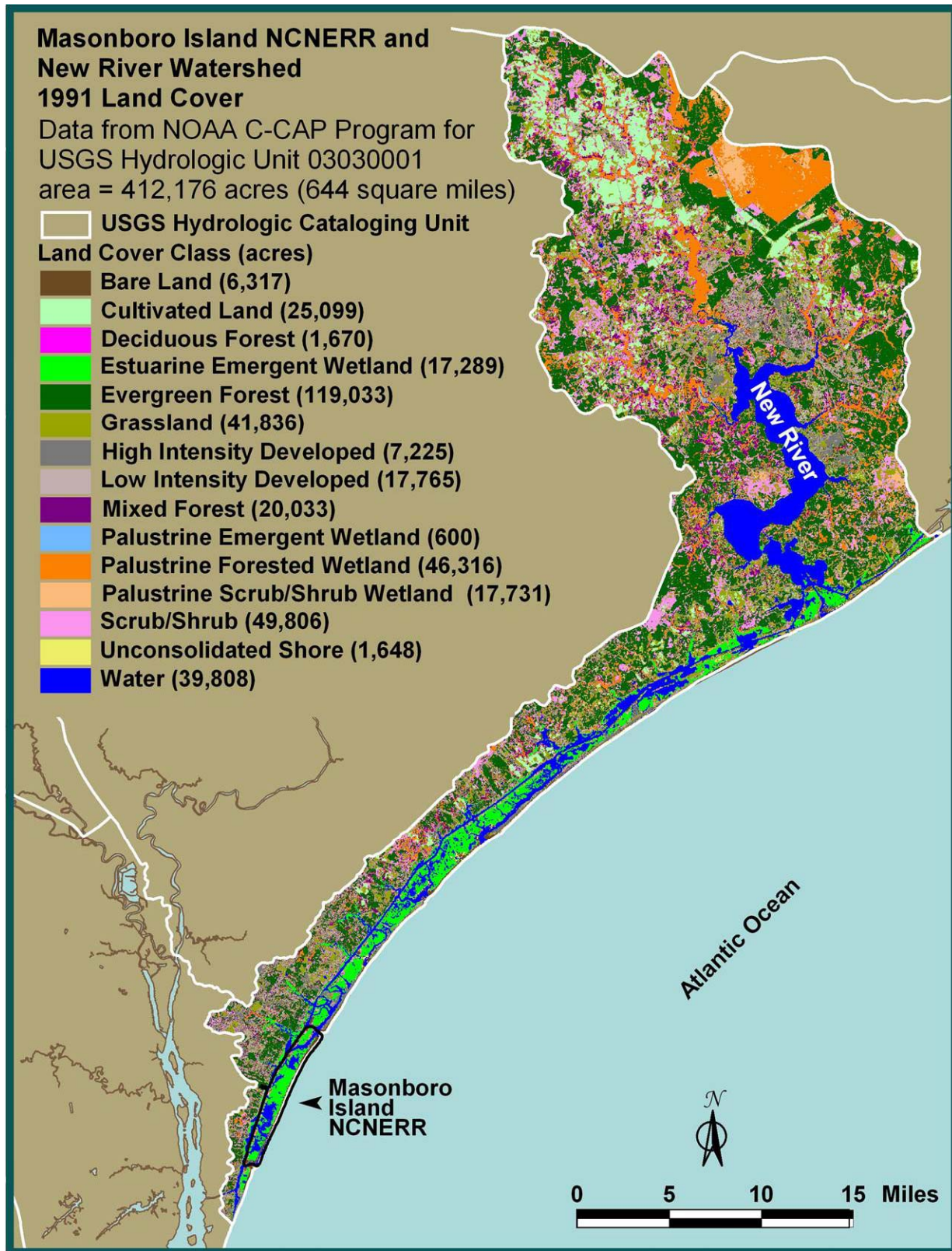


Figure 4.11a: Land use classification from 1991 in the Masonboro Island watershed.

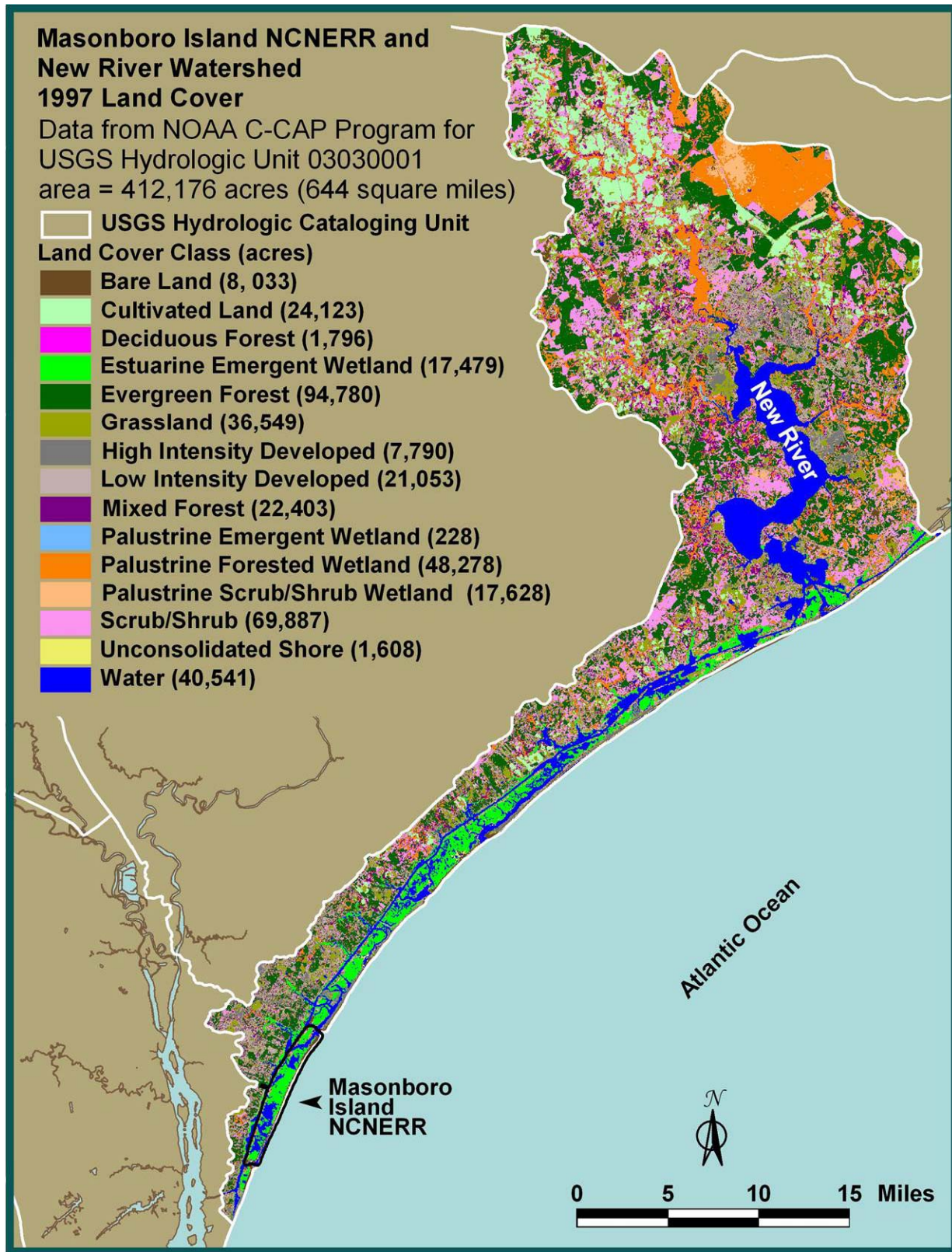


Figure 4.11b: Land use classification from 1997 in the Masonboro Island watershed.

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The major land cover types were Evergreen Forest (29% in 1991, 23% in 1997) and Scrub/Shrub (12% in 1991, 17% in 1997), dispersed throughout the watershed. Palustrine Forested Wetland was also prevalent (11% in 1991, 12% in 1997) with a large stand found in Hofmann State Forest in the northeast region. Low and High Density Developed (6% in 1991, 7% in 1997) were concentrated around Jacksonville at the head of Morgan Bay, and suburban Wilmington, west of the Masonboro Island component. 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 4.12 and Table 4.7 show the changes between 1991 and 1997 associated with these three groups.

Table 4.7: Change in land cover from 1991 to 1997 in the Masonboro Island watershed

Category	Acres	% of total
Total mapped area	412,176	n/a
Water area	39,705	9.6
Total land area	372,471	90.4
Decrease in vegetative cover	32,449	8.7
Increase in vegetative cover	18,644	5.0
Change from one unvegetative cover to another	602	0.16
Unchanged land cover	320,776	86.1
Net decrease of vegetation = 3.7%		
Percent of land area with changed cover types = 13.9%		

Changes that occurred between 1991 and 1997 affected 14% of the watershed (see Figure 4.12). The increase in vegetated conditions (5%) was due primarily to succession: Grassland to Scrub/Shrub and Palustrine Scrub/Shrub Wetland to Palustrine Forested Wetland throughout the northwestern region. Decrease in Vegetative Cover (9%) was dominated by conversion of Evergreen Forest to Scrub/Shrub and Grassland clustered west of the Intracoastal Waterway, 20 miles either side of the mouth of the New River. Between 1991 and 1997, the loss of vegetated conditions to Low and High Density Developed was 1%, primarily from Evergreen Forest and Grassland, spread throughout the watershed.

In the ten-year period from 1990 to 2000, the population of Wilmington grew by 62.7%, while the population of New Hanover County grew by 33.9% (Development Services Department, 2005).

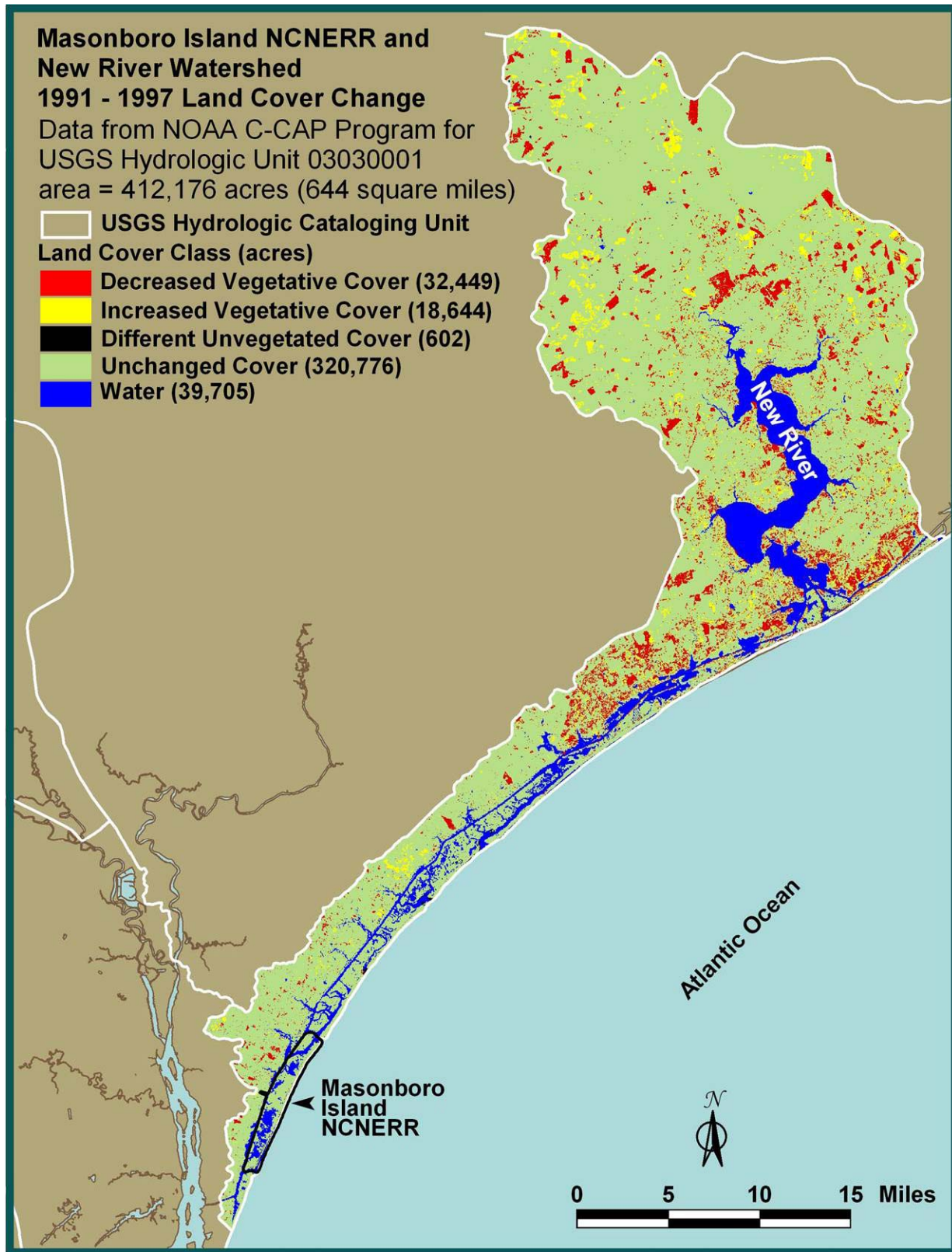


Figure 4.12: Changed land cover between 1991 and 1997 in the Masonboro Island watershed.

While part of the increase in Wilmington is attributable to annexation, these figures indicate explosive immigration to the area. In the five years from 2000 to 2005, population growth for Wilmington was 4.7% and 9.7% for New Hanover County. Projections for the area indicate continued growth, with Wilmington moving from a 2005 population of 94,531 to 110,220 in 2020. New Hanover County is expected to grow from 176,575 to 230,386 during the same period. Thus, it is highly anticipated that the loss of vegetative cover noted from 1991-1997 has continued in the years since 1997. This will be investigated further with the anticipated release of new Land Cover/Change data since covering the time period 1997 to 2005.

Bounded by the Cape Fear River to the west and the Intracoastal Waterway to the east, Wilmington must accommodate this increase in population in a fairly constricted setting. Accomplishing this task will increase pressure on the existing municipal infrastructure, some components of which (such as the sanitary sewer) are currently at or exceeding capacity. The city of Wilmington has experienced a series of sewer system failures since 2005 that have dumped millions of gallons of sewage into both the Cape Fear River and the tidal creeks feeding Masonboro Sound (Gannon 2006a and 2006b) (See section 4.5). Accommodating this growth will also increase the conversion of vegetative cover to impervious surface in both the Cape Fear and New River watersheds. These changes could negatively impact adjacent water quality by enhancing storm water runoff (Mallin et al. 2000b, Mallin et al. 2001). It will be critical to continue the water quality monitoring currently in place to document the changes as the Wilmington area and New Hanover County grow.

B: Visitor Use

As the only undeveloped barrier island in the Wilmington, N.C. area, Masonboro Island receives heavy visitor use, especially during the summer months. Holidays are marked by intense visitation, especially at the northern and southern termini of the island. Heavy visitor use is associated with some degradation of the resource, especially in the form of littering. Several citizen groups and dedicated individuals have worked to police the island following holiday events. Recent collaboration with the North Carolina Coastal Land Trust has worked to coordinate cleanup efforts and increase citizen awareness of the consequences of littering on the island. Other impacts, such as camp fire rings, are mitigated by natural processes of sand drift and ocean overwash. The impacts of recreational use on Masonboro Island have been investigated by former NCNERR staff and UNCW researchers for over a decade (Buerger et al. 1994; Buerger et al. 1995; Buerger et al. 2000; Buerger et al. 2003).

C: Sea Level Rise, Shoreline Change, and Hurricane Impacts

Sea level rise is a well documented phenomenon (Kaufman and Pilkey 1993). As sea level rises, barrier islands retreat landward (Leatherman 1988). Research in the late 1970s found that Masonboro Island had migrated landward as much as 200 feet in the previous 30 years (Hosier and Cleary 1977). More recent estimates put overall landward migration of the island at approximately 12 feet (3.6 m) per year. The southern portion of the island suffers from sediment deficiency and while this condition enhances migration of barrier islands, if the rate of sea-level rise is too great, then the barrier island may be drowned and left as a submerged sand shoal on the continental shelf (Morton and Miller 2005).

An additional consideration is the impact of sea level rise on the flora of the island. Migration requires plants to reestablish themselves in areas affected by overwash. This overwash may bury marshes on the back side of barrier islands. Barriers that are forced to migrate too rapidly may outpace the ability of vegetative communities to reestablish themselves (Schafale and Weakley 1990). Lack of stabilizing vegetative communities can enhance erosion and lead to loss of the island over time. As Masonboro Island continues to erode and migrate shoreward due to sea level rise, storms and human alterations, there will be a plethora of opportunities to study shoreline change on this barrier island. Alterations from hurricanes as well as shoreline recovery have been studied previously (Moundalexis et al. 1997; Moundalexis et al. 1998; Sault et al. 1999). The height of the Dunes on Masonboro was reduced dramatically following the impacts of Hurricane Bertha and Fran in 1996.

4.11: 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 worked on 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

There are no research facilities on Masonboro Island. The NCNERR office is located directly across Masonboro Sound from Masonboro Island at the University of North Carolina at Wilmington's Center for Marine Science. This arrangement is codified by a long-standing memorandum of agreement between the North Carolina Department of Coastal Management and the University of North Carolina Wilmington and an annual contract for services. The Center for Marine Science office covers 1,450 square feet, and provides offices for research staff as well as other staff, a common area/workspace, a storage area/mud room, and a large laboratory. The Center for Marine Science also affords NCNERR access to conference rooms, a machine shop, and boat dock access to Masonboro Sound. NCNERR owns three boats designated for research and stewardship that are housed at the Wilmington office.

B: Historical Research Activities

There has been a great deal of work conducted on Masonboro Island and the surrounding waters. Many of these projects have been highlighted in the previous sections of this chapter. Others are presented in Appendix 6, the bibliography of work conducted within NCNERR. The large body of work is due in part to the presence of a major research university (UNCW) in such proximity to the Reserve. Another is the uniqueness of an undeveloped barrier island in the

southern North Carolina region. Masonboro is ideal for use as a control site for adjacent impacted areas. Some of the major findings from the prior research are presented below. Masonboro Island is an extremely dynamic landform rapidly moving shoreward. The extensive marshes on the soundside of Masonboro Island are important nursery areas for estuarine nekton (Ross and Birchy 2002). Masonboro Island was dramatically altered due to hurricanes, specifically by the cumulative effect of two storms in 1996 (Buerger et al. 2003). Visitor use has caused impacts to the environmental resources of Masonboro Island (Buerger et al. 1994; Buerger et al. 1995; Buerger et al. 2000; Buerger et al. 2003). Researchers from NOAA's Center for Coastal Environmental Health and Biomolecular Research in Charleston, SC recently completed a project at Masonboro Island 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).

C: Current Research Activities

There are currently several research and monitoring projects being conducted on Masonboro Island and its adjacent Sounds. This work is being done by NCNERR staff and outside researchers from universities, government agencies, and non-government agencies. A representative sample of these studies is discussed in greater detail below.

All the water quality monitoring programs mentioned in section 4.5 are still being conducted. The SWMP monitoring conducted by NCNERR staff was recently enhanced with satellite uplinks that allow NCNERR SWMP data to be incorporated into the Integrated Ocean Observing System. The integrated ocean observing system is a network of monitoring platforms across the nation that provide weather and water quality data in near real time. This data is available via the internet to anyone with a computer connection. NCNERR data is available from NOAA's Centralized Data Management Office at <http://cdmo.baruch.sc.edu/>. Efforts continue to add telemetry capability to NCNERR's remaining SWMP stations.

The sea turtle nesting monitoring program that was restarted in 2006 is also ongoing. Data from 2007 indicate total number of nest declined from 2006 levels. Red Foxes (*Vulpes vulpes*) were also found to be an extremely significant predator on sea turtle eggs. This research will allow the continued success of Loggerhead nesting to be documented for Masonboro Island. This data is critical as it can be used to compare against similar barrier islands with development. The difference between the nesting successes on Masonboro to that from developed neighbors will allow researchers to determine the impact of ocean development on sea turtle nesting success.

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 Masonboro to better understand the public use that Masonboro receives. This will allow more efficient management of the island to maximize public benefit without negatively impacting the natural community.

Work is being conducted on Masonboro to study the groundwater: lens height; recharge and discharge rates; and geochemical makeup. This work is being conducted by researchers from UNCW and will provide valuable information regarding the water cycle on Masonboro Island.

Other studies include an investigation by a UNCW researcher into the common mudsnail (*Ilyassoma obsoleta*). The goals of this project are to examine the neural mechanisms of metamorphosis within this species relative to environmental conditions. A study by another UNCW researcher is examining the use of Masonboro Island by several sparrow species. Goals of this project are to determine habitat use, diet and population size and age. NCNERR staff is working on a project examining the changes in water quality around several oyster reef restoration projects at Masonboro Island. The goal of this project is to document water quality changes as the oyster reefs transform from bare shell to living reef. Monthly sampling includes physical-chemical water quality parameters as well as fecal coliform and Chlorophyll *a* concentrations.

4.12: Future Research Needs

Despite the large body of work that has been completed at Masonboro Island, there still is much we do not know. Below are some high priority research needs for Masonboro Island.

A study measuring the impact of red fox predation on bird populations needs to be conducted. Red foxes have been shown in other areas to dramatically impact the nesting success of birds. Given the high diversity of bird species on Masonboro coupled with the threatened status of some of them, this usefulness of this study is clear. The results from this study would provide information that would help manage Masonboro as well as many other coastal areas. The North Carolina Wildlife Resources Commission and the Bald Head Island Conservancy would be ideal partners to assist with this project.

A hydrological study of Masonboro sound needs to be conducted so the sources and fates of nutrients and pollutants entering the tidal creeks on the mainland side of Masonboro Sound could be predicted. This study will help managers better manage shellfish beds in the region. It would also help clear up the relationship of Masonboro and Myrtle Grove Sound relative to the Cape Fear and New Rivers. Ideal partners to help accomplish this study would include the United States Geological Survey, and UNCW. The Geological Survey has a long history of conducting hydrological investigations and has the required equipment and expertise to do so at Masonboro. UNCW also has several local experts in the physical circulation of water on staff.

The sea turtle nesting monitoring program currently being conducted on Masonboro could benefit greatly from a research project aimed at determining the nesting success of sea turtles relative to the frequency of beach renourishment. Beach renourishment is being conducted at almost all of North Carolina's beaches. The impact of this on sea turtle nesting success is not well understood. Masonboro would be an ideal place to conduct this test as areas of the beach receive nourishment and other areas do not. Ideal partners to assist with this project would include the N.C. Wildlife Resources Commission, UNCW Department of Biological Sciences, and The Pleasure Island Sea Turtle Project.

A study into the potential impacts of sea level rise also needs to be conducted. Marsh accretion rates for various areas of Masonboro need to be determined. This would allow us to predict which areas of the island were most in danger of eroding away and would allow stewardship activities to be targeted in areas with the greatest chance of success. This dataset would also assist the nationwide effort to understand the impacts sea level rise will have on the coastal areas of the United States.

Chapter 4: Masonboro Island Component

A study needs to be conducted into why seagrass does not currently inhabit the Masonboro region. Seagrass occurs both north and south of the Masonboro region. Selected areas could be reseeded with appropriate seagrass species and monitored for success. Environmental conditions (such as light penetration, turbidity, nutrient concentrations, sediment surface stability, etc.) at the restoration locations would be monitored in the hopes that the critical parameter limiting sea grass growth at Masonboro could be determined.