

M E M O R A N D U M

TO: David Owens, Director  
Division of Coastal Management

FROM: Lee J. Otte, Ph.D.

DATE: December 3, 1987

RE: OBSERVATIONS ABOUT BUXTON WOODS

A. BACKGROUND ON MY WORK IN BUXTON WOODS

Buxton Woods is a maritime forest located on Hatteras Island, Dare County, North Carolina. The forest is about 45 miles south of Manteo, between the villages of Buxton and Frisco from east to west, and between the Cape Hatteras National Seashore and Pamlico Sound from south to north. The forest includes approximately 3,000 acres of mixed pine and oak forest interspersed with shrub-to marsh-dominated fresh water wetlands. About 920 of these acres are managed by the National Park Service. The remaining 2,000 acres are privately owned. It is estimated that approximately 1,200 individuals own property within the forest.

The 2,000 acres of privately owned land have been nominated as an area of environmental concern (AEC) by the North Carolina Chapter of the Sierra Club. They justify this nomination by stating that the Buxton Woods is a coastal complex natural area. The Handbook for Development in North Carolina's Coastal Area, written by the North Carolina Division of Coastal Management, describes such an area as an ecosystem that supports native plants and animal communities and provides habitats that have remained essentially unchanged by human activity.

The North Carolina Coastal Resources Commission has the task of deciding if this nomination is justified. Part of the process involved in reviewing and considering this nomination is to establish guidelines for the use of such a forest.

In my view, the integrity of Buxton Woods should be preserved by implementing appropriate, effective controls over development within the boundaries of the forest. Various people are concerned with the recent increase in unrestricted clearing, bulldozing, and dredging that has taken place in parts of the forest and especially around its fringe. Some developmental controls should be implemented, by local or state government, to protect the forest from action that may lead to its ultimate destruction. These developmental controls/use standards must be based on facts known about the forest.

I was asked by the Phipps Family, one of the major landowners in Buxton Woods, to serve as their scientific advisor. I have been studying barrier islands and developing an understanding of their complexity for over ten years. I have conducted extensive ecosystem analyses on the Nags Head Woods for the Nature Conservancy for the past five years. I have been in most, if not all, of the other North Carolina maritime forests.

The Phipps Family gave me the task of conducting a comprehensive environmental survey of their property, reporting on the natural features of the tracts that make up the property, and suggesting the uses that could reasonably be made of each tract without significant adverse effects on those natural

features. I was also authorized to release to the State any information about the woods that I gathered while working on my second task, in the hope that this additional knowledge might assist in the AEC nomination process.

The Phipps Family property in the Buxton Woods that I was asked to survey consists of four noncontiguous tracts. Those tracts, listed from east to west, are as follows:

- A 48.88-acre tract extending from the Front or First Sedge on the north to the Cape Hatteras National Seashore on the south
- A 102.20-acre tract extending from the Front or First Sedge on the north to the Jennette Sedge on the south.
- An approximately 100-acre tract extending from the Pamlico Sound on the north to the Jennette Sedge on the south.
- A 176-acre tract extending from the Pamlico Sound on the north to the Water Association well field on the south.

These tracts extend from near the eastern edge of the forest to the western edge of the forest. They also cut across all the major ridges and swales in the forest. In particular, these tracts include a portion of both the Jennette Sedge and the Great Ridge, which are the most significant topographical features in the Buxton Woods. Accordingly, my survey of the Phipps Family properties, consisting of both extensive field work and the study

of aerial photographs permits me to make observations about the environmental setting of the Buxton Woods as a whole.

I submitted a series of statements in July to Mr. Rich Shaw, the AEC Nomination Coordinator for the Division of Coastal Management. Those statements presented my initial reaction to the AEC nomination and my observations concerning the Buxton Woods, based on my early visits to the forest. I am including those statements in this report as attachments A and B. My observations, as presented in those statements, were borne out by the many additional days I and my assistants have spent in the forest.

At this time, I would like to present an additional series of observations, based on my continued work in the forest. My field work was completed yesterday and I will have a final report to submit before the end of the Buxton Woods AEC nomination comment period.

# 1. RIDGES IN THE BUXTON WOODS

The ridge and swale system in the Buxton Woods is complex. The distribution pattern, sizes and shapes of the ridges and swales vary significantly. Most of them, however, are continuous from east to west across the island. Many of the ridges merge toward the east with a corresponding decrease in size and wetness of the intervening swales. Toward the west the ridges become irregular and discontinuous, with significant increase in size and wetness of the swales.

The ridges definitely decrease in height from south to north and from east to west across Hatteras Island. The ridges are commonly referred to as relict beach ridges. Their shape, size, pattern, and grain size distribution, however, suggest they are aeolian dunes that have moved some distance across the island. The shapes of all the dunes indicate that their sand source was to the south and east, except for one dune, the one that runs along the north side of this island. This dune is different in terms of shape and sediment composition. The sand source was probably the Pamlico Sound.

Most of the ridges in the interior of the island are complex dune systems, especially the larger ridges in the southern half of the forest. As one walks from south to north over these dunes it is not uncommon to cross from two to four dune crests, separated by very narrow swales. These intradunal low spots are small and isolated. Some are definitely wetlands, some are marginal as to their classification. The dune crests in the

larger, higher ridge systems are from 15 feet to at least 25 feet above water table. Even the lower dunes to the north and west have isolated areas where water table is between 5 and 10 feet below ground surface.

The Phipps' 48.88-acre tract contains approximately 60% ridge land. An even greater overall percentage of high ground is found east of the 48.88 acre tract. To the west, the 176-acre tract contains less ridge land, about 52%. That tract, in the western portion of the forest, is positioned where the island quickly constricts, losing most of the northern wetlands and leaving mostly the southern, higher ridges.

The 48.88-acre tract contains three major east-to-west oriented ridges separated by similarly oriented swales. The southernmost ridge, the southern limits of which are not on the Phipps property, extends for about 500 feet north of the south property line before the ridge surface drops into the first major swale. This ridge is actually a series of coalescing ridges with small, minor, intervening wet areas. This ridge complex, commonly referred to as the Great Ridge, extends from east to west down the entire length of Buxton Woods and, in a sense, forms the backbone of the forest. It narrows in some places and broadens in others and varies in height from place to place. But, relative to any other land to its north or south, the Great Ridge consistently contains the highest ground. This ridge extends through the southern portion of all the Phipps tracts.

On the Phipps' 48.88-acre tract, this ridge complex consists of three coalescing ridges, each of which is up to 200 feet wide at its point of maximum width. The ridges are highest on their north sides, where they commonly attain heights of 10 to 15 feet above water table. Further to the west, on the Phipps' 102.20-acre tract, this ridge complex contains a number of acres with land 20 to 30 feet above water table. The ridge complex begins to separate as one travels westward, until the intervening small wet areas become continuous wetlands.

The other two ridges on the Phipps' 48.88-acre tract are between 200 and 400 feet wide. Overall they are lower than the southernmost ridge, but they have numerous high spots that are up to ten feet above water table. Their north sides are not as well developed as the highest ground of the southern ridge complex. These ridges also change in character from east to west. On the 176-acre tract about 52% of the land still consists of continuous ridges that contain high ground as much as ten feet above water table. These ridges are confined to the southern half of the property. The north half of the tract contains a series of smaller, less high, east-to-west-oriented, isolated ridges up to 200 feet wide and 1000 feet long that make up about 20% of the total land area on this tract.

If development is to take place in the woods, and if septic tanks are going to be used as the primary sewage disposal method, the high areas on the ridges would be the best building sites. The greater the distance between the septic tank effluent pipes

and water table, the cleaner the effluent when it reaches the underlying aquifer. Most coastal county regulations state that a distance of 2 feet between the effluent pipes and water table is sufficient for filtration. This requirement can be met on the ridges in the Buxton Woods.

## 2. SWALES

Most of the swales are continuous from east to west down the length of the island. Each individual swale varies in width and in degree of wetness, but it is possible to walk them out and see that they are not divided by north to south oriented ridges. Several if not all of the swales interconnect in the western portions of the forest.

It is obvious from both aerial photography and from walking through the swales that they are readily changing. Most of the wetlands that showed up as open water or marsh on aerial photos taken 30-plus years ago are now dominated by shrubs and willow trees. Water levels still appear to reach several feet in depth during the winter months in the swales, but water levels appear to drop more during the growing season than they used to. It is possible that the several manmade ditches that cut through the forest and that cut across the swales are effectively draining the wetlands and helping to dry them to the point that they are beginning to change.

Each of the three major swales on the Phipps' 48.88-acre tract is continuous from east to west and is between 200 and 400 feet wide. The southside of each swale is fairly linear along its contact with the high slip face of the adjacent ridge/dune. The north edge of each swale is more irregular because of its contact with the low-lying portion of the adjacent ridge/dune.

The southernmost swale on the 48.88-acre tract is covered with a dense growth of tall shrubs and vines. Occasional small pockets of marsh vegetation can be found, especially to the west along the length of the swale. The central swale contains an extensive open marsh. A tall, dense, shrubby transition zone separates the marsh from the adjacent upland forest on both sides of the swale. It appears that the shrub zone is expanding and invading the marsh. The northernmost swale also contains a mixture of marsh and shrub vegetation, although the shrub growth is here more abundant and the two zones are not as well defined. They exist as a patchwork of marsh and shrub growth. The major east-to-west-flowing drainage ditch that cuts through Buxton Woods runs down the length of this swale and appears to have a drying effect on this particular wetland.

### 3. MANMADE PONDS

The digging of small manmade ponds in the Buxton Woods is an issue of environmental concern that has surfaced during the AEC nomination process. Most of these ponds are dug for dual purposes. They serve as a local source of sand for the construction industry when they are excavated. Once dug they have been used as a focal point for residential development, with homes positioned to have a view of the water.

Most of the ponds thus far dug are relatively small -- less than an acre in size. They appear to be up to ten feet in depth, with deep water right up to the edge of the pond. Some of the ponds have been dug in wetlands, whereas others are situated on low but dry land adjacent to some of the higher ridges. The ponds are widely scattered around the periphery of the forest, primarily because this is where most development has thus far taken place.

The major argument against the digging of these ponds seems to be that some wetlands are destroyed during their construction. This factor must not be considered without also looking at the new environment being formed after the pond is completed. It must be remembered that the amount of open "deep" fresh water environments in the Buxton Woods have been decreasing for at least the past 40 years. Aerial photographs over this length of time show all major sedges in the forest to be steadily "drying up." The sedges that now support marsh-or-shrub-dominated

vegetation historically contained numerous pools of open water. Several processes may contribute to this environmental change.

- \* Manmade drainage ditches probably help to lower water level in some of the wetlands.
- \* Peat soils have been and are continuing to accumulate in these wetlands. This soil possibly has been prevented from completely filling the swales by being burned occasionally by fires started either from lightning or human activities. Now that fires are controlled in the forest, the peat soils have a chance to fill the wetlands.
- \* It is possible that the wetlands have gone through a long-term natural succession pattern and they are now reaching the point where the open water stage of the pattern is disappearing.

As these natural pools disappear, for whatever reason, the plant and animal life dependent on this environment will also disappear from the island.

If maximum natural diversity in Buxton Woods is to be encouraged and maintained, the same form of open fresh water pools must be created and preserved. If natural and/or human processes are resulting in a decline in the open water environments of Buxton Woods, then, at this point, only human activities are going to preserve this environment.

Small isolated pools, constructed to mimic the natural environment as closely as possible, would help to maintain populations of numerous open water plant and animal species. The best location to dig these ponds is in the wetlands - thereby encouraging a continuous intervening wetland. If these manmade pools are maintained in as natural a state as possible, they

cannot help but improve the overall environmental setting of the forest.

#### 4. THE WATER ASSOCIATION WELL FIELD

The primary source of fresh water on Hatteras Island is the surficial water table aquifer that underlies most of the island. What will happen to the island if potential maximum projected growth does occur? It has been estimated by Ralph Heath that maximum growth, which tends to increase use of the aquifer, would cause some drawdown of the water table. If the resultant cone of depression reaches the Pamlico Sound or the Atlantic Ocean, the influx of saline waters from one or both of these water bodies would poison the aquifer. Even if drawdown is not that significant, some serious environmental changes would occur in the forest. A drawdown of 5 feet would dry up any wetland within the drawdown area. The "uplands" on the ridges would also become drier. When land is cleared in and around Buxton Woods at the present time, minimal wind erosion occurs probably because most of the sand is within the capillary fringe of the water table. The relatively high water content of the intergranular pores within this fringe gives the sediment some cohesiveness. Lower the water table, lower the capillary fringe, dry the surficial sediments, and the potential for increased erosion becomes a real threat.

To stop overuse of the aquifer, development must be controlled and limited. One practical way to prevent significant drawdown of the aquifer is to make sure that as much water as possible that is withdrawn from the aquifer is returned to the aquifer. This means that drainage ditches should not be used,

flat roof drainage should be fed into the ground, that road drainage should be kept to a minimum, and that recreational facilities like swimming pools should be allowed to flow back into the ground. Septic tanks can contribute to the return of withdrawn water, but they should be used only where there is adequate separation from the water table. These forms of water conservation could play a critical role in the potential development of Buxton Woods.

## 5. THE FOREST COVER

The ridges on the Phipps property and elsewhere in the forest are dominated by loblolly pine. The forest is a patchwork of even-age stands of loblolly pine. The older the stand the more laurel oak is mixed in. Most of the ridges have small one land dirt roads running east to west partially down their length. Several dirt roads also run north to south across multiple ridges. Some of these roads are still actively used for vehicular traffic, others can only be negotiated on foot. These are mostly old logging roads. The boundaries between stands of trees are usually perpendicular to these roads. In most cases it appears that a few acres of timber were cut at a time. The most recent extensive cutting took place in the 1950's. although one large tract several tens of acres in size in the center of the forest was cut as recently as the early 1970's. A few isolated pockets of forest containing trees as old as 70-80 years are scattered along the ridges. These older stands, however, are in the minority. The older forest contains a mixed canopy of loblolly pine and laurel oak. The younger forest has a canopy dominated by loblolly pine. A few areas where the young pine has already been removed now have a laurel oak dominated canopy.

The ridge forest has been modified extensively by human activity. It is probable that the forest has historically been a loblolly pine/laurel oak system in its interior, fringed around its exposed edges by live oak, loblolly pine and red cedar. Very few additional species capable of reaching canopy height are

found on the upland terrain. A few small mulberry and persimmon trees were found, but nothing else that would eventually become part of the canopy. If any additional canopy species were at one time present and have since been removed by cutting shrub-and subcanopy-sized, individuals of these species should still be present. They are not, however, suggesting that the forest has the same relative species composition since it was first cut by humans.

Most of the 30+ year old pine forest that now covers most of the ridges is either at or is approaching prime cutting size for pulp wood. Some of the stands contains pines large enough to harvest for sawed lumber. These stands of marketable timber are a potential major economic resource for many landowners in the Buxton Woods.

## 6. INTRODUCTION OF WEEDY SPECIES

The Buxton Woods is a relatively simple ecosystem when it comes to plant species diversity. The marshy fresh water wetlands probably contain a higher species diversity than the dry portions of the forest. The largest concentration of species, however, is found in open manmade clearings. Most of these species are "exotics." They are not found in the natural portions of the forests. They are found only where two specific environmental factors are present: openings in the canopy sufficiently large to allow direct sunlight to reach ground surface for a significant amount of time each day, and ground that has been cleared of its natural leaf-litter cover. Both factors must be present for the exotics to become established. Natural tree-throw clearings in the woods contain predominantly native species because the natural ground cover is still present. Manmade clearings that remain shaded by overhanging trees also still contain predominantly native species.

It is recommended that as little large-scale clearing of the natural leaf litter as possible take place. This type of clearing around a building is necessary for fire prevention, but this is also an area where the occupants can prevent growth of exotic "weedy" species. The area of primary concern is along roadways. When roads are built through the woods, whether paved or not, the shoulder of the road should be kept as narrow and as natural as possible. The roadway system should also be kept as shaded as possible.

Even where areas of concentrated growth of exotic species were found in cleared portions of the forest, these species were not spreading into the remainder of the forest. The shade provided by the predominantly pine canopy and the thick leaf litter hinders any major encroachment. Extensive clearing activities or a major fire that opens the forest and burns off the leaf litter would set the stage for a population explosion of exotic weeds.

## 7. LARGE SCALE DISTURBANCE

It is amazing to note the degree of manmade disturbance as one walks through Buxton Woods. We have thus far not found any stands of trees older than about 80 to 90 years. A few older trees are found on home sites, but none in the forest proper. All through the forest one can find areas ranging from a fraction of an acre to several tens of acres in size where the canopy trees have been cleared by cutting. Cut-tree stumps are very common. These various patches are in all stages of recovery. We have not found any, however, that are not rapidly returning to a natural state--except of course those where not only have trees been cut but the leaf litter (seed beds) has been removed and the dunes bulldozed flat. The forest displays considerable resiliency.

The evidence of cutting that we found in the forest points up an important fact: that the Coastal Area Management Act does not, and therefore any use standards adopted for a Buxton Woods AEC will not, restrict forestry operations. Only the occurrence of events that preclude timber harvesting on specific tracts in Buxton Woods, such as controlled residential development or acquisition by the State, will reduce or eliminate the possibility of that kind of clearing.

I find it hard to imagine, based on what I have seen in Buxton Woods, that a well-planned and well-executed residential development could have a significant adverse effect on the integrity of the forest.

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GEOLOGY DEPARTMENT

(919) 757-6360

July 10, 1987

Mr. Rich Shaw  
AEC Nomination Coordinator  
Division of Coastal Management  
North Carolina Department of Natural Resources  
and Community Development  
P. O. Box 27687  
Raleigh, North Carolina 27611

Dear Mr. Shaw:

The Division of Coastal Management of the North Carolina Department of Natural Resources and Community Development currently is attempting to design a list of developmental restrictions for the Buxton Woods on Hatteras Island. This effort is the result of Buxton Woods being nominated as a Coastal Complex Natural Area of Environmental Concern. Part of the process in approving this nomination is to establish guidelines for the use of such an area.

I am very much in favor of preserving the integrity of Buxton Woods by implementing the proper controls over development within the boundaries of the forest. I must question, however, the correctness in designating this forest as a Coastal Complex Natural Area (CCNA). The Handbook for Development in North Carolina's Coastal Area, written by the Division of Coastal Management, describes a CCNA as a system that supports native plant and animal communities and provides habitats which have remained essentially unchanged by human activity. The Area of Environmental Concern (AEC) nomination papers, submitted by the Sierra Club, uses the following terms to describe the Buxton Woods:

- the largest surviving stand of maritime forest in North Carolina,
- has plant and animal communities not found elsewhere,
- unusual biotic diversity,

In addition, the AEC detailed review, written by the staff of the Division of Coastal Management states the following about Buxton Woods:

- recognized as one of the most ecologically valuable habitats in the state,
- the Fish and Wildlife Service classifies the habitats in Buxton Woods as unique and irreplaceable on a national basis or within the ecoregion setting,
- a unique island habitat containing unusual biotic diversity.

I will admit that the Buxton Woods is of some significance, but I must disagree with such superlative descriptions of this forest. I have conducted extensive research projects dealing with maritime forests on the North Carolina Outer Banks, including some work in Buxton Woods. I would like to make a few comments concerning the above descriptions of Buxton Woods, based on my knowledge of these systems.

- I agree that the Buxton Woods is the largest surviving stand of maritime forest in North Carolina - but - biggest does not mean best. There is no comparison between the quality of the Nags Head Woods and the Buxton Woods. The Nags Head Woods is probably the best, large preserved tract of maritime forest in North Carolina, not Buxton Woods.

- I disagree about the unusual biotic diversity in Buxton Woods. If unusual diversity means high diversity, than this statement is wrong. The plant species diversity in this forest is low, relative to the other North Carolina maritime forests, probably because of its isolated nature.

- I agree that the forest has plant and animal communities not found elsewhere, but then that statement could apply to every community in existence. All biotic communities, in a sense, are unique. It would be rare to find exact duplications of species diversity and abundance. Except for the wetland community in Jennette Sedge (most of which is already protected), the Buxton Woods is a very simple forest system, currently dominated by loblolly pine, one of the commonest trees on the North Carolina coastal plain.

- The forest has been manipulated extensively by human activity. Major portions of the forest have been cut during the past 85 years. Most of the forest was cut around the turn of this century. A second major cutting occurred in the early 1950s. Additional cutting has taken place in the 1960s and 1970s. The forest is now primarily a young loblolly pine and loblolly oak forest.

- The fringe of the forest has been lost to development. In addition, roads, homes, ponds, sand pits, garbage dumps, and powerlines can be found scattered throughout the forest.

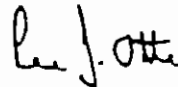
I do not understand how such a manipulated system can be called unique, the best, irreplaceable on a national level, or one of the most ecologically valuable habitats in the state.

I agree that the forest is a major stabilizing force for Hatteras Island. The forest is also probably the major recharge area for the island's shallow aquifer. The preservation of Buxton Woods, as a forest system, is critical for the island's long term existence, but, please do not call it something it is not.

The guidelines for nominating an area as a Coastal Complex Natural Area of Environmental Concern contains a "catch-all" statement that would allow the Buxton Woods to be included in this category. This statement would allow the inclusion of "areas that may have been altered in the past and/or be subject to limited future modification if the modification benefits the habitat present or enhances the area's biological, scientific, or educational values." The Buxton Woods could fit this description if future development were limited, however, an abandoned corn field or a forest that had just been clearcut would also fit this description.

I do not believe this AEC nomination is justifiable, based on the ecological/environmental qualities of Buxton Woods. I do believe, however, that the people of Hatteras Island and/or Dare County need to sit down and decide on a set of guidelines for future development. This should be done not just for Buxton Woods, but for the entire island system.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "Lee J. Otte". The signature is fluid and cursive, with the first name "Lee" and last name "Otte" clearly distinguishable.

Lee J. Otte, Ph.D.

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Dear Mr. Shaw:

The nomination of Buxton Woods, on Hatteras Island, Dare County, North Carolina, as an Area of Environmental Concern (AEC) and the consequences of this nomination, are of interest to many people. Environmentalists, myself included, are concerned with the recent increase in unrestricted clearing, bulldozing, and dredging that is taking place throughout the forest. Some developmental controls should be implemented, whether by state or local government, to protect the forest from action that may lead to its ultimate destruction. Landowners in the forest, however, must have some voice in deciding what they can do with their property. A common ground could be found that will guarantee the overall preservation of the forest, while allowing some development to take place.

I am writing this letter primarily to discuss the proposed developmental restrictions that were presented by your office to the Coastal Resources Commission. I hope everyone viewed these restrictions as a first step in a long, drawout process, during which modifications are made as new information is gathered concerning the environmental setting of Buxton Woods.

I see two major problems regarding these proposed restrictions. First, the restrictions were designed to apply uniformly not only for the entire Buxton Woods but also for all maritime forests. I recognized no effort, however, to determine the degree of homogeneity of these forests. Are these forests the same throughout, in regards to topography, wetland types,

soil types, vegetational systems, water chemistry, etc.? If homogeneous, fine; blanket restrictions would work. If not homogeneous, however, problems may arise when permissible development begins to cause environmental damage. This concern leads to what I consider the second major problem. An attempt should be made to understand the environmental setting of the forest before the proposed restrictions or a revision of these restrictions are submitted to the Coastal Resources Commission.

I have conducted extensive research on the Nags Head Woods. This ecosystem is probably the best preserved large tract of maritime forest remaining on the North Carolina barrier islands. During the years in which I have worked in this area, I have developed an understanding of these forest systems. I have taken a close look at Buxton Woods over the past several months. Rather than just walking and looking, I have conducted several small-scale research projects, sufficient to allow me to present a brief description of the Buxton Woods. You will find attached to this letter a series of brief discussions outlining the environmental setting of the Buxton Woods.

You will note, as you read through these discussions, that the Buxton Woods is relatively diverse at many levels, yet simple at other levels. The complexity of this ecosystem necessitates a very clear understanding of the forest before any developmental restrictions are established.

Sincerely yours,

*Lee J. Otte*

Lee J. Otte, Ph.D.

## TOPOGRAPHY OF THE BUXTON WOODS

The Buxton Woods is a relatively simple geomorphic system. The local landscape consists primarily of a series of east- to west-oriented aeolian sand ridges, separated by low-lying swales. It is thought that this system has only been in existence since the 17th century. The dunes consist primarily of fine- and medium-sized sand. This dune field sits on top of a sequence of coarser sands that contains a large quantity of shell debris.

Elevations change from ridge to ridge and along the length of each ridge within the dunefield. The southernmost ridge in the privately owned portion of the forest has the highest average elevation and the highest maximum elevation of all the ridges in this section. Elevations on this ridge appear to range up to 40 or more feet above the adjacent interdune lows. Average ridge height and maximum ridge height decreases from south to north as one moves from one ridge to another. Height on any single ridge varies along the length of the ridge. In some areas the ridges are sufficiently low that the ridge is difficult to distinguish from the adjacent low-lying swales.

The low-lying swales between the ridges can be divided into two basic landforms: the "sedges" and the flats. The primary difference between the two is a change in elevation. The swale, or a portion of a swale, is considered a "sedge" (local term for a graminoid-dominated, freshwater wetland = marsh) if ground surface is sufficiently low to support year-round standing water. Some of these sedges still are dominated by marsh vegetation. A significant portion of these wetlands, however, are overgrown with a mixture of small willow trees, tall shrubs, and a dense tangle of vines, with little or no grass cover. Aerial photographs taken in the 1940s of Jennette Sedge (the largest wetland on the island) show the wetland to be mostly open water and marsh vegetation. Aerial photographs taken in the 1980s show a significant portion of this wetland now covered with shrubs and small trees. Something is happening to these wetlands. It is important to determine if this change is part of the natural succession pattern or if it is being caused by human activity.

The majority of the acreage within the swales is flat, but sufficiently high that water table remains from one to three feet below ground surface. Flooding should occur on these flats only after major storms. The flats in Buxton Woods and in the Nags Head Woods are sufficiently dry to support a loblolly pine-dominated forest, rather than wetland vegetation.

A major inaccuracy concerning the topography of Buxton Woods must be corrected before developmental restrictions are finalized. The topographic maps of Buxton Woods are not correctly drawn. The general positions of the dune ridges within the forest are accurate, but their sizes, shapes, and elevations are not. We found many dunes in Buxton Woods that are at least 20 feet higher than the adjacent swales, but are not recorded on the topographic maps. In addition, the wetlands that are illustrated on the maps are not accurately located. The accurate location, distribution, size, shape, and quality of these features are important to know when trying to evaluate potential developmental restrictions.

## THE QUALITY OF THE FOREST VEGETATION

The majority of Buxton Woods has been severely altered during the past century. Aerial photographs dating back to the 1940s and tree cores recently taken from throughout the forest indicate at least three major episodes of cutting within Buxton Woods. The majority of the trees in the forest were cut during the early 1900s. Most of the largest trees now found in the forest are less than 80 years old. A significant portion of the forest was again cut in the early 1950s. Most of the forest now consists of isolated, 70 - 80 year old trees mixed in with a relatively dense growth of younger trees, most of which are about 30 years old. Only isolated "pure" stands of the older trees remain, scattered throughout the forest. The third episode of cutting took place in the center of the forest in the late 1960s - early 1970s. A dense growth of very young trees now dominates this area.

The plant species diversity in Buxton Woods is low, relative to the other maritime forests on the North Carolina Outer Banks. This paucity of species possibly is due to the isolated nature of Hatteras Island. Nags Head Woods, just 50 miles north of Buxton Woods, but immediately adjacent to the mainland, supports more species and contains a much higher number of well-developed plant communities. It could be argued that the relatively frequent episodes of cutting have eliminated many of the forest species from the Buxton Woods, leaving only the species typically present in the early successional stages of forest development, and that the other species will return as the forest approaches maturity. The Nags Head Woods also has undergone repeated cutting over the past 100 years, yet this forest system contains at least 12 major tree species, compared to the two that dominate Buxton Woods. These 12 species are present not only in the canopy, but also in the subcanopy and the shrub layers as transgressives and are very abundant as seedlings scattered throughout the forest. A similar low diversity exists for the subcanopy, shrub, and herb species in the Buxton Woods.

The Buxton Woods is now essentially a loblolly pine forest that is in various stages of recovery from cutting. Very little to none of the forest can be considered mature and undisturbed. The various stages of forest development would probably respond differently to development.

## WATER - SOILS - SEDIMENTS

The number one environmental concern on Hatteras Island appears to be the protection of the island's shallow aquifer, from which the residents draw their drinking water. Two features of this water must be maintained in order to guarantee its availability: quantity and quality.

Quantity refers to the amount of water available to recharge the aquifer. Maximum potential recharge is ultimately controlled by the amount of precipitation that falls on the island. How much of this water actually makes it into the subsurface to become part of the aquifer is controlled by features found on and/or in the ground. Precipitation that reaches ground surface can be either quickly lost back to the atmosphere by evapotranspiration, can be lost to surface runoff, or can infiltrate into the subsurface. The sandy soils/sediments on Hatteras Island are probably very conducive to infiltration. The vegetation on the island will pump some amount of water back into the atmosphere. Surface runoff is probably only significant after major storms, when the subsurface literally becomes saturated and can hold no more water. Many factors play some role in determining how much water will move along each of the above mentioned pathways. Before deciding how much and what type of development will be allowed on Hatteras Island, especially when this development is thought to affect the flow of water into the island's aquifer, the potential effects should be examined. It is entirely possible that some development may favor infiltration, whereas other types of development may hinder infiltration.

The quality of the aquifer will be determined by what nature and by what humans put in the water. The natural background water chemistry of the Hatteras Island aquifer appears to be adequate for human use. Human activity, however, will prove to be the ultimate controlling factor relative to long term water quality. The current, major water quality problem on Hatteras Island is septic tank discharge. Regulations require all septic tanks to be at least 50 feet away from an open water wetland. Assuming that water from the wetland becomes part of the subsurface ground water system as it soaks into the ground, 50 feet is considered an adequate distance for septic tank discharge to "clean itself" as it filters through the soil/sediment and moves toward the nearby wetland. One must remember, however, that the septic tank discharge pipes need only be one foot above water table. The net direction of movement of any water flowing through unsaturated, unconsolidated sandy soils is downward, not sideways. Water discharged from the septic tanks, therefore, need only move one foot before reaching the aquifer, not 50 feet to get to the local wetland and then into the aquifer. It is theoretically possible, but not probable, that a one foot distance is sufficient to filter out all contaminants.

The most important thing to, do in light of this little fact, is to locate the areas that can best handle septic tank discharge. These areas should have one or both of the following qualifications: sufficient elevation above the water table to give maximum downward filtering distance and/or the soils/sediments that can best act as a filter.

The available topographic map does not show many high spots in the Buxton Woods. We have found many additional sites that are 10 to 20 feet or more above the adjacent wetlands in Buxton Woods. These high spots would be ideal locations for development, based on filtering distance for septic tank discharge.

I examined the soils/sediments in Buxton Woods, primarily observing differences in dominant grain sizes (based on laboratory analyses). The sands that underlie the ridges are significantly finer grained than the sands that underlie the adjacent swales. The finer-grained sands serve best as water filters. Based on grain size differences, the ridges again appear best for development.

These observations should be taken into consideration when determining developmental restrictions. A relatively simple test could be designed to verify the accuracy of these observations. Ground water quality adjacent to septic tanks already set in swales vs. septic tanks already set in the ridges could be examined. If one is found to be a better filtering system than the other, this may be the primary controlling factor over development.