

FORA MRC

CAHA 325 - Natural Resource Mgmt

SURVEY FOR SPECIAL STATUS BIRDS
WITHIN FORT RALEIGH NATIONAL HISTORIC SITE

Final Report

15 October 1997

Conducted by John Fussell, Contract Biologist
for the U.S Park Service
(per Order #1443PX519096121, Item 01)

SUMMARY

From autumn 1996 into early autumn 1997, I surveyed for rare bird species within Fort Raleigh National Historic Site. The only rare bird species observed during the surveys was the peregrine falcon. Individuals were seen flying over Fort Raleigh on one date in autumn 1996 and on two dates in autumn 1997, obviously in migratory flight. Other rare species not observed may sometimes occur at Fort Raleigh. In this report, surveys for rare species initially considered as possibly occurring within the Fort Raleigh boundary are described, as well as my current evaluation of the possibility of each species occurring here. Also included is a table listing all Neotropical migrant species observed during autumn 1996.

INTRODUCTION

In July 1996, I was contracted by the U.S. Park Service to survey Fort Raleigh National Historic Site (hereafter NHS) for special status bird species, for a period of one year, beginning 27 July 1996. "Special status bird species" here refers to bird species that are Federally listed, including Federal Species of Concern, and species that are State listed as Endangered, Threatened, or of Special Concern. (All Federally listed species are also State listed; in this report, for convenience, the term "State listed species" refers to species that are State listed but are not Federally listed.)

Fort Raleigh NHS consists of 355 acres, and lies at the north end of Roanoke Island, in Dare County (see Figures 1 & 2). Most of the tract lies north of US 64/264 but also includes some land south of this highway, in the vicinity of Alder Branch and westward to Croatan Sound. The main purpose of the Historic Site is to preserve the location of the first attempted English settlement in the New World.

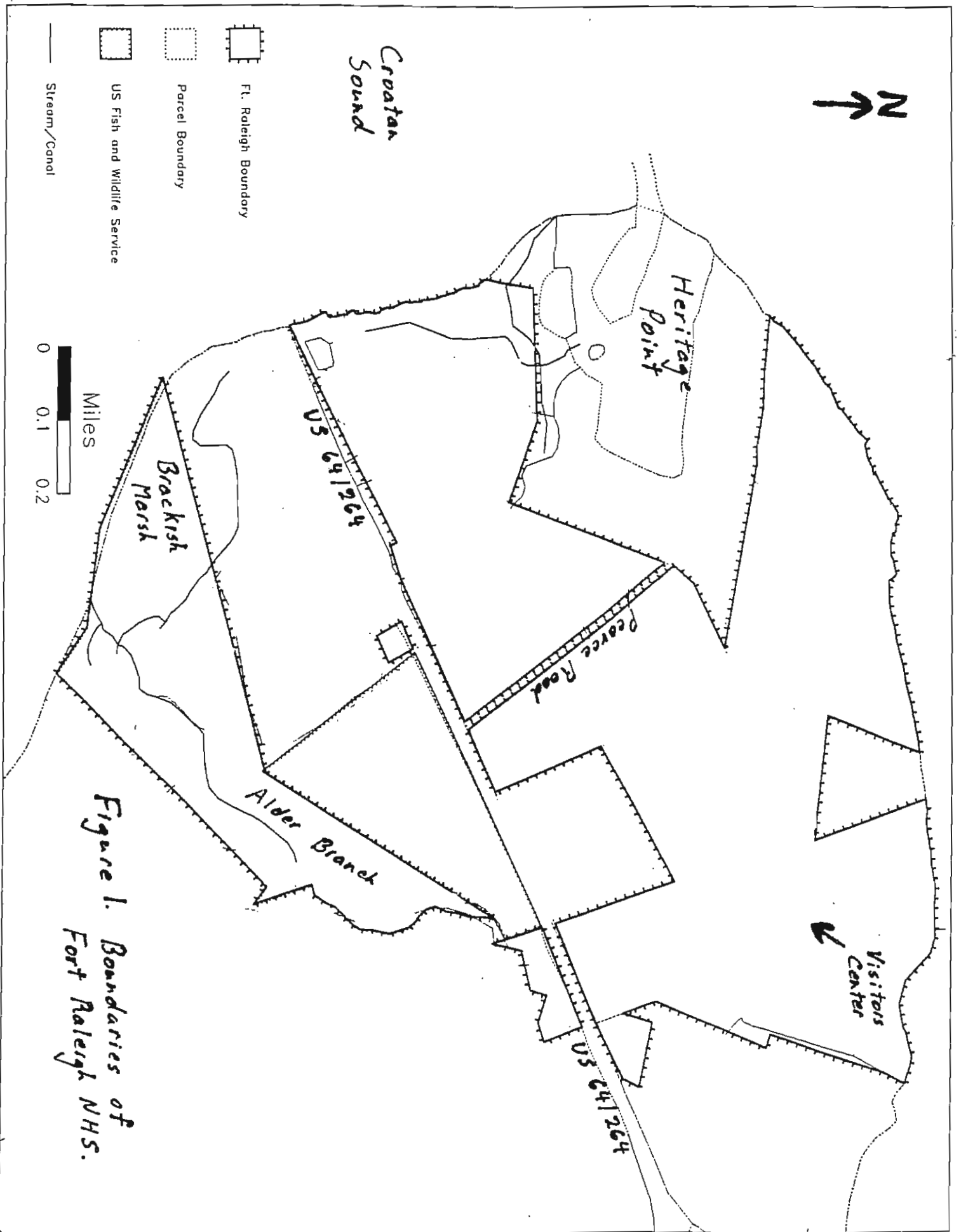
A portion of the NHS lying north of US 64/264 has been developed for administrative/interpretive purposes. Here there are various buildings, including an interpretive center and The Lost Colony Theatre, as well as maintained lawns, hiking trails, parking lots, etc. However, the majority of the property is undeveloped. Habitats include upland forests dominated by pines or a mixture of pines and hardwoods, brackish marsh, and swamp forests dominated by hardwoods. (Plant taxonomy within this report follows Radford et al 1968.; common names are based primarily on Schafale and Weakley 1990).

Description of Habitats (excludes developed portions of NHS)

Below are descriptions of the habitats of Fort Raleigh, excluding developed areas. Given first are major upland habitats, followed by major wetland habitats, and then brief descriptions of four minor habitats.

Majority of Upland Forest within Fort Raleigh

Most of the NHS lies on upland soils that vary from well drained to excessively well drained, i.e. Baymeade and Fripp sands. Excluding the developed areas, these upland habitats are, for the most part, forested. In most of this forested area, the canopy is closed or nearly closed, and is almost exclusively loblolly pine (*Pinus taeda*). A very few longleaf pines (*Pinus palustris*) occur within the area, at least along US 64/264. (Adjacent to Roanoke Sound most sites have mixed canopies or are hardwood dominated as discussed later. In general, areas mapped as having Baymeade sand are dominated by loblolly pine.) Most of the canopy pines appear to be of roughly the same age; they



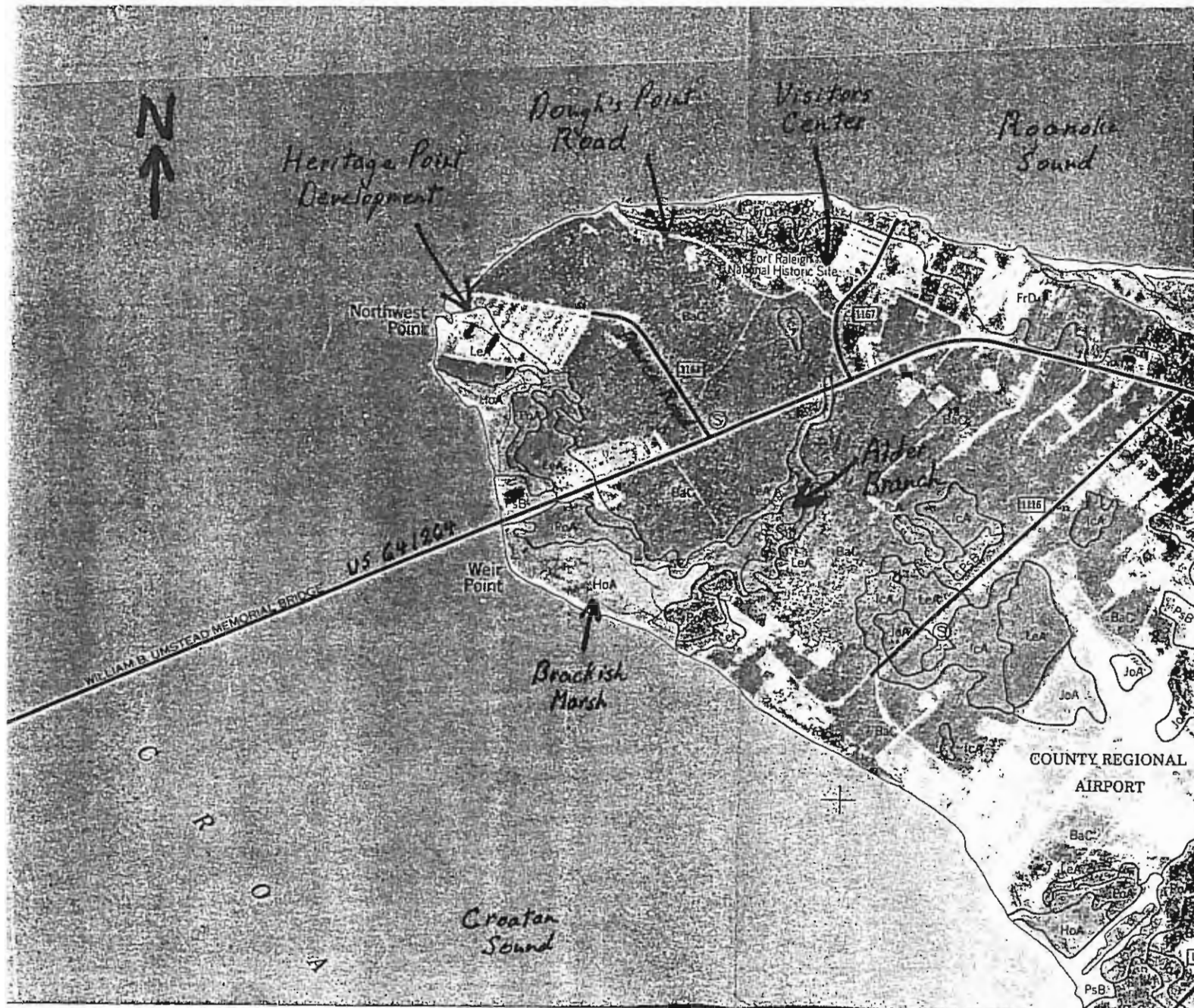


Figure 2. Location map and soils map of Fort Raleigh NHS
 (see Figure 1 for Fort Raleigh boundaries)
 (from County Soils Survey, based on Manteo
 7 1/2' quad sheet, 1"=2000').

soils cited in text: BaC = Baymeade sand
 FrD = Fripp sand
 HoA = Hobonny muck
 LeA = Leon sand
 PoA = Ponzer muck

undoubtedly came in as agricultural lands were abandoned. In 1997, at a site where pines were cut down for pine beetle control in 1995, I counted the rings of 10 pine stumps. The trees ranged in age from 43 to 65 years, with an average of 53 years. These figures are probably representative of most pines within the NHS.

Over most of the area, the average canopy height is about 60'. Hardwoods that occasionally intrude into the canopy are laurel oak (*Quercus laurifolia*), live oak (*Quercus virginiana*), and southern red oak (*Quercus falcata*). In a few limited areas, laurel oak is codominant with loblolly pine. (Note: it is recognized that many authorities consider the "laurel oaks" of maritime forests and other coastal forests to actually be hybrids of various oak species; whatever they should technically be considered they are a major component of many coastal forests and are obviously different from the live oak.)

Within most of the upland forest, the subcanopy is poorly developed or absent. Overall, the most frequently observed species within this stratum are laurel oak, red bay (*Persea borbonia*), flowering dogwood (*Cornus florida*), and American holly (*Ilex opaca*). Southward, southern red oak is relatively frequent.

Over much of the area, there is a dense growth of shrubs and young trees, up to about 20' in height. Dominance varies from site to site, but the most typical species overall are laurel oak, flowering dogwood, American holly, red bay, and wild olive (*Osmanthus americana*). The southern magnolia (*Magnolia grandiflora*), which is not native to the area, is prominent in a few areas. In spots, these shrubs and young trees have a dense cover of woody vines; common are wild muscadine (*Vitis rotundifolia*), saw greenbrier (*Smilax bona-nox*), glaucous greenbrier (*Smilax glauca*), and Carolina jessamine (*Gelsemium sempervirens*).

Most areas also have a distinct stratum of low growing shrubs, young trees, and vines that is about one-two feet high. This may be dense or open. Again, dominance varies from site to site, but the most common species overall are young laurel oak, red bay, wild olive, American holly, wax-myrtle (*Myrica cerifera*), blue huckleberry (*Gaylussacia frondosa*), and the vines wild muscadine, Carolina jessamine, and poison ivy (*Rhus radicans*).

Herbaceous cover varies from open to moderately dense. The dominant species by far is partridgeberry (*Mitchella repens*). Also common is bracken (*Pteridium aquilinum*). A very distinctive species that is common in spots is pink ladyslipper (*Cypripedium acaule*). Also frequent is pipsissewa (*Chimaphila maculata*).

About 1995, there were several die-offs of pine trees, typically less than an acre or two, because of pine beetle activity. (At a few of these sites, the pines were cut in an attempt to suppress beetle activity.) At these die-off sites, because of canopy absence (whether logging occurred or not), understory vegetation has become quite dense. Species that appear to have responded especially favorably to the increased sunlight are laurel oak, wild olive, red bay, and wax-myrtle.

Upland Forest along North Shore of Fort Raleigh

Along a portion of the north shore of Fort Raleigh, the forest is somewhat more maritime in aspect, in that the semievergreen laurel oak (sometimes in combination with the evergreen live oak) makes up a dominant or codominant portion of the canopy. Also, broadleaf evergreen vegetation makes up a larger component of the lower vegetational strata than is the case in the more inland portions of the forest. This type forest occurs north of the developed portion of Fort Raleigh (i.e. administrative offices, visitors center, and associated parking areas) and north of Dough's Point Road). It is roughly correlated with the area mapped as Fripp sand in the County Soil Survey, but extends into adjacent portions of the area mapped as Baymeade sand.

Within most of this forest type, the canopy is closed to somewhat open, with the more open examples typically being closest to the sound shoreline. The canopy height averages about 50-60', but is lower near the sound. At most sites, laurel oak dominates the canopy. However, live oak dominates some sites immediately next to the sound, and farther inland, the canopy at most sites is dominated by a mixture of laurel oak and loblolly pine.

Subcanopy vegetation varies from sparse to moderately well developed. The dominant species in this stratum is laurel oak. Also frequent are American holly, flowering dogwood, and red bay.

At most sites, there is a dense understory, up to about 15' high, of young trees, shrubs, and vines. In general, this stratum has no clear dominants, but consists of a mixture. Common are laurel oak, American holly, yaupon (*Ilex vomitoria*), wild olive, red bay--note that these are all evergreen or semievergreen, and wild muscadine. However, at some sites adjacent to the sound, laurel oak is clearly dominant. Also quite prominent is the exotic southern magnolia. It will be interesting to see if this species, which seems well suited to this environment, becomes increasingly prominent in future years.

A low shrub stratum is most prominent where higher shrubs are most sparse. Common in this low stratum are yaupons, red bays, seedling laurel oaks, and vines, primarily wild muscadine

and Carolina jessamine. Blue huckleberry is common at some sites, especially more inland.

Herb vegetation varies from medium to dense. Partridgeberry is by far the dominant species. In spots near the sound, where canopy vegetation has been thinned by salt spray and/or wind damage, the ground is almost covered by partridgeberries. Also common is bracken.

Woody vines are prominent, especially where the canopy is somewhat open. The most common species is wild muscadine. Also common are glaucous greenbrier and Carolina jessamine. At a few sites, trees and shrubs are almost blanketed by the epiphyte Spanish-moss (*Tillandsia usneoides*).

It is difficult to say with certainty what the "original" or "natural" composition of the upland forest would have been. Indeed, even if man were not present today, the natural factors acting on this area would be rather different now from those operant at the time of the first English settlement in the area, when Roanoke Island was almost connected to the mainland by marsh vegetation, and natural fires may have been of somewhat regular occurrence (see Frost, in prep.). At that time, much of what is now Fort Raleigh NHS might have been open canopied longleaf pine, maintained by occasional fire.

At present, if human interference were removed, the composition of most or all of the upland forest would presumably be similar to that described for the Coastal Fringe Evergreen Forest community type (see Schafale and Weakley 1990). Dominant species of this community type are laurel oak, live oak, and loblolly pine. This is considered one of the most endangered community types in the state (see Schafale and Weakley 1990). The forest along the north shore of Fort Raleigh is currently a good example of Coastal Fringe Evergreen Forest. The rest of the upland forest within Fort Raleigh appears to be succeeding toward typical Coastal Fringe Evergreen Forest. It is definitely the case that pine dominance is declining, and based on dominance within the lower vegetational strata, it appears that, barring human interference, laurel oak will become the dominant canopy species within all or most of the upland forest within a few decades. However, it is likely that much of the forest will have a higher percentage of "inland elements", for instance, southern red oak, than the typical Coastal Fringe Evergreen Forest.

Moist/Wet Pine Forest

Within the NHS boundary, there are two areas that are wet to moist and are dominated by loblolly pine. One of these areas is in the western portion of the property, north of US 64/264; the other lies along the border of Alder Branch. The distribution of

these areas corresponds closely with the areas mapped as having Leon sand in the County Soil Survey. The two areas are notably different and are discussed separately here.

In the area north of US 64/264, dominance varies somewhat according to degree of wetness, but can generally be described as follows. The canopy is closed to almost closed, about 60' high, and is strongly dominated by loblolly pine at most sites, intermixed with a few red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), and swamp tupelo (*Nyssa sylvatica*). At some sites, especially wetter ones, there have been die-offs of pines. Subcanopy vegetation is of medium density, on average. Common are sweet gum, swamp tupelo, sweetbay, and red bay. Shrub vegetation, often overgrown with woody vines, is generally dense, and about five feet high. The dominant species is fetterbush (*Lyonia lucida*). Other common shrubs are inkberry (*Ilex glabra*), red bay, and wax-myrtle; wax-myrtle is most common in the wetter sites. The most common vines are laurel-leaved greenbrier (*Smilax laurifolia*) and glaucous greenbrier. Herbaceous vegetation is patchy. Virginia chainfern (*Woodwardia virginica*) is overall the dominant species; royal fern (*Osmunda regalis*) generally dominates the wetter sites.

In the area that borders Alder Branch, loblolly pine is also dominant, but there are a few pond pines (*Pinus serotina*). The canopy is somewhat open, and about 75' high. Subcanopy vegetation is of medium density; the major species are red maple, red bay, swamp tupelo, and sweetbay. Shrub vegetation is very dense and up to seven feet high. The dominant species is fetterbush; also common is red bay. The shrubs are overgrown with numerous laurel-leaved greenbrier vines. Herbaceous vegetation is patchy; Virginia chainfern is the major species.

Along at least 150 yards of this area, the pines are notably mature. A couple had DBH's of 24". These mature pines lie next to a strip of mature baldcypresses (*Taxodium distichum*) and swamp tupelos (see below under "Swamp Forest"), making this one of the more noteworthy sites within Fort Raleigh NHS.

Beach Strand

There are distinctive although narrow beach strands along two sections of Fort Raleigh shoreline: along the north shore of the NHS, from the east boundary westward a little past the Elizabethan Gardens (excluding The Lost Colony Theatre area); and along the Croatan Sound shoreline south of US 64/264. These are rather different from each other and are discussed separately below. In the County Soil Survey, these areas are not mapped as being distinct from adjacent areas. Presumably, this is because they are so narrow. It should be stressed that these shorelines are constantly changing; the following descriptions may not be applicable in the future, perhaps maybe not even next year.

The beach strand along the north shore of Fort Raleigh is narrow, typically less than 60' in width, with almost no dune development. The strand is only one-two feet higher than the adjacent sound.

At the times of my surveys, no vascular plants were seen within about 20' of the water. Typically, the middle 20' or so of the strand has a medium dense growth of herbaceous vegetation. Dominant species within this zone are saltmeadow cordgrass (*Spartina patens*) and bitter panic grass (*Panicum amarum*). Also common are rough buttonweed (*Diodia teres*), cocklebur (*Xanthium strumarium*), and trailing wild bean (*Strophostyles helvola*). Also frequent are sea rocket (*Cakile edentula*), seabeach sandmat (*Euphorbia polygonifolia*), and American beachgrass (*Ammophila breviligulata*). Just inland is another distinctive strip, in that the herbaceous ground cover is a bit sparser, and there are no clear dominants in this zone. Common species within this strip are rough buttonweed, trailing wild bean, saw greenbrier, trumpetvine (*Campsis radicans*), saltmeadow cordgrass, and bitter panic grass. Also frequent is bear-grass (*Yucca filamentosa*). Notably this strand is vegetated by species that are not only typical coastal dune plants, such as the bitter panic grass, saltmeadow cordgrass, trailing wild bean, sea rocket, seabeach sandmat, and American beachgrass, but also by more ubiquitous species, such as rough buttonweed, cocklebur, trumpetvine, etc.

The transition from beach strand to forest may be quite abrupt, but typically there is a zone of 50' or so where vegetation consists primarily of thick young trees, shrubs, and vines, like live oak, sassafras (*Sassafras albidum*), yaupon, wild muscadine, trumpetvine, saw greenbrier, and glaucous greenbrier. Within this shrub zone are frequent small sandy openings that support a variety of herbaceous species. Especially common are rough buttonweed and the composites *Solidago arguta*, *Heterotheca nervosa*, *Heterotheca gossypina*, *Hypochoeris radicata*, and rough buttonweed. Prickly-pears (*Opuntia* sp?) are frequent in these areas. These cacti appear to be intermediate between *Opuntia drummondii* and *Opuntia compressa* (such intermediates are mentioned under the account of *Opuntia drummondii* in Radford et al 1968).

(Westward of this beach strand, to the Fort Raleigh-Heritage Point development boundary, the shore consists of eroding bluffs, up to 15-20' high, with slopes of up to 60°. On the lowest portion of the least steep slopes, there are often numerous young trees, shrubs, and herbaceous vegetation, with a species composition similar to that described in the preceding paragraph).

The beach strand south of US 64/264 tends to be even more narrow, only about 30' wide. It is one-two feet higher than the adjacent sound along most of its length, but near the southern property line is so low that it is frequently overwashed by

slightly higher than average water levels. The soundside half of the strand cross-section is barren; the inland half typically has a dense cover of herbaceous vegetation. Dominant along most of the strand is saltmeadow cordgrass; common reed (*Phragmites communis*) is dominant where the strand is lowest, near the south property line. Common along most of the strand are bitter panic grass, seaside goldenrod (*Solidago sempervirens*), saw greenbrier, and American beachgrass.

Along the inland margin of this barrier strand, lying between it and the adjacent brackish marsh, are intermittent narrow strips, about 5-15' wide, with a sparse growth of mostly dead/dying stunted trees and shrubs over a dense ground cover of herbaceous vegetation. The most common trees/shrubs are loblolly pine and wax-myrtle; also common are red maple, red bay, and live oak. The major herbaceous species are saltmeadow cordgrass, poison ivy, saw greenbrier, rattan vine (*Berchemia scandens*), and peppervine (*Ampelopsis arborea*).

(The section of shoreline lying just north of US 64/264 does not have a distinctive beach strand. For the most part, the shore consists of stumps and eroding peat. Along a section of this shoreline, where this retreating shoreline borders shrub swamp (see below), there is a very narrow strip, a few feet in width, where the dominant vegetation is somewhat different from that of the shrub swamp as a whole. Frequent in this strip are seaside oxeye (*Borrichia frutescens*), marsh elder (*Iva frutescens*), and groundsel-tree (*Baccharis halimifolia*). Along the rest of the shoreline, there is a narrow (about 50' at the widest) tree covered ridge lying between the shore and the shrub swamp. This ridge has an open growth of small trees and shrubs--loblolly pine, live oak, yaupon, southern red cedar (*Juniperus silicicola*), red bay, serviceberry (*Amelanchier canadensis*), and wax-myrtle--over a medium dense herbaceous growth--mostly saltmeadow cordgrass, American beachgrass, and bitter panic grass.

Swamp Forest

Swamp forests are found in two areas of the NHS--in the western section--north of US 64/264, and within the Alder Branch floodplain south of US 64/264. These swamp forests lie within the areas mapped as having Ponzer muck in the County Soil Survey. However, the northern area appears to lie only within the southern and eastern portions of the Ponzer map unit. The two areas are different from each other and are discussed separately below.

The swamp forest lying north of US 64/264 reaches its best development in a relatively small area, only about two acres or so, indicated by the easternmost tip of the area mapped as Ponzer muck. It is assumed that this area has been least affected by

occasional flooding from the sound. In this area, the closed canopy is about 70' high. Dominant are swamp tupelo and ash (*Fraxinus* sp). There are a few sweet gums, and at least one baldcypress. The subcanopy is of medium density. Common species within this stratum are swamp tupelo, red maple, ash, red bay, and sweetbay. Shrub vegetation is patchy, mostly associated with little islands formed by tree bases and stumps. Common shrubs are wax-myrtle, red bay, young red maple, and fetterbush. Herb vegetation is patchy, with royal fern being the most common species. Laurel-leaved greenbrier is thick on the islands. Elsewhere the swamp forest is scruffier, only about 40' high. In these areas, the canopy is dominated by swamp tupelo at some sites, or a combination of swamp tupelo and dying loblolly pines at other sites. Understory vegetation is patchy; common species in this stratum are red maple, wax-myrtle, and red bay. Herb vegetation is also patchy. Royal fern is generally dominant, but dominance shifts toward sawgrass closer to the estuary. Marsh pennywort (*Hydrocotyle umbellata*) is common.

For the most part, the Alder Branch swamp forest is low, with the canopy only 40' high. The canopy is open. In some areas, red maple is dominant; in others, red maple and Carolina willow (*Salix caroliniana*) are codominant. There are a few scattered small baldcypresses. Shrub vegetation is dense, and about 10-15' high. Wax-myrtle is dominant; red maple and red bay are also common. Herbaceous vegetation is dense. Royal fern is dominant. Also common are marsh fern (*Thelypteris palustris*), swamp loosestrife (*Decodon verticillatus*), and whorled pennywort (*Hydrocotyle verticillata*).

Along the north border of the Alder Branch swamp forest, there is a 200-yard strip, about 50-100' wide, dominated by mature baldcypresses and swamp tupelos. This strip is located near the southern tip of the Fish and Wildlife Service property and adjacent to the mature pines cited earlier. The largest tupelo noted had a DBH of 18"; the largest baldcypress had a DBH of 20". This is one of the most notable sites within Fort Raleigh.

Shrub Swamp

Within the western portion of the NHS, north of US 64/264, is a fairly extensive shrub swamp. All of the area mapped as Hobonny is shrub swamp; in addition, some of the adjacent Ponzer map unit is also shrub swamp. In the areas that I walked through, the mass of vegetation is about 10' high or higher, made up of young trees, shrubs, and common reed. The most common species of trees and shrubs appear to be red maple, wax-myrtle, and red bay. Hempvine (*Mikania scandens*) is quite common. There are also frequent openings within the taller vegetation, and these have a medium cover of small herbs, like marsh pennywort, spadeleaf (*Centella asiatica*), and swamp smartweed (*Polygonum*

hydropiperoides). Other areas may be somewhat different--some areas may be more strongly dominated by common reed. Based on aerial photography, it is evident that the portion of this habitat mapped as Hobonny muck was a low, herb-dominated brackish marsh until recent years. It would be interesting to know what factors have led to this marsh becoming a shrub swamp, especially in regard to the brackish marsh south of US 64/264, which has not undergone similar changes.

Brackish Marsh

The brackish marsh south of US 64/264 is about 70 acres in extent, but about one-third of this is on private land. The location of this marsh is indicated by the area mapped as Hobonny muck in the County Soil Survey. This marsh has been ditched in the past, but this ditching has probably had negligible effect on the marsh's hydrology. Typically, the majority of the marsh surface varies from being saturated but not inundated to being inundated with only an inch or two of water. During higher than average water levels in the adjacent Croatan Sound, such as occasionally occur during storms with strong southwest winds, the marsh is inundated with up to two feet of water (sometimes more), which flows into the marsh across the southern end of the beach strand, which is very low, and through a ditch that cuts through the southern end of the beach strand. I observed that the marsh was flooded with two feet or more of water on 24 July 1997, as a result of strong southwest winds associated with the remnants of Hurricane Danny, the center of which passed through the northeastern corner of the state on that afternoon.

Overall, black needlerush (*Juncus roemerianus*) is the dominant plant within the marsh, but dominance varies from site to site. Also very common are sawgrass and common cattail (*Typha latifolia*) (note that many of the cattails within this marsh may actually be hybrids). Most sites are dominated by black needlerush alone or by various combinations of black needlerush, sawgrass, and common cattail. The exotic common reed now dominates some sites, and may become more of a problem in the future. Narrowleaf cattail (*Typha angustifolia*) is another major species, especially near the barrier beach. Other common/frequent species within the marsh are water-parsonage (*Sium suave*), arrowleaf morning-glory (*Ipomoea sagittata*), crimson-eyed hibiscus (*Hibiscus moscheutos*), hempvine, marsh fleabane (*Pluchea foetida* and *P. purpurascens*). The marsh has a nice floral display during the course of the growing season. Other species that contribute to this display, although uncommon in some cases, are seaside goldenrod, seashore mallow (*Kosteletskyia virginica*), red milkweed (*Asclepias lanceolata*), large marsh-pink (*Sabatia dodecandra*), Virginia blueflag (*Iris virginica*), and lobelia (*Lobelia elongata*).

Within about 150' of the barrier beach, there is a more even mix of species, and some species are noticeably more common in this area, like narrowleaf cattail and three-square (*Scirpus americanus*). Soil conditions may be somewhat different here because of the occasional deposition of mineral material washed/blown in from the adjacent beach strand.

Also within the marsh are a few small pools and mostly bare flats, both apparently formed by die-off of marsh species. Patches of little spikerush (*Eleocharis parvula*) are frequent on the flats and around the pool margins. Also seen in these situations were coastal water-hyssop (*Bacopa monnieri*) and toothcup (*Ammannia teres*).

I refer to this marsh as brackish because it obviously has some saline influence. However, the level of salinity is, on average, obviously quite low, and it does not fit the Brackish Marsh community type description in Schafale and Weakley (1990). Based on their classification, it would more properly be considered Tidal Freshwater Marsh, or perhaps intermediate between Tidal Freshwater Marsh and Brackish Marsh.

Minor Habitats

Four habitats, very limited in size and considered to have little potential for rare species, are a small freshwater pond next to the parking lot near the US 64/264 bridge; a nearby isolated (by upland) former brackish marsh that is becoming a shrub swamp; a very small area of old field habitat; and an area of young pine growth adjacent to US 64/264.

The *freshwater pond* is about 300' x 150'. Formerly a boat basin connected to Croatan Sound when the land was privately owned, it became a freshwater pond when the connection filled in, although there may be some slight saline influence. The banks are rather steep, and are covered with a moderate growth of common reed. The margins of the pond have a rather dense growth of the exotic alligator weed (*Alternanthera philoxeroides*), with some coastal water-hyssop.

The *former brackish marsh* is about 400' x 200' in extent; it lies just east of the freshwater pond, although separated from it by a narrow berm. Dominant plants in this marsh are common cattail and sawgrass. Also common and apparently increasing are many shrubs and young trees, as wax-myrtle, red maple, sweet gum, swamp tupelo, and swamp rose (*Rosa palustris*). Other common marsh plants are royal fern, false nettle (*Boehmeria cylindrica*), hempvine, water-hemp (*Amaranthus cannabinus*), spadeleaf, Virginia buttonweed (*Diodia virginiana*), mermaidweed (*Proserpinaca palustris*), giant foxtail grass (*Setaria magna*), and common foxtail grass (*Setaria geniculata*).

The area of *old field* habitat that lies adjacent to US 64/264 is less than an acre in extent. Currently it has a dense, three feet high mixture of many herbaceous species with numerous young loblolly pines. Common herbs are dogfennel (*Eupatorium capillifolium*), seaside goldenrod and other goldenrods, common broomsedge (*Andropogon virginicus*) and other grasses, common plantain (*Plantago lanceolata*), bitterweed (*Helenium amarum*), ragweed (*Ambrosia artemisiifolia*), numerous asters, lespedeza (*Lespedeza cuneata*), and Virginia creeper (*Parthenocissus quinquefolia*).

The area of *young pine growth* lies adjacent to US 64/264, and is about 10 acres in extent. It consists of a dense growth of young loblolly pines, about 25' high. Due to shading, understory vegetation is generally sparse. Noted were sweet gum, American holly, sassafras, winged sumac (*Rhus copallina*), wild muscadine, Carolina jessamine, poison ivy, and glaucous greenbrier.

METHODS

After reconnaissance surveys of Fort Raleigh NHS in late summer 1996, I developed a list of rare birds that might occur within Fort Raleigh and appropriate methods to survey for them. The list is given below. This list is rather "ambitious"--habitat within Fort Raleigh is marginal for several birds on the list.

Rare Bird Species Considered To Be of Possible Occurrence within Fort Raleigh National Historic Site

This list is based on the occurrence patterns of rare bird species within the region, and on an evaluation of suitability of habitat within Fort Raleigh NHS for rare species based on reconnaissance surveys, aerial photography, and the County Soil Survey.

Under each species, the assumed probability of occurrence at the beginning of the project is discussed, and there is a brief description of surveys that were carried out for each species.

Species that Are Federally Listed (includes Federal Species of Concern)

Bald eagle (*Haliaeetus leucocephalus*) (Federal:Threatened; State:Endangered). The State Natural Heritage Program tracks only breeding sites and regular non-breeding sites (i.e. sites used by birds over long periods).

Eagles are migratory and presumably individuals visit the shorelines of Fort Raleigh NHS occasionally to rarely. Nesting by eagles within the Fort Raleigh boundaries is extremely unlikely at this time. Likewise, use of the area by individuals on a long-term basis is also very unlikely, because of a poor food supply.

Survey activities carried out: In February 1997, I surveyed all of the canopy within Fort Raleigh by small airplane (Outer Banks Airways) to ascertain that no eagles nest within the area. Otherwise, no special surveys were carried out for this species. However, I did watch for eagles while I was conducting other work in the area, including plant survey work.

Peregrine falcon (*Falco peregrinus*) (Federal:Endangered; State:Endangered). The State Natural Heritage Program tracks only regular wintering sites (and, in the mountains, evidence of breeding).

This species is a regular fall migrant and winter resident on the nearby barrier island strand, at Bodie Island and Pea Island NWR.

However, at Fort Raleigh NHS/Roanoke Island, it certainly occurs much less often. At the beginning of the project, it was assumed that peregrines probably fly over Fort Raleigh NHS regularly, although uncommonly, during the peak fall migration period, from late September into October, and that wintering individuals might sometimes briefly visit the area.

Survey activities carried out: Because of its scarcity/unpredictability in the area, no special censuses were planned for this species. However, I watched for it while I carried out other work/surveys, including plant survey work.

Black rail (*Laterallus jamaicensis*) (Federal:Special Concern; State:Significantly Rare). Of major interest are sites used by this species in the breeding season. However, some individuals at least are permanent residents, and, apparently, birds that vocally respond to tape-recorded calls in winter are permanent resident individuals.

In North Carolina, the black rail is found primarily in brackish marshes dominated by black needlerush, with varying amounts of finer grasses, such as saltmeadow cordgrass and/or salt-grass (*Distichlis spicata*). It is more likely to be found in extensive marshes. The species is known to be a fairly common permanent resident in the extensive brackish marshes of the eastern and southern portions of Roanoke Island. At the beginning of the project, I assumed that the brackish marsh south of US 64/264 was probably moderately suitable as breeding habitat and marginal as wintering habitat.

Survey activities carried out: I surveyed the brackish marsh for black rails by playing tape-recorded calls at sunset on the following occasions: twice in October 1996, once in November 1996, and once in February 1997 (all for wintering birds), and twice in May 1997 and once in September 1997 (for breeding birds).

Piping plover (*Charadrius melodus*) (Federal:Threatened; State:Threatened). Of primary interest are regularly breeding sites and potential breeding habitat, regular wintering areas, and sites where large numbers congregate during the migrations.

This species is a regular migrant and winter resident at nearby Oregon Inlet, and breeding, or attempted breeding, has occurred at that site on two or more occasions, including 1996. At Fort Raleigh, habitat suitable for breeding birds is not present; because lunar tides are inconsequential here, habitat is also unsuitable for wintering birds. At the beginning of this project, it was assumed that migrating birds perhaps rarely to occasionally visit the estuarine shorelines of Fort Raleigh for brief periods, with occurrences most likely during the

migrations, March-April and August-October, and when water levels are low enough to expose a narrow strip of sandflats.

Survey activities carried out: I walked all the shorelines of Fort Raleigh in search of this species on six occasions, three in the fall migration, three in spring migration. A survey was made in each of the following months: August 1996, September 1996, October 1996, late March 1997, April 1997, and May 1997.

Red-cockaded woodpecker (*Picoides borealis*) (Federal:Endangered; State:Endangered). This species is quite sedentary; it is very unusual to find birds more than a half-mile or so from their roosting cavities.

Red-cockaded woodpeckers nest in open, park-like stands of living pines. Currently, the northeastern breeding limit of the species is in southeastern Virginia and northeastern North Carolina. The nearest location where this species is known to breed is within the Dare County Air Force Range, on the Dare County mainland, about 15 miles south-southwest of Fort Raleigh. At the beginning of the project, it was assumed that this species does not occur within Fort Raleigh because of unsuitable habitat--dense understory vegetation through most of the area; the likelihood that most trees are too young to be suitable as cavity trees; and the fact that this easily observed species had never been reported here before.

Survey activities carried: All of the areas within Fort Raleigh that are dominated by pines (excluding the young pines along US 64/264) or where pines are codominant, were surveyed on 15 dates from October 1996 to early April 1997. Survey methods followed Henry (1989). Most surveys were conducted when deciduous foliage was absent or sparse.

Bachman's sparrow (*Aimophila aestivalis*) (Federal:Special Concern; State: Special Concern). With this species, within the state, concern is primarily for breeding habitat.

In coastal North Carolina, this species breeds in open park-like stands of pine, primarily longleaf pine, where there is a dense ground cover of herbaceous vegetation. Farther south, as well as farther inland in the upper Coastal Plain and lower Piedmont, birds sometimes nest in old-field habitat. In the outer Coastal Plain, the northern regular limit of the species is within the Croatan National Forest. Sightings north of this area are extremely unusual. At the beginning of this project, it was considered very unlikely that this species might occur within Fort Raleigh, given the lack of suitable habitat plus the fact that Fort Raleigh lies outside the current range of the species.

Survey activities carried out: I didn't plan any formal surveys for this species, but on one morning in May, I listened for it

while walking all roads and trails within Fort Raleigh. I also listened for it while conducting other bird surveys and plant surveys.

Species that Are State Listed

Note: it should be pointed out that within this category, the classification may be applicable to a particular species only within certain areas (typically breeding areas only). For instance, the golden-crowned kinglet is considered to be of "Special Concern" as a breeder within the mountains; however, eastward throughout its winter range, the bird is not considered as "Special Concern". Thus, wintering birds within Fort Raleigh NHS would not represent occurrences of a "Special Concern" species.

Yellow rail (*Coturnicops noveboracensis*) (State:Significantly Rare). This status is applicable only as related to overwintering sites.

This extremely secretive species is largely silent while in North Carolina; thus its status is very poorly known. It is apparently an uncommon or occasional fall migrant/winter resident. Primary habitats, apparently, are wet meadows and similar areas, including some clearcuts, and higher marshes that are only rarely flooded. They probably occur in many of the same marshes where black rails occur as summer and permanent residents. At the beginning of this project, it was assumed that this species may sometimes winter in the brackish marsh, although the marsh is probably marginal habitat.

Survey activities carried out: During all the surveys for black rails, listed under that species, I also played tape-recorded calls of the yellow rail.

Snowy egret (*Egretta thula*) (State:Special Concern).

Little blue heron (*Egretta caerulea*) (State:Special Concern).

Tricolored heron (*Egretta tricolor*) (State:Special Concern).

This discussion applies to each of the three species above. Concern for these species is in regard to breeding sites.

These species nest typically within colonies made up of a mixture of egret/heron species, often with ibises as well. In coastal North Carolina, these colonies are typically located on small islands within the sounds, although they sometimes are located on the barrier islands and mainland. Such colonies occur annually on small islands in the vicinity of Oregon Inlet and during some years on small islands within the impoundments at Pea Island NWR. At the beginning of this project, it was assumed that there was very little likelihood of a heron/egret nesting colony occurring within Fort Raleigh NHS.

Survey activities carried out: No surveys were planned other than that during late spring-summer 1997 I watched for any activity that would suggest nesting by any of these species within the Fort Raleigh NHS boundary.

Other Species of Special Interest

Although not formally listed by the N.C. Natural Heritage Program, the following two species of Neotropical migrants are nevertheless of interest/concern, and have two of the highest Concern Scores (exceeded only by Bachman's warbler, which is probably extinct, and painted bunting) for Neotropical migrants in the Southeastern Coastal Plain, as ranked by the Partners in Flight Southeastern Working Group.

Black-throated green warbler (Coastal Plain nesting populations) (*Dendroica virens*).

This species has a wide breeding range across North America. However, the South Atlantic Coastal Plain nesting population has a very limited nesting range, occurring only in a narrow strip from southeastern Virginia (Great Dismal Swamp) to the vicinity of Charleston, South Carolina. Further, because they are largely restricted to nonriverine swamps and shun riverine swamps, a large percentage of their habitat has been lost. The black-throated green warbler is a locally common nester on the Dare County mainland, but there is no evidence that it breeds within any maritime forests of the barrier islands of the county. I do not know of any evidence of breeding by the species on Roanoke Island. At the beginning of the project, it was assumed that there was a slight possibility that one or two pairs nests in upland/wetland transition areas along Alder Branch and southwest of the Heritage Point development, in the zones where pines and swamp hardwoods (with baldypresses at Alder Branch) are intermixed. Habitat at these sites is actually suitable for the species, but is very limited in extent as well as isolated from populations on the Dare mainland.

Survey activities carried out: I surveyed the above areas for black-throated green warblers on one morning in April and one morning in May.

Swainson's warbler (*Limnethlypis swainsonii*).

This species is widespread, but local, across the Coastal Plain of North Carolina. It is generally uncommon on the Dare County mainland. The only barrier island location in Dare County where there is evidence of breeding is at Kitty Hawk Woods. Here birds have declined in recent years, and are no longer found at several sites where they were regular 20 years ago. I do not know of any breeding season records on Roanoke Island. However, birds may sometimes nest in the two areas described above under black-throated green warbler.

Survey activities carried out: I surveyed the above areas for Swainson's warblers on one morning in April and one morning in May.

Other Neotropical migrant species

During fall 1996, it was apparent that a very good variety of Neotropical migrant species use Fort Raleigh NHS during the fall migration. I recorded all species that I observed and also acquired a similar list from Jeff Lewis, an avid Manteo birder who works at the Elizabethan Gardens and compiles daily lists of the birds that he observes there.

RESULTS

Given below are the results of the surveys for each species and my current evaluation of the probable status of each species based on my surveys and additional knowledge of the habitat available. The single species observed within Fort Raleigh NHS and other species considered of possible occurrence are summarized in Table 1.

Bald eagle.

Observations: No eagles or eagle nests were observed during the surveys.

Probable status: Rare visitor, at any season.

It is likely that bald eagles sometimes, although rarely, visit the shorelines of Fort Raleigh. However, such visits are likely to be brief, given that prey species are not common here. It is extremely unlikely that eagles would nest within Fort Raleigh in the near future. If the population continues to increase, then nesting in marginal areas will become somewhat more likely. Perhaps the area of Fort Raleigh NHS that currently has the greatest potential as habitat for nesting eagles is along the margins of Alder Branch. This would change though if new development (in nearby private land or the Fish and Wildlife Service property) encroaches on the area.

Peregrine falcon.

Observations: Individuals were observed on three dates: 10 October 1996, 30 September 1997, and 1 October 1997. On all three dates birds observed were flying southward along the Croatan Sound shoreline, obviously in migratory flight.

Probable status: Uncommon during peak fall migration, occasional to rare winter visitor, occasional spring migrant. Most records will be of birds flying over, but not feeding or resting in the area.

Peregrines probably migrate over Fort Raleigh NHS regularly in the fall migration, especially during the migration peak, about late September-early October. Each year, several birds may pass through the area during this migration peak. Certain weather conditions, such as brisk westerly winds, may enhance the number of birds that pass through, by causing some shift from the more heavily used migratory pathway down the Outer Banks. However, there is probably little lingering or feeding by these birds within Fort Raleigh as favored prey species are uncommon here; thus Fort Raleigh is probably not of much importance to migrating birds as a feeding/stopover point. I observed one peregrine

Table 1. Probable status of rare bird species within Fort Raleigh NHS based on this survey.

Species	Observed during study	Probable status
Federally listed species		
Bald eagle	no	Rare visitor, any season.
Peregrine falcon	yes	Uncommon during peak fall migration, occasional to rare in winter, occasional in spring.
Black rail	no	Rare in summer--might nest, rare in winter, occasional in migration. Brackish marsh.
Piping plover	no	Rare to occasional migrant. Shorelines.
State listed species		
Yellow rail	no	Rare in winter and spring, occasional in fall. Brackish marsh.
Notably rare Neotropical migrants		
Black-throated green warbler	no	May rarely nest. Swamp forests.
Swainson's warbler	no	May rarely nest. Swamp forests.

falcon flying over Manteo in the winter of 1996-1997, suggesting that wintering birds from Bodie Island-Pea Island may sometimes briefly visit Fort Raleigh. However, Fort Raleigh would not be of any importance as a feeding area for peregrines in winter, because of the scarcity of prey species, especially as compared to the waterfowl-shorebird rich Bodie Island-Pea Island nearby. During the spring migration period, March to May, an occasional peregrine falcon may fly over Fort Raleigh.

Black rail.

Observations: No observations were made.

Probable status: Rare summer resident or visitor (may sometimes nest or attempt to do so), rare winter resident or visitor, occasional in migration (probably most likely in autumn migration). To be expected only within the brackish marsh south of US 64/264.

The brackish marsh within Fort Raleigh NHS is at least superficially similar to many sites where black rails are known to nest in North Carolina. Further, black rails are known to be permanent resident in the brackish marshes on the east side of Roanoke Island. However, the Fort Raleigh brackish marsh is rather small in size; such smaller marshes typically have relatively few marsh birds, perhaps because mammalian predators present more of a problem. Further, within the Fort Raleigh marsh, fine grasses such as saltmeadow cordgrass and salt-grass, which may be important for nesting black rails, make up a very minor component of the marsh. Additionally, this marsh is apparently subject to deep flooding occasionally during the nesting season, especially early in the nesting season, when the birds are typically setting up territories. Perhaps because of these same reasons, Virginia rails, which were observed from autumn to spring, were not observed during the nesting season. Black rails may rarely nest, or attempt to. Because of the flooding problem, this marsh is also very marginal as winter habitat for the species. However, one or two may rarely winter here.

Black rails are probably most likely to occur in this marsh as brief visitors during the migrations, especially autumn migrations. Verifying the presence of such visitors would be virtually impossible, except by netting, because nonresidents are very unlikely to call. An individual marsh such as this is, by itself, of little importance to migrating rails. However, collectively, such marshes may be very significant by providing numerous islands of cover at a time when the birds are especially vulnerable.

Piping Plover.

Observations: No observations of this species were made.

Probable status: Rare to occasional for brief periods during the migrations. Along the shorelines of NHS.

Piping plovers undoubtedly sometimes occur along the shorelines of Fort Raleigh NHS during the migrations, as they do on other sound shorelines (for instance, I have seen them on Cedar Island). However, considering the poor habitat quality (only seven shorebirds were seen on all six surveys), occurrences are likely to be only rare to occasional. Individuals might show up any time from March to May, and from late June to October, but are most likely in March-April and August-October, during the migration peaks. For the most part, Fort Raleigh is of virtually no importance to piping plovers as a stopover or feeding area. However, "inland" shorelines such as this may rarely be important during storm events. A hurricane causing strong northeast winds could temporarily provide a protected and extensive shoreline at Fort Raleigh (Croatan Sound shoreline).

Red-cockaded woodpecker.

Observations: No observations of this species were made.

Probable status: This species does not occur within Fort Raleigh. Further, the possibility of any colonizations is virtually nil at this time.

Although most of Fort Raleigh is dominated by pines, habitat is unsuitable for red-cockaded woodpeckers. Red-cockaded woodpeckers prefer open, park-like stands; in most of the forest within Fort Raleigh, there is rather dense understory vegetation. Further, most pines within Fort Raleigh are probably too young to be suitable as cavity trees for red-cockadeds. Trees selected for cavity construction are usually infected by a heartwood decaying fungus (*Phellinus pini*). This fungus is uncommon in loblolly pines (the predominant pine species within Fort Raleigh) before they are about 75 years old (Wahlenberg 1960). During the surveys, I counted the rings on 10 (canopy sized) pines cut down within Fort Raleigh in 1995-1996 for pine beetle control. The range in age of these trees was 43-65 years old; the mean age was only 53.

Bachman's sparrow.

Observations: No observations of this species were made.

Probable status: This species does not occur within Fort Raleigh; there is no habitat suitable for the species.

At least in the outer Coastal Plain of the state, this bird is largely restricted to open stands of pine with dense herbaceous ground cover, maintained by frequent fire.

Yellow rail.

Observations: No observations of this species were made.

Probable status: Rare winter resident or visitor, occasional in fall migration, rare in spring migration. Brackish marsh south of US 64/264.

Because this marsh is somewhat regularly flooded deeply by severe southwesterers, its potential as winter habitat is reduced. Yellow rails are most likely to occur in this marsh as brief visitors during the autumn migration. Verifying the presence of such visitors would be virtually impossible, except by netting, because nonresident birds are very unlikely to call. An individual marsh such as this is, by itself, of little importance to migrating rails. However, collectively, such marshes may be very significant by providing numerous islands of cover at a time when the birds are especially vulnerable.

Snowy egret, little blue heron, tricolored heron.

Observations suggesting nesting within Fort Raleigh. None.

Probable status in regard to nesting: Although occasional individuals of these species were seen in the brackish marsh, nesting within Fort Raleigh is extremely unlikely. Situations preferred or required by these birds for nesting are simply not present.

Black-throated green warbler (Coastal Plain nesting populations).

Observations: No observations were made. (Note: Jeff Lewis made a few observations of black-throated green warblers in spring 1997 in Elizabethan Gardens-Fort Raleigh. However, they were undoubtedly individuals of northern populations passing through the area in migration--they were seen in upland areas, were seen for only a few days, and were seen relatively late in the migration period, much later than the local nesting population arrives.)

Probable status: Possibly a rare nester along Alder Branch or in the swamp forest north of US 64/264.

Considering that it is common on the Dare County mainland, it is likely that a pair or two may nest along Alder Branch or in the swamp forest north of US 64/264 during some years, i.e. rarely, in spite of the small extent and isolated nature of suitable habitat. Unpaired males are perhaps as likely as breeding pairs. Fort Raleigh is insignificant in regard to importance as breeding habitat for this bird.

Swainson's warbler.

Observations: No observations of this species were made.

Probable status: Possibly a rare nester along Alder Branch or in the swamp forest north of US 64/264.

Considering the fact that it has nested at Kitty Hawk Woods and that very good nesting habitat is present along Alder Branch and bordering the upper end of the swamp forest north of US 64/264, it is likely that a pair or two nests in these areas during some years, i.e. rarely, although the extent of suitable habitat is limited. Unpaired males are perhaps as likely as breeding pairs. Fort Raleigh is insignificant in regard to importance as breeding habitat for this bird.

Neotropical migrants (overall).

The total number of Neotropical migrant species observed within the Fort Raleigh boundary, including the Elizabethan Gardens, during the autumn migration of 1996 was rather impressive (see Table 2 for a list of these species). It was observed that the numbers and variety of migrants at Fort Raleigh compared very favorably with those on Pea Island, long known as a migrant trap in fall migration. Note that the list includes 13 species generally regarded as scarce in the Outer Banks area in fall. On many mornings, it was observed that large numbers of migrants, apparently making their way westward from the barrier islands, piled up in wooded areas of Fort Raleigh, especially near the US 64/264 bridge across Croatan Sound. The birds presumably feed here and wait for nightfall before resuming their migratory flight. The relatively extensive wooded area of Fort Raleigh may be of importance to the survival of many of these migrants.

Table 2. List of Neotropical migrant bird species recorded within Fort Raleigh NHS during autumn 1996. (Includes observations within Elizabethan Gardens.)

Yellow-billed Cuckoo	Yellow-rumped Warbler
Ruby-throated Hummingbird	Black-throated Green Warbler
Eastern Wood-Pewee	*Blackburnian Warbler
Empidonax sp.	*Yellow-throated Warbler
Eastern Phoebe	Pine Warbler
Great Crested Flycatcher	Prairie Warbler
Eastern Kingbird	Palm Warbler
House Wren	*Bay-breasted Warbler
Blue-gray Gnatcatcher	Blackpoll Warbler
Veery	Black-and-white Warbler
Gray-cheeked Thrush	American Redstart
Swainson's Thrush	Prothonotary Warbler
Hermit Thrush	Ovenbird
Wood Thrush	Northern Waterthrush
Gray Catbird	*Kentucky Warbler
White-eyed Vireo	Common Yellowthroat
Solitary Vireo	Hooded Warbler
*Yellow-throated Vireo	*Wilson's Warbler
*Philadelphia Vireo	*Canada Warbler
Red-eyed Vireo	Yellow-breasted Chat
*Blue-winged Warbler	Summer Tanager
*Golden-winged Warbler	Scarlet Tanager
Orange-crowned Warbler	Rose-breasted Grosbeak
*Nashville Warbler	Blue Grosbeak
Northern Parula	Indigo Bunting
Yellow Warbler	Chipping Sparrow
*Chestnut-sided Warbler	*Clay-colored Sparrow
Magnolia Warbler	Bobolink
Cape May Warbler	Orchard Oriole
Black-throated Blue Warbler	Baltimore Oriole

* denotes a species considered to be scarce (occasional, rare, or very rare) in the Outer Banks area in fall

OVERALL CONCLUSIONS REGARDING IMPORTANCE OF FORT RALEIGH NHS TO
RARE BIRD SPECIES AND NEOTROPICAL MIGRANT BIRDS OVERALL

1. The only rare bird that can definitely be assumed to occur annually within Fort Raleigh is the peregrine falcon, which is apparently uncommon as a fly-by during the autumn migration. However, Fort Raleigh is probably not of importance to this species as a feeding/stopover point.
2. Both the bald eagle and piping plover probably visit Fort Raleigh occasionally to rarely. In both cases, Fort Raleigh is not important as a stopover/feeding area. At this time, the probability of eagles nesting within Fort Raleigh is virtually nil.
3. Both the black and yellow rail may sometimes occur within the brackish marsh south of US 64/264, and the black rail may rarely nest, or attempt to, at this location. However, nesting habitat is marginal. Both rails are most likely to occur here during the migrations. Small marshes such as this, individually, are probably of little importance to migrating rails. However, collectively such marshes may be very important by providing numerous islands of cover at a time when the birds are particularly vulnerable.
4. The value of the brackish marsh to rails would probably be lost if the marsh becomes overgrown with the exotic common reed. Common reed dominated wetlands are typically very poor habitat for marsh birds. Currently, some patches of reed have become established in the marsh.
5. The black-throated green warbler and the Swainson's warbler both may rarely nest within the swamp forests of Fort Raleigh--north of Fort US 64/264 and along Alder Branch. However, considering the small extent and insular state of suitable habitat, these areas are of virtually no importance to these birds.
6. Fort Raleigh NHS may be of some importance to migrating Neotropical migrant birds that are in the process of making reorientation flights in from the barrier islands, in that the large wooded area provides a suitable feeding/resting area.

BIBLIOGRAPHY

- Frost, Cecil C. In prep. Vegetation and Natural History of the Albemarle-Pamlico Region, Virginia and North Carolina. PhD dissertation (draft), Univ. of North Carolina, Chapel Hill.
- Henry, V. Gary. 1989. Guidelines for Preparation of Biological Assessments and Evaluations for the Red-cockaded Woodpecker. U.S. Fish & Wildlife Service, Atlanta.
- Radford, A.E., H.E. Ahles, and C. R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. Univ. of North Carolina Press, Chapel Hill.
- Schafale, Michael P. and Alan S. Weakley. 1990. Classification of the Natural Communities of North Carolina: Third Approximation. NCDEH&NR, Natural Heritage Program, Raleigh.
- United States Department of Agriculture, Soil Conservation Service. 1992. Soil Survey of Dare County, North Carolina.
- Wahlenberg, W.G. 1960. Loblolly Pine: Its Use, Ecology, Regeneration, Protection, Growth, and Management. Duke Univ., School of Forestry, Durham.