

III. REFUGE ENVIRONMENT

Physical Environment

Climate

Located in southeast Florida, Hobe Sound National Wildlife Refuge is characterized by a subtropical climate. Temperatures very rarely fall below freezing in the winter months and often reach mid- to high-90s in the summer months of July, August, and September. Temperatures measured at the Palm Beach International Airport weather station range from an average annual maximum of 83°F to a minimum of 67°F (Winsberg 1990). The average January temperature is 65.1°F, and the average August temperature is 81.8°F.

Specific weather data for the refuge is gathered from a fire weather station located at nearby Jonathan Dickinson State Park. According to this data, the refuge receives an average of 50 inches of rain per year, with most of it occurring from June through November.

During the wet season, thunderstorms that result from easterly trade winds and land-sea convection patterns occur almost daily. Wet season rainfall follows a bimodal pattern with peaks during May-June and September-October. Tropical storms and hurricanes also provide major contributions to wet season rainfall with a high level of variability and a low level of predictability. During the dry season, rainfall is governed by large-scale winter weather fronts that pass through the region approximately every 2 weeks. High evapotranspiration rates in south Florida roughly equal mean annual precipitation (U.S. Army Corps of Engineers 2002).

Air Quality

The existing air quality within Martin County is considered good, and the region meets current National Ambient Air Quality Standards. This condition is not expected to change in the immediate future (U.S. Army Corps of Engineers). Prescribed burning at the Jonathan Dickinson State Park temporarily reduces air quality during certain times of the year.

Noise/Traffic

Noise at the headquarters area is influenced by traffic along U.S. Highway 1 moving at a speed limit of 55 mph. The noise levels are expected to gradually increase in the future, as this highway is presently being widened. The populations of the surrounding municipalities of Hobe Sound, Stuart, Jupiter Island, and Jupiter are increasing faster than the national average, resulting in an increase in vehicular traffic.

Traffic noise is heard by visitors using trails which hinders the outdoor experience somewhat. The perception of traffic noise by wildlife is not well understood. However, more importantly than the

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traffic noise is the habitat dissection from U.S. Highway 1 through the sand pine scrub. This results in significant road kill on a routine basis as animals attempt to cross the highway. This also results in difficulty in recruiting wildlife populations to the narrow strip of sand pine scrub land that is bordered by the highway on one side and the Indian River Lagoon on the other side.

Geology and Soils

The refuge is comprised of two separate tracts of land bisected by the southerly portion of the Indian River Lagoon. The beach tract is known as the Jupiter Island Tract and is composed of 735 acres of a barrier island. The upland tract is west of the beach on a 300-acre mainland site, referred to as the Mainland Tract.

According to the reference book, "Soil Survey of Martin County, 1989 USDA" the refuge includes two broad soil groups: 1) soils of the sand ridges and coastal islands; and 2) soils of the tidal swamps. Soils of the sand ridges and coastal islands are composed of the soil complex known as Palm Beach-Canaveral-Beaches. Tidal swamp soils allow wetland vegetation to flourish and appear as isolated pockets on both the Mainland Tract and the Jupiter Island Tract. Seventeen different soil types exist throughout the refuge resulting in a wide variety of sub-habitats within the ecosystem.

Mainland Tract - Geology

The Mainland Tract is situated on a relic dune rising as high as 50 feet above sea level. This ancient dune is part of the Atlantic Coastal Ridge, formed during the Pleistocene (about 10,000 years ago) and Holocene epochs. Elevation in nearby Jonathan Dickinson State Park ranges from sea level to 92 feet. This ancient sand dune is characterized by siliceous sandy, well-drained soils. The scrub ecosystem is probably the oldest plant community in Florida. The scrub habitats in southern Florida became established in the Pleistocene and sand ridges which were deposited originally as coastal dunes formed by two processes: beach ridge deposition from changing sea levels and wind blown deposition (Austin 1999).

Mainland Tract - Soils

Soils on the Mainland Tract of the refuge are predominately associated with those of the southern section of the Atlantic Coastal Ridge. According to Austin (1999), "The sands on the scrub ridges are fine and white near the surface. They are quartzose with little calcareous or organic content and are locally known as "sugar sand." Geologists believe that their "sugary" appearance results from having been heavily leached of calcareous and organic materials. Technically, the sands are called St. Lucie Fine Sand, the most abundant phase, or Lakewood Fine Sand. St. Lucie sands range from white to gray in profile and may reach 50 feet in depth. Lakewood may be almost as deep but only the top 24 to 36 inches are white; below there is a yellow subsoil. As with most soils in the Mainland Tract, they are moderately to extremely well drained and permeable and are deep sand of marine origin. They are slightly to

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strongly acidic, are of low natural fertility, and make relatively poor agricultural land (Fernald 1989).

Jupiter Island Tract - Geology

The 735-acre Jupiter Island Tract has very little elevation ranging from sea level to 12 feet. The entire barrier island was formed through the deposition of marine sediment caused by fluctuating sea levels. The barrier island beach is subject to accretion and erosion. The erosion process is partly attributed to the nearby St. Lucie Inlet, with water flowing to/from the Indian River Lagoon and inhibiting the littoral drift of sand in a southerly direction. The Atlantic Ocean side of the barrier island is a high-energy shoreline. The erosion potential along this section of shoreline is greater than at many other locations of Florida because the continental shelf narrows continuously from northern Florida to southern Florida. Once south of Jupiter Inlet, the effects of a narrower shelf are offset partly by wave sheltering by the Bahama Banks offshore. Jupiter Island lacks this sheltering, so its sediment transport and erosion potential are relatively higher. The sand deposited in the inlet is periodically dredged and pumped onto the beach. In March 1963, a severe storm caused the Atlantic Ocean to break through a narrow portion of the island. This natural inlet created near Peck Lake was usable for navigation. In fact, due to its more gentle currents, it was actually preferred over the nearby man-made St. Lucie Inlet. However, due to increased shoaling in Peck Lake and severe degradation to adjacent southerly beaches, the inlet was closed by the Army Corps of Engineers in August 1964.

Jupiter Island Tract - Soils

Five soil types comprise the Jupiter Island portion of the refuge. These soils, known as Palm Beach-Canaveral-Beaches soils complex, are described as nearly level to sloping, well-drained soils that are sandy throughout and contain shell fragments. Soils of the tidal swamps are composed of the soil complex known as Bessie-Okeelanta Varient-Terra Ceia Varient. These are described as "nearly level, very poorly drained organic soils; some have a clayey layer in the substratum, some have sandy substratum, and some have more than 50 inches of organic material. Isolated pockets of tidal swamp soils exist on the Jupiter Island Tract as well as in small areas of the Mainland Tract.

Hydrology

The majority of the 300 acres of the Mainland Tract of Hobe Sound Refuge is atop a relic dune of the Atlantic Coastal Ridge. This tract is composed of very permeable soils of the Paola series. The water table averages greater than 6 feet in depth. Bordered on the east by the Indian River Lagoon, these soils readily leach and drain into the brackish water of the lagoon. The extreme permeability of the soils allows only those plant species adapted to very dry conditions to exist. Several low-lying, mostly freshwater wetlands transverse

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the refuge draining from U.S. Highway 1 into the lagoon. These wetlands are subject to saltwater intrusion affected by tidal cycles.

The 735-acre Jupiter Island portion of the refuge has lithology (i.e., physical character and composition of sediment or rock) similar to that of the Mainland Tract with two major aquifers, a shallow (non-artesian) surficial aquifer approximately 150 feet below the land surface and the Floridian (artesian) aquifer approximately 600 to 1,500 feet below the land surface. It is the surficial aquifer that supplies most of the potable water in Martin County, including supplying water to Jupiter Island residents. Much of the rain that falls on Jupiter Island infiltrates the shallow unconfined aquifer, while the rest runs off or remains on the surface where it adds to the Indian River Lagoon system, the mangrove community, and the tidal creeks on the refuge (St. Lucie Inlet Preserve State Park Management Plan 2002). Three mosquito impoundments exist on the Island Tract, but are, for the most part, filled in or choked off by exotic plants.

Water Quality

Human activities have degraded water quality in large areas of south Florida during the last century. Water in urban and agricultural canals commonly has high concentrations of nutrients and toxic compounds compared to water in marshes that are remote from canals. Drainage of nutrients and contaminants from urban and agricultural lands has degraded lakes, streams, canals, and estuaries of the region (McPherson and Halley 1997). In addition, discharge of nutrient-laden sewage and storm water runoff into canals also carries bacteria, viruses, oil and grease, toxic metals, and pesticides. The urban canal water discharges into coastal waters or enters the groundwater system and the public water supply (Klein et. al., 1975). The alteration of freshwater flows to the estuaries along the coast of Florida has reduced water quality of these habitats. Diseased fish and an increase in stranded and dying dolphins have been attributed to a decrease in water quality of the lagoon (Harbor Branch Oceanographic Institute 2002). A fish kill in August 2002, along the refuge beach of Jupiter Island, was believed to be attributable to discharges of water from Lake Okeechobee and associated canals (Port St. Lucie News, August 10, 2002).

The County Coalition for Responsible Management of Lake Okeechobee and St. Lucie and Caloosahatchee Estuaries and Lake Worth Lagoon is an association of nine counties (Lee, Hendry, Glades, Highlands, Palm Beach, Martin, St. Lucie, Okeechobee, and Osceola) that is influenced by Lake Okeechobee and its water management. The coalition represents the interests of approximately 2.2 million people in the 9-county area. The coalition is extremely concerned with issues associated with Lake Okeechobee discharges that impact the Indian River Lagoon and the St. Lucie Estuary, as well as other important water bodies and the natural resources that are sustained by them.

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Fertilizers are widely used in south Florida to maintain high levels of agricultural productivity. From July 1, 1990, through June 30, 1991, fertilizers sold in south Florida contained 127,000 metric tons (140,000 tons) of inorganic nitrogen and 50,800 metric tons (56,000 tons) of phosphate (McPherson and Halley 1997). Nutrient loading from the Everglades Agricultural Area and urban areas has significantly increased nutrient concentrations, particularly phosphorus, in the South Florida Ecosystem (Stober et. al., 1996).

Herbicides, such as atrazine, bromocil, simazine, 2-4-D, and diuron, which have the highest rates of application, are among the most frequently detected pesticides in Florida's surface waters. By far the most frequently detected insecticides in surface waters are the chlorinated hydrocarbons that are no longer used in the state, such as DDD, DDE, DDT, dieldrin, and heptachlor (Shahane 1994). These are also the most frequently detected pesticides in bottom sediments (Shahane 1994). For the St. Lucie River Estuary, which is north of the refuge, the pesticides ametryn, atrazine, hexazinone, bromacil, norflurazon, and simazine are in the top ten as far as the number of times detected in the estuary from 1992 to 1997 (Florida Department of Environmental Protection 1998).

Biological Environment

The refuge provides habitat and protection for approximately 40 plant and animal species listed as either threatened or endangered by federal and state agencies (Appendix IV). Nevertheless, the refuge has very limited information about its resources, since they have not been adequately described or surveyed. Much work needs to be done to describe, both qualitatively and quantitatively, the habitats and resources of the refuge.

General descriptions of the biological resources of the 300-acre Mainland Tract, the Indian River Lagoon, and the 735-acre Jupiter Island Tract are provided.

Mainland Tract

The primary vegetation classes on the Mainland Tract consist mainly of sand pine scrub, wetland, mangrove, and hammock habitats (Figure 8).

Sand Pine Scrub

Distribution and Characteristics. Compared with other ecosystems in Florida, scrub habitat is scattered across the landscape with concentrations along coastal and central ridges in peninsular Florida (Figure 9). In the panhandle, scrub is restricted to a narrow strip along the Gulf coast and on barrier islands. Scrub is frequently cited as Florida's most distinct ecosystem; physiognomy and composition are quite distinct from surrounding habitats and between 40-60 percent of scrub species is considered to be endemic. Scrub habitat, a xeric vegetative community, contains a biological treasure of plants and animals adapted to life on scattered ridges of sand. There are more endangered or potentially endangered wildlife

Figure 8. Vegetation on Mainland tract, Hobe Sound National Wildlife Refuge.*

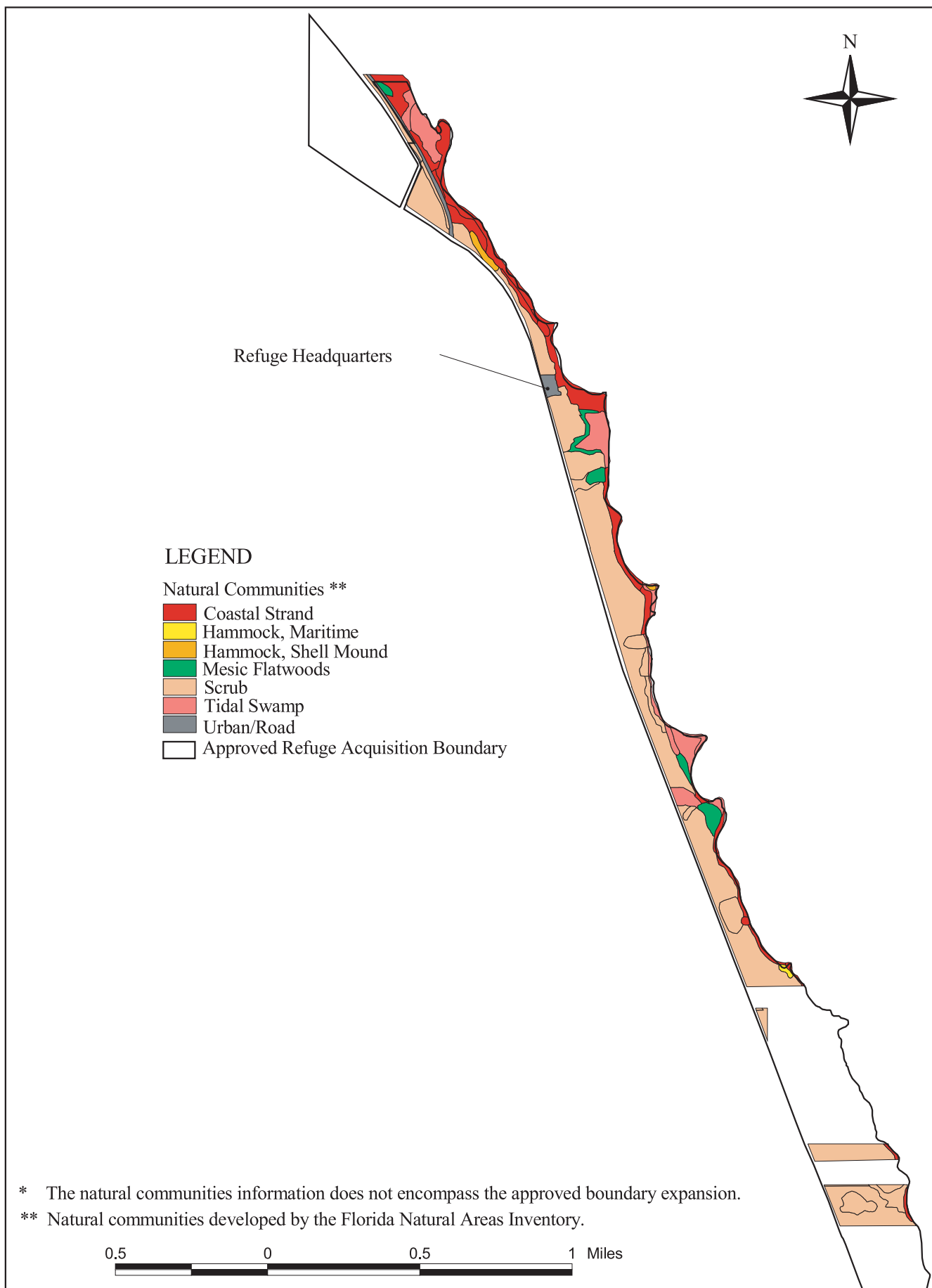
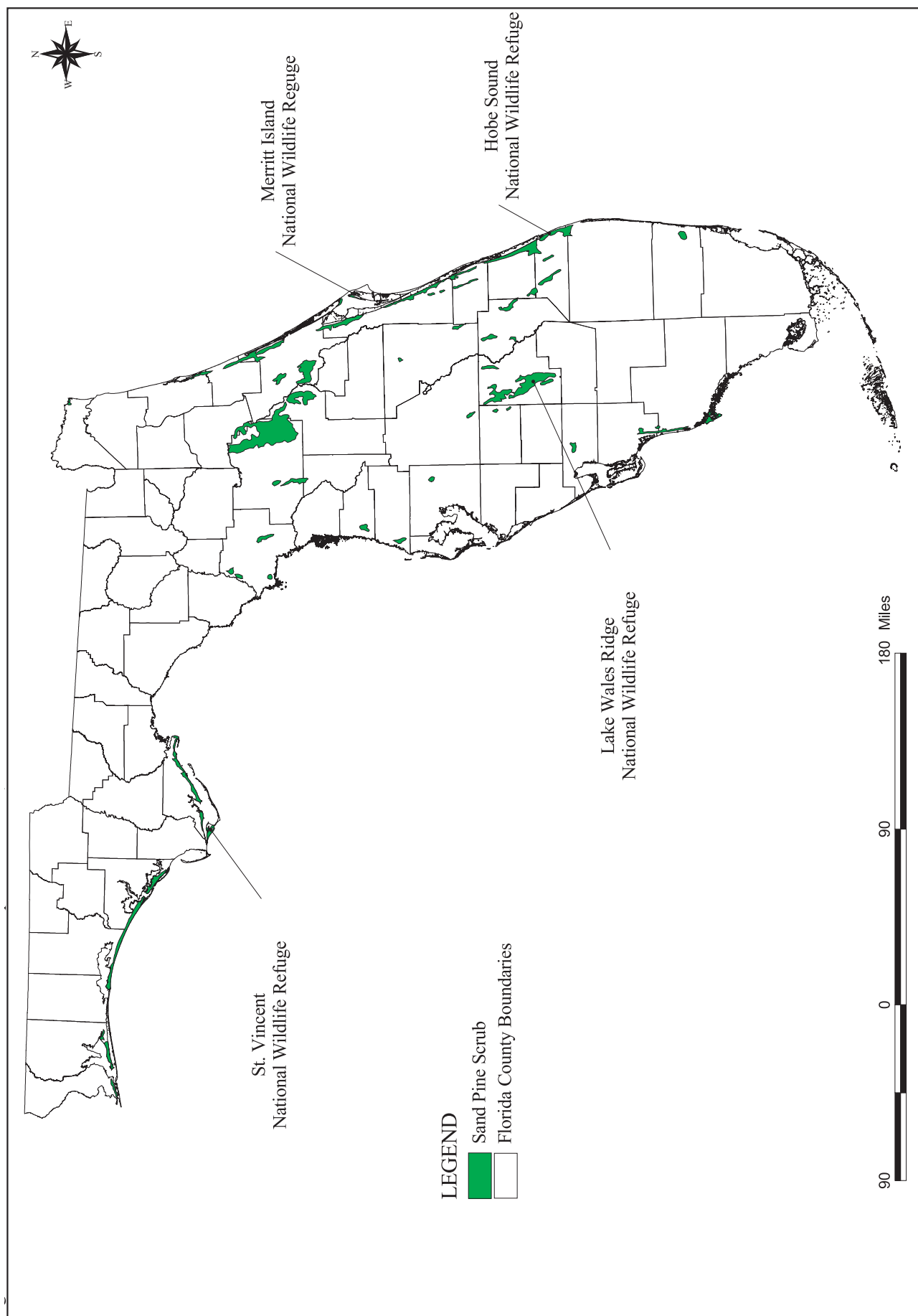


Figure 9. General distribution of scrub in Florida. Adapted from Davis 1967.



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species located here than in any other habitat in Florida. The ancient origins of these sand dune communities date back to the Pliocene savannahs and provide a relic example of an extremely old and formerly extensive ecosystem (Deyrup and Eisner 1993). Of the original distribution of Florida scrub ecosystem, only 10 percent remains, the rest replaced by citrus groves and housing developments.

Currently, the highest, oldest, and driest areas of the refuge are composed primarily of mature sand pine trees (*Pinus clausa*); hence the habitat is referred to as a sand pine scrub habitat. The scrub midstory consists of dense growing xeric plants such as Chapman's, myrtle, and sand live oak; varnish leaf; satinleaf; rosemary; gopher apple; and saw palmetto. The scrub understory is also relatively closed, supporting many species of lichens, grasses, and forbs which cover the scrub floor (Fernald 1989). At lower elevations, a more mesic environment supports slash pine and dense understory growth of saw palmetto, coin vine, gumbo limbo, Spanish lime, staggerbush, and many forbs (Richardson 1977).

Fire Ecology. Sand pine cones require stress, like fire, to open and release seed, while shrubby species like rosemary and scrub oaks quickly regenerate from stored energy in their roots. Shade intolerant species like scrub mints will respond to the increased duration and intensity of light from seed sources. Although the first prescribed burn on the refuge took place in January 2002, half of the sand pine scrub community is between 45 and 65 years. This age

roughly marks late-middle senescence of the scrub community. Some studies have concluded that the sand pine scrub community should be managed on a 15- to 25-year rotation, with many native species becoming absent after 20 years (Roberts and Cox 2000). Sand pines become sexually mature 15 to 17 years after their seeds are released by fire. The age of the youngest stand on the refuge is over 30 years. These trees are found in the area set-back by wildfire in 1971.

Several new sand pines have regenerated without fire following mechanical treatment, which is a disturbance that mows or chops the scrub habi-

tat, opening the canopy to allow sunlight to penetrate. Sand temperatures reached sufficient intensity to release pine seeds. Research is necessary to evaluate mechanical versus prescribed fire as methods to rejuvenate this habitat. Attempts at creating bare ground through prescribed fire have met with mixed success (Greenberg 2003). Bare ground and open areas in the scrub are necessary to attract and maintain other species, such as the scrub jay.



*Seedlings following treatment
USFWS Photo*

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Wildlife. The most common mammals are the gray fox, bobcat, white-tailed deer, raccoon, Virginia opossum, striped and eastern spotted skunk, eastern mole, least shrew, mice species, gray squirrel, and perhaps up to five bat species.

The birds of sand pine scrub habitat are the: Florida scrub jay, northern mockingbird, northern cardinal, blue jay, Carolina wren, chuck-will's widow, mourning dove, white-eyed vireo, eastern towhee, osprey, great horned and eastern screech owls, red-bellied and downy woodpeckers, great-crowned flycatchers, and bob-white. In its position in the North American Continent, Florida is a natural funnel for neotropical migratory birds (e.g., warblers, vireos, tanagers, orioles, and thrushes) which depend on scrub habitat areas for forage, cover, and rest prior to their long flight to Central and South America. Occasionally, wood storks are observed flying over the Mainland and Jupiter Island tracts. For many years, bald eagles have nested across U.S. Highway 1 in Jonathan Dickinson State Park and are occasionally observed flying over the refuge.

Gopher tortoises occur on the refuge as well as the scrub lizard, corn snake, black racer, and green anole. Seven wildlife scrub species are evaluated in greater detail as follows:

Florida scrub jay (Aphelocoma coerulescens)

Federal and State of Florida Threatened Species

The Florida scrub jay is endemic to the scrub habitat of Florida and is genetically and behaviorally different from scrub jays of the western United States. Its range has been considerably reduced by development, which has resulted in fragmented distribution of scrub habitat.

The jay has extremely specific habitat requirements within the scrub, including an open canopy and open understory (Fernald 1989). Historically, habitat at the refuge supported a breeding population of scrub jays, however, much of the scrub canopy has closed and there is dense undergrowth of vegetation. Scrub habitat on adjacent Jonathan Dickinson State Park supports a larger, but declining scrub jay population (Roberts, pers. comm. 2002).

Gopher tortoise (Gopherus polyphemus)

State of Florida Species of Special Concern

This species prefers xeric habitats with an abundance of herbaceous ground cover; an open canopy and sparse shrub cover; this early successional scrub habitat is similar to the habitat requirements of the Florida scrub jay (Franz 1986; Cox et al., 1987; Fernald 1989). The tortoise burrows 6 feet down, for an average of 15 feet, into a well-drained sandy soil to prevent dessication and to regulate body temperatures. The gopher tortoise is designated as a keystone species in the scrub habitat of the refuge. Burrows are known to provide habitat for up to 81 species of vertebrates and invertebrates. Thirty-two commensal vertebrate species use the burrows, including the listed eastern indigo snake, Florida pine snake, and gopher frog,

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which are described below. Tortoise dung provides the major food source for many invertebrates, which, in turn, are food sources for the Florida mouse and gopher frog (Jackson and Milstrey 1989; Cox et al., 1987; Fernald 1989).

The 1978 survey of gopher tortoise habitat on the refuge resulted in the discovery of two abandoned burrows on the southernmost part of the refuge. In 1986, seven gopher tortoises were released, and in 1992, four additional tortoises were released with the hope that they would form a local population. Later that same year, a follow-up survey revealed six burrows at the site: four were active, one was inactive, and one was abandoned.

In the winter of 1998-99, a portion of the sand pine scrub was surveyed for tortoises. Twenty-two burrows were found: five were active, seven were inactive and ten were abandoned. Relatively few tortoises are thought to be left on the refuge because the habitat has almost reached a climax successional stage.

Eastern indigo snake (Drymarchon corais couperi)
Federal and State of Florida Threatened Species

The eastern indigo snake has decreased dramatically throughout the United States due to loss of habitat. It has a home range between 125 to 250 acres, is diurnal, and feeds on small mammals, birds, frogs, lizards, and other snakes (Richard Roberts, pers. comm. 2002). Gopher tortoise burrows are particularly important to the indigo snake, since they provide winter shelter and protection from dessication (Fernald 1989). Since gopher tortoise burrow habitat is relatively scarce on the refuge, the probability of finding an indigo snake on the refuge is low. An underground survey of gopher tortoise burrows is needed to determine the population level of the indigo snake and other species that inhabit these burrows.

Florida pine snake (Pituophis melanoleucus mugitus)
State of Florida Species of Special Concern

This snake feeds on small mammals, birds, and lizards. It is closely associated with gopher tortoises (Fernald 1989), as indicated by the fact that 85 percent of its life is spent in gopher tortoise burrows. Surveys of gopher tortoise burrows are needed to assess the current status of this species on the refuge.

Florida gopher frog (Rana capito)
State of Florida Species of Special Concern

This frog occurs in both active and inactive gopher tortoise burrows, but it prefers the former (Fernald 1989). It requires temporary grassy ponds for breeding, which could drive the frogs to move elsewhere. Periodic surveys of known gopher tortoise burrows on the refuge are needed to determine the presence of this species. In a survey conducted in 1999, no frogs were found (Gilligan 1999).

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Florida mouse (*Peromyscus floridanus*)
State of Florida Species of Special Concern

This species is restricted to the State of Florida, and it has one of the narrowest habitat ranges of any Florida mammal (Fernald 1989). It requires fire-maintained, dry, upland vegetative communities located on deep, well-drained sandy soils. The current status of this species on the refuge is unknown. During small mammal live-trapping surveys, conducted in 1999 and 2000, no Florida mice were trapped.

Scrub lizard (*Sceloporus woodi*)
State of Florida Rare Species

According to Fernald (1989), this species is endemic to Florida, occurring in sand pine scrub and associated xeric communities. It needs dry, well-drained sandy soils with numerous patches of open, bare sand and high sun exposure. To maintain suitable habitat conditions, periodic major disturbances of the canopy and ground cover are essential to preserve local populations. During the 1999 survey, this species was commonly found on the refuge (Gilligan 1999).

Plants. Plants are the best indicators of the sand pine scrub community. Over 75 species are found in this habitat. The following 13 plants, native to sand pine scrub habitat, are evaluated in greater detail.

Giant wild pine (also known as swollen wild pine)
(*Tillandsia utriculata*)
State of Florida Endangered

As described in Long and Lakela (1971), this epiphyte's leaves may reach nearly 7 feet in height. Large plants often fall to the ground and continue to grow, flower, and fruit normally. The plant dies after flowering. This species is known to occur in the sand pine scrub habitat of the refuge, although its abundance is unknown. Its presence is threatened by the invasion of an exotic weevil that appears to prefer wild pine for food, which, in turn, kills the plant.

Large-leaved rosemary (also known as large-flowered rosemary)
(*Conradina grandiflora*)
State of Florida Endangered Species

This endemic shrub can reach over 3 feet in height, with few slender, usually curved branches (Long and Lakela 1971). This endemic Florida species is usually found in sandy soil in scrub habitat and it occurs on the refuge. The abundance of this species on the refuge is unknown.

Sand dune spurge (*Chamaesyce cumulicola*)
State of Florida Endangered Species

This endemic small herb has smooth, string-like, flexible stems and is found in south Florida (Long and Lakela 1971). It shows a strong preference for disturbed, open areas, especially railroad rights-of-way and roadsides adjacent to scrub (Bradley et al., 1998). This species occurs on the refuge, though no population estimates have been made.

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Nodding pinweed (also known as scrub pinweed) (*Lechea cernua*)
State of Florida Threatened Species

This small perennial herb can reach up to 2 feet in height, with leaves about 0.4-inch long, and 0.2-inch wide. It primarily inhabits sunny open areas of scrub (Bradley et al., 1998) and occurs in sand scrub vegetation (Long and Lakela 1971). This species is known to occur on the refuge, but its abundance is unknown.

Reflexed (inflated) wild pine (also known as curly wild pine)
(*Tillandsia balbisiana*)
State of Florida Threatened Species



These erect or pendent epiphytes grow on shrubs and trees in scrub habitat (Long and Lakela 1971). It occurs on the refuge, but the population size is unknown. It is also at risk due to an exotic weevil, which kills the plant.

Shell mound prickly pear cactus
(also known as common prickly
pear) (*Opuntia stricta*)
State of Florida Threatened
Species

Long and Lakela (1971) describe this perennial species as reaching almost 7 feet in height, with few to many green flowers. The cactus can be found in open and

sunny areas of the refuge. Unfortunately, it is thought to be endangered due to predation from the exotic moth (*Cactoblastus cactorum*) (Bradley et al., 1998).

Lakela's mint (*Dicerandra immaculata*)
Federal Endangered Species

This fragrant smelling mint was introduced to the refuge in 1991, to save it from extinction. Plants were taken from the last remaining population near Vero Beach and Fort Pierce, Florida. They were planted near the headquarters trail and in the "sand pit." Ongoing monitoring efforts, conducted by the Fish and Wildlife Service's Vero Beach Ecological Services' Office, and the Bok Tower Gardens, have shown plant growth and new seedling establishment in most areas.

Giant leather fern (*Acrostichum danaeifolium*)
State of Florida Threatened Species

This fern is confined to small wetlands located at the base of the scrub land hills. Small patches exist in this limited environment.

Lakela's mint
USFWS Photo

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Geiger tree (Cordia sebestena)
State of Florida Endangered Species

This tree, although occurring on the refuge, is north of its natural range. Its presence is most likely a horticultural escapee.

Inkberry (Scaevola plumieri)
State of Florida Threatened Species

Habitat is being overtaken by its exotic relative, beach naupaka (*Scaevola sericea*). The invasive beach naupaka plant grows quickly and completely covers the sand. The growth pattern prevents the native inkberry from sprouting, spreading, or competing with the beach naupaka.

Four-petal pawpaw (Asimina tetramera)
Federal Endangered Species

This species has yet to be found on the refuge, but a population exists across U.S. Highway 1 in Jonathan Dickinson State Park.

Burrowing four-o'clock's (Okenia hypogaea)
State of Florida Endangered Species

This plant has not been recorded on the refuge; however, it is present at nearby Blowing Rocks Preserve, which is owned by The Nature Conservancy.

Golden polypody (Phlebodium aureum)
State of Florida Threatened Species

This species roots in the boots of native cabbage palms. Its preferred growing location limits its ability to spread. No effort has been made to determine the occurrence of this species on the refuge, but it would most likely be in the hardwood hammocks.

Wetlands

In some areas of the Mainland Tract, the steep hillside plunges into small depressional wetlands which contain giant leather fern, swamp and royal ferns, American beauty berry, and cabbage palm. The invasive species known as Old World climbing fern (*Lygodium microphyllum*) is an ongoing problem in the wetland areas, requiring continual control. *Lygodium* can completely cover and smother all plants including canopy trees.

Mangroves

Mangroves line the shoreline of the Indian River Lagoon. Generally, the red mangrove (*Rhizophora mangle*) colonizes the fringes of the waterway with its aerial prop roots providing shelter for numerous marine animals. Mangrove prop roots decrease shoreline erosion by dampening the impact of high-energy boat wakes. The resulting water clarity facilitates seagrass growth and establishment. Black mangrove (*Avicennia germinans*), with its vertical pneumatophores, is generally

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found immediately inland of the red mangrove. The white mangrove (*Laguncularia racemosa*) is found on slightly higher elevations behind the black mangroves. Buttonwood (*Conocarpus erecta*) is also commonly found associated with the mangrove community, occupying higher ground inland and out of direct contact with brackish water.

A large percentage of mangroves have either been disturbed by excessive wave action, removed prior to the establishment of the refuge, or overtaken by invasive exotic plants. A mangrove re-planting program is ongoing at the refuge in partnership with the Environmental Learning Center of Vero Beach. An exotic plant removal program is also ongoing to maintain the shoreline clear of exotic plants, primarily Australian pine and Brazilian pepper, which interfere with mangrove restoration.

Hammocks

Three hammock habitats comprised of hardwood tree species grow atop native American Indian shell middens. Species include such tropical trees as mastic, ironwood, marlberry, red and white stopper, black stopper, paradise tree, poisonwood, white indigoberry, coral bean, lancewood, Jamaica caper, and strangler fig. Hammocks are excellent refugia for neotropical migratory birds, land crabs, tree frogs, and other animal species which need high humidity and/or dense cover. Although hammocks occupy a very small percentage of the refuge's acreage, they comprise about 20 percent of the plant diversity on the refuge (Bergh 1998).

Indian River Lagoon

The Indian River Lagoon is the most biologically diverse estuary in the United States. Because of its diversity, it has been designated as an Estuary of National Importance. In an estuary, salt water from the ocean mixes with fresh water from the inland; an estuary is of critical importance as a breeding, staging, and resting area for fish, shellfish, reptiles, birds, and mammals.

The Indian River contains 1,800 species of wildlife and plants and it supports one of the most productive aquatic faunas in the continental United States (Woodward-Clyde 1994). Species are supported by natural communities, namely, freshwater inlets and seagrass beds, oyster and clam beds, and diverse land forms and substrates. They are also supported by altered habitats such as spoil islands and mosquito impoundments.

The growing population of south Florida, and its associated demand for limited water resources, is affecting south Florida's estuaries, including the Indian River Lagoon. Fresh water, destined for estuaries, is being diverted for municipal and agricultural consumption, dams for irrigation, weirs for flood control, storm water collection and treatment systems, and drainage canals. These diversions in the natural cycle change the quantity and timing of water flows downstream to the estuary.

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In addition to water diversions, removing vegetation from the land and replacing it with an impervious surface can affect the natural flow of water to an estuary. Removal of the vegetation eliminates the uptake of water, and adding impervious surfaces cuts percolation of water into underground aquifers. The cumulative effect is that the estuary gets higher than normal freshwater input during the wet season and lower than normal freshwater inputs during the dry season.

Fish

South Florida has a great diversity of fish species. Of the 1,800 species identified in the Indian River Lagoon, at least 700 of them are fish species (Indian River Lagoon National Estuary Plan 1996; Woodward-Clyde 1994). More than twice as many species of fish occur in the southern half of the Indian River Lagoon, probably because of climate, presence of hard bottom and reef habitat, and the presence of several inlets to the Atlantic Ocean (Woodward-Clyde 1994).

According to G. Gilmore et al., 1981, several major fish habitat types occur in the lagoon: freshwater tributaries and canals; canal and river mouths; mosquito impoundments; mangrove marshes; open sand bottoms; grassflats; lagoon reefs; and Atlantic inlets. These diverse aquatic habitats foster the abundance of fishery resources that bring fishermen in great numbers to the refuge.

The Florida Committee on Rare and Endangered Plants and Animals (1992) has developed a category system, similar to, but not the same as the federal designations, to which various fishes are assigned. These categories are Threatened, Rare, and Species of Special Concern. The word, "Threatened" means that the species are likely to become endangered in the state within the foreseeable future if current trends continue. "Rare" includes species that are potentially at risk because they are found within a restricted geographic range or habitat in the state or are sparsely distributed. "Species of Special Concern" warrant special attention because they are vulnerable to exploitation or environmental changes and have experienced long-term population declines. The species assigned to the listed categories below are those that have been observed on the refuge.

Threatened: Atlantic sturgeon (*Acipenser oxyrinchus*); opossum pipefish (*Microphis brachyurus lineatus*); mangrove rivulus (*Rivulus marmoratus*); bigmouth sleeper (*Gobiomorus dormitor*); river goby (*Awaous tajasica*); and slashcheek goby (*Gobionellus pseudofasciatus*).
Rare: Mountain mullet (*Agonostomus monticola*).

Species of Special Concern: Lake Eustis pupfish (*Cyprinodon variegatus hubbsi*); mangrove rivulus (*Rivulus marmoratus*); striped croaker (*Bairdiella sanctaeluciae*); and spottail goby (*Gobionellus stigmaturus*).

Many of these species follow the Gulf Stream and other currents into the south Florida area. The opossum pipefish and many gobies depend on the brackish water conditions (e.g., the mouth of the St. Lucie

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River) for reproduction, although opossum pipefish have been found in Lake Okeechobee (G. Gilmore, Harbor Branch Oceanographic Institute, pers. comm. 1996).

The favorite edible sport fish caught at the refuge include red drum (*Sciaenops ocellatus*); spotted sea trout (*Cynoscion nebulosus*); snook (*Centropomus sp.*); snapper (*Lutjanus sp.*); shark (30-40 species); summer flounder (*Paralichthys dentatus*); spot (*Leiostomus xanthurus*); bluefish (*Pomotomus saltatrix*); Atlantic mackerel (*Scomberomorus maculatus*); weakfish (*Cynoscion regalis*); pompano (*Trachinotus carolinus*); and Atlantic croaker (*Micropogonias undulatus*). The state threatened species of sport fish, common snook (*Centropomus undecimalis*), is recovering from low population numbers in recent years.



Visitors fishing on beach
USFWS Photo

Seagrasses

Florida's shallow coastal areas support six species of seagrass: manatee grass (*Syringodium filiforme*); turtle grass (*Thalassia testudinum*); shoal grass (*Halodule wrightii*); star grass (*Halophila engelmanni*); paddle grass (*Halophila decipiens*); and Johnson's seagrass (*Halophila johnsonii*). The most common grass in the Indian River Lagoon is manatee grass (*Syringodium filiforme*). The grass beds with the greatest density occur in shallow water where the salinity is fairly consistent. About 60 species of drift algae are growing on or found interspersed with

marine grassbeds. They begin as attached forms but eventually break away, providing refugia for invertebrates, fish, and other algae.

Importance

Seagrass beds are considered some of the most productive habitat in the estuarine system. They are important as nursery grounds for many fish species. Grassbeds are used as cover or foraging habitat by 29 fish species and the Atlantic bottlenose dolphin. They also serve as critical food sources for the endangered West Indian manatee. In addition to being productive habitats, seagrass beds improve water quality by removing nutrients, dissipating the effects of waves and currents, entrapping silt, and stabilizing bottom habitats.

Issues

In September 1998, the National Marine Fisheries Service listed Johnson's seagrass as threatened under the Endangered Species Act of 1973. Its distribution is limited to the Indian River Lagoon from

Melbourne, south to Hobe Sound, and further southward to Lake Worth Lagoon and Biscayne Bay. A decision on designation of critical habitat for Johnson's seagrass is pending. See Figure 10 for the distribution of Johnson's seagrass at the refuge.

The seagrass communities of south Florida have experienced substantial declines in acreage and quality in recent years. Since the 1940s, an estimated 30 percent of the seagrass communities have been destroyed in estuarine habitats. This percentage of loss is also the case for the Indian River Lagoon. More than 59,306 acres of seagrasses have been eliminated since 1987. The cause of this loss includes such factors as: degraded water quality, freshwater flow management problems, severe temperature variability, and dredging from boat propellers (Haddad and Sargent 1994). It has been estimated that propellers alone have caused 64,200 acres of seagrasses to be moderately or severely damaged (Haddad and Sargent 1994). Seagrass beds in Monroe and Dade counties, which are located south of Martin, Collier, and Lee counties on the southwest Florida coast, have experienced the heaviest damage from propellers.

Mammals

Florida manatee (West Indian manatee). Manatees use the Indian River Lagoon, adjacent to the refuge, predominately during the winter months to the delight of visitors. The relatively sheltered waterway provides a resting and feeding area for the manatee as it travels south to the warm waters of the Riviera Beach power plant. It forages primarily on seagrass beds and secondarily on over-hanging mangroves and submerged, rooted, or floating species of plants. In 1976, nearly 10 percent of the state's manatee population was observed migrating through the lagoon along the refuge (Lund 1976; Packard 1981; Lefebvre and Powell 1990). Today, fewer sightings are recorded.

Ecological studies of seagrass beds and their use by manatees were performed at the refuge in 1976 and during 1988-1989. Seagrass beds appeared to be declining in area and productivity due to silt, propeller dredging, and increased water turbidity from excessive power boat speeds.

Boating along the waterway is the largest threat to the manatee. Along the refuge, the state regulated slow-speed zone for boats ends at Bridge Road, leaving 3 miles of unregulated speed along the refuge boundary and another significant portion along the Peck Lake area. Propeller wounds and blunt force trauma are two of the common causes of mortality. Blunt force trauma can occur from power boats, as well as from personal watercraft.

In addition to boating impacts, red tides and cold stress are other common sources of manatee mortality. While some manatees remain in both Hobe Sound and Jupiter Sound areas throughout the year, others migrate up the coast. Deteriorating water quality, turbidity, and lack of food contribute to the stress of migrating manatees.

Figure 10. Location of seagrass beds in relation to Hobe Sound National Wildlife Refuge.*



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Atlantic bottlenose dolphin. The only Indian River Lagoon resident cetacean is the Atlantic bottlenose dolphin (*Tursiops truncatus*). Hundreds of dolphins, protected by the Marine Mammal Protection Act of 1972, are known to occur throughout the lagoon. They feed on small fish such as mullet, spotted sea trout, silver perch, Atlantic croaker, and oyster toadfish. The average dolphin eats about 9 kilograms (20 pounds) of fish per day (Woodward-Clyde 1994). Based on the estimated population level in the lagoon, dolphins probably consume about 1,000,000 kilograms (2.2 million pounds) of fish annually (Woodward-Clyde 1994).

The dolphins frequent seagrass beds in the summer; presumably due to the supply of pinfish, pigfish, and mullet. In the winter, they are thought to move offshore; however, Beeler et al., (1988) believe that the resident dolphin population in the lagoon does not go out into the Atlantic Ocean, but rather that transient dolphins from ocean populations may come into the lagoon in the summer.

Studies conducted in 1983 revealed that about 20 dolphin strandings a year occur in the lagoon (Woodward-Clyde 1994). More recently, a fungal skin disease that causes lesions and secondary bacterial infection is on the rise, infecting at least 12 percent of the population. Some scientists suspect that the dolphin's immune system is being suppressed by chemicals or biological agents (i.e., toxic dinoflagellates) that occur in the Indian River Lagoon. Dolphin skin is sensitive to changes in water salinity.

Reefs

Reefs are a prominent coastal resource in the South Florida Ecosystem, which contains several kinds of coastal reef assemblages: worm reefs, vermetid reefs, and the more familiar coral reef. The southern third of the Indian River Lagoon contains a reef-like habitat, created by dredging along the edges of the Intracoastal Waterway, which supports aquatic life such as gorgonian corals and other invertebrates. Also, in the Atlantic Ocean, adjacent to the refuge, are expanses of hard bottom which support invertebrate growth and many juvenile fish species.

Jupiter Island Tract

The refuge's 735-acre Jupiter Island Tract is composed primarily of Atlantic coastal dune, Australian pine-lined lagoonal shore, mangrove swamps, mosquito impoundments, and 3.5 miles of sandy beach (Figure 11).

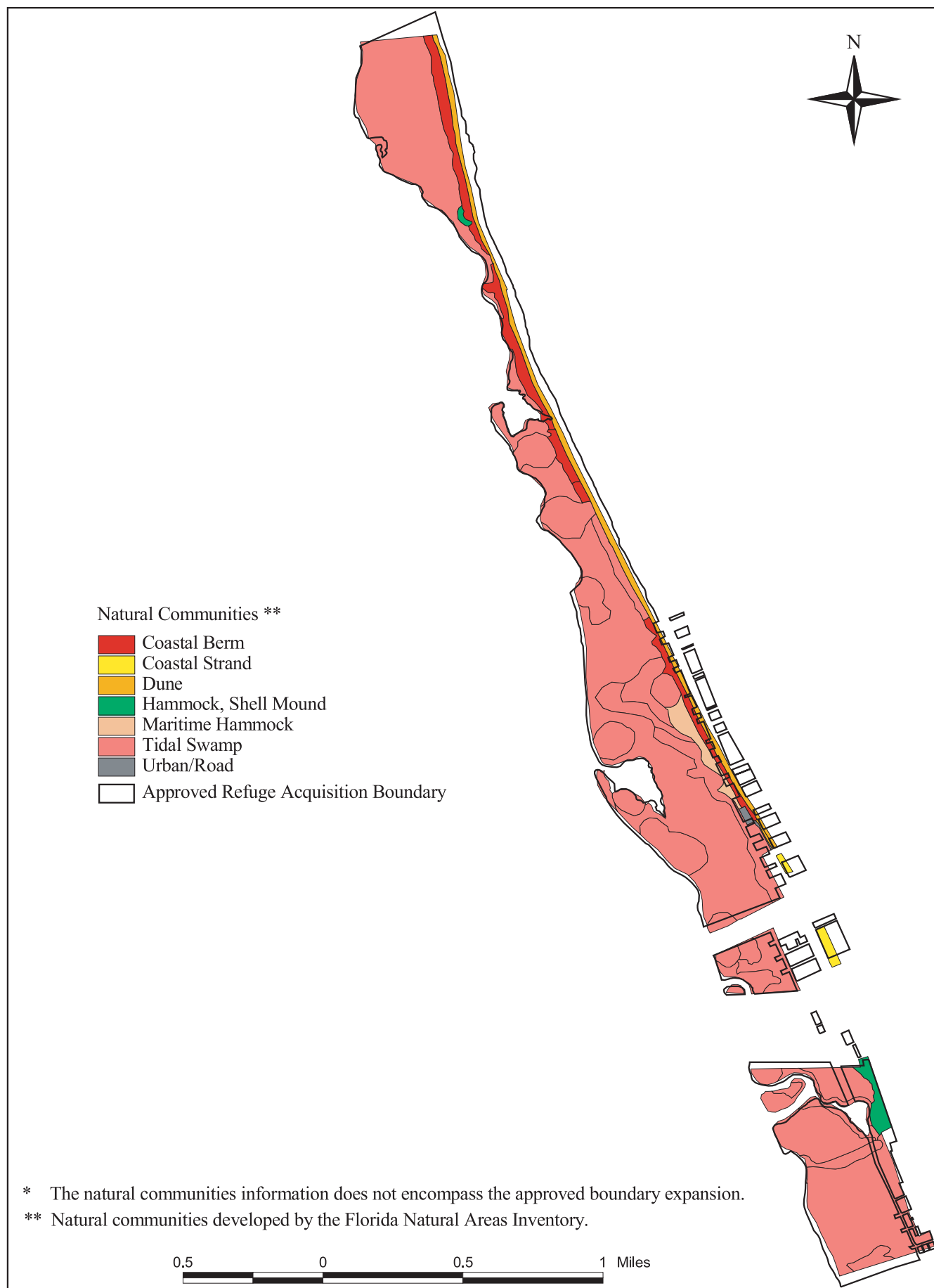
Atlantic Coastal Dune

Three vegetative zones progress from ocean to inland: the foredune, the middledune and the backdune. The foredune is nearest the ocean with characteristic plants such as sea oats, marsh elder, bay bean, railroad vine, and sea purslane. The middledune is inhabited and stabilized by sea oats, bay cedar, beach sunflower, ink berry, beach star, black bead, and coastal panic grass. The backdune is furthest from the ocean and supports the following native plants: saw palmetto, seashore elder, sea grape, pigeon plum, Spanish bayonet, stinging nettle, and prickly pear.



*Dune
USFWS Photo*

Figure 11. Vegetation on Jupiter Island Tract, Hobe Sound National Wildlife Refuge. *



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While there are no records documenting the occurrence of beach jacquemontia (*Jacquemontia reclinata*) on the refuge, according to the Multi-Species Recovery Plan (1999), this species once occurred on Jupiter Island in Martin and Palm Beach counties. Currently, the northern most extent of the species occurs 10 miles south of the refuge on Juno Beach (Palm Beach County). Beach jacquemontia is a perennial vine which is found in open areas on the crest and lee sides of stable dunes (Austin 1979). Loss of habitat and beach erosion led to listing this species as endangered on November 24, 1993 (58 FR 62050). Considerable interest exists in the potential for restoring beach jacquemontia to the refuge in partnership with Fairchild Tropical Gardens.

Due to positioning of the refuge within the Atlantic Flyway, the refuge dune and beach serve as important resting and foraging areas for migrating shorebirds.

The southeastern beach mouse (*Peromyscus polionotus niveiventris*) is a subspecies of the old field mouse that occurs in habitats along the east coast of Florida. This species' historical range encompassed the eastern counties of Volusia to the north, Broward to the south, and Martin, where the refuge is located. Due to the extensive development in coastal habitats, this species has been extirpated in the southern counties, and now only exists in Volusia and Brevard counties, and in a few places in Indian River and St. Lucie counties. No formal surveys of the refuge have been conducted to document its presence. However, its favorite food source, sea oats, have become reestablished on the refuge in recent years suggesting that reintroduction of the beach mouse could be possible.

Mangroves

Three species of mangroves can be found along the shoreline of the Jupiter Island interface with the Indian River Lagoon. Many species of invertebrates including threatened species of mangrove crabs, (*Aratus pisonii* and *Goniopsis cruentata*) are believed to exist in this habitat. Australian pine and Brazilian pepper are more pervasive on this side of the lagoon than the Mainland Tract at this time.

Mosquito Impoundments

In Florida, impounding marshes and mangrove swamps for mosquito control began in Brevard County in 1954. The practice spread to other counties bordering the Indian River Lagoon until, by 1970, most of the impoundments were completed. There are 192 impoundments along the Indian River Lagoon (Rey and Kain 1991). A mosquito impoundment is simply a marsh or mangrove swamp which has been totally or partially enclosed with an earthen dike. Impoundments allow the swamp to be flooded during the mosquito breeding season thus preventing the mosquitos from laying eggs on moist soil. The salt marsh mosquitos (*Aedes taeniorhynchus* and *Aedes sollicitans*) will not lay their eggs upon standing water. There are five mosquito impoundments in Martin

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County, of which three (totaling 625 acres) are on the refuge (Figure 12). These are identified as F-1, F-2, and F-3. Very little information is available about these impoundments other than that they have been breached in several locations and no longer function as mosquito control impoundments. Today, they are mostly brackish due to the loss of water control structures. While the impoundments were intact, as many as 18 alligators were observed in 1979.

The town of Jupiter Island would like to proceed with plans to restore at least one of these impoundments in partnership with the refuge.

Hammocks

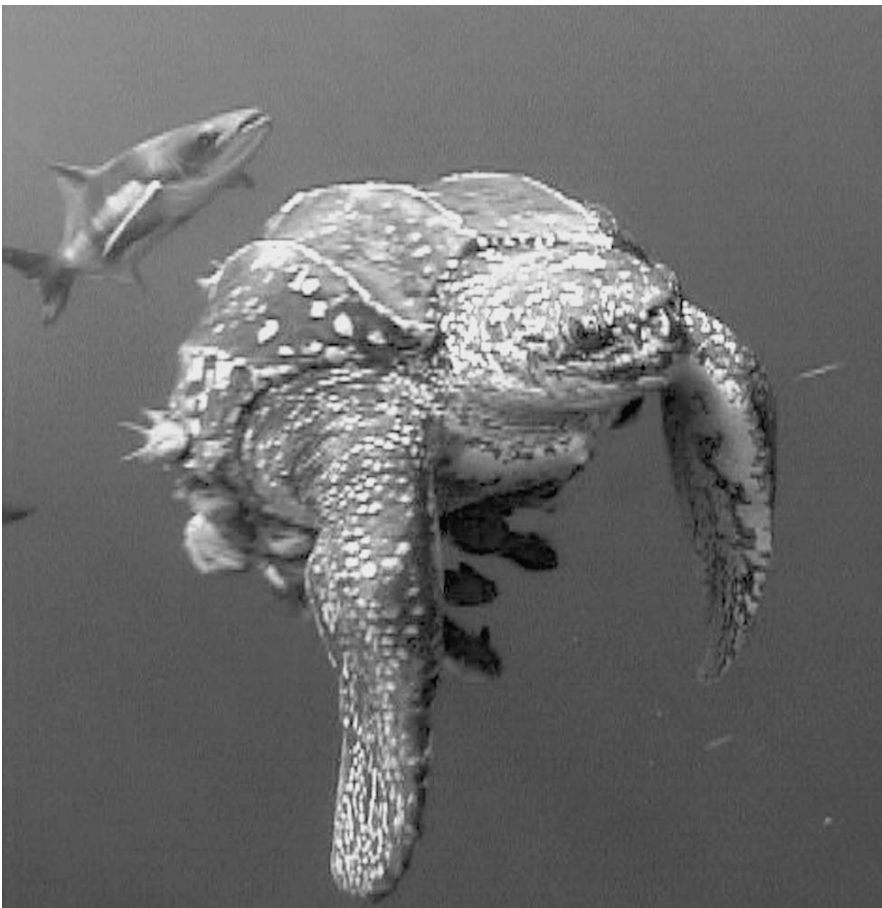
Several hardwood hammocks exist on the Jupiter Island Tract. At least one is over a Native American Indian shell midden. Hammocks thrive on a limestone substrate. The dense canopy from oak trees, pigeon plum, red stopper, white stopper, marlberry, and strangler figs creates high humidity levels and higher temperatures. Hammocks are very important to migratory birds and contain 20 percent of all the refuge plant diversity.

Sandy Beach

This 3.5-mile tract of sandy beach attracts hundreds of visitors every year. Sea turtles and migratory shorebirds are the most important of these visitors.

Sea turtles. Of the seven species of sea turtles occurring worldwide, the refuge is a nesting ground for three: loggerhead (*Caretta caretta*); green (*Chelonia mydas*); and leatherback (*Dermochelys coriacea*). Two other species, the hawksbill (*Eretmochelys imbricata*) and the Kemp's ridley (*Lepidochelys kempii*), are occasional visitors and occur in the coastal waters adjacent to the refuge (Florida Department of Environmental Protection 1998 and Ecological Associates 2002).

All species mentioned above are protected under the Endangered Species Act of 1973, and Florida Statute, Chapter 370.12, as either threatened (loggerhead) or endangered (green, leatherback, hawksbill, and Kemp's ridley). The refuge's beach is of critical importance to marine turtle nesting as the coastline from Brevard County to Broward County accounts for 80 percent of the loggerhead nests worldwide. Florida's green turtle nesting population is



Leatherback sea turtle

*Photo provided by
Jim Abernethy's Scuba Adventures*

Figure 12. Location of mosquito impoundments, F-1, F-2, and F-3, Hobe Sound National Wildlife Refuge.



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also important on a worldwide scale, because it is one of the largest remaining in the Caribbean Sea and western Atlantic Ocean. Like the loggerhead, more than 90 percent of green turtle nests in the United States occurs between Brevard County and Broward County (Meylan et al., 1995). Florida is the only area in the continental United States where leatherback turtles nest regularly. More than 80 percent of Florida's leatherback nesting occurs in Martin, Palm Beach and Broward counties (Meylan et al., 1995 and Florida Department of Environmental Protection 1997).

Nesting Success

During the 2002 sea turtle nesting season, 1,062 loggerhead, 143 green, and 33 leatherback turtle nests were recorded along the refuge's beach (Figure 13). When compared to annual data since 1973, this represents below average nesting for loggerhead, and above average nesting for green and leatherback turtles. Despite the somewhat lower than average nesting by loggerhead turtles during 2002, regression analysis indicates that nesting data for all three species exhibit increasing trends from 1973 through 2002 (Figures 14, 15, and 16).



*On the beach
USFWS Photo*

Nest Predation Rates and Control Efforts

Incubating sea turtle eggs and hatchlings are vulnerable to a variety of native (e.g., raccoons, ghost crabs, foxes, coyotes, crows and night herons) and non-native (e.g., fire ants, feral hogs and armadillos) predators. In earlier years, it was estimated that more than 90 percent of nests on the refuge was destroyed by raccoons. Utilizing proactive control measures, nest depredation rates dropped to an acceptable level (1.0 to 6.7 percent per year) through 1986. However, from 1987 through 1991, raccoon depredation rates exceeded 13 percent. In 1988,

armadillos were first discovered to be predators of sea turtle nests on the refuge. By 1991, the depredation rate increased to 20 percent. Since 1992, armadillos are considered to be the primary predator of sea turtle nests on the refuge (Bain et al., 1997 and Ecological Associates 2002). The overall predation rate reached a high of 61 percent in 1997; armadillos accounted for 75 percent of the nest loss.

The continued application of proactive measures to control predation is necessary to minimize turtle egg and hatchling loss. To that end, in 1999, the refuge contracted the services of the U.S. Department of Agriculture to apply existing technologies to reduce the predation rate. The overall predation rate (all species combined) has dropped

Figure 13. Number of sea turtle nests observed on refuge by species 1991-2002.

Species	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Logger-head	1862	917	1546	1714	1376	1373	1155	1562	1384	1399	1259	1062
Green	6	33	6	47	9	69	14	81	18	133	16	143
Leather-back	7	2	5	9	24	2	16	15	33	36	58	33
Total	1875	952	1557	1770	1409	1444	1185	1658	1435	1568	1333	1238

Figure 14. Annual number of green turtle (*Chelonia mydas*) nests, Hobe Sound National Wildlife Refuge, 1973-2002. Data analysis by Ecological Associates, Inc.

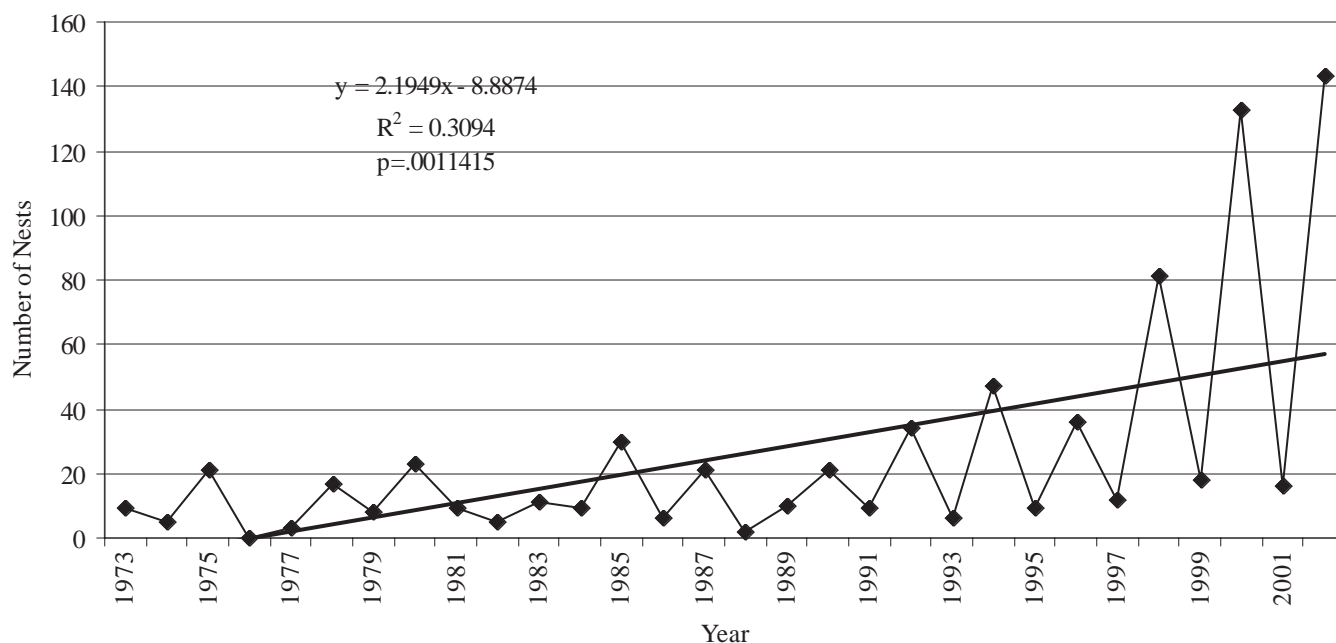


Figure 15. Annual number of loggerhead turtle (*Caretta caretta*) nests, Hobe Sound National Wildlife Refuge, 1973-2002. Data analysis by Ecological Associates, Inc.

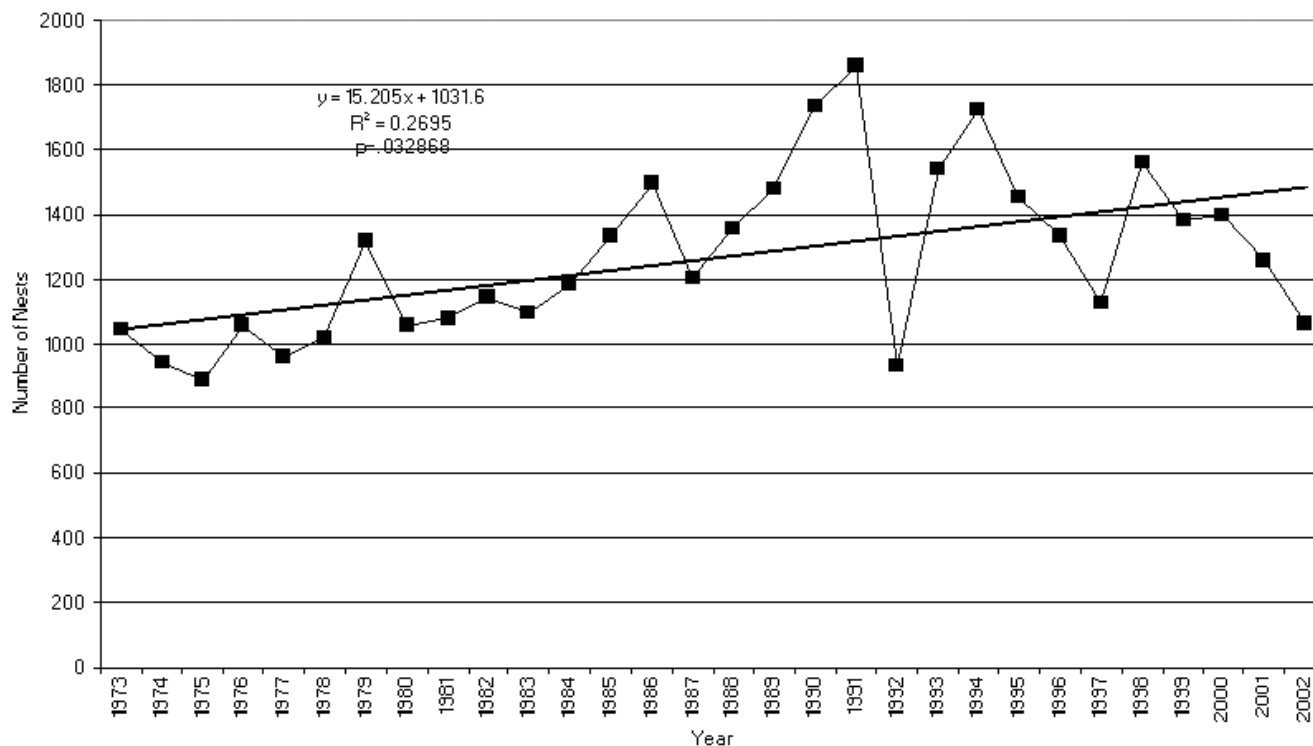
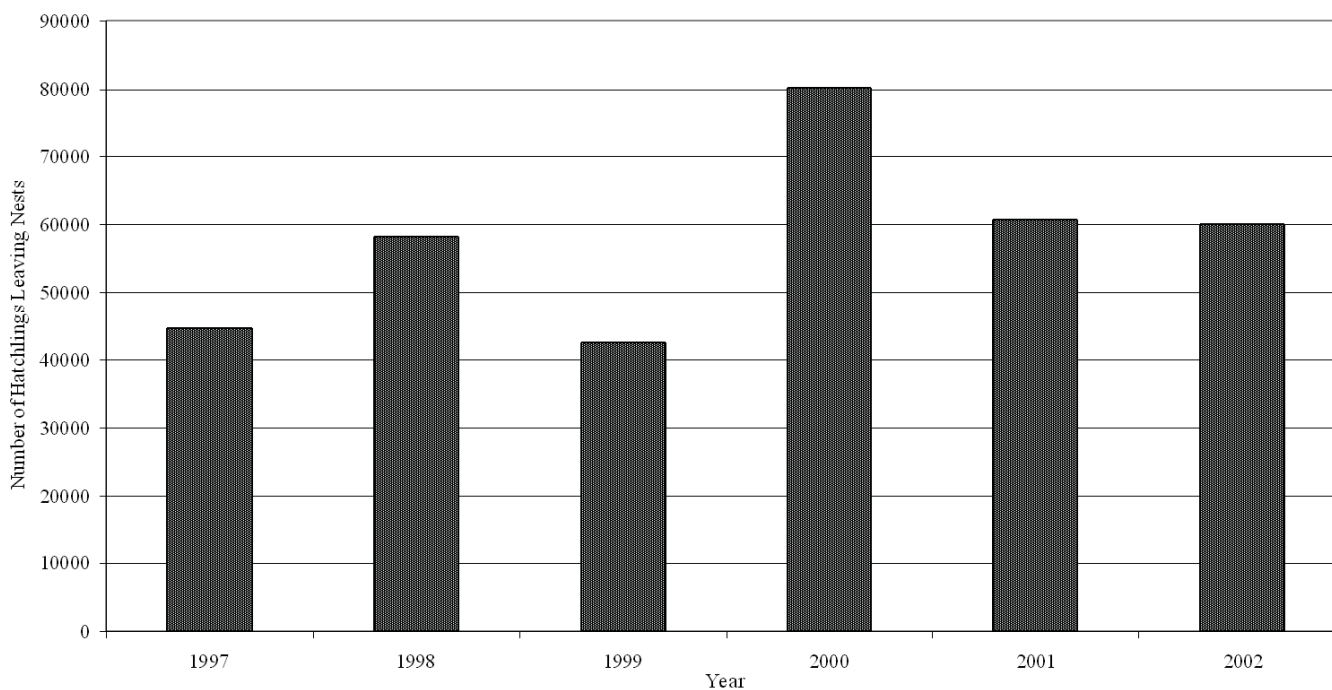


Figure 16. Annual loggerhead turtle (*Caretta caretta*) hatchling productivity, Hobe Sound National Wildlife Refuge, 1997-2002. Data analysis by Ecological Associates, Inc.



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from 60.8 percent in 1997, to 10 percent in 2002 (Engeman et al., 2002). (See Figure 17.)

Effects of Beach Erosion on Nesting Habitat

The loss of sea turtle nesting habitat due to wave action and erosion is a major concern to the refuge.

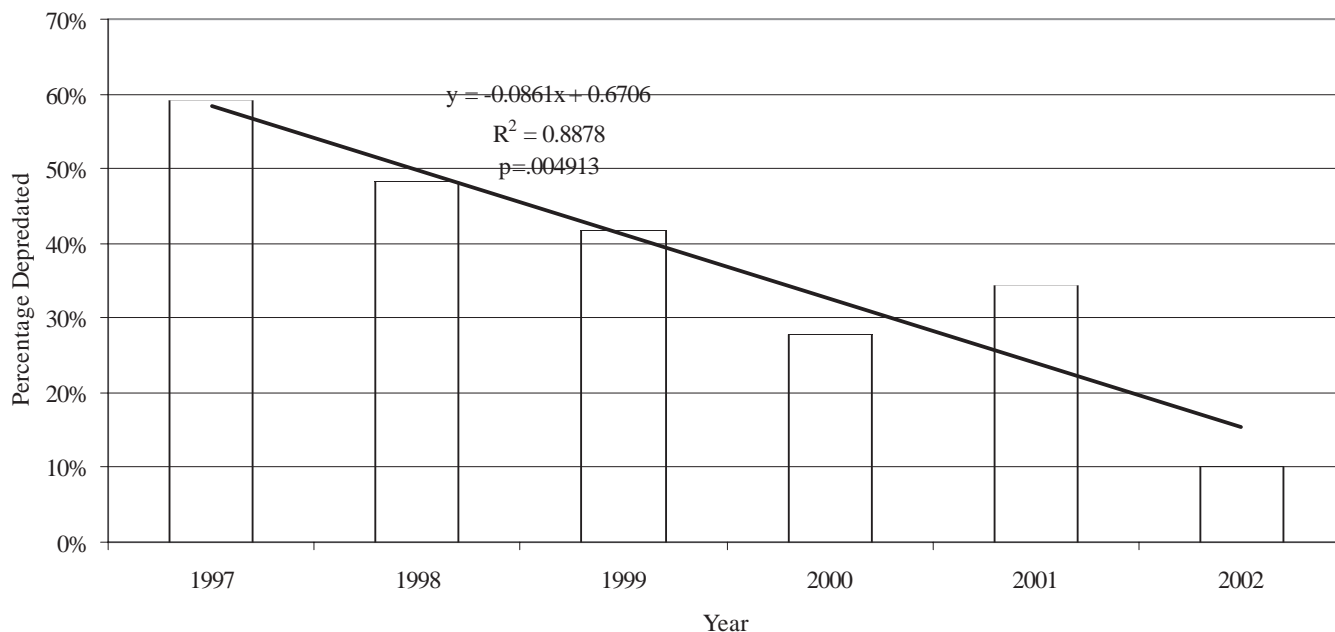
To partially combat the effects of beach erosion, sand fences were erected in 1972 to build dunes. Typically, sand fences are constructed of narrowly spaced wooden or plastic slats or plastic fabric. Sand fences must be placed properly to assure that movements of adult turtles and emergent hatchlings are unimpeded (National Marine Fisheries Service and Fish and Wildlife Service 1991). From 1974 to 1978, and again from 1997 to 1999, sea oats were planted to build and stabilize the dunes. Sea purslane was planted from 1975 through 1978, for the same purposes (Bain et al., 1997). Extensive erosion along the northern beach of the refuge has exposed the stumps of black and red mangroves, and Australian pine extends into the water. This situation has created hazardous conditions for nesting turtles and hatchlings. Extensive efforts to remove Australian pine from the beach has enhanced turtle nesting success.

Beach renourishment projects have been the primary method with which to control the ongoing beach erosion process. Beach nourishment involves pumping, trucking or scraping sand onto a beach to restore sand lost by natural erosion forces (National Marine Fisheries Service and Fish and Wildlife Service 1991). Beach renourishment has occurred numerous times over the last three decades. Since 1965, 2,308,300 cubic yards of sand have been placed on Jupiter Island, north of the refuge.

Between the 1996 and 1997 sea turtle nesting seasons, dredged sand was placed along two regions of refuge beach. Extensive escarpments were observed throughout the 1997 season within both of these filled areas, and they appeared to have a large impact on nesting sea turtles during that year. However, the size and persistence of escarpments were greatly reduced by the 1998 season and has had little effect, since then, on the turtle's ability to access suitable nesting habitat.

Birds. Although the Jupiter Island beach is significant for sea turtle nesting, the importance of this same beach to migratory birds cannot be underestimated. In 1974, 225 least terns were recorded nesting on the Island Tract at Peck Lake on a backdune area cleared of Australian pines. Additional observations were not recorded until 1998 when 11 nests and 17 fledglings were observed on the narrow foredune strip. These positive signs in nesting result from the removal of exotic Australian pine and retardation of dune vegetation. Nesting attempts declined and were thwarted by inadequate habitat space and human disturbance in 1999, 2000, and 2001 (Marian Bailey, pers. comm. 2003)

Figure 17. Percentage of marked sea turtle nests depredated, Hobe Sound National Wildlife Refuge, 1997-2002. Data analysis by Ecological Associates, Inc.



It is common to observe little blue and tricolored herons and snowy egrets foraging along the Intracoastal Waterway and ocean coast. However, nesting habitat is not available on the refuge for these species.

Piping plovers are occasionally observed on the beach, usually during fall migration; however, they are also seen on nearby beaches during the breeding season and winter months. Refuge biologists are cooperating with state and local biologists to conduct a winter census of piping plovers on nearby beaches, including the refuge. This census will provide more information on the seasonal use of the refuge by non-breeding plovers. Additional study is needed to determine the contribution that the refuge makes toward the recovery of this species.

Exotic Species

A discussion of the biological environment of the refuge would not be complete without a major discussion of exotic species.

Wildlife

Some exotic wildlife survive due to the refuge's northerly geographic location. However, the refuge seems to be immune to many of the exotic wildlife species that commonly occur in extreme south Florida. As urban areas expand, the likelihood increases that new species may become established. South Florida supports more introduced animal species than any other region in the continental United States (Simberloff et al., 1997). (See Figure 18 for a list of exotic wildlife species that occur on the refuge.)

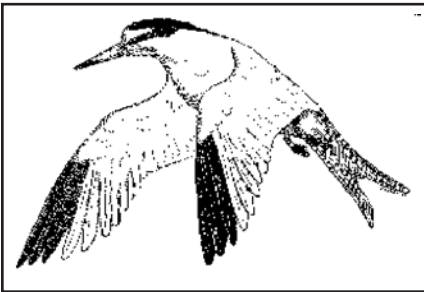
Figure 18. Exotic wildlife reported on Hobe Sound National Wildlife Refuge.

Exotic Wildlife	Breeding Status
<i>Birds</i>	
European starling (<i>Sturnis vulgaris</i>)	yes
parakeet spp.	no
parrot spp.	no
<i>Mammals</i>	
nine-banded armadillo (<i>Dasypus novemcinctus</i>)	yes
feral cat (<i>Felis domesticus</i>)	yes
house mouse (<i>Mus musculus</i>)	yes
black rat (<i>Rattus rattus</i>)	unknown
Norway rat (<i>Rattus norvegicus</i>)	unknown
<i>Reptiles</i>	
brown anole (<i>Anolis sagrei sagrei</i>)	yes
Indo-Pacific gecko (<i>Hemidactylus garnotii</i>)	yes
Mediterranean gecko (<i>Hemidactylus turcicus turcicus</i>)	yes
Amphibians	
Cuban brown tree frog (<i>Osteopilus septentrionalis</i>)	yes
<i>Invertebrates</i>	
Mexican elongate twig ant (<i>Pseudomyrmex gracilis</i>)	yes
imported red fire ant (<i>Solenopsis invicta</i>)	yes
German cockroach (<i>Blatella germanica</i>)	yes
Oriental cockroach (<i>Blatella orientalis</i>)	yes
Asian tiger mosquito (<i>Aedes albopictus</i>)	yes
Florida bromeliad weevil (<i>Metamasius mosieri</i>)	yes

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The greatest exotic mammal threat to the refuge is the nine-banded armadillo. Raccoons and armadillos are major predators of endangered sea turtle nests and eggs. Often, armadillos fail to find the egg chamber, leaving it vulnerable to secondary predators such as fire ants. The refuge currently controls armadillos under an approved Predator Control Plan with technical assistance and support from the U. S. Department of Agriculture.

The European starling is the most common exotic bird species observed at the refuge. It is the most common exotic bird found throughout North America and populations now number in the millions. Parrot and parakeet species occur as free-flying flocks and likely pose no threat to native wildlife species. They may, however, help to spread the seeds of non-indigenous exotic plants.

At least four species of exotic animals have naturalized populations in south Florida. Exotic lizards such as the brown anole, Indo-Pacific gecko, and Mediterranean gecko are the primary concerns. The brown anole may prove to be a predator of the Florida scrub lizard and/or the six-lined racerunner and has already impacted native green anole populations (Marian Bailey 2003). It does compete for space and food and is common throughout south Florida. Geckos are commonly found in refuge buildings, being particularly visible at night. They primarily feed on insects, and their effects on native wildlife are poorly understood. The Cuban brown tree frog is a confirmed resident and predator on native tree frogs. Exotic insects such as the imported red fire ant, German cockroach, Oriental cockroach, Mexican elongate twig ant, Florida bromeliad weevil, and Asian tiger mosquito have been documented as occurring on the refuge. Fire ants pose a significant public health risk and are secondary predators on sea turtle eggs and hatchlings. They also displace native, less aggressive ant species and prey on native insects. The Martin County Mosquito Control periodically treats larval mosquitos during severe outbreaks on Jupiter Island. The Florida bromeliad weevil kills the giant wild pine and reflexed wild pine and has decimated large bromeliad populations near the refuge. The weevil has been documented killing giant wild pine at the refuge (Marian Bailey 2002). A recent concern is over the threat of spread of the lobate lac scale insect from Palm Beach County where it is killing many species of native trees. A survey performed by the Department of Agriculture, April 2003, found no evidence of the insect on the refuge or at the neighboring Jonathan Dickinson State Park.

Plants

A number of non-native invasive plants inhabit the refuge. These plants compete with native species for space and are of limited value to wildlife compared with their native counterparts. These alien plants, lacking natural predators and insects to keep them in check, rapidly expand forming dense, monotypic forests and thickets which are undesirable to humans and wildlife.

A number of exotic plants are found on the Mainland Tract, including Australian pine (*Casuarina equisetifolia*); Brazilian pepper

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(*Schinus terebinthifolius*); common bamboo (*Bambusa vulgaris*); golden bamboo (*Phyllostachys aurea*); Surinam cherry (*Eugenia uniflora*); rosary pea (*Abrus precatorius*); melaleuca (*Melaleuca quinquenervia*); lantana (*Lantana camara*); and Old World climbing fern (*Lygodium microphyllum*). (See Figure 19.) Old World climbing fern, a native of Asia, was first found in Martin County in the late 1950s (Beckner 1968). This species prefers wet sites and grows particularly well along the ecotone between wet and dry habitats. This species has heavily impacted over 15 acres of habitat on the refuge and remains one of the most significant exotic species problems that face the refuge. Fourteen exotic plants are found on the Jupiter Island Tract. Of these, Australian pine (*Casuarina equisetifolia*); Brazilian pepper (*Schinus terebinthifolius*); and Scaevola (*Scaevola sericea*) are the most detrimental to native plants. As shown in Figure 20, Australian pine and Brazilian pepper are very prevalent on the Jupiter Island Tract.

Beginning in 1981 and continuing through the present, much of non-native plant control activities on the refuge has focused on removal of Australian pine from the Jupiter Island Tract's dune. Brazilian pepper was introduced in the late 1800s as an ornamental shrub. This widely adaptable and aggressive tree rapidly invades disturbed sites such as fence rows, roadsides, canal banks, dredge spoil sites, and abandoned farmland. It also invades pine flatwoods, sand pine scrub, cypress swamps, freshwater marshes, and mangroves. Beach naupaka (*Scaevola sericea*), a native of Hawaii, was first reported in south Florida in the mid 1970s. It is one of the top five most invasive plants on the refuge. Naupaka is most frequently found on the foredune to middledune, the western edge of the Jupiter Island Tract, and the eastern edge of the Mainland Tract, which borders the Indian River Lagoon. More recently, efforts are underway to address Australian pine along the lagoon shoreline, as well as Brazilian pepper and Old World climbing fern.

Socioeconomic Environment

History of Martin County

Hobe Sound National Wildlife Refuge is located predominately within Martin County, although land acquisition possibilities could include additions from St. Lucie and Palm Beach counties. Martin County was established in 1925, when a large portion of Palm Beach and a smaller section of St. Lucie counties were combined.

The county was named for John W. Martin, the Governor of Florida from 1925 to 1929. Prior to statehood in 1845, the coast and inland were inhabited or traversed by several Native American tribes, including the Ays, Calusa, and Seminoles. During the colonial period, other native peoples were driven south from Georgia into the general region. The Spanish controlled much of the area until 1819, when it was transferred to the United States.

Transportation has always been part of Martin County's history. Located on Florida's Treasure Coast, Martin County is the site of several shipwrecks from the 1700s when Spanish ships carrying

Figure 19. Exotic vegetation on Mainland Tract, Hobe Sound National Wildlife Refuge. *

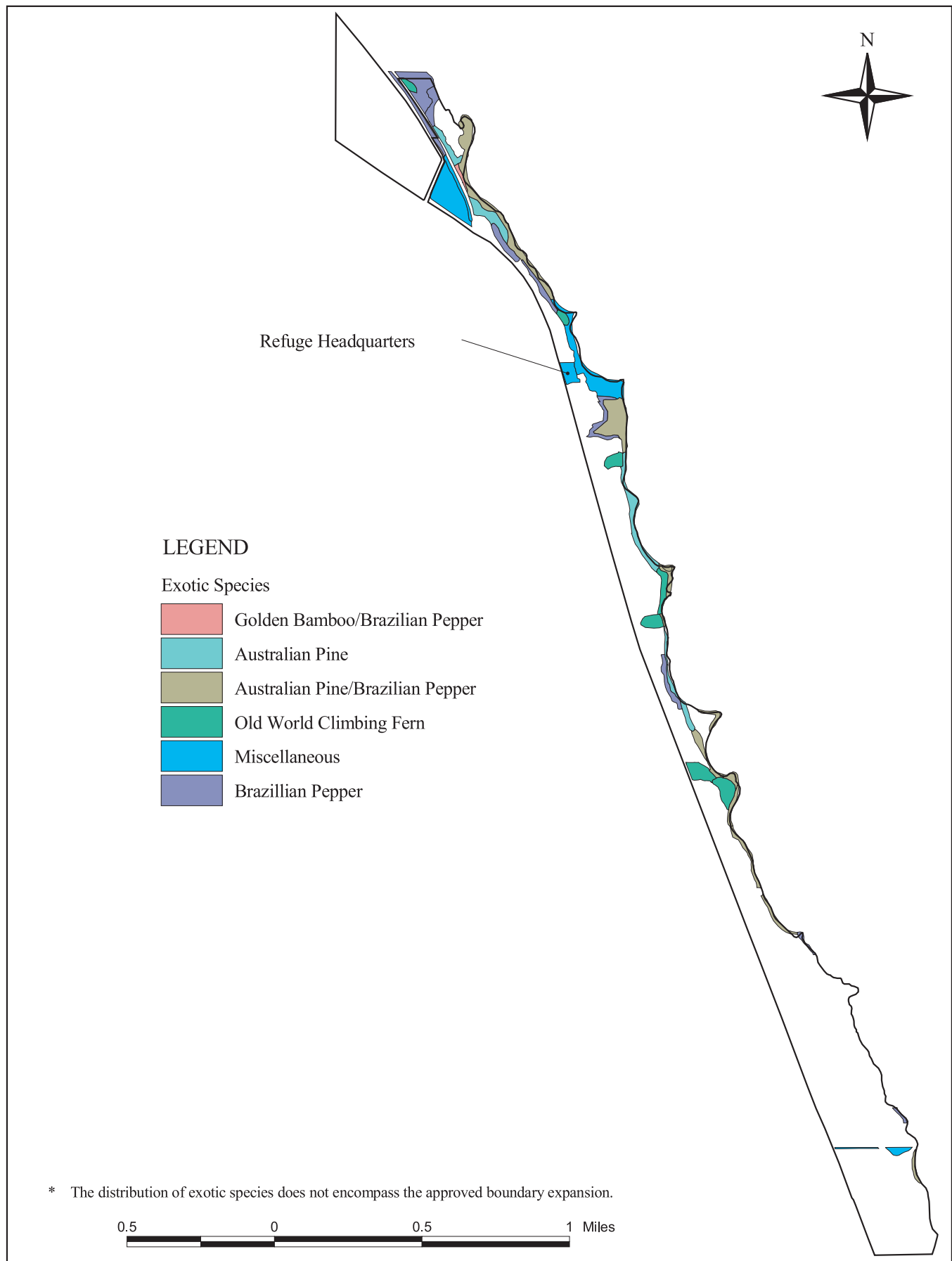


Figure 20. Exotic vegetation on Jupiter Island Tract, Hobe Sound National Wildlife Refuge. *



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treasures wrecked offshore during hurricanes. Ships from other countries have met the same fate over the years and have added to the local lore. During the early 1900s, Henry Flagler's Florida East Coast Railway was developed and ran through Martin County on its route from Jacksonville to Miami. Citrus and pineapples could be shipped north by rail and the first tourists began arriving south soon thereafter. Much later, many Martin County communities were negatively impacted by the development of the highway system, which bypassed many smaller towns throughout the county. Martin County was formed when local residents became upset over excessive taxes from Palm Beach County. Locals lobbied Governor John Martin and others. Eventually Martin County was formed on May 29, 1925, and was named for the governor. Stuart became the county seat. Later in the 1920s, land speculation in Florida peaked and then declined. Many land investors pulled out of the state. This economic downturn was furthered by devastating hurricanes in the late part of the decade, which wiped out many agricultural crops, houses, and businesses. It took nearly two decades for the local communities to recover. From the 1940s through the 1960s, the county began to grow—mostly through in-migration from the north. Starting in the 1970s and into this current period, many of the in-migrating residents are from south Florida. Martin County is one of the fastest growing areas in the state.

Land Use and Values

Over the period of 1980 to 1995, the population and density of Martin County have increased more than 70 percent. Nevertheless, the majority of land (54 percent) remained in agricultural production. Important agricultural products in Martin County included citrus, sugarcane, and ornamental crops. Martin County is roughly 12 percent forested, primarily by pine and other softwoods. Of the forested land, approximately 29 percent is owned by the state and 1 percent by the county, while 35 percent is corporately owned and 35 percent is individually owned.

Increasing land values in Martin County have influenced the average value per acre of farmland and buildings. The average increased 44 percent over a 10-year period from a little more than \$2,000 in 1982, to \$3,000 in 1992. The 1992 farmland and building average in Martin County was more than 50 percent higher than the state average for that same period (\$3,189 and \$2,037). Total value of agricultural crops increased 95 percent over that 10-year period, even though total farm land decreased almost 30 percent. Most of the total value (88 percent) is attributable to crops (including sugarcane, citrus, and greenhouse crops), while livestock, poultry, and related products contribute a much smaller portion (12 percent).

Demographics

Over the 10-year period from 1980 to 1990, the population and density of Martin County increased nearly 60 percent (64,014 to 100,900). In the decade between 1990 and 2000, Martin County grew an additional 26 percent (from 100,900 to 126,731), while the State of Florida grew by 24 percent and the rest of the country grew by 9

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percent (Martin County Demographic Characteristics Report, December 2001). (See Figure 21.) This increase has been due entirely to in-migration.

Like many counties in south Florida, Martin County's population has become more diverse. Caucasian and African American populations decreased as a percentage of the total population from 1980 to 1990, while the Hispanic and Asian populations have more than doubled. The education level of the population is slightly higher than the state average.

In the year 2000, the U.S. Census Bureau reported Martin County's median age at 48 years, compared to the State of Florida's median age of 41 years and a national median age of 34 years. There is an age disparity based on the location of people within the communities of Martin County. The year 2000 data show the median age in the coastal communities of Hutchinson Island, Sewall's Point, and Jupiter Island is 61 years. The urbanized areas of the city of Stuart and surrounding locations have a median age of 52 years. The inland farming communities of western Martin County and Indiantown have a median age of 27 years.

Martin County has become increasingly popular as a vacation spot or winter home for many individuals. It is estimated that during the peak seasonal months, the population is 28 percent greater than the permanent population (Martin County Demographic Characteristics Report, December 2001). The county's average family wage in the year 2000 was \$52,924, ranking it among the highest in the State of Florida. Jupiter Island was ranked as the wealthiest community in the nation for the fourth year in a row by Worth Magazine, with an average home sale value of \$4 million. In general, the residents of Martin County who are likely to visit the refuge are seasonal visitors who are interested in wildlife interpretation, over the age of 50, and well-educated. Nevertheless, a large percentage of recreational visitors are fishermen who live in the area year-round.

Resource Economics

Estuarine and marine fish are integral to the economy of south Florida and reflect, to a large extent, the health of aquatic systems and the South Florida Ecosystem as a whole. An estimated 94 percent (by weight) of commercially and recreationally important marine fish species of south Florida's Atlantic coast are dependent on estuarine habitats for critical life processes (Chambers 1991). The estuarine and coastal ecosystems of south Florida and the refuge provide a nursery for a wide variety of fish and shellfish species, which support offshore fisheries in the south Atlantic. The Indian River Lagoon is a key nursery area for various marine species including spotted sea trout, red drum, snook, and croaker. The lagoon provides half of Florida's east coast fish catch and 90 percent of the state's 750,000 pound clam (*Mercenaria campechiensis* and *M. mercenaria*) harvest (Indian River Lagoon National Estuary Plan 1998).

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In September 1998, the National Oceanographic and Atmospheric Administration reported that Florida was ranked first in saltwater recreational fishing. There were 4.4 million saltwater fishing participants, including over 2 million out-of-state tourists who took 24 million fishing trips. Florida anglers spend hundreds of millions of dollars each year fishing for Atlantic croaker (*Micropogonias undulatus*); red drum (*Sciaenops ocellatus*); spotted sea trout (*Cynoscion nebulosus*); snook (*Centropomus sp.*); snapper (*Lutjanus sp.*); grouper (*Epinephelus sp.*); shark (30-40 species); and spiny lobster (*Panulirus argus*).

In 1997, the National Marine Fisheries Service reported that the top ten species caught were herring (caught for bait); Atlantic

Figure 21. Socioeconomic profile of Martin County, Florida 1980-2000.

Characteristic	2000	1990	1980
Population (Number)	126,731	100,900	64,014
Population Density (Pop./sq miles)	228	182	115
Race/ethnicity (Percentage)			
Caucasian	89.9	88.9	90.4
African American	5.3	5.9	7.1
Hispanic	7.5	4.4	2.1
Native American	0.3	0.2	0.2
Asian	0.6	0.6	0.2
Education:			
Percentage of population over 25 with a high school degree	85.3	79.7	70.3
Percentage of population over 25 with a college degree	26.3	20.3	15.9

croaker; spotted sea trout; pinfish (*Lagodon rhomboides*); summer flounder (*Paralichthys dentatus*); spot (*Leiostomus xanthurus*); black sea bass (*Centropristis striata*); bluefish (*Pomatomus saltatrix*); Atlantic mackerel (*Scomberomorus maculatus*); and weakfish (*Cynoscion regalis*). It also reported that there were 272 commercial fishing license holders and 12 wholesale seafood dealers in Martin County. County commercial landings generated a dockside value of \$1,071,529.

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National and Regional Context

According to the 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation for Florida, for people 16 years and older, there were 3.1 million participants in fishing, 226,000 participants in hunting, and 3.2 million wildlife watchers.

In the 4-county (Palm Beach, Martin, St. Lucie, Indian River) state planning region encompassing the refuge, there were 62 million participants in outdoor recreation in 1992. Of these participants, 47 percent were tourists, 39 percent were residents of the region, and 14 percent were Florida residents located outside of the region. The most popular outdoor recreation activities were saltwater beach activities, bicycle riding, fishing, hiking, picnicking, and nature study. The activities with the highest projected facility needs for the year 2000 include freshwater and saltwater non-boat fishing and hiking, bicycling and horseback riding trails.

Numerous recreational and educational activities and services are also provided by nearby state park lands such as Jonathan Dickinson State Park, Seabrook Preserve State Park, and St. Lucie Inlet Preserve State Park. These include boating, fishing, camping, and wildlife observation.

Refuge Recreation Use

Access to the refuge occurs primarily through three public use areas: the headquarters area on the mainland, the beach parking lot and dune walk-overs on Jupiter Island, and the Peck Lake area 2 miles north of the parking lot dune walk-overs (Figure 22).

As shown in Figure 23, a large majority (nearly 78 percent) of the refuge's visitors participate in interpretation and nature observation. The small museum run by the Nature Center attracts families that enjoy the displays, as well as the snakes, lizards, fish, insects, birds, and other creatures found within the scrub habitat of the refuge. Others enjoy walking to the Indian River Lagoon to watch pelicans, osprey, herons, egrets, and a variety of shorebirds along its sugar sand beach or walking along the short sand pine scrub trail. Beach-related recreation such as swimming, surfing, shelling, or sunbathing is the second most popular activity on the refuge. Saltwater fishing is the third most important activity occurring on the refuge. The refuge is open for day use only; camping is not permitted.

Wildlife Observation and Photography. Wildlife observation and photography, notably of birds, manatees, and dolphins can occur at most locations along the Indian River Lagoon where access permits. Other observation sites are found along U.S. Highway 1, at the headquarters area, at the Sand Pine Scrub Trail, and along the beach and Peck Lake crossover.

Figure 22. Location of recreational and administrative facilities, Hobe Sound National Wildlife Refuge.

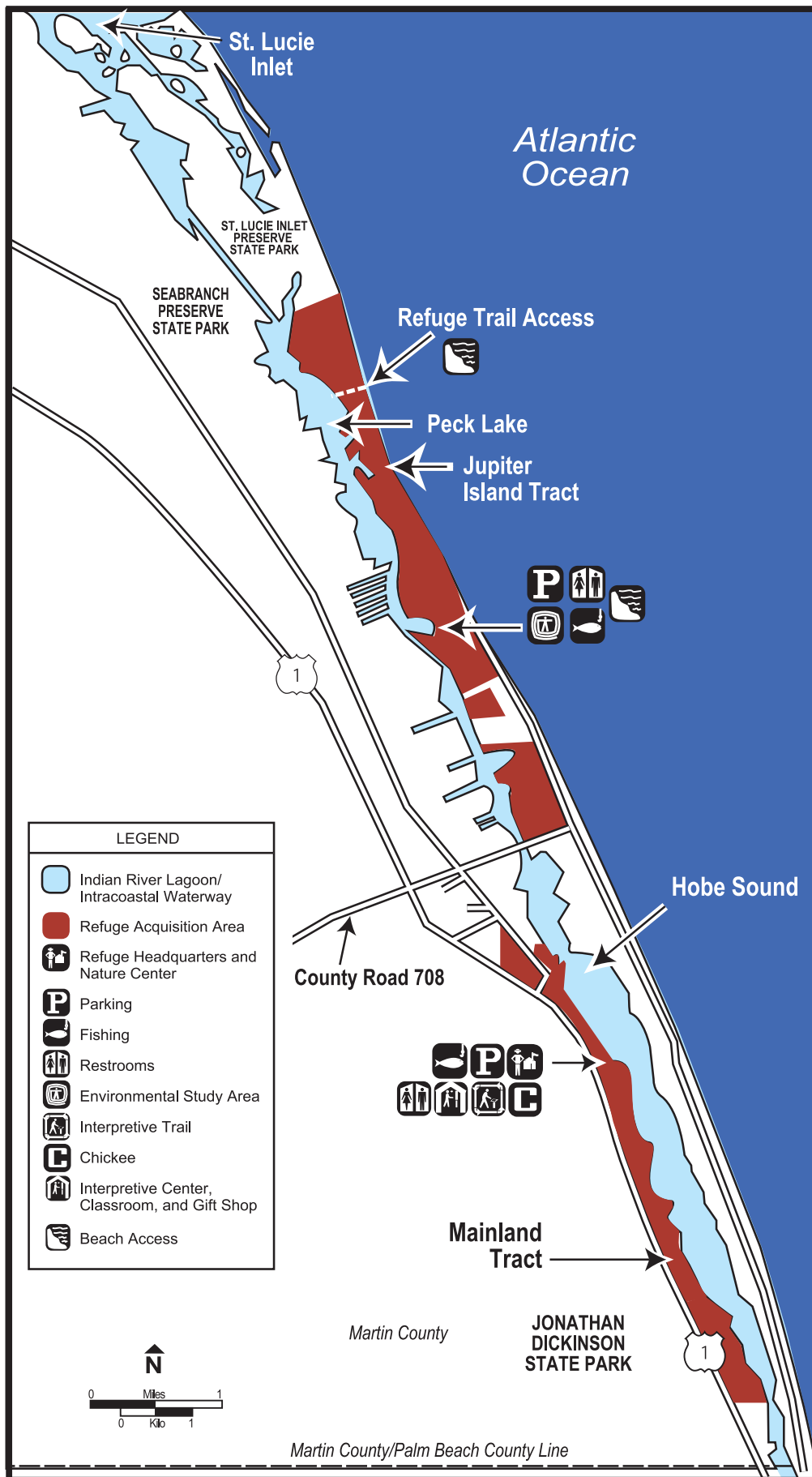


Figure 23. Summary of public use on Hobe Sound National Wildlife Refuge.*

PUBLIC USE:	2002	2001	2000	1999
Total Visitors	111,014	109,267	113,659	121,682
Interpretation and Nature Observations	86,126	17,121	23,009	21,616
Environmental Education	30,521	38,132	32,321	36,555
Beach and Water Use	34,329	92,877	96,610	103,429
Saltwater Fishing	14,126	15,621	18,237	6,000
VISITOR FACTORS:	2002	2001	2000	1999
Number of Visitors	111,014	109,267	113,659	121,682
Percent Beach Related	85%	85%	85%	85%
Single Entry Vehicles	2,702	1,915	1,885	1,568
Golden Age Passports	392	501	551	465
Golden Access Passports	4	0	31	0
Duck Stamps	80	103	143	178
Golden Eagle Passports	13	8	7	7
Golden Eagle Upgrades	4	6	1	0
Total Fees	\$38,190	\$44,377	\$44,826	\$40,411

*Information is derived from the Hobe Sound National Wildlife Refuge Annual Narratives, Calendar Years 1999-2002.

Interpretive Programs. The headquarters area, with its Jackson Burke Educational Center and classroom, hosts lecture programs, turtle walks, an environmental education school for school groups, and an environmental education day camp during the summer. The beach area and Peck Lake area have interpretive displays.

Fishing/Hunting. Sport fishing occurs in the sound, on the beachfront, and in Peck Lake Lagoon, except for those areas that are posted closed. Only rods, reels, or poles and lines are permitted; these must be attended at all times. Fishing use is governed by both state and refuge regulations. Hunting is not allowed on the refuge for a variety of reasons including the narrow lay of the land, the number of rare species, the close proximity to developed areas, and safety issues.

Boating/Canoeing. Boating (e.g., motor or sail), canoeing, kayaking, and personal watercraft are permitted in the Intracoastal Waterway and in the Peck Lake area. Boat access is along the Intracoastal Waterway, but no docking or launching facilities are available at the refuge. The waterway is patrolled

by law enforcement officers from the Florida Fish and Wildlife Conservation Commission, the Martin County Sheriff's Office, the Coast Guard, and the Fish and Wildlife Service.

Recreation Economics

Data concerning average recreational expenditures per visitor-day by specific activities for the Southeast Region (Laughland and Caudill 1997) show that non-consumptive activities (such as swimming and sunbathing) and saltwater fishing, which are major refuge recreational activities, contribute to Martin County's economy. Each visitor-day of non-consumptive activities, on average, produces about \$12 in spending for residents, and nearly \$36 in spending for non-residents (1992 dollars). Saltwater fishing produced significantly higher spending averages for non-residents (\$81), but less for residents (\$20). Refuge visitation and the accompanying spending by visitors undoubtedly contributes to the economy of Martin County.

Cultural Environment

Prehistoric Influences

By the time European explorers stepped foot on the Florida peninsula, five tribal groups were associated with the east coast of Florida. These groups were the Timucua to the north, and the Ays, the Guacata, the Jeaga, and the Tequesta to the south. All tribes were known to collect shellfish and other marine and aquatic resources, which resulted in large shell and bone middens near their villages (Andrews and Andrews 1985). Most of what is known about these groups was gained from the diary of a ship-wrecked Englishman who was forced to travel up the Florida coast. This Englishman was the now renowned Jonathan Dickinson. His account is an important look at the lives of the indigenous population of Florida. Jonathan Dickinson State Park is adjacent to the Hobe Sound National Wildlife Refuge.

The prehistoric indigenous people of Florida engaged in intensive shellfish collecting and resulted in many of the shell middens evident today. The Joseph Reed Shell Ring (8MT13) is a semi-circular mound of oyster shells between 700 and 800 feet in diameter and rising up to 2 meters in height at the refuge on the Jupiter Island Tract. Little research had been conducted in the area of Hobe Sound National Wildlife Refuge until 1980, when four sites were recorded in the Florida Master Site File (Fryman et al., 1980). A recent study by Russo and Heide (2002), discusses the significance of this most impressive site in detail.

Ten state-listed archaeological sites are either on the refuge or very near its boundaries. All sites have the chronology of being labeled "pre-historic, period unknown" and may be eligible for listing on the National Register of Historic Places. The 8MT6 site (near Olympia light), the 8MT7 site (at the northern end of Jupiter Island), the 8MT9 site (also on Jupiter Island) and the 8MT13 site were the earliest recorded sites. The "Rolling Hills Site" (8MT374) is a shell midden on a former xeric dune environmental setting. The Hobe Sound #1 site, listed as 8MT1280, is a

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*"These people neither
sow nor plant any
manner of thing what-
soever; nor care for
anything but what the
barren sand produce."*

Jonathan Dickinson 1696

shell midden in a tropical hardwood hammock. A site known as 8MT1279, is also a shell midden located in a tropical hammock setting. The Hobe Sound #2 site is 8MT1286, a large shell midden in a tropical hardwood hammock and scrub environmental setting. The Simpson Hill site (8MT375) is a shell scatter on a xeric dune in the right-of-way of U.S. Highway 1. The Hobe Sound #3 site, 8MT1287, is a shell midden in a scrub/xeric hammock environmental setting.

Historic Influences

The First Spanish Period (1513-1763) was mostly concerned with the shipping routes of the Spanish that hugged the Florida coast. Little was known about the interior of the state until Ponce de Leon's visit in 1513, and little was known after his foray into the interior. As outposts were established on the east coast, at least one documentation of native-European hostilities is recorded near the Hobe Sound National Wildlife Refuge. The disease and trouble that the Spanish brought with them to the natives may have contributed to a migration of the Indians to the south.

Little development of land was initiated until the Second Spanish Period. It is during this time (1783-1821) that Eusebio Maria Gomez was awarded a land grant (1815) that is now part of the refuge. This land, petitioned from the Spanish government, was described as "12,000 acres on the shores of Jupiter Island and of the River St. Lucia" (U.S. Works Project Administration, Spanish Land Grants, Con 627, III: 186-187, in Fryman et al., 1980:23). Although the legal status of the land has changed hands several times, the name Gomez, as in "Gomez Tract" or "Gomez Grant," is still used to refer to the land on the Hobe Sound National Wildlife Refuge.

Modern Influences

Another settler to the area is a person by the name of Peck who settled on the shores of what is now referred to as Peck Lake (Fryman et al., 1980). A Georgia cotton farmer and banker, Samuel H. Peck is said to have settled here with his family around 1837 and departed around 1845 (Hutchinson 1998).

Settlement of the general area was facilitated by the work of the Florida Coast Line Canal and Transportation Company created in 1881. This company worked at improving the inland waterway from the St. Johns River to Key Biscayne (Fryman et al., 1980). By the mid-1880s, settlers were established in settlements of Scots and English pineapple growers. Initially, homesteaders used the waterways to receive and send supplies and agricultural products. By 1894, the Florida East Coast Railway was established and the new transportation and job opportunities increased settlement of the area (Weed et al., 1982). The railroad greatly increased the ability of farmers to transport their crops to market.

The development of the area continued when the Olympia Improvement Association purchased the Gomez Grant from the

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Indian River Association and set about making plans to create an extensive community. By 1932, the Hobe Sound Company purchased portions of the old Gomez Grant. Shortly afterwards, the town of Hobe Sound was established (Hutchinson 1998). With the help of an initial 173-acre tract donation by the Reed family, the Hobe Sound National Wildlife Refuge was created on September 30, 1969.

From the 1940s through the 1960s, Martin County began to really grow, mostly through in-migration from the north. Starting in the 1980s through today, many of the new in-migrating residents are from south Florida. Martin County is part of the Treasure Coast and one of the fastest growing areas in the state.