Threatened and Endangered Species Survey for Patrick Air Force Base, Florida

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Abstract

A review of previous environmental work conducted at Patrick Air Force Base (PAFB) indicated that several threatened, endangered, or species of special concern occurred or had the potential to occur there. This study was implemented to collect more information on protected species at PAFB.

A map of landcover types was prepared for PAFB using aerial photography, groundtruthing, and a geographic information system (GIS). Herbaceous vegetation was the most common vegetation type. The second most abundant vegetation type was disturbed shrubs/exotics. The beach and associated dune vegetation comprised 3.2% of the land area, but was the most extensive natural community within PAFB. A few isolated mangrove communities exist along the Banana River.

Seventy-seven species of vascular plants occurred on the dunes, including four species listed by state agencies: spider lily (*Hymenocallis latifolia*), prickly pear cactus (*Opuntia stricta*), beach star (*Remirea maritima*), and inkberry (*Scaevola plumieri*). Surveys of other habitats revealed eighty-four species of vascular plants including two state-listed species: spider lily and prickly pear cactus. Many of these areas are dominated by invasive, exotic species, particularly Brazilian pepper (*Schinus terebinthifolius*) and Australian pine (*Casuarina equisetifolia*), and native species of open or disturbed sites such as camphorweed (*Heterotheca subaxillaris*) and beardgrass (*Andropogon* spp.). Due to the isolation of PAFB from other natural areas, most exotic plant populations on the base are not an immediate threat to intact native plant communities.

Dune habitat was surveyed for the southeastern beach mouse (*Peromyscus polionotus niveiventris*) by quarterly trapping along eight 100 m transects. No beach mice were found. The limited extent of dune habitat, its fragmented condition, and the isolation of PAFB from extant populations of the beach mouse probably accounts for its absence.

Surveys of birds on PAFB found an avifauna characteristic of species that occur in the Indian River Lagoon system. Twenty-five species of waterbirds were observed during quarterly surveys on PAFB, including five species listed as species of special concern by the state of Florida: Snowy Egret (*Egretta thula*), Little Blue Heron (*Egretta caerulea*), Tricolored Heron (*Egretta tricolor*), White Ibis (*Eudocimus albus*), and Brown Pelican (*Pelecanus occidentalis*). The Golf Course was used extensively by almost all species of waterbirds on PAFB. Twenty-two species of shorebirds were observed on PAFB. Although no listed species were observed, the potential exists for several protected species of shorebirds to use the beach at PAFB during some parts of the year. The Airfield runways and associated grass areas were important sites at PAFB for loafing and feeding for some shorebirds.

Surveys of rooftop nesting by Least Terns (*Sterna antillarum*) on PAFB found a large colony on a rooftop in the PAFB Industrial Area. This colony produced some independent young. Two rooftop Least Tern colonies reported from previous years were inactive during 1996. A small number of Black Skimmers (*Rhynchops niger*) attempted to nest at the Least Tern colony but were unsuccessful.

Surveys for the gopher tortoise (*Gopherus polyphemus*) revealed burrows and tortoises only at the Waste Study Site; five burrows and three tortoises were observed. No Florida scrub lizards (*Sceloporus woodi*), eastern indigo snakes (*Drymarchon corais couperi*), or diamondback terrapins (*Malademys terrapin terrapin*) were observed. American alligators (*Alligator mississippiensis*) were observed on the Golf Course and using ditches, ponds, and areas along the Banana River.

The amount of dune habitat could be expanded by not mowing areas adjacent to the dunes to allow dune species to colonize and expand. Planting dune species as part of the beach renourishment project will also increase this habitat. Exotic plants dominate several areas on the base and are used by threatened, endangered, and species of special concern. However, the use of native vegetation in landscaping projects throughout the base would improve habitat for wildlife, and invasive, exotic plants should not be used in any horticultural plantings. Water quality of ponds, ditches, and canals is important for waterbirds; it should be maintained and protected from contamination. Nesting Least Terns are sensitive to disturbance; rooftops used for nesting should be protected from disturbance. Monitoring of Least Tern and Black Skimmer nesting should be continued to determine what roofs are being used and whether nesting is successful. Furthermore, based on the large numbers of waterbirds observed on PAFB, continued monitoring of them is recommended.

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Acknowledgments

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Introduction

Patrick Air Force Base (PAFB) is located on a barrier island on the central east coast of Florida (Figure 1), south of the city of Cocoa Beach. The U.S. Navy established the installation in 1940 as the Banana River Naval Air Station which served as an active base for anti-submarine sea-patrol planes during World War II. After the installation's deactivation in 1947, it was transferred to the U.S. Air Force (USAF) in 1948. It was renamed Patrick Air Force Base in 1950 in honor of the chief of the U.S. Army Air Service from 1921 to 1927, Major General Mason M. Patrick. At this time the USAF began developing the Eastern Test Range. From 1950 to the present, the 45th Space Wing, formerly the Eastern Space and Missile Center (ESMC), has been responsible for launch, test, and support operations associated with the ballistic and cruise missile programs, the Apollo, Space Shuttle, Delta, Atlas, and Titan programs. The missions of PAFB include safety, planning, engineering, support services, scheduling, test operations, launch and range operations, directing or supporting operations, and test results evaluation for the 45th Space Wing. Responsibilities also include providing similar support to additional Department of Defense (DOD) programs and activities.

The main base covers approximately 784 ha and is bounded by the Atlantic Ocean on the east and the Banana River on the west (Figure 1). There is little topographic relief across PAFB, with elevations from 0 to 6.1 m above mean sea level (MSL), and the highest elevations corresponding to sand dunes along the Atlantic Ocean (Berger 1993). From the dunes, the site gently slopes northwest toward the Banana River shoreline.

PAFB, like Cape Canaveral Air Station (CCAS) and Kennedy Space Center (KSC) to the north, is located on a barrier island. Barrier islands are linear islands of sand that parallel many gently sloping coastlines around the world (Johnson and Barbour 1990). Barrier island ecosystems are important natural areas that support many plants, animals, and natural communities. Examples of natural communities that comprise the barrier island ecosystem are coastal dunes, strand, and scrub communities, and maritime hammocks. These are among some of the most fragile and endangered natural upland communities in Florida and the nation. Barrier islands along the Atlantic coast are especially important for nesting sea turtles, populations of small mammals (e.g., southeastern beach mouse), and as foraging and loafing habitat for a variety of resident and migratory shorebirds, wading birds, and song birds (Johnson and Barbour 1990, Breininger et al. 1994).

Threats to the barrier island ecosystem include development/urbanization, fragmentation, isolation, edge effects, erosion, invasion by exotics, and the introduction of predators and competitors to native flora and fauna. All of these threats are present to some degree at PAFB.

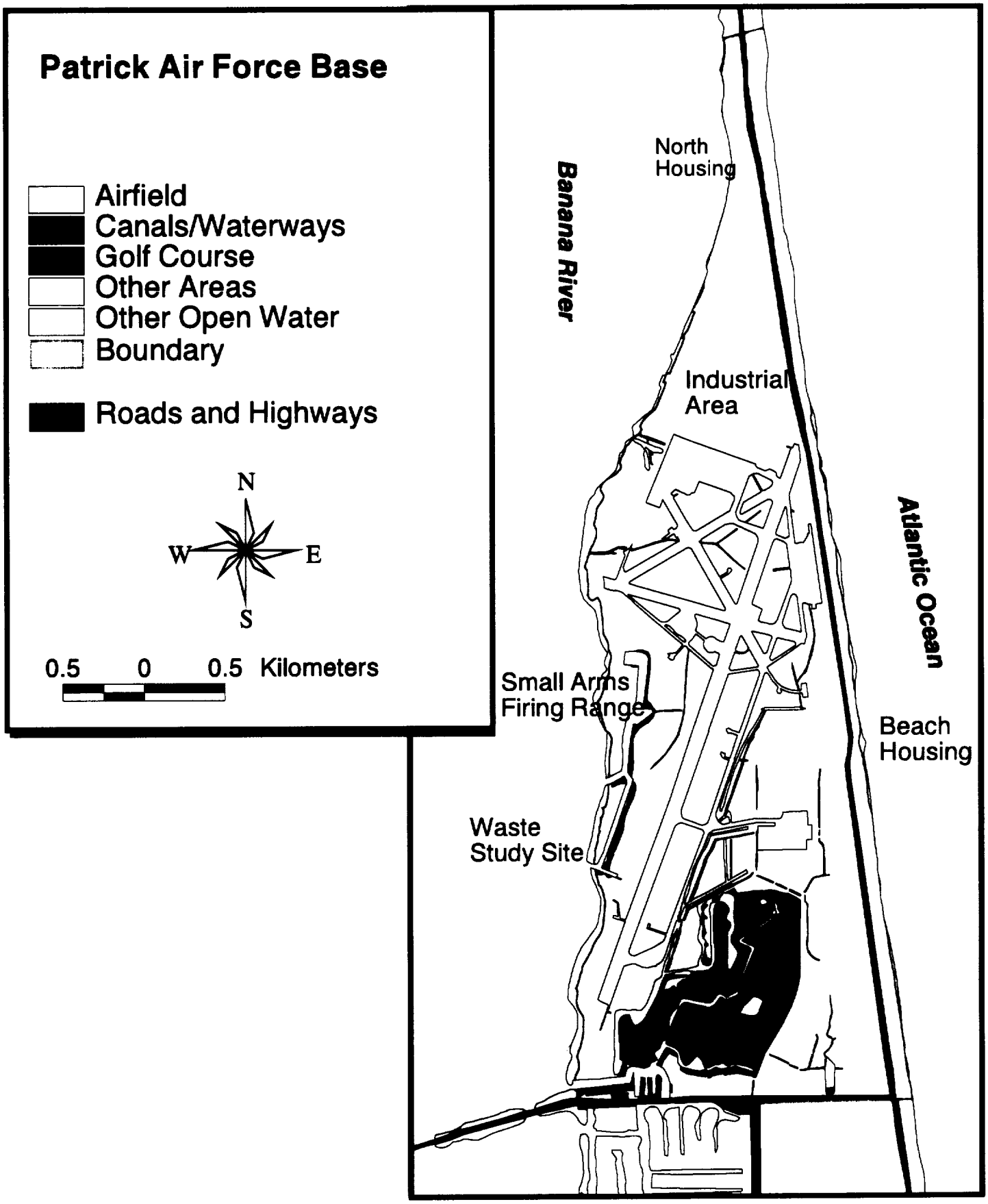

Figure 1. Land cover and barrier island geography of Patrick Air Force Base, Florida.

Approximately 200,000 ha of Florida's barrier islands have been lost to development (Johnson and Barbour 1990). In Brevard County, the greatest amount of barrier island development is between Cocoa Beach and Melbourne Beach. Barrier islands in north and south Brevard County retain one of the four largest natural to semi-natural coastal areas in the state (Johnson and Barbour 1990).

Increasing human populations in Florida have resulted in significant growth and development of coastal areas. Development results in fragmentation and isolation of coastal habitat and the introduction of exotic species. Urbanization separates native flora and fauna in a way that restricts movement or seed dispersal between native patches. Increasing edge allows invaders (exotics) to colonize easily, reducing the integrity of native communities. Development of the barrier island in and around PAFB has isolated small patches of coastal dune habitat. Often these small isolated patches can not support stable populations of native species. Because of the degradation of these natural communities, many rare, threatened, and endangered species have already been lost. To optimize maintenance of existing natural communities and encourage enhancement of native plants and animals environmental decision makers will need to focus efforts on planning and implementing a long-term ecosystem management strategy.

Shoreline erosion is of major concern to PAFB and other barrier island ecosystems worldwide. Erosion is apparent in the progressive retreat of backshore cliffs and the concomitant landward displacement of the shoreline (Carter 1988). The erosion can be attributed to a variety of causes; sea-level rise, tectonic instability and subsidence, climatic change, and numerous man-made causes (i.e., dredging, aggregate extraction, infilling or impedance of supply) (Carter 1988). Intense development on the barrier island, coupled with frequent storms contribute most to the erosion of the beaches and dunes in Florida. The seriousness of this erosion has prompted beach restoration or renourishment projects. A common technique for countering beach sediment loss or starvation is to import borrowed material. This is done by direct filling of the depleted beach zone or by gradually feeding or nourishing the beach over a period of time (Carter 1988). It is necessary to select sources of fill with care so the imported sediment will merge into the indigenous beach material, and not initiate new and unstable conditions (Carter 1988). It is equally important to revegetate renourished areas with native coastal species such as sea oats (*Uniola paniculata*) and other beach herbs. Most dune species can colonize newly deposited sand if it remains in place long enough (Johnson and Barbour 1990). The root systems of these sand-binding grasses help retain sand in place (Carter 1988), although severe storms can still cause erosion. These projects are expensive and often offer no long-term solution. Most newly restored beaches are lost to erosion within five years (Johnson and Barbour 1990).

In 1992, PAFB initiated an ongoing beach renourishment project in an effort to rebuild portions of the lost dunes. This renourishment project was scheduled to continue for two or three years (1992 to present) and to be conducted primarily during the winter months (Ehrhart 1994a). In August of 1995 Hurricane Erin hit Brevard County and washed away much of the newly restored beach and dune. At that time native coastal plants like sea oats and sea grape (*Coccoloba uvifera*) had not yet been planted to help stabilze these dunes. In 1996 the renourisment efforts entailed the dumping of fill on the beach and the planting of native coastal species for dune stabilization (D. Oddy pers. obs.).

Another noticeable threat to barrier islands and native vegetation at PAFB is exotics. Exotics are most prominent in the vegetation of the tropical portions of Florida and are common on disturbed sites (Johnson and Barbour 1990). There are two categories of naturalized exotics on Florida beaches (Johnson and Barbour 1990), those that blend into the native plant communities (e.g., Spanish bayonet, *Yucca aloifolia*) and those that exclude native vegetation (e.g., Brazilian pepper (*Schinus terebinthifolius*), and Australian pine, *Casurina equisetifolia*). All three of these species occur on PAFB. Spanish bayonet can be found in the coastal dunes while Brazilian pepper and Australian pine are located at the Waste Study Site and Small Arms Firing Range at PAFB (Figure 1). Brazilian pepper is also found in many inland habitats and on the coast, along mangrove borders, rivers, canals, and ditches. Brazilian pepper forms monospecific stands that exclude native plant species and reduce structural diversity. In south Florida, Australian pine has spread primarily on beaches and poses the greatest threat to coastal vegetation than any of the other exotic species listed above (Johnson and Barbour 1990).

A further impact of increased development is the introduction of predators and competitors to native species. Examples of these are house mice (*Mus musculus*), rats, house cats (*Felis catus*), European starlings (*Sturnus vulgaris*) and raccoons (*Procyon lotor*). All of these species potentially compete with or are predators of native species on PAFB.

Scope of This Project

The objective of this project was to survey PAFB for threatened and endangered species to develop a more detailed and accurate database for reference during development of National Environmental Policy Act (NEPA), Endangered Species Act, and other regulatory documentation and provide information to guide wildlife and biotic resource management.

PAFB was surveyed from aerial imagery and field surveys. Based on these surveys, previous work conducted, and habitat present on the base the following threatened, endangered and species of special concern could potentially occur: southeastern beach mouse, Least Tern, gopher tortoise, Florida scrub lizard, eastern indigo snake, various wading bird and shorebird species, loggerhead sea turtle, green sea turtle, and rare plants like beach star, inkberry, spider lily, and prickly pear cactus.

Specifically, in this project we: 1) reviewed previous work done on the base; 2) developed a vegetation and land use map of the base; 3) surveyed for rare plants; 4) surveyed coastal dunes for the southeastern beach mouse; 5) surveyed wading bird use of various habitats; 6) surveyed shorebird use of coastal beaches; 7) determined nesting use of base roofs by Least Terns and Black Skimmers; and 8) surveyed appropriate habitat for gopher tortoises, eastern indigo snakes, and Florida scrub lizards. Sea turtle nesting on PAFB's beaches is being studied by the University of Central Florida and was not part of this project.

Review of Previous Work on Threatened and Endangered Species

Flora and fauna reported in this section are from previous work done on PAFB, primarily biological assessments (BA's). Areas on base which support significant resources used by protected animal species include the Atlantic Ocean beaches used by Least Terns (*Sterna antillarum)*, shorebirds, nesting sea turtles, and potentially the southeastern beach mouse (*Peromyscus polionotus niveiventris*), and the Banana River lagoon and shallow water habitats used by the West Indian manatee (*Trichechus manatus latirostris*), wading birds, and shorebirds (Figure 1). The beach at PAFB provides excellent nesting ground for marine turtles. Sea oats and other beach grasses growing on the dunes constitute a potential food source for the southeastern beach mouse, a possible resident of the base. Manatees feed on submerged aquatic vegetation along the Banana River shoreline and use coastal waters for wintering and as migration corridors. Wading birds utilize the Banana River shoreline, canals, and drainage ditches for feeding and roosting. Many of the buildings on base have roofs with substrate suitable for Least Tern nesting.

Fauna

The federal and state threatened and endangered species and species of special concern at PAFB are concentrated in or along the Banana River, Atlantic Ocean, and the Golf Course. These species as well as protected species with a potential to occur at PAFB and their status as designated by the U.S. Fish and Wildlife Service (USFWS) and Florida Game and Fresh Water Fish Commission (FGFWFC) are listed in Table 1 (Halliburton 1992, USFWS 1984). Protected species reported to be resident at the base in or along the Banana River include the common snook (*Centropommus undecimalis*), American alligator (*Alligator mississippiensis*), West Indian manatee (*Trichechus manatus latirostris*), and the eastern indigo snake (*Drymarchon corais couperi*) (Halliburton 1992, Berger 1993, Vista Tech 1995). The Florida scrub lizard (*Sceloporus woodi*) potentially occurs on base in the coastal dunes and other areas. Resident protected bird species include the Brown Pelican (*Pelecanus occidentalis*), Little Blue Heron (*Egretta caerulea)*, Snowy Egret (*Egretta caerulea)*, Tricolored Heron (*Egretta tricolor)*, White Ibis (*Eudocimus albus)*, Reddish Egret (*Egretta rufescens)*, Southeastern American Kestrel (*Falco sparverius paulus)*, Wood Stork (*Mycteria americana)*, and the Osprey (*Pandion haliaetus)*, in wetland areas and the Banana River. The Least Tern and Black Skimmer (*Rynchops niger*) are also residents of the river and along the beach. Transient protected bird species include Roseate Spoonbill (*Ajaia ajaja*), American Oystercatcher (*Haematopus palliatus*), Piping Plover (*Charadrius melodus*), Arctic Peregrine Falcon (*Falco peregrinus tundrius*), and Burrowing Owl (*Athene cunicularia*). The threatened southeastern beach mouse may be a resident of dunes on the base (Halliburton 1992, Berger 1993, Vista Tech 1995). Four species of protected sea turtles nest on the beaches along PAFB. The leatherback (*Dermochelys coriacea*), Atlantic ridley (*Lepidochelys kempi*), and Atlantic green (*Chelonia mydas mydas*) are all endangered, while the Atlantic loggerhead (*Caretta caretta caretta*) is threatened.

Table 1. Protected fauna with the potential to occur at Patrick Air Force Base (USFWS 1984, Halliburton 1992).

Scientific Name	Common Name	Federal Status[1] (FWS)	State Status[1] (FGFWFC)
Fish			
Centropommus undecimalis	Common snook	NL	SSC
Reptiles			
Alligator mississippiensis	American alligator	T(S/A)	SSC
Caretta caretta caretta	Atlantic loggerhead turtle	T	T
Chelonia mydas mydas	Atlantic green turtle	E	E
Dermochelys coriacea	Leatherback turtle	E	E
Drymarchon corais couperi	Eastern indigo snake	T	T
Gopherus polyphemus	Gopher tortoise	C2	SSC
Lepidochelys kempi	Atlantic ridley turtle	E	E
Nerodia fasciata taeniata	Atlantic salt marsh water snake	T	T
Sceloporus woodi	Florida scrub lizard	C2	NL
Birds			
Ajaia ajaja	Roseate Spoonbill	NL	SSC
Athene cunicularia	Burrowing Owl	NL	SSC
Charadrius alexandrinus tenuirostris	Southeastern Snowy Plover	C2	T
Charadrius melodus	Piping Plover	T	T
Egretta caerulea	Little Blue Heron	NL	SSC
Egretta rufescens	Reddish Egret	C2	SSC
Egretta thula	Snowy Egret	NL	SSC
Egretta tricolor	Tricolored Heron	NL	SSC
Eudocimus albus	White Ibis	NL	SSC
Falco peregrinus tundrius	Arctic Peregrine Falcon	T	E
Falco sparverius paulus	Southeastern American Kestrel	C2	T
Haematopus palliatus	American Oystercatcher	NL	SSC
Haliaeetus leucocephalus	Bald Eagle	E	E
Mycteria americana	Wood Stork	E	E
Pandion haliaetus	Osprey	NL	SSC*
Pelecanus occidentalis	Brown Pelican	NL	SSC

Table 1. Continued.

Scientific Name	Common Name	Federal Status[1] (FWS)	State Status[1] (FGFWFC)
Birds			
Rynchops niger	Black Skimmer	NL	SSC
Sterna antillarum	Least Tern	NL	T
Sterna dougallii	Roseate Tern	T	T
Mammals			
Peromyscus polionotus niveiventris	Southeastern beach mouse	T	T
Trichechus manatus latirostris	West Indian manatee	E	E

1. E = Endangered
   T = Threatened
   T(S/A) = Threatened due to Similarity of Appearance
   C2 = A candidate for listing, with some evidence of vulnerability, but for which not enough data exist to support listing. See note below;
   SSC = Species of Special Concern
   NL = Not Listed
   SSC* = Species of Special Concern in Monroe County only

Note: Although C1 and C2 species are not protected under the Endangered Species Act, Volume 55, Number 35, pages 6184-6229 of the Federal Register designates them as "candidates," and the USFWS "encourages their consideration in environmental planning..."

As of 1996 the following species status' have changed: the Bald Eagle has been downlisted by both FGFWFC and USFWS from endangered to threatened; and the Arctic Peregrine Falcon has been delisted by the USFWS but still remains endangered at the state level (Wood 1996).

The University of Central Florida (UCF) Marine Turtle Research Group has studied sea turtle nesting activity level, distribution, and success at PAFB since 1987. Since the beginning of the nesting beach research program, the PAFB nesting colony has had very high reproductive success (Ehrhart 1994a). In 1993, the hatching rate in marked nests exceeded 80%.

During the first three years of the study, the 7 km section of beach surveyed averaged 770 loggerhead nests (about 110/km) and very few green turtle nests. The 1990 loggerhead nest production nearly doubled the previous three-year average and has continued to increase. The mean annual nest production for the five years since 1990 is 1487 (212/km). In Florida, green turtle nest production follows a pattern of alternate high and low years. There were no green turtle nests at PAFB in 1993. More green turtle nests were deposited in 1994 (24 nests) than in any year since the study began (Ehrhart 1994b).

In 1993, a beach nourishment project had significant effects on nest distribution and nesting success ratios, but hatchling emergence remained very high overall. However, in 1994 a vertical scarp formed along the entire southern half of the PAFB beach as opposed to forming along a smaller portion of the nourishment area as in 1993. This resulted in a decline of hatchling emergence along the affected section of beach and reduced overall success to 60.45%. Reproductive success at PAFB in 1994 fell below characteristic numbers for loggerheads.

Altogether, clutch size data, hatchling emergence data, and survey results indicate that approximately 98,770 loggerhead hatchlings and 1,832 green turtle hatchlings emerged from the nest and moved toward the ocean at PAFB in 1994 (Ehrhart 1994b). Measures taken at PAFB to remedy the problem of hatchling misorientation by beachfront lighting appear to have been effective. No misorientations were observed in 1993 or 1994. PAFB continues to be a key element in the system of southeast beaches that constitute the primary nesting ground for the Western Atlantic loggerhead turtle and Atlantic green turtle.

Flora

No federally listed rare or endangered plant species occur at PAFB (Vista Tech 1995). The following plants listed by the State of Florida or the Florida Natural Areas Inventory (FNAI) have been observed on base: spider lily (*Hymenocallis latifolia*), beach star (*Remirea maritima*), inkberry (*Scaevola plumieri*), and prickly pear cactus (*Opuntia stricta*). State law also affords some protection to the black mangrove (*Avicennia germinans),* red mangrove *(Rhizophora mangle),* and white mangrove (*Laguncularia racemosa*) occurring along the Banana River shoreline and the edges of some canals. These protected plants and their status are listed in Table 2.

For further information on previous work conducted on PAFB involving flora and fauna with no protected status see Appendix A.

Conclusions and Recommendations Based on Previous Work

Very few surveys of the flora and fauna at PAFB have been conducted. Most of those performed were done in conjunction with environmental assessments written for various projects. Additional surveys and studies of threatened and endangered species of plants and animals are needed to provide a more detailed and accurate database for reference during development of National Environmental Policy Act (NEPA), Endangered Species Act, and other regulatory documentation. These surveys would also better define critical needs in the areas of wildlife and biotic resource management at PAFB.

Table 2. Protected flora with the potential to occur at Patrick Air Force Base.

Scientific Name	Common Name	Designated Status			
		CITES[2]	FDA[3]	FCREPA[4]	FNAI[5]
Avicennia germinans	Black mangrove			SSC	
Hymenocallis latifolia	Spider lily				G4,S2S3
Laguncularia racemosa	White mangrove				
Opuntia stricta	Prickly pear cactus	II	T		
Remirea maritima	Beach star		E		G4, S3
Rhizophora mangle	Red mangrove			SSC	
Scaevola plumieri	Inkberry		T		

1. T = Threatened
   SSC = Species of Special Concern
   II = Appendix II species
   Global Element Rank:
   G4 = Apparently secure globally (may be rare in parts of range)

State Element Rank:
S1 = Critically imperiled in state because of extreme rarity (5 or fewer occurrences or less than 1000 individuals) or because of extreme vulnerability to extinction due to some natural or man-made factor.
S2 = Imperiled in state because of rarity (6 to 20 occurrences or less than 3000 individuals) or because of vulnerability to extinction due to some biological or man-made factor.
S3 = Either very rare and local throughout its range (21-100 occurrences or less than 10,000 individuals) or found locally in a restricted range or vulnerable to extinction because of other factors.

2. CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora

3. FDA = Florida Department of Agriculture and Consumer Services

4. FCREPA = Florida Committee on Rare and Endangered Plants and Animals

5. FNAI = The Florida Natural Areas Inventory assigns two ranks for each element. The global element rank is based on an element's worldwide status; the state element rank is based on the status of the element in Florida.

Vegetation and Land Cover

Introduction

Vegetation/land cover maps are important in understanding the spatial extent and context of the components of the landscape within an area. Using a Geographic Information System (GIS), spatial information on vegetation/land cover can be compiled, analyzed, and queried to supply important information for environmental decision making and policies. This map, developed as a part of this threatened and endangered species survey of PAFB, can be used in determining habitats and vegetation types in which rare, threatened, or endangered flora and fauna may exist.

Methods

A vegetation/land cover map was produced for PAFB by photointerpretation of 1:12000 scale true color aerial photography from 1991. This was the most recent photography available for the area and accurately represents the extent of vegetation and development found in 1996. Fourteen vegetation/land cover classes were used to characterize the vegetation into potential rare, threatened, and endangered species habitat. The vegetation/land cover classes are based on dominant vegetation type and may often include species not specifically listed with the class descriptions (Appendix B). Maps were groundtruthed for accuracy and digitized as polygon coverages into the GIS Arc/Info (ESRI 1991). A minimum mapping unit of 100 m^2 was used. The vegetation/land cover maps were registered to the rectified aerial photography using state plane coordinates in 1927 datum. The aerial photography was rectified using multiple ground control points and a high precision Global Positioning System (GPS) (Trimble Navigation 1994). All aerial photo rectification had a root mean square (RMS) error of 0.007. The RMS error in Arc/Info is the calculated difference between the recorded and specified tic locations, expressed as a residual of the means squared (ESRI 1991). The higher the RMS value the greater the error.

Results

Herbaceous vegetation represents 43% of the land area within the base and is the dominant vegetation type (Figure 2; Table 3). Mowed grass, sparse, and dense herbaceous vegetation surrounds developed areas (i.e., Golf Course and facilities), roadways, and the Airfield. The beach and associated dune vegetation comprised 3.2% of the base land area. This is the most extensive natural community, made up of mostly native vegetation, found within PAFB. Disturbed shrub and exotic species are the second most abundant types of vegetation. The presence of these shrubs and other non-native vegetation indicate that most of these areas have at one time been severely disturbed, allowing these invasive species to colonize nearly 21% of the non-developed

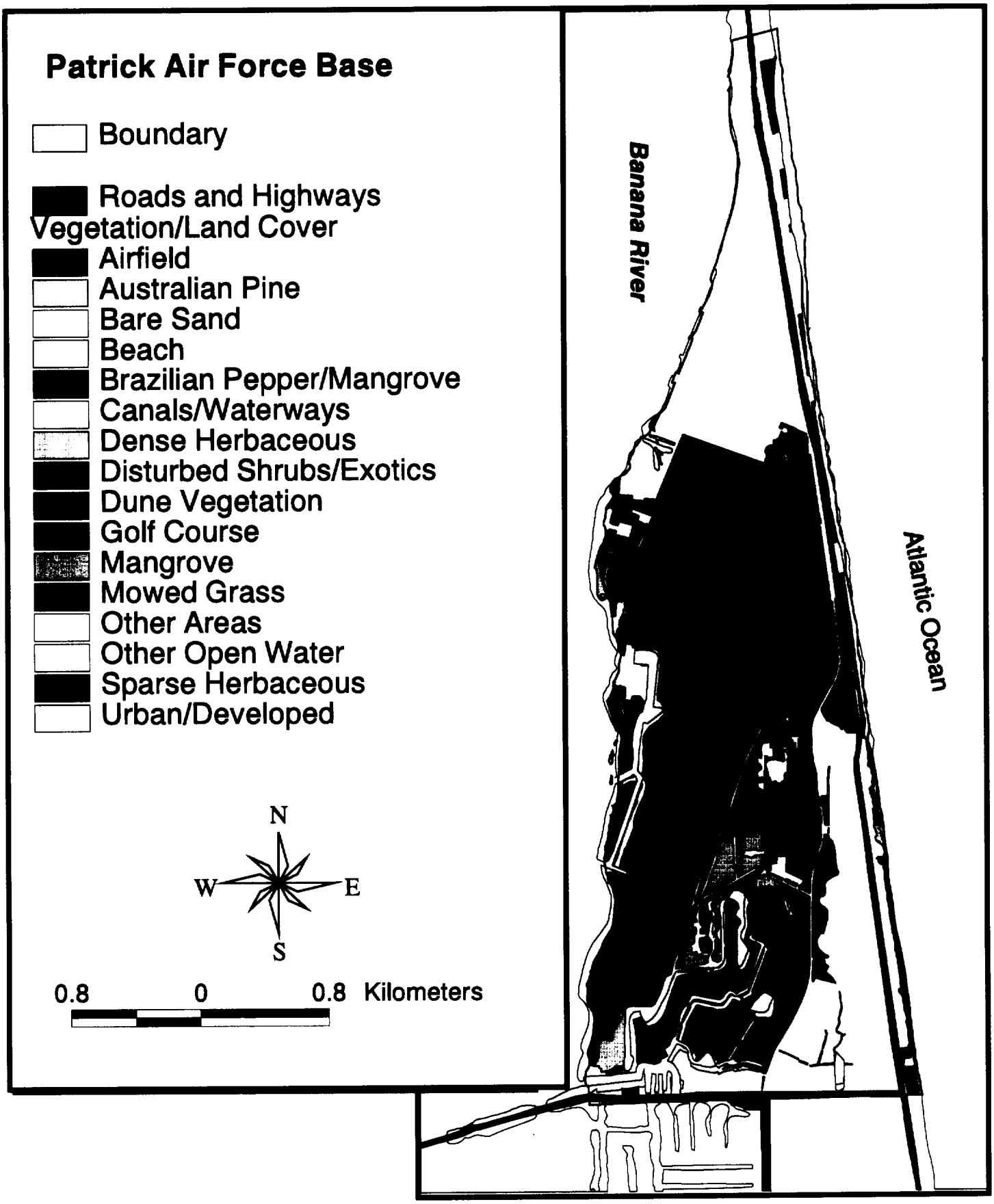

Figure 2. Vegetation and land cover for Patrick Air Force Base, Florida.

areas. A few isolated mangrove communities exist along the Banana River but probably provide little ecological value because of their small areas and sparse distribution.

Table 3. Vegetation and land cover for Patrick Air Force Base, Florida.

Vegetation/Land Cover Type	Area (ha)	Subtotal	% Total Land Area
Urban/Developed	401.73		51.30%
		401.73	51.30%
Mangrove	0.2		0.03%
		0.2	0.03%
Dune Vegetation	8.35		1.07%
		8.35	1.07%
Beach	16.15		2.06%
		16.15	2.06%
Disturbed Shrubs/Exotics	17.71		2.26%
Bare Sand	1.64		0.21%
Brazilian Pepper/Mangrove	1.2		0.15%
Australian Pine	0.39		0.05%
		20.94	2.67%
Mowed Grass	200.91		25.66%
Golf Course	66.28		8.46%
Sparse Herbaceous	48.96		6.25%
Dense Herbaceous	19.58		2.50%
		335.73	42.87%
Other Open Water	1660.37		n/a
Canals/Waterways	37.55		n/a
		1697.92	
TOTAL LAND AREA		**783.1**	
TOTAL		**2481.02**	

Conclusions

Managing vegetation and land cover for rare, threatened, and endangered species within an urban area like PAFB may be very difficult. The beach and dune communities have the greatest potential to continue to provide habitat for these species. Reducing mowing activities on the east side of State Route A1A would increase colonization of these areas by native dune flora. Restoration activities, such as planting dune and coastal strand species, may also enhance these areas. The Brazilian pepper/mangrove vegetation found in the southwest portion of the base may be an area that could be managed to increase mangrove abundance and provide roost sites for pelicans, ospreys, and wading birds. The thick shrub edge of the canal provides avifauna with quiet, undisturbed refuge for foraging and resting. Revegetation of the lagoon margin with mangrove and salt marsh vegetation may also enhance its utilization by marine invertebrates, fishes, otters, birds, and other species. The use of native

vegetation in landscaping projects throughout the base would also provide food and cover for wildlife using the base.

Although highly disturbed, the Golf course, Industrial Area, and Airfields provide habitat for the majority of threatened and endangered animal species found on PAFB. The Golf Course provides foraging and resting habitat for waterbirds and shorebirds. The Airfield canals and grassy areas provide foraging areas for waterbirds and shorebirds while runways provide roosting habitat for shorebirds, gulls, and terns. The tar and gravel roofs of some buildings in the Industrial Area provide nesting habitat for Least Terns and Black Skimmers.

Vascular Plants

Introduction

No previous comprehensive surveys of the flora or of threatened and endangered plant species of PAFB have been conducted. The occurrence of several state-listed plant species, however, had been noted (see Review of Previous Work on Threatened and Endangered Species section). The purpose of this survey was to examine the natural and semi-natural vegetation remaining on the base and determine the occurrence and location of threatened and endangered plant species.

Methods

A preliminary reconnaissance survey of the base in July 1995 indicated that the coastal dunes were the areas most likely to support plant species listed by state or federal agencies. An initial survey of these coastal dunes was conducted in July 1995 and a comprehensive survey in September 1995. The dunes were divided into ten sections using landmarks (Table 4) to specify locations of dune species. The comprehensive dune survey was repeated in spring (May 1996) to determine any spring-flowering species not present or identifiable in fall.

Table 4. Locations of Coastal Dune Plant Survey Sections on Patrick Air Force Base.

Section	Description
1	South end of base, private property boundary to south parking lot
2	South parking lot to beginning of south housing area
3	South housing area to Radar Site
4	Radar Site to Enlisted Club
5	Enlisted Club to center parking lot
6	Center parking lot to Main Gate
7	Main Gate to Officers' Club
8	Officers' Club to end of north housing
9	End of north housing to north parking lot
10	North parking lot to private property boundary

Additional areas surveyed in the fall (November 1995) included: the Small Arms Firing Range, the Waste Study Site, areas fringing the Banana River Lagoon, the Golf Course including ponds, and ditches associated with the Airfield. In spring (May 1996), the Waste Study Site, lagoon fringe, and some Airfield ditches were surveyed again.

Results

Seventy-seven vascular plants occurred on the coastal dunes (Table 5). These included four species listed by state agencies (Florida Department of Agriculture and Consumer Services [FDA] [Wood 1996] or Florida Natural Areas Inventory [FNAI] [FNAI 1995a]): spider lily, prickly pear cactus, beach star, and inkberry. Spider lily occurred as scattered individuals or small clumps in six of the ten sections of the dunes. Prickly pear cactus occurred in five of the dune sections as scattered individuals or small clumps, as did inkberry. Beach star occurred in one dune section in a small population.

Eighty-four vascular plants occurred in the other areas surveyed (Table 6). These included occurrences of two of the state-listed species: spider lily and prickly pear cactus. Spider lily occurred in one clump along the lagoon fringe. Prickly pear cactus occurred in open areas of the Waste Study Site and the Small Arms Firing Range.

Several other plant species occurred that are not threatened or endangered but have some protection under state law. Along the lagoon fringe, in the marina area by the Golf Course, and along the canals near the Waste Study Site, black mangrove and white mangrove occur (Table 6); a few small red mangroves (*Rhizophora mangle*) also occur (V. Larson, pers. comm.). The cutting or removal of mangroves is regulated under Florida Administrative Code 62-321. Sea oats occur along the dunes (Table 5). Picking sea oats is prohibited under Florida Statute 161.

Discussion

Flora

Dunes on PAFB constitute a narrow strip of vegetation bordered by the Atlantic Ocean, State Route A1A, Base Housing, or areas of mowed grass. Erosion has affected these dunes, including major storms in 1995. The flora of the remaining dunes (Table 5) includes four major elements: 1) common dune or coastal strand species such as sea oats, bitter panicum (*Panicum amarum*), beach sunflower (*Helianthus debilis*), sea grape, and railroad vine (*Ipomoea pes-caprae*); 2) less common, state-listed dune species, beach star, inkberry, prickly pear cactus, and spider lily; 3) native species of disturbed or open areas such as ragweed (*Ambrosia artemisiifolia*), begger-ticks (*Bidens pilosa*), and southern crabgrass (*Digitaria ciliaris*); and 4) introduced species such as sow thistle (*Sonchus asper*) and *Vitex trifolia.*

Other areas on PAFB support different groups of plants (Table 6). The Waste Study Site and the adjacent Small Arms Firing Range are dominated by invasive, exotic species, particularly Brazilian pepper and Australian pine, and native

Table 5. Plant species occurring on coastal dunes of Patrick Air Force Base. Presence in a section is indicated by "P" and absence by "-". State listed species are indicated by bold type.

		Section of Dune from South to North									
Genus	Species	1	2	3	4	5	6	7	8	9	10
Ambrosia	*artemisiifolia*	P	P	P	P	P	P	P	-	P	P
Ampelopsis	*arborea*	-	-	-	-	-	-	-	-	-	P
Atriplex	*pentandra*	-	-	-	-	-	-	-	-	P	-
Baccharis	*halimifolia*	-	-	-	-	-	-	-	-	P	-
Baptisia	*lecontei*	-	-	-	P	-	-	-	-	-	-
Bidens	*pilosa*	-	P	-	P	-	P	-	-	-	P
Boerhavia	*diffusa*	-	-	-	-	P	-	-	-	-	P
Borrichia	*frutescens*	-	-	-	P	P	-	-	-	-	-
Bumelia	*tenax*	-	-	-	-	-	-	-	-	-	P
Caesalpinia	*bonduc*	-	-	-	-	P	-	-	-	-	P
Cakile	*lanceolata*	P	P	P	P	P	P	P	-	P	P
Canavalia	*rosea*	-	-	P	P	P	P	P	-	P	P
Carissa	*grandiflora*	-	-	-	-	P	-	-	-	-	-
Cenchrus	*incertus*	P	-	P	P	P	P	P	P	P	P
Chamaesyce	*bombensis*	-	-	-	-	-	-	-	-	P	P
Chamaesyce	*hyssopifolia*	-	-	-	P	-	-	-	-	-	-
Chamaesyce	*mesembryanthemifolia*	-	P	P	P	P	P	-	-	P	P
Chenopodium	*ambroisioides*	-	-	-	-	P	-	-	-	-	-
Chloris	*petraea*	-	-	P	-	P	P	P	-	P	-
Cnidoscolus	*stimulosus*	P	-	-	P	P	-	-	-	P	P
Coccoloba	*uvifera*	P	P	P	P	P	P	P	P	P	P
Commelina	*diffusa*	P	-	-	P	-	P	P	-	P	P
Crotolaria	*pallida*	-	-	-	-	P	-	-	-	-	-
Croton	*glandulosus*	-	-	P	-	-	-	-	-	P	P
Croton	*punctatus*	-	-	P	-	P	P	P	-	P	-
Cuscuta	*obtusifolia*	-	-	P	P	-	-	-	-	-	-
Cynadon	*dactylon*	P	-	-	P	-	P	-	P	P	P
Cyperus	*esculentus*	-	P	-	-	P	P	P	-	P	-
Dactyloctenium	*aegyptium*	P	P	P	-	P	P	P	-	-	P
Desmodium	*incanum*	-	-	-	-	P	-	-	-	-	-
Digitaria	*ciliaris*	P	P	-	-	P	P	P	-	P	P

Table 5. Continued.

		Section of Dune from South to North									
Genus	Species	1	2	3	4	5	6	7	8	9	10
Erythrina	*herbacea*	-	-	-	-	P	-	-	-	-	-
Fimbristylis	*spathacea*	-	-	-	-	P	P	-	-	-	-
Froelichia	*floridana*	P	-	-	-	-	-	-	-	-	-
Gaillardia	*pulchella*	-	P	-	P	-	P	-	-	P	P
Galactia	*volubilis*	-	-	-	-	P	P	-	-	-	-
Helianthus	*debilis*	P	P	P	P	P	P	P	-	P	P
Heterotheca	*subaxillaris*	P	P	-	P	P	P	P	-	P	P
Hydrocotyle	*bonariensis*	-	-	-	P	P	P	P	-	-	-
Hymenocallis	***latifolia***	-	-	P	P	P	-	P	-	P	P
Indigofera	*spicata*	-	-	-	P	P	P	-	-	-	-
Ipomoea	*imperati*	-	-	-	P	P	P	-	-	P	P
Ipomoea	*pes-caprae*	P	P	P	P	P	P	P	P	P	P
Iva	*imbricata*	P	P	P	P	P	P	P	P	P	P
Lepidium	*virginicum*	P	P	-	P	P	P	P	P	-	P
Melilotus	*alba*	-	-	P	P	-	P	-	-	-	-
Momordica	*charantia*	-	-	-	-	P	-	-	-	-	-
Oenothera	*humifusa*	P	P	P	P	P	P	P	P	P	P
Oenothera	*laciniata*	-	-	-	-	-	-	-	P	-	-
Opuntia	***stricta***	-	-	P	P	P	-	P	-	P	P
Panicum	*amarum*	P	P	P	P	P	P	P	P	P	-
Panicum	*repens*	-	-	-	-	-	P	-	-	-	-
Paspalum	*setaceum*	P	-	P	-	-	P	P	P	-	P
Phyla	*nodiflora*	-	P	-	P	P	P	P	P	P	P
Phyllanthus	*abnormis*	-	-	-	-	P	P	-	-	P	P
Physalis	*walteri*	P	-	P	P	P	P	-	-	P	P
Phytolacca	*americana*	-	-	-	-	P	-	-	-	-	-
Poinsettia	*cyatophora*	-	-	P	-	-	P	-	-	-	-
Portulaca	*oleracea*	-	-	-	-	P	P	-	-	-	-
Portulaca	*pilosa*	P	P	P	P	P	P	P	-	P	P
Quercus	*virginiana*	-	-	-	P	P	-	-	-	-	-
Remirea	***maritima***	-	-	-	-	-	P	-	-	-	-
Sabal	*palmetto*	-	-	-	-	P	P	P	-	-	-

Table 5. continued.

		Section of Dune from South to North									
Genus	Species	1	2	3	4	5	6	7	8	9	10
Scaevola	***plumieri***	P	P	P	P	P	-	-	-	-	-
Schinus	*terebinthifolius*	-	-	P	-	-	-	-	-	-	-
Serenoa	*repens*	-	P	P	P	-	-	P	-	P	P
Sesuvium	*portulacastrum*	P	P	P	P	P	P	-	-	-	-
Sonchus	*asper*	-	-	-	-	P	-	P	P	-	-
Spartina	*patens*	-	-	P	P	P	P	P	-	-	-
Sporobolus	*virginicus*	P	P	P	P	P	P	P	P	P	P
Stentaphrum	*secundatum*	-	-	P	-	P	-	P	P	-	P
Stylosanthes	*hamata*	-	P	-	-	-	P	-	-	-	-
Tribulus	*cistoides*	P	P	-	P	P	P	-	-	P	-
Uniola	*paniculata*	P	P	P	P	P	P	P	-	P	P
Vigna	*luteola*	-	-	-	P	-	P	-	-	-	-
Vitex	*trifolia*	-	-	P	-	-	P	-	-	-	-
Yucca	*aloifolia*	P	P	P	P	P	P	P	P	P	P

Table 6. Plant species occurring in various areas on Patrick Air Force Base. Sites are: Small Arms Firing Range, Golf Course and ponds, Lagoon Fringe, Waste Study Site, and Airfield Ditches. Presence in a site is indicated by "P" and absence by "-". State-listed species are indicated by bold type.

Genus	Species	Small Arms	Golf Course	Lagoon Fringe	Waste Study Site	Airfield Ditches
Ambrosia	*artemisiifolia*	P	-	P	P	P
Andropogon	*longiberbis*	-	-	-	P	-
Andropogon	spp.	P	-	-	-	P
Andropogon	*virginicus* L. var. *corymbosus*	-	-	-	P	-
Araucaria	sp.	-	P	-	-	-
Avicennia	*germinans*	-	P	P	-	-
Azola	*caroliniana*	-	P	-	-	-
Baccharis	*halimifolia*	-	P	P	-	-
Bacopa	*monnieri*	-	P	P	-	-
Baptisia	*lecontei*	-	-	-	P	-
Bidens	*pilosa*	P	P	P	P	P
Borrichia	*frutescens*	-	-	P	-	-
Bursera	*simaruba*	-	-	-	P	-
Casuarina	*equisetifolia*	P	P	-	P	-
Catharanthus	*roseus*	P	-	-	P	-
Cenchrus	*echinatus*	P		P	-	
Cenchrus	*incertus*	P	-	-	-	-
Chamaesyce	*hyssopifolia*	P	-	-	P	-
Chamaesyce	*maculata*	P	-	-	-	-
Chloris	*petraea*	P	-	P	-	-
Commelina	*diffusa*	-	P	P	-	P
Crotolaria	*spectabilis*	-	-	-	P	-
Cynadon	*dactylon*	P	-	P	P	-
Cyperus	*esculentus*	P	P	P	-	-
Cyperus	*ligularis*	P	P	-	P	-
Dactyloctenium	*aegyptium*	P	-	-	-	-
Dalbergia	*ecastophyllum*	-	-	P	P	-
Dichromena	*colorata*	-	-	P	-	-
Erigeron	*quercifolius*	-	-	P	-	-
Ficus	*aurea*	-	-	P	-	P
Gaillardia	*pulchella*	-	-	P	-	-
Galium	*tinctorium*	-	-	-	-	P
Gaura	*angustifolia*	-	-	-	P	-
Helianthus	*debilis*	P	-	P	P	P
Heliotropium	*curassavicum*	-	-	P	-	-
Heterotheca	*subaxillaris*	P	-	-	P	-
Hydrocotyle	*bonariensis*	P	-	P	-	P
Hydrocotyle	sp.	-	P	-	-	-
Hymenocallis	*latifolia*	-	-	P	-	-
Ipomoea	*alba*	-	-	P	-	-
Ipomoea	*pes-caprae*	P	-	P	P	P
Iva	*frutescens*	-	-	P	-	-
Iva	*imbricata*	-	-	P	-	-
Juniperus	*silicicola*	-	P	-	-	-
Laguncularia	*racemosa*	-	P	P	-	-

Table 6. continued.

Genus	Species	Small Arms	Golf Course	Lagoon Fringe	Waste Study Site	Ditches
Lemna	sp.	-	P	-	-	-
Ludwigia	*peruviana*	-	-	-	-	P
Melaleuca	*quinquenervia*	-	P	-	-	-
Melothria	*pendula*	-	-	-	P	-
Mentzelia	*floridana*	P	-	-	P	-
Mikania	*scandens*	-	-	P	-	-
Oenothera	*humifusa*	-	-	P	-	-
Opuntia	*stricta*	P	-	-	P	-
Panicum	*repens*	-	P	P	-	-
Panicum	*rigidulum*	-	P	-	-	-
Panicum	*tenerum*	P	-	-	-	-
Parietaria	*floridana*	-	-	-	P	-
Paspalum	*distichum*	-	-	P	-	-
Paspalum	*setaceum*	P	-	-	-	-
Paspalum	*urvillei*	-	-	-	-	P
Phyla	*nodiflora*	-	P	P	P	-
Phyllanthus	*abnormis*	-	-	-	P	-
Physalis	*walteri*	P	-	-	P	-
Pluchea	*odorata*	-	-	P	-	-
Poinsettia	*cyatophora*	P	-	-	P	-
Polygonum	*hydropiperoides*	-	-	-	-	P
Quercus	*virginiana*	-	P	-	-	-
Rhynchelytrum	*repens*	P	-	-	P	-
Rumex	*verticillatus*	-	P	-	-	-
Sabal	*palmetto*	P	P	-	P	P
Sabatia	*stellaris*	-	-	P	-	-
Sagittaria	*lancifolia*	-	-	-	-	P
Schinus	*terebinthifolius*	-	P	P	P	-
Scirpus	*americanus*	-	-	P	-	P
Sesuvium	*portulacastrum*	-	-	P	-	-
Spartina	*bakeri*	-	-	P	-	-
Sporobolus	*virginicus*	-	-	-	P	-
Stenotaphrum	*secundatum*	-	-	P	-	-
Typha	*domingensis*	-	P	-	-	P
Urena	*lobata*	-	-	P	-	-
Vigna	*luteola*	-	P	P	-	P
Vitex	*trifolia*	-	P	-	P	-
Wedelia	*trilobata*	-	-	-	P	-
Zanthoxylum	*clava-herculis*	P	-	-	-	-

species of open or disturbed sites such as camphorweed (*Heterotheca subaxillaris*) and beardgrass (*Andropogon* spp.). Ponds on the Golf Course, ditches, and areas fringing the lagoon support some wetland plants such as southern cattail (*Typha domingensis*), arrowhead (*Sagittaria lancifolia*), and bullrush (*Scirpus americanus*). Salt-tolerant wetland species such as black mangrove and white mangrove occur along the lagoon fringe and in the marina area by the Golf Course.

Rare Plants

Spider lily is a herbaceous, perennial species in the Amaryllidaceae (amaryllis family). Wunderlin (1982) gives its habitat as coastal swales and mangrove swamps, but in east central Florida it also occurs on dune flats and slopes, not just swales. Its range includes Florida, the Bahamas, and parts of the West Indies (Austin et al. 1991). Spider lily is not listed by the FDA. The FNAI lists it as G4/S2S3 (FNAI 1995a), with 75 known occurrences in the state. G4 indicates that the species is apparently secure globally. S2S3 indicates that in Florida it is either (S2) imperiled because of rarity or because of vulnerability to extinction due to some natural or man-made factor, or (S3) very rare or local throughout its range or found locally in a restricted range or vulnerable to extinction because of other factors. It occurs on coastal dunes and strand of KSC (Schmalzer and Hinkle 1990) and Canaveral National Seashore (CNS) (Johnson et al. 1990).

Prickly pear cactus is a succulent, perennial species in the Cactaceae (cactus family). It occurs on coastal dunes, shell middens, and coastal hammocks in central Florida (Wunderlin 1982). Its range includes all of Florida, west to east Texas, and north to South Carolina (Duncan and Duncan 1987, Hall 1993). Prickly pear cactus is listed as threatened by the FDA (Wood 1996). The FNAI (FNAI 1995a) does not currently list this species. It occurs on coastal dunes and strand of KSC (Schmalzer and Hinkle 1990). Johnson et al. (1990) reported it as rare to occasional in dune and strand vegetation of the southeast Florida coast.

Beach star is a small, perennial, herbaceous species in the Cyperaceae (sedge family). It ranges in height from 5-30 cm, and it spreads by slender, elongate, horizontal stolons (Godfrey and Wooten 1979). It is know from the coastal dunes on the east coast of Florida, the Florida Keys, the West Indies, and the Old World tropics (Small 1933, Godfrey and Wooten 1979, Wunderlin 1982, Austin et al. 1991). Beach star is listed as endangered by the FDA (Wood 1996). The FNAI lists it as G4/S3 (FNAI 1995a), with 20 known occurrences in the state. G4 indicates that the species is apparently secure globally; S3 indicates that in Florida it is either very rare or local throughout its range or found locally in a restricted range or vulnerable to extinction because of other factors. Johnson et al. (1990) reported beach star from two sites in Brevard County, both on CCAS; these were dunes in the False Cape area and in the central and southern Cape. A recent survey found it relatively abundant on dunes on the southern part of Cape Canaveral (Schmalzer and Oddy 1995). Cape Canaveral

is near the northern limits of the range of beach star (Johnson and Barbour 1990), and it was not reported in recent surveys of CNS in Brevard County (Johnson et al. 1990) and Volusia County (Johnson and Muller 1993). It occurs in the False Cape area of KSC (Schmalzer and Hinkle 1990).

Inkberry, is a small shrub, ranging from 30-180 cm in height, in the Goodeniaceae (*Goodenia* family). It occurs in coastal dunes and strand in peninsular Florida, the Florida Keys, the West Indies, and tropical Africa, and its stems often spread beneath the sand (Small 1933, Wunderlin 1982, Austin et al. 1991). Inkberry is listed as threatened by the FDA (Wood 1996). The FNAI (FNAI 1995a) does not currently list this species. Johnson et al. (1990) reported inkberry from one site in Brevard County, Sebastian River State Recreation Area; however, the freeze of 1989 had affected the plant. Cape Canaveral appears near the northern limits of the range of inkberry (Johnson and Barbour 1990), and it was not reported in recent surveys of CNS in Brevard County (Johnson et al. 1990) and Volusia County (Johnson and Muller 1993). It occurs in the False Cape area of KSC (Schmalzer and Hinkle 1990) and on CCAS (Schmalzer and Oddy 1995).

Black mangrove and white mangrove occur along the lagoon fringe, as do a few small red mangrove. These species are not listed by the FDA (Wood 1996) or FNAI (1995a). However, black mangrove and red mangrove were listed as a species of special concern by the Florida Committee on Rare and Endangered Plants and Animals (FCREPA) (Ward 1978) because of their importance to estuarine and lagoon ecosystems and the extensive loss of coastal areas in Florida. Trimming or removal of mangroves is regulated by state law.

Sea oats is the main dune building grass along Florida's coasts (Johnson and Barbour 1990). Its growth is stimulated by sand accretion, and its extensive root and rhizome system help to stabilize the accumulating dune (Wagner 1964). Its seeds are a major food source for insects, birds, and small mammals (Wagner 1964). Due to its importance to fragile coastal dune communities, picking sea oats is prohibited by state law. Sea oats occur along the dunes on PAFB, but the area they occupy has been reduced by erosion.

Invasive Exotic Plants

Several species occurring on PAFB are considered Category I invasive exotic plants (Exotic Pest Plant Council 1995); these are species that are widespread in Florida and have an established potential to invade and disrupt native plant communities. Brazilian pepper, Australian pine, melaleuca, and torpedo grass (*Panicum repens*) are in this class. Brazilian pepper and Australian pine are common on the Waste Study Site and the Small Arms Firing Range. Australian pine was introduced into Florida around the turn of the century when it was planted as windbreaks around houses and along roads (Johnson and Barbour 1990). It tends to invade newly exposed sand such as newly accreted beaches,

beaches where dredge spoil has been dumped or where storm overwash has destroyed the existing vegetation (Johnson and Barbour 1990). Once it has colonized it invades the coastal grasslands and coastal strand due to its high salt tolerance, where it often replaces sea grape and other coastal shrubs and grasses. In addition, its dense shade and thick leaf litter prevent germination and growth of native vegetation (Johnson and Barbour 1990). Melaleuca occurs on the Golf Course. Torpedo grass was found in wet areas of the lagoon fringe and around ponds on the Golf Course but also in one location on the dunes. Both PAFB and the surrounding areas are highly developed; therefore, most exotic plant populations on the base are not an immediate threat to intact native plant communities. However, invasive exotic plants should be avoided in any horticultural plantings on the base. The coastal dunes, although disturbed and eroded, are the most natural community remaining. Torpedo grass is not a dominant species on the dunes now, and it is not known whether it is a threat to this community.

Beach Renourishment

Beach renourishment projects have been conducted periodically for several years to counter the effects of beach erosion and to protect Air Force facilities as well as State Route A1A. As these projects continue, the habitat available for dune plants, including the state-listed species, may increase. Most dune species can colonize newly deposited sand if it remains in place long enough (Johnson and Barbour 1990). Root systems of sand-binding grasses such as sea oats help retain sand in place (Carter 1988), although severe storms will still cause erosion.

At both the southern and northern ends of dune vegetation on PAFB (Sections 1-2 and 9-10), there are areas of mowed grass between the dunes and State Route A1A. Dune species would colonize these areas if they were not mowed. Dune species have more extensive root systems than lawn grasses and should provide somewhat greater protection from erosion. Consideration should be given to mowing less of these areas and allowing dune species to establish on them.

Mammals

Southeastern Beach Mouse

Introduction

The southeastern beach mouse is a federally and state listed threatened species (USFWS 1989, Wood 1996). It was first described by Chapman in 1889 and historically occurred along the Florida east coast from Ponce de Leon Inlet (Volusia County) to Hollywood Beach (Broward County) (Humphrey 1987). Presently, the species exists in Brevard County on CNS, KSC, CCAS, and in Indian River County at the southern portion of Sebastian Inlet State Recreation Area (Stout 1992).

The southeastern beach mouse is a small, nocturnal, buff colored mouse with a white underside that extends from its chin to the tip of its tail. The dorsal side of the mouse is a tawny, buff color from the back of the head to the tail in adults, and gray in juveniles. The beach mouse is a monogamous species whose principal habitat is the sea oats zone of the primary dune. Additional habitats occupied by this species include open, sandy areas with scattered shrubs behind the foredune, stands of woody shrubs dominated by oaks (*Quercus spp.*), rosemary (*Ceratiola ericoides*), saw palmetto (*Serenoa repens*), and grasslands (Keim 1979, Stout 1979, Humphrey 1987). Sea oats and various beach grasses are the primary food resources for this species (Blair 1951), although invertebrates are also consumed (Layne 1978). Food use may change seasonally since seeds are often scarce in late spring and early summer (Blair 1951). The beach mouse digs its own burrows and may have many within its homerange.

The abundance of small mammals varies seasonally, annually, and among habitats (Ehrhart 1976). Populations are often lowest in the summer and highest in winter and spring (Stout 1979). Breeding activity is most evident from November through January when juveniles are present. Potential predators include raccoons (*Procyon lotor*), spotted skunks (*Spilogale putorius*), hawks, owls, snakes, bobcats (*Lynx rufus*), house cats, and dogs (*Canine familiaris*). In addition, the house mouse, is a potential competitor. Reasons for decline in southeastern beach mouse populations include habitat loss due to development and erosion, habitat fragmentation, competition from the house mouse, and predation from increasing numbers of house cats (Stout 1992). The species is also vulnerable to ocean surges from storms and natural catastrophes such as hurricanes and tropical storms.

Methods

For this survey eight 100 m transects (Figure 3) were established using field surveys and aerial photography. Transects were set up using a compass and meter (m) tapes. PVC poles marked the location of the trapping stations at 10 m intervals along the transects. A 1.2 m pole was placed at each end of the transect to identify the ends. A GPS was used to record the end points of each transect. Data were differentially corrected and transferred into Arc/Info as a point coverage file. A Sherman live trap (3"x3-1/2"x9") was placed at each trapping station. The traps were baited with sunflower seeds and opened in the late afternoon and checked at first light the next morning. A mark-recapture method was employed for this survey.

The northernmost transect, NP (Figure 3), was located just south of PAFB's northern boundary, north of the beach crossover. Transect N (Figure 3), was to the east of the north beach parking lot in between the middle and southern beach crossovers. Transect OC (Figure 3) was north of the Officers' Club, directly south of the north beach parking lot. Transect R (Figure 3) was on the dunes just north of the Radar Facility. Two transects, NH (behind Cul-de-sac #4) and H (behind Cul-de-sac 1024-1028), were located behind Beach Housing (Figure 3). The final two transects were located near PAFB's southern boundary (Figure 3). Transect SP was just north of the beach crossover at the southern beach parking area, and transect S was approximately 100 m south of the crossover.

Each of the eight transects was trapped for 5 days each quarter from October 1995 to July 1996 (four quarters). All small mammals captured were examined and the following data were recorded: transect number, station number, status, species, and general condition. In addition, sex, reproductive condition, and weight were recorded for any mice. Mice were weighed in a plastic bag with a Pesola 50 g scale. Actual weight was determined by subtracting the bag weight. Mice were then released at the capture site. Ear tags were not used on house mice or rats.

Due to the outbreak of hantavirus, a rodent borne disease, within the southwest U.S. protective measures were taken to insure the safety of the biologists conducting the survey. Because hantavirus is transmitted in the urine, feces, and saliva of infected rodents (primarily the deer mouse, *Peromyscus maniculatus*, from the western U.S.) all contact with the animals and the aerosols produced were minimized. Respirators equipped with High Efficiency Particulate Filters (HEPA) and gloves were worn while checking the traps and handling rodents. All mammal work up bags, gloves, and HEPA filters were disposed of as biohazardous material after their use. The Sherman live trap was sprayed with Lysol disinfectant in the field and soaked in an EPA approved disinfectant for 10 minutes, scrubbed, rinsed, and dried. Respirators were cleaned and

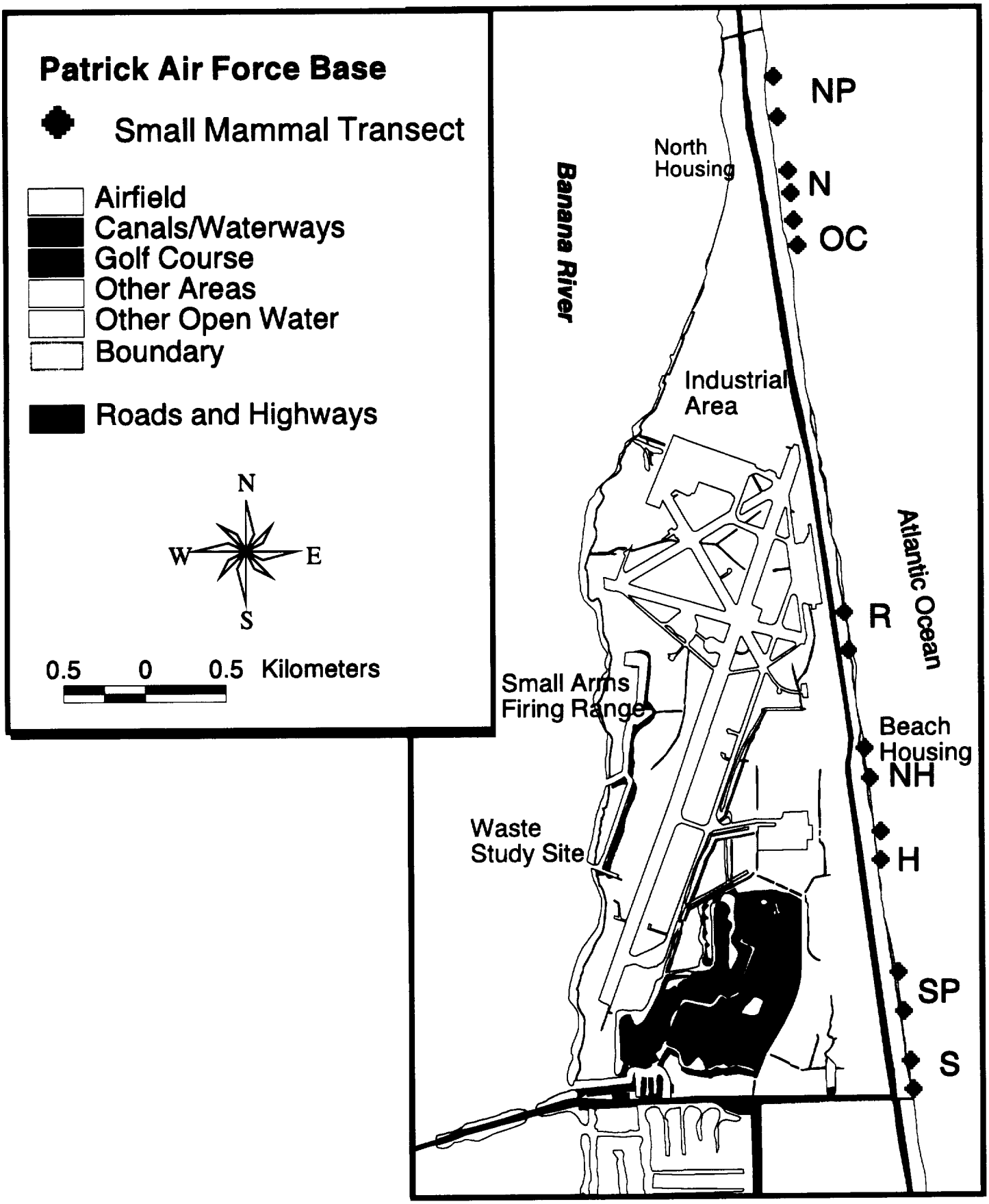

Figure 3. Small mammal transects along the dune at Patrick Air Force Base, Florida.

scrubbed with microbiological soap, and the biologists showered and laundered their clothes. These steps were all part of a protocol developed for handling small mammals and followed the recommendations of the Center for Disease Control (CDC) (Mills et al. 1995).

Results

The total number of possible trapnights was based on the number and size of the transect (i.e., 8 transects x 10 traps = 80 possible traps per night). The actual number of trapnights was adjusted for data analysis by subtracting the disturbed, inoperable, or stolen traps and any that were unable to be set due to weather or habitat conditions from the total. No beach mice were captured on any of the eight transects. The total number of potential trapnights for the study was 1600 while the actual number of trapnights differed with each transect (Table 7).

Table 7. The number of actual trapnights per quarter and the total actual number of trapnights for the eight 100 m small mammal transects at PAFB.

Transect	October	January	April	June	Total
NP	50	50	50	49	199
N	47	47	48	40	182
OC	50	50	50	50	200
R	46	48	49	50	193
NH	50	48	50	50	198
H	46	48	48	50	192
SP	45	50	50	49	194
S	50	50	44	48	192
TOTAL					1550

Fifteen traps were disturbed by humans, five were stolen, and twenty-six traps snapped prematurely or were jammed by sand rendering them inoperable.

Transect NP yielded six house mice and four ghost crabs (*Ocypode quadrata).* At transect N four house mice and two ghost crabs were caught. On OC, the transect by the Officers' Club, one black rat (*Rattus rattus*), and three ghost crabs were captured and one black rat and one ghost crab were captured on transect R. Two black rats were caught on transect NH, two on SP, and four on S. Thirteen house mice were captured on transect H, in addition to one black rat and one ghost crab.

Discussion

No southeastern beach mice were captured on any of the transects. The difference between the total and actual number of trapnights on the eight transects was due in part to the presence of humans. Many traps were moved to different locations or removed as were quite a few of the PVC station poles. A

good portion of traps that had snapped prematurely were the result of weather, namely high winds and rain. Weather also resulted in the jamming of traps by sand, preventing them from closing. In addition, the beach restoration project during the last two quarters of trapping resulted in some lost poles and disturbed traps.

The absence of the southeastern beach mouse was expected as the dune habitat is narrow and highly fragmented. The dunes are surrounded by development to the north and south and bordered by State Route A1A, a heavily traveled road to the west. High numbers of predators such as cats and dogs and competitors such as house mice and possibly rats, decrease the likelihood of a beach mouse population at PAFB. Another factor relating to the absence of beach mice is an insufficient food supply. Sea oats are very sparse along the dunes and absent in some areas. These things coupled with the steadily eroding dunes make PAFB an unlikely place for the southeastern beach mouse. If the large areas adjacent to the dunes were not mowed, the native dune vegetation would spread into these areas potentially creating a bigger food supply and increasing the stability of the dunes.

Other Mammal Species

The only other mammal observed on PAFB was the gray squirrel, (*Sciurus carolinensis*) which was seen on the Golf Course and in the Industrial Area during wading bird surveys. The gray squirrel is one of the most common Florida mammals and can be found in densely wooded areas, small wooded lots and back yards. Their diet consists of acorns, nuts, buds, fruit, berries, seeds, fungi, insects, and potentially eggs and young birds (Whitaker 1980).

Birds

Waterbirds

Introduction

The term waterbirds, as used here, refers to species of birds that utilize wetland habitats for foraging and/or nesting activities (not including shorebirds, gulls, and terns). Fifty-one species of waterbirds are expected to occur on PAFB (Table 8). There are several distinct subgroups within the waterbirds, each with unique ecological characteristics and conservation concerns. The Ciconiiformes (egrets, herons, ibises, and storks) are often referred to as wading birds. These birds inhabit a variety of wetland habitats and usually nest in colonies near water. This group of birds includes many state and federally protected species (Wood 1996).

Wading birds in Florida have undergone two periods of drastic decline over the past century (Odgen 1978a, 1991). The first occurred around the turn of the century and was the result of hunting for the plume trade. After a period of recovery, wading birds again underwent drastic reduction in numbers from approximately 1930 to the present, due to the use of pesticides that caused eggshell thinning, and to the destruction of nesting and foraging habitat. Current threats to wading birds include habitat loss and degradation, habitat fragmentation, pollution, and pesticide contamination (Odgen 1978a, 1991, Kale and Maehr 1990, Stevenson and Anderson 1994). Some wading birds, such as the Wood Stork, are vulnerable to artificial fluctuations in water levels in wetlands that interfere with their feeding or nesting behaviors (Ogden 1978b, Breininger et al. 1994).

A variety of ducks occur year-round in Florida wetlands and are expected to occur on PAFB (Table 8). Several of these species have undergone drastic declines during this century. The main cause of declines in the numbers of ducks is from the loss of wetlands that are used for breeding (Kale and Maehr 1990, Stevenson and Anderson 1994). Lead poisoning resulting from lead shot discharges by hunters also has serious impacts on duck numbers. Other threats facing ducks include oil spills that threaten species that use coastal waters and pollution that adversely impacts many species. Ducks exhibit a variety of dietary preferences and foraging strategies. Some species are mostly vegetarian, while others are carnivorous or omnivorous. Some ducks forage on the substrate often diving several feet to reach the bottom, while others skim food off the surface or tip-up to reach shallow food items below the surface. These different foraging strategies make ducks useful monitors of environmental change in Florida wetlands.

Peninsular Florida has only two species of duck that are native breeders; the Mottled Duck (*Anas fulvigula*) and the Wood Duck (*Aix sponsa*) (Stevenson and

Table 8. Waterbirds expected to occur in wetlands on Patrick Air Force Base. (Based on Cruickshank 1980, Kale and Maehr 1990, Robertson and Woolfenden 1992, Stevenson and Anderson 1994)

SPECIES	HABITAT [a]	SEASON [b]	FORAGING METHOD / DIET [c]
Podicipediformes			
Podicipedidae			
Pied-billed Grebe (*Podilymbus podiceps*)	Fw (Bm,I,Oc)	R,Wm	Dives; fish, aq. invert., some veg.
Horned Grebe (*Podiceps auritus*)	E,I (Fw,Oc)	Wm	Dives; fish, crustaceans, amphibians, aq. insects
Gaviiformes			
Gaviidae			
Common Loon (*Gavia immer*)	Oc, E (occ. large lakes)	Wm	Dives; fish, crustaceans, small amount veg.
Pelicaniformes			
Pelecanidae			
American White Pelican (*Pelecanus erythrorhynchos*)	Fw,I,E	Wm	Surface; fish
Brown Pelican (*Pelecanus occidentalis*)	Oc,E,I	R	Dives; fish
Phalacrocoracidae			
Double-crested Cormorant (*Phalcrocorax auritus*)	Fw,I,E,Oc	R, Wm	Dives; fish, aq. invert., occ. sm. vert.
Anhingidae			
Anhinga (*Anhinga anhinga*)	Fw (I, E)	R, Wm	Dives; fish, aq. invert., occ. sm. vert.
Ciconiiformes			
Ardeidae			
American Bittern (*Botaurus lentiginosus*)	Fm (Bm)	Wm	Surface; fish,aq. insects, sm. vert.
Least Bittern (*Ixobrychus exilis*)	Fm,Bm	R, Wm	Surface; sm. fish, aq. invert., sm. vert.
Great Blue Heron (*Ardea herodias*)	E,I,Fw,Bm (Be,Oc,Up)	R, Wm	Surface; fish, sm. vert., invert.
Great Egret (*Casmerodius albus*)	E,I,Fw,Bm (Be,Up)	R, Wm	Surface; fish, sm. vert., invert.
Snowy Egret (*Egretta thula*)	Fw,E,I,Bm (Up)	R, Wm	Surface; aq. invert., sm. fish, sm. vert.
Little Blue Heron (*Egretta caerulea*)	Fw,E,I,Bm (Up)	R, Wm	Surface; aq. invert., sm. fish, sm. vert.
Tricolored Heron (*Egretta tricolor*)	E,I,Bm (Fw)	R, Wm	Surface; sm. fish, (also sm. vert., invert.)
Reddish Egret (*Egretta rufescens*)	E,I,Bm (Fw)	R, N	Surface; fish (also aq. invert.)
Cattle Egret (*Bubulcus ibis*)	Up (also aquatic habitats)	R, Wm	Surface; invert., sm. vert.
Green Heron (*Butorides striatus*)	Fw (Bm)	R, Wm	Surface; sm. fish, sm. vert., invert.
Black-crowned Night Heron (*Nycticorax nycticorax*)	Fw,Bm, E, I	R, Wm	Surface; fish, sm. vert., invert.
Yellow-crowned Night Heron (*Nyctanassa violacea*)	Fw,Bm, E, I,Be	R, Wm	Surface; crustaceans (also fish, sm. vert.)
Threskiornithidae			
Whit Ibis (*Eudocimus albus*)	Fw,E,I,Up	R, Wm, N	Substrate; invert., snakes
Glossy Ibis (*Plegadis falcinellus*)	Fw (Bm,Up)	R, Wm, N	Substrate; insects, crayfish, snakes, fish
Roseate Spoonbill (*Ajaia ajaja*)	Bm,E,I (Fm)	R, N	Strains water; sm. fish, insects, crustaceans, some veg.
Ciconiidae			
Wood Stork (*Mycteria americana*)	Fw,Bm,E,I	R, Wm, N	Snatches fish (also invert., sm. vert.)

Table 8. Continued.

SPECIES	HABITAT [a]	SEASON [b]	FORAGING METHOD / DIET [c]
Anseriformes			
Anatidae			
Fulvous Whistling-Duck (*Dendrocygna bicolor*)	Fw	Wm	Strains aquatic veg., occ. diving
Wood Duck (*Aix sponsa*)	Fw	R, Wm	Shallow; 30% animal (vert., invert.)
Green-winged Teal (*Anas crecca*)	Fw (Bm, E, I)	Wm	Dabbling; 11% animal (invert.)
American Black Duck (*Anas rubripes*)	Fw, Bm, E, I	Wm (rare)	Dabbling; mostly veg.
Mottled Duck (*Anas fulvigula*)	Fw, Bm, E, I	R	Dabbling; 44% invert., 56% veg.
Mallard (*Anas platyrhynchos*)	Fw (Bm, E, I)	Wm	Dabbling; 97% veg.
Northern Pintail (*Anas acuta*)	Fw, Bm, E, I	Wm	Dabbling; mostly veg.
Blue-winged Teal (*Anas discors*)	Fw (Bm, E, I)	Wm	Dabbling; aquatic veg., aquatic invert.
Northern Shoveler (*Anas clypeata*)	Fw	Wm	Dabbling; aquatic veg., aquatic invert.
Gadwall (*Anas strepera*)	Fw (Bm, E)	Wm	Dabbling; aquatic veg.
American Wigeon (*Anas americana*)	Fw, E	Wm	Dabbling; aquatic veg.
Canvasback (*Aythya valisineria*)	Fw, E	Wm	Diving; >80% aquatic veg.
Redhead (*Aythya americana*)	E, Fw	Wm	Diving & Dabbling; 90% aquatic veg.
Ring-necked Duck (*Aythya collaris*)	Fw (E)	Wm	Diving & Dabbling; >97% aquatic veg.
Greater Scaup (*Aythya marila*)	E (Fw)	Wm	Diving; 52% animal, 48% aq. & emerg. veg.
Lesser Scaup (*Aythya affinis*)	E, Fw	Wm	Diving; 40% animal, 60% aq. & emerg. veg.
Hooded Merganser (*Lophodytes cucullatus*)	Fw, E, Bm	Wm	Diving; fish, aquatic invert.
Red-breasted Merganser (*Mergus serrator*)	E (Fw)	Wm	Diving; fish, crustaceans
Ruddy Duck (*Oxyura jamaicensis*)	Fw, E, Bm	Wm	Diving; 80% aquatic veg., 20%, aquatic invert.
Gruiformes			
Rallidae			
Yellow Rail (*Coturnicops noveboracensis*)	Fm	Wm	Surface; invert., some veg.
Black Rail (*Laterallus jamaicensis*)	Bm	R	Surface; invert., some veg.
Clapper Rail (*Rallus longirostris*)	Bm	R	Surface; invert., sm. fish, 10% veg.
King Rail (*Rallus elegans*)	Fm (Bm)	R	Surface; invert., sm. fish, some veg.
Virginia Rail (*Rallus limicola*)	Fm, Bm	Wm	Surface; insects, invert., sm. fish, some veg.
Sora (*Porzana carolina*)	I, Bm, Fw	Wm	Surface; insects, seeds
Purple Gallinule (*Porphyrula martinica*)	Fw	R, Wm	Surface; insects, seeds
Common Moorhen (Gallinula chloropus)	Fw	R, Wm	Surface; aq. veg, insects,snails, aq. worms
American Coot (*Fulica americana*)	Open Water	R, Wm	Dives; mostly aq. veg, some animal

a Fw=fresh water habitats (marshes, lakes, streams), Fm=freshwater marsh, Bm=brackish marsh (incl. mangroves), I=impondment, E=estuary, Be=beach, Oc=ocean, Up=upland. Habitats in brackets are less commonly used.

b R=resident, Wm=winter migrants, N=nomadic

c First part of entry gives method of foraging, second part gives specific diet. Abbreviations: aq.=aquatic, emerg=emergent, invert.=invertebrate, occ.=occasionally, sm.=small, veg.=vegetation, vert. = vertebrate.

Anderson 1994). However, several species of exotic waterfowl have been introduced to the state including the domestic Mallard. The Mallard (*Anas platyrhynchos*) occurs naturally in peninsular Florida as an uncommon wintering resident but does not naturally breed in this part of the state (Robertson and Woolfenden 1992, Stevenson and Anderson 1994). Mottled Ducks and Mallards are both members of a closely related group of ducks referred to as the Mallard Complex. Members of this group are capable of cross-breeding to produce viable hybrid offspring (Johnsgard 1961).

In a few parts of the world, domesticated Mallards have recently come into contact with other members of this complex due to human activities. When this happens, it usually results in a serious decline in pure-bred individuals of the native species. This has occurred in the New Zealand Grey Duck (*Anas superciliosa superciliosa*), Hawaiian Duck (*Anas wyvilliana*), Mexican Duck (*Anas platyrhynchos*), Black Duck (*Anas rubripes*), Australian Black Duck (*Anas superciliosa rogersi*), and Meller's Duck (*Anas melleri*) (Mazourek and Gray 1994). Genetic introgression due to hybridization may eventually result in the disappearance of the genotype of the native species.

Hybridization and genetic introgression is currently occurring in Mottled Ducks in Florida due to contact with domestic (naturalized) Mallards (Mazourek and Gray 1994). Mottled Ducks and domestic (naturalized) Mallards have the potential to interbreed in locations that juxtapose the two species, such as disturbed habitat with artificial sources of food near naturally occurring Mottled Duck habitat (Paul Grey, National Audubon Society, pers. comm.). The Florida Game and Fresh Water Fish Commission Waterfowl Management Section is currently developing legal guidelines to deal with these hotspots of genetic introgression between Mottled Ducks and domestic Mallards (Rick Brust, FGFWFC, pers. comm.).

There are several other species of waterbirds, from a variety of taxonomic groups, that are found in Florida. Nine species of rails have the potential to occur in wetland habitats on PAFB (Table 8). Globally, many species of rails have undergone drastic declines in recent years. Rails are threatened by habitat loss, habitat degradation, and pollution. Grebes are threatened by accidental poaching by hunters and the loss of habitat. Loons, Anhingas, and Double-crested Cormorants (*Phalacrocorax auritus*) are threatened by pollution, pesticides, and entanglement in lost or discarded fishing gear (Stevenson and Anderson 1994).

Pelicans are long-lived animals that utilize a variety of Florida habitats (Table 8). The southeastern U.S. population of Brown Pelicans suffered a catastrophic decline in numbers in the 1960's and early 1970's due primarily to pesticides that caused eggshell thinning. By the late 1980's, populations in Florida, South Carolina, and North Carolina had recovered and the Louisiana population was stable, following the reintroduction of individuals from Florida. The species was removed from the endangered species list in Florida, Alabama, Georgia, South

Carolina, and North Carolina in 1985; the remainder of the population on the Atlantic and Gulf coasts and California remains listed as endangered. Since recovery in the southeast, nesting has declined on the Gulf coast but increased on the Atlantic coast. Loss of preferred nesting habitat (e.g., mangroves) will cause Brown Pelicans to move to other suitable locations (Wilkinson et al. 1994).

The Indian River Lagoon system (IRL), composed of the Indian River, Banana River, and Mosquito Lagoon, is an important area for waterbird populations in Florida with as much as one tenth of all wading birds (herons, ibises, and storks) using the system for at least part of the year (Schikkor and Swain 1995). Impoundments within the IRL are heavily used by foraging wading birds, ducks, and other waterbirds and thus are vital habitats within the state (Breininger and Smith 1990, Smith and Breininger 1995).

Habitat alteration has a large potential to effect waterbirds in Florida. Most of the declines in waterbird populations witnessed during this century have been caused wholly or in part as the result of habitat destruction and degradation. Waterbirds need a variety of different types of habitats for foraging and nesting. As the result of decades of mosquito control efforts, cutting of mangroves, and dredging and filling, natural habitat types in the IRL have been drastically reduced (Schmalzer 1995). In most cases, these changes have had serious negative effects on waterbird populations. All remaining habitat used by waterbirds should be protected wherever it occurs within the system.

Waterbirds are susceptible to a variety of disease that can cause problems ranging from endemic infections of adults to high levels of adult and juvenile mortality and nesting failures at nesting colonies. One particular parasite that has caused problems in nesting wading birds in Florida is *Eustrongylides ignotus* (Spalding 1991, Spalding et al. 1993). This is a large, red nematode that primarily infects members of the family Ardeidae (herons and egrets) although it is also known to occur in the Therskiornithidae (ibises, spoonbill), Ciconiidae (Wood Stork), and Pelecanidae (American White Pelican) (Spalding et al. 1993, 1993). It is acquired by the birds through the ingestion of infected fish that are the second intermediate host of the parasite. An oligochate is the first intermediate host, although the specific species has yet to be identified (Spalding et al. 1993).

A study in central and south Florida found that epizootic infection by this disease was associated with birds feeding on infected fish which were most prevalent at sites with both physical disturbance and a source of nutrient enrichment (Spalding et al. 1993). Adults feeding at such sites brought back infected fish to nestlings which resulted in a high rate of infection and a mortality rate by fledging age among waders as high as 80%. The authors believed that the high prevalence of the parasites was not a normal part of the disease etiology, but was due to physical and/or chemical alteration of the feeding sites resulting in

high populations of the oligochate intermediate host. The presence of the parasite in nestlings is believed to be unusual and due to the alteration of adult feeding habitat used by the parents (Spalding et al. 1993).

As pointed out by Spalding et al. (1993), a *Eustrongylides* epizootic might easily be overlooked or attributed to other factors. There are several areas of possible favorable conditions for a *Eustrongylides* epizootic at PAFB. Impoundments at the Golf Course are heavily used by Ardeids and also may receive large nutrient loads due to fertilization and the use of treated effluent as irrigation water (gray water). These freshwater ponds could be ideal sites for *Eustrongylides* to thrive. Many of the other impoundments around the base could also be sources for infection if *Eustrongylides* is present. Further investigation of the quality of water in these impoundment's is warranted. If high nutrient concentrations are found, monitoring of nesting colonies of Ardeids in the vicinity of PAFB, including examination of nestlings for infection, may be warranted.

Methods

Waterbird surveys were conducted quarterly for three areas on PAFB: the Banana River fringe, the Golf Course, and the Airfield canals and canals of the Industrial Area. Surveys were conducted using a vehicle with one observer driving slowly and a second observer recording data. Species, number, and behavior (foraging, perched, loafing, flying, other) were recorded for all waterbirds observed. Surveys were conducted in the early and late morning and early afternoon. Five quarterly surveys were conducted during the study (August and November 1995; February, May, and August 1996). The August 1995 survey did not include the Golf Course, but the subsequent four surveys covered identical routes that included the Banana River fringe, the ditches and wetlands associated with the Airfields and adjacent Industrial Area, and the retention ponds, ditches, and grass areas associated with the Golf Course.

The Banana River fringe area was located on the west side of the base. Shoreline consisted of alternating rock (used for shoreline stabilization), sand, and mud substrate. Vegetation along the river fringe consisted of mowed grass areas around the North Housing Units, unvegetated rock, or sand areas around the Industrial Area, and a thin strip of Brazilian pepper and mangrove along the southern third of the base. Surveys covered approximately 5780 m of river shoreline. The Golf Course waterbird habitat consisted of freshwater canals with cattails and other emergent vegetation and a canal connected to the Banana River. The length of these canals was approximately 4530 m . There were also a few large, freshwater ponds located at the south end of the Golf Course and at the maintenance facility. Grass areas of the Golf Course, including depressional areas, were also used by waterbirds. Airfield canals were either freshwater, dominated by cattail, or were connected to the Banana River and had elements of brackish marsh. Mowed grass and herbaceous depressions at the Airfield

were also used by waterbirds. Approximately 7130 m of runway were traversed during surveys at the Airfields.

Results

Twenty-five species of waterbirds were observed during the five quarterly waterbird surveys at PAFB (Table 9). Species ranged from abundant year-round (e.g., Double-crested Cormorant, Cattle Egret, White Ibis, Mottled Duck, Common Moorhen, American Coot) to those birds present on only one survey (e.g., American White Pelican, Wood Stork, American Wigeon, Ring-necked Duck, and Lesser Scaup). Figure 4 shows the seasonal abundances of the seven most common species based on the number of individuals observed during the four complete quarterly surveys. Some species showed little seasonal variation (Brown Pelican, Cattle Egret, Common Moorhen, Mottled Duck, White Ibis), while others were more abundant in winter (American Coot, Double-crested Cormorant).

Discussion

The assemblage of waterbird species observed at PAFB during quarterly surveys was characteristic of species present in the IRL system (Table 8). Relative and seasonal abundances based on these surveys should be regarded as preliminary assessments of the biodiversity occurring on PAFB. These surveys were not designed to measure density or determine significant differences in the rate of occurrence between species. It would require much more intensive survey methodology to determine precisely which species are most dependent on PAFB habitats. Short duration, low effort surveys such as this one are more apt to produce a snapshot of biodiversity rather than a complete assessment (Dawson 1981, Van Riper 1981). However, it is clear from the results of this study that habitats on PAFB are important for a variety of waterbirds.

Five state-listed species of special concern were observed using wetland habitats on PAFB including: Snowy Egret, Little Blue Heron, Tricolored Heron, White Ibis, and Brown Pelican. One federally-listed endangered species, the Wood Stork, was observed at PAFB. The Snowy Egret, Little Blue Heron, Tricolored Heron, and White Ibis used ponds, ditches, and canals on PAFB for foraging (Table 9). Brown Pelicans were observed using the Banana River west of PAFB as foraging habitat and pilings and dock structures at PAFB for roosting sites.

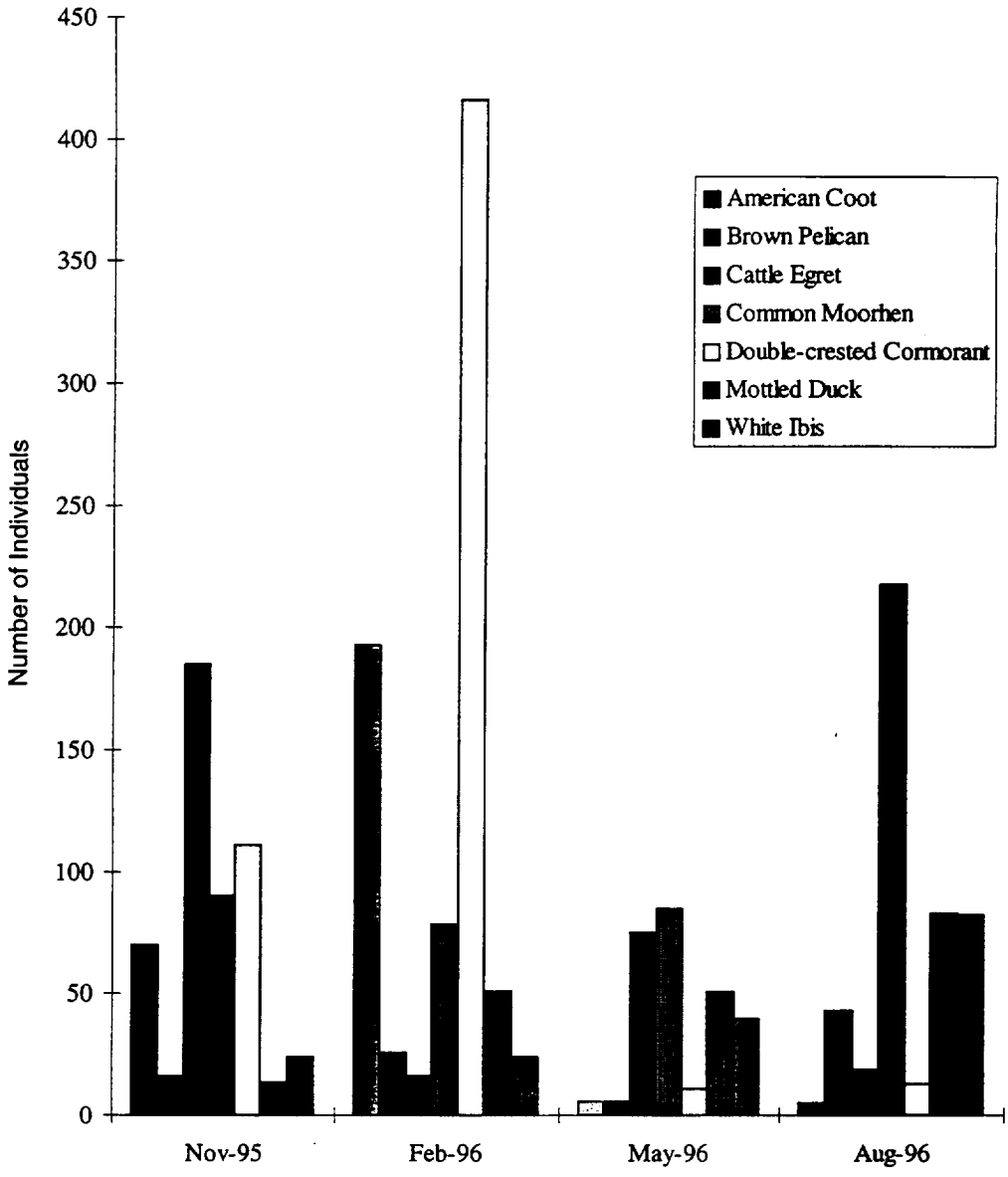

Figure 4. Seasonal abundance of the seven most common species of waterbirds observed during quarterly surveys at Patrick Air Force Base.

Table 9. Species of waterbirds observed on PAFB quarterly surveys.

Species	Total[a]	Season[b]	Behavior[c]	Location[d]
Pied-billed Grebe	23	2/3/4	f/l	4, 2, 3
American White Pelican	45	3	f	1
Brown Pelican	91	2/3/4/5	pr/l (f in river)	4, 1
Double-crested Cormorant	569	1/2/3/4/5	p/l/f	4, 3, 1, 2
Anhinga	43	2/3/4/5	pr/l	4, 1
Great Blue Heron	65	1/2/3/4/5	f/l	4, 3, 2, 1
Great Egret	25	1/2/3/4/5	f/l	4, 1, 2, 3
Snowy Egret	72	1/2/3/4/5	f/pr/l	1, 4, 2 3, 3
Little Blue Heron	11	2/3/4/5	f/l	1, 4, 2
Tricolored Heron	48	2/3/4/5	f/l/pr	4, 3, 2, 1
Cattle Egret	304	1/2/3/4/5	f/l	2, 4, 5, 3
Green Heron	7	3/4/5	f/l	4, 3
Black-crowned Night Heron	12	2/4/5	pr/fly/l	4, 1
White Ibis	200	1/2/3/4/5	f	4, 2, 3
Glossy Ibis	35	1/3/5	f	2, 4
Wood Stork	1	2	l	4
Mottled Duck	199	2/3/4/5	f/l	4, 3, 2
Mallard	33	2/3/4/5	l/f	4, 2 3
Blue-winged Teal	50	2/3/4	l/f	4, 2
Northern Shoveler	29	2/3	l/f	4, 2
American Wigeon	1	3	l	4
Ring-necked Duck	2	3	l	4
Lesser Scaup	64	3	l	4
Common Moorhen	472	1/2/3/4/5	f/l	4, 3, 2 3, 1
American Coot	274	2/3/4/5	l/f	4, 2

[a]Total number of individuals observed over all quarterly surveys.

[b]Quarters during which species was observed. 1=August 1995, 2=November 1995, 3=February 1996, 4=May 1996, 5=August 1996.

[c]Behaviors observed. l=loafing, f=foraging, pr=perched, fly=flying.

[d]Locations observed, in order of frequency of observations. 1=Banana River, 2=Airfield, 3=ditches, 4=Golf Course, 5=Industrial Area

A high number of waterbirds were observed using the Golf Course. All species of waterbirds observed at PAFB, except the American White Pelican, were recorded at the Golf Course (Table 9). A concern for waterbirds using these habitats is the water quality. The Golf Course wetlands receive inputs of pesticides, herbicides, and fertilizer from greens maintenance activities. Another source of nutrients is found in the reclaimed irrigation water used. Previous studies have found pesticide residues and breakdown products, and some metals, primarily arsenic, in soils, groundwater, and sediments of drainage ditches in or near the Golf Course (USAF 1995). These contaminants may threaten the health of birds feeding in these systems (Lincer and Salklind 1973, Olendorf et al. 1988, Spalding 1991, Frederick and McGehee 1994). Contaminants in these wetlands may also effect groundwater and seep into the Banana River (USAF 1995). Water quality of the Golf Course wetlands is being monitored as part of the USAF Installation IRestoration Program (USAF 1995).

The ditches and herbaceous areas around the Airfield were also found to be important areas for waterbirds (Table 9). These areas may receive inputs of contaminants from aircraft as runoff from the runway surfaces. Potential contaminants may include airplane fuel, petroleum based solvents and lubricants, and cleaning solvents. It may be desireable to monitor the Airfield for potential sources of contamination. Some ditches directly receiving Airfield run-off are connected to the Banana River. Run-off from Airfields might become groundwater that eventually reaches the Banana River (USAF 1995). Thus, Airfield contaminants have the potential to affect many important areas of waterbird foraging habitat. The water quality in these wetlands should be monitored, and contamination levels should be kept to a minimum.

The Banana River was found to be important for waterbirds as feeding and roosting habitat. The danger of contamination of this sensitive habitat from runoff has already been mentioned. The shallow water at the edge of the river is used by many species of waterbirds and shorebirds for foraging. The water quality of this region should be monitored and contamination levels should be kept to a minimum. Direct runoff of stormwater to the river should not be allowed. Recent monitoring (USAF 1995) indicates no surface flow to the Banana River under normal conditions.

Finally, many species of waterbirds are highly susceptible to disturbance. Wetland habitats throughout PAFB should be protected from human disturbance whenever possible to allow feeding, loafing, and nesting behaviors to occur. The Brazilian Pepper/Mangrove area on the southwestern edge of the base deserves special protection from disturbance as it represents the last remaining area of well vegetated river shoreline at PAFB. If exotic vegetation is removed from this area, it should be done in stages to allow some vegetative cover to remain for the birds to use. The large canal that enters the base near the south end may be suitable for heron nest sites and should also be protected from disturbance.

The large number of Mottled Ducks occurring at PAFB along with domestic Mallards prompted a concern for hybridization between the two (Table 9). Hybrid Mottled-Mallards are not easily identified, and male hybrids are more visually distinct than are females (Paul Grey, National Audubon Society, pers. comm.). On 3 June 1996, a survey of the Golf Course was conducted to search for hybrid Mottled-Mallards. Several definitive Mottled-Mallard hybrids were observed in close proximity to other definitive Mottled Ducks. One definitive male domesticated Mallard was observed. A Mottled Duck nest was observed in the dune vegetation on PAFB during a plant survey. Thus, the opportunity for breeding between these two species exists at PAFB, and there is evidence that hybridization is occurring.

Domestic Mallards are not adapted to competing against native Mottled Ducks in Florida; they must rely on an artificial food source to persist. Feeding of domestic Mallards (and other wildlife) at PAFB should be discouraged. The Florida Game and Freshwater Fish Commission Waterfowl Management Section has expressed interest in investigating this situation at PAFB (Rick Brust, FGFWFC, pers. comm.).

Shorebirds, Gulls, and Terns

Introduction

The Atlantic coast of Brevard County is home to many species of shorebirds, gulls, and terns at various times of the year (Tables 10 and 11). Most of these birds are present in Brevard County in winter or during migration; a few species breed in Brevard County. The variety of coastal wetlands that occur in Brevard County include beaches, estuaries, salt marshes, mudflats, freshwater marshes, wet grassy fields, and ponds. All types except mudflats occur on PAFB. Some species of shorebirds that migrate and winter along the Atlantic coast have declined in numbers observed during migration from 1972-1989 (Howe et al. 1989). Thus, there is reason for concern for the status of wintering and migratory shorebirds using beaches and other coastal wetlands at PAFB. The variety of birds using these systems can be divided into shorebirds, gulls, and terns.

Many species of shorebirds use the barrier islands of Brevard County. Many species of shorebirds that use coastal wetlands visit Brevard County as they pass through on migration from high latitude breeding grounds to southern hemisphere wintering sites (Table 10). Members of most of these species remain in Florida for periods ranging from a few days to the entire winter. Merritt Island has been named as one of the top four wintering habitats for shorebirds in Florida (Paul 1991); shorebirds using Merritt Island may visit PAFB due to the close proximity.

Table 10. Species of shorebirds likely to occur in coastal Brevard County.

Species	Status[a]	Habitat[b]
Charadriidae		
Black-Bellied Plover (*Pluvialis squatarola*)	W/M	B,E,SM,I(FW)
Wilson's Plover (*Charadrius wilsonia*)	R, W/M	B,E,SM,MF
Semipalmated Plover (*Charadrius semipalmatus*)	W/M	E, MF, SM, B, I(FW)
Piping Plover (*Charadrius melodus*)	W	B, E, MF, SM
Killdeer (*Charadrius vociferus*)	R, W/M	B. E. FW, I(FW, G)
Haematopodidae		
American Oystercatcher (*Haematopus palliatus*)	R, W	B, E, SM
Recurvirostridae		
Black-necked Stilt (*Himantopus mexicanus*)	BR (W-)	SM, E, FW, I(FW)
American Avocet (*Recurvirostra americana*)	W	SM, E, FW, I(FW)
Scolopacidae		
Greater Yellowlegs (*Tringa melanoleuca*)	W/M	SM, E, FW, I(FW), B
Lesser Yellowlegs (*Tringa flavipes*)	W/M	SM, E, FW, I(FW), B
Willet (*Catoptrophorus semipalmatus*)	R, W/M	SM, E, B, I(FW)
Spotted Sandpiper (*Actitis macularia*)	W/M	SM, E, FW, I, FW, (B-)
Whimbrel (*Numenius phaeopus*)	W/M	SM, E, G, B, (I-)
Long-billed Curlew (*Numenius americanus*)	W/M	B, SM, E
Marbled Godwit (*Limosa fedoa*)	W/M	E, MF, B, SM (G-)
Ruddy Turnstone (*Arenaria interpres*)	W/M	E, B, G, FW, SM, MF
Red Knot (*Calidris canutus*)	M (W-)	B, E, SM, (I-)
Sanderling (*Calidris alba*)	W/M	B, E, SM
Semipalmated Sandpiper (*Calidris pusilla*)	M (W-)	W, SM, B, I(FW)
Western Sandpiper (*Calidris mauri*)	W/M	B, E, SM, I(FW)
Least Sandpiper (*Calidris minutilla*)	W/M	SM, E, B, I(FW)
Dunlin (Calidris alpina)	W/M	E, SM, FW, I(FW)
Stilt Sandpiper (Calidris himantopus)	M (W-)	B, E, SM, FW, I(FW)
Short-billed Dowitcher (*Limnodromus griseus*)	W/M	E, SM, MF, G, FW
Common Snipe (*Gallinago gallinago*)	W/M	FW, (E-, SM-)

a M=present during migration, W/M=winter resident with peak numbers during migration, R=year-round resident, BR=breeding resident.(-) denotes reduced presence.

b B=beach, E=Estuary, FW=freshwater, SM=salt marsh, MF=mudflats, G=grassy fields, I=occurs inland, I(FW)=freshwater interior.

Table 11. Gull and tern species likely to occur in coastal Brevard County.

Species	Status[a]
Laridae	
Laughing Gull (*Larus atricilla*)	BR
Bonaparte's Gull (*Larus philadelphia*)	W
Ring-billed Gull (*Larus delawarensis*)	W (R-)
Herring Gull (*Larus argentatus*)	W (R-)
Great Black-backed Gull (*Larus marinus*)	W (R-)
Gull-billed Tern (*Sterna nilotica*)	BR, M(fall)
Caspian Tern (*Sterna caspia*)	BR
Royal Tern (*Sterna maxima*)	BR
Sandwich Tern (*Sterna sandvicensis*)	R
Common Tern (*Sterna hirundo*)	M(pelagic)
Foerster's Tern (*Sterna forsteri*)	W
Least Tern (*Sterna antillarum*)	B
Black Tern (*Chlidonias niger*)	M
Black Skimmer (*Rynchops nigra*)	BR

[a] BR=permanent breeding resident, W=winter, R=present year-round, M=migration, B=breeding season only. (-) denotes a reduced presence during indicated season.

Shorebirds that breed at high latitudes make extremely long-distance migrations. These birds rely on staging areas where they can rest undisturbed and refuel for the remainder of their journey. Brevard County beaches may be an important staging area for several species including Ruddy Turnstone, Sanderling, Red Knot, and Dunlin (E. D. Stolen, pers. obs.). Members of these species also overwinter in Brevard County, often in large numbers. Human disturbance during certain times of the year may impact migratory, overwintering, and breeding populations of shorebirds using PAFB. Sand deposited during beach renourishment efforts could also effect the availability of prey species for shorebirds by changing the depth to prey species, the density of sand, sand grain size, or salinity of the inter-tidal region of the beach. The timing of beach renourishment can affect the amount of disturbance to migratory species, wintering populations, and nesting shorebirds.

Two species of plover, the Snowy Plover and the Piping Plover, are species with special conservation concerns. Although neither species breeds in Brevard County, both have the potential to occur on beaches there during non-breeding seasons (July through March). Both species have undergone recent declines in numbers that make their continued existence uncertain (Woolfenden 1978a, 1978b, Stevenson and Anderson 1994). The Snowy Plover is listed as a threatened species by the state, while the Piping Plover is listed as threatened at both the state and federal level (Wood 1996). Because neither species breeds in the area, and both are only rarely sighted in Brevard County, no special actions need to be taken by resource managers at PAFB for these species. The main threat to both species in Florida is disturbance by humans on their primary habitat, the open beaches (Woolfenden 1978a, 1978b).

The American Oystercatcher is a widespread species of shorebird that breeds along both the Atlantic and Pacific coasts of North America, and in the West Indies (American Ornithologists Union 1983). The American Oystercatcher is a resident breeding species in Florida, and migrants from more northern portions of the species range winter in Florida (Stevenson and Anderson 1994). Brevard County breeding locations are an important part of the population of American Oystercatchers in the state (DeGange 1978). The American Oystercatcher is listed by the state as a species of special concern (Wood 1996). To protect this species, human disturbance along the beach should be reduced and potential nesting habitat along the dunes and Banana River should be preserved (DeGange 1978).

Five species of Larids (gulls and terns) nest in Brevard County; seven others do not breed here, but use the beaches, coastal wetlands, and other habitats at various times of the year (Table 11). MINWR is home to important breeding colonies of Caspian Terns, Royal Terns, and Laughing Gulls (Cruickshank 1980, Paul 1991). The current status of these colonies is unclear. Gulls and terns require undisturbed nesting and roosting habitats (Burger 1981, Safina and

Burger 1983). The beach along PAFB is a potential roosting area for these birds, and for Brown Pelicans and Double-crested Cormorants.

Methods

Two shorebird surveys were conducted along approximately 6740 m of beach at PAFB. Surveys were initiated within one hour of low tide and took approximately one hour to complete. Observers rode on 4-wheel all-terrain vehicles at approximately 10 km/hr, recording observations of all species of birds along the beach. When necessary, the observers stopped to count, identify large groups of birds, and record data. Birds observed within 50 m of shore were also recorded when identification was possible (usually gulls, terns, Brown Pelicans, and Double-crested Cormorants). Shorebirds, gulls, and terns were also recorded during four quarterly waterbird sampling efforts on PAFB (see Waterbirds section). The location, identity, and number observed were recorded. Shorebirds, gulls, and terns seen during some other work performed at PAFB were also recorded. Finally, Least Tern and Black Skimmer nesting was monitored on the entire base (see Least Tern and Black Simmer section).

Results

Twenty-three species of shorebirds, gulls, and terns were observed on PAFB (Table 12). The most common species were Black-bellied Plover, Ruddy Turnstone, Sanderling, Laughing Gull, Ring-billed Gull, Herring Gull, Royal Tern, Least Tern, Black Tern, and Black Skimmer. ur areas of PAFB were found to be important for shorebirds, gulls, and terns: the beach, the edge of the Banana River on the west side of the base, the runways and associated grassy areas of the Airfield, and the Golf Course (Figure 1).

The Banana River fringe was used by shorebirds as foraging and resting habitat. The north ends of the runways were used by Laughing Gulls, terns (Least Tern, Royal Tern, Black Tern, and Black Skimmer), and plovers (Black-bellied Plover and Killdeer) for resting habitat, and the grassy area around the Airfield provided foraging habitat for Black-bellied Plover and Killdeer. The grass areas of the Golf Course provided resting and feeding areas for shorebirds and gulls, and the ponds were used by foraging Least Terns. The beach was used as resting and foraging habitat by several species of shorebirds, gulls, and terns (see Table 12).

Discussion

The edge of the Banana River along PAFB provided foraging and roosting habitat for several species of shorebirds. This stretch of river is fairly well protected and undeveloped compared with adjacent areas to the north. Additional foraging habitat for these species can be found along the causeway to

Table 12. Species of shorebirds, gulls, and terns observed on PAFB.

Species	Number[a]	Location[b]
Black-bellied Plover	192	Airfield, Beach, Banana River
Semipalmated Plover	13	Banana River, Beach
Killdeer	38	Banana River, Airfield, Golf Course
Willet	9	Beach, Banana River
Spotted Sandpiper	8	Banana River
Whimbrel	6	Golf Course
Ruddy Turnstone	131	Banana River, Beach
Sanderling	348	Beach, Banana River
Dunlin	1	Banana River
Common Snipe	7	Airfield, Banana River
Laughing Gull	257	Banana River, Beach, Airfield, Golf Course
Bonaparte's Gull	1	Banana River
Ring-billed Gull	252	Beach, Banana River, Golf Course, Airfield
Herring Gull	86	Beach, Banana River, Golf Course
Great Black-backed Gull	7	Beach, Banana River, Golf Course
Caspian Tern	2	Beach, Banana River
Royal Tern	322	Airfield, Banana River, Beach
Sandwich Tern	46	Airfield, Beach
Least Tern	249	Banana River, Beach, Golf Course, Airfield
Black Tern	100	Airfield, Beach
Black Skimmer	100	Airfield, Banana River, Golf Course

[a] Total number observed over entire study.

[b] Location of observations in order of frequency of observations (see Figure 1)

the south of PAFB. Thus, the Banana River edge of PAFB is an important part of one of the few areas of suitable foraging and resting habitat for species of birds using the Banana River in this section of Brevard County. This habitat should be protected from unnecessary disturbance whenever possible. The edges of the Banana River could be revegetated to provide additional cover for birds. The distribution of seagrass that provides habitat for prey species should be evaluated.

Many species of shorebirds are highly susceptible to disturbance on beach resting habitat (Pfister et al. 1992). The beaches at PAFB are heavily used by people, and this disturbance may affect shorebirds. Of special concern are the juvenile Least Terns that fledge from roof nesting colonies on the base (see Least Tern and Black Skimmer below). The use of beach habitat by the birds is poorly understood and warrants further investigation. Beach renourishment should be timed to minimize the amount of disturbance to migratory and wintering shorebirds and Least Terns.

The large number of shorebirds, gulls, and terns that were observed roosting on the ends of the runway included birds that were displaced by human activity from the beaches in the area. These roosting sites are important resting areas for these species and should be protected from unnecessary disturbance whenever possible. Runway roosting is fairly common in coastal regions and other areas with an abundance of shorebirds. This artificial roosting area has been studied on the Shuttle Landing Facility (SLF) at Kennedy Space Center (Larson et al. in prep.). In most situations, roosting flocks prefer to stay in areas of minimum disturbance and will seldomly remain on runways with steady air traffic. Wide, open, quiet spaces that simulate natural beaches or mudflats are preferred habitat. If shorebird roosting and aircraft activity are a problem a complete understanding (investigation) of the species using the area should be conducted before any management action is taken. In many cases hasty management actions can provide negative results to the species or the situation in question. The ditches and mowed grass areas of the runway are also used by shorebirds as foraging habitat (see Waterbirds section). Because these areas are subject to runoff from the runways, they could be subject to contamination.

The Golf Course was also found to be an important area for shorebirds, gulls, and terns. The grass areas were used for foraging by Whimbrels (and wading birds; see Waterbirds section). The Golf Course ponds were used by foraging Least Terns. These wetlands are subject to pesticide, herbicide, and fertilizer runoff resulting from the Golf Course greens maintenance (USAF 1995). These pollutants may represent a threat to the health of bird species utilizing these wetlands.

Least Terns and Black Skimmers

Introduction

Life-History

The Least Tern breeds along the Atlantic coast, from Maine south to Florida, and west to Texas. A separate population breeds along the Pacific coast from central California to southern Baja California and Chiapas. An interior population breeds along the Colorado, Red, Missouri, Mississippi, and Ohio River systems. The Least Tern also is found breeding in the Atlantic-Caribbean region, in Bermuda, the Bahamas, Greater Antilles, parts of the Lesser Antilles, and islands off of Belize, Honduras, and Venezuela. The Atlantic coast population winters along the coast of South America from Colombia east to eastern Brazil (American Ornithologist's Union 1983).

Each year from mid-March through April, Least Terns arrive in Florida from their South American wintering grounds in search of nesting sites (Stevenson and Anderson 1994). The Least Tern nests in colonies ranging from a few to several hundred pairs (Stevenson and Anderson 1994). Colony sites are located on sparsely vegetated sand and shell substrates on coastal beaches, river banks, lakeshores, spoil islands of rivers or estuaries, marsh sand flats, and recently on gravel roofs (Thompson and Slack 1982, Gochfeld 1983, Burger 1984, Burger and Gochfeld 1990, Stevenson and Anderson 1994).

The Least Tern selects sparsely vegetated sites for nesting (Tomkins 1959, Burger 1984, Kotliar and Burger 1986). Colony sites are used year after year, with some colonies persisting for many years. However, occasionally colony sites are abandoned by terns. In New Jersey, Burger (1984) estimated that 15% of colony sites were abandoned in any given year. There are several factors that cause Least Terns to abandon a colony site. Although some vegetation is beneficial as cover for mobile chicks, colonies will abandon sites that become too vegetated (Tomkins 1959, Burger 1984). Other factors that are correlated with abandonment are human disturbance, presence of mammalian predators, and flooding (Tomkins 1959, Kotliar and Burger 1986). Of these, human disturbance is probably the factor most responsible for recent declines (Burger 1984, Kotliar and Burger 1986). Human-caused disturbances can exacerbate many of these problems. For instance, building bridges to barrier islands can allow mammalian predators access to once safe colony sites (Tomkins 1959).

The underlying cause of colony abandonment is reproductive failure (Burger 1984, Kotliar and Burger 1986). In New Jersey, Burger (1984) found that Least Terns always reoccupied colonies in which there was successful reproduction (those in which pairs produced an average of more than 0.5 young per pair). Moderately successful colonies were usually reoccupied. Some colonies were occupied for several years during which reproductive success was low. Thus, large colony sites

may represent areas that are important for tern reproduction that should be protected from disturbance (Burger 1984). Least Terns are often observed at the beginning of the breeding season at colonies that are later abandoned. This suggests that disturbance early in the nesting season will have the most effect on abandonment (Burger 1984).

Usually the number of nesting pairs will decline in the years prior to abandonment. Colonies that are abandoned often go through several years of reduced reproductive success prior to abandonment (Burger 1984, Kotliar and Burger 1986). At some colony sites, Least Terns may show strong site tenacity, returning for several years despite poor reproductive success. At other sites, they may abandon immediately following reduced reproductive output or disturbance (Fisk 1978a, 1978b). The Least Tern is adapted to nesting on a dynamic substrate, and colony site turn-over is a part of their natural behavior (Burger 1984). However, recent disturbance by human activities has increased the rate of turn-over and decreased the reproductive success of colonies.

Nesting Behavior

Least Terns spend about a week engaged in courtship prior to nesting; courtship usually takes place away from the colony site (Tomkins 1959). Pairs build a simple scrape in the sand or gravel and lay from 1-3 (usually 2) eggs. Incubation lasts about three weeks with both sexes participating. The chicks can fly about one month after hatching (Stevenson and Anderson 1994). Least Terns will often lay a second clutch if their first nesting attempt is not successful (O'Meara and Gore 1988). Second attempts by unsuccessful pairs, and late nesting by inexperienced second-year birds causes a second peak in the number of pairs nesting in late June (Lohrer and Lohrer 1973, O'Meara and Gore 1988). The parents forage for food in small ponds, ditches, rivers, or ocean waters; they will travel up to 5 km from the colony site in search of small fish. The majority of juveniles will depart the colony within three weeks after fledging (O'Meara and Gore 1988). Once fledged, juveniles learn to forage by watching adults (Tomkins 1959).

Status

The Least Tern is listed as a threatened species by the FGFWFC (Wood 1996). Both the interior and the California populations are considered threatened by the USFWS. Least Terns were nearly extirpated by the feather trade in the late 1880's. Following legal protection, the population recovered until the 1930's to early 1940's when the population began to decline precipitously due to human encroachment on nesting habitat. By 1974, surveys by the USFWS found that the production of fledglings was generally poor from Key West to Maine (Fisk 1975). There is some evidence that populations have stabilized recently, perhaps due to increased roof nesting offsetting losses at ground colonies (Gore 1991).

Roof-nesting

With the loss and degradation of natural colony sites, the Least Tern has adapted to nesting on gravel rooftops. Nesting on rooftops was first reported by Goodnight (1957) in Pensacola, Florida, and has since become widespread throughout the state (Gore 1991). By 1975, Fisk (1975) reported that 21% of the colonies along Florida's Atlantic coast occurred on roofs. Several studies have shown that roof colonies have higher reproductive success than do nearby beach colonies; this may reflect superiority of the roof environment or the degradation of existing ground colonies (Fisk 1978a, 1978b, Gore and Kinnison 1991). Roof colonies have been reported typically to be larger than ground colonies (Gore and Kinnison 1991), and colony size is correlated with reproductive success (Nisbet 1975). Least Terns nest on roofs surfaced with tar and gravel (pea-rock or shell). Roof slope varies from none to slightly pitched. Roofs used by Least Tern colonies range in size from tens of square meters to a few hectares; buildings are from one to six stories high (Fisk 1978b).

There are many hazards to eggs and young of roof nesting Least Terns. High winds can blow eggs out of scrapes where they may be abandoned by parents, or blow eggs completely off roofs. Heavy rains can flood nests and wash eggs and chicks off roofs (Fisk 1975, Gore and Kinnison 1991). Chicks can become trapped in gutters or washed down drain spouts (Goodnight 1957, Fisk 1978b). Chicks may also stick to exposed tar and die of exposure (Fisk 1978a). Chicks that fall off roofs and survive face the threat of ground predators or being crushed by vehicles if adequate shelter is lacking (Fisk 1978b, Burger 1981, O'Meara and Gore 1988).

Humans entering rooftop colonies can cause chicks to run off the edges and parents to fly off scrapes leaving nests exposed; repeated intrusion may cause the colony to be abandoned (Fisk 1978b, Burger 1981). Roof repairs during or just prior to nesting season disrupt colonies and may cause them to be abandoned. Human disturbance at colonies increases stress on parents, increases intraspecific aggression rates, and exposes chicks to aggression from adults when they wander into adjacent territories (Burger 1981). Recently, many tar and gravel roofs are being resurfaced with smooth plastic material that is unsuitable for tern nesting (Gore 1991, Gore and Kinnison 1991). This results in a further decrease in available nesting habitat.

Black Skimmers

Black Skimmers breed along the east coast from Massachusetts, New York, and New Jersey, south to southern Florida. They breed along the Gulf coast from Tampa, Florida, through Texas, and south to Tabasco, Mexico. They also occur on the Pacific coast from southern California south to northern Argentina. In Florida, the Black Skimmer is a permanent resident. Numbers in Brevard County may increase in winter due to an influx from northern portions of the breeding range (American Ornithologist's Union 1983). Although they are primarily beach

nesters, small numbers of Black Skimmers attempt to nest on roofs in a few locations in Florida each year. Roof nesting in Black Skimmers was first noted in 1975 (Greene and Kale 1976). The Black Skimmer is listed as a species of special concern in Florida by FGFWFC (Wood 1996).

Roof nesting Black Skimmer colonies are usually small and have low nesting success when compared with beach colonies (Greene and Kale 1976, Safina and Burger 1983, Gore 1987). Several factors make roof nesting more difficult for Black Skimmers than for Least Terns. These include:

1. Black Skimmers are more sensitive to human disturbance than are Least Terns. When disturbed, they typically take longer to return to nests. This exposes their nests to predators for long periods of time and may contribute to the low reproductive success on roofs. They may also be more likely to abandon colony sites than are Least Terns (Greene and Kale 1976, Safina and Burger 1983).

2. Black Skimmers make deeper scrapes than Least Terns. This may expose the eggs of roof nesting Black Skimmers to tar (Greene and Kale 1976, Gore 1987). It may also be that the adults cannot dig an adequate scrape on roofs and that they crush their eggs beneath their bodies while incubating (Gore 1987).

3. Black Skimmers lay large eggs that can blow in strong wind. Roofs are exposed to higher winds that blow eggs out of nests. This problem may be compounded by the shallower scrapes made by Black Skimmers when nesting on roofs. Eggs blown out of nests may be abandoned, or parents attempting to return them to scrapes may damage them (Gore 1987).

Methods

Roof nesting by Least Terns on PAFB was assessed by examining potential sites available for roof nesting, gathering available historic evidence of previous Least Tern rooftop colonies, assessing potential hazards for roof nesting Least Terns at PAFB, and monitoring nesting success during the 1996 nesting season. Methods were based on recommendations from FGFWFC (O'Meara and Gore 1988, J. Gore, FGFWFC, pers. comm.). Field work was conducted in three phases:

1. Specification of the roofs of all buildings on PAFB were obtained from the Planning Office. Roofs suitable for Least Tern nesting were identified using this information and by inspection of all buildings from the ground. A representative sample of roofs was examined by accessing the roof prior to nesting season to confirm interpretations made from the ground and to identify specific hazards to roof nesting Least Terns.

2. Ground surveys of all buildings at PAFB were conducted in April, May, and June to locate nesting colonies. Buildings that had been identified as potential colony sites were the primary focus, but surveys included the entire base and were

capable of detecting colony activity at any building at PAFB. Surveys were conducted prior to 0900 by slowly driving a vehicle around all buildings while watching and listening for Least Terns.

3. Nesting activity was monitored at one active colony site throughout the nesting season. Colony surveys were conducted between 0800 and 1000, and took between 45 minutes and 1 hour. Surveys were conducted every two weeks from the time of discovery of the colony until the completion of nesting. The roof was accessed by 1-3 observers who remained outside of the colony and counted individuals with binoculars and a 15-60x spotting scope. Counts were made of: number of adults on scrapes, number of adults standing on roof, number of unattended nests, number of immobile chicks, number of mobile chicks, and number of juvenile/fledglings. The ground around the building was surveyed for chicks that had fallen/washed off the roof at the time of each survey. The roof was characterized for specific hazards to nesting Least Terns. Black Skimmers nesting on this roof were also monitored during the surveys.

Retention ponds at PAFB were monitored for Least Tern foraging during visits to perform other field work. Beaches were surveyed for juvenile Least Terns following beach mouse trapping activities and during several visits at the end of the nesting season.

Results

Roof Inspections

Suitable roofs for Least Tern and Black Skimmer nesting were identified based on information provided by the PAFB Planning Office and ground surveys. In the Industrial Area, all of the roofs with area greater than 465 m^2 were inspected (n=61). Twenty-three (38%) had roofs that were identified as suitable for Least Tern nesting from the ground. Sixteen (27%) had roofs that were identified as unsuitable for Least Tern nesting due to slope and/or substrate visible from the ground. The remaining roofs were identified as possibly suitable for Least Terns but would require inspection of the substrate to verify their suitability. One otherwise suitable roof was being resurfaced and several roofs were being reconstructed to terra cotta style. Closer inspection of 18 rooftops by accessing several tall building roofs confirmed the suitability determinations for 15 roofs in the suitable category, and moved three roofs from the unknown to the suitable category.

South of the Industrial Area, 31 roofs with area greater than 465 m^2 were inspected. Fourteen (45%) were found to be suitable, 15 (48%) unsuitable, and 2 (0.06%) were of undetermined suitability. This area included the Commissary and Hospital buildings where nesting has occurred in previous years. All of the roofs in the housing areas (North Housing and Beach Housing) were unsuitable due to slope and substrate. A few buildings along the beach, east of State Route A1A,

and at the south end of the base near the Golf Course were also found to be suitable for Least Tern nesting.

Colony Surveys

Searches for colony sites from the ground were conducted once every two weeks beginning 5 April 1996 through the end of June. One Least Tern nesting colony was found on the roof of Building 310 near the Banana River at the northwest corner of the Industrial Area (Figure 5). No evidence of nesting on any other roof on PAFB was observed. The Commissary and Hospital roofs (Figure 5) were visited on 20 May, 3 June, and 17 June, 1996. On 20 May, two Least Terns were observed standing on the Commissary roof. No nesting was observed on either roof during 1996.

Colony Monitoring

The colony located on the roof of Building 310 was visited biweekly from 20 May 1996, when it was discovered, through 31 July 1996 when nesting had ceased (6 visits). Table 13 shows the number of adults, nests, immobile downy and mobile chicks, fledglings, and abandoned eggs of Least Terns observed during colony visits. A maximum of 349 nest scrapes was observed on 17 June. A maximum of 92 mobile chicks was observed on this same date. The large number of unattended eggs observed on 1 July and 16 July was probably due to disturbance by observers temporarily causing the incubating adults to flee.

During the 17 June visit, 39 dead chicks were observed in the parking lot near the edge of the roof. The majority of these (34) were found at the north end of the building below the center of the roof. Most of the chicks were fairly fresh (little decomposed), and it appeared that they had run off the roof *en mass*, possibly to escape a predator. Six live chicks were found in the parking lot during this visit; three of these were captured and returned to the rooftop. The live chicks were found on the east side of the building near the drain spouts; they may have washed down the spouts during rains. Three additional dead chicks were discovered on 1 July and five were found on 31 July, bringing the total number of known chick mortalities due to falling off the roof to 47.

Adult Least Terns were observed leaving Building 310 rooftop and foraging in the Banana River to the west. Adult Terns also were seen leaving and returning from

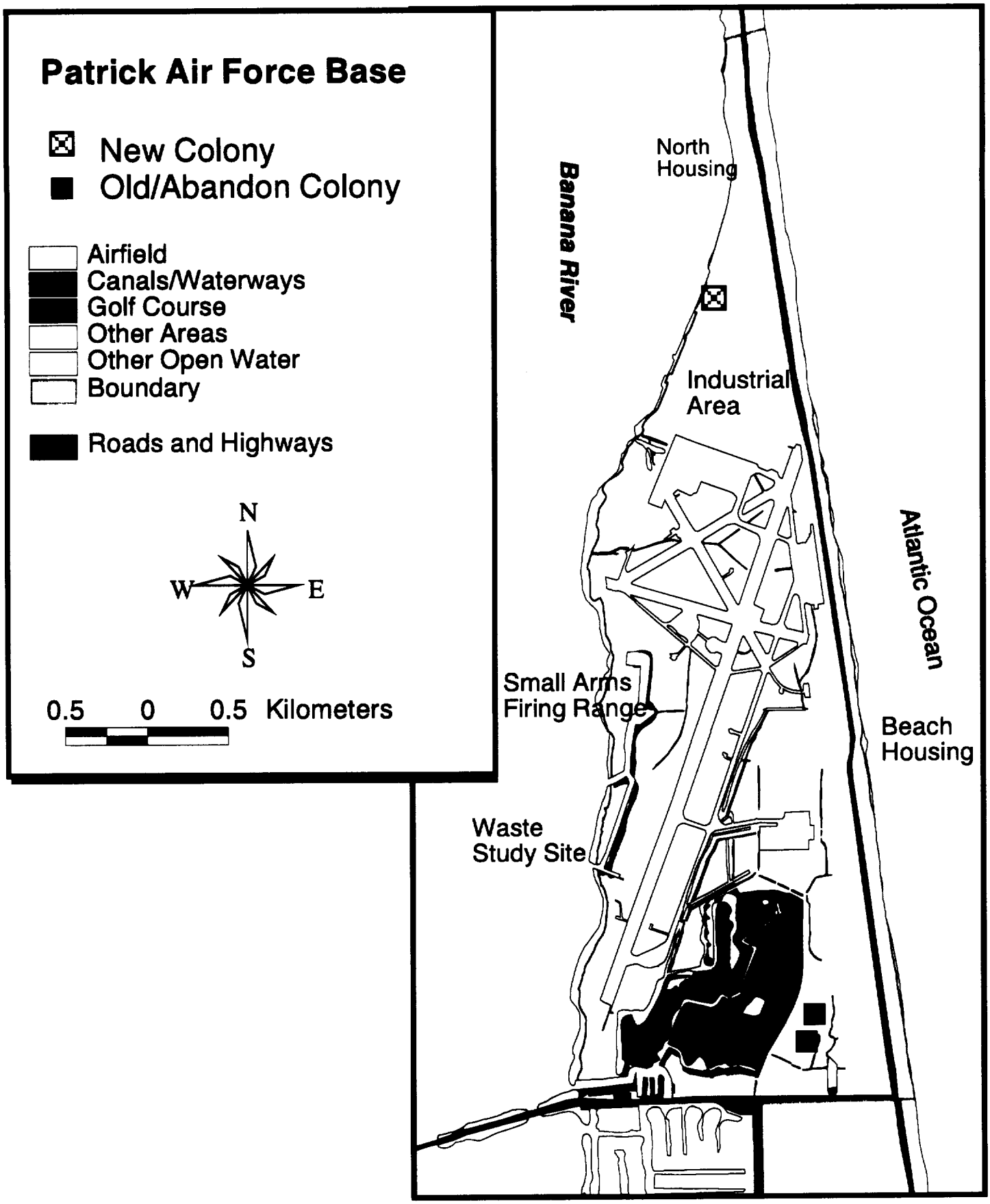

Figure 5. Locations of Least Tern and Black Skimmer roof nesting colonies on Patrick Air Force Base, Florida.

Table 13. Summary of Least Tern nesting on Building 310 rooftop at PAFB during 1996.

Date	Adults	Nests	Downy Chicks	Mobile Chicks	Fledglings	Unattended Eggs
5/20/96	280	205	0	0	0	0
6/3/96	250	185	68	61	2	0
6/17/96	508	349	11	92	0	0
7/1/96	272	95	2	7	7	116
7/16/96	164	10	0	1	6	81
7/31/96	2	0	0	0	0	0

the colony in the direction of the Industrial Area, the Golf Course, and the Atlantic Ocean. Adult Least Terns were observed foraging in the large ponds located at the south end and near the maintenance facility of the Golf Course. Adult and juvenile Least Terns were observed along the PAFB beach, loafing on the beach, and foraging in the surf.

Table 14 shows the number of adults, nests, and abandoned eggs of Black Skimmers observed during colony visits. A maximum of 14 nest scrapes was observed on 20 May. None of these were successful in producing young and all were abandoned by 16 July 1996. It was not clear what factors led to the nest failures. Final inspection of the Black Skimmer nesting scrapes revealed little to no exposed tar in these nests. In contrast, many of the Least Tern scrapes did have exposed tar in the bottoms. Thus, it appears that the Black Skimmers chose an area of thicker gravel to nest when building their scrapes. During visits on 3 June, 17 June, and 1 July, unattended Black Skimmer eggs were observed outside of scrapes. It is possible that these were blown out by wind or moved by the Black Skimmers during disturbance by predators. This may account for some of the failed nests.

Table 14. Summary of Black Skimmer nesting on Building 310 rooftop at PAFB during 1996.

Date	Adults	Nests	Unattended Eggs
5/20/96	23	14	0
6/03/96	27	8	3
6/17/96	13	6	8
7/01/96	13	2	5
7/16/96	0	0	0
7/31/96	0	0	0

Discussion

The colonies on the Commissary and Hospital roofs were not active in 1996. Least Tern colony sites are dynamic and there are several reasons why colony sites may be abandoned (Tompkins 1959, Fisk 1978a, 1978b, Burger 1984, Kotliar and Burger 1986, O'Meara and Gore 1988, Erwin 1989). On several visits to the Commissary building we noticed an abundance of Fish Crows (*Corvus ossifragus*) and Boat-tailed Grackles (*Quiscalus major*). These birds are known predators of Least Tern eggs and chicks (Fisk 1978b), and they are attracted to areas of human occupation where waste food is available. Perhaps an increase in the presence of these predators, due to increased food availability over time, reduced the success rate of Least Terns nesting on the Commissary and Hospital roofs causing the colony to be abandoned. These sites should be monitored in

the future for nesting Least Terns and Black Skimmers. If found, colonies should be protected. It may be necessary to reduce the amount of waste food available in the parking lot and adjacent areas.

A new colony of Least Terns and Black Skimmers was discovered on the roof of Building 310 (Figure 5). This colony was fairly large compared to other reported rooftop Least Tern colonies in Florida (Fisk 1978a, 1978b, Gore 1991, Gore and Kinnison 1991, Hovis and Robson 1989). The Least Tern colony was successful in producing chicks and fledglings. The Black Skimmers were not successful in rearing young. A few workers at this building who were interviewed reported that the Least Tern colony had been active for at least two previous seasons and that Least Terns had nested on other buildings in the vicinity. This building was the site of the only Least Tern and Black Skimmer nesting that occurred on PAFB in 1996.

Because Least Tern and Black Skimmer colony sites are dynamic and because the birds are so sensitive to disturbance, a program of monitoring should be in place at PAFB. This should include surveys at the beginning of nesting season for colony activity (mid-March through early April) and monitoring of active colonies during nesting season (late April through July). Any activity at a building should result in the rooftop becoming immediately off-limits, except for safety or maintenance emergencies. Disturbance to the colony is the factor most likely to cause colony failure and abandonment; it is also the easiest to eliminate (Burger 1981, Erwin 1980, O'Meara and Gore 1988). It is recommended that no persons access the rooftop during colony-site selection and nesting season (between mid-March and late July).

If it is necessary to access a roof with an active nesting colony, it is important that disturbance to the birds is minimized. If an emergency warrants entry onto the rooftop, a staff biologist should be consulted and should accompany the workers onto the roof to insure that colony disturbance is kept to a minimum. The number of persons accessing the roof should be minimized, as should the duration of time spent on the roof. One long visit may cause less overall disturbance than several shorter duration visits. Early morning (before 10:00 AM) or evening (after 4:00 PM) access will minimize the stress on nesting adults and young that might result from heat during mid-day. Visits should be limited to the edges of the roof away from the colony as much as possible

There are several improvements that could be made to buildings at PAFB on which Least Terns are nesting that would enhance the birds nesting success rate (O'Meara and Gore 1988, J. Gore, FGFWFC, pers. comm.):

1. Roof edges. A lip or parapet on the edge of a roof prevents eggs and chicks from washing or blowing off the edge, and it deters mobile chicks from running off the edge. A 15-30 cm lip is sufficient protection for eggs and chicks. If there is no lip or parapet on a building, a suitable lip can be made from

hardware cloth bent into an "L" shape. The screen can be secured to the roof with 2 x 4s or cinder blocks, or could be permanently attached to the roof or the side of the building. An 1.3 cm mesh size is optimal (any larger and chicks might fit through; smaller mesh has more wind resistance).

2. Shade and shelter. Although roofs are generally cooler than beach nesting habitat, the lack of shade and cover can be a serious problem. Cover protects chicks from predators and provides shade during the heat of the day. Some roofs have many structures that provide for these needs while others have almost no cover. A simple solution is to place a few cinder blocks on top of the roof.

3. Drainage system. Many chicks are killed when they are washed off of roofs through drainage pipes or openings. It is not difficult to provide screens for drains that prevent this from occurring. Screens should be of 1.3 cm or less mesh size. It is important that screens be cleaned prior to nesting season to prevent flooding that could drown eggs and chicks.

Any screens that are in place, either on drains or around roof edges, must be cleaned prior to nesting season (before mid-March) to prevent flooding which would result in drowning of eggs and young. If it was deemed appropriate, a few roofs which the birds had used in previous years could be maintained in suitable condition in the hopes that the Least Terns would choose to nest there in the future (candidates would include: Building 310, the Commissary, and the Hospital). It might even be possible to attract Least Terns to these roofs with decoys (Kotliar and Burger 1984).

Another consideration is the location and condition of feeding areas for the colony. Least Terns catch small fish in fresh or saltwater near the colony location (Tomkins 1959). Often the birds will fish in retention ponds located near the colony building. The quality and quantity of water in these ponds may be crucial to the health of the adults and their offspring. If pollution from runoff contaminates these ponds, toxins may accumulate in the Least Tern's tissues, possibly resulting in lowered nesting success, abnormal development of young, or even death of the adults (Lincer and Salkind 1973, Ohlendorf et al. 1988). If the retention ponds are drained during nesting season, this would eliminate a crucial resource for the nesting terns. Therefore, it is important to consider potential impacts to waters in which nesting Least Terns forage (O'Meara and Gore 1988).

Other Avian Species

Several other species of birds with conservation concerns have the potential to occur on PAFB. Some of these species were observed during the scheduled quarterly waterbird surveys, the two shorebird surveys, and during other work performed at PAFB. Below are brief discussions of the status of these birds and observations made during this work.

Osprey

The Osprey has nearly a world-wide distribution (American Ornithologist's Union 1983). Florida is home to a resident population and also serves as wintering habitat for some individuals breeding in the eastern U. S. (Stevenson and Anderson 1994). Although Ospreys in some parts of North America have undergone recent declines due to eggshell thinning caused by pesticides, the Florida population was not affected. Florida Ospreys are threatened by destruction of habitat and disturbance by humans encroaching into their habitat (Ogden 1978c). The Osprey is listed by the state as a species of special concern for Monroe County only (Wood 1996). During bird surveys at PAFB, two observations were made at the beach (birds foraging in the ocean) and five near the Banana River. No nesting of Ospreys was observed on PAFB. If Osprey nests occur in the future, they should be protected from disturbance.

Bald Eagle (*Haliaeetus leucocephalus*)

The Bald Eagle ranges throughout North America as far south as Baja California, Arizona, New Mexico, the Gulf Coast, and Florida. The Florida population is currently around 1000 individuals (300-325 nesting pairs), which makes the Florida population second in size only to that of Alaska among states. Many Bald Eagles nesting in more northern portions of the breeding range winter in Florida (Stevenson and Anderson 1994). Over the last several decades, the Bald Eagle has undergone a sharp decline in numbers due to habitat loss, eggshell thinning due to pesticides, and disturbance and mortality due to humans (Stevenson and Anderson 1994). The Florida population declined by 50% during the three decades before 1978 (Robertson 1978). There is evidence that the Bald Eagle may be increasing in numbers following this long period of decline. The Bald Eagle is currently listed as threatened by both the state and federal government (Wood 1996). One Bald Eagle was observed near the Banana River during one of the quarterly waterbird surveys at PAFB. No suitable Bald Eagle nesting habitat occurs on PAFB. Bald Eagles occurring on PAFB should be protected from disturbance by humans.

Southeastern American Kestrel

This bird is a resident subspecies occupying a portion of the southeastern coastal plain, from South Carolina south to Alabama and Florida. It is listed by the state as a threatened species (Wood 1996). It is difficult to differentiate this subspecies from the more widespread American Kestrel (*F. s. sparverius*) which winters in Florida (Wiley 1978) . Fourteen observations of kestrels at PAFB were recorded during October through February; none were identified to subspecies. Observations were made near the Airfields, the Golf Course, and near the Banana River at the south end of the base. No kestrels were observed in the summer. This suggests that no Southeastern American Kestrels were occupying PAFB during the period of this study. The preferred habitat for Southeastern American Kestrels is open pine/oak woodlands (Bohall-Wood and Collopy 1986). This habitat type is not present on PAFB, and it is unlikely that the Southeastern American Kestrels would nest there. Because their diet consists mainly of insects, kestrels are susceptible to pesticide and herbicide contamination (Breininger et al. 1994).

Arctic Peregrine Falcon

The Arctic Peregrine Falcon is one of three subspecies occurring in North America. It breeds on the arctic tundra and winters throughout the continental U.S. south throughout South America and the West Indies. Many individuals pass through Florida during migration; a few remain in Florida during the winter (Snyder 1978, Kale and Maher 1992, Stevenson and Anderson 1994). This subspecies is listed by the state as endangered (Wood 1996). Because it is difficult to differentiate between the subspecies, all Peregrine Falcons observed on PAFB should be considered to be protected. One Peregrine Falcon was observed at PAFB at the Airfield in October 1995 and was not identified to subspecies.

Burrowing Owl

The Burrowing Owl is an open country bird occurring from southwest Canada through the western U. S., south to Baja California and central Mexico, and also in peninsular Florida and some islands of the West Indies (American Ornithologists Union 1983). The Burrowing Owl nests in underground burrows excavated in well-drained prairies and open grasslands. In Florida, they often inhabit open areas of college campuses, airfields, and golf courses (Stevenson and Anderson 1994). Burrowing owls nest in Brevard County (E. Stolen, pers. obs.). Sightings of Burrowing Owls have been reported on Brevard County barrier islands at Satellite Beach and Port Canaveral (Cruickshank 1980). No Burrowing Owls were observed on PAFB during this study. If any were nesting on PAFB, it is very likely that they would have been detected during waterbird surveys and plant surveys in suitable habitat (i.e., the Airfield and Golf Course). Because Burrowing Owls engage in post-breeding dispersal (Owre 1978, Stevenson and Anderson 1994), the presence of suitable habitat at PAFB and

the proximity to breeding populations nearby makes future colonization of Burrowing Owls at PAFB a possibility. The Burrowing Owl is listed by the state as a species of special concern (Wood 1996). Resource managers at PAFB should be aware of the possibility of nesting by Burrowing Owls. The main threat to Burrowing Owls in Florida is the loss of suitable nesting habitat due to development (Owre 1978). Like the kestrel, the Burrowing Owl's diet consists mainly of insects, making it susceptible to pesticide and herbicide contamination (Breininger et al. 1994).

Neotropical Migrants

Many species of neotropical migrant birds have undergone recent population declines (Robbins et al. 1989). One of the causes of these declines is the loss of suitable wintering habitat, including sites along major migration corridors. PAFB is located along one of the major migratory pathways for neotropical migrants that breed in eastern North America (Taylor and Anderson 1973, Taylor and Kershner 1986). Thus, habitat at PAFB that is suitable for migrants is of conservation concern. During small mammal trapping in October, many neotropical migrants were observed using the dune habitat including: American Redstart *(Setophaga ruticilla)*, Magnolia Warbler (*Dendroica magnolia*), Black-throated Blue Warbler (*Dendroica caerulescens)*, Black-throated Green Warbler (*Dendroica virens)*, Prairie Warbler (*Dendroica discolor*), Yellow-rumped Warbler (*Dendroica coronata*), and Savannah Sparrow (*Passerculus sandwichensis*).

Reptiles

Gopher Tortoise

Introduction

The gopher tortoise (*Gopherus polyphemus*) is a terrestrial turtle with legs adapted for digging and an average carapace length of 23 to 28 cm. The FGFWFC has listed the gopher tortoise as a species of special concern (Wood 1996). Suitable habitat for the gopher tortoise is generally characterized by well-drained, sandy soils for digging burrows, herbaceous ground cover for food, and an open canopy for sunlit nesting activities and herb growth (Auffenberg and Franz 1982, Diemer 1986, Cox et al. 1987). Gopher tortoise burrows average 4.5 m in length and 2 m in depth. Gopher tortoise homerange on KSC has been reported as 1.9 ha for males and 0.65 ha for females (Becky Smith pers. comm.). Burrows are not only used for protection from extreme weather conditions, predators, and fire by gopher tortoises, but are also used as refuge from these same conditions by various commensals (Cox et al. 1987). Jackson and Milstrey (1989) found that 60 vertebrate and 302 invertebrate species, some of which are protected species, use gopher tortoise burrows. The purpose of this study was to determine presence/absence of gopher tortoises on PAFB.

Methods

The Industrial Area, Airfield, Golf Course, Waste Study Site, Small Arms Firing Range, and the coastal dunes were surveyed as potential sites for gopher tortoises (Figure 1). There are several methods for determining occupancy of tortoises and commensals in burrows which include physical observations of the burrow and surrounding area, the Y-stick method, bucket trapping, burrow excavation, and viewing the burrow with a specialized camera system. For this study, the camera system and physical appearance of the burrow were the primary methods used to determine contents of burrows. The only site where gopher tortoise burrows were observed was the Waste Study Site (Figure 6). This site was visited quarterly to determine occupancy by gopher tortoises and commensals. Throughout the study, four burrows were viewed on two occasions with a specialized gopher tortoise camera system to determine occupancy. Burrows were also classified as to activity level by physical appearance (i.e., fresh tracks, newly thrown sand, and lack of leaf litter).

Results

The only burrows on PAFB were found at the Waste Study Site (n=5) (Figure 6). Four tortoise burrows were viewed with the gopher tortoise camera system on two occasions. During August 1995, two burrows where found but the activity levels could not be determined (Table 15). The camera system was used during

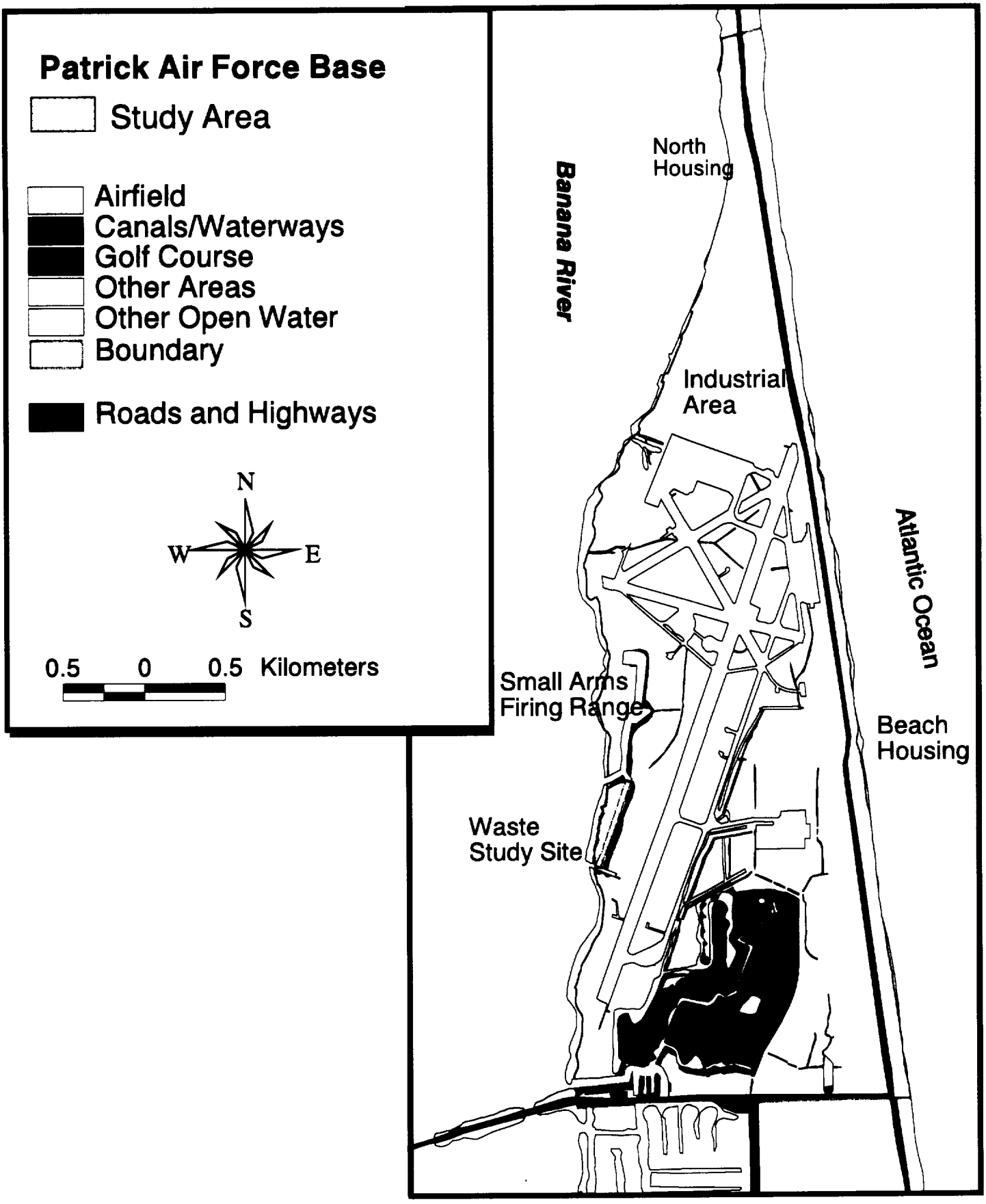

Figure 6. Location of gopher tortoise study area on Patrick Air Force Base, Florida.

February and May of 1996. February yielded two active burrows; gopher tortoises were seen in both, with the camera (Table 15). One burrow had many turns making it difficult to maneuver the camera to verify occupancy by a tortoise. Although it appeared to be active from the outside, the burrow was classified as undetermined. In the fourth burrow, which was determined to be inactive, an unidentified rodent was observed. The May survey resulted in five burrows, one of which was collapsed. Four were viewed by camera, three had tortoises in them (Table 15). The fourth, which was classified as undetermined, appeared active from the outside but when viewed with the camera yielded a short tunnel and no tortoise. This burrow could have been in the process of being excavated. Tortoises can occupy more than one burrow, and it is possible to have two tortoises in one burrow (Douglass 1986, Breininger et al. 1991). Thus, the fact that four tortoise burrows were observed does not indicate that there are four tortoises present on this site. During this study, a total of five tortoises were seen on two different occasions (minimum number seen was three) . It is likely that the same tortoises were viewed twice, as these were unmarked tortoises.

Table 15. Summary of gopher tortoise surveys at the Waste Study Site on PAFB.

	August 1995	February 1996	May 1996
Active	0	2	3
Inactive	0	1	0
Collapsed	0	0	1
Undetermined	2	1	1
Total Burrows	2	4	5
Tortoises seen	0	2	3
Commensals seen	0	1	0

Discussion

The Waste Study Site is a disturbed area of Australian pine and Brazilian pepper, which is not considered prime habitat. This area is surrounded on three sides by water and on the fourth by the Small Arms Firing Range (Figure 1). This results in an isolated population with no potential for natural recruitment. Furthermore, it is very likely that this population of gopher tortoises was introduced. Personal communication with various Air Force personnel indicated that gopher tortoises found attempting to cross roads were relocated to the Waste Study Site. If this is the case, it is unknown where the tortoises originally came from and whether they have the upper respiratory disease (URTD) that has become prevalent in gopher tortoise populations. Marking these tortoise would be a good way to identify individuals to give an accurate number of members of this population and to determine sex ratios while URTD testing would determine the health of the population. It is difficult to determine what the future of this population might be.

Florida Scrub Lizard

The Florida scrub lizard, is a gray or gray brown spiny lizard with an average snout-vent length of 45 mm (Smith 1946) and an example of a gopher tortoise burrow commensal (Layne per. comm. in Jackson and Milstrey 1989). FCREPA lists the Florida scrub lizard as threatened (DeMarco 1992). FNAI lists the Florida scrub lizard as G3S3 (FNAI 1995b). The G3S3 listing is a global and state listing assigned by FNAI to those species that are either very rare and local throughout their range or found locally in a restricted range or are vulnerable to extinction because of other factors (FNAI 1995b). Like the gopher tortoise, the Florida scrub lizard prefers open sandy areas. Due to the similarity in habitat preference, the Florida scrub lizard and gopher tortoise distributions face similar consequences as a result of human disturbance such as agricultural clearing, urban expansion, and certain forestry practices (Auffenberg and Franz 1982). No Florida scrub lizards were observed on PAFB. No species specific survey was conducted for the Florida scrub lizard; however, while performing other surveys observers looked for lizards. Based on the land cover map (Figure 2) the only areas on PAFB that exhibit open sandy areas required by this species are the Waste Study Site and the coastal dunes, both of which are fragmented, isolated, and have been invaded by exotic species. In addition, the dunes are somewhat developed and heavily traveled by the public.

Eastern Indigo Snake

Previous work on PAFB lists the eastern indigo snake as one of the reptile species observed (Halliburton 1992, Berger 1993, and Vista Tech 1995). The eastern indigo snake is the largest nonpoisonous snake in North America with a maximum recorded length of 2.6 m (Moler 1992). The indigo is iridescent black in color with variable coloration on the throat and is often confused with the black racer (*Coluber constrictor*). Historically, the indigo occurred throughout Florida (including the Keys), Alabama, Georgia, Mississippi, and South Carolina. Habitat preferences include xeric sandhills and pinelands, mangrove swamps, wet prairies, and scrub (Moler 1992, Steiner et al. 1983). The average homerange size on KSC was estimated in 1991 as 176.9 ha for males and 27.2 ha for females (Becky Smith pers. comm.). Female homeranges were found to overlap while males did not. Prey consists of birds, turtles, frogs, other snakes, small mammals, lizards, and fish (Ashton and Ashton 1981, Breininger et al. 1994, Moler 1992). The indigo snake is an example of a gopher tortoise burrow commensal. It depends on gopher tortoise burrows for refuge from heat in the summer and cold in the winter.

The eastern indigo snake is listed as threatened by FGFWFC and USFWS (Wood 1996). FNAI (1995b) gives the indigo a global rating of G4T3 and a state rating of S3. The global ranking of G4T3 means that the indigo is apparently scarce globally (T3 refers to the subspecies and is equivalent to the S3 listing).

The S3 listing is a state listing and means that the indigo is very rare and local throughout its range or found locally in a restricted range or is vulnerable to extinction because of other factors (FNAI 1995b). Due to the slow, docile, and diurnal nature of the indigo it was an easy target, prior to federal protection, for collection by the pet trade. Human exploitation combined with habitat loss and degradation now restrict the species mostly to Florida (Breininger et al. 1994). No eastern indigo snakes were observed during the survey of PAFB. No species specific survey was conducted for the eastern indigo snake; however, while performing other surveys observers looked for indigos. Due to the large homerange requirements of this species, the small number of gopher tortoise burrows, and the highly developed and fragmented nature of PAFB, it is unlikely that PAFB supports a population of eastern indigo snakes.

American Alligator

Large populations of the American alligator can be found throughout Florida, Louisiana, and southern Georgia. Cold temperatures and the amount of suitable wetland limit the range of alligators. Alligators utilize wetlands along the edge of large lakes, ponds, and the interior of freshwater marshes and swamps. The courtship and breeding of this species begins in spring and ends in June. Alligators are very vocal during courtship. The young also emit a sound to inform the female that the nest is ready to be opened. The American alligator is listed as threatened by USFWS because of its similarity in appearance to the endangered American crocodile (*Crocodiles acutus*) (Wood 1996). The alligator was once hunted extensively for food and for its hide. Today due to protection by the federal government, hunting of alligators can only be done by permit. No species specific survey was conducted for the American alligator; however, while performing other surveys observers looked for alligators and noted their general location. American alligators were seen on numerous occasions in ditches in and surrounding the Golf Course and along the Banana River fringe. Signs should be posted at the Golf Course informing the public to not feed the wildlife. If fed, the alligators may become nuisances and would have to be removed.

Diamondback Terrapin

Like the alligator, the diamondback terrapin (*Malademys terrapin terrapin*) was once hunted as a food source. The diamondback terrapin is a medium sized turtle 22.9 cm in length with a carapace gray to black in color. There are several subspecies of this genus and the coloration varies with each subspecies. Diamondback terrapins inhabit salt or brackish marshes of the Atlantic and Gulf coasts from Cape Cod to southern Texas including both coasts of Florida (Stevenson 1976). KSC/MINWR/CNS is the largest area of protected habitat for this species along the Atlantic coast of Florida (Seigel 1993). Studies done by Siegel in the 1970's on KSC showed two large populations of this species, one in the northern Indian River along the Shiloh dike and the second on a small spoil island in the northern Banana River (Seigel 1993). In 1992-93, study sites on

KSC were resampled, and the results showed a decline in the populations of diamondback terrapin (Seigel 1993). Terrapin populations are affected by habitat loss, predation by raccoons, and human disturbances. Due to the lack of long-term studies on this species, the extent of damage to the populations caused by these encounters is not well known. The subspecies reported on PAFB is not a listed species, but due to reports by Seigel and others it is believed to be rare. No diamondback terrapins were observed on PAFB. No species specific survey was conducted for the diamondback terrapin; however, while performing other surveys observers looked for terrapins.

Other Reptiles

As mentioned in the Review of Previous Work on Threatened and Endangered Species, monitoring of sea turtle nesting is being conducted by UCF and is not part of this project. Although we did not collect data on these species, two observations of false crawls were made while trapping small mammals. These two crawls were observed at PAFB's northern boundry along small mammal transect NP. Both of the crawls extended from the waters edge, up over the escarpment to the edge of the vegetation. This particular section of the beach was undergoing re-creation as part of the ongoing beach renourishment project.

Summary and Recommendations

Surveys on PAFB found thirteen protected species using habitats on the base, including four plants (spider lily, prickly pear cactus, beach star, and inkberry), and nine animals (Snowy Egret, Little Blue Heron, Tricolored Heron, White Ibis, Wood Stork, Brown Pelican, Least Tern, Black Skimmer, and gopher tortoise). In addition, many other species use the base. Many of these other species are important components of the adjacent beach and estuarine communities. Some, such as Mottled Duck and mangroves, may have implications for management despite the lack of listing by state or federal agencies.

There are many ways that land use decisions at PAFB can be made to have a positive impact on wildlife. The following recommendations are based on the results of surveys for protected flora and fauna on PAFB performed during this study and on known characteristics of the habitat requirements of these species.

1) **Reduce mowing on all areas east of State Route A1A.** The dune community is the least disturbed of any community type on PAFB and thus has the most potential to provide natural habitat for threatened and endangered flora and fauna. Reducing the amount of mowing that now occurs in many areas west of the primary dunes, would allow native dune vegetation to be re-established. This would provide habitat for threatened and endangered plants and animals, and would help stabilize the dunes against erosion. Planting dune species such as sea oats, beach grasses, and sea grape would further enhance this area.

2) **Protect Least Tern Roof-nesting colonies.** Least Terns are extremely sensitive to disturbance while nesting. Roofs on PAFB represent some of the only protected habitat for Least Terns in the area. Maintaining adequate roof drainage and minor roof enhancements are recommended to increase the nesting success of Least Terns on PAFB roofs. Eliminating or reducing disturbance will also enhance nesting success and is essential for continued use of roof colonies on PAFB. Reduction of the amount of supplemental food for potential predators (e.g., gulls, crows, and grackles) will also enhance Least Tern nesting success. Maintaining good water quality in foraging areas is important for these colonies.

3) **Management of exotic plants and animals.** Exotic plants are often invasive and threaten native communities. There are large areas of invasive exotics on PAFB near the Banana River (Waste Study Site) and behind the primary dunes in the housing unit east of State Route A1A. Removal of these plants may not be practical and could potentially reduce habitat for threatened and endangered species. More consideration should be given to the restoration of areas with the potential to provide habitat for threatened and endangered species, such as dunes and the Banana River fringe. It is recommended that an effort be made to use only native plants in all landscaping activities on PAFB. Native plants are better adapted to the conditions and require less water, nutrients, and maintenance

activities. Native plants have more potential to provide habitat for threatened and endangered species than do exotic species.

Planting mangroves and other aquatic plants along the Banana River shoreline and large connected canals would greatly enhance the area for wading birds and aquatic species (e.g., diamondback terrapin), and would improve the aesthetic quality of the base. The area along the river on the south end of the base (Waste Study Site) near the camping facility could be enhanced by planting mangroves along the river and canal and removing some of the exotic plants and their replaceing them with native vegetation. This area could serve as a natural area to enhance the recreational facilities of the base. The river shoreline along the North Housing Unit is another area that would be enhanced by planting native vegetation. Planting native wetland plants along ditches and retention ponds would increase habitat for threatened and endangered birds and would help maintain water quality.

Domesticated Mallards on PAFB are an exotic species that threatens the native population of Mottled Ducks in the vicinity of PAFB. It may be necessary to remove these birds to prevent further hybridization of Mottled Ducks in the area. Feeding of Mallards should be strictly prohibited, as should feeding of any wildlife on PAFB. All areas on PAFB should be maintained free of garbage and food refuse to discourage exotic and native species that threaten other species of concern.

4) **Reduce direct runoff to wetlands**. There are many potential sources of contaminants to ground and surface waters on PAFB. It is recommended that runoff to wetlands, ponds, and canals be monitored to reduce potential contaminants that might enter the food chain or become available to wildlife. This may include planting of native vegetation on the perimeters of canals and ponds, and reducing potential sources of contaminants, especially from the Golf Course, the Industrial Area, and the Airfield.

5) **Reduce disturbance to flora and fauna**. Many species of threatened and endangered animals are sensitive to disturbance by humans. Any activities that cause disturbance to these species should be eliminated whenever possible. Some species, such as Least Terns and wading birds, may require special measures to ensure that they are not adversely affected by disturbance. The public should be educated concerning all sensitive threatened and endangered species that might be affected by human disturbance. For example, signs informing beachgoers of the presence of sensitive plants would help prevent picking or trampling of protected species.

In addition, monitoring of Least Tern and Black Skimmer nesting on roofs should be continued to determine what roofs are being utilizied and whether nesting is successful. Based on the large numbers of waterbirds observed using PAFB, monitoring of these populations should also be continued.

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Appendix A. Previous Descriptions of Vegetation and Fauna of Patrick Air Force Base.

Vegetation/Habitat Types

Landscaped Areas

Descriptions of flora and fauna reported in this section are from previous work done on PAFB, primarily biological assessments (BA's). PAFB is highly developed with facilities that include base housing, offices, medical facilities, a shopping center, aircraft hangars and support buildings, roadways, runways, taxiways, aprons, marina, Golf Course, and recreational grounds. There is little elevation, and vegetation is limited to plants that are tolerant of relatively saline soil. Typical shrubs and trees near buildings include privet (*Ligustrum spp.*), podocarpus (*Podocarpus spp.*), oleander (*Nerium oleander*), yucca, Norfolk Island pine (*Araucaria heterophylla*), Australian pine, and cabbage palm. Runway lateral clearance areas (Berger 1993, Vista Tech 1995), roadway shoulders, and recreational areas are all grassed.

Recreational Areas

The only areas that are not landscaped and regularly maintained are recreational and canal areas near the Banana River at the southwest end of the base. These areas are grown up in groundselbush (*Baccharis halimifolia*) and the exotic species Australian pine and Brazilian pepper. There is little natural habitat with the exception of tree cover occurring along the shore of the Banana River west of the primary runway. This undeveloped area is used for picnicking and camping. Other recreational areas include ballfields and the Golf Course. The vegetation surrounding the Airfield, combined with the Golf Course make up the largest vegetated area on base (Berger 1993, Vista Tech 1995).

Wetlands

Wetlands primarily occur intermittently along the shoreline of the Banana River. Additional wetlands include drainage ditches, small depressions, and other water bodies where wetland vegetation is restricted to the banks. Common wetland plants include water pennywort (*Hydrocotyle umbellata*), duckweed (*Lemna sp.*), cattail, rushes (*Juncus spp.*), and sedges. Approximately 1.8 ha of potential wetlands occur east of South Patrick Drive. There are a number of ponds and drainage ditches on the Golf Course. There are 6.6 km of ditches that were created in 1958 for drainage and irrigation water. Most of the ditches intersect the shallow water aquifer and therefore contain water throughout the year. There are also 16.4 ha of canals on base that are connected to the Banana River (Berger 1993).

Atlantic Ocean Beaches and Dune System

The beach and dune system along the Atlantic Ocean have been less impacted by development. Vegetation adjacent to the ocean on recent dunes is subject to wind-borne salt spray and sand movement during storms. Common dune vegetation includes sea oats and other grasses including slender cordgrass (*Spartina patens*) and bitter panicum. Small shrubs such as inkberry, marsh elder (*Iva imbricata*), and croton (*Croton punctatus*) occur along with herbs including beach sunflower, railroad vine, and camphorweed (NASA 1992).

Banana River Lagoon

The Banana River is classified as Class III waters by the Florida Department of Environmental Protection (FDEP). This classification is intended to protect the waterways for recreation and for the propagation and maintenance of healthy fish and wildlife populations. In the vicinity of PAFB, the Banana River is designated as an Aquatic Preserve by the Florida Legislature and as Outstanding Florida Waters by FDEP. Such waters are deemed to have "exceptional recreational or ecological significance" and receive special protection from the FDEP.

The intermittently exposed, unvegetated flats and sand bars, mangrove islands, salt marshes, and nearshore waters of the Banana River on or adjacent to PAFB are less impacted by development. Plants in salt marshes include smooth cordgrass (*Spartina alterniflora*), saltwort (*Batis maritima*), glasswort (*Salicornia virginica*), salt grass (*Distichlis spicata*), and sea ox-eye (*Borrichia frutescens*). Mangrove islands consist of red, black, and white mangroves (Vista Tech 1995).

The Banana River shoreline of PAFB includes a sparsely vegetated sand and/or rock beach zone with a mixed grass and forb border along the upland edge. It is typified by flat to moderately sloping beaches, ending in short, relatively steep bluffs. Normal water line is 0.2 m above MSL. At the top of the bluff the ground elevation is between 0.9 and 2.1 m above MSL. Bluffs vary in height up to 1.2 m. Depth of the beach zone varies from approximately 0.6 m to 4.6 m with sandy areas tending to be wider than rocky shorelines (Berger 1993). Common plants in the sparsely vegetated areas above the mean high tide line include slender cordgrass, water hyssop (*Bacopa monnieri*), and beach sunflower. Crabgrass (*Digitaria sanguinalis*) is the predominant species at the top of the slope and is mixed with other grasses and forbs.

The shallow flats of the Banana River support a variety of seagrasses such as shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), widgeon grass (*Ruppia maritima*), and star grass (*Halophila engelmannii)* (Woodward-Clyde 1994). Other submerged aquatic vegetation include various macroalgae

such as *Caulerpa, Gracilaria, Acanthophora, Penicillus, Halimeda,* and *Sargassum.*

Wildlife

Fish

Freshwater fish observed on base include the largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), warmouth (*Lepomis gulosus*), white catfish (*Ictalurus catus*), channel catfish (*Ictaluras punctatus*), brown bullhead (*Ictalurus nebulosus*), lake chubsucker (*Erimyzon sucetta*), gar (*Lepisosteus spp.*), and blue tilapia (*Tilapia aurea*). The ditches and ponds were stocked with largemouth bass, redear sunfish, bluegill, and catfish for recreational purposes (Halliburton 1992). There are a number of fish species that occur in the Banana River and are also found in man-made ponds on base. These include striped mullet (*Mugil cephalus*), sea catfish (*Arius felis*), menhaden (*Brevoortia tryannus*), hogchoker (*Trinectes maculutus*), gizzard shad (*Dorosoma cepedianum*), mosquitofish (*Gambusia affinis*), and tidewater silverside (*Menidia beryllina*) (Berger 1993, Vista Tech 1995).

Reptiles and Amphibians

Reptiles and amphibians reported to be observed on base are the green anole (*Anolis carolinensis*), brown anole (*Anolis sagreis*), eastern garter snake (*Thamnophis sirtalis sirtalis*), southern toad (*Bufo terrestris*), southern leopard frog (*Rana utricularia*), and a variety of skinks and geckos (Halliburton 1992, Berger 1993, Vista Tech 1995). The diamondback terrapin and garter snake may be present in the mangrove areas and salt marshes.

Birds

Bird species which are commonly seen in the developed areas include the Cattle Egret (*Bubulcus ibis*), Mourning Dove (*Zenaida macroura*), Fish Crow (*Corvus ossifragus*), European Starling, Yellow-rumped Warbler (*Dendroica coronata*), Rock Dove (*Columba livia*), and House Sparrow (*Passer domesticus*). Other resident bird species occurring in nonwetland areas are the Mockingbird (*Mimus polyglottos*), Boat-tailed Grackle (*Quiscalus major*), and Least Tern (Berger 1993, Vista Tech 1995).

The Great Blue Heron (*Ardea herodias*), Tricolored Heron, Green-backed Heron (*Butorides striatus*), Wood Stork, and White Ibis are wading birds commonly found in the wetland and freshwater habitats on base. Other birds found in these areas include the following shorebirds: Ring-billed Gull (*Larus delawarensis*), Herring Gull (*Larus argentatus*), Great Black-backed Gull (*Larus marinus*),

Double-crested Cormorant, Brown Pelican, and various waterfowl: Mallard, Mottled Duck, and Northern Pintail (*Anas acuta*) (Berger 1993, Vista Tech 1995).

The Snowy Egret, Wood Stork, American Coot (*Fulica americana*), and Common Gallinule (*Gallinula chloropus*) are reported to use the wetland areas for nesting and foraging. Several species of wading birds use drainage ditches for feeding. The wading birds, shorebirds, and waterfowl listed above in addition to Least Terns, sandpipers, plovers, and Ospreys are also common along the Banana River (Berger 1993, Vista Tech 1995).

Several bird species have been observed feeding along the sandy and rocky beach areas along the Banana River shoreline. These include the Great Blue Heron, Wilson's Plover (*Charadrius wilsonia*), Black-bellied Plover (*Pluvialis squatarola*), and Least Sandpiper (*Calidris minutilla*). Birds seen feeding and resting within the nearshore areas include Ring-billed Gull, Brown Pelican, Double-crested Cormorant, Osprey, and Belted Kingfisher (*Ceryle alcyon*) (Berger 1993).

Mammals

Common mammal species reported on PAFB are the southern short-tailed shrew (*Blarina carolinensis*), eastern mole (*Scalopus aquaticus*), raccoon (*Procyon lotor*), eastern cottontail rabbit (*Sylvilagus floridanus*), eastern fox squirrel (*Sciurus niger*), rice rat (*Oryzomys palustris*), hispid cotton rat (*Sigmodon hispidus*), house mouse, armadillo (*Dasypus novemcinctus*), opossum (*Didelphis virginiana*), and Norway rat (*Rattus norvegicus*). The marsh rabbit (*Sylvilagus palustris*), rice rat, hispid cotton rat, and raccoon can be found in the mangrove and salt marsh communities (Berger 1993, Vista Tech 1995). Terrestrial mammals routinely found near the Waste Study Site, Small Arms Firing Range, and in the open fields between runways include the raccoon, opossum, and rabbit (Halliburton 1992). Small mammals also may use portions of the Banana River shorelines for foraging and nesting within the banks (Berger 1993).

The report of eastern fox squirrel is not likely. The subspecies present in central Florida is Sherman's fox squirrel. This species requires longleaf pine (*Pinus palustris*) sandhill and flatwoods communities (Kantola 1992), which are not present on PAFB.

Appendix B. Vegetation and Land Cover Classifications Used in Mapping Patrick Air Force Base.

The vegetation classifications are described by the dominant plant species or the vegetative community found within the area. Land cover classifications were used in situations where land management practices have altered the composition of the species or the community type. Descriptions of vegetation and land cover classifications for Patrick Air Force Base (PAFB) are provided.

Australian Pine

Contrary to its name, this species is actually a hardwood. Its name is derived from its needle-like leaves and its characteristic cone shaped crown structure. Australian pine (*Casuarina equisetifolia*), an invasive exotic, was introduced to south Florida from Australia and is colonizing northward to south Volusia County on the east and into the Tampa Bay area on the west coast of Florida. It is common on disturbed sites, forming dense thickets, and its frequently planted as wind breaks and soil stabilizers. The Waste Study Site and recreational area along the southwest side of PAFB contain stands of Australian pine.

Bare Sand

This category includes exposed mineral soils that lack vegetation because it has been removed or covered up by dredge material. Over time herbaceous vegetation may colonize these areas. Exotic species tend to have the greatest ability to spread within these very disturbed areas.

Beaches

Beaches are constantly affected by wave and tidal action and are subject to water and wind erosion. Differing beach dimensions are due to factors such as tides, soil material size, water level, and wave energy. Severe beach erosion has occurred along the Atlantic Ocean beach on PAFB.

Brazilian Pepper/Mangrove

These areas are comprised of a mixture of Brazilian pepper (*Schinus terebinthifolius*), white mangrove (*Laguncularia racemosa*), black mangrove (*Avicennia germinans*), and red mangrove (*Rhizophora mangle*). The Brazilian pepper/mangrove community occurs along the large canal margins adjacent to the Waste Study Site. Red and black mangroves are found in the lower wet regions along the water's edge. White mangrove and Brazilian pepper occupy high elevations several meters from the water's edge. Common on disturbed sites, Brazilian pepper is an aggressive invader of Florida's native plant communities.

Canals/Waterways

This class includes low elevation areas designed to retain water. All of the ponds, ditches, and canals on PAFB were developed from soil extraction practices, and were constructed to provide stormwater drainage/retention or marina access. Wetland vegetation such as southern cattail (*Typha domingensis*), arrowhead (*Sagittaria lancifolia*), and bullrush (*Scirpus americanus*) can be found within these regions. In brackish water areas, salt tolerant herbs and shrubs can be found. Some areas of PAFB, such as the Airfield, included canals that were too small to be mapped seperately.

Dense Herbaceous

These areas were dominated by several species of herbaceous plants greater than 15 cm tall and are not consistently mowed. Species found in this community may include ragweed (*Ambrosia artemisiifolia*), begger-ticks (*Bidens pilosa*), southern crabgrass (*Digitaria ciliaris*), camphorweed (*Heterotheca subaxillaris*), beardgrass (*Andropogon* spp.), and others.

Disturbed Shrubs/Exotics

This category includes a mixture of disturbed shrubs and exotic plants in which there is no dominant species. Australian pine (*Casuarina equisetifolia*), Brazilian pepper (*Schinus terebinthifolius*), groundselbush (*Baccharis halimifolia*), Vitex (*Vitex trifolia*), cabbage palm (*Sabal palmetto*), ragweed (*Ambrosia artemisiifolia*), camphorweed (*Heterotheca subaxillaris*), and begger-ticks (*Bidens pilosa*) are among the common species found in the area. Disturbed shrubs and exotics occur within the high elevation spoil disposal and disturbed soils region called the Waste Study Site and at the north end of the large canal adjacent to the Waste Study Site. Brazilian pepper and Australian pine forms nearly pure stands at some locations within the region. Small patches of bare sand and herbaceous vegetation can also be found within this class.

Dunes Vegetation

Dune vegetation is restricted to a region between the beach and A1A. This community is very narrow along the barrier island within PAFB. Saw palmetto (*Serenoa repens*), Spanish bayonet (*Yucca aloifolia*), sea grape (*Coccoloba uvifera*), sea oats (*Uniola paniculata*), bitter panicum (*Panicum amarum*), beach sunflower (*Helianthus debilis*), railroad vine (*Ipomoea pes-caprae*), prickly pear cactus (*Opuntia stricta*), spider lily (*Hymenocallis latifolia*), ragweed (*Ambrosia artemisiifolia*), begger-ticks (*Bidens pilosa*), southern crabgrass (*Digitaria ciliaris*), sow thistle (*Sonchus asper*), beardgrass (*Andropogon* spp.), and Vitex *(Vitex trifolia)* can be found in these areas. The composition of the species within the dune vegetation class can vary depending on the level of disturbance from dune erosion and human activity.

Golf Course

This area is maintained exclusively for recreational golfing and is dominated by manicured fairways and greens. Several small clumps of vegetation, including cabbage palm (*Sabal palmetto*) and melaleuca (*Melaleuca quinquenervia*) stands, exist in the area.

Mangrove

Black mangroves (*Avicennia germinans*) dominate the small islands found in the Banana River within 50 m of the PAFB shoreline. Dead branches indicate that there were once large mangroves in these areas which were probably killed in freezing temperatures. Small mangroves have begun to reestablish on these islands.

Mowed Grass

This category is dominated by many types of grass and herbaceous species that are consistently maintained at a height less than 15 cm. Species found in this community may include ragweed (*Ambrosia artemisiifolia*), begger-ticks (*Bidens pilosa*), southern crabgrass (*Digitaria ciliaris*), St. Augustine grass (*Stenotaphrum secundatum*), camphorweed (*Heterotheca subaxillaris*), beardgrass (*Andropogon* spp.), and others. Large areas of mowed grass exist around the Airfield and other facilities. This is the most extensive vegetation type found at PAFB.

Other Open Water

This category includes the Banana River and the Atlantic Ocean, which border PAFB on the east and west.

Sparse Herbaceous

These areas have sparse herbaceous vegetation with areas of bare ground and sand. Some of these areas are mowed, but the vegetation within these areas is very sparse compared to the mowed grass category. Species found in this community may include ragweed (*Ambrosia artemisiifolia*), begger-ticks (*Bidens pilosa*), southern crabgrass (*Digitaria ciliaris*), camphorweed (*Heterotheca subaxillaris*), beardgrass (*Andropogon* spp.), and others.

Urban/Developed

All facilities, parking, and housing areas were classified as urban/developed. Although these areas may have vegetation, they have little to no ecological value for most rare, threatened, or endangered species and are comprised mostly of non-native landscaping vegetation. However, tar and gravel roofs of some buildings in the Industrial Area were used by nesting Least Terns and Black Skimmers.

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13. ABSTRACT *(Maximum 200 words)*

A review of previous environmental work conducted at Patrick Air Force Base (PAFB) indicated that several threatened, endangered, or species of special concern occurred or had the potential to occur there. This study was implemented to collect more information on protected species at PAFB.

A map of landcover types was prepared for PAFB using aerial photography, groundtruthing, and a geographic information system (GIS). Herbaceous vegetation was the most common vegetation type. The second most abundant vegetation type was disturbed shrubs/exotics. The beach and associated dune vegetation comprised 3.2% of the land area, but was the most extensive natural community within PAFB. A few isolated mangrove communities exist along the Banana River.

Continued on separate page.

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Seventy-seven species of vascular plants occurred on the dunes, including four species listed by state agencies: spider lily (*Hymenocallis latifolia*), prickly pear cactus (*Opuntia stricta*), beach star (*Remirea maritima*), and inkberry (*Scaevola plumieri*). Surveys of other habitats revealed eighty-four species of vascular plants including two state-listed species: spider lily and prickly pear cactus. Many of these areas are dominated by invasive, exotic species, particularly Brazilian pepper (*Schinus terebinthifolius*) and Australian pine (*Casuarina equisetifolia*), and native species of open or disturbed sites such as camphorweed (*Heterotheca subaxillaris*) and beardgrass (*Andropogon* spp.). Due to the isolation of PAFB from other natural areas, most exotic plant populations on the base are not an immediate threat to intact native plant communities.

Dune habitat was surveyed for the southeastern beach mouse (*Peromyscus polionotus niveiventris*) by quarterly trapping along eight 100 m transects. No beach mice were found. The limited extent of dune habitat, its fragmented condition, and the isolation of PAFB from extant populations of the beach mouse probably accounts for its absence.

Surveys of birds on PAFB found an avifauna characteristic of species that occur in the Indian River Lagoon system. Twenty-five species of waterbirds were observed during quarterly surveys on PAFB, including five species listed as species of special concern by the state of Florida: Snowy Egret (*Egretta thula*), Little Blue Heron (*Egretta caerulea*), Tricolored Heron (*Egretta tricolor*), White Ibis (*Eudocimus albus*), and Brown Pelican (*Pelecanus occidentalis*). The Golf Course was used extensively by almost all species of waterbirds on PAFB. Twenty-two species of shorebirds were observed on PAFB. Although no listed species were observed, the potential exists for several protected species of shorebirds to use the beach at PAFB during some parts of the year. The Airfield runways and associated grass areas were important sites at PAFB for loafing and feeding for some shorebirds.

Surveys of rooftop nesting by Least Terns (*Sterna antillarum*) on PAFB found a large colony on a rooftop in the PAFB Industrial Area. This colony produced some independent young. Two rooftop Least Tern colonies reported from previous years were inactive during 1996. A small number of Black Skimmers (*Rhynchops niger*) attempted to nest at the Least Tern colony but were unsuccessful.

Surveys for the gopher tortoise (*Gopherus polyphemus*) revealed burrows and tortoises only at the Waste Study Site; five burrows and three tortoises were observed. No Florida scrub lizards (*Sceloporus woodi*), eastern indigo snakes (*Drymarchon corais couperi*), or diamondback terrapins (*Malademys terrapin terrapin*) were observed. American alligators (*Alligator mississippiensis*) were observed on the Golf Course and using ditches, ponds, and areas along the Banana River.

The amount of dune habitat could be expanded by not mowing areas adjacent to the dunes to allow dune species to colonize and expand. Planting dune species as part of the beach renourishment project will also increase this habitat. Exotic plants dominate several areas on the base and are used by threatened, endangered, and species of special concern. However, the use of native vegetation in landscaping projects throughout the base would improve habitat for wildlife, and invasive, exotic plants should not be used in any horticultural plantings. Water quality of ponds, ditches, and canals is important for waterbirds; it should be maintained and protected from contamination. Nesting Least Terns are sensitive to disturbance; rooftops used for nesting should be protected from disturbance. Monitoring of Least Tern and Black Skimmer nesting should be continued to determine what roofs are being used and whether nesting is successful. Furthermore, based on the large numbers of waterbirds observed on PAFB, continued monitoring of them is recommended.