

Katrina L. Flint. BOGUE BANKS, NORTH CAROLINA: AN ANALYSIS OF THE LAND USE AND LAND COVER CHANGES FROM 1939 TO 1983. (Under the direction of Dr. Simon Baker) Department of Geography and Planning, May 1988.

The barrier islands of North Carolina have undergone great urban development since the 1930s. Bogue Banks, a barrier island located in Carteret County, is an example of such development. The purpose of this research was to determine the nature of change on Bogue Banks by analyzing the land use and land cover for a number of years from 1939 to 1983. This research identifies the sequence, location, and rate of development along the barrier island.

Aerial photographs provided the only comprehensive land use and land cover information of Bogue Banks for particular years from 1939 to 1983. The various land uses depicted on the aerial photographs were delineated, measured with a planimeter, and categorized according to the United States Geological Survey land use and land cover classification system. These quantitative results were totaled for each land use category and the percentage of the island devoted to each category was calculated for each study year. Once the data were compiled, an analysis of the changing land use was performed. A historical approach was taken to integrate the quantitative information with factors relating to local events.

The results of the study reveal that Bogue Banks has evolved

from an island of predominantly forest land in 1939 to an island which consists of more than 50% of urban or built-up land in 1983. The factors which proved to influence the rate of development on Bogue Banks were: 1) the evolution of transportation routes, 2) changing land ownership, and 3) varying attitudes toward development of local governments on the island.

This study is unique because no other research has been conducted to quantify land use change on Bogue Banks. Hence, this study has produced the only comprehensive data which reveal the types and rates of land use changes on Bogue Banks from 1939 to 1983.

BOGUE BANKS, NORTH CAROLINA:
AN ANALYSIS OF THE
LAND USE AND LAND COVER CHANGES
FROM 1939 TO 1983

A Thesis
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Master of Arts in Geography

by
Katrina L. Flint

May 1988

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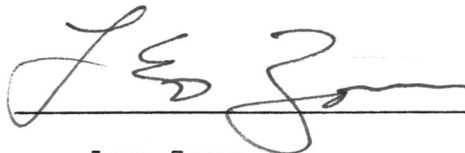
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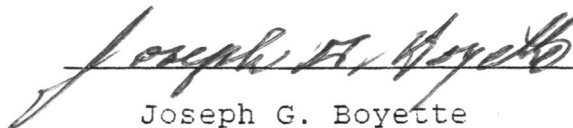
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CHAPTER 1

INTRODUCTION

Overview

Barrier islands are a preeminent feature of North Carolina's coast. These long, narrow chains of sand features are called barrier islands because they protect the coastal mainland from the high-energy waves and storm surges of the ocean. Most low-lying coastlines of the world have such features but each one is unique. The latitude, shape, vegetation and position with respect to the prevailing wind and waves characterize each island. The United States has a chain of barrier islands along the east and Gulf coasts with North Carolina's portion extending more than three hundred miles along the coast.

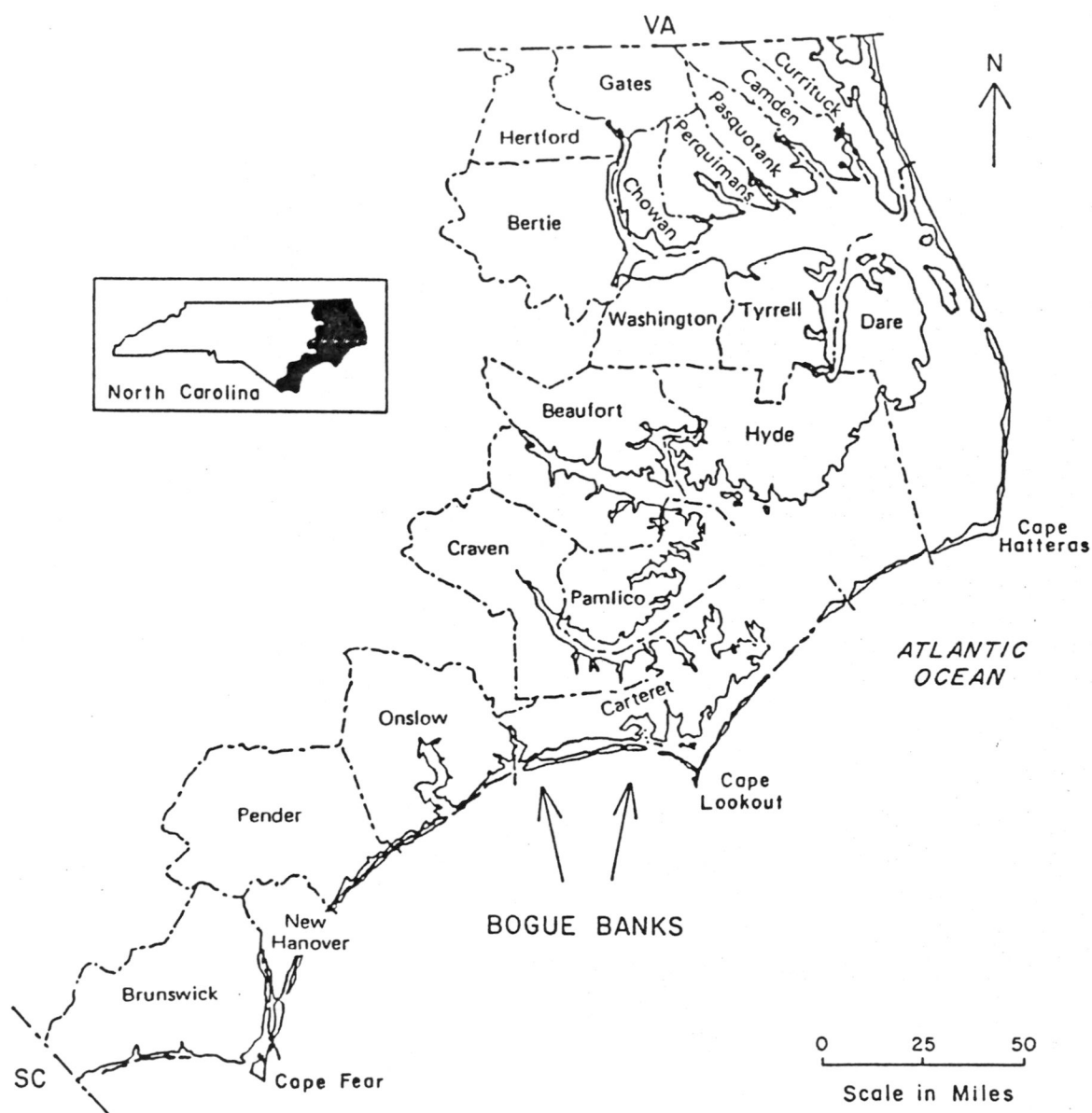
Research Problem

The barrier islands of North Carolina have undergone great urban development since the 1930s. Bogue Banks, in Carteret County (see Figure 1), is an example of such development. The establishment of residential, commercial, and service areas, began in the early 1900s and has intensified as the years have progressed.

The barrier islands, and Bogue Banks in particular, have been described by a few authors (Pilkey, Jr., Pilkey, Sr., and Turner, 1975 and Pilkey, Jr., Neal, and Pilkey, Sr., 1978).

Figure 1

LOCATION OF BOGUE BANKS*



Source: N. C. Dept. of Natural Resources
Division of Coastal Management

*Counties shown are under the jurisdiction
of the North Carolina Coastal Area
Management Act.

Pilkey et al. (1975) were concerned with the history of the island and how people might live there in harmony with the environment. Pilkey et al. (1978) described the origin and evolution of barrier islands and what factors must be considered before selecting a site for construction on one of North Carolina's barrier islands.

None of the previous works relating to Bogue Banks were land use studies. Moreover, no detailed quantitative study of the land use and land cover changes on the island has ever been performed. Hence, this study aims to provide a quantitative and qualitative analysis of the land use and land cover changes on the island since the 1930s.

The information may be used by various federal, state, and local agencies. The quantitative data on the location, type, and magnitude of land use and land cover changes on Bogue Banks can be used as a guide for estimating future trends in land use change.

Research Objective

The objective of this research is to investigate the factors which influenced the increase of urban or built-up land on Bogue Banks from 1939 to 1983. The sequence and rate at which the growth occurred will also be identified. A historical approach is taken to integrate the quantitative information on land use and land cover changes with local events.

The quantitative approach to developmental changes on Bogue Banks is made possible by the availability of aerial photographs

of the island for six different years from 1939 to 1983. Land use is interpreted from the aerial photographs and is then arranged according to the nationally accepted classification system used by the United States Geological Survey (U.S.G.S.), A Land Use and Land Cover Classification System for Use with Remote Sensor Data, Geological Survey Professional Paper 964 (Anderson, Hardy, Roach, and Witmer, 1976). Land use maps are then compiled for each year of photographic coverage. The areas are measured and the calculations then reveal the amount and type of land use and land cover changes between the study years. The quantitative results are then analyzed by identifying the impact that certain factors had on the development of the island.

Hypothesis

This study of the land use and land cover changes on Bogue Banks from 1939 to 1983 aims to explain: 1) where and when the development began on the island, 2) the sequence and nature of the land use change, and 3) the rate of change. Primarily, the study focuses on the key elements which have influenced the development on Bogue Banks. It is hypothesized that the combination of 1) the evolution of transportation routes, 2) changing land ownership, and 3) varying attitudes of local governments on the island have influenced the rate and type of development.

Location and Physical Description

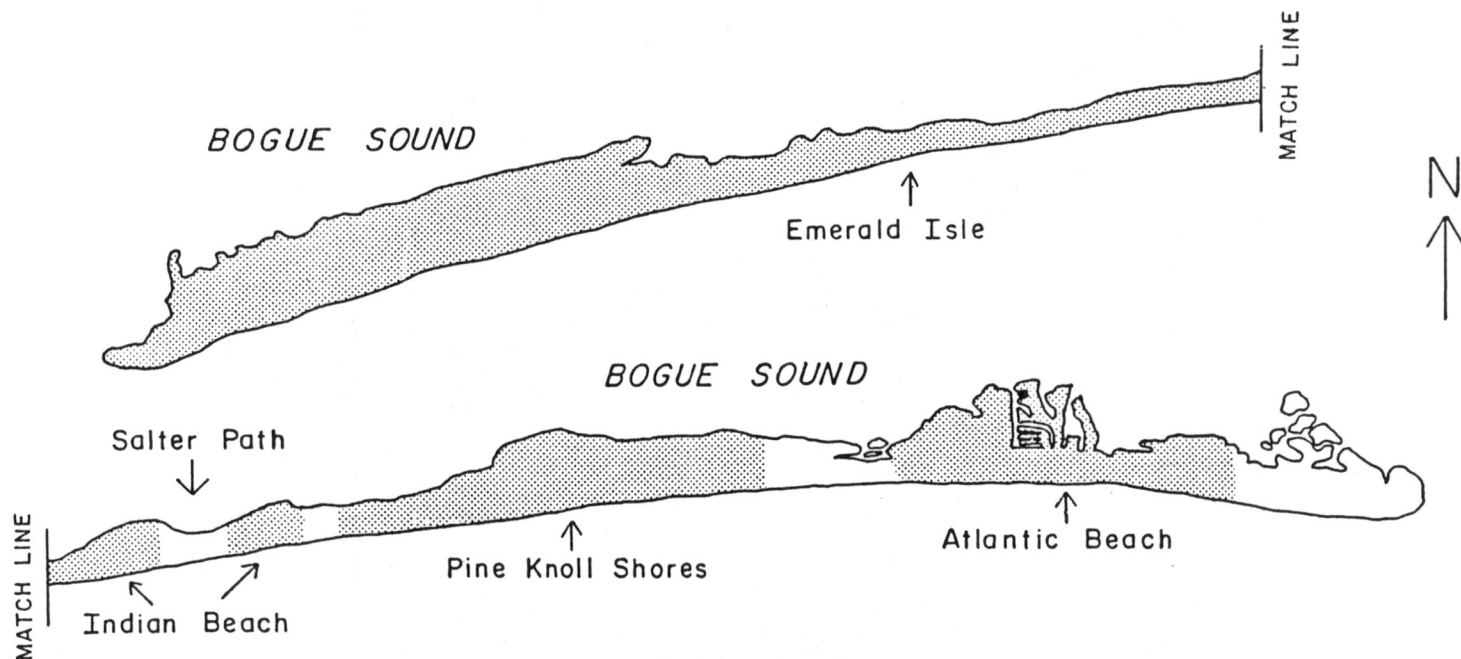
This study deals with Bogue Banks, one of the North Carolina barrier islands, which is located west of Cape Lookout in Carteret County (see Figure 1). The island is separated from the mainland by Bogue Sound. Across from the western end of Bogue Banks on the mainland is the Town of Cape Carteret and across from the eastern end is Morehead City. The barrier island is 25 miles in length with its axis in an east-west position and varies in width from 0.2 to 1.2 miles (see Figure 2).

Bogue Banks is one of the largest islands on the North Carolina coast. A virtually unbroken cover of maritime forest is indigenous to the island because of its east-west orientation and the shelter provided by Cape Lookout from high-energy waves. The diversity of plant and wildlife species found here exceeds that of any other North Carolina coastal islands (Schoenbaum, 1982).

Other characteristics unique to Bogue Banks are the soils and relief. The major soil differences are determined by relief, which in turn affects drainage, vegetation and the length of time required for soil development to occur. The relief and natural vegetation on Bogue Banks are represented in the profile shown in Figure 3. The relief creates a distinct landscape division between the "sand strand" and the marsh. The "sand strand" is composed of three categories: the beach-foredune, the shrub zone, and the maritime forest (United States Department of Agriculture [U.S.D.A.], 1977). The marsh is comprised of the low-lying area bordering the sound.

Figure 2

BOGUE BANKS OF CARTERET COUNTY, NORTH CAROLINA *



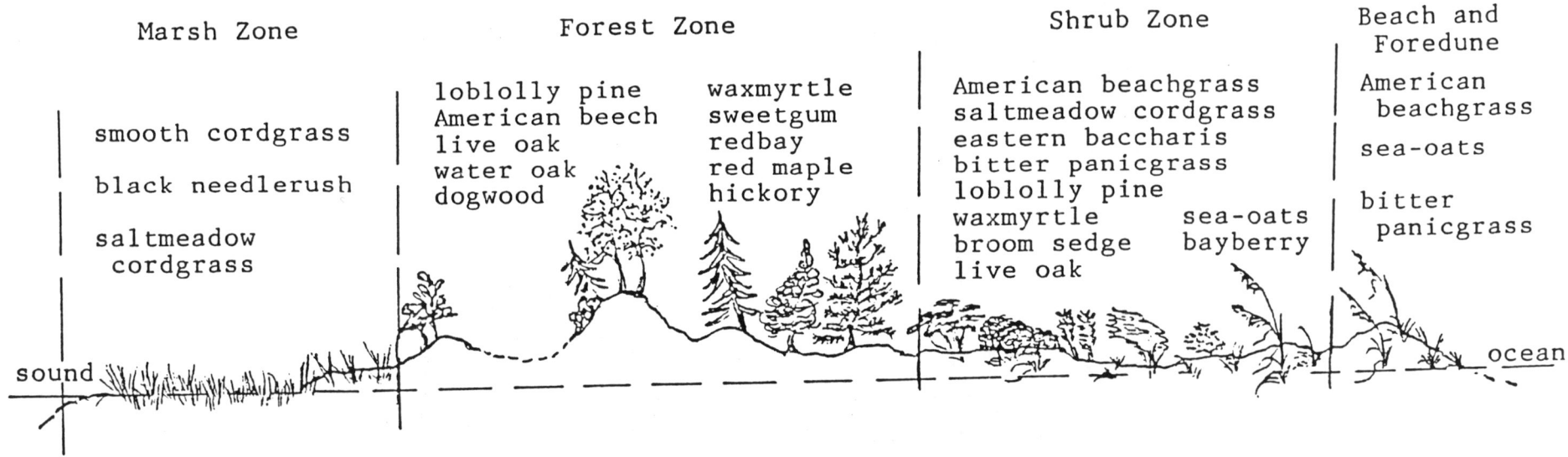
* Incorporated areas are shaded

Source: N.C. Dept. of Transportation

0 2 4
Scale in Miles

Figure 3

TOPOGRAPHY AND DOMINANT VEGETATION
BOGUE BANKS, NORTH CAROLINA



Source: Soil Survey of the Outer Banks, North Carolina

As shown in Figure 3 the beach-foredune is located directly next to the ocean. Hence, the area is constantly altered by the deposition of sands and by erosion caused by wind and ocean waves. The beach is bare except for some scattered clumps of sea-oats just above the high-water mark. The foredune is formed by blowing sand being continuously trapped in the grasses. The foredunes are vegetated with American beachgrass, seaoats, bitter panicum, and marsh elder. These plants are tolerant to salt spray and also stabilize foredunes on the sand strand near the ocean (U.S.D.A., 1977).

Behind the protection of the foredune is the shrub zone. This area has grasses and scattered shrubs. As the distance from the ocean increases, the vegetation becomes more dense. Some of the common plants are waxmyrtle, yaupon holly, bayberry, and eastern baccharis.

The maritime forest is located behind the shrub zone and is farther from the salt spray of the ocean. As a result, the area is densely vegetated with live oak, red cedar, loblolly pine, redbay, flowering dogwood, as well as other pine and hardwoods (Graetz, 1974).

The relief suddenly changes from the maritime forest to the marsh area. This area is low and frequently flooded. Common vegetation includes smooth cordgrass, black needlerush, and saltmeadow cordgrass.

Human Occupancy

The physical state and the natural vegetation on the island have been altered over time by man. In order to investigate the impact of human occupancy on one particular island, the history of the first inhabitants in the entire coastal area must be examined.

The coastal areas of North Carolina have been inhabited for hundreds of years. In fact, Algonkian Indians were living in the area when English colonists arrived in the sixteenth century. They had been there since approximately 1000 A.D. and were the southernmost of the many Algonkian-speaking tribes who inhabited the middle- and north-Atlantic seaboard at this time. They were ethnically and linguistically related to the Indians of the Powhatan Confederation met by the Jamestown colonists of Virginia in 1607.

The Algonkians occupied areas which coincided almost exactly with the estuarine area of North Carolina. They lived on the shores of the rivers and sounds, raising beans, maize, gourds, and tobacco, hunting waterfowl and other game, spearing and trapping fish, and harvesting oysters and shellfish (Schoenbaum, 1982).

Bogue Banks is located within the Algonkian region and consequently, the Indians inhabited this area also. Later, in the early 1700's, Josiah Bogue settled in the area and the island is named after him. It was inhabited by Europeans for a long time, but mostly by widely scattered individuals who did not form

distinct communities. The main attraction was the free land, the lack of taxes and the lack of laws. Some of the first settlers came from the Cape Lookout area. In the eighteenth century settlers were attracted to the discovery of whales off the Cape which appeared in considerable numbers from February to April during their spring migration northward. These whalers lived in small communities in the woods on the eastern side of Shackleford Banks. The people no longer live there and only cemeteries and the descendants of their domestic animals remain to mark their former existence (Schoenbaum, 1982).

It was in the mid 1800s when the whaling industry began to fail that the people migrated to Harkers Island and Bogue Banks where the fishing was good. The people settled on the middle of Bogue Banks on the soundside. This first permanent settlement was Salter Path (see Figure 2) and the settlers were squatters. In the late 1800s Tom Thomas, one of the early landowners on the island, owned 100 acres of land in the area that is known now as Pine Knoll Shores and Salter Path (Davis & Hamilton, 1982). Then in the early 1900s he died leaving the land to his son, Alonza Thomas. The son, in turn, sold the land a few years later to John A. Royall, who owned it until 1917. At that time he presented a deed for about four acres of land to Harvey Willis. That land is located in the western end of Salter Path and joins what is now called Indian Beach.

Mr. Royall then sold the remainder of the land to Mrs. Alice Green Hoffman, a wealthy lady born in New York City, who came to

the area seeking a quiet country estate for a summer home (Davis & Hamilton, 1982). This large tract of land included the area where the squatters had formed the community of Salter Path. Mrs. Hoffman moved onto the property in 1918 and hired people from Salter Path and other areas of the county to work for her. She was an avid conservationist and accordingly, instructed her employees not to cut trees, kill the wildlife or in any way alter the area, and not to allow anyone else to do so either.

In 1923 some of the Salter Path cattle ventured into a fenced portion of Mrs. Hoffman's estate. The people had already been warned to keep their cattle out of the fenced areas. The cattle destroyed her strawberry patch and other vegetation on her land. Mrs. Hoffman was so angry that she sued the Salter Path people for trespassing on her land (Stephens, 1984). She did not have intentions to drive the villagers off her land but wanted them "to control their cattle, not to build outside the 80 3/4 acre village, and not to damage the land and its vegetation" (Stephens, 1984).

This resulted in the 1923 judgement. The court concluded that Mrs. Hoffman was the owner of the property and should therefore continue to pay all of the property taxes. Although, according to squatters' rights, the Salter Path people were to remain on this property as permanent residents. The agreement consisted of the terms of which they had to abide in order to remain on the land. The families residing in Salter Path at the time were required to sign this judgement leaving the rights to

their ancestors as heirs from one generation to the next (Sharpe, 1954). The subject resurfaced in 1974 when Carteret County brought suit against the squatters "to quiet their titles to the land", and the squatters were forced to pay county taxes (Schoenbaum, 1982).

From colonial times the eastern end of the island was considered to be of military significance. It is part of Beaufort Inlet and guards the entrance to the port. The construction of Fort Dobbs at that location began in 1756 but was never completed. Then in 1826 Lieutenant Eliason arrived for the purpose of surveying the site of Fort Macon. By 1834 the fort was completed and garrisoned. At the beginning of the Civil War in 1861, Fort Macon was seized from the Federal Government by North Carolina. One year later, April 22, 1862, the fort was heavily bombarded by Union forces and it was surrendered the next morning.

With the fall of Fort Macon, the North Carolina coast was occupied by Federal forces from Beaufort to the Virginia line. For the remainder of the war, the fort was used as an important coaling station for Union ships. Then after the war, the fort was utilized as a federal prison for several years. It was garrisoned once again during the Spanish-American War from June to September 1898. Following that, the fort was completely abandoned until a 1924 Act of Congress gave the fort to the state of North Carolina. It has been a state park since then, except from 1941 to 1946 when it was garrisoned during World War II

(Branch, Jr., 1985).

Also located at the eastern tip of the island beside Fort Macon was a lifesaving station. On January 28, 1915 this station and one located at the western end of the island at Bogue Inlet became part of the United States Coast Guard. To the present both stations are still run by the U. S. Coast Guard.

Justification and Previous Research

Knowledge of the ways people use land is essential for an understanding and evaluation of man's impact on the natural environment. Bogue Banks has been the scene of tremendous land use changes. Concurrently, problems of accelerated development, and destruction of important wetlands and wildlife habitat are taking place on this barrier island. In order to deal with these problems knowledge about the land use and land cover must be gained. According to Anderson (1976), one of the prime prerequisites for better use of land is information on existing land use patterns and changes in land use through time. Hence, this study focuses on the changing land use and land cover on Bogue Banks and aims at providing the necessary information to confront problems related to the increasing rate of alteration of the environment.

This research is similar to a study conducted by Lins (1980), Patterns and Trends of Land Use and Land Cover on Atlantic and Gulf Coast Barrier Islands, which is also an analysis of U.S.G.S. Level II land use and land cover maps of

barrier islands based on aerial photographic coverage. Any study relating to land use and land cover change through time should utilize aerial photographs. As C. P. Lo (1976) states, "the bird's-eye view afforded by the aerial photograph is a great advantage for land use analysis because it presents a holistic view of the spatial relationships of the different land uses within the limitations of the photo-scale."

The classification system which forms the basis of this land use and land cover analysis, is based on the U.S.G.S. national land use and land cover mapping programs (Anderson et al., 1976). The system was carefully designed to ensure that the data on cover characteristics and distinguishable activities related to land resources are objectively and consistently classified.

There is little research relating to Bogue Banks. Pilkey et al. (1978) wrote about the barrier islands along North Carolina's coast. Pilkey et al. (1975) wrote specifically about Bogue Banks. They do not concentrate on land use and land cover but rather, on the natural state and dynamics of a barrier island. Other research on the area focused on the history of the different communities that occupy the island. Mansfield (1979) compiled a history of Pine Knoll Shores. Stephens (1984) researched the history of Salter Path and included stories about the first settlers to the area. Also, Davis and Hamilton (1982) compiled the Heritage of Carteret County, Book I which contains history of various communities and predominant families in the county.

This study differs from previous work related to Bogue Banks. No other work has been conducted relating to quantitative land use and land cover change on Bogue Banks over such a long period of time. Moreover, no similar study for any barrier island of North Carolina was found in the literature.

CHAPTER 2

METHODOLOGY

Overview

The methodology necessary for conducting a land use and land cover analysis consists of four major segments: 1) choosing a standard classification system to depict land use and land cover, 2) constructing the land use and land cover maps, 3) measuring the area of each polygon of land use and land cover depicted on the maps, and 4) calculating data and illustrating the results by means of a computer software package.

Classification System

The U.S.G.S. land use and land cover classification system (Anderson et al., 1976) is the basis for the land use and land cover study of Bogue Banks, North Carolina. This particular classification system is the nationally accepted system. It is employed throughout the nation in federal and state agencies. The system allows the user to classify land use and land cover at various scales which includes mapping at great detail. This method is the most up-to-date and comprehensive system available. Statistics generated can be employed with other such statistics used by government agencies.

The U.S.G.S. classification system was intentionally developed to be used with different remote sensors that provide

data at a range of resolutions dependent upon altitude and scale. It is a four level classification system. Level I is generalized so that data from LANDSAT can be categorized. Level II is compatible with high altitude photography taken at 40,000 feet above (less than 1:80,000 scale). Level III is more detailed and is typically employed to categorize medium-altitude photography taken between 10,000 and 40,000 feet (1:20,000 to 1:80,000 scale). The most detailed classification level is Level IV. Low-altitude photography taken below 10,000 feet can be precisely categorized by Level IV (more than 1:20,000 scale). In addition, Levels III and IV require the use of supplemental information such as personal interviews and field research.

The U.S.G.S. classification system is also designed for the user to develop his own Level III and Level IV categories that will satisfy specific needs. The capability of having greater detail provides flexibility when several different purposes must be served. The general relationship between the classification level and the data source is not governed by a strict rule. The user should employ the classification level that best satisfies his needs. The more generalized first and second levels of the U.S.G.S. land use and land cover classification system are shown in Table 1. These two levels are used for national mapping.

For this land use and land cover study of Bogue Banks, North Carolina, a classification system was needed. The remote sensor data available for this area varied from 1:20,000 enlargements to National High Altitude coverage at 1:80,000. The U.S.G.S.

Table 1

Land Use and Land Cover Classification System
for Use with Remote Sensor Data

Level I	Level II
1 Urban or Built-up Land	*11 Residential. *12 Commercial and Services. 13 Industrial. 14 Transportation, Communications, and Utilities. 15 Industrial and Commercial Complexes. *16 Mixed Urban or Built-up Land. *17 Other Urban or Built-up Land.
2 Agricultural Land	21 Cropland and Pasture. 22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas. 23 Confined Feeding Operations. 24 Other Agricultural Land.
3 Rangeland	*31 Herbaceous Rangeland. 32 Shrub and Brush Rangeland. *33 Mixed Rangeland.
4 Forest Land	41 Deciduous Forest Land. 42 Evergreen Forest Land.

(table continues)

Level I	Level II
	*43 Mixed Forest Land.
5 Water	51 Streams and Canals.
	52 Lakes.
	53 Reservoirs.
	54 Bay and Estuaries.
6 Wetland	61 Forested Wetland.
	*62 Nonforested Wetland.
7 Barren Land	71 Dry Salt Flats.
	*72 Beaches.
	*73 Sandy Areas other than Beaches.
	74 Bare Exposed Rock.
	75 Strip Mines, Quarries, and Gravel Pits.
	*76 Transitional Areas.
8 Tundra	81 Shrub and Brush Tundra.
	82 Herbaceous Tundra.
	83 Bare Ground Tundra.
	84 Wet Tundra.
	85 Mixed Tundra.
9 Perrenial Snow or Ice	91 Perrenial Snowfields.
	92 Glaciers.

*Level II categories mapped on Bogue Banks, North Carolina.

Note. From A Land Use and Land Cover Classification System for Use with Remote Sensor Data, Geological Survey Professional Paper

964 (p. 8) by J. R. Anderson, E. E. Hardy, J. T. Roach, and R. E. Witmer, 1976, Washington: U.S. Government Printing Office.

classification system at Level II satisfied the amount of detail desired for the study. Moreover, the available aerial photography could be interpreted at this degree of detail.

Before understanding the Level II classes, the reader must be familiar with Level I. The definitions according to A Land Use and Land Cover Classification System for Use with Remote Sensor Data, Geological Survey Professional Paper 964 (Anderson et al., 1976) for the Level I categories applicable to this study are cited in Appendix A. The Level II classes applicable to this study, shown in Table 1, are paraphrased below to relate to Bogue Banks' conditions.

The Level II categories present on Bogue Banks belonging to the Level I category of urban or built-up land are: residential (11), commercial and services (12), mixed urban or built-up land (16), and other urban or built-up land (17).

11-Residential

Residential land uses vary from high density (multi-family dwellings) to low density (single family dwellings) (see Figures 4 and 5). On Bogue Banks multi-family dwellings include condominiums, apartments and townhomes. Low density is represented by houses on lots larger than one acre. Linear residential developments along transportation routes extending outward from urban areas are considered as residential appendages to urban centers. Residential strips are distinguishable by their uniform size and spacing of structures, driveways and lawn areas, whereas, commercial strips are more likely to have



Figure 4. High Density Residential Land Use at Emerald
Isle (Level II Category 11).



Figure 5. Low Density Residential Land Use at Emerald
Isle (Level II Category 11).

buildings of different sizes and spacing, large driveways and parking areas. Some residential development along Bogue Banks is linear and normally extends back only one residential parcel from the shoreline to the first road. This is commonly found on the narrower parts of the island.

12-Commercial and Services

Commercial areas are those used predominantly for the sale of products and services. They are often adjoined by residential and other contrasting uses which help define them. Urban central business districts, shopping centers, commercial strip developments along highways and access routes to cities are all considered to be commercial and services areas. Commercial strip development is the predominant commercial land use on Bogue Banks (see Figure 6).

Institutional land uses including various educational, religious, health, correctional and military facilities are also considered to be in the commercial and services category. Small institutional units like many churches and schools are included within another category, such as Residential, unless mapped at a large scale (see Figure 7). Fort Macon and the surrounding state park, located at the eastern end of Bogue Banks, are considered an institutional land use. Also, the two Coast Guard stations, one at both ends of the island, are classified as an institutional use.

16-Mixed Urban or Built-up Land

The mixed urban or built-up category is used for a



Figure 6. Commercial Strip Development at Emerald Isle
(Level II Category 12).



Figure 7. Chapel by the Sea at Emerald Isle
(Level II Category 12).

mixture of Level II urban or built-up uses where individual uses cannot be separated at mapping scale. Where more than one-third intermixture of another use or uses occurs in a specific area, it is classified as mixed urban or built-up land. Where the intermixed land use or uses total less than one-third of the specific area, the category appropriate to the dominant land use is applied (Anderson et al., 1976, p. 13).

This category includes developments along transportation routes and in cities, towns, and built-up areas where separate land uses cannot be mapped individually. In some areas on Bogue Banks, the individual land uses are difficult to depict, and delineate between residential land use and commercial and service land use (see Figure 8). Therefore, the mixed urban or built-up land category was used.

17-Other Urban or Built-up Land

Other urban or built-up land consists of uses such as golf driving ranges, zoos, urban parks, cemeteries, waste dumps, water-control structures, and spillways, the extensive parts of golf courses and undeveloped land within an urban setting. The only area considered to be other urban or built-up on Bogue Banks is the open areas of the golf courses with a residential area surrounding it (see Figures 9 and 10).

As shown in Table 1, the Level II categories present on Bogue Banks belonging to the Level I category of rangeland are: herbaceous rangeland (31) and mixed rangeland (33).



Figure 8. Mixed Residential and Commercial Land Uses
at Atlantic Beach (Level II Category 16).



Figure 9. Golf Course at Pine Knoll Shores (Level II
Category 17).



Figure 10. Golf Course at Pine Knoll Shores (Level II
Category 17).

31-Herbaceous Rangeland

The herbaceous rangeland category includes lands dominated by naturally occurring grasses and forbs. It includes the tall grass, short grass, bunch grass or palouse grass, and desert grass regions. Typical occurrences of grasslands on Bogue Banks include such species as the various bluestems (*Andropogon*), American beachgrass (*Ammophila breuiliigulata*), sea-oats (*Uniola paniculata*), coastal panicgrass (*Panicum amarulum*), bitter panicum (*Panic amarum*), and marsh elder (*Iva imbricata*) (Graetz, 1973; USDA, 1977) (see Figure 11).

33-Mixed Rangeland

When more than one-third intermixture of either herbaceous or shrub and brush rangeland species occurs in a specific area, it is classified as mixed rangeland. Where the intermixed land use or uses total less than one-third of the specific area, the category appropriate to the dominant type of rangeland is applied (Anderson et al., 1976, p. 15).

The majority of rangeland on Bogue Banks is mixed rangeland. The areas were found to be grass or a combination of grass and shrub (see Figure 12).

The only Level II category present on Bogue Banks belonging to the Level I category is mixed forest land (43) (see Table 1).

43-Mixed Forest Land

Mixed forest land includes all forested areas where both evergreen and deciduous trees are growing and neither predominates. When more than one-third intermixture of either



Figure 11. Grasslands at east end of island near Fort Macon State Park (Level II Category 31).



Figure 12. Mixed Grass and Shrub near Fort Macon State Park (Level II Category 33).

evergreen or deciduous species occurs in a specific area, it is classified as Mixed Forest Land. Where the intermixed land use or uses total less than one-third of the specific area, the category appropriate to the dominant type of forest land is applied, whether deciduous or evergreen.

The mixture of trees on Bogue Banks ranges from evergreen to deciduous (see Figure 13). While the evergreen are predominant, the deciduous are intermittently present. The evergreens consist of loblolly pine (*Pinus taeda*), live oak (*Quercus virginiana*), red cedar (*Juniperus virginiana*), and redbay (*Persea borbonia*). The deciduous trees common on Bogue Banks are white poplar (*Populus alba*), flowering dogwood (*Cornus florida*), and red maple (*Acer rubrum*) (Graetz, 1975).

The only Level II category present on Bogue Banks belonging to the Level I category of wetland is nonforested wetland (62) (see Table 1).

62-Nonforested Wetland

"Nonforested wetlands are dominated by wetland herbaceous vegetation or are nonvegetated. These wetlands include tidal and nontidal fresh, brackish, and salt marshes and nonvegetated flats" (Anderson et al., 1976, p. 18).

The following are examples of vegetation associated with nonforested wetland. Narrow-leaved emergents such as cordgrass (*Spartina*) and rush (*Juncus*) are dominant in coastal salt marshes on Bogue Banks (see Figures 14 and 15).

The Level II categories present on Bogue Banks belonging to



Figure 13. Mixed Evergreen and Deciduous Trees at Emerald Isle (Level II Category 43).



Figure 14. Marsh at Emerald Isle (Level II Category 62).



Figure 15. Marsh at Atlantic Beach (Level II Category 62).

the Level I category of barren land are: beaches (72), sandy areas other than beaches (73), and transitional areas (76) (see Table 1).

72-Beaches

The beaches of Bogue Banks are smooth sloping accumulations of sand along the shoreline (see Figure 16). The surface is stable inland, but the shoreward part is subject to erosion by wind and water and to deposition in protected areas. The only identifiable inland boundary is the natural boundary to which the vegetation grows.

73-Sandy Areas other than Beaches

Sandy areas other than beaches are composed primarily of dunes-accumulations of sand transported by the wind. On Bogue Banks, examples of this are seen away from the shoreline in areas where the vegetation is scarce and where only dunes are present. Other sandy areas where no dunes are present have been subjected to blowing and have less than 15 percent vegetative cover (see Figures 17 and 18).

76-Transitional Areas

The transitional areas category is intended for those areas which are in transition from one land use activity to another. They are characterized by the lack of any remote sensor information which would enable the land use interpreter to predict reliably the future use or discern the past use. All that actually can be determined in these situations is that a transition is in progress, and



Figure 16. Beach at Emerald Isle (Level II Category 72).



Figure 17. Sandy Area other than Beach near Fort Macon State Park (Level II Category 73).



Figure 18. Sandy Area other than Beach near Fort Macon State Park (Level II Category 73).

inference about the past or future use should be avoided
(Anderson et al., 1976, p. 19).

Examples of the transitional phase can be seen when wetlands are drained for development, land is altered by dredging and filling, or when any type of land use ceases as areas become temporarily bare as construction is planned for such future uses as residences or shopping centers (see Figure 19).

Table 2 (page 38) has been compiled to summarize these definitions and the applications to Bogue Banks. This will provide a quick reference to accompany the analysis in chapters 3 and 4.



Figure 19. Transitional Area at Emerald Isle (Level II
Category 76).

Table 2

Level I Land Use and Land Cover Definitions
with Applications to Bogue Banks, North Carolina

Level I Category	Classification according to Anderson	Application to Bogue Banks
1-Urban or Built-up Land	Areas of intensive use with much of the land covered by structures	Residential and commercial land uses
3-Rangeland	Predominantly grasses, grasslike plants, forbs, and shrubs	Grasses, shrub, and brush
4-Forest Land	Tree-crown areal density of 10% or more	Deciduous and evergreen trees
6-Wetland	Areas where the water table is at, near, or above the land surface	Nonforested wetlands
7-Barren Land	Less than one-third of the area has vegetation or other cover	Beaches, sandy areas, and transitional areas

Construction of Land Use and Land Cover Maps

To construct Level II land use and land cover maps of Bogue Banks, aerial photographs were used as the primary source of data. The years of coverage were 1939, 1953, 1958, 1964, 1976, and 1983. The aerial photographs from 1939 to 1964 are part of a coastal collection of aerial photographs in the Department of Civil Engineering at North Carolina State University. They were made available with the cooperation of Dr. Richard Fischer. A total of 64 photographs of Bogue Banks were used from this coastal collection. In addition, aerial photographs from the North Carolina Department of Transportation for 1976 and National High Altitude Coverage for 1983 were provided by the Department of Geography and Planning at East Carolina University. These years of coverage determined the time period and time intervals to be studied.

In addition to the aerial photographs, a base map was used to construct the land use and land cover maps. The base map would assure the same scale, 1:24,000, for each year of the study. The North Carolina Department of Transportation Photogrammetry Unit produced a base map of Bogue Banks. Mr. Harold Bisette in the Photogrammetry Unit produced a positive print from orthophotoquad negatives obtained from the North Carolina Geological Survey. Prints were on a plastic film to provide a stable base which is unaffected by fluctuations in atmospheric humidity.

Next, identification and interpretation of land use and land cover was conducted for each set of aerial photographs based on the U.S.G.S. Level II land use and land cover classification system. A china marker was used directly on the aerial photographs to delineate the different land use and land cover types. Supplemental information for interpretation of the aerial photographs included topographic maps, land use plans, a book on coastal vegetation (Graetz, 1975), other publications relating to Bogue Banks (Pilkey et al., 1975 & 1978) and actual field investigation and personal knowledge of the area.

The aerial photographs were at various scales. The method used to convert the information to the scale of 1:24,000 was a manual reducer/enlarger. The aerial photographs were placed in the machine and the image was reduced to the scale of the base map. The boundary lines for the land use and land cover were drawn onto Albanene. The drawings were then placed under plastic film which was on a light table. The light table facilitated the process of tracing the information on the plastic film. The base map was also placed under the plastic film and used as a guide.

The base map was used as the outline for Bogue Banks although through the years the island has varied in shape, particularly the east and west ends. Hence, to accurately recapture the shape of the island for the various years, the tracings from the aerial photographs were used. The scale chosen for the base map is the same as that of the topographic maps, and the orthophotoquads which have a scale of 1:24,000. Portions of

Bogue Banks appear on the following U.S.G.S. topographic maps: Swansboro, Salter Path, Mansfield, and Beaufort (see Figure 2).

Areal Measurements on the Land Use and Land Cover Maps

After the six maps were completed, the various polygons delineating the land use and land cover types were measured by means of a compensating polar planimeter. The areas were measured in square inches and converted to acres. The conversion factor was based on the number of acres per square inch at the scale of 1:24,000. Hence, the conversion factor was 91.83 acres per square inch.

The tool chosen to make the planimetric measurements was the compensating polar planimeter. Although other measuring devices exist, the planimeter was the only tool available. The drum on the planimeter records to the hundredth of a square inch. To assure precision, each polygon was measured a minimum of three times. The average of the readings was recorded. A limitation with using the planimeter is that some areas are too small to be measured. The minimum mapping area in this study was an area of 0.03 square inches. Therefore, any area of 2.75 acres or less was not mapped, but rather the area was generalized with its surroundings.

A limitation that exists when using aerial photography is the quality of the image. The image quality varies between the years of coverage. Therefore, the interpretation may vary

slightly for some areas between the years. Another factor is changes in vegetation through the years as well as seasons. One area that is difficult to interpret consistently is the barren sandy areas. Some years the areas appear barren while other years they appear covered with scattered grasses and shrubs. This is an example of not only the image quality varying but also the vegetation changing naturally. Another area that is difficult to interpret consistently is the beaches. The changing tide affects the amount of beach seen on the aerial photographs. Moreover, the tidal conditions are unknown for each time the aerial photographs were taken. Hence, to avoid the measuring of an area which is not stable or consistent, the beaches were not measured for this study.

Calculations and Graphics

The land use and land cover maps were constructed and measured to provide quantified information of land use and land cover on Bogue Banks from 1939 to 1983. In order to utilize the planimetric data for this study, a software package was obtained. The software chosen was LOTUS 1-2-3. This program has the capability of producing a spreadsheet and also graphics corresponding to the spreadsheet.

The process of designing the spreadsheet for this study began by entering the planimetric data. The data were systematically entered for each year according to the section of

the island for which they corresponded. The sections of the island from west to east are Swansboro, Salter Path, Mansfield, and Beaufort. These names were derived from the name of the U.S.G.S. topographic map on which each section is located. The data for each section were shown in three subcolumns: 1) the land use and land cover type, 2) the area in square inches, and 3) the area in acres (see Appendix A).

The LOTUS 1-2-3 program has the capability of calculating numbers within the spreadsheet. Thus, every column of planimetric data recorded in square inches was calculated into acres and recorded in the third subcolumn. After data for every year were entered, totals were calculated columnwise and rowwise. Hence, the totals for Bogue Banks were calculated in square inches and acres for every year, for each land use and land cover type, and for each section individually. After establishing the database, bar graphs were generated which illustrated the land use and land cover changes in acreages of Level I and Level II for each category during the study period.

To analyze these results, supplemental information was needed. Information sources included governmental records, public utilities, census data, interviews and publications. By employing this methodology a statistical and cartographical analysis of the land use and land cover changes on Bogue Banks, North Carolina was completed.

CHAPTER 3

LEVEL I ANALYSIS

Overview

The U.S.G.S. Level I data (see Table 3) obtained from the land use and land cover maps are examined briefly in this chapter and the following chapter examines the Level II data in more detail. This chapter briefly investigates the increasing rate of urban development as well as the overall decreasing rate of other land use and land cover types.

On Bogue Banks, five of the nine U.S.G.S. land use and land cover Level I categories exist. These five are urban or built-up land (Level I Category 1), rangeland (Level I Category 3), forest land (Level I Category 4), wetland (Level I Category 6), and barren land (Level I Category 7). The majority of the land on the island was forest land until 1976. From that point in time, the urban or built-up land category has accounted for the majority of the land use (see Figure 20).

Urban Development

The growth of urban development is exemplified in Table 3. The total acres and the percent of the island occupied by urban or built-up land, Level I Category 1, are used as an indicator for this analysis. In 1939 only 2.01% (149.68 acres) of the island was utilized for urban or built-up land. During the next

Table 3

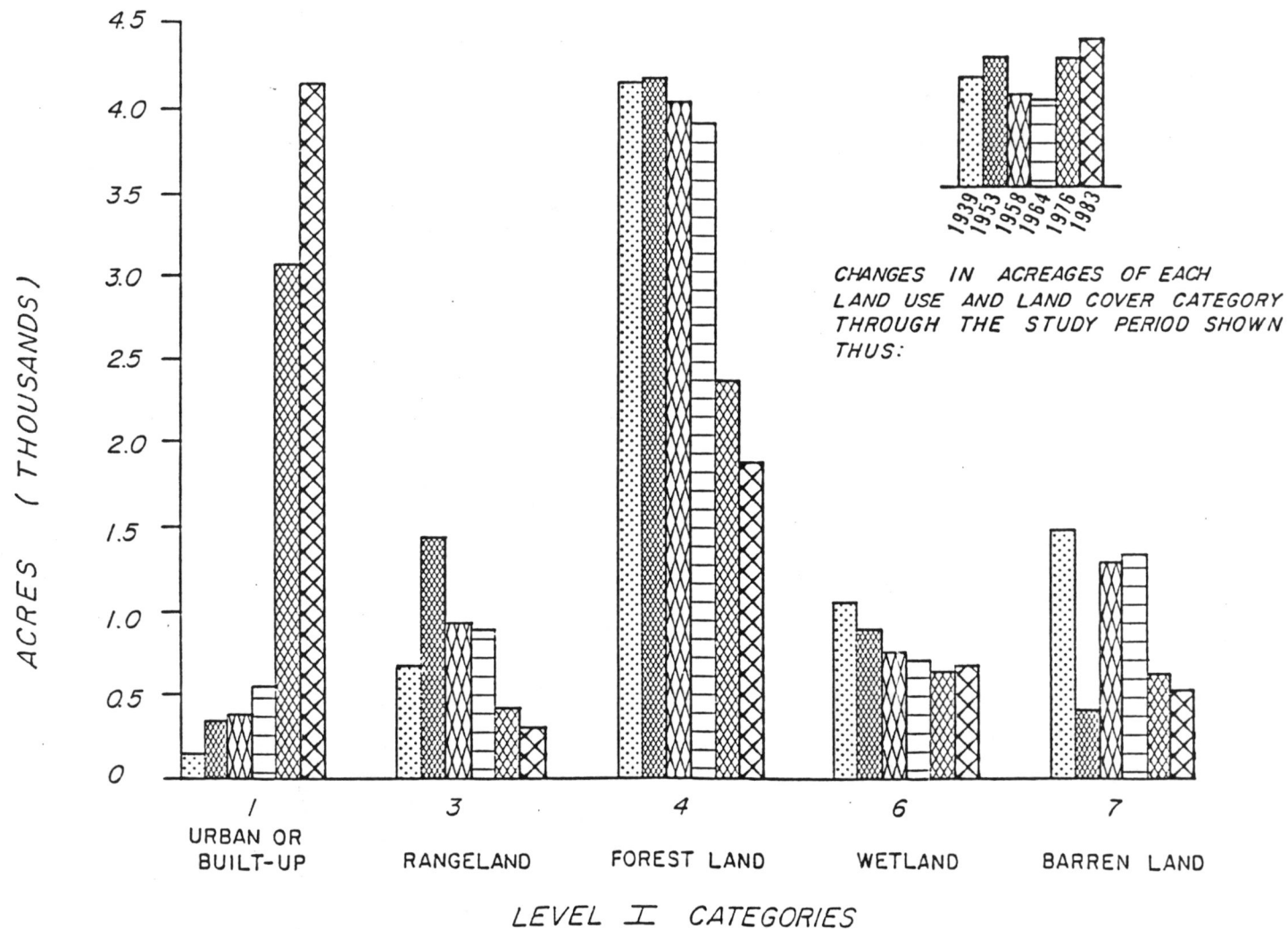
LEVEL I LAND USE AND LAND COVER TOTALS
FOR BOGUE BANKS, NORTH CAROLINA
IN ACRES AND AS A PERCENTAGE OF THE ISLAND AREA

<u>CATEGORY</u>	<u>1939</u>	<u>1953</u>	<u>1958</u>	<u>1964</u>	<u>1976</u>	<u>1983</u>
1	149.68	350.79	365.48	547.31	3071.71	4147.04
Urban	2.01%	4.83%	4.99%	7.45%	43.31%	55.51%
3	661.18	1454.59	918.30	874.22	416.91	303.04
Rangeland	8.85%	20.01%	12.54%	11.91%	5.88%	4.06%
4	4158.06	4163.57	4032.26	3905.53	2366.46	1839.35
Forest Land	55.68%	57.28%	55.06%	53.18%	33.37%	24.62%
6	1034.92	894.42	726.38	701.58	622.61	657.50
Wetland	13.86%	12.30%	9.92%	9.55%	8.78%	8.80%
7	1463.77	405.89	1281.03	1315.01	614.34	523.43
Barren Land	<u>19.60%</u>	<u>5.58%</u>	<u>17.49%</u>	<u>17.91%</u>	<u>8.66%</u>	<u>7.01%</u>
*TOTAL	7467.62	7269.26	7323.44	7343.65	7092.03	7470.37
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

*Differences in the total area of the island are accounted for by continuing changes in erosion and deposition in this dynamic environment.

Figure 20

LEVEL I LAND USE AND LAND COVER CHANGES
BOGUE BANKS, NORTH CAROLINA



25 years the percent of land use consisting of urban or built-up land increased by only 5.49% to a total of 7.45% (547.31 acres). During the years that followed, 1964 to 1983, urban development on Bogue Banks boomed. The percent of urban or built-up land increased from 7.45% (547.31 acres) in 1964 to 55.51% (4147.04 acres) in 1983.

Two important factors contributed to the urban development: 1) access to the barrier island and 2) change in land ownership. In 1928 the first bridge was built to connect Atlantic Beach with Morehead City. The roads on the island were limited. Only a single lane existed between Fort Macon at the east end of the island and Salter Path located midway on the island. In the 1930s, the first houses were built along Atlantic Beach. The area between Atlantic Beach and Fort Macon was called Money Island Beach and was owned by Mrs. Alice Robinson. The remainder of the land was owned by Mrs. Alice Hoffman and Mr. Henry Fort. Alice Hoffman was a distant member of the Roosevelt family (Teddy) and daughter of Alfred Green, one time governor of New Jersey. Mr. Henry Fort was a Philadelphian who had dreams of a giant resort similar to Atlantic City. The dreams were later dissolved when the state refused his request for a bridge permit (Pilkey et al., 1975). Alice Hoffman owned the land from Atlantic Beach to the west end of Salter Path while Henry Fort owned the remainder of the island west of Salter Path. Therefore, with only one bridge to the island and the majority of the island under the ownership of two people, development was virtually

nonexistent.

During the next 25 years the rate of development increased. One of the two factors contributing to the development, land ownership, experienced a turnover because the ownership of both large parcels of land underwent changes. In 1954, Henry Fort's daughter sold the western half of the island. Then in 1955 when Alice Hoffman died, her land went to the Roosevelt family. Development on Bogue Banks began soon thereafter.

From the land use and land cover statistics of this study, the percent of urban or built-up land increased the greatest from 1964 to 1983. The other contributing factor, access to the island, underwent change and also accounts for the increased development. In 1962 ferry service began which linked Emerald Isle at the west end of Bogue Banks to the mainland. Later, in 1971, the B. Cameron Langston Bridge opened at the western end of the island. With this second access to the island, development was no longer restricted to the eastern end. Consequently, the percent of urban or built-up land increased from 7.45% (547.31 acres) in 1964 to 55.51% (4147.04 acres) in 1983.

Other Level I Land Use and Land Cover Changes

The other four Level I categories to be examined are rangeland (3), forestland (4), wetland (6), and barren land (7). As shown in Table 3 all of these categories experienced a general decrease in acres by 1983. The different categories and their respective rates of change will be discussed. In one case, two

categories, rangeland and barren land, are added together for a more accurate analysis.

The rangeland, Level I Category 3, on Bogue Banks comprised 8.85% (661.18 acres) of the total island in 1939. In 1953 20.01% (1454.59 acres) of the island was interpreted as rangeland. From 1953 to 1983 the percent of rangeland decreased to 4.06% (303.04 acres). The fluctuations in the amount of rangeland in the earlier study years, particularly from 1939 to 1953, can be explained by increases and decreases in the amount of barren land, Level I Category 7. Rangelands often expand into barren areas while conditions sometimes favor a reversal of this process. Fluctuations in measurements may also be due to the variable quality of aerial photographs from one year to the next resulting in differences of interpretation. Therefore, caution should be taken when relying on these calculations for accuracy.

In 1939, the amount of barren land, Level I category 7, was 19.60% (1463.77 acres) and 5.58% (405.89 acres) in 1953. Then in 1958 the percent of barren land increased to 17.49% (1281.03 acres). The decrease in 1953 is explained by an increase in rangeland as barren areas were gradually covered by natural vegetation. In the later years of the study, 1964 to 1983, rangeland and barren land together experienced a decrease in acreage during the period when the drastic increase occurred in the urban or built-up category.

To better explain this fluctuation in land cover, the two categories of rangeland and barren land have been added together

and are displayed in Table 4. The results show a steady trend from 1939 to 1964. Then from 1964 to 1983 the total acreage of rangeland and barren land decreases.

Table 4: Level I Rangeland and Barren Land

	1939	1953	1958	1964	1976	1983
Percent	28.46%	25.59%	30.03%	29.81%	14.54%	11.06%
Acres	2124.95	1860.48	2199.33	2189.23	1031.25	826.47

Forest land, Level I Category 4, covered more than 50% of Bogue Banks (more than 3900 acres) from 1939 to 1964. From 1964 to 1976, forest land decreased by 20% to account for only 33.37% (2366.46 acres) of the island. The trend did not change as Bogue Banks continued to develop. From 1976 to 1983, forest land dropped from 33.37% of the land area to 24.62%. Once again, as the percent of each land use and land cover category decreased, urban or built-up was the category that experienced an increase in the percent of total land use and land cover on Bogue Banks (see Figure 20).

The wetland areas, Level I Category 6, are located on the northside of Bogue Banks adjoining Bogue Sound. The general trend has been a decrease in the total acres of wetland. The percent of wetland decreased from 13.86% of the total land area in 1939 to 8.80% in 1983. The wetland areas experienced the greatest decrease in acreage between 1953 and 1958. During this time period extensive dredging and filling occurred transforming

the Atlantic Beach area on the soundside.

Summary

Through the spectrum of time from 1939 to 1983 urban areas on Bogue Banks increased more than 50% (approximately 4,000 acres). The remainder of the island in 1983 was forest land (24.62%), wetland (8.80%), barren land (7.01%), and rangeland (4.06%). The two factors which contributed to the increase in urban development by 1983 were: 1) the two bridges which connect the barrier island to the mainland, and 2) the change in land ownership with the new owners developing the land.

This chapter was a brief overview of the land use and land cover changes that have occurred on Bogue Banks. The next chapter deals with the more detailed Level II land use and land cover changes from 1939 to 1983. Also, a more indepth analysis will be given to explain the nature and the timing of the changes.

CHAPTER 4

LEVEL II ANALYSIS

Overview

This chapter will examine the two periods of growth that occurred on Bogue Banks between 1939 and 1983. The first growth period was from 1939 to 1964 and is a period of slow growth. The second period of growth was from 1964 to 1983 and is a period of accelerated growth. Figures 21a and 21b illustrate the two periods of growth with Level II categories 11 (residential) and 12 (commercial and services).

Slow Growth Period

In 1939 Bogue Banks was predominantly forested (Level II Category 43) with areas of wetland (Level II Category 62), grassy areas (Level II Category 31 and 33), and sandy areas other than beaches (Level II Category 73) (see Table 5 and Appendix B 1939 Data). The island was only accessible by boat or bridge. The bridge connecting the island with the mainland had been completed in 1928 and joined the eastern part of the island with Morehead City. The road on the island extended from the bridge to Fort Macon in the east and to Salter Path in the west.

Commercial and urban development was practically nonexistent. The only commercialized area (Level II Category 12), which consisted of a motel, pavillion and a bath house, was

Figure 21a

LEVEL II LAND USE AND LAND COVER CHANGES
BOGUE BANKS, NORTH CAROLINA

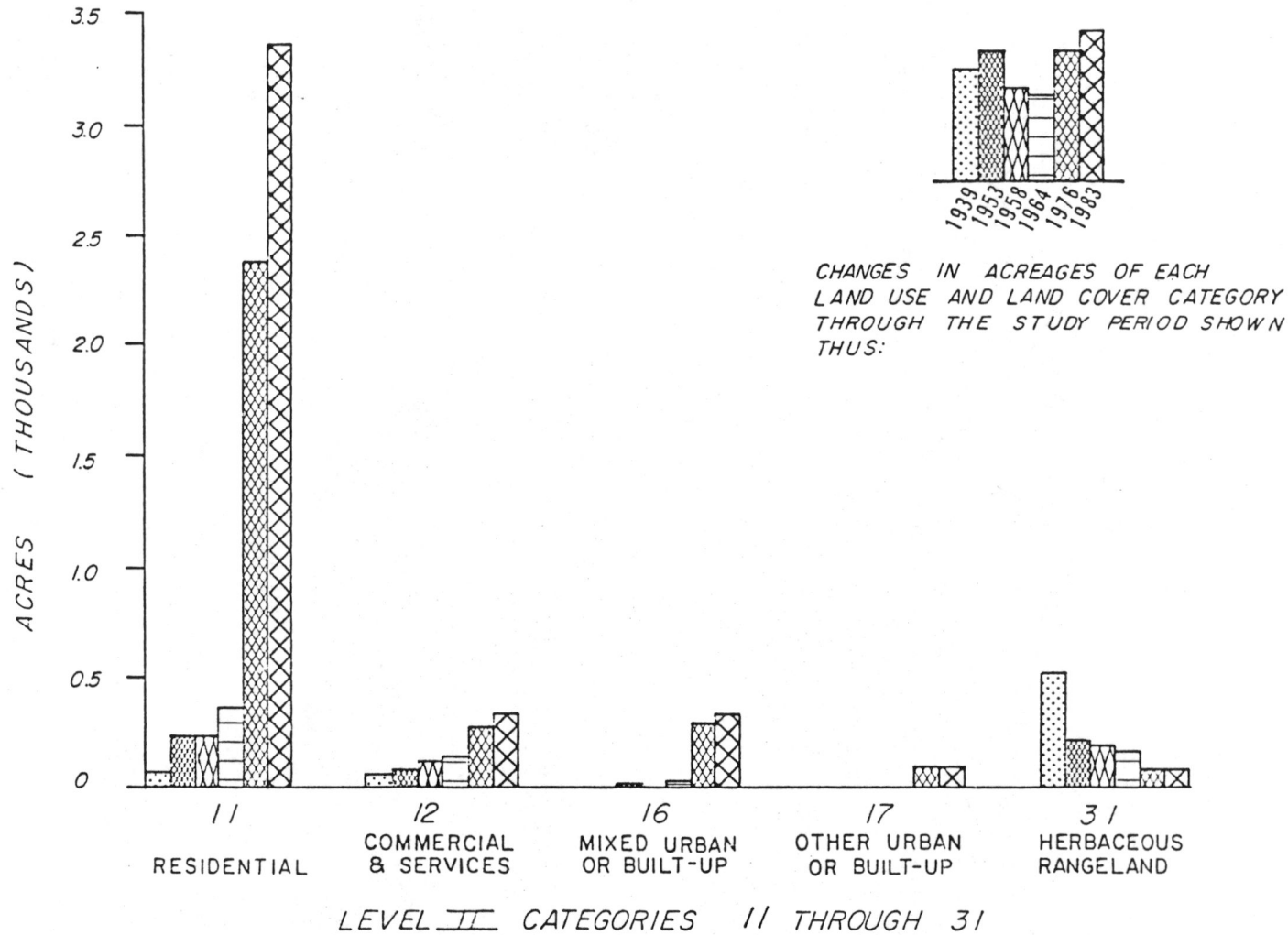


Figure 21b

LEVEL II LAND USE AND LAND COVER CHANGES
BOGUE BANKS, NORTH CAROLINA

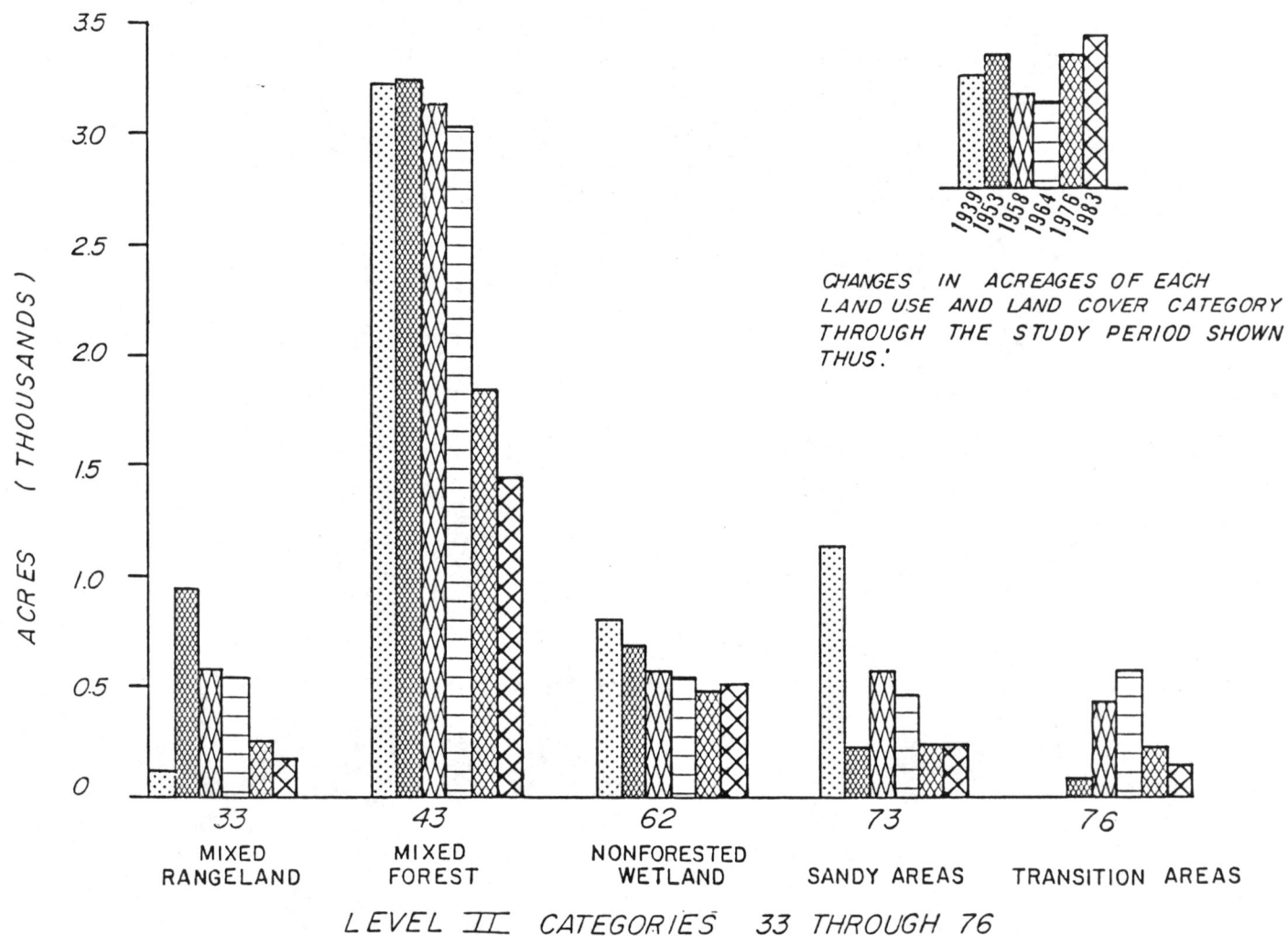


Table 5

LEVEL II LAND USE AND LAND COVER TOTALS
FOR BOGUE BANKS, NORTH CAROLINA
IN ACRES AND AS A PERCENTAGE OF THE ISLAND AREA

<u>CATEGORY</u>	<u>1939</u>	<u>1953</u>	<u>1958</u>	<u>1964</u>	<u>1976</u>	<u>1983</u>
11 Residential	73.46 0.98%	247.02 3.40%	247.02 3.37%	383.85 5.23%	2400.44 33.85%	3381.18 45.26%
12 Commercial & Services	76.22 1.02%	90.91 1.25%	118.46 1.62%	136.83 1.86%	280.08 3.95%	340.69 4.56%
16 Mixed Urban or Built-up Land	0.00 0.00%	12.86 0.18%	0.00 0.00%	26.63 0.36%	292.94 4.13%	326.00 4.36%
17 Other Urban or Built-up Land	0.00 0.00%	0.00 0.00%	0.00 0.00%	0.00 0.00%	98.26 1.39%	99.18 1.33%
31 Herbaceous Rangeland	506.90 6.79%	222.23 3.06%	183.66 2.51%	162.54 2.21%	81.73 1.15%	82.65 1.11%
33 Mixed Rangeland	154.27 2.07%	1232.36 16.95%	734.64 10.03%	711.68 9.69%	335.18 4.73%	220.39 2.95%
43 Mixed Forest Land	4158.06 55.68%	4163.57 57.28%	4032.26 55.06%	3905.53 53.18%	2366.46 33.37%	1839.35 24.62%
62 Nonforested Wetland	1034.92 13.86%	894.42 12.30%	726.38 9.92%	701.58 9.55%	622.61 8.78%	657.50 8.80%
73 Sandy Areas other than Beach	1463.77 19.60%	293.86 4.04%	720.87 9.84%	574.86 7.83%	311.30 4.39%	317.73 4.25%
76 Transitional Areas	0.00 0.00%	112.03 1.54%	560.16 7.65%	740.15 10.08%	303.04 4.27%	205.70 2.75%
*TOTAL	7467.62	7269.29	7323.44	7343.65	7092.03	7470.37

*Differences in the total area of the island are accounted for by continuing changes in erosion and deposition in this dynamic environment.

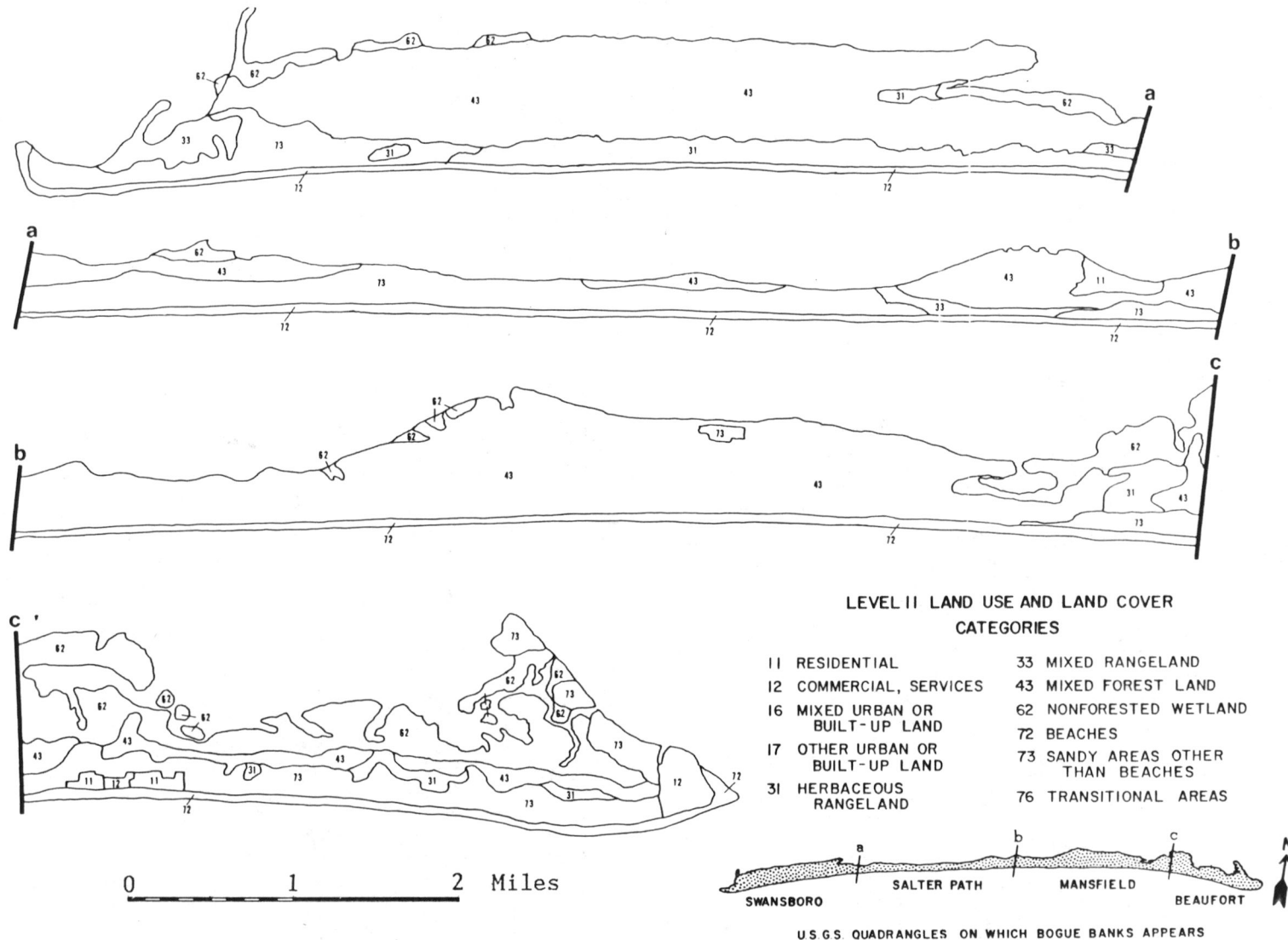
located on the oceanside of Atlantic Beach (Register of Deeds, Carteret County, Book 1, p.104). The only service areas, which are classified with the commercial areas (Level II Category 12), were located at the eastern end of the island. They were Fort Macon State Park and the adjacent United States Coast Guard Station.

Two residential areas (Level II Category 11) were identified in 1939: a few cottages were located along the oceanfront at Atlantic Beach and the community of Salter Path (see Figure 22 Beaufort and Salter Path sections). The origin of Salter Path dates back to the 1800's. Families had migrated to Bogue Banks and settled on the soundside of the western half of the island. By March 1896 the first permanent settlers moved to the area which became the village of Salter Path. These early settlers moved to Bogue Banks for various reasons. Bogue Banks lay within the lee of Cape Lookout therefore it was partially protected from fierce winter storms. Seafood was abundant and wildlife was plentiful. Furthermore, their livestock would have free range, the cattle could thrive on the marsh grasses, and their hogs could eat the roots, acorns, and berries. Moreover, there were areas on the island suitable for gardening. The island was wide enough for a garden to be located in an area protected from salt spray and blowing sand. Possibly the major factor for the people settling on the island was that the owners of the land did not object (Stephens, 1984).

In the 1930's the majority of the land was owned by two

Figure 22

BOGUE BANKS, NORTH CAROLINA: LAND USE & LAND COVER, LEVEL II - 1939



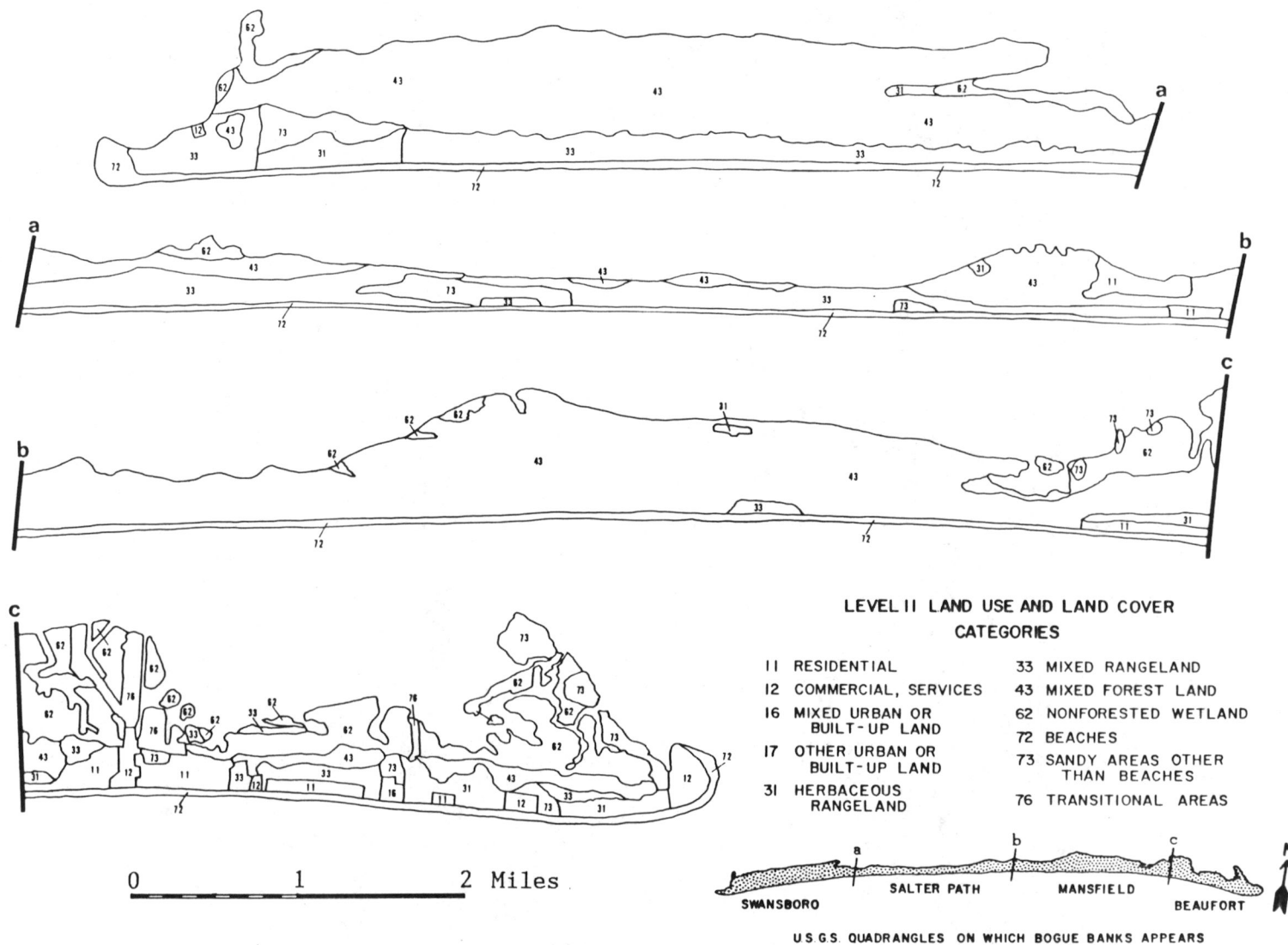
people, Alice Green Hoffman and Henry Fort. A portion of the island not owned by these two individuals was located in the Beaufort section. The area was incorporated in 1935 as the Town of Atlantic Beach. This was the site of the first development other than in the village of Salter Path.

The bridge used in 1939 was obsolete by 1953. A new bridge was constructed to the east of the former one. In the process of building the bridge a causeway was also built allowing the road on the island to connect with the new bridge. The area had previously been wetland and water. The causeway was constructed by means of dredging a canal from the east side of the causeway site. On the other side of the new canal (east), another large area was filled by dredging. This created a large square area with water surrounding it on three sides (see Figure 23 Beaufort section). The individual who brought in the dredge and greatly increased the rate of production of new land was A. B. Cooper (Pilkey et al., 1975). He filled in marshes by means of techniques similar to those used in Florida.

Residential areas (Level II Category 11) along Atlantic Beach increased in the 14 years after 1939. In that year Atlantic Beach only had 32.14 acres and by 1953 the residential areas occupied 178.15 acres (see Appendix B 1939 and 1953 Data). Houses existed in the center of Atlantic Beach, where the first cottages were built, and extended easterly to a newly constructed pier, "Triple S", and westerly to the forested area (see Figure 23). Construction in Atlantic Beach only occurred in areas that

Figure 23

BOGUE BANKS, NORTH CAROLINA: LAND USE & LAND COVER, LEVEL II - 1953



were previously sandy areas other than beaches (Level II Category 73).

The other residential area (Level II Category 11), Salter Path, experienced a slight increase in residential land use. In 1939 Salter Path had 41.32 acres of residential land use and this increased to 68.87 acres in 1953.

The only commercial and service areas (Level II Category 12) for 1953 were found in Atlantic Beach and at both ends of the island where the U.S. Coast Guard Stations were located.

Forest covered the land from Atlantic Beach to the community of Salter Path (Mrs. Alice Hoffman's property). The area west of Salter Path remained virtually unchanged. Only natural changes in vegetation and shifting sandy areas occurred (see Figures 22 and 23). Overall, from 1939 to 1953 Bogue Banks underwent little land use change.

Between 1953 and 1958 two important events influenced the future of Bogue Banks. In 1953 Alice Hoffman died. Her land went to the remaining members of the Roosevelt family: Eleanor, wife of Brigadier General Theodore Roosevelt, Jr., and to Eleanor's children Grace Roosevelt McMillen, Theodore Roosevelt, III, Cornelius Roosevelt, and Quentin Roosevelt (Mansfield, 1979). On March 31, 1954 the property west of Salter Path which then belonged to Henry Fort's daughter, Anita Fort Maulick, was sold. The property was sold to eight different parties: Robert Holding, Jr., Lewis R. Holding, Frank B. Holding, First Citizens Bank and Trust Company, George Spell, Hiram Grantham, James A.

Singleton, Jr. and William E. McLean (Register of Deeds, Carteret County, Book 154, pp. 166-184).

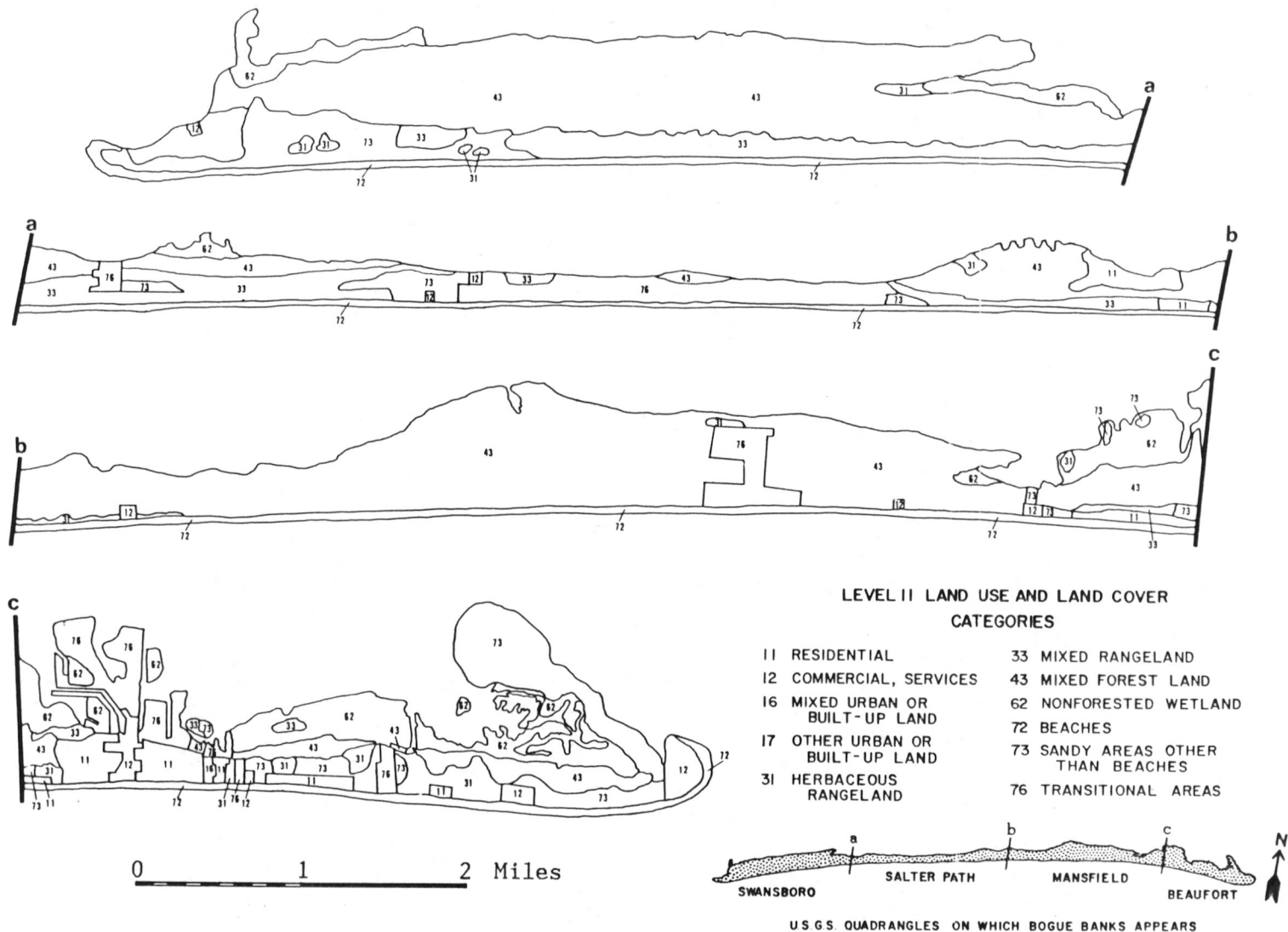
At that time the Roosevelt heirs recognized the potential for a model community to be developed. The area is now Pine Knoll Shores and is located in the Mansfield section. To insure an even development of the community, a set of covenants and restrictions was drawn up for property owners to abide when building on the land. One of the most important of these was that the area should remain in as natural a state as possible with respect to the preparation of homesites (Mansfield, 1979). The Roosevelts heirs donated more than 300 acres to the State of North Carolina. This is the site of the Roosevelt State Park Natural Area and the North Carolina Marine Resource Center, a public aquarium and meeting place.

Bogue Banks was destined for change. The eight new land owners of the western part of the island also had intentions of developing their properties. Little time passed before evidence of this became apparent. One example was the extension of the main road 4 miles west of Salter Path in 1955. Development followed with the increased accessibility toward the western end of the island. By 1957 the western section of Bogue Banks was incorporated as the Town of Emerald Isle. Although the idea to develop was present, the land use was only gradually changing (see Figure 24).

Conversely, development may have been stalled by the occurrence of seven hurricanes which passed by or over Bogue

Figure 24

BOGUE BANKS, NORTH CAROLINA: LAND USE & LAND COVER, LEVEL II – 1958



Banks between August 1953 and September 1958. These storms were Barbara (8/13/53), Carol (8/30/54), Hazel (10/15/54), Connie (8/12/55), Diane (8/17/55), Ione (9/19/55), and Helene (9/12/58) (Pilkey et al., 1975). Extensive damage to Bogue Banks was caused by four of the storms: Hazel \$2,198,000, Connie \$120,000, Diane \$470,000, and Ione \$132,000 (Pilkey et al., 1975).

Hurricanes are best known for their destructive capabilities. Some of the destruction comes from high winds and torrential rain, but the overwhelming cause of damage and loss of life is from the storm surge. The storm surge is a surge of wind-driven water as much as 25 feet above normal tide level, which occurs when a hurricane pounds into a shoreline. Of the seven hurricanes mentioned, the only ones that had a storm surge (hurricane tide) were Hazel with a surge of 7.0 feet above sea level, Ione with a surge of 7.2 feet above sea level and Helene with a surge of 4.2 feet above sea level (Pilkey et al., 1975). Hazel, in particular, caused extensive damage. Buildings were destroyed and roads were buried in sand. Dunes along the beach were eroded back from the beach as much as 150 feet. These storms discouraged many people, property values decreased, and insurance rates inflated.

Meanwhile dredging and filling continued at the Atlantic Beach causeway. Since 1953 the area west of the new bridge and around the old causeway road had been filled. The causeway was classified as a transitional area (Level II Category 76) in 1958 (see Figure 24).

The residential area (Level II Category 11) from the causeway to the ocean had increased in density, particularly the first two rows along the oceanfront. Other growth included three piers and a marina near the eastern end of the island. Toward the west of Atlantic Beach the Roosevelt property had begun to develop by 1958. In fact, a developing road pattern was noticeable on aerial photographs of 1958.

By 1958 the main road, which came across from Morehead City and branched east and west at Atlantic Beach, continued west beyond Salter Path. One of the first signs that development was progressing to the western end was the construction of a motel and a pier 4 miles west of the community of Salter Path. The remaining western portion was still undisturbed.

From 1958 to 1964 only two important events occurred to affect the development on Bogue Banks. On September 11, 1960 Hurricane Diane passed inland but generated a storm surge of 10.6 feet above sea level which caused \$1,600,000 damage to Bogue Banks. After such destructive storms as Diane and the ones in the 1950s the desire to build on this and other barrier islands was diminished. Moreover, there was only one bridge to provide for access or evacuation of the island. The other event that was influential to the future of the island was the establishment of ferry service in May 1962. The ferry was located at the western section of Emerald Isle where the distance across the sound was the narrowest. The island was then accessible at both the eastern and western ends and the improved access somewhat

counteracted negative feelings generated by the hurricanes.

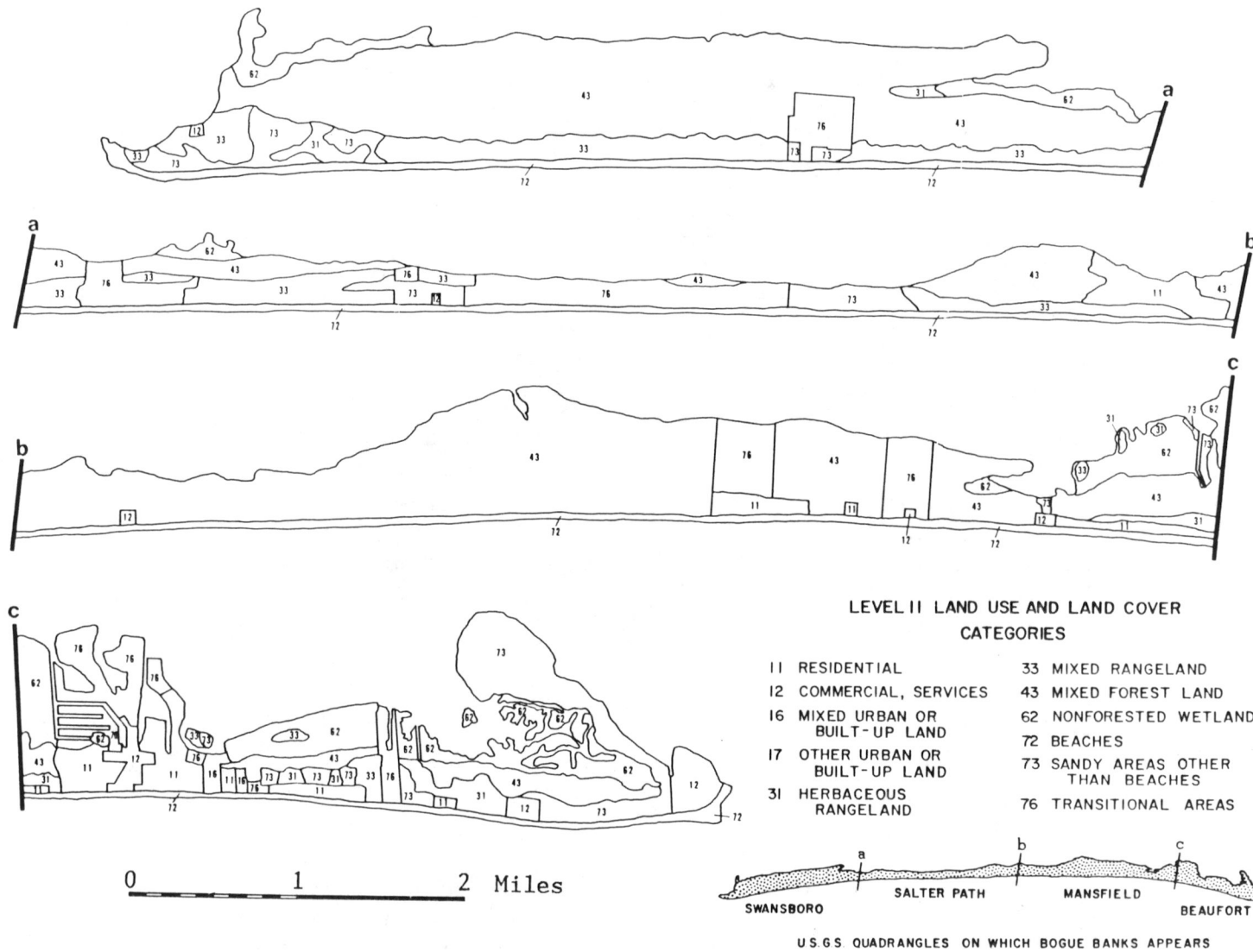
According to interpretations of the 1964 aerial photographs, development did increase but only slightly in the years from 1958. As shown in Table 5 residential areas (Level II Category 11) increased 2%, commercial areas (Level II Category 12) increased 0.2%, in addition a small section of mixed residential and commercial (Level II Category 16) was identified. Transitional areas (Level II Category 76) increased by 2.5% from 1958. Conversely, the areas of natural vegetation decreased. The barren areas (Level II Category 73) and the forested areas (Level II Category 43) had the largest decrease (see Appendix B 1964 Data).

The 1964 aerial photographs indicate that the dredging and filling process at Atlantic Beach was still in progress. Two more areas had been filled. The area east of the new bridge was lengthened and the area southwest of the old causeway road was filled with narrow canals dividing it (see Figure 25 Beaufort section). One of the previously filled areas was now a residential section. Other changes caused by the dredging of channels on the soundside resulted in spoil banks located west of Atlantic Beach. Through the years these banks became vegetated (see Figure 25 Mansfield section).

Additional changes on the island from 1958 to 1964 included: a new motel and pier in Atlantic Beach, a section of the Roosevelt land was in transition, the road extended westward to the ferry dock at Emerald Isle, and it continued to the western

Figure 25

BOGUE BANKS, NORTH CAROLINA: LAND USE & LAND COVER, LEVEL II - 1964



end of Bogue Banks.

The greatest land use changes from 1939 to 1964 occurred in the transitional areas (Level II Category 76) and the sandy areas other than beaches (Level II Category 73) (see Table 5). The transitional areas on Bogue Banks increased from 0.00% (0.00 acres) to 10.08% (740.15 acres). Concurrently, the sandy areas other than beaches decreased from 19.60% (1463.77 acres) to 7.83% (574.86 acres). The other level II categories which experienced a decrease from 1939 to 1964 were the herbaceous rangeland (Level II Category 31), nonforested wetland (Level II Category 62), and mixed forest (Level II Category 43). The categories other than transitional areas (Level II Category 76) which experienced an increase were the mixed rangeland (Level II Category 33), residential (Level II Category 11), commercial and services (Level II Category 12), and mixed urban or built-up land (Level II Category 16).

Overall the development from 1939 to 1964 was relatively slow (see Figure 21a and 21b). The largest increase of any land use or land cover type was only 10.08% as revealed in Level II Category 76 (transitional areas). The improved access to and on the island and the change of land ownership occurred before 1964, but the accelerated growth is not seen until after 1964. The next period, 1964 to 1983, will prove to be the time of accelerated growth.

Accelerated Growth Period

In this study from 1939 to 1983, the statistics showing land use changes reveal that from 1939 to 1964 development was relatively slow and from 1964 to 1983 the rate of development rapidly increased. The influential factors which occurred before 1964, the change of land ownership and the increased access to the island by the addition of the ferry at the western end of the island, as well as the incorporation of the Town of Emerald Isle, played an important role in the development which occurred after 1964.

The statistics for 1964, shown in Table 5, indicate that only 5.23% (383.85 acres) of the island was classified as residential (Level II Category 11) and 1.86% (136.83 acres) was considered commercial and services (Level II Category 12). By 1976 the residential areas occupied 33.85% (2400.44 acres) and commercial and services occupied 3.95% (280.08 acres). In addition, mixed acres of residential and commercial areas (Level II Category 16) accounted for 4.13% (292.94 acres) and other areas of urban or built-up (Level II Category 17) first appeared on 1.39% of the land area. The total land area of urban or built-up land, the Level I category which is comprised of residential, commercial and services, mixed residential and commercial and other areas of urban or built-up, accounted for 43.32% in 1976 whereas in 1964 this category only occupied 7.45% of the island. This is indicative of the rapid rate of development from 1964 to 1976.

Which existing land use categories were affected during the period of rapid development? The areas that could be intruded upon were either the grass and shrub areas (Level II Categories 31 and 33), the forested areas (Level II Category 43), the wetlands (Level II Category 62), or the sandy areas other than beaches (Level II Category 73). They all experienced a decrease in land area from 1964 to 1976. The land use and land cover maps for this study reveal that the forested areas (Level II Category 43) experienced the largest decrease. In 1964, 53.18% (3905.53 acres) of the land area was forested and by 1976 the forested area had decreased to only 33.37% (2366.46 acres). The grass and shrub categories (Level II Categories 31 and 33) also experienced a decrease in land area. In 1964 the two categories, grass areas (Level II Category 31) and mixed grass and shrub (Level II Category 33), occupied 11.90% (874.22 acres) of the island and by 1976 they only accounted for 5.88% (416.91 acres). Barren areas (Level II Category 73) were also partially utilized for development. The category which experienced the least decrease in land area was the wetland (Level II Category 62). Overall, the land use and land cover changes from 1964 to 1976 showed an increase of acreage for all categories of development and conversely, a decrease in acreage for any areas related to natural vegetation.

By 1976 the majority of the causeway area at Atlantic Beach was developed with residential and commercial land uses. The only section that was still classified as transitional (Level II

Category 76) was the last filled section that had narrow canals cut between the filled areas (see Figure 26 Beaufort section). Mobile homes and houses were situated on the filled land. The developer designed the area for the majority of the landowners to have access to the water. Along the main road in Atlantic Beach, strip development had begun. Visual differentiation between residential and commercial areas on the aerial photographs was becoming more difficult. Therefore, the category of mixed urban or built-up (Level II Category 16) was used to categorize them together.

The easternmost section of the island (Beaufort section) encountered a few changes from 1964 to 1976 (see Figures 25 and 26 Beaufort section). One area of wetland was filled and resulted in a peninsula shaped area. Another area which had been dredged and filled previously was completely occupied with mobile homes and boats in the marina area. This is the Triple S Mobile Home Park and Marina (see Figure 27).

The Mansfield section experienced tremendous urban growth from 1964 to 1976 (see Figures 25 and 26). Hotels, trailer parks, a golf course, residential areas of houses and townhouses, and a state-owned marine resource center were built. The residential areas (Level II Category 11) alone increased by 879%.

In 1964 only 79.89 acres were classified as residential areas and by 1976 782.39 acres were residential.

The Mansfield section was not the only section of Bogue Banks which experienced tremendous land use change. The

Figure 26

BOGUE BANKS, NORTH CAROLINA: LAND USE & LAND COVER, LEVEL II - 1976

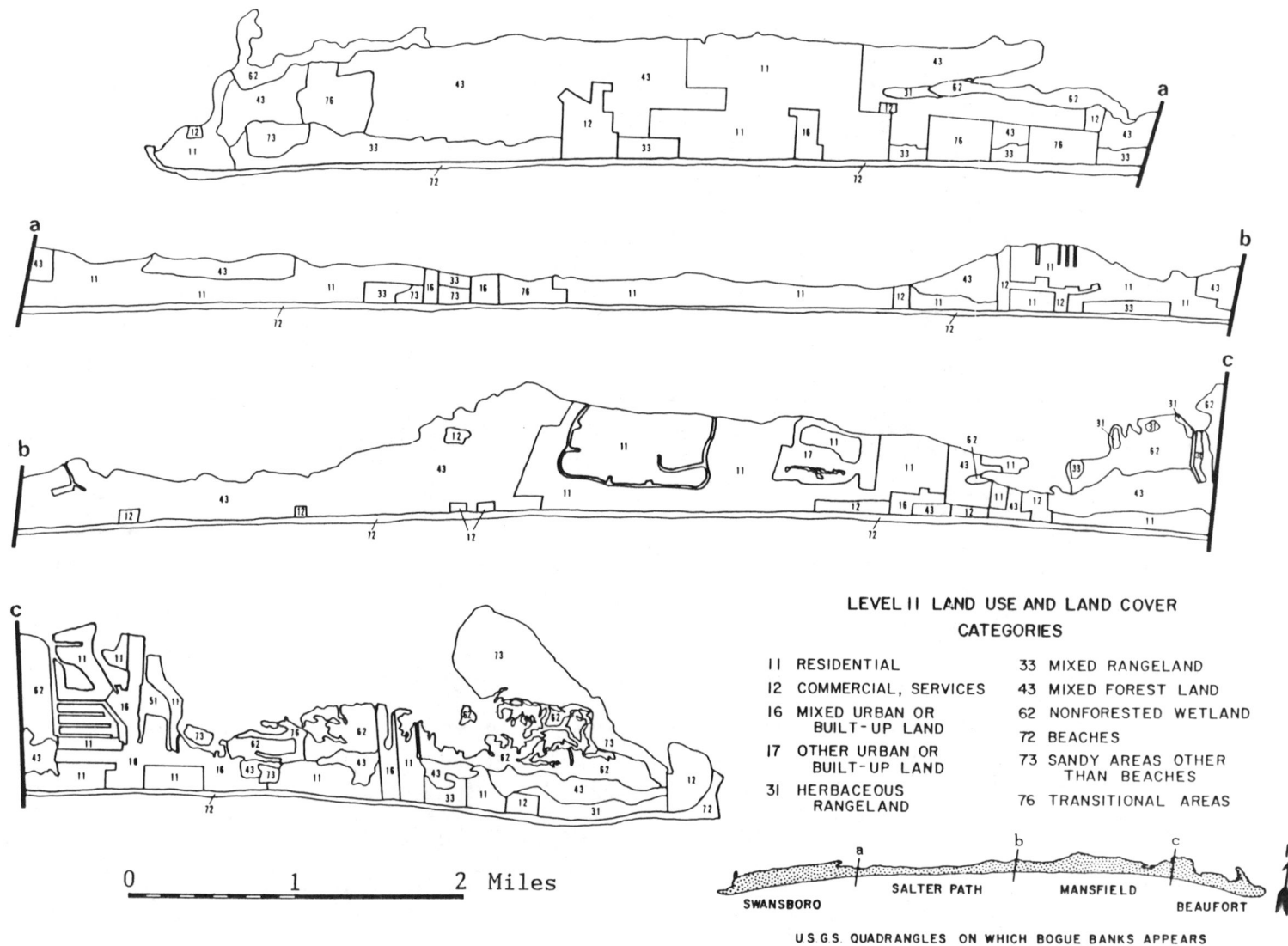




Figure 27. Triple S Mobile Home Park and Marina adjacent to Marsh at Atlantic Beach.

residential areas in the Salter Path and Swansboro sections both increased by more than 500% from 1964 to 1976 (see Figures 25 and 26).

Six mobile home parks opened in the area of Indian Beach, located in the Salter Path section, with a total of more than 800 units. Also a marina had been dredged on the sound for boat slips and water access (see Figure 28).

Emerald Isle, located in the Swansboro section, was also experiencing urban growth. Residential areas existed on most of the eastern part of the town limits. In fact, the majority of the town was becoming residential. Even at the western end of the island residential areas were developing (see Figure 26 Swansboro section).

Mobile home parks were located by Emerald Isle Fishing Pier, and Bogue Inlet Fishing Pier. A small commercial area (Level II Category 12) developed in the center of the Town of Emerald Isle. Other commercial areas seen on the 1976 land use and land cover map are motels, campgrounds, or service areas. The two service areas (Level II Category 12) depicted on the 1976 map are the Emerald Isle Police and Fire Station and Town Hall and a church, Chapel By the Sea. The transition areas (Level II Category 76) in Emerald Isle had obvious street patterns but few signs of development. The 1976 intentions of these areas are revealed on the 1983 aerial photographic coverage.

Certain events occurred between 1964 and 1976 to influence development. The ferry service at the western end of the island



Figure 23. Tradewinds Marina and Mobile Home Park at Indian Beach.

was replaced with a highrise bridge on May 5, 1971. With this improved access to the western end of the island there was pressure to develop. Also, the influential factors which occurred before 1964 played an important role.

With the increase in tourism, the demand for summer homes increased. Between 1960 and 1970 the permanent population of Emerald Isle increased from 14 to 122, a 771 percent increase (Moore, 1976). The Town of Atlantic Beach, at the eastern end of the island by the bridge connecting Morehead City to Atlantic Beach, experienced an increase in permanent population from 76 to 300, a 294.7 percent increase. The Towns of Pine Knoll Shores and Indian Beach were not incorporated until 1973, therefore no population data are available for that time period in those areas.

Utilities and services on the island were limited and electricity and water were in demand. In 1948 Salter Path had electricity supplied by Carteret-Craven Electric Membership Corporation (formerly Rural Electric Administration). There were 68 billing consumers. By 1966 the power lines had been extended from Salter Path to the ferry at Emerald Isle and the number of consumers had increased to 665. The large growth on the beach area demanded an additional substation at Emerald Isle in the early 1970s. The Emerald Isle substation served 1,693 consumers at that time. The number of consumers in the Salter Path area was 925 by 1970. Through this time period, 1964 to 1976, the demand for electricity was clearly linked to the increase in

population. Since no accurate population figures are available, the number of electric consumers must be used as an indicator of growth.

Water service was also in demand. Bogue Banks Water and Sewer Corporation began service in 1969. Prior to 1969 all residents relied on private wells for their water supply. Bogue Banks Water and Sewer Corporation serves Emerald Isle, Indian Beach, and Salter Path. The residents in Atlantic Beach either had access to water from an Atlantic Beach private system or they had private wells.

This increased demand for services obviously revealed an increase in population. Why was there an increase in population in the early 1970s? The ferry at Emerald Isle had been the only link to the western end of the island from the mainland until 1971. In May 1971 the B. Cameron Langston bridge opened. This highrise bridge suddenly made the western end of the island more accessible. The main road now stretched the complete length of the island. The increase in traffic led to an acceleration in development, as well as, an increased demand for services. This explains the expansion of residential land use in Emerald Isle from 0 acres in 1964 to 569 in 1976.

The early 1970s was not just a growth period for the western part of the island. Pine Knoll Shores and Indian Beach both became incorporated as municipalities in 1973 (see map Figure 2 Bogue Banks). Even though they were neighboring communities, their reasons for incorporation varied.

Indian Beach was incorporated by Legislative Act in 1973. The reason for incorporating was the lack of available land for commercial purposes in adjacent communities (Indian Beach Board of Commissioners, 1982). Those communities would not permit commercial uses or mobile homes based on zoning or deed restrictions. Indian Beach borders on the west of Salter Path. The community of Salter Path is not incorporated. A small area on the east of Salter Path was later annexed on June 24, 1975. This non-contiguous area was considered as a satellite within the corporate limits of Indian Beach. Therefore, the boundaries of Indian Beach exclude the community of Salter Path.

The economy of Indian Beach is primarily vacation oriented. The growth of tourism during the late sixties and early seventies stimulated a need for the services being provided in Indian Beach.

Pine Knoll Shores was incorporated on August 3, 1973 and was first designed by the Roosevelt family to be a model community. To insure an even development in the community, a set of covenants and restrictions was drawn up for property owners to abide by when building on the land. One of the most important of these was that the area should remain in as natural a state as possible with respect to the preparation of homesites (Mansfield, 1979).

This set of covenants and restrictions preceded the incorporation of the town. It was not until the population of the community began to grow that they felt it was necessary to

incorporate as a town. By doing this Pine Knoll Shores could maintain its intended character.

While most of the island was developing rapidly, development around Atlantic Beach had slowed down. The damage to the natural environment caused by dredging and filling had finally become obvious to the public. By 1971 political action had been taken to control this process. The Dredge and Fill Act GS-229 was the first permit program to regulate the filling or excavating of wetlands or waters (C. Jones, personal communication, Jan 6, 1987).

It was now recognized that the wetlands and waters of coastal areas are fragile areas of the natural environment and that man must respect them and act accordingly. The Federal Coastal Zone Management Act of 1972 (CZMA) initiated an effort for all coastal states to manage their shorelines and in turn conserve a vital national resource. The major requirements of CZMA are coastal land-use planning based on land classification, and identification and protection of critical areas (Pilkey et al., 1978).

In 1974 the North Carolina Coastal Area Management Act (CAMA) was passed in compliance with the federal CZMA, qualifying North Carolina for federal aid in implementing effective coastal management. The intentions of CAMA were to insure good land-use and resource development, and conservation of resources to protect the quality of life for citizens of the coastal zone. Moreover, the goal of CAMA is not to stop or prohibit

development, but rather to control it (Pilkey et al., 1975). The 20 county area in North Carolina that is under the jurisdiction of CAMA is shown in Figure 1.

By 1976 the island consisted of four municipalities, Atlantic Beach, Pine Knoll Shores, Indian Beach, and Emerald Isle (see Figure 2). Two bridges, one at either end of the island, connected the island with the mainland. Water and electric services were established for the length of the island. Land use plans required for coastal counties and towns reflected the effect of CAMA initiated in 1974.

Between 1976 and 1983 residential land use (Level II Category 11) experienced the only substantial increase (see Table 5). In 1976 33.85% of the island was classified as residential and by 1983 the residential areas increased to 45.26%. The building of condominiums was the main factor responsible for this increase. The areas which remained virtually unchanged were the commercial and services (Level II Category 12), mixed residential and commercial (Level II Category 16), other urban or built-up land (Level II Category 17), herbaceous rangeland (Level II Category 31), and sandy areas other than beaches (Level II Category 73).

Conversely, the areas which experienced a decrease in land use were the categories of mixed rangeland (Level II Category 33), mixed forest land (Level II Category 43), and transitional areas (Level II Category 76). Therefore, the increase in residential areas occurred in these areas.

The land use changes in the Beaufort section between 1976 and 1983 were relatively small compared to the other sections of the island (see Figures 26 and 29). Only two areas experienced a change. Houses had been built on a previously wooded area toward the eastern end of the island. The other change occurred on the peninsula-shaped area that was classified as transitional (Level II Category 76) in 1976. Condominiums were completed on this site by 1983 causing the area to be classified then as residential (Level II Category 11) (see Figure 30).

In the Mansfield section, the areas which experienced a land use change were all areas of mixed forest land (Level II Category 43). Large condominium complexes were built in these areas. On the other hand, in the Salter Path section only one condominium complex, Summer Winds, was built (see Figure 31). This complex replaced a mobile home park which had also been classified as residential (Level II Category 11). The only difference was the increase in density. The other changes in this section were also increases in residential areas. Single and double family dwellings were built in areas which were previously transitional areas (Level II Category 76), forest land (Level II Category 43), and mixed rangeland (Level II Category 33). A section of the road that was added in 1962 had a "dog leg" in it. By 1978 the "dog leg" was eliminated by connecting the road straight through and continuing to the west. In this area, previously forested areas and residential areas were developed.

The bulk of the residential growth was still occurring in

Figure 29

BOGUE BANKS, NORTH CAROLINA: LAND USE & LAND COVER, LEVEL II — 1983

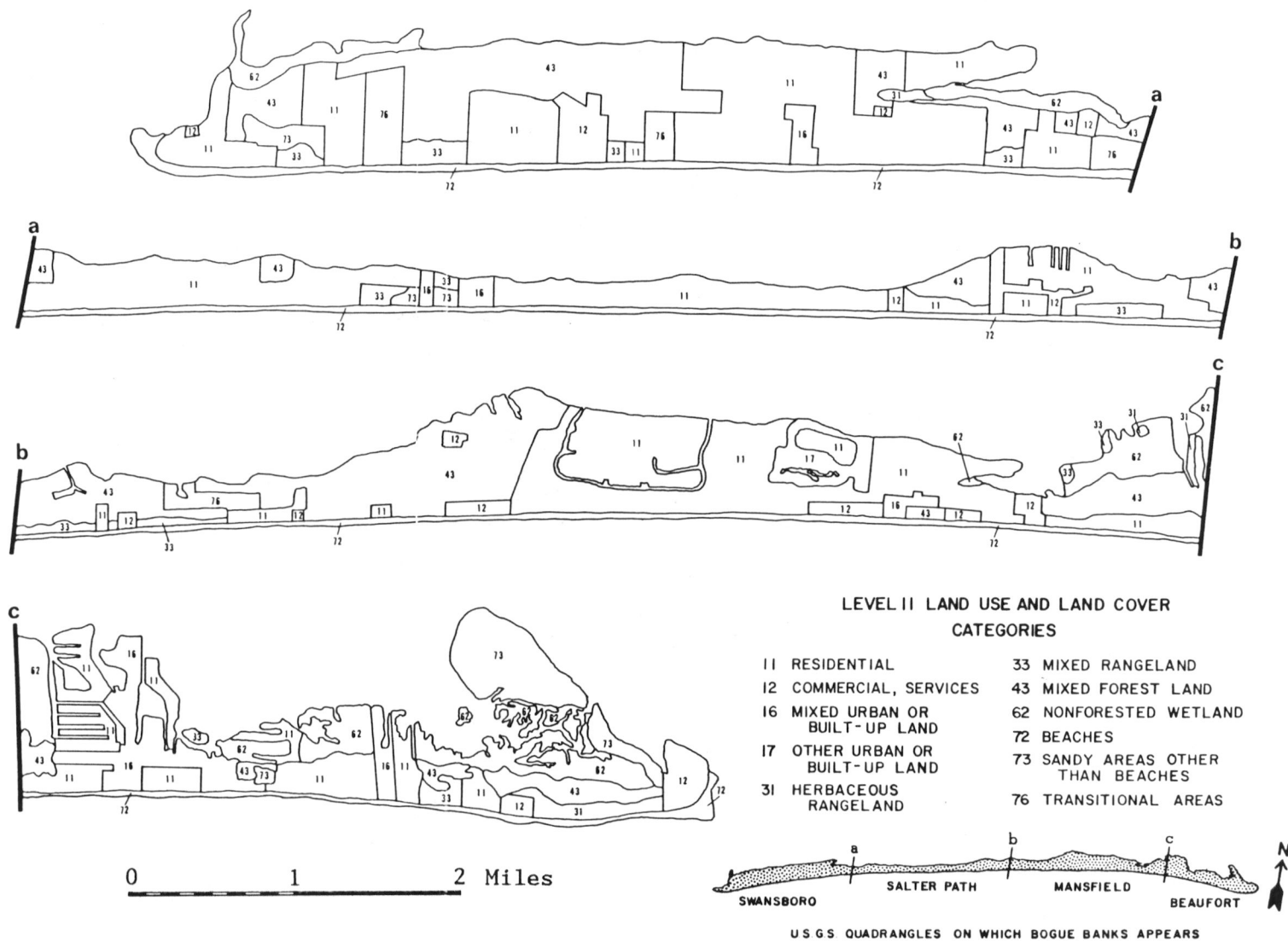




Figure 30. Eight and One-Half Marina Village at Atlantic Beach located on peninsula.



Figure 31. Summer Winds Condominiums at Indian Beach
adjacent to Mobile Home Park.

the Emerald Isle, the Swansboro section, in 1983. Across from the church, Level II Category 12, one area was in a transitional stage while the area beside it had developed into a residential area. Other areas near there which had previously been transitional areas were also residential areas. Another residential area also developed at the point, seen as a thumb-like structure on the soundside (see Figure 29 Swansboro section). The growth toward the remaining western end was residential (Level II Category 11) and consisted of condominiums as well as single and double family dwellings. As stated in the Emerald Isle Land Use Plan (1976), the higher density areas were to be located near the bridge with decreasing intensity as the distance from the bridge increases.

As seen in Table 5 for 1964 and 1983, all the categories devoted to land use (Level II Categories 11 through 17) experienced an increase and all the land cover categories (Level II Categories 31 through 76) experienced a decrease. Overall, the percent of increased development was 48.06%. The residential category (Level II Category 11) increased the greatest (40.03%) followed by mixed urban or built-up land (Level II Category 16) with an increase of 4.00%. The other two categories which experienced an increase were commercial and services (Level II Category 12) and other built-up land (Level II Category 17) with 2.70% and 1.33% respectively.

Overall, this accelerated growth period on Bogue Banks, 1964 to 1983, was influenced by the increased accessibility at the

western end of the island with the addition of a second bridge and the increase of traffic and tourism. The addition of condominiums and houses, as well as hotels, piers, and entertainment areas are all signs of this accelerated growth.

Summary

This Level II analysis identified two growth periods that occurred on Bogue Banks between 1939 and 1983 and the changes in the land use and land cover categories between each study period. The results indicate that Bogue Banks has evolved from a predominantly forested island in 1939 to an urban area with 45.26% residential land use in 1983.

CHAPTER 5

CONCLUSIONS

Although the island of Bogue Banks is one physical entity, it has developed at varying rates along its length. This study demonstrates that evolution of transportation routes, changing land ownership, and varying attitudes of local governments on the island have been responsible for: 1) where and when development began, 2) the sequence of the land use change, and 3) the rate of change.

The purpose of this study was to determine the nature of change by analyzing land use and land cover for a number of years from 1939 to 1983 on Bogue Banks, North Carolina. The study was based on land use and land cover maps for each study year and statistics generated from these maps. The changes were correlated with historical events. A comprehensive understanding of the island's history and the nature of its development was gained from this analysis.

Aerial photographs provided an invaluable source of information. Complete historical land use and land cover information could not have been recaptured through any other source. The combined use of the aerial photographs and the U.S.G.S. land use and land cover classification system made this study possible.

Level I of the U.S.G.S. classification system consists of

the broad categories, while the Level II categories are subheadings and more specific. By first observing the Level I results, the largest increase of any land use or land cover between 1939 to 1983 is seen in Category 1, urban or built-up land. Conversely, the largest decrease of any land use or land cover is seen in Category 4, forest land. Urban or built-up land increased from 2.01% in 1939 to 55.51% of the island's area in 1983. Forest land decreased from 55.68% to 24.62%. While urban development was increasing not only was the forest land experiencing a decrease of acreage but other land cover categories such as rangeland (Level I Category 3), wetland (Level I Category 6), and barren land (Level I Category 7) were also experiencing a decline.

It is evident that Bogue Banks has evolved from an island of predominantly forested land in 1939 to an island which now consists of more than 50% of urban or built-up land. The greatest increase of urban or built-up land occurred between 1964 and 1976 when the percent of urban or built-up land increased from 7.45% to 43.31%. Accordingly, the largest decrease of forest land occurred between the same time period, 1964 to 1976. The percent of forest land decreased from 53.18% in 1964 to 33.37% in 1976.

A more indepth view is gained by observing the Level II land use and land cover results. The greatest increase of all the Level II categories occurred in Category 11, residential. Residential areas increased from occupying 0.98% of the island in

1939 to 45.26% in 1983. The majority of Level I Category 1 land use, urban or built-up land, on Bogue Banks is now residential. Residential areas increased the greatest from 1964 to 1976, 5.23% to 33.85%. This growth continued and by 1983 45.26% of the island was classified as residential.

This study focused on the factors which influenced the rate of development on Bogue Banks. As stated in the hypothesis the influential factors were: 1) evolution of transportation routes, 2) changing land ownership, and 3) varying attitudes of local governments on the island. Each one of these factors contributed to the evolving land use changes on Bogue Banks.

The first factor, evolution of transportation routes, proved to be a vital part of the island development. In 1928, the first bridge was built to connect Morehead City on the mainland with Atlantic Beach. By 1939, a single lane ran from the bridge to the eastern end of the island and to Salter Path, located midway on the island. In 1953, the first bridge was replaced and the road extended toward Emerald Isle. In 1962, a ferry service began in Emerald Isle near the western end of the island. This provided transportation from the mainland and across Bogue Sound. As a result of the ferry service the road was further extended to the ferry dock. By 1971, a bridge replaced the ferry service. The island was then accessible at both ends and the road ran the complete length of the island. Accessibility to the island and on the island had the effect of influencing and accelerating development.

The second factor, changing land ownership, proved to have a tremendous impact on the island development. In 1939, the majority of the island was owned by a few individuals. Mr. A. B. Cooper owned most of Atlantic Beach and Mrs. Alice Robinson owned the area between Atlantic Beach and Fort Macon called Money Island Beach. The majority of the area from Atlantic Beach to the western end of the island excluding the community of Salter Path was owned by two people, Mrs. Alice G. Hoffman and Mr. Henry Fort. This land was virtually all maritime forest. In the early 1950s, Mrs. Hoffman died and her land went to several members of the Roosevelt family. These new owners saw the potential for developing the large tract of land.

Also in the early 1950s, Mrs. Anita Fort Maulick, Henry Fort's daughter came to own the land on the western portion of the island that was previously her father's property. She sold the property to eight different parties on March 31, 1954. The individuals who purchased the property soon became known as developers and real estate agents. These two major changes in land ownership, the Hoffman property and the Fort property, proved to be a major catalyst for development on Bogue Banks.

The third factor, varying attitudes of local governments, proved to have an effect on the character of particular areas along Bogue Banks. Four municipalities are incorporated on Bogue Banks: Atlantic Beach (1937), Emerald Isle (1957), Pine Knoll Shores (1973), and Indian Beach (1973). By incorporating, each town established their own unique character.

Atlantic Beach was incorporated in 1937. Mr. A. B. Cooper was chiefly responsible for the effort. Atlantic Beach had a permanent population of 15 in the late 1930s. The character of the area was primarily resort-oriented. Mr. Cooper had developed an entertainment area with a four-lane bowling alley and refreshments. He then added an indoor miniature golf course, a lounge, shuffleboard, and a dance floor.

Emerald Isle was incorporated in 1957 before which little development had occurred at the western end of the island. A few of the individuals who purchased parts of the Fort property were the ones who formed the Town of Emerald Isle. Unlike Atlantic Beach, entertainment arcades and pavillions were not built in Emerald Isle in the early days of incorporation. Essentially, a residential town was being planned to control future development.

The other two municipalities on Bogue Banks were incorporated in 1973 as Pine Knoll Shores and Indian Beach. Pine Knoll Shores was developed by the Roosevelt family, heirs of Mrs. Alice G. Hoffman's estate. They wanted to incorporate the area to insure planned development in the community. The Roosevelts like Mrs. Hoffman wanted to preserve the natural environment. Therefore, their efforts of incorporation were to protect the area from uncontrolled development and degradation of the fragile environment.

Indian Beach was also incorporated in 1973. This town had different objectives for its incorporation. The adjacent communities of Emerald Isle and Pine Knoll Shores did not have

any land available for commercial purposes, nor would their zoning ordinances and deed restrictions permit commercial uses or mobile homes.

As shown in Figure 2, Indian Beach lies on either side of the community of Salter Path. On June 24, 1975, the North Carolina General Assembly ratified an act to annex a certain non-contiguous area (eastern section) to the Town of Indian Beach as "satellite corporate limits". It is believed that the satellite area was incorporated because the town limits from another community (Pine Knoll Shores) were approaching and the owners preferred the low taxes and less red tape of Indian Beach.

The growth of tourism during the late sixties and the early seventies stimulated the economy of Indian Beach as a vacation resort community. Year round (permanent) residents are either retired persons or are employed by vacation related businesses. There are mobile home parks, travel trailer parks, and commercial establishments designed to provide necessary services and entertainment for the seasonal population of Indian Beach.

By focusing on each municipality, it became evident that the varying attitudes of each of the local governing bodies have, therefore, influenced the character and rate of development of various parts of Bogue Banks. Moreover, this study has clearly demonstrated that the developemnt on Bogue Banks from 1939 to 1983 was also influenced by the evolution of transportation routes, and the changing land ownership.

In addition to Bogue Banks, several barrier islands in North

Carolina have experienced tremendous urban growth since the 1950s, and the fragile coastal environment has been the victim of this growth. The government as well as the citizens of the coastal areas have recognized that the valuable resources unique to the area should be protected.

In 1974 the Coastal Area Management Act (CAMA) was established for the protection, preservation, orderly development and management of the coastal area of North Carolina. CAMA is a cooperative program of coastal area management between local governments and the state. Local governments are involved through land use planning which gives them the opportunity and responsibility to establish and enforce policies to guide development of their communities. Each county as well as the municipalities within the coastal counties are encouraged by CAMA to develop land use plans which reflect the desires, needs, and best judgement of its citizens. The land use plans are reviewed by the Coastal Resources Commission. Upon approval, the plans become part of the North Carolina Coastal Management Plan.

North Carolina wishes to stimulate, encourage, and support local planning as an essential element of wise resource management. Local knowledge and understanding of the problems associated with land use and growth management are necessary to prevent environmental degradation while achieving economic growth.

Again, the land use plans developed by local governments are encouraged by CAMA. The plans reflect a clear expression of

local sentiment and desires. Most importantly, the plans enable local communities to address emerging problems before they become severe.

The land use and land cover data compiled in this study of Bogue Banks can be a valuable resource for state government agencies, local governments, and residents on Bogue Banks. These statistics for the first time provide quantified data needed for an understanding of change and its impact on the natural environment. The historical information about the island and each municipality may also enrich the knowledge of citizens and government officials. It is hoped that the results of this study will assist people who live and work on the island in making rational decisions about future growth and development.

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APPENDIX A

U.S.G.S. LEVEL I LAND USE AND LAND COVER DEFINITIONS
AS THEY APPEAR IN A LAND USE AND LAND COVER CLASSIFICATION
SYSTEM FOR USE WITH REMOTE SENSOR DATA, GEOLOGICAL SURVEY
PROFESSIONAL PAPER 964 BY J. R. ANDERSON, E.E. HARDY, J. T.
ROACH, AND R. E. WITMER, 1976.

1-Urban or Built-up Land

Urban or Built-up Land is comprised of areas of intensive use with much of the land covered by structures. Included in this category are cities, towns, village, strip developments along highways, transportation, power, and communications facilities, and areas such as those occupied by mills, shopping centers, industrial and commercial complexes, and institutions that may, in some instances, be isolated from urban areas.

As development progresses, land having less intensive or nonconforming use may be located in the midst of Urban or Built-up areas and will generally be included in this category. Agricultural land, forest, wetland, or water areas on the fringe of Urban or Built-up areas will not be included except where they are surrounded and dominated by urban development. The Urban or Built-up category takes precedence over others when the criteria for more than one category are met. For example, residential areas that have

sufficient tree cover to meet Forest Land criteria will be placed in the Residential category (p.10).

2-Agricultural Land

This category does not apply in the case of Bogue Banks.

3-Rangeland

Rangeland historically has been defined as land where the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs and where natural herbivory was an important influence in its precivilization state. Management techniques which associate soil, water, and forage vegetation resources are more suitable for rangeland management than are practices generally used in managing pastureland. Some rangelands have been or may be seeded to introduced or domesticated plant species. Most of the rangelands in the United States are in the western range, the area to the west of an irregular north-south line that cuts through the Dakotas, Nebraska, Kansas, Oklahoma, and Texas. Rangelands also are found in certain places historically not included in the western range, such as the Flint Hills, the Southeastern States, and Alaska. The historical connotation of Rangeland is expanded in this classification to include those areas in the Eastern States which commonly are called brushlands (pp. 14-15).

4-Forest Land

Forest Lands have a tree-crown areal density (crown closure percentage) of 10 percent or more, are stocked with

trees capable of producing timber or other wood products, and exert an influence on the climate or water regime. Forest Land generally can be identified rather easily on high-altitude imagery, although the boundary between it and other categories of land may be difficult to delineate precisely.

Lands from which trees have been removed to less than 10 percent crown closure but which have not been developed for other uses also are included. For example, lands on which there are rotation cycles of clearcutting and blockplanting are part of Forest Land. On such lands, when trees reach marketable size, which for pulpwood in the Southeastern United States may occur in 2 to 3 decades, there will be large areas that have little or no visible forest growth. The pattern can sometimes be identified by the presence of cutting operations in the midst of a large expanse of forest. Unless there is evidence of other use, such areas of little or no forest growth should be included in the Forest Land category. Forest land which is grazed extensively, as in the Southeastern States, would be included in this category because the dominant cover is forest and the dominant activities are forest related. Such activities could form the basis for Levels III or IV categorization. Lands that meet the requirements for Forest Land and also for an Urban or Built-up category should be placed in the latter category. The only exceptions in

classifying Forest Land are those areas which would otherwise be classified as Wetland if not for the forest cover. Since the wet condition is of much interest to land managers and planning groups and is so important as an environmental surrogate and control, such lands are classified as Forested Wetland.

Auxiliary concepts associated with Forest Land, such as wilderness reservation, water conservation, or ownership classification, are not detectable using remote sensor data. Such concepts may be used for creating categories at the more detailed levels when supplemental information is available.

At Level II, Forest Land is divided into three categories: Deciduous, Evergreen, and Mixed. To differentiate these three categories effectively, sequential data, or at least data acquired during the period when deciduous trees are bare, generally will be necessary (p. 16).

5-Water

This category does not apply since there were no water bodies completely surrounded by land.

6-Wetland

Wetlands are those areas where the water table is at, near, or above the land surface for a significant part of most years. The hydrologic regime is such that aquatic or hydrophytic vegetation usually is established, although

alluvial and tidal flats may be nonvegetated. Wetlands frequently are associated with topographic lows, even in mountainous regions. Examples of wetlands include marshes, mudflats, and swamps situated on the shallow margins of bays, lakes, ponds, streams, and manmade impoundments such as reservoirs. They include wet meadows or perched bogs in high mountain valleys and seasonally wet or flooded basins, playas, or potholes with no surface-water outflow. Shallow water areas where aquatic vegetation is submerged are classed as open water and are not included in the Wetland category.

Extensive parts of some river flood plains qualify as Wetlands, as do regularly flooded irrigation overflow areas. These do not include agricultural land where seasonal wetness or short-term flooding may provide an important component of the total annual soil moisture necessary for crop production. Areas in which soil wetness or flooding is so short-lived that no typical wetlands vegetation is developed properly belong in other categories.

Cultivated wetlands such as the flooded fields associated with rice production and developed cranberry bogs are classified as Agricultural Land. Uncultivated wetlands from which wild rice, cattails, or wood products, and so forth are harvested, or wetlands grazed by livestock, are retained in the Wetland category.

Remote sensor data provide the primary source of land

use and vegetative cover information for the more generalized levels of this classification system. Vegetation types and detectable surface water or soil moisture interpreted from such data provide the most appropriate means of identifying wetlands and wetland boundaries. Inasmuch as vegetation responds to changes in moisture conditions, remote sensor data acquired over a period of time will allow the detection of fluctuations in wetland conditions. Ground surveys of soil types or the duration of flooding may provide supplemental information to be employed at the more detailed levels or classification.

Wetland areas drained for any purpose belong to other land use and land cover categories such as Agricultural Land, Rangeland, Forest Land, or Urban or Built-up Land. When the drainage is discontinued and such use ceases, classification may revert to Wetland. Wetlands managed for wildlife purposes may show short-term changes in land use as different management practices are used but are properly classified Wetland.

Two separate boundaries are important with respect to wetland discrimination: the upper wetland boundary above which practically any category of land use or land cover may exist, and the boundary between wetland and open water beyond which the appropriate Water category should be employed (p. 18).

7-Barren Land

Barren Land is land of limited ability to support life and in which less than one-third of the area has vegetation or other cover. In general, it is an area of thin soil, sand, or rocks. Vegetation, if present, is more widely spaced and scrubby than that in the Shrub and Brush category of Rangeland. Unusual conditions such as a heavy rainfall, occasionally result in growth of a short-lived, more luxuriant plant cover. Wet, nonvegetated barren lands are included in the Nonforested Wetland category.

Land may appear barren because of man's activities. When it may reasonably be inferred from the data source that the land will be returned to its former use, it is not included in the Barren category but classified on the basis of its site and situation. Agricultural land, for example, may be temporarily without vegetative cover because of cropping season or tillage practices. Similarly, industrial land may have waste and tailing dumps, and areas of intensively managed forest land may have clearcut blocks evident.

When neither the former nor the future use can be discerned and the area is obviously in a state of land use transition, it is considered to be Barren Land, in order to avoid inferential errors (pp. 18-19).

The following do not apply to this study: Level I Categories 8 (Tundra) and 9 (Perrenial Snow and Ice).

APPENDIX B

The following data represent the results of the planimetric analysis of the maps of Bogue Banks for each year of aerial photographic coverage. Each polygon of land use or land cover is listed by its Level II type in square inches and the acreages represented by these measurements. The data are grouped according to the four U.S.G.S. topographic quadrangles (Swansboro, Salter Path, Mansfield, and Beaufort) within which each portion of the island lies.

The data are the result of aerial photographic interpretation. The measurements were calculated to the hundredth of a square inch for accuracy. However, the varying quality of the photographic coverage causes the calculations to be only approximations.

1939 LEVEL II LAND USE AND LAND COVER RAW DATA

Based on an analysis of Figure 22.

SWANSBORO			SALTER PATH		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.00	0.00	11	0.45	41.32
12	0.00	0.00	12	0.00	0.00
16	0.00	0.00	16	0.00	0.00
17	0.00	0.00	17	0.00	0.00
31	0.12	11.02	31	0.00	0.00
	3.68	337.93	33	0.49	45.00
	0.24	22.04	43	1.59	146.01
33	1.03	94.58		0.48	44.08
	0.16	14.69		1.10	101.01
43	9.27	851.26	62	0.23	21.12
	9.82	901.77	73	4.30	394.87
62	0.60	55.10		1.93	177.23
	0.20	18.37		0.54	49.59
	0.12	11.02	<u>76</u>	<u>0.00</u>	<u>0.00</u>
	0.06	5.51	TOTAL	11.11	1020.23
	0.70	64.28			
73	2.94	269.98			
<u>76</u>	<u>0.00</u>	<u>0.00</u>			
TOTAL	28.94	2657.55			

1939 LEVEL II LAND USE AND LAND COVER RAW DATA

MANSFIELD			BEAUFORT		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.00	0.00	11	0.12	11.02
12	0.00	0.00		0.23	21.12
16	0.00	0.00	12	0.11	10.10
17	0.00	0.00		0.72	66.12
31	0.78	71.63	31	0.07	6.43
33	0.00	0.00		0.43	39.49
43	4.59	421.50		0.20	18.37
	9.98	916.46	33	0.00	0.00
	5.64	517.92	43	0.37	33.98
	0.45	41.32		1.04	95.50
62	0.07	6.43		0.95	87.24
	0.05	4.59	62	2.36	216.72
	0.08	7.35		1.75	160.70
	1.80	165.29		2.41	221.31
73	0.14	12.86		0.07	6.43
	0.68	62.44		0.14	12.86
<u>76</u>	<u>0.00</u>	<u>0.00</u>		0.03	2.75
TOTAL	24.26	2227.80		0.43	39.49
				0.06	5.51
				0.05	4.59
				0.06	5.51

TYPE	SQ. IN.	ACRES
73	4.20	385.69
	0.23	21.12
	0.32	29.39
	0.66	60.61
<u>76</u>	<u>0.00</u>	<u>0.00</u>
TOTAL	17.01	1562.03

1939 TOTALS

TYPE	SQ. IN.	ACRES
11	0.80	73.46
12	0.83	76.22
16	0.00	0.00
17	0.00	0.00
31	5.52	506.90
33	1.68	154.27
43	45.28	4158.06
62	11.27	1034.92
73	15.94	1463.77
<u>76</u>	<u>0.00</u>	<u>0.00</u>
TOTAL	81.32	7467.62

TOTALS BY SECTION

SWANSBORO	28.94	2657.55
SALTER PATH	11.11	1020.23
MANSFIELD	24.26	2227.80
<u>BEAUFORT</u>	<u>17.01</u>	<u>1562.03</u>
TOTAL	81.32	7467.62

1953 LEVEL II LAND USE AND LAND COVER RAW DATA

Based on an analysis of Figure 23.

SWANSBORO			SALTER PATH		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.00	0.00	11	0.60	55.10
12	0.04	3.67		0.15	13.77
16	0.00	0.00	12	0.00	0.00
17	0.00	0.00	16	0.00	0.00
31	0.10	9.18	17	0.00	0.00
33	1.97	180.91	31	0.05	4.59
	0.92	84.48	33	2.96	271.82
	0.90	82.65		0.10	9.18
	1.96	179.99		0.22	20.20
	1.18	108.36		1.78	163.46
43	0.15	13.77		0.69	63.36
	5.03	461.90	43	1.55	142.34
	7.96	730.97		0.10	9.18
	5.35	491.29		0.27	24.79
62	0.46	42.24		2.60	238.76
	0.08	7.35	62	0.23	21.12
	0.59	54.18	73	0.82	75.30
73	0.89	81.73		0.09	8.26
<u>76</u>	<u>0.00</u>	<u>0.00</u>	<u>76</u>	<u>0.00</u>	<u>0.00</u>
TOTAL	27.58	2532.67	TOTAL	12.21	1121.24

1953 LEVEL II LAND USE AND LAND COVER RAW DATA

MANSFIELD			BEAUFORT		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.32	29.39	11	0.54	49.59
12	0.00	0.00		0.73	67.04
16	0.00	0.00		0.30	27.55
17	0.00	0.00		0.05	4.59
31	0.08	7.35	12	0.28	25.71
	0.30	27.55		0.05	4.59
33	0.25	22.96		0.15	13.77
43	4.28	393.03		0.47	43.16
	8.73	801.68	16	0.14	12.86
	7.55	693.32	17	0.00	0.00
62	0.06	5.51	31	0.07	6.43
	0.03	2.75		0.56	51.42
	0.15	13.77		0.80	73.46
	1.63	149.68		0.46	42.24
	0.09	8.26	33	0.18	16.53
73	0.05	4.59		0.14	12.86
	0.04	3.67		0.07	6.43
	0.03	2.75		0.18	16.53
<u>76</u>	<u>0.00</u>	<u>0.00</u>	43	0.32	29.39
TOTAL	23.56	2163.51		0.53	48.67
				0.92	84.48
			62	1.27	116.92

TYPE	SQ. IN.	ACRES
(62)	0.24	22.04
	0.05	4.59
	0.33	30.30
	0.17	15.61
	0.06	5.51
	0.05	4.59
	0.03	2.75
	0.06	5.51
	1.54	141.42
	1.83	168.05
	0.25	22.96
	0.34	31.22
	0.03	2.75
	0.05	4.59
73	0.08	7.35
	0.15	13.77
	0.16	14.69
	0.32	29.39
	0.20	18.37
	0.49	45.00
76	0.25	22.96
	0.55	50.51
	0.36	33.06
	<u>0.06</u>	<u>5.51</u>
TOTAL	15.86	1456.42

1953 TOTALS

TYPE	SQ. IN.	ACRES
11	2.69	247.02
12	0.99	90.91
16	0.14	12.86
17	0.00	0.00
31	2.42	222.23
33	13.50	1239.71
43	45.34	4163.57
62	9.62	883.40
73	3.20	293.86
<u>76</u>	<u>1.22</u>	<u>112.03</u>
TOTAL	79.12	7265.59

TOTALS BY SECTION

SWANSBORO	27.58	2532.67
SALTER PATH	12.21	1121.24
MANSFIELD	23.56	2163.51
<u>BEAUFORT</u>	<u>15.86</u>	<u>1456.42</u>
TOTAL	79.21	7273.85

1958 LEVEL II LAND USE AND LAND COVER RAW DATA

Based on an analysis of Figure 24.

SWANSBORO			SALTER PATH		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.00	0.00	11	0.56	51.42
12	0.03	2.75		0.15	13.77
16	0.00	0.00	12	0.03	2.75
17	0.00	0.00		0.04	3.67
31	0.07	6.43	16	0.00	0.00
	0.05	4.59	17	0.00	0.00
	0.20	18.37	31	0.08	7.35
33	0.90	82.65		0.03	2.75
	0.36	33.06	33	2.42	222.23
	0.03	2.75		0.12	11.02
	0.03	2.75		0.65	59.69
	1.46	134.07	43	0.45	41.32
	1.56	143.25		1.10	101.01
43	4.75	436.19		0.17	15.61
	5.73	526.19		2.47	226.82
	7.66	703.42	62	0.29	26.63
62	0.95	87.24	73	0.17	15.61
	0.76	69.79		0.66	60.61
73	2.82	258.96	76	0.20	18.37
<u>76</u>	<u>0.00</u>	<u>0.00</u>		<u>2.52</u>	<u>231.41</u>
TOTAL	27.36	2512.47	TOTAL	12.11	1112.06

1958 LEVEL II LAND USE AND LAND COVER RAW DATA

MANSFIELD			BEAUFORT		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.24	22.04	11	0.07	6.43
12	0.06	5.51		0.66	60.61
	0.03	2.75		0.58	53.26
	0.04	3.67		0.10	9.18
16	0.00	0.00		0.25	22.96
17	0.00	0.00		0.08	7.35
31	0.14	12.86	12	0.37	33.98
	0.05	4.59		0.05	4.59
	0.09	8.26		0.15	13.77
	0.05	4.59		0.49	45.00
33	0.18	16.53	16	0.00	0.00
43	7.65	702.50	17	0.00	0.00
	5.75	528.02	31	0.12	11.02
	4.61	423.34		0.07	6.43
	1.55	142.34		0.11	10.10
62	0.11	10.10		0.79	72.55
	1.44	132.24		0.15	13.77
73	0.06	5.51	33	0.18	16.53
	0.09	8.26		0.03	2.75
	0.04	3.67		0.08	7.35
	0.03	2.75	43	0.31	28.47

TYPE	SQ. IN.	ACRES
76	0.08	7.35
	<u>1.07</u>	<u>98.26</u>
TOTAL	23.36	2145.15

TYPE	SQ. IN.	ACRES
(43)	0.07	6.43
	0.03	2.75
	1.13	103.77
	0.48	44.08
62	0.12	11.02
	0.16	14.69
	0.14	12.86
	0.55	50.51
	1.62	148.76
	0.28	25.71
	0.20	18.37
	0.04	3.67
	1.25	114.79
73	0.06	5.51
	0.05	4.59
	0.14	12.86
	0.44	40.41
	0.07	6.43
	0.37	33.98
	0.12	11.02
	0.18	16.53
	2.55	234.17

TYPE	SQ. IN.	ACRES
76	1.19	109.28
	0.14	12.86
	0.45	41.32
	0.13	11.94
	0.10	9.18
	<u>0.22</u>	<u>20.20</u>
TOTAL	16.92	1553.76

1958 TOTALS

TYPE	SQ. IN.	ACRES
11	2.69	247.02
12	1.29	118.46
16	0.00	0.00
17	0.00	0.00
31	2.00	183.66
33	8.00	734.64
43	43.91	4032.26
62	7.91	726.38
73	7.85	720.87
<u>76</u>	<u>6.10</u>	<u>560.16</u>
TOTAL	79.75	7323.44

TOTALS BY SECTION

SWANSBORO	27.36	2512.47
SALTER PATH	12.11	1112.06
MANSFIELD	23.36	2145.15
<u>BEAUFORT</u>	<u>16.92</u>	<u>1553.76</u>
TOTAL	79.75	7323.44

1964 LEVEL II LAND USE AND LAND COVER RAW DATA

Based on an analysis of Figure 25.

SWANSBORO			SALTER PATH		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.00	0.00	11	1.11	101.93
12	0.05	4.59	12	0.06	5.51
16	0.00	0.00	16	0.00	0.00
17	0.00	0.00	17	0.00	0.00
31	0.39	35.81	31	0.00	0.00
	0.14	12.86	33	0.41	37.65
33	0.80	73.46		0.19	17.45
	0.07	6.43		1.35	123.97
	2.27	208.45		0.19	17.45
	1.15	105.60		0.81	74.38
43	6.07	557.41	43	0.45	41.32
	6.06	556.49		1.11	101.93
	5.95	546.39		0.20	18.37
62	1.00	91.83		1.92	176.31
	0.80	73.46		0.34	31.22
73	1.02	93.67	62	0.30	27.55
	0.29	26.63	73	0.46	42.24
	0.06	5.51		0.70	64.28
	0.10	9.18	76	0.82	75.30

TYPE	SQ. IN.	ACRES
<u>76</u>	<u>0.83</u>	<u>76.22</u>
TOTAL	27.05	2484.00

TYPE	SQ. IN.	ACRES
(76)	0.08	7.35
	<u>2.07</u>	<u>190.09</u>
TOTAL	12.57	1154.30

1964 LEVEL II LAND USE AND LAND COVER RAW DATA

MANSFIELD			BEAUFORT		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.45	41.32	11	0.04	3.67
	0.06	5.51		0.65	59.69
	0.36	33.06		0.90	82.65
12	0.05	4.59		0.04	3.67
	0.05	4.59		0.05	4.59
	0.07	6.43		0.10	9.18
16	0.00	0.00		0.35	32.14
17	0.00	0.00		0.07	6.43
31	0.29	26.63	12	0.40	36.73
	0.03	2.75		0.17	15.61
	0.03	2.75		0.64	58.77
33	0.05	4.59	16	0.12	11.02
43	7.50	688.73		0.10	9.18
	5.74	527.10		0.07	6.43
	2.27	208.45	17	0.00	0.00
	3.02	277.33		0.10	9.18
62	0.08	7.35		0.09	8.26
	1.19	109.28		0.05	4.59
	0.21	19.28		0.65	59.69
73	0.10	9.18	33	0.19	17.45
	0.05	4.59		0.09	8.26

TYPE	SQ. IN.	ACRES
(73)	0.03	2.75
76	1.03	94.58
	<u>0.90</u>	<u>82.65</u>
TOTAL	23.56	2163.51

TYPE	SQ. IN.	ACRES
43	0.25	22.96
	0.52	47.75
	1.13	103.77
62	0.80	73.46
	0.04	3.67
	0.17	15.61
	1.25	114.79
	0.04	3.67
	0.20	18.37
	0.28	25.71
	1.28	117.54
73	0.07	6.43
	0.06	5.51
	0.20	18.37
	3.15	289.26
	0.15	13.77
76	0.09	8.26
	0.34	31.22
	1.19	109.28
	0.18	16.53
	0.06	5.51
	0.06	5.51
	<u>0.41</u>	<u>37.65</u>
TOTAL	16.79	1541.83

1964 TOTALS

TYPE	SQ. IN.	ACRES
11	4.18	383.85
12	1.49	136.83
16	0.29	26.63
17	0.00	0.00
31	1.77	162.54
33	7.75	711.68
43	42.53	3905.53
62	7.64	701.58
73	6.26	574.86
<u>76</u>	<u>8.06</u>	<u>740.15</u>
TOTAL	79.97	7343.65

TOTALS BY SECTION

SWANSBORO	27.05	2484.00
SALTER PATH	12.57	1154.30
MANSFIELD	23.56	2163.51
<u>BEAUFORT</u>	<u>16.79</u>	<u>1541.83</u>
TOTAL	79.97	7343.65

1976 LEVEL II LAND USE AND LAND COVER RAW DATA

Based on an analysis on Figure 26.

SWANSBORO			SALTER PATH		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.79	72.55	11	3.25	298.45
	5.41	496.80		2.10	192.84
12	0.05	4.59		0.25	22.96
	0.88	80.81		0.24	22.04
	0.05	4.59		1.91	175.40
	0.10	9.18		12	0.07
16	0.31	28.47		0.40	36.73
17	0.00	0.00	16	0.11	10.10
31	0.14	12.86		0.20	18.37
33	1.93	177.23	17	0.00	0.00
	0.32	29.39	31	0.00	0.00
	0.14	12.86	33	0.20	18.37
	0.15	13.77		0.12	11.02
	0.20	18.37		0.28	25.71
	0.96	88.16	43	0.20	18.37
43	7.25	665.77		0.75	68.87
	2.97	272.74		0.55	50.51
	0.23	21.12		0.34	31.22
	0.40	36.73	73	0.10	9.18

TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
62	0.97	89.08	(73)	0.15	13.77
	0.72	66.12	<u>76</u>	<u>0.40</u>	<u>36.73</u>
73	0.45	41.32	TOTAL	11.62	1067.06
76	1.05	96.42			
	0.69	63.36			
	<u>0.60</u>	<u>55.10</u>			
TOTAL	26.76	2457.37			

1976 LEVEL II LAND USE AND LAND COVER RAW DATA

MANSFIELD			BEAUFORT		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	6.11	561.08	11	0.50	45.92
	0.30	27.55		0.65	59.69
	1.27	116.62		0.20	18.37
	0.13	11.94		0.14	12.86
	0.10	9.18		0.37	33.98
	0.61	56.02		0.29	26.63
12	0.10	9.18		0.76	69.79
	0.05	4.59		0.45	41.32
	0.08	7.35		0.31	28.47
	0.22	20.20	12	0.16	14.69
	0.09	8.26		0.62	56.93
	0.18	16.53	16	0.55	50.51
16	0.22	20.20		0.52	47.75
17	1.07	98.26		0.91	83.57
31	0.04	3.67		0.37	33.98
	0.03	2.75	31	0.56	51.42
	0.04	3.67	33	0.26	23.88
	0.08	7.35	43	0.30	27.55
33	0.05	4.59		0.11	10.10

TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
43	7.96	730.97	(43)	0.28	25.71
	0.10	9.18		0.25	22.96
	0.55	50.51		0.87	79.89
	0.17	15.61	62	0.75	68.87
	1.53	140.50		0.33	30.30
62	0.03	2.75		0.75	68.87
	1.08	99.18		1.40	128.56
	<u>0.25</u>	<u>22.96</u>		0.05	4.59
TOTAL	22.44	2060.67		0.20	18.37
				0.25	22.96
			73	0.10	9.18
				2.50	229.58
				0.09	8.26
			76	0.30	27.55
				<u>0.26</u>	<u>23.88</u>
			TOTAL	16.41	1506.93

1976 TOTALS

TYPE	SQ. IN.	ACRES
11	26.14	2400.44
12	3.05	280.08
16	3.19	292.94
17	1.07	98.26
31	0.89	81.73
33	3.65	335.18
43	25.77	2366.46
62	6.78	622.61
73	3.39	311.30
<u>76</u>	<u>3.30</u>	<u>303.04</u>
TOTAL	77.23	7092.03

TOTALS BY SECTION

SWANSBORO	26.76	2457.37
SALTER PATH	11.62	1067.06
MANSFIELD	22.44	2060.67
<u>BEAUFORT</u>	<u>16.41</u>	<u>1506.93</u>
TOTAL	77.23	7092.03

1983 LEVEL II LAND USE AND LAND COVER RAW DATA

Based on an analysis of Figure 29.

SWANSBORO			SALTER PATH		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	1.27	116.62	11	3.84	352.63
	1.40	128.56		2.77	254.37
	1.65	151.52		0.36	33.06
	0.11	10.10		0.28	25.71
	6.83	627.20		1.96	179.99
	1.14	104.69	12	0.10	9.18
12	0.73	67.04		0.54	49.59
	0.04	3.67	16	0.13	11.94
	0.84	77.14		0.28	25.71
	0.06	5.51	17	0.00	0.00
16	0.15	13.77	31	0.00	0.00
	0.39	35.81	33	0.23	21.12
17	0.00	0.00		0.10	9.18
31	0.17	15.61		0.35	32.14
33	0.26	23.88	43	0.20	18.37
	0.43	39.49		0.25	22.96
	0.10	9.18		0.64	58.77
	0.19	17.45		0.35	32.14

TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
43	0.96	88.16	62	0.00	0.00
	5.56	510.57	73	0.12	11.02
	0.74	67.95		0.13	11.94
	0.68	62.44	<u>76</u>	<u>0.00</u>	<u>0.00</u>
	0.14	12.86	TOTAL	12.63	1159.81
	0.26	23.88			
62	1.06	97.34			
	0.82	75.30			
73	0.51	46.83			
76	0.97	89.08			
	0.40	36.73			
	<u>0.41</u>	<u>37.65</u>			
TOTAL	28.27	2596.03			

1983 LEVEL II LAND USE AND LAND COVER RAW DATA

MANSFIELD			BEAUFORT		
TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
11	0.08	7.35	11	0.50	45.92
	0.32	29.39		0.46	42.24
	0.05	4.59		0.61	56.02
	6.06	556.49		0.29	26.63
	0.37	33.98		0.35	32.14
	2.46	225.90		0.35	32.14
	0.75	68.87		1.03	94.58
12	0.09	8.26	12	0.45	41.32
	0.03	2.75		0.35	32.14
	0.11	10.10		0.17	15.61
	0.27	24.79	16	0.67	61.53
	0.30	27.55		2.06	189.17
	0.14	12.86		0.41	37.65
	0.20	18.37	17	0.00	0.00
16	0.28	25.71	31	0.60	55.10
17	1.08	99.18	33	0.25	22.96
31	0.03	2.75		0.08	7.35
	0.10	9.18	43	0.31	28.47
33	0.13	11.94		0.11	10.10
	0.19	17.45		0.95	87.24
	0.05	4.59		0.24	22.04

TYPE	SQ. IN.	ACRES	TYPE	SQ. IN.	ACRES
(33)	0.04	3.67	62	0.75	68.87
43	1.75	160.70		0.35	32.14
	5.12	470.17		0.76	69.79
	0.17	15.61		2.09	191.92
	1.60	146.93	73	0.08	7.35
62	1.29	118.46		0.50	45.92
	0.04	3.67		2.12	194.68
73	0.00	0.00	<u>76</u>	<u>0.00</u>	<u>0.00</u>
<u>76</u>	<u>0.46</u>	<u>42.24</u>	TOTAL	16.89	1551.01
TOTAL	23.56	2163.51			

1983 TOTALS

TYPE	SQ. IN.	ACRES
11	36.82	3381.18
12	3.71	340.69
16	3.55	326.00
17	1.08	99.18
31	0.90	82.65
33	2.40	220.39
43	20.03	1839.35
62	7.16	657.50
73	3.46	317.73
<u>76</u>	<u>2.24</u>	<u>205.70</u>
TOTAL	81.35	7470.37

TOTALS BY SECTION

SWANSBORO	28.27	2596.03
SALTER PATH	12.63	1159.81
MANSFIELD	23.56	2163.51
<u>BEAUFORT</u>	<u>16.89</u>	<u>1551.01</u>
TOTAL	81.35	7470.37