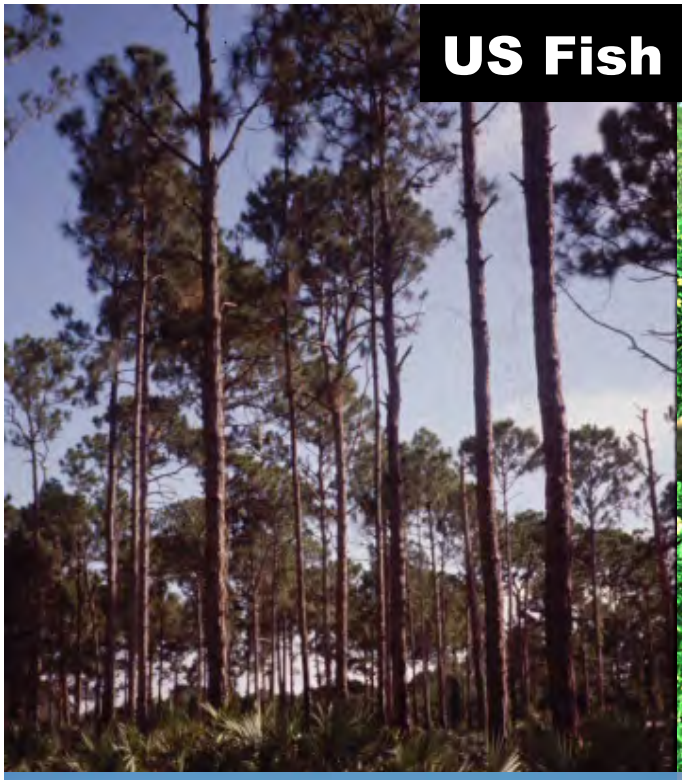


US Fish and Wildlife Service

HABITAT MANAGEMENT PLAN

for

Merritt Island National Wildlife Refuge

Prepared By:
Fred Adrian, Marc Epstein,
Ralph Lloyd, and James Lyon
2006

MERRITT ISLAND NWR HABITAT MANAGEMENT PLAN
TABLE OF CONTENTS

MERRITT ISLAND NWR HABITAT MANAGEMENT PLAN
TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

List of Appendices

CHAPTER I
INTRODUCTION

A. SCOPE AND RATIONALE

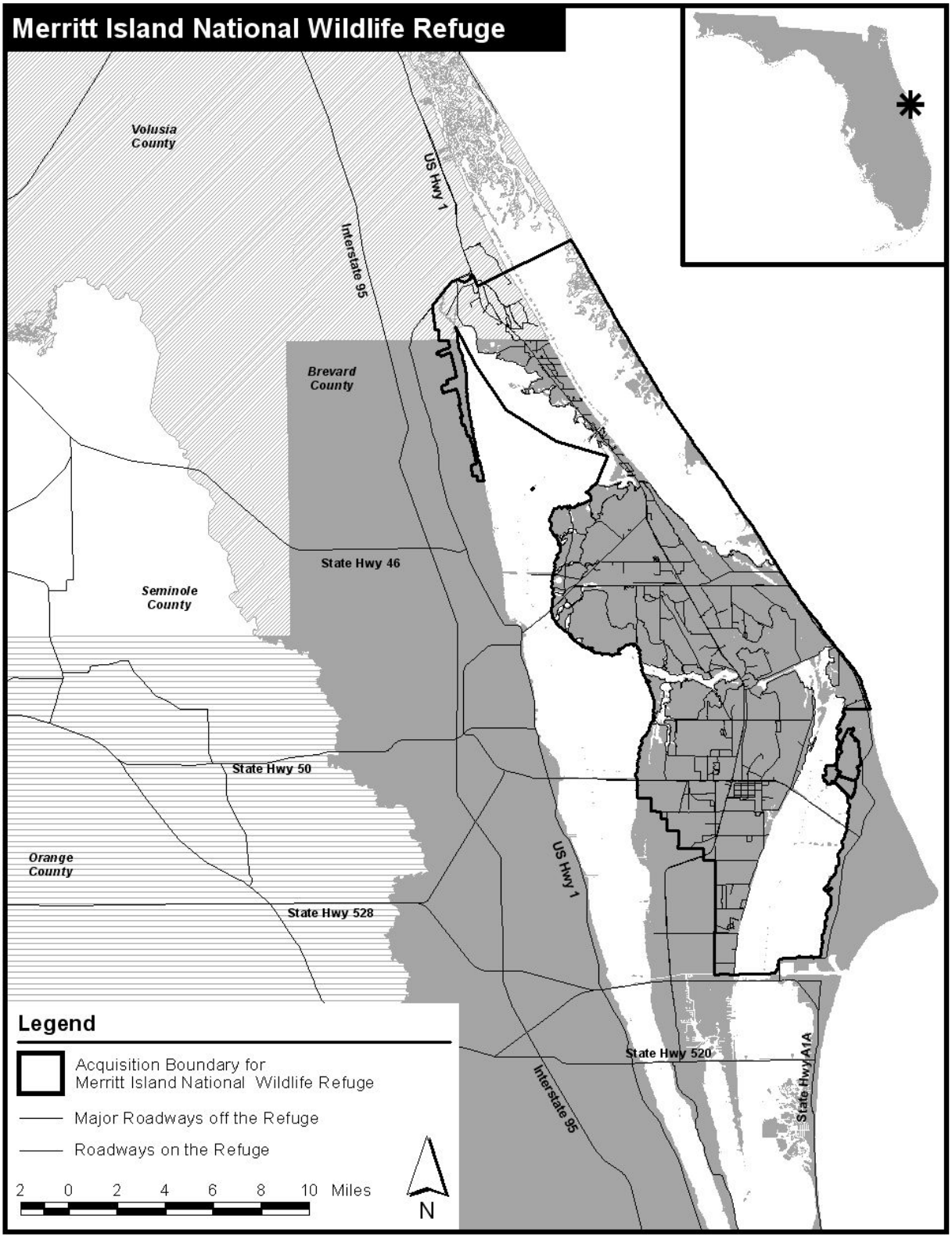
Managed by the U.S. Fish and Wildlife Service (FWS or Service), Merritt Island National Wildlife Refuge (MINWR or Merritt Island NWR) encompasses a complex array of habitats, ranging from the estuarine waters of the Indian River Lagoon system to sandy oak scrub ridges. The refuge's location on the central east coast of Florida (Figure 1) contributes to this diversity, as does its subtropical climate. The mixture of wetlands and uplands that is the refuge provides for the needs of 10 threatened or endangered species, a myriad of birds, a variety of mammals, and numerous reptiles and amphibians.

This Habitat Management Plan (HMP) is a step-down plan to the Merritt Island National Wildlife Refuge Comprehensive Conservation Plan (CCP). The wildlife and habitat management goals and objectives contained in the HMP are a reflection of the information and recommendations derived from the 2003 Wildlife and Habitat Management Review of the refuge (U.S. Fish and Wildlife Service 2003), internal scoping within the Service, and information and recommendations gathered from the public and governmental partners during public scoping for the CCP. The planning process of the CCP defined a vision for the refuge, identified the priority issues to be addressed, and delineated goals and objectives to provide direction and guidance for refuge management. This Habitat Management Plan steps down from the CCP to provide additional detail for refuge managers to achieve the goals and objectives delineated in the CCP and to serve the purposes of the refuge.

The HMP has several purposes. The first purpose is to take the goals and objectives from the CCP and provide managers with a selection of strategies, techniques, and methodologies by which these goals and objectives may be achieved. Secondly, descriptions of the various strategies, techniques, and practices discussed in the HMP should give managers some idea of the resources needed to manage the refuge's habitats. It should be noted that in order to achieve all of the goals and objectives stated in the CCP and this plan, increases in funding and staffing would be needed. Without these increases, some progress would be made, but it is inevitable that many goals and objectives would not be met. The third function of this plan is to give the reader some insight as to the complexity of Merritt Island National Wildlife Refuge. Not only are there many different habitats on the refuge, but linkages and interconnections exist between them. In light of this, managers must realize that actions taken in one area could very well have effects elsewhere.

Finally, and perhaps most importantly, this plan is an attempt to consolidate management knowledge from a variety of sources. The principles, thoughts, and guidance contained herein are based on information gleaned from two main sources. Where scientific information is available, it has been included and documented. In addition, the authors have attempted to articulate the accumulated practical knowledge gained during their combined fifty plus years of experience managing the wetland and upland habitats on MINWR. Appendix B lists the authors of this plan and the chapter(s) for which each is responsible.

Figure 1. Refuge Location and Acquisition Boundary



B. THE CONCEPT OF HOLISTIC MANAGEMENT

The experience of the authors of this plan, combined with an understanding of basic ecological principles, has led to the realization that individual parcels of habitat do not exist in isolation. Rather, these entities exist in a continuum of space and time.

B-1: HABITAT MANAGEMENT WITH RESPECT TO TIME

In order to effectively manage refuge lands, managers must not only look at the present condition of the patch in which they are interested, but also attempt to determine what past activities have brought the site to its present condition. As difficult as this can be to accomplish, it is even harder to foretell the future, but this too must be attempted.

Past uses of lands now managed by the refuge range from hunting and fishing areas for Native Americans to space exploration. The activities that have had the most profound impacts on today's management are: the cultivation of citrus and other agriculture, the development of residential communities, the impoundment of marshes for mosquito control, and the development of infrastructure to support the space program of the United States. The anthropological artifact that is common to all of these is the alteration of the hydrology of refuge lands and waters. Citrus and other agricultural interests dug numerous canals in an attempt to make soils more suitable for crops. Finger canals were dug along the edges of the several lagoons to enhance the value of these areas for residential development. One of the major alterations to the hydrology came from the construction of impoundments to reduce the impact of mosquitoes on workers at the Kennedy Space Center. Some of these modifications can be used to the refuge's advantage, while others may need to be restored to near natural conditions.

Past human activities have also caused or enhanced problems with exotic species. A wide range of non-native plants were used for landscaping and windbreaks around human dwellings and croplands. When the land was acquired for the Kennedy Space Center (KSC), these plants remained and many escaped into the wild lands. The spread of these invasive species was accelerated by additional land clearing activities associated with developing the area for the space program. The present feral hog problem can also be traced to animals escaping or being abandoned when the government acquired the lands now managed by the refuge.

The exclusion of fire from the ecosystem between the late 1950s and the early 1980s has had widespread impact on both wetland and upland habitats. The lack of fire in the marsh areas of the refuge contributed to the encroachment of woody vegetation into these grassy sites. In the uplands, shrub vegetation became dense and overgrown. Forests also became denser and trees spread into grass and shrubland areas. More information on the lack of fire in the pyrogenic vegetation in both wetlands and uplands is available in the Refuge Fire Management Plan (Adrian 2003).

Much of the habitat management would involve the restoration of some of the changes to the ecosystem resulting from past activities. Other management actions would use these changed ecosystems to benefit existing wildlife. In either case, managers must attempt to foresee not only the effects that management actions would have on the ecosystem, but also those impacts that may occur from outside influences. It is expected that human populations would increase in Florida, and there would be more pressures on the refuge for both consumptive and non-consumptive uses. It can also be expected that Kennedy Space Center would continue to remove lands from the refuge to support space exploration purposes. These facts must be taken into consideration when planning specific management projects. In like manner, the

effects of increased human activity on the outcome of management activities in areas open to the public must be considered prior to their implementation. Finally, managers need to be heedful of the impacts of future population expansion in the vicinity of the refuge on some of the refuge's management practices. The use of fire and the off site concerns about smoke is the obvious activity here, but timber harvesting, mechanical treatment of scrub, water level manipulation, and even hydrological restoration can affect refuge neighbors.

B-2: HABITAT MANAGEMENT WITH RESPECT TO SPACE

When managing the refuge's habitats, it is important to look at where individual pieces exist in the overall landscape for two reasons. First, there are always linkages between different components of an ecosystem. Management actions taken in one area may well have effects in other areas. Second, although it is sometimes important to focus on a specific habitat, say for the continued existence of a threatened or endangered species, but one must not lose sight of the fact that species exist across the continuum of the landscape. Focusing on one or another of the components of the overall system may well imperil those species that exist in the ecotones between those components.

It is important that the interconnectivity between different portions of the landscape be kept intact. Linkages are sometimes obvious, such as the effects of activities in the uplands on nearby wetland areas. Other times linkages are not so apparent. The landscape mosaic of oak scrub, pine flatwoods, and grassy swales is an example. Oak scrub requires periodic fire, but is difficult to ignite because it lacks fine flashy fuels. In many cases, fires that burn in scrub ignite in the more flammable pine flatwoods or in grassy swales. These fires then spread into the scrub areas (Myers 1990). If the mosaic of scrub, flatwoods, and swales is altered, the fire regime in the scrub would also be altered. Historical human activities have severed many of the linkages that once were in force on Merritt Island. Roads, non-vegetated areas, and buildings present physical barriers not only to wildlife, but also to ecological processes. Duncan and Schmalzer (2004) found that, even without considering fire suppression, modern day fires on Merritt Island NWR are smaller than historic fires. They further report that anthropological features play a major role in reducing landscape flammability. The lack of fire during the 1960s and 1970s played a role in reducing connectivity in the landscapes of the refuge. During the period of fire suppression, forests increased in extent and density (Adrian 2003 and Duncan et al 1996). This creates barriers to movement of species, such as the threatened Florida scrub-jay (*Aphelocoma coerulescens*).

Ditches built for agricultural and other uses may also disrupt linkages. These ditches can disrupt the surface and subsurface flow of water between the uplands and the wetlands. Although the hydrological processes on Merritt Island are not completely understood, it is possible that the disruption of water flow could lead to subtle changes in nutrient balances, pH, and other soil and water chemistry factors.

Another important break in connectivity is the system of dikes surrounding some of the marshes that border the estuarine areas of the refuge. These were constructed in the 1950s and 1960s to help control salt marsh mosquitoes. Through proper management, these impounded marshes have become an integral part of the refuge's efforts to create good habitat for migratory waterfowl and other species. However, in some cases the dikes restrict the flow of nutrients and the movement of wildlife between the lagoon waters and the marshes.

These are but a few examples of the changes in ecosystem of Merritt Island NWR that have occurred in the past. More detailed discussions of the changes that have occurred over time can be found in the individual chapters.

C. LEGAL MANDATES

Legal mandates are discussed in detail in the Merritt Island National Wildlife Refuge CCP. However, a brief summary is warranted to give the reader some insight as to the legal authorities under which habitat management operates.

C-1: ESTABLISHMENT OF THE REFUGE

On August 28, 1963, Merritt Island National Wildlife Refuge was established when the National Aeronautics and Space Administration (NASA) transferred management authority through a cooperative agreement for part of its wildlands of the John F. Kennedy Space Center (KSC) to the U.S. Fish and Wildlife Service. The refuge was established "for use as an inviolate sanctuary, or for any other management purpose, for migratory birds" 16 U.S.C. § 715d (Migratory Bird Conservation Act). The NASA/FWS cooperative agreement was expanded on June 2, 1972 to include all lands and waters of KSC, except those areas with NASA facilities and other property related to the space program. Since most of MINWR is owned by NASA, it is considered an overlay refuge. On April 2, 1975 (under Public Law 93-62d), Canaveral National Seashore was designated. A portion of the refuge was transferred to the National Park Service (NPS) to form Canaveral National Seashore (CNS). However, the refuge retained primary management authority for most of the undeveloped lands in the overlap (~34,345 acres) under the conditions of the Public Law. This provides for a unique situation where natural resource management of a large section of a National Park is managed by the FWS as a refuge. The NPS retains management authority over cultural resources within the overlap area.

C-2: FEDERAL LAWS, MANDATES, AND POLICIES

MINWR operates under a variety of laws and policy statements. The principle ones are listed.

- The National Wildlife Refuge System Administration Act of 1966
- The Endangered Species Act
- National Wildlife Refuge System Improvement Act of 1997
- Title 50 of the Code of Federal Regulations
- U.S. Fish and Wildlife Service Manual – specifically 601 3(D2G), which states:

  Through the comprehensive conservation planning process, interim management planning, or compatibility reviews, determines the appropriate management direction to maintain and, where appropriate, restore, biological integrity, diversity, and environmental health, while achieving refuge purpose(s).

D. RELATIONSHIP TO OTHER PLANS

In addition to the legal and policy mandates, management on Merritt Island NWR is influenced by other plans. These fall into three arenas, those that are national or regional in scope, those that relate to activities of local entities, and those that pertain to the refuge itself. Many of these plans are consistent with refuge goals and objectives, but, since different agencies would have varying missions, it is inevitable that conflicts would arise. When this occurs, the refuge would recognize the differences of opinions and take measures to address the other agency's concerns, where possible. However, the refuge would continue to manage with the mission, goals, objectives, and purpose of the refuge taking precedence.

D-1: NATIONAL AND REGIONAL PLANS

Several national and regional level plans relate to the refuge and its management activities, including those listed.

- North American Bird Conservation Initiative
- North American Waterfowl Management Plan
- North American Colonial Waterbird Conservation Plan
- U.S. Shorebird Conservation Plan
- U.S. Shorebird Conservation Plan: Southeastern Coastal Plains-Caribbean Region
- Western Hemisphere Shorebird Reserve Network
- Partners in Flight Bird Conservation Plans
- Atlantic Coast Joint Venture Management Plan
- North Florida Ecosystem Unit Management Plan for Fish and Wildlife Service Trust Resources
- Threatened and Endangered Species Recover Plans
- National Estuary Plan
- Indian River Lagoon Comprehensive Conservation and Management Plan

D-2: LOCAL PLANS

Several local level plans relate to the refuge and its management activities, including those listed.

- Mosquito Lagoon Aquatic Preserve Management Plan
- Banana River Aquatic Preserve Management Plan
- Facilities Master Plan for John F. Kennedy Space Center
- General Management Plan for Canaveral National Seashore
- Canaveral National Seashore Water Resources Management Plan
- Indian River Lagoon Surface Water Improvement and Management Plan (SWIM)
- Mosquito Control Agreements

D*C-3: JOINT REFUGE-KSC PLANS*

There are two management plans that were developed with KSC to improve habitat management on the refuge. The Conceptual Plan for Wetlands Restoration and Enhancement provides for NASA funding for specific wetland restoration and enhancement activities. The Compensation for Scrub-jay Habitat Loss from Proposed New Construction at Kennedy Space Center provides for mitigation of habitat loss due the construction of new KSC facilities of scrub-jay habitat at a 2:1 ratio. Several scrub restoration projects have been funded under this agreement.

D-4: REFUGE PLANS

On the refuge level, two plans would have an influence on habitat management. Of these, the one that has the greatest influence refuge wide is the refuge's Fire Management Plan. Many habitats in both the refuge's uplands and wetlands are fire maintained, while others are fire influenced. In order to properly manage these habitats, it is essential that the policies and

procedures detailed in the Fire Management Plan be followed to ensure a safe and effective fire program.

Habitat management can, and should, interact with the activities covered by the refuge's Visitor Services Plan. Occasionally management activities may impact the safety of the visiting public, as with prescribed burning operations. At other times, management activities, such as timber harvesting, impoundment draw downs, and mechanical manipulation of vegetation, may impact the visual experience of refuge visitors. In these cases it is essential that the need and rationale for these management events be communicated to refuge visitors and other interested persons. Visitor Services personnel and habitat managers have worked closely in the past to develop programs to convey this information. It is essential that this effort continue.

CHAPTER II
BACKGROUND

A. LOCATION

Merritt Island National Wildlife Refuge is located on the central east coast of Florida (Figure 1) in Brevard and Volusia counties. It is an overlay of the National Aeronautics and Space Administration's John F. Kennedy Space Center. The refuge derives its name from Merritt Island, Florida, which, along with Cape Canaveral, is a barrier island complex formed during the Pleistocene and Recent ages (White 1970). The refuge's approximately 140,000 acres is part of a complex of federally owned lands that include the National Park Service (NPS) [Canaveral National Seashore (CNS)] and the Department of Defense (DOD) [Cape Canaveral Air Force Station (CCAFS)]. These agencies manage the largest area of relatively undeveloped barrier island and lagoon water habitat on the east coast of Florida (at over 180,000 total acres).

B. ADMINISTRATIVE UNITS

Due to the size of the Merritt Island National Wildlife Refuge, it was necessary to divide the refuge into several different classes of subunits: management units; prescribed burn units; impoundments; and the estuarine system. These different sets of systems overlap in many cases, and can seem to be confusing. However, they were designed to facilitate different management activities, and with some explanation, are more simple than they first appear.

B-1: MANAGEMENT UNITS

The refuge lands that are on Kennedy Space Center were divided into nine management units (Figure 2) during the late 1970s to facilitate habitat management activities. The borders of these units were chosen using existing infrastructure and natural boundaries. The management units are large, ranging in size from 10,000 acres to 29,000 acres and containing a wide variety of vegetation and habitat types. In the late 1990s the refuge became responsible for lands independent of the space center. Some of these are owned in fee simple, while others are managed under an agreement with the State of Florida. These tracts are located on the western side of the Indian River Lagoon and are known as the Turnbull Creek area.

B-2: PRESCRIBED BURN UNITS

It is obvious that burning tracts of land as big as those of the management units would be impracticable. Therefore, the prescribed burn units were developed as a subset of the management units (Figure 3). Numbering of the burn units reflects the management unit in which the burn unit resides. For example Burn Unit 1.2 A is in Management Unit I. The size and configuration of the burn units have changed over time as the primary objectives of the burning program have changed. Even today, modifications of the burn unit perimeters are ongoing.

While a detailed history of the burning program is available in the refuge's Fire Management Plan (Adrian 2003), a short summary is warranted here. During the first decade of the refuge, little prescribed burning occurred. With the catastrophic wildfires experienced in 1981, when

two refuge personnel were killed, it was recognized that prescribed burning was needed to manage fuels in the wildlands. Prescribed burn units were developed to facilitate the burning process. As was the case with the management units, existing roads and natural barriers were used to form the perimeters of these units. These units were large, some up to 4,000 acres. Many of the upland units encompassed several different vegetative communities that historically had widely varying fire regimes.

As time progressed and fire management prescriptions were expanded to include habitat management goals, the size of the prescribed burn units was reduced. This not only enabled managers to reduce the number of different vegetation types within a specific unit, but had other advantages, such as reducing the time needed to burn a unit and make smoke management less cumbersome.

B3: SCRUB RESERVE UNITS

Four areas exist on the refuge where scrub oak and scrubby flatwoods vegetation predominate. These sites are the primary habitat for the Florida scrub-jay (*Aphelocoma coerulescens*). Due to the importance of the scrub-jay, the refuge has recently recognized these areas as scrub reserve units (SRUs). SRUs are discussed further in Chapter IV.

B-4: IMPOUNDMENTS UNITS AND ESTUARINE MARSHES

Originally, approximately 26,000 acres of estuarine marshes surrounded the lagoon waters of the Indian River Lagoon, Banana River, and Mosquito Lagoon. By the end of the 1960s, almost all of these marshes had been impounded. The impoundments were named by the Brevard County and Volusia County mosquito control districts (as shown in Figure 4). There is no relationship between the impoundment names and the refuge management unit in which they are located. Rather, the impoundment names were based on either local areas (e.g., the Shiloh impoundments in the north Indian River Lagoon) or by the city/county location (with the T-series representing the Titusville area, the C-series representing the Cocoa area, and the V-series representing Volusia County). In recent years, some of these impoundments have been restored by removing the mosquito control dikes to reestablish the natural exchange between the marsh and the lagoon. The long term plans for the impoundments include additional restoration projects. When dikes are removed, the restored marsh retains its original name.

B-5: ESTUARINE SYSTEM

The large open estuary of Merritt Island NWR is a major ecological landscape feature (Figure 4). This aquatic habitat encompasses portions of the Mosquito Lagoon, Indian River Lagoon, and Banana River and is considered part of the Indian River Lagoon system. Portions of the estuarine system can be found in most of the management units. However, due to it uniqueness, the lagoon system is usually managed as a separate entity.

Figure 2: Management Units

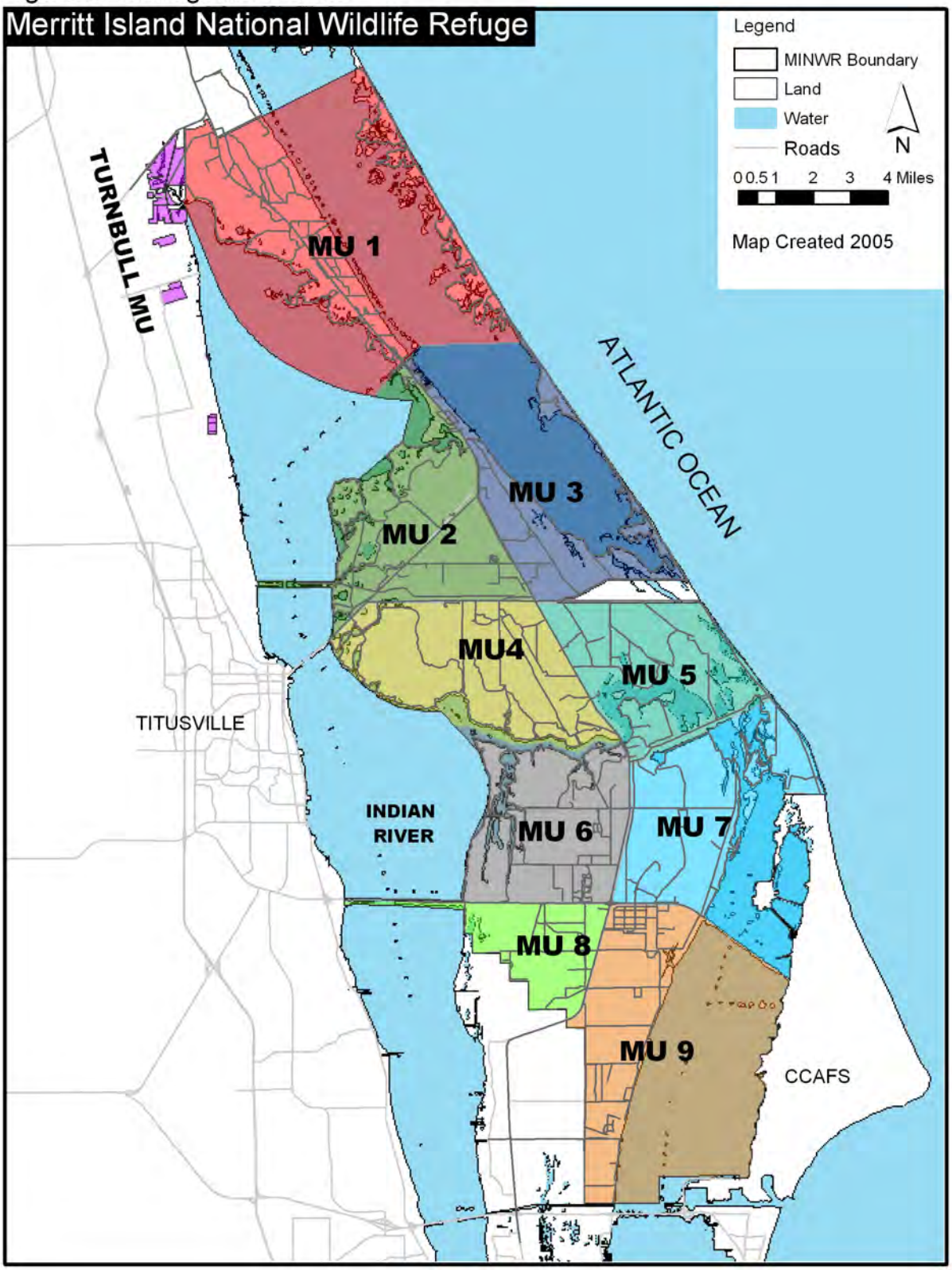


Figure 3: Fire Management and Burn Units

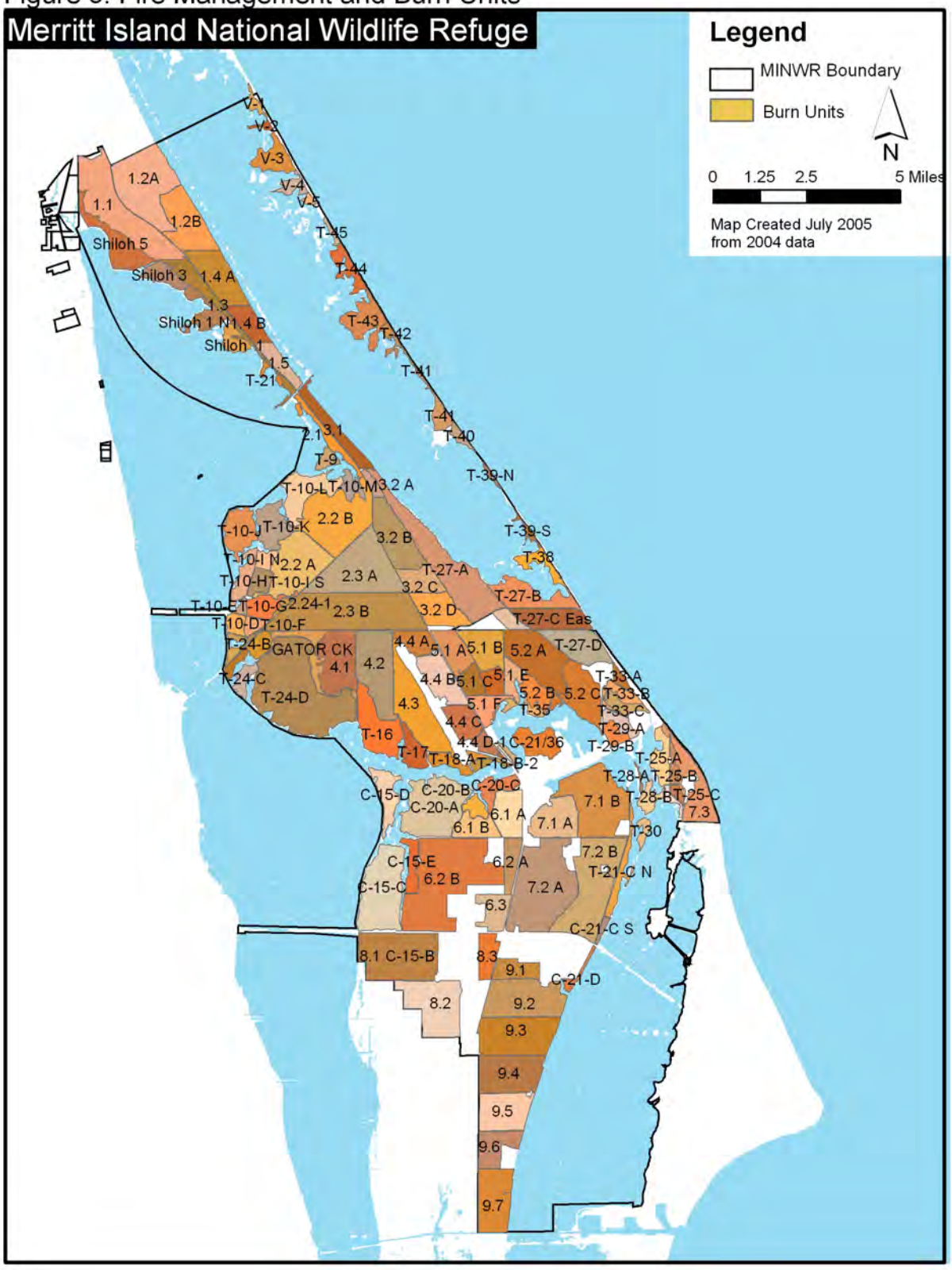
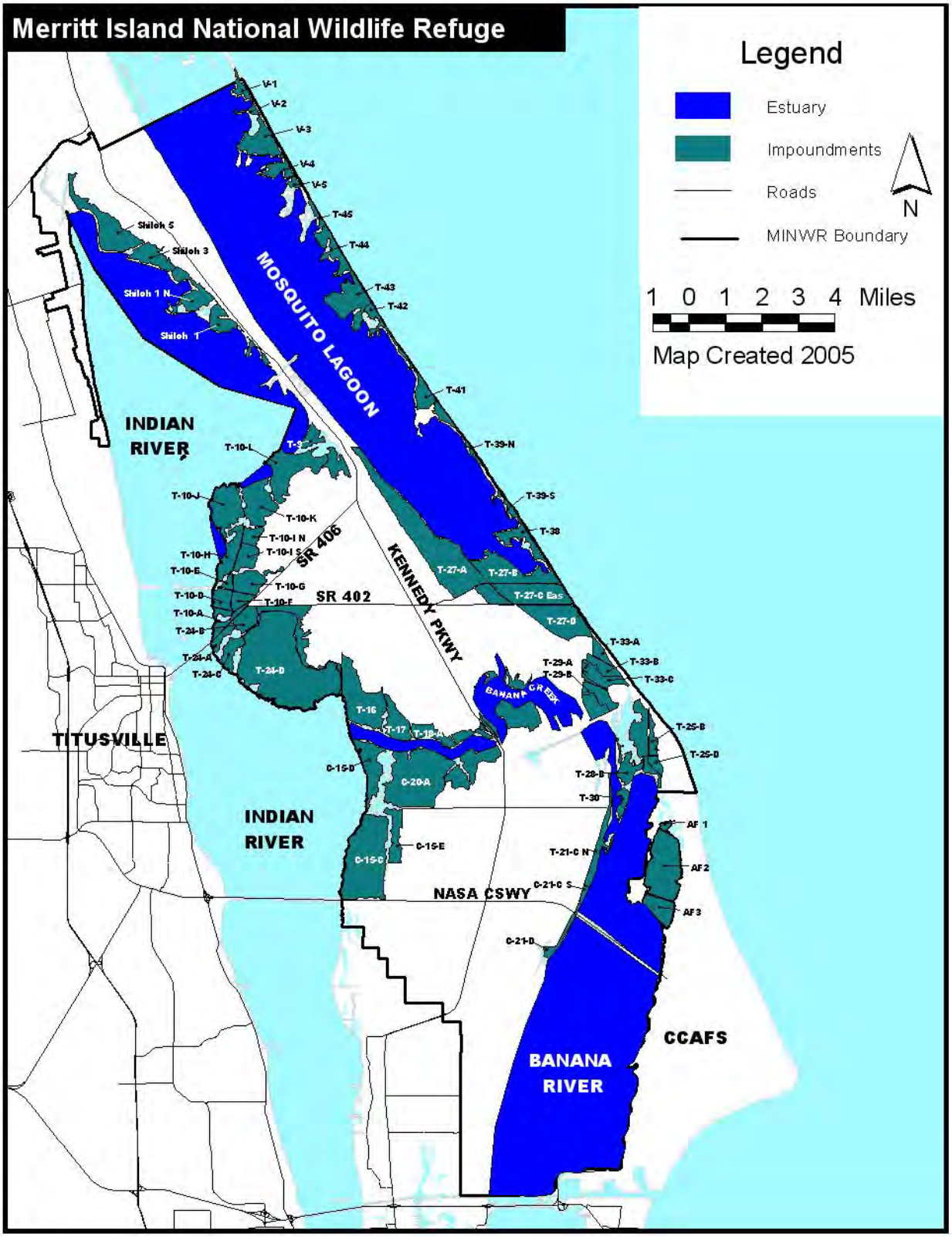


Figure 4: Estuary and Impoundment Units



C. PHYSICAL AND GEOGRAPHIC SETTING

C-1: PHYSICAL ENVIRONMENT

Climate

General Climatic Conditions: The main factors influencing climate at Merritt Island National Wildlife Refuge are latitude and the proximity of large bodies of water. Generally, the climate at the refuge can be described as subtropical with short, mild winters and hot, humid summers, with no appreciable spring or fall seasons. Summer weather patterns usually begin in April and prevail for nine months.

Temperature: Summer temperatures (measured in Fahrenheit) range from the low 70s at dawn to the upper 80s and low 90s during the afternoon. November may have some cool days, but winter weather typically starts in December and lasts through March. Average temperatures during the winter range from lows in the 50s to highs near 75°. Temperature extremes range from a low of 19° to a high of 100° (Patrick Air Force Base 2004).

Atmospheric Moisture: As one would expect with large bodies of water in and around the refuge, the relative humidity (RH) is typically high. Mean dawn RH is between 88% and 95% throughout the year, while readings in the mid-afternoon are between 55% and 67%. Very low RH can occur with the passage of cold fronts in the winter. Readings in the 30 to 40% range are common and an RH as low as 26% has been recorded. On the other end of the spectrum, RH of 100% is not uncommon with fog occurring 90 days per year on average.

Precipitation: The average annual precipitation for the refuge, as recorded at the Shuttle Landing Facility (SLF), is 49.0 inches (Patrick Air Force Base 2004). Rainfall typically occurs during two time periods separated by dry seasons. Between late May and early October, weather patterns are dominated by the effects of the Bermuda High. This system causes southeast winds, which bring moist warm air on shore, leading to the formation of thunderstorms. These rainfall events are short duration, high intensity localized storms. The refuge averages 83 thunderstorm days per year. Sixty percent of the annual precipitation days occur during these months.

From November to February, the weather patterns are influenced by cold continental air masses. Rainfall during this period comes from the effects of frontal passage. Rain events are more widespread and less intense than those in the summer. The transitional periods between these two wet seasons tend to be dry. Although uncommon, snow does occur on the refuge. The SLF has reported snow in both December and January; however accumulations were less than 0.05 inches.

Annual precipitation amounts can vary widely. In 1998, the annual rainfall was only 34.1 inches. The total accumulation of rainfall for the months of April, May, and June was only 1.03 inches, as compared to the expected amount of 10.42 inches. Conversely, in the year 2001 the refuge received a total of 61.80 inches of rain or 12.80 inches above the SLF average.

These fluctuations in precipitation can impact refuge management operations to a great extent. In 1998, for example, many of the impoundments on the refuge dried out completely. The dry conditions contributed to numerous wildfires, one of which reached over 4,000 acres in size. On the other hand, the wet conditions in 2001 made the maintenance of non-paved roads difficult,

The frequent rains and generally wet conditions also resulted in decreased opportunities for prescribed burning.

Lightning: Due to its importance in fire management, a major refuge management activity, lightning deserves a special mention. The National Weather Service (NWS) Office in Melbourne, Florida states that Florida is the "lightning capital of the United States" (National Weather Service 2005). The NWS data estimate that over 22,000 lightning strikes occur in Brevard County each year. Regarding the intensity of lightning on the refuge itself, research on Kennedy Space Center shows that within cloud and cloud to ground discharges average 2.4 per minute per storm, with a rate of 30.6 discharges per minute recorded during a storm on July 14, 1980 (National Aeronautics and Space Administration 1984).

Tropical Cyclones: Tropical depressions, storms, and hurricanes can impact refuge activities and infrastructure. Large amounts of rainfall can accompany tropical cyclones. In addition, wind and wave action can result in major damage to important refuge habitats. In 2004, three hurricanes impacted the central Florida area. Beach erosion destroyed sea turtle nests and damaged beach mouse habitat on the refuge. The combination of wind and wave action resulted in several millions of dollars in damage to the impoundment dikes. Several refuge buildings suffered damage. On top of all this, substantial staff time was spent in addressing hurricane damage both on Merritt Island National Wildlife Refuge and other refuges in Florida.

Physiography

Geology: Florida has a complex geologic history with repeated periods of deposition when the Florida Plateau was submerged and with erosion during periods of lower sea level when the land was exposed (Randazzo 1997). The Avon Park limestone formation is the oldest deposit known to exist under Brevard County. This was deposited in the early Eocene in an open ocean. A period of lower sea levels, with resultant erosion followed. In the late Eocene, seas rose once again and the limestone of the Ocala group formation were deposited. Following another sea level fall and rise, the Hawthorne formation of calcareous clay, phosphoric limestone, phosphorite, and rediolarian clay was laid down in the late Miocene. Overlying the Hawthorne formation are unconsolidated deposits of fine sand, shells, clay, and calcareous layers of the late Miocene or Pliocene ages. The surface strata of Merritt Island are primarily unconsolidated white to brown quartz sand containing beds of coquina of Pleistocene and Recent ages. (Schmalzer et al 2001)

Topography: The alternating high and low sea levels during the Pleistocene and Holocene shaped the land surface of Merritt Island NWR. The outer barrier island formed after sea levels rose when the Wisconsinan glaciers retreated. Merritt Island itself was formed as a prograding barrier island complex. The eastern edge of Merritt Island, where it joins Mosquito Lagoon and the Banana River, forms a relic cape aligned with False Cape. The ridge and swale topography of the Island is apparently the result of successive stages of the growth of this Cape (White 1970). The ridges rise to a maximum of about ten feet above sea level, while trough elevations are near sea level.

The western side of the island is substantially older. Erosion has reduced the old dune ridges and the area is flatter. Elevations at the center of the Island approach four feet above sea level and drop off to around one-half foot at the Indian River Lagoon shoreline.

Soils: Relatively minor differences in elevation and internal drainage of the land have resulted in major differences in soil types. Over twenty soil series, representing four soil orders, are found on the refuge. Detailed maps and descriptions of these can be found in the *Soil Survey of Brevard County* (Soil Survey Staff 1974). Based on soils characteristics, five general associations of soils have been identified on the refuge.

Paola-Pomello-Astatula Association: These are soils found on narrow ridges in the area between the Indian River Lagoon and Banana River. They are well to excessively drained acid sands. Internal drainage is rapid, and water tables are generally below three feet. Slopes range from nearly level to strongly sloping. The natural vegetation is scrub oaks, palmetto, and grasses.

Canaveral-Palm Beach-Welaka Association: These soils are nearly level to gently sloping sands that are well to excessively drained. They are found on narrow ridges and sloughs parallel to the Atlantic Ocean. Natural vegetation is scrub oaks, cactus, palmetto, and some pine.

Myakka-Eau Gallie-Immokalee Association: These associations are nearly level, poorly drained, acid soils, they are sandy to a depth of 40 inches and loamy below that level. They are found on flatwoods sites between the ridges. Water tables are usually within 30 inches of the surface and standing water may exist on these sites for short periods of time after heavy rainfall. The natural vegetation is palmetto and pines.

Copeland-Wabasso Association: These soils are nearly level and poorly or very poorly drained. The pH of these areas is higher than that of most flatwoods soils due to the presence of limestone or coquina. Natural vegetation is palm, mesic hardwoods, and pine.

Salt Water Marsh-Salt Water Swamp Association: These associations are nearly level, very poorly drained saline to brackish soils of variable texture. The marsh soils are shallow sands covered with marl or limestone, irregularly stratified mixed sand and shell, or silty clays over sand and shell. The natural vegetation is the salt marsh community. Swamp soils consist of mixed sand and organic matter. Natural vegetation is salt tolerant trees, such as mangroves.

Air Quality Resource

Kennedy Space Center and, therefore, the Merritt Island National Wildlife Refuge is considered to be an attainment, or clean air area, under the Clean Air Act. The ambient air quality is influenced by NASA operations; land management practices, such as prescribed burning; vehicle traffic; and off site emission sources. The daily air quality conditions are most influenced by the considerable on site vehicle traffic, utilities fuels combustion (two regional power plants exist within 10 miles of the refuge), NASA's refurbishment and maintenance operations, and incinerator operations. Space launches and training fires by the KSC Fire Department, as well as prescribed burning and wildfires on the refuge influence air quality as episodic events. Smoke from wildland fires can disrupt KSC operations, such as launches, landings, and payload preparation.

Ambient air quality at KSC and the refuge is monitored by one Permanent Air Monitoring System (PAMS). This is located at NASA's Environmental Health Facility. This station is equipped with analyzers for sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and total inhalable particulates (10-micron).

Water Resources

Surface Waters: The largest surface waters on and around the refuge are part of the Indian River Lagoon system. This includes the Indian River Lagoon, Banana River, Mosquito Lagoon, and Banana Creek. These can best be described as shallow estuarine lagoons with water depths generally less than five feet. The Indian River Lagoon is designated as an Estuary of National Significance. All of Mosquito Lagoon and the northern portion of the Indian River Lagoon have been designated as Class II waters by the State of Florida. The rest of the lagoon system is designated Class III. All of the surface waters within the boundaries of the refuge have been designated as Outstanding Waters of Florida. All of these designations place restrictions on the use of the surface waters.

In addition to the lagoon system, numerous creeks, mosquito control impoundments, borrow ponds, and miscellaneous wetlands are on the refuge. In the 1960s, many of the marshes were impounded to control the production of the salt marsh mosquito (*Aedes* spp.). These impoundments contain about 8,000 acres of open water and 14,000 acres of wetlands. Approximately 950 acres of borrow ponds, 6,000 acres of grassy swales, and 370 acres of canals and ditches are on the refuge.

The quality of the surface waters on the refuge is generally good. The best areas are those adjacent to undeveloped areas, such as Mosquito Lagoon and the northern end of the Indian River Lagoon. Monitoring of water quality is conducted by both NASA and the refuge.

Ground Water: The surficial aquifer supports the refuge's freshwater wetlands and provides groundwater discharge to the surrounding lagoons (Clark 1987). This aquifer occurs in saturated Pleistocene and Holocene deposits of sand, shell, coquina, silt, and marl. The upper boundary is the water table, while the lower limit is the confining layer at the base of the Pleistocene and Holocene deposits. The surficial aquifer is recharged by direct infiltration. The high sand ridges in the center of the refuge, which are composed of permeable sands, are especially important.

The surficial aquifer can be divided into several sub systems. The Dune or Barrier Island subsystem has a lens of freshwater three meters or less thick on top of intruded saltwater. The primary dune acts as the principle recharge area. The Dune-Swale subsystem runs north to south in the center of the refuge. Most of it is east of Kennedy Parkway (State Road 3) and includes high ridges, which serve as recharge areas. The pine flatwoods and swale soils in this area have pronounced humic hardpans (spodic or B_h horizons) that restrict infiltration. Water perches above this layer and will only infiltrate slowly. The West Plain subsystem is located in the flatwoods and hammock areas west of Kennedy Parkway (State Road 3). Spodic horizons limit infiltration in much of the area north of Banana Creek. South of the Creek, a limestone hardpan is the limiting factor. The fourth division of the surficial aquifer, the Marsh subsystem, is found under the impoundments.

The other aquifers found under the refuge include the Floridan Aquifer. This is associated with Eocene limestones and is artesian. Secondary artesian aquifers occur within the Hawthorne formation and in the Caloosahatchee Marl Equivalent.

Water Quality: Ground water can be contaminated from either point sources or non-point sources. Merritt Island NWR/Kennedy Space Center has been used since the 1960s as the nation's primary launch site for space exploration. Many hazardous chemicals have been used to support space operations over the years, and, especially in the early years, less than

adequate care had been taken in the handling and disposing of these chemicals. Point source pollution has been documented on Merritt Island NWR/Kennedy Space Center in several instances. Contaminated areas have been found in and around launch pads A and B, landfill sites, sewage treatment plants, and some abandoned processing sites. The locating and meditating of contaminated sites is an ongoing process, the majority of which is handled by NASA. The refuge has been involved on a limited basis in detecting possible point sources in the citrus grove areas where chemicals have been stored

The citrus grove operations also have the potential for non-point source pollution. The application of fertilizer, insecticides, and other chemicals during grove care taking operations fall under the area non-point source pollutants. The refuge is cooperating with Florida Research Center for Sustainable Agriculture in a study to determine the affects of various citrus management practices on the environment including ground and surface waters (Adair 2001).

The areas of the refuge subject to known point source pollution and agricultural activities are relatively small. A recent study of the surficial aquifer on the refuge found that contamination was in large areas of the refuge was low (Schmalzer et al 2001). This investigation looked at number of possible pollutants. Organochlorine pesticides, aroclors, and chlorinated herbicides were below detection levels. Seven polycyclic aromatic hydrocarbons (PAC) occurred at low concentrations in some areas. PAC can have both natural and human activity sources. Most trace elements were below detection levels or were found in low concentrations. They concluded that widespread contamination of the surficial aquifer on the refuge has not occurred.

C-2: BIOLOGICAL RESOURCES

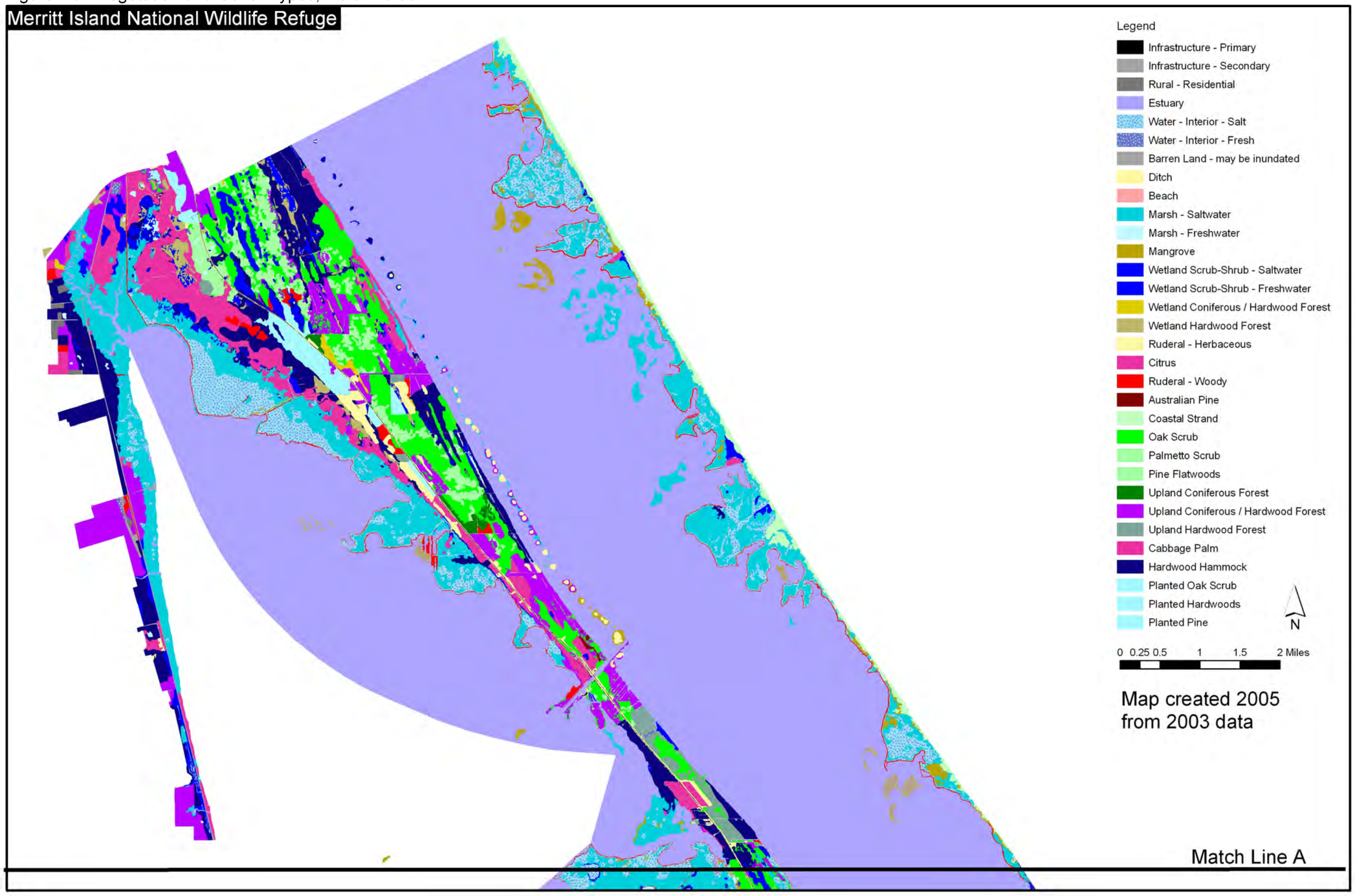
Vegetation

Schmalzer (Schmalzer et al 2002b) lists 1,024 species of plants on the refuge. Of these 803 are native and 221 are introduced. These plants are organized into vegetative communities. A habitat/vegetation map delineating these communities has been developed for the area inside the acquisition boundary of Merritt Island National Wildlife Refuge (figures 5 a, b, and c). This map was developed using the terminology of the National Vegetation Classification System (NVCS). In the NVCS, the floristic association is the most applicable level to refer to when managing the vegetation on the refuge. However, the verbiage is cumbersome, and it is sometimes difficult to use in everyday conversation. Table 1 gives the mandated NVCS terminology along with a colloquial name for the various habitat types found on the refuge. A detailed description of the individual habitat types can be found in the designated chapter. Figure 6 shows the distribution of the major cover type categories on the refuge.

Vegetative Changes Over Time

As was discussed in Chapter I, the landscape of Merritt Island has changed dramatically over time. Early aerial photography shows that the landscape of the refuge as late as the 1940s was open in nature (Breininger et al 1994; Duncan et al 1996; Duncan et al 2004). Agriculture, urbanization, development of Kennedy Space Center infrastructure, fire suppression, and other factors have caused considerable alteration of this landscape. Each of the habitats and vegetation types listed in Table 1 has been affected in some way. This information is detailed in the appropriate chapters.

Figure 5 a: Vegetation and Cover Types; North Portion



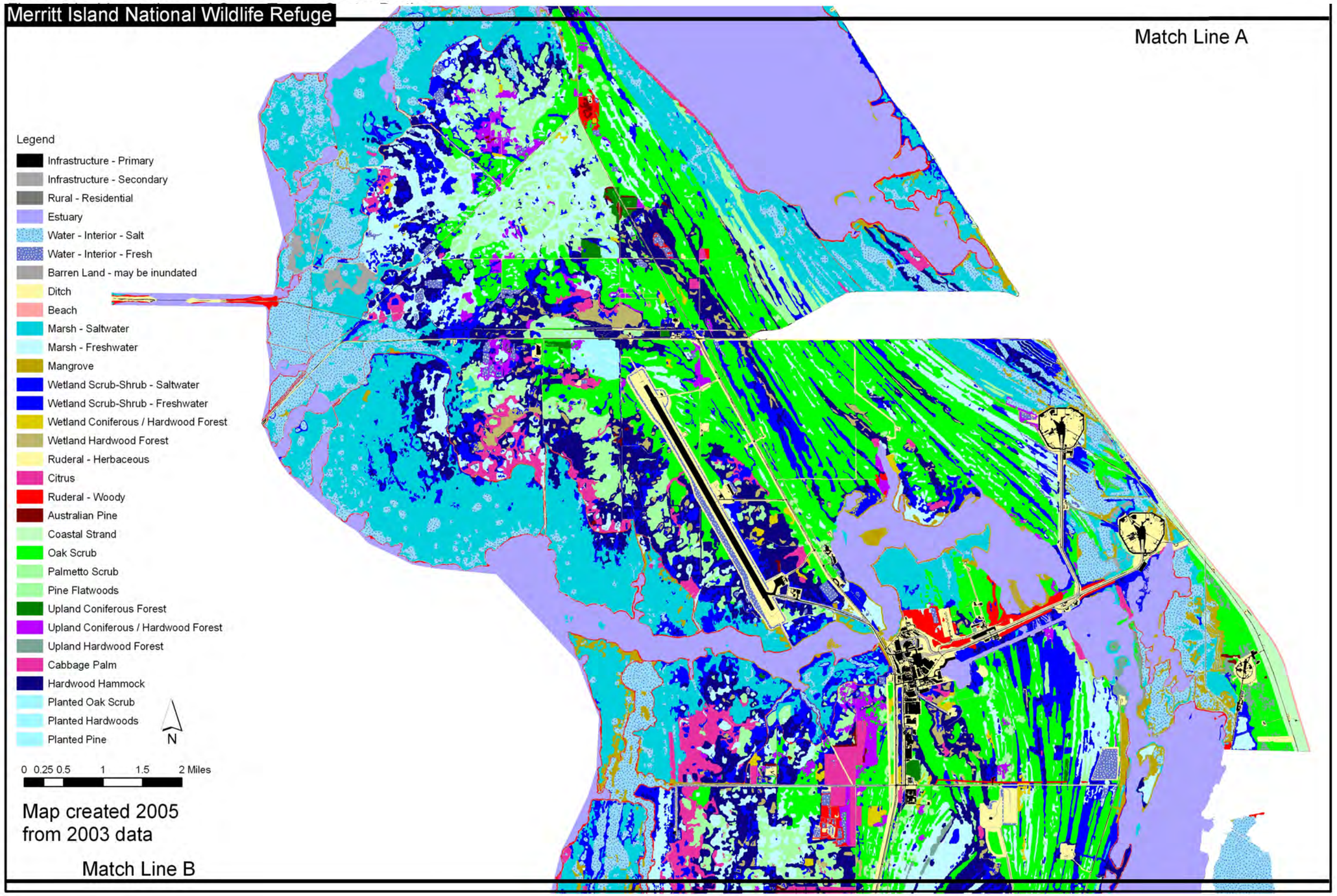

Merritt Island National Wildlife Refuge
Match Line A
Legend
Infrastructure - Primary
Infrastructure - Secondary
Rural - Residential
Estuary
Water - Interior - Salt
Water - Interior - Fresh
Barren Land - may be inundated
Ditch
Beach
Marsh - Saltwater
Marsh - Freshwater
Mangrove
Wetland Scrub-Shrub - Saltwater
Wetland Scrub-Shrub - Freshwater
Wetland Coniferous / Hardwood Forest
Wetland Hardwood Forest
Ruderal - Herbaceous
Citrus
Ruderal - Woody
Australian Pine
Coastal Strand
Oak Scrub
Palmetto Scrub
Pine Flatwoods
Upland Coniferous Forest
Upland Coniferous / Hardwood Forest
Upland Hardwood Forest
Cabbage Palm
Hardwood Hammock
Planted Oak Scrub
Planted Hardwoods
Planted Pine
N
0 0.25 0.5 1 1.5 2 Miles
Map created 2005
from 2003 data
Match Line B

Figure 5 c: Vegetation and Cover Types; South Portion

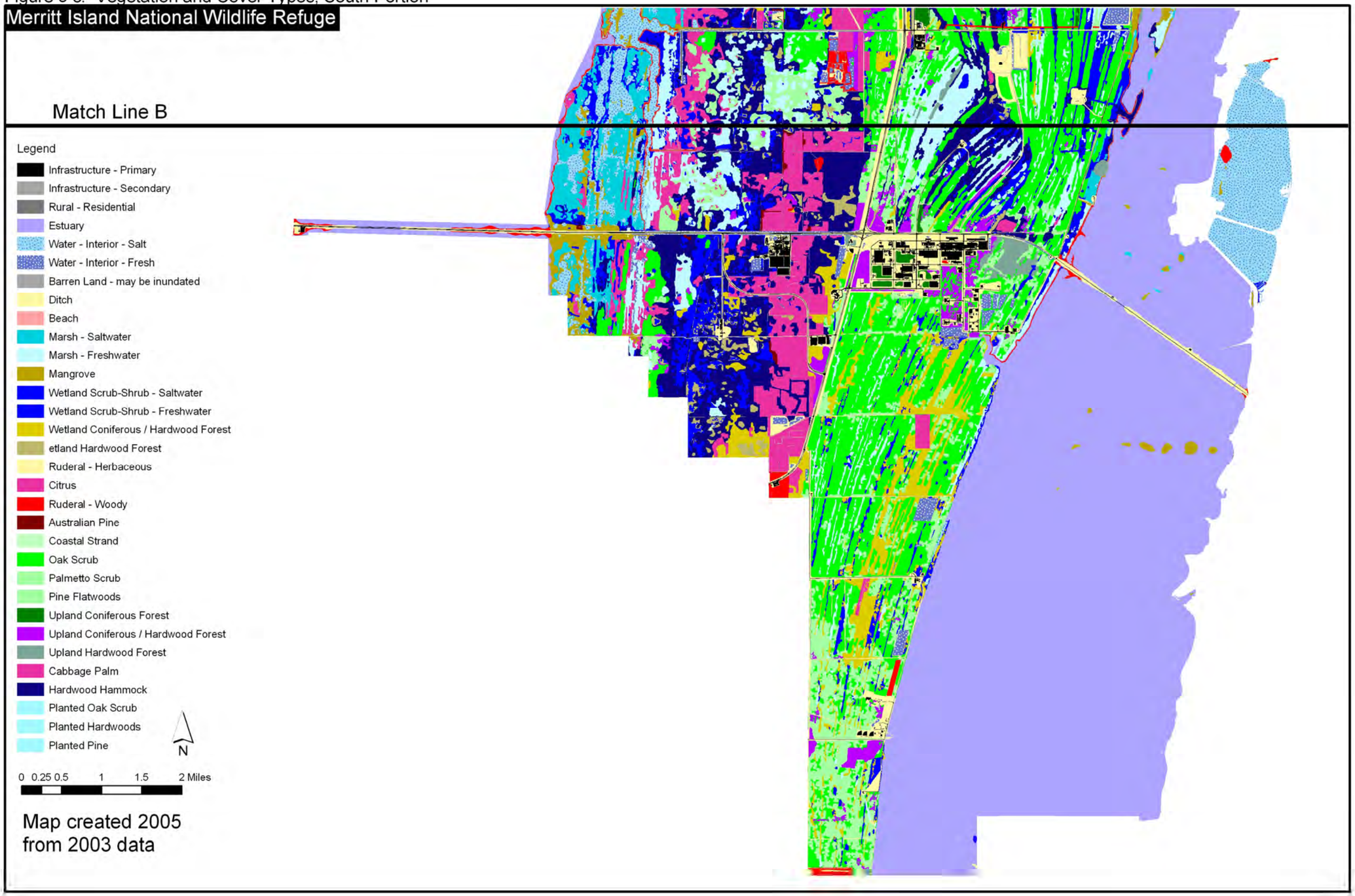


Figure 6: Vegetation and Cover Types Distribution

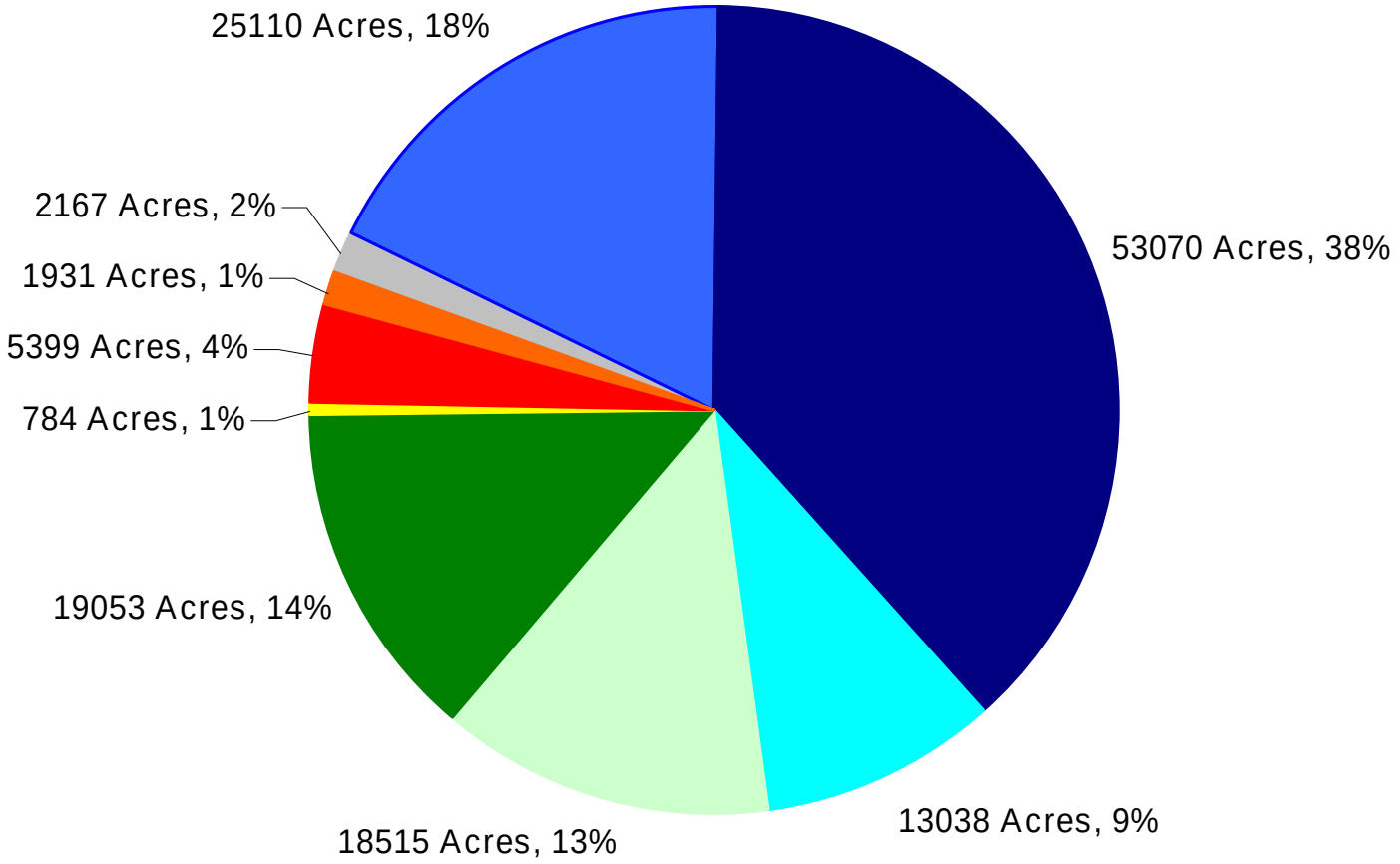


Table 1. Vegetation and cover types on Merritt Island National Wildlife Refuge

Cover Type and (Colloquial terminology from Vegetation Map & HMP Text)	Floristic Alliance (NVCS)	Floristic Association (NVCS)	Acres	Chapter
Non-habitat Acres				
Infrastructure-primary	N/A	N/A	1,390.36	N/A
Infrastructure-secondary	N/A	N/A	726.91	N/A
Rural-residential	N/A	N/A	46.24	N/A
Total Non-habitat Acres			**2,163.51**	
Saline Wetland Habitat Types				
Estuary	N/A	N/A	53,069.68	VIII
Barren land-may be inundated	N/A	N/A	260.76	VIII
Water-interior-salt (Open water in impoundments)	N/A	N/A	7,660.05	VIII
Marsh-saltwater (Salt marsh, impounded or otherwise)	SPARTINA BAKERI-DISTICHLIS SPICATA TIDAL HERBACEOUS ALLIANCE	Spartina bakeri-Distichlis spicata Association	13,635.37	VII
Wetland shrub-scrub-saltwater	BERRICHIA FRUTFSCENS TIDAL SHRUBLAND ALLIANCE	N/A	1,893.92	VIII
Mangrove	AVICENNIA GERMINANS-LANGUNCULARIA RACEMOSA-RHIZOPHORA MANGLE TIDAL SHRUBLAND ALLIANCE	Avicennia germinans-Languncularia racemosa-Rhizophora mangle Association	1,659.84	VIII
Total Saline Wetland Acres			**78,179.62**	

Cover Type and (Colloquial terminology from Vegetation Map & HMP Text)	Floristic Alliance (NVCS)	Floristic Association (NVCS)	Acres	Chapter
Freshwater Wetland Habitats				
Ditch	N/A	N/A	375.36	VIII
Water-interior-fresh (Borrow Pond)	N/A	N/A	960.73	VIII
Marsh-freshwater (Swale)	SPARTINA BAKERI SEASONALLY FLOODED HERBACEOUS ALLIANCE	Spartina bakeri Association	5,912.51	IV, V, VII
Wetland shrub-scrub-freshwater (Willow)	SALIX CAROLINIANA TEMPORARILY FLOODED SHRUBLAND ALLIANCE	Salix caroliniana Association	5,488.89	IV, V, VIII
Total Freshwater Wetlands			**12,737.49**	
Beach and Dune Habitats				
Beach	N/A	N/A	65.98	VII
Coastal strand	SERENOA REPENS-COCCOLOBA UVIFERA SHRUBLAND ALLIANCE	Serenoa repens-Coccoloba uvifera Association	718.02	VII
Total Beach and Dune			**784.00**	
Upland Shrubland Habitats				
Oak scrub (Also scrubby flatwoods)	QUERCUS GEMINATA-QURECUS MYRTIFOLIA-SERENOA REPENS SHRUBLAND ALLIANCE	Quercus geminata -Quercus myrtifolia-serenoa repens Association	15,344.24	IV
Palmetto scrub	SERENOA REPENS-ILEX GLABRA-LYONIA SPP. SHRUBLAND ALLIANCE	Serenoa repens-Ilex glabra-Lyonia spp. Association	3,142.76	IV

Cover Type and (Colloquial terminology from Vegetation Map & HMP Text)	Floristic Alliance (NVCS)	Floristic Association (NVCS)	Acres	Chapter
Planted oak scrub	QUERCUS GEMINATA-QUERCUS MYRTIFOLIA-SERENOA REPENS SHRUBLAND ALLIANCE	Quercus geminata -Quercus myrtifolia-serenoa repens Association	24.81	IV
Total Upland Shrubland			**18,511.81**	
Wetland Forest Habitats				
Wetland hardwood forest	ACER RUBRUM-ULMUS AMERICANA SEASONALLY FLOODED FOREST ALLIANCE	Acer rubrum - Ulmus americana Association	1,185.64	V
Wetland coniferous/hardwood forest	PINUS ELLIOTTII-QUERCUS VIRGINIANA SATURATED TEMPERATE FOREST ALLIANCE	Pinus elliottii-Quercus virginiana Association	1,603.24	V
Total Wetland Forest			**2,788.88**	
Mesic and Upland Forest and Woodland Habitats				
Cabbage palm (Palm Hammock)	SABAL PALMETTO TEMPERATE FOREST ALLIANCE	Sabal palmetto Association	2,880.61	V
Hardwood Hammock	QUERCUS VIRGINIANA-SABLE PALMETTO FOREST ALLIANCE	Quercus virginiana-Sabal palmetto Association	9,569.24	V
Upland hardwood forest	QUERCUS VIRGINIANA-SABLE PALMETTO FOREST ALLIANCE	Quercus virginiana-Sabal palmetto Association	594.57	V
Planted hardwoods	QUERCUS VIRGINIANA-QUERCUS LAURIFOLIA FOREST ALLIANCE	Quercus virginiana-Quercus laurifolia Association	285.41	V

Cover Type and (Colloquial terminology from Vegetation Map & HMP Text)	Floristic Alliance (NVCS)	Floristic Association (NVCS)	Acres	Chapter
Pine flatwoods	PINUS ELLIOTTI-SERENOA REPENS ALLIANCE	Pinus elliotti-Serenoa repens Association	2,999.18	V
Upland coniferous/hardwood forest	PINUS ELLIOTTII-QUERCUS VIRGINIANA SATURATED TEMPERATE FOREST ALLIANCE	Pinus elliottii-Quercus virginiana Association	2,730.07	V
Upland coniferous forest	PINUS ELLIOTTI-SENORA REPENS ALLIANCE	Pinus elliotti-Senora repens Association	274.53	V
Planted pine	ELLIOTTII TROPICAL FOREST ALLIANCE	Pinus elliottii var densa Association	203.98	V
Total Mesic and Upland Forest			**19,537.59**	
Non-native Vegetation				
Ruderal-herbaceous (Lawns, disturbed areas)	No floristic dominance	N/A	3,745.96	N/A
Australian pine	CASURINA SPP. FOREST ALLIANCE	Casurina spp. Association	111.71	IX
Ruderal-woody (Brazilian pepper)	SCHINUS TEREBINTHIFOLIUS-MYRICA CERIFERA SHRUBLAND ALLIANCE	Schinus terebinthifolius-Myrica cerifera Association	1,540.83	IX
Citrus	CITRUS SPP. WOODLAND ALLIANCE	Citrus spp. Association	1,930.92	VI
Total Non-native Vegetation			**7,329.42**	
TOTAL MINWR ACRES			**142,032.32**	

Wildlife

The diverse habitats of the refuge support a wide variety of animal species. The refuge's biodiversity is important to the overall ecological integrity of the North Florida Ecosystem in general and the Indian River Lagoon system in particular. The refuge also serves as an important site for the recovery of federally and state listed threatened and endangered species. The refuge's habitats provides protection and management opportunities for 10 regularly occurring federally listed threatened and endangered species (where a total of 93 species have some level of management concern by the federal government or by the State of Florida) (Epstein and Blihovde 2006, Appendix C). The habitat needs of many of the refuge's fauna will be discussed in subsequent chapters.

Birds: Avian species are highly important wildlife resources identified on the refuge with more than 330 birds using the refuge for nesting, roosting, feeding, or loafing. Over 23 species of migratory waterfowl and 34 species of migratory shorebirds winter on the refuge.

The primary purpose for which the refuge was established was for protection and management of migratory birds. The refuge historically supported vast numbers of waterfowl, including blue-winged teal, American widgeon, northern pintail, lesser scaup, red heads, and mergansers. The refuge also provides important habitat for neotropical migrants.

The refuge supports breeding populations of two federally listed birds: the Florida scrub-jay (*Aphelocoma coerulescens*) and the bald eagle (*Haliaeetus leucocephalus*). Habitat for these species is being lost or degraded throughout much of central Florida. This greatly increases the importance of proper management of refuge lands for these species.

Mammals: The refuge provides habitat for over 30 species of both terrestrial and aquatic mammals. The mammalian fauna of the refuge is characteristic of the central Florida coastal barrier ecosystem. In addition, the refuge provides habitat for the federally listed southeastern beach mouse (*Peromyscus polionotus niveiventris*) and the West Indian manatee (*Trichechus manatus*).

Reptiles and Amphibians: It is believed that refuge habitats support over 71 species of reptiles and amphibians. Terrestrial herpetofauna have been studied on the refuge since the 1970s. Long-term monitoring has provided considerable data on the biodiversity of herps on the refuge (Seigel and Pike 2003). These data should be beneficial in detecting long-term changes in these species. Reptiles and amphibians are a critical component of refuge ecosystems. The biomass of reptiles and amphibians may exceed that of all other vertebrates in aquatic and terrestrial systems (Seigel and Seigel 2000). The ecological distribution of reptiles and amphibians on Merritt Island would be a function of available habitat, primarily wetland, freshwater communities. However, several species are specific to terrestrial habitats. Exotic species are becoming potential threats to the refuge. Presently on the refuge, the brown anole (*Anolis sagrei*) may be displacing native species (Campbell 2000, Campbell and Echternacht 2002). The Cuban frog (*osteopilus septentrionalis*), which consumes smaller species, has been positively identified on the southern portion of the refuge. Additional research and monitoring is being conducted on gopher tortoise distribution and fecundity, as well as on upper respiratory tract disease in gopher tortoises.

Fish: A variety of fish species utilize the refuge. Paperno (2001) identified 132 fish species in the lagoon waters of the refuge. Surveys conducted in 1994 (Gilmore 1995) listed 782 fish species for east central Florida, with at least half of these using the Indian River Lagoon at

some point during their life history. Fish species within the refuge are important not only to commercial and recreational interests, but also to the ecology of the area. Important fish habitat, such as fish spawning and fish settlement sites in the refuge, must be protected to ensure healthy, sustainable fish populations.

Invertebrates: A wide variety of marine, freshwater, and terrestrial invertebrates are found within the refuge's boundary. For example, the mangrove crab is found on the refuge and is listed by the Florida Committee on Rare and Endangered Plants and Animals. Some of the more common invertebrates include conchs, snails, oysters, land crabs, dragonflies, butterflies, and cicadas.

CHAPTER III
RESOURCES OF CONCERN

A. IDENTIFICATION OF RESOURCES OF CONCERN

Resources of concern for Merritt Island National Wildlife Refuge fall into three areas: individual species, groups of species, and ecosystems. The management activities described in this plan can affect these resources of concern. Hopefully, these effects would be positive, but they could be detrimental in the small scale. In some cases a management action that is beneficial to one resource will have a negative influence on another. Managers must be aware of this, and must sometimes make difficult decisions. These decisions should be made in light of the priorities of the National Wildlife Refuge System, refuge priorities, and the overall health of refuge ecosystems.

In order to provide the reader with a coherent analysis of a complex situation, endangered and threatened species will be covered first. Other species of concern will then be discussed as species groups. Finally, a list of the habitat types found on the refuge will be presented along with a short discussion on resources of concern that would be expected to be found there. Each of the habitats listed is explained in detail in the following chapters.

A-1: FEDERALLY THREATENED AND ENDANGERED SPECIES

The species that have the highest priority on the refuge are those listed as threatened or endangered under the Endangered Species Act. Seventeen federally listed animal species have been recorded on the refuge (Epstein and Blihovde 2006). Six of these are only incidentally present and do not make an important contribution to the refuge's biota. Of these incidental species, three are reptiles [i.e., Kemp's ridley sea turtle (*Lepidochelys kempi*), hawksbill sea turtle (*Eretmochelys imbricate*), and Atlantic salt marsh snake (*Nerodia clarkii taeniata*)] and four are birds [i.e., piping plover (*Charadrius melodus*), Audubon's crested caracara (*Polyborus plancus audubonii*), snail kite (*Rosthrhramus sociabilis*), and roseate tern (*Sterna dougallii*)]. No specific management is conducted for these species. A seventh species, the American alligator (*Alligator mississippiensis*), is listed by similarity in appearance to another listed species, the American crocodile (*Crocodylus acutus*). Alligators are plentiful on the refuge and they can sometimes become a problem. Management is limited to the control of nuisance individuals at the present time. However, alligators may be included in managed public hunts in the future. No federally listed plants are known to occur on the refuge.

Four of the federally listed species [listed as threatened (T) or endangered (E)] for which active management occurs are reptiles. Of these, three are sea turtles: the loggerhead turtle (*Caretta caretta*) (T), green turtle (*Chelonia mydas*) (E), and leatherback turtle (*Dermochelys coriacea*) (E). The other listed reptile is the eastern indigo snake (*Drymarchon couperi*) (T). The refuge manages for three species of federally listed birds. The first is the endemic Florida scrub-jay (*Aphelocoma coerulescens*) (T). The other two species are the wood stork (*Mycteria Americana*) (E) and the bald eagle (*Haliaeetus leucocephalus*) (T). Two listed mammals are found on the refuge. One is the southeastern beach mouse (*Peromyscus polionotus niveiventris*) (T). The refuge's beach mouse population may be used as a source for re-

establishing the southeastern beach mouse in areas of its range where it has been extirpated. The other mammal is the West Indian manatee (*Trichechus manatus*) (E).

A-2: SPECIES LISTED UNDER OTHER AUTHORITIES

Along with species protected under the Endangered Species Act, species listed by the State of Florida as either threatened or endangered that are present on the refuge and should be considered resources of concern. This includes four bird species and one mammal species.

Together, the State of Florida and the U.S. Fish and Wildlife Service (Service or FWS) have designated a total of 56 animal species as Species of Special Concern (SSC). Birds of Conservation Concern (BCC) are ones that have the highest conservation concern for the U.S. Fish and Wildlife Service, other than federally threatened or endangered species (see Epstein and Blihovde 2006 in Appendix C).

In addition to animal species, the refuge supports 33 plant species that are listed by the State of Florida as threatened, endangered, or commercially exploited.

A-3: SPECIES GROUPS

Several wildlife species groups are considered resources of concern for the refuge. It should be noted that many individual species within these groups can be found on the lists previously mentioned. The first group is migratory waterfowl. One of the primary purposes of the Merritt Island Refuge is to provide habitat for migratory birds. Other species groups that would be considered resources of concern would include such migratory bird species groups as shorebirds, wading birds, rails, raptors, and neotropical migratory birds.

A-4: ECOLOGICAL UNITS

While all of the refuge's habitat types or ecological units are important, several can be classified as resources of concern. Some are now only remnants of what were once expansive ecosystems, while other run the risk of being severely degraded from pollution, over use, and natural disasters. It should be obvious that if these systems are mismanaged or otherwise become despoiled, the wildlife species that depend on their existence could be greatly affected. The habitat types that are resources of concern are: oak scrub, interior wetlands, the beach and dune system, the marsh and impounded wetlands, and the estuarine system. Additional resources of concern are exotic, invasive, and nuisance species.

Oak Scrub: Oak scrub is a habitat that once occupied vast acreages throughout the central Florida area, the vast majority of which has succumbed to urbanization over the past 50 years. It is likely that this vegetative community would only persist on lands that are publicly owned. While scrub is important, it should be remembered that it exists as part of the shrubland complex on the refuge. The other components in this matrix, palmetto scrub, scrubby flatwoods, and grassy swales, must also be managed correctly to reap the full habitat benefits that oak scrub can provide. Oak scrub and the related vegetation types are discussed in Chapter IV.

Interior Wetlands: The interior wetlands can be considered resources of concern due to the values they provide and the changes that have occurred in them over the past 50 years. Fire exclusion between the 1950s and the early 1980s, along with extensive ditching in the 1950s and 1960s allowed some of once grassy wetlands to be invaded with woody vegetation. This, in

turn, had disrupted the natural composition of the shrubland and woodland landscapes. The process of restoring these wetlands to their former condition is costly and difficult. Interior wetlands are discussed in several chapters. Their relationship with shrublands in covered in Chapter IV, their association with forest and woodlands is covered in Chapter V, and their relationship to other wetlands is covered in Chapter VIII.

Beach and Dune System: Due to their values and exposed location, beaches and dunes are resources of concern. In addition to environmental influences, such as storms and sea level rise, human activity, such as development and associated lighting, impact these habitats. Additional information on the beach and dune system can be found in Chapter VII.

Marsh and Impounded Wetlands: Most of the salt marsh areas along the edges of the entire Indian River Lagoon, including those on the refuge, were impounded for mosquito control by the mid 1960s. This changed the character of the marshes. In recent years, seven of the refuge's impoundments have been restored by removing the dike system surrounding them, allowing natural tide and hydrology to become reestablished. Other impoundments have been left intact and are managed under various regimes. The questions of managing specific impoundments and identifying impoundments that should be restored can greatly affect the type and quality of habitat. These decisions can also affect the refuge's ability to meet its primary purpose, to provide for migratory birds. Other considerations in the marshes and impoundments cause concern, such as mosquito control, sea level rise and/or marsh bottom subsidence, and fisheries habitat. Marshes and impounded wetlands are discussed in Chapter VIII.

Estuarine System: The estuarine system, discussed in Chapter VIII, is in itself a resource of concern. Three main estuarine water bodies overlap the refuge's boundary: portions of the Banana River, Indian River Lagoon, and Mosquito Lagoon, along with their tributaries. Many of the threats to this aquatic ecosystem are external. Some of these, such as shoreline development, pollution, and reduced water quality, are beyond even the indirect control of the refuge. Others, such as recreational boating and fishing, are earmarked for more intensive management in the coming years to reduce impacts to the refuge's lagoon system. Of specific concern are the seagrass beds, where damage from boats can seriously reduce their viability over time. In addition to providing habitat for fish and similar aquatic resources, the estuarine system serves the federally endangered West Indian manatee and numerous migratory birds.

Exotic, Invasive, and Nuisance Species: It might be surprising to the reader to find exotic species mentioned in a chapter on resources of concern. While the general connotation of concern is a species or area that one would want to improve, protect, or benefit, concern can also be expressed for those things that are detrimental to biological integrity. Such is the case with exotic, invasive, and nuisance species, both plants and animals. These species have been recognized as a serious threat to native species and habitats by the refuge and its partners in the Comprehensive Conservation Plan. This plan discusses the problems and some possible solutions in Chapter IX. Some species, such as Melaleuca, (*Melaleuca quinquenervia*), air potato (*Dioscorea bullbifera*), Old World climbing fern *(Lygodium microphyllum*), and cogangrass (*Imperata cylindrica*) are targeted for complete extermination. Others, including Brazilian pepper (*Schinus terebinthifolius*) and feral hogs (*Sus scrofa*) would have increased control efforts, but eradication is not likely using methods currently available to the refuge.

B. IDENTIFICATION OF HABITAT REQUIREMENTS AND THE POTENTIAL REFUGE CONTRIBUTION TO THE HABITAT NEEDS OF THE RESOURCES OF CONCERN

A comprehensive description of the habitat requirements for the fauna described as species of concern will not be given here. Rather, general habitat requirements for the species in question along with the refuge's capability to contribute to those requirements will be discussed. The reader will be referred to the specific chapter within the Habitat Management Plan where more information is available.

B-1: FEDERALLY THREATENED AND ENDANGERED SPECIES

Sea Turtles and Marine Mammals: Sea turtles use the beach and dune system for nesting. The refuge's beach, along with beach and dune areas controlled by the National Park Service and the U.S. Air Force, are some of the last relatively undeveloped beaches on the east coast of Florida. Barring severe tropical cyclones, and, with proper management, this stretch of beach can provide well protected nesting habitat far into the future. The control of predators and the removal of flotsam that may hinder nesting adults or impair hatchlings from returning to the sea are some of the management activities that are ongoing and should continue. The problem with artificial lighting on structures near the beach disorientating adults and hatchlings is also a concern. This is addressed both through negotiations with the Kennedy Space Center and Cape Canaveral Air Force Station, encouraging them to alter lighting patterns and shade the beach by restoring dunes and dune vegetation.

The estuarine system is utilized by both sea turtles and the West Indian manatee. Mosquito Lagoon is an important nursery area for juvenile green and loggerhead sea turtles, while manatees can be found in most of the lagoon system. The watershed for the estuarine system in and around the refuge is, like the beach and dune system, relatively undeveloped. Offsite threats exist that could degrade the estuarine system, such as sediment from runoff and non-point source pollution, over which the refuge has limited control. However, with proper management and protection, the lagoon system waters should provide suitable habitat for these and other species for a considerable period of time. Exercising control of use where it is feasible is paramount to maintaining the integrity of the estuarine waters. Protection of seagrass beds through limitations on boating activities would help both the juvenile sea turtles and manatees. No motor and slow speed zones can reduce impacts to the manatee from the ever increasing amounts of recreational boating. Management of the estuarine system and the beaches are discussed in Chapter IV.

Florida Scrub-jay: The Florida scrub-jay requires specific habitat parameters of optimal scrub set in a suitable shrubland landscape. The details of these habitat requirements are described in Chapter IV. The refuge is part of the Merritt Island Primary Core Recovery Unit (PCRU), one of four PCRUs. Failure to maintain a viable population of jays on one of these PCRUs would impact the Service's ability to recover this species. The maintenance of the refuge's scrub-jay population is therefore essential to the continued existence of the scrub-jay.

The refuge can provide between 17,000 and 20,000 acres of habitat for the scrub-jay, which would support between 680 and 800 families. This would go a long way towards providing a stable population for the Merritt Island PCRU. The restoration of degraded scrub-jay habitat and the proper management of habitat in good condition are essential to making these figures a reality. Prescribed burning, mechanical treatment, and other management techniques must be employed continuously to ensure the continued existence of scrub-jays on the refuge and to contribute greatly to the overall recovery of this species.

Bald Eagle: The bald eagle uses the pine forests for nesting and requires large areas for foraging. The refuge's pine forests and woodlands presently support 11 bald eagle nest sites. The wetlands of the refuge provide thousands of acres of foraging habitat that harbor abundant fish and migratory birds. These habitat components would become more and more important in the future as urbanization increases along the central east coast of Florida. Management of the pine areas of the refuge (Chapter V) can ensure the existence of nesting areas in the future. Continued management of the estuary impoundments, marshes, and other refuge wetlands (Chapter VIII) are necessary to provide food and other essential needs for the bald eagle.

Wood Stork: Wood storks use various wetlands for foraging and wood storks use mangroves and other woody vegetation for nesting. The refuge's impoundments, restored salt marshes, interior wetlands, and lagoons can provide a wide range of foraging opportunities for this species. The refuge also has ample sites for nesting. Historically, nesting occurred on several of the refuge's mangrove islands, but the rookeries were abandoned in the late 1980s due to habitat changes resulting from freezing temperatures. One of the objectives in the refuge's Comprehensive Conservation Plan is to reestablish wood stork nesting.

Indigo Snake: The indigo snake utilizes a wide variety of habitats. It can be found in the wetlands (Chapter VIII), shrubland communities (Chapter IV), pine forests, and hardwood hammocks (Chapter V). While no management activities are directed specifically for the indigo snake, maintaining diversity in the aforementioned communities should provide sufficient habitat for this species.

Southeastern Beach Mouse: The southeastern beach mouse's primary habitat, as its name implies, is the beach and dune system (Chapter VII). However, the beach mouse has also been found in the shrubland communities some distance inland from the ocean. As was mentioned in the discussion on sea turtle habitat requirements, the refuge manages a portion of the last relatively undisturbed beach on Florida's east coast. Not only would proper management of the refuge's beaches continue to maintain the beach mouse population here, but it may provide a source for reestablishing beach mouse population in other areas. Further studies may also show that shrubland restoration may also provide habitat for this threatened species.

B-2: SPECIES GROUPS

Migratory Waterfowl: Migratory waterfowl require staging and wintering areas that provide ample food and cover habitat. The diversity of the refuge wetlands provides the needed plant and animal foods to maintain their migratory energy demands. These food sources also serve to replenish their nutritional needs for molting and reproducing. Refuge habitats and sanctuaries also serve as areas for loafing and resting that are free from disturbance. The diversity of the waters and marshes on what is now Merritt Island NWR provided these requirements for many years. In the present day situation, marsh impoundments are managed to provide and enhance food and cover habitat. Closed areas, including KSC's Security Area, serve as ideal sanctuaries with limited disturbance. The estuarine systems also provide food and habitat for many migratory waterfowl species.

Wading Birds: Wading birds need shallow water for foraging and areas with woody vegetation for roosting and breeding. Once again, the refuge's impoundments play an important role in providing their habitat needs. Some impoundments are managed primarily for wading birds, while others, such as those managed for wintering waterfowl, provide habitat incidental to their principle management purpose. These birds utilize the restored salt marshes, interior wetlands,

and the estuarine system. Islands with mangroves and other areas are available in good supply for roosting and nesting. The refuge's habitats presently support one of the largest concentrations of migratory and resident wading bird populations on the east coast of Florida.

Shorebirds: One of the keys to providing good foraging habitat to shorebirds is to have very shallow water or bare, moist mud or sand. These criteria are met in several habitat types on the refuge. Impoundments, even when managed primarily for other water birds, have a diversity of habitats that include shallow water conditions. This increases when water is being drawn down. The edges of the lagoons can also provide important shorebird foraging areas when parts of the bottoms are exposed as wind tides rise and fall. In addition, the beach system provides loafing and foraging habitat for shorebirds. Migratory shorebirds share many of the same habitats as waterfowl under shallow water level conditions. These feeding and loafing habitats are vital to replenishing their nutritional demands for migration and reproduction. Many of the migratory shorebirds spend up to nine months of the year in migration from the Artic to the Antarctic and back. Merritt Island NWR provides important over wintering and staging habitat that supplements their migratory needs.

Neotropical Migratory Birds: Neotropical migratory birds, also known as songbirds, are a diverse group of species. It follows, therefore, that they would use a wide range of habitats, and this proves to be the case. Neotropical migrants can be found in most of the upland vegetative communities, including shrublands, pine forests, woodlands, and mesic hammocks. They can also be found in the interior wetlands associated with these upland communities, as well as in impounded and restored marshes, hydric forests, and shrublands. Management is aimed toward keeping these habitats diverse and healthy to provide the widest range of niches for neotropical migrants as can be accomplished. More research is needed to define the specific needs of many of these species.

C. RECONCILING CONFLICTING HABITAT NEEDS FOR RESOURCES OF CONCERN

When managing an area as extensive and diverse as Merritt Island NWR, it is inevitable that species would have conflicting habitat requirements. One example is the habitat needs of the Florida scrub-jay as opposed to those of the bald eagle. The scrub-jay requires an open shrubland landscape with few trees. The eagle, on the other hand, requires stands of pines for nesting. Since both of these are listed species, and in some areas of the refuge the land could be managed for either species, a dilemma arises.

One approach to solving this dilemma is to look at the historic landscape. When one looks at aerial photography taken prior to development of much of the infrastructure in and around the refuge, one finds that the extent and density of the pine forests was much less than is the case today. Studies of historical documents have shown that during this time period eagles flourished in the Merritt Island area (Hardesty and Collopy 1991). Although there is no hard data, photographic evidence indicates that the open shrublands of that era would also have provided suitable habitat for the jays (Duncan and Schmalzer 2004). The 1943 aerial photography provides a benchmark.

Furthermore, managers familiar with forest and shrubland ecology realize that while south Florida slash pine (*Pinus elliotti* var. densa), the nesting substrate of choice of the eagles, will grow on both mesic flatwoods soils and the drier sand ridge soils, it is better suited for the wetter flatwoods. Conversely, the scrub oaks critical to scrub-jay habitat are plants typically found on drier sites.

Providing habitat for both species could be accomplished by combining these two pieces of knowledge. Concentrating timber management to produce eagle nesting habitat is an option in the flatwoods areas, while pines would be removed in the higher sand ridges. The scrubby flatwoods is an area that has vegetative characteristics of both areas (Chapter IV) that could be managed either way. Use old aerial photography as a guide to assist with decision making in the scrubby flatwoods.

A different situation presents itself when considering the needs of the various waterbirds that frequent the refuge. The marshes of the refuge were extensively altered through ditching and the constructing mosquito control impoundments from the 1950s through the 1960s. Due to several constraints, total restoration of the landscape by removing all of the dikes is not an option. However, some of the impoundments and ditched marshes have been targeted for restoration. Thus, the use of old aerial photography to help mimic a historic landscape is also helpful in impoundment restoration. In this case impoundment management can have multiple objectives. For example, some impoundments would be selected to manage for the needs of one assortment of species groups (i.e., multiple species management), while other impoundments would be selected to support a different array of species groups. A second concept is to accommodate two or more species groups in one impoundment (i.e., featured species management). An example of this would be an impoundment that has been selected to be managed for wintering waterfowl. After most of the habitat requirements of the waterfowl have been met, the management scheme calls for lowering water levels to consolidate the bottom sediments and to increase resource and habitat availability for other species. While performing this management operation, the decreasing water levels would create foraging habitat for wading birds and shorebirds.

Unfortunately, not all conflicts can be resolved as easily as the two cases above. It would be expected that difficult decisions would need to be made to manage the refuge. In the final analysis, the resolution of conflicting habitat needs comes down to refuge priorities.

CHAPTER IV
SHRUBLAND MANAGEMENT

A. HABITAT GOALS AND OBJECTIVES

The Merritt Island National Wildlife Refuge Comprehensive Conservation Plan (CCP) outlines goals, objectives, and strategies which direct management actions for the shrublands. Three goals, with subordinate objectives and strategies, from the refuge's CCP are applicable to shrubland management.

1. Rare, Threatened, & Endangered Species

WILDLIFE AND HABITAT MANAGEMENT GOAL 1; Preserve, protect, and enhance populations of rare, threatened, and endangered species of plants and animals at existing or increased levels on the refuge, and preserve, protect, manage, and restore their native east central Florida coastal and estuarine habitats occurring on the refuge to contribute to recovery goals.

Under this goal two objectives pertain specifically to shrubland management. The first addresses scrub habitats, while the other concerns the number of Florida scrub-jays themselves.

1.a. Florida Scrub-jay-Scrub Habitat

Wildlife and Habitat Management Objective 1.a(1): Annually maintain 500-650 Florida scrub-jay family groups with 350-500 territories being in optimal condition to support scrub-jay recovery efforts.

The strategies for Wildlife and Habitat Management Objective 1.a(1) are listed.

The listed strategies involve developing plans and databases to improve shrubland management activities.

- Develop management plans for each of the four population concentrations on the refuge using maps and inventories to develop site specific management for the different scrub and upland habitat cover types.
- Develop GIS databases of existing scrub-jay territories and update biannually.
- Discourage future development (e.g., by KSC) where it would hamper connectivity.
- Coordinate with KSC to ensure proper management of corridor areas that are not part of the refuge.
- Assist CCAFS and CNS in the management of their scrub lands.

The strategies listed concern activities that would increase the overall knowledge of the refuge's Florida scrub-jay population.

- Continue conducting the annual Florida scrub-jay surveys using a variety of government, university, non-governmental organization, and private partners, as well as volunteers.
- Continue partnerships with Dynamac to maintain Florida scrub-jay demographic studies in the Happy Creek and TEL-IV areas.
- Use partnerships to provide additional Florida scrub-jay demographic information in other population centers to determine which areas are sinks (where mortality exceeds production) and which areas are sources (where production exceeds mortality).

- Encourage long term research studies in areas least likely to be affected by NASA development and operations at KSC.
- Use existing research and local experts to better understand Florida scrub-jay population dynamics.

The listed strategies describe possible methods of reducing Florida scrub-jay mortality.

- Investigate dynamics of predator/jay interactions and develop techniques to reduce mortality from predators.
- Investigate methods of reducing vehicular mortality of scrub-jays.

The strategies listed would help establish connectivity between the four Florida scrub-jay population concentrations on the refuge and between the populations on the refuge, Canaveral National Seashore, and Cape Canaveral Air Force Station.

- Determine vegetation types suitable for corridors through research.
- Keep abandoned groves in corridor areas in an open condition by using fire, mechanical treatment, and other suitable means.
- Discourage KSC from building additional structures in corridors.
- Encourage KSC to properly manage corridors on non-refuge lands.

Wildlife and Habitat Management Objective 1.a(2): Continue to annually provide 11,000 to 13,000 acres of oak scrub/scrubby flatwoods in optimal condition to support Florida scrub-jay recovery efforts.

Strategies for Wildlife and Habitat Management Objective 1.a(2) are described.

Strategies that would determine and implement methods of creating suitable persistent openings needed to achieve optimal Florida scrub-jay habitat in the refuge's oak scrub and scrubby flatwoods vegetation are described.

- Initiate research to assess the suitability of using herbicides and/or mechanical methods, along with fire, to create persistent openings.
- In conjunction with the above strategy, determine the suitable size, shape, and spatial distribution of scrub openings.
- Coordinate with Dynamac, Archbold Biological Station, and other partners on research and information exchange.

Strategies designed to improve the application of fire in the maintenance and restoration of Florida scrub-jay habitat are listed.

- Determine the need for burning based on the condition of scrub habitat, rather than using a time rotation.
- Determine what live fuel moisture ranges are the best for burning oak scrub.
- Improve firing techniques to provide for sufficient unburned scrub in each jay territory when prescribed fire is used.

Strategies that would improve monitoring prescribed fire to determine its effectiveness are as listed.

- Use fire effects funding to establish a viable program of first order (vegetative responses) fire effects monitoring.
- Establish a monitoring program on secondary effects (wildlife populations and movement) using non-fire funding.

Strategies to maintain and improve the quality of the scrub component of the shrubland landscape are described.

- Maintain, as a priority, existing good quality scrub habitat through the judicious use of fire and other management actions.
- Restore remaining overgrown oak scrub and scrubby flatwoods through mechanical treatment and prescribed burning. Emphasize those areas that are adjacent to areas already occupied by scrub-jays.
- Restore once grassy swales in the oak scrub/scrubby flatwoods matrix to their original condition. Emphasize those areas where other species of concern, such as Henslow's sparrow (*Ammodramus henslowii*) and Curtiss' reedgrass (*Calamovilfa curtissii*), exist.

Strategies that would address vegetative barriers to scrub-jay movements are listed.

- Prevent and control rank stands of cabbage palm growth in upland habitats through the use of fire combined with chemical and mechanical treatments.
- Remove woody overgrowth in the ridge-trough swales through mechanical and chemical treatments.
- Reduce overgrown edges along fire lines, roads, and other rights-of-way through mechanical treatment, chemical treatment, and fire application.

Strategies that use timber management to improve shrubland habitat are included.

- Emphasize scrub-jay management in scrubby flatwoods areas.
- Reduce the density and extent of forests to more historic proportions.

2. Migratory Birds

WILDLIFE AND HABITAT MANAGEMENT GOAL 2: Maintain and actively manage refuge coastal barrier island wetlands and uplands primarily to contribute to migratory bird priorities of the refuge and peninsular Florida physiographic area, while providing consistency with regional and national goals.

The objective associated with this goal is general in nature, and does not specifically address any shrubland habitat management concerns. However, there are several neotropical migrant species that utilize the scrub lands/swale landscape. Once the habitat requirements for these species become better defined, scrub land management activities must be reviewed to make sure that they are compatible.

2.e. Neotropical Migratory Birds

Wildlife and Habitat Management Objective 2.e(1): Within 5 years of plan approval, initiate research to determine usage and habitat requirements of neotropical migratory birds on the refuge.

Strategies for Wildlife and Habitat Management Objective 2.e(1) are listed.

Strategies that would improve the baseline knowledge of neotropical migratory birds use in refuge habitats are listed.

- Encourage research projects that would determine migratory bird use in shrub lands, pine lands, and hammock areas of the refuge.
- Continue present breeding bird surveys.
- Develop additional volunteer programs for surveying neotropical migrants on the refuge

and on adjacent conservation lands.
- Determine the role of Merritt Island NWR in the conservation of neotropical migrants within the overall landscape as related to other local conservation areas. This role should also be linked to efforts of the North Florida Ecosystem and any applicable management plans at the regional and national levels.
- Protect habitats that are known to be important to migratory birds, such as coastal scrub and hardwood hammocks.

Strategies that would focus management considerations on Florida Priority Bird Species (Hunter 1999) are included.

- Promote the diversity of native species and community structure to provide appropriate food and cover. Examples would include promoting native species, such as palmetto, that provide fleshy fruits.
- Monitor mesic hammocks to determine their condition. Develop management techniques to ensure their continued health and survival.
- Restore abandoned citrus groves to native habitat, where applicable. Use soil types and adjacent vegetation to help determine which native species should be planted.
- Promote grassy-herbaceous ground cover through the use of prescribed fire techniques in numerous wetland swale/trough habitats and document the techniques and results (e.g., for wintering Henslow's sparrows).
- In fire maintained vegetative types, use prescribed fire to mimic the natural role of fire in the ecosystem. This would include timing fires to promote flowering and fruiting of native species and using fire to manipulate vegetative structure.

4. Wildlife & Habitat Diversity
WILDLIFE AND HABITAT MANAGEMENT GOAL 4: Protect, manage, and enhance the natural diversity of fish, wildlife, and habitats and the important landscapes of the refuge's coastal barrier island system to ensure that refuge fish and wildlife populations remain naturally self sustaining.

Again, the objective under this goal that would relate to shrubland management is general in nature. However, maintaining the diversity of habitats and sustaining wildlife populations would be directly impacted by shrubland management actions.

4.f. Upland Habitat Diversity
Wildlife and Habitat Management Objective 4.f(1): Within the 15-year life of the plan, determine the appropriate matrix of upland vegetative communities necessary to support native wildlife diversity.

Strategies for Wildlife and Habitat Management Objective 4.f(1) are listed.

Strategies that would improve baseline knowledge of resident species use of refuge habitats are listed.

- Encourage research projects that would determine wildlife use in shrub lands, pine lands, and hammock areas of the refuge.
- Develop volunteer programs for surveying resident wildlife on the refuge and on adjacent conservation lands.
- Determine habitat needs of resident species of high interest.

Strategies that would promote the use of prescribed burning to keep fire as a viable ecosystem force are listed.

- In fire maintained vegetative types, use prescribed fire to mimic the natural role of fire in the ecosystem. This would include timing fires to promote flowering and fruiting of native species and using fire to manipulate vegetative structure.
- Promote grassy-herbaceous ground cover through the use of prescribed fire techniques in numerous wetland swale/trough habitats and document the techniques and results.
- Work toward using more growing season burns to mimic the natural role of fire in the landscape.
- Develop prescribed fire plans and use firing techniques that result in a mosaic of burned and unburned vegetation.

Strategies that would help direct management towards re-creating the more open landscape, as evidenced by 1940s aerial photography and research on historic landscape characteristics, are listed.

- Use timber management to develop a wide range of stand densities and age classes.
- Use mechanical and chemical means to reduce hardwood hammocks to historic sizes and extents.

4.h. Citrus Groves

Wildlife and Habitat Management Objective 4.h(2): Within the 15-year life of the CCP: restore 200 targeted acres of abandoned citrus groves to native habitat: 120 acres for Florida scrub-jay habitat on sand ridge sites and 80 acres for neotropical migratory birds in the more mesic areas.

This objective relates specifically to shrubland management. The restoration of old citrus groves on sandy soils would create additional scrub habitat for the Florida scrub-jay.

Strategies for Wildlife and Habitat Management Objective 4.h(2) are listed.

- Initiate a pilot study to accurately determine the cost of restoring abandoned citrus groves to native habitat.
- Select specific groves to be maintained in an open grass condition to provide corridors for jays and adjacent foraging areas for painted buntings along soft edge habitat.
- Develop interim annual management plans for groves to include burn cycles and mechanical manipulation. Include cabbage palm (*Sable palmetto*) removal, mowing, burning, exotic species control, and citrus tree removal as part of the planning process.
- Use soil maps, old aerial photography, and hydrological studies to determine historical vegetation on grove sites.

Figure 7: Location of Upland Shrub Vegetation

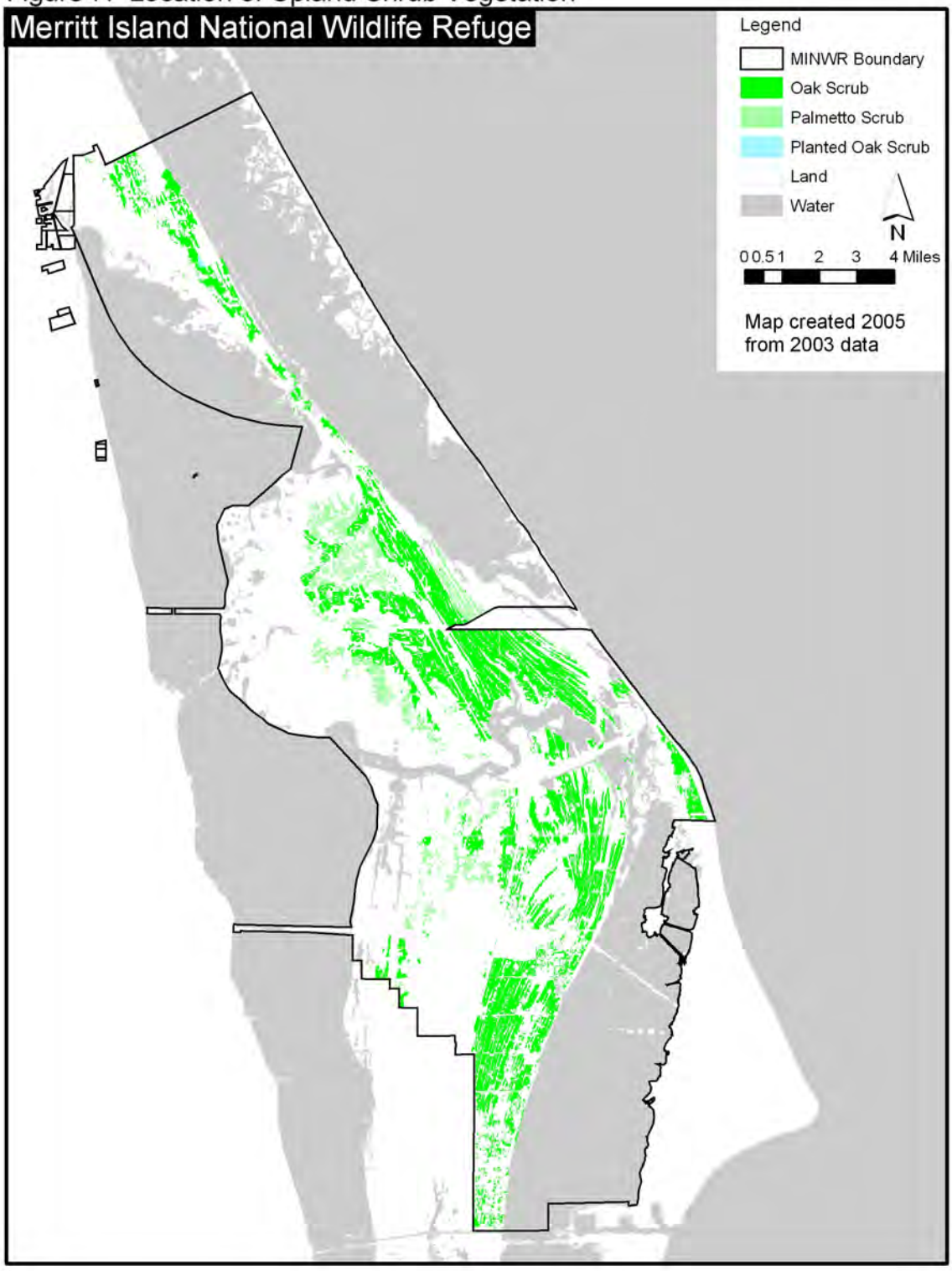
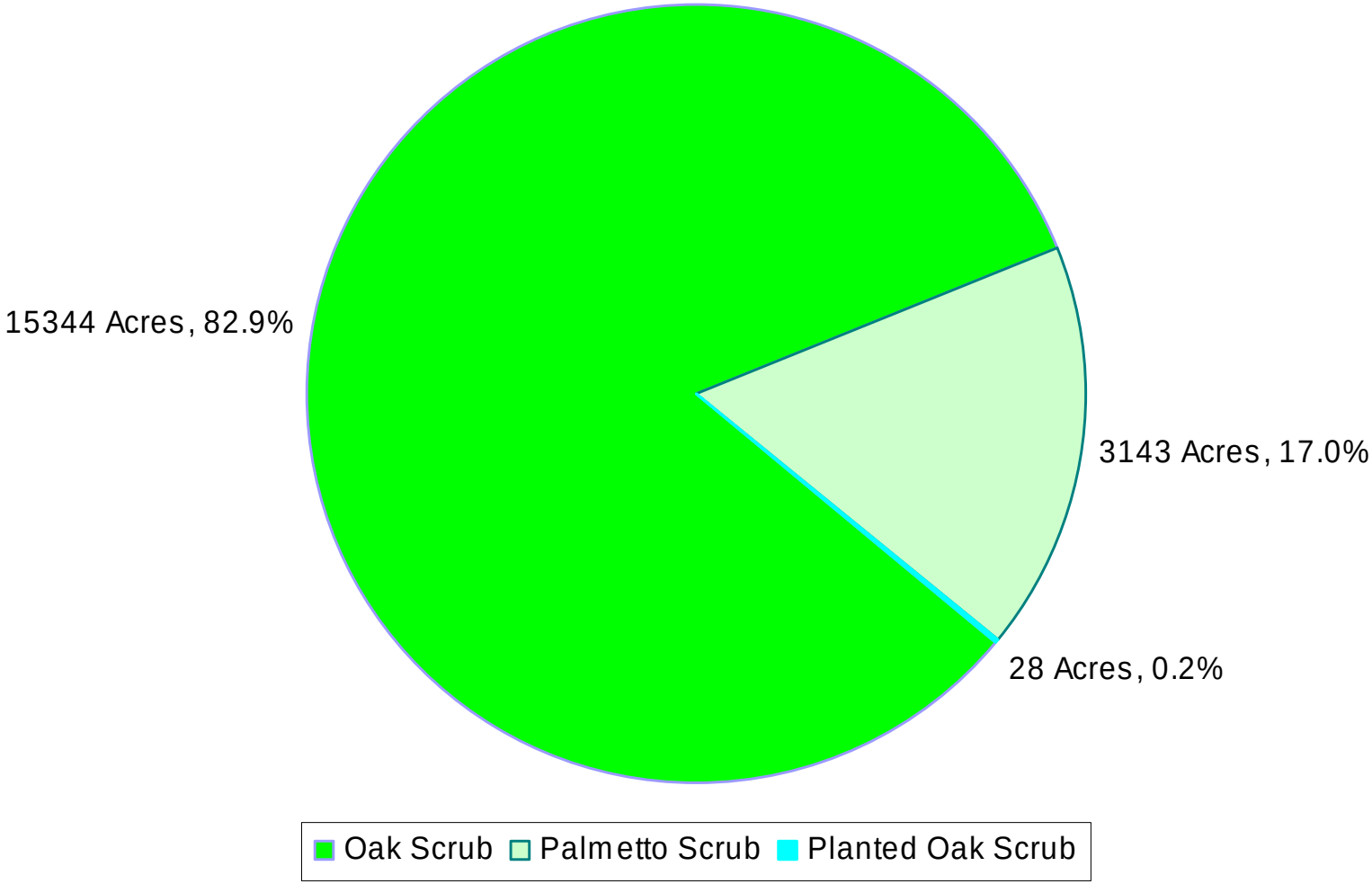


Figure 8: Upland Shrubland Distribution



B. DESCRIPTION OF THE RESOURCE

The National Vegetation Classification Standard (Federal Geographic Data Committee 1997) defines shrublands as having shrubs greater than 0.5 meters tall, generally covering more than 25% of the area. Trees can be present, but generally shrublands have less than 25% coverage of trees. The shrublands of the refuge must be considered as they relate to the overall landscape. The natural shrublands found on the refuge include what is locally know as palmetto flatwoods, along with several types of vegetation dominated by scrub oaks, commonly known as scrub. Patches of forest and woodland are also associated with the shrublands. Mixed in with these upland communities are freshwater swales. Figure 7 shows the location of shrublands on the refuge, while Figure 8 gives the proportion of each sub-type of shrub vegetation.

The landscape has changed dramatically over the years (Duncan et al 1999). Aerial photography from the 1940s shows that this landscape was much more open than it is now. Openings consisting of sand and some herbaceous vegetation were common throughout most of the oak scrub areas. The coverage of pine woodlands in both the scrub and palmetto areas was scattered and open. Although stands of hardwoods existed throughout the refuge, most were small in area. The swales associated with the shrublands were grassy, with few woody species present. Although some roads were present, they were narrow and few and far between.

The open nature of the landscape and the lack of natural and human made barriers, along with the flammability of several of the vegetative communities suggest that fire played an important role in the maintenance of the landscape. Duncan and Schmalzer (2004) showed that with little human alteration to the landscape, naturally ignited fires in the 1920s and 1940s would have spread extensively. Present day observations of fires in the shrubland areas would lead us to believe that many of these fires would have been very intense (Adrian, personal observation).

Time, however, has changed the scene. Although some alteration of the landscape for agricultural and residential uses occurred in the 1940s and 1950s, the acquisition of the land by NASA for the Kennedy Space Center dramatically increased the amount of human activity on and around the refuge. One of the most important changes is the role of wildland fire in the ecosystem. The use of fire by humans, common for most of the time prior to the 1950s, was essentially stopped when KSC was developed. The spread of naturally ignited fires was inhibited by the increased number of roads and other infrastructure. In addition, wildfires were usually suppressed as quickly as possible.

Human alteration of the landscape was not limited to the removal of fire as an ecosystem force. The natural hydrological patterns were altered by the construction of ditches and canals for both agriculture and development. The construction of roads, buildings, rights-of-way, and other infrastructure necessary for the space program fragmented once large continuous expanses of shrubland vegetation. Ruderal areas, lands once cleared and then abandoned, not only increased fragmentation, but have enhanced the spread of exotic plants.

All of this activity, or the lack of it in the case of fire use, resulted in major changes in the vegetation. With the exclusion of fire, the shrub layer in both the flatwoods and oak scrub became denser. The sandy openings once common in the shrubland landscape disappeared. Forests and woodlands increased in both size and density. Many of the once grassy swales became overgrown with brush and trees.

Over the last two decades, refuge management activities have been directed towards addressing some of the changes in the shrublands. A fuels reduction prescribed burning program was begun in 1981, prompted by a severe wildfire season in which two refuge employees were killed during fire suppression actions. Prescribed burning of large units of the refuge continued until the early 1990s. At that time the focus of prescribed burning program shifted. Although fuels management was still a priority in the burning program, more emphasis was placed on using fire, along with other management techniques, to return the shrubland vegetation to a lower, more open configuration.

B-1: VEGETATIVE COMMUNITIES

Shrubland vegetative communities occur in both the flatwoods and sand ridge soil types. The shrub habitats form a continuum, grading into each other, so that divisions between them are somewhat arbitrary. Evidence shows that the observed differences in species and stand structure are the result of not only differences in soil conditions, but also burning frequency (Myers and Ewel 1990).

Oak Scrub and Scrubby Flatwoods: (QUERCUS GEMINATA-QUERCUS MYRTIFOLIA-SERENOA REPENS SHRUBLAND ALLIANCE; Quercus geminata -Quercus myrtifolia-serenoa repens Association): This community is found on the well drained soils of the Paola-Pomello-Astatula association, which are located on the higher ridges of the refuge. The vegetation consists of palmetto (*Serenoa repens*), sand live oak (*Quercus geminata*), myrtle oak (*Q. myrtifolia*), and Chapman's oak (Q*. chapmanii*) (Schmalzer and Hinkle 1992). As the elevation decreases towards palmetto, flatwoods, or swales, more mesic vegetation can be found. The species mix here would include gallberry (*Ilex glabra*) and various *Lyonia* species. This lower elevation species complex is also known as the scrubby flatwoods. Pines can be associated with both the true oak scrub and the scrubby flatwoods. Sand pine (*Pinus clausa*) is present on the drier sites, while south Florida slash pine (*P. elliottii* var. *densa*) is found in the scrubby flatwoods.

Fire is essential in maintaining both the vertical and horizontal structure of the oak scrub and scrubby flatwoods. Historically, fires ranged through oak scrub areas, keeping the oaks short. The stands were open in nature with numerous sandy openings. Pine stands, although always an important component of the landscape, were scattered and sparse. In the absence of fire during the 1960s and 1970s, the oaks and palmettos became tall dense thickets with no open areas. Pine stocking increased dramatically in some areas, effectively changing the landscape from shrubland to forest. Many of these overgrown oak scrub areas have been cut and burned over the past 15 years in an attempt to create a more natural landscape. In addition, pines densities have been reduced through commercial harvesting, burning, and mechanical treatment. Although much success has been experienced in recreating the vertical structure of oak scrub, persistent openings remain lacking in many areas.

Palmetto Scrub: (SERENOA REPENS-ILEX GLABRA-LYONIA SPP. SHRUBLAND ALLIANCE; Serenoa repens-Ilex glabra-Lyonia sp. Association): The palmetto scrub occurs on the soils of the Myakka-Eau Gallie-Immokalee association. The majority of the vegetation is palmetto, gallberry, wax myrtle (*Myrica cerifera*), and several species of *Lyonia*. In many instances, this type is found in close association with the oak scrub. No real definitive break occurs between these two types, but rather it is a gradual progression from one to the other. As

the elevation on the land rises, scrub oaks can be found mixed in with the palmetto scrub vegetation.

Planted Oak Scrub: (QUERCUS GEMINATA-QUERCUS MYRTIFOLIA-SERENOA REPENS SHRUBLAND ALLIANCE; Quercus geminata -Quercus myrtifolia-Serenoa repens Association): An attempt to restore a 10-acre abandoned citrus grove near WSEG Road in the Shiloh Scrub Reserve Unit was conducted in 1992. Prior to planting, old citrus trees were removed and an attempt was made to control exotic grasses on the site. Sand live oak, myrtle oak, and Chapman oak were planted at a stocking rate of 400 stems per acre in August of 1992. Additional oaks were planted in 1993, along with palmetto, rusty lyonia (*Lyonia fruticosa*), shiny blueberry (*Vaccinium myrsinites*), and south Florida slash pine. This effort was marginally successful.

B-2: FIRE ECOLOGY

Fire has been an important ecological factor in the development of the shrub landscape and is one of the primary tools utilized in its management. It is important, therefore, to understand the role fire plays in each of the subsets of shrubland vegetation. A short overview of the role of fire in the shrubland vegetation is provided. More detail on fire and its role in refuge ecosystems can be found the refuge's Fire Management Plan (Adrian 2003).

Palmetto Scrub: The fire regime in the palmetto flatwoods consists of moderately intense fires that occur every three to five years. Experience has shown that it takes from two to three years for the vegetation to recover enough to sustain any sort of successful prescribed burn, however, in periods of drought, it is possible that a one-year rough can support some fire. This vegetative community grows back quickly and by the time five years has passed sufficient fuel exists on the site to support catastrophic fires during periods of drought. After 10 years, fuel loads tend to remain constant, with decomposition approximately equaling accumulation.

Much of the shrub vegetation in the palmetto flatwoods is highly flammable and easily ignited. Species, such as saw palmetto, contain resins and oils that ease ignition and increase rates of spread. Head fires in this habitat can burn vigorously and backing fires also spread well, but with much lower intensity. Simulations have shown that prior to the development of the infrastructure of today, fires in the flatwoods burned large expanses if no suppression actions were taken (Duncan and Schmalzer 2004).

Scrubby Flatwoods: The addition of the scrub oaks to the vegetative mix makes the scrubby flatwoods slightly less flammable than the palmetto flatwoods, but it still ignites fairly easily. Fires in this type are hotter than those in the palmetto-gallberry flatwoods and 10 to 20-foot flames are not uncommon with head fires during normal years. In dry years, head fires can have flames of 30 feet or more, especially if the fuel loadings are high. Fires back well in the scrubby flatwoods, but may go out where there are thick stands of oaks. The natural fire interval in this type is probably between five and 10 years, only slightly longer than that of the palmetto flatwoods. Again, modeling indicates that without roads or other human made barriers, fires in the scrubby flatwoods would burn large acreages.

Oak Scrub: On the drier oak scrub sites, with the significantly less palmetto and less fertile soils, the fire interval is longer, perhaps eight to 12 years. In the natural system, fires often started in other, more flammable areas of the landscape, such as the swales and flatwoods, and

burned into the oak scrub. Therefore, scrub located in a more easily ignited vegetation matrix burned more often than stands surrounded by nonflammable vegetation (Myers 1990). This further complicates determining a realistic estimate of fire interval. Fire intensity in the oak scrub is high. Natural fires occurred under severe burning conditions, dry fuel conditions, and high winds. This resulted in a fire with 20 to 40-foot flames and rapid rates of spread.

B-3: OPTIMAL SCRUB

The goals in the Comprehensive Conservation Plan refer to having scrub in optimal condition. It should be recognized that optimal scrub is not a type of scrub per se, but rather it is a description of a landscape. The characterization of optimal scrub is based on what is thought to be the best landscape configuration for the Florida scrub-jay and is derived in a large part from work done by G. E. Woolfenden from the Archbold Biological Station and D.R. Breininger from the Dynamac Corporation, a biological contractor for KSC. The research of these and others indicates that the best habitat for scrub-jays has focal patches of oak scrub or scrubby flatwoods with the listed attributes (Breininger et al 1998):

- 10 to 50 percent of the oak scrub is bare sand or sparse herbaceous vegetation;
- The shrub layer is more than 50 percent scrub oaks;
- The oak scrub or scrubby flatwoods has a mosaic of scrub oaks that occur in optimal height of four to six feet or shorter;
- The area has less than 15 percent pine canopy closure; and
- The area is greater than 984 feet from a forest.

These focal patches exist in a matrix of palmetto and grassy swales. Palmetto areas and grassy marshes are not used by scrub-jays to any great extent (Breininger et al 1995). That is not to say that these non-scrub areas are not important. Fires, either natural or prescribed, necessary for the scrub ecosystem, often ignite in these more flammable vegetation types. In addition, they provide habitat for prey species for the scrub-jays and habitat for other species of conservation concern. The key to producing good scrub-jay habitat seems to be implementing management practices that produce a wide open vista. A more detailed description of optimal scrub will be available in the Service's Florida Scrub-jay Recovery Plan (currently in revision).

B-4: IMPORTANCE OF SHRUBLAND MANAGEMENT TO FLORIDA SCRUB-JAY RECOVERY

The matrix of shrublands on the refuge provides habitat for numerous species. Included is the threatened Florida scrub-jay. The four primary core recovery units (PCRU) are the only sites where it would be possible to support at least 400 breeding pairs of scrub-jays in perpetuity. The continued existence of all of the PCRUs is essential for the continued existence of the species when considering the possibility of deleterious events, such as environmental catastrophes, epidemics, and unpredictable demographic fluctuations. The Florida scrub-jay population on the refuge is part of the Merritt Island Primary Core Recovery Unit (MIPCRU) which also includes lands owned and/or managed by Cape Canaveral Air Force Station and Canaveral National Seashore.

Several unique elements are present on the refuge that would help increase the chances of a successful recovery effort. First, the refuge has an existing large population of scrub-jays. Second, portions of the sub-populations on the refuge have been studied for over 20 years as part of KSC's environmental monitoring program. This has resulted in a long term database

covering many aspects of scrub-jay biology. Third, even though the landscape has been fragmented by the construction associated with KSC, large tracts of relatively contiguous tracts of shrubland are still available. Properly managed, these can provide sufficient habitat for the long term survival of the species. Finally, the refuge has an ongoing program to manage and restore shrublands to improve and maintain jay habitat.

The survival of the Florida scrub-jay as a species depends on the continued existence of viable populations of jays in all of the PCRUs. It would follow, therefore, that the survival of scrub-jays on the refuge is linked to the survival of the jays in all regions of the refuge. Four areas of the refuge have extensive acreages of oak scrub and scrubby flatwoods. These are known as scrub reserve units (SRUs): Shiloh, Happy Creek, Swartz Road, and the Southern Woodlands (see Figure 9) (Breininger et al 1996). Together, these four landscapes total about 13,600 acres. This could provide for a scrub-jay population of between approximately 550 and 680 family groups, assuming that about 20 to 25 acres is needed for each territory. Analysis of edaphic conditions and historical aerial photography shows that the SRUs were once dominated by scrub with many openings, swales, and limited forests and woodlands. The northernmost SRU, Shiloh, was primarily well drained soils, while the others included patches of well drained soils mixed in with more poorly drained flatwoods soils.

Wildlife and Habitat Management Objective 1.a(1) of the CCP states, in part, that the refuge should maintain a population of between 500 and 650 family groups of Florida scrub-jays. The question needs to be asked: Is the refuge meeting this goal? The 2001 population estimate of Florida scrub-jays in the Merritt Island Primary Recovery Unit was 665 pairs. In that year, Cape Canaveral Air Force Station accounted for 114 family groups (Stevens and Knight 2003). This indicates that the number of jay groups on the refuge could be expected to be about 550. While this population meets the stated goals, it would be preferable to support as many jay families as the habitat would allow. Table 1 shows a little over 15,340 acres of oak scrub and scrubby flatwoods on the refuge. Using 23 acres per family group territory as an average territory size, one would estimate that 12,650 acres of scrubland is occupied, leaving approximately 2,700 acres of potential jay habitat unoccupied. It is likely that some of this habitat occurs in small isolated patches that are not large enough to sustain jays. However, some habitat is not occupied because it is in poor condition. Restoration, through techniques described later, would be required to attract jays to these areas.

The second part of Wildlife and Habitat Management Objective 1.a(1) states that between 350 and 500 of the jay territories be maintained in optimum condition, as defined above. Not all scrub-jay habitat can be in optimal condition at the same time. Management activities would, of necessity, remove some well managed territories from optimal status for a period of time. When vegetation is removed by fire or mechanical means, there are from one to two years where the vertical structure is too short to meet optimal conditions. On the other end of the management cycle, just prior to subsequent burning, there would be times when the vertical structure may well be too tall. In a well managed scrub landscape, approximately 70% of the scrub habitat would be optimal, while the other 30% is either recovering from or being prepared for treatment. Seventy percent of the scrub habitat shown in Table 1 would be 10,738 acres.

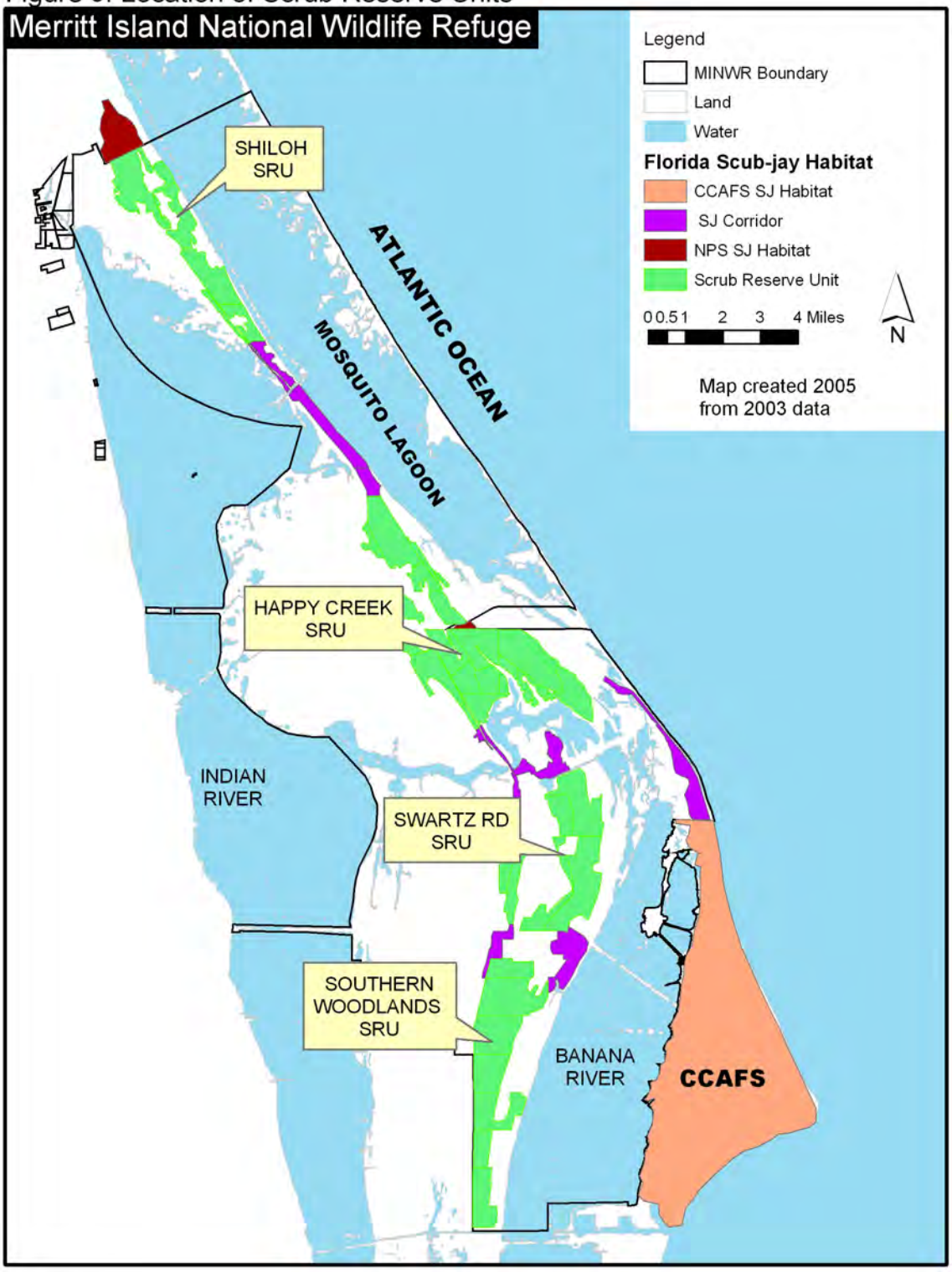
The maintenance and enhancement of the refuge's scrub-jay population would require action on several fronts. The first is to manage the shrubland areas that are in relatively good condition as previously discussed. Next are the places on the refuge where the shrubland landscape needs additional attention to get it into optimal condition. In some cases it is the patches of

scrub within the landscape that need treatment, such as stands of overgrown scrub that need mechanical treatment to bring the vertical structure into a suitable condition. Other patches of scrub are the correct height, but have insufficient openings. In this instance, methods of creating suitable open sandy areas must be developed. In other cases, visual barriers, such as woody vegetation in swales or tall brush along roads and fire lines, are present and must be removed to improve the quality of the habitat.

It would be necessary not only to restore and manage these specific patches of scrub, but also to restore the landscape in which these patches exist. This would require the transformation, as much as possible, of the landscape to the way it appeared prior to the impacts of urbanization and fragmentation. Aerial imagery, flown in 1943, is available to help target historic conditions. Since this time period is prior to the fire exclusion period and before most of the present infrastructure was constructed, the vegetative matrix represented by this photography has been selected as a target for the restored landscape. In many cases landscape restoration would require the removal of forests and woodlands that have encroached into the shrubland areas. It may be advisable to remove these wooded areas, but managers must also consider the impact on other resources of concern. Examples would be the removal of potential nesting sites for bald eagles in the pine flatwoods or the disruption of habitat for neotropical migrants in hardwood areas.

Two other factors need to be taken into account when planning where to concentrate restoration or landscape alteration efforts. First, since scrub-jays do not disperse over long distances, they are more likely to move into restored areas that are close to sites that are presently occupied. The other important landscape consideration in the management of shrublands for jays is the transfer of genetic material between sub-populations found in an area. Connectivity needs to be established and maintained between these areas. In addition to describing four scrub reserve units, Breininger et al (1996) also discussed possible linkages between them. While these linkage corridors may not meet the specific habitat requirements for the scrub-jay, the birds can cross them if the vegetation is low and open. On the other hand, if the vegetation consists of forests, jays would be less likely to traverse them in search of new territories. Likewise, infrastructure in the corridors would inhibit jay use and dispersal. The construction of additional roads and buildings in these corridors should be discouraged.

Figure 9: Location of Scrub Reserve Units



C. HABITAT MANAGEMENT TECHNIQUES

C-1: POTENTIAL MANAGEMENT TECHNIQUES

Prescribed Burning: As previously noted, the shrublands on the refuge are pyrogenic systems and require periodic fire for their continued existence. While the oak scrub and scrubby flatwoods require fire, they can be difficult to ignite. Historically, wide ranging, naturally ignited fires started in more flammable vegetation, such as marsh grasses and pine or palmetto flatwoods. These fires then burned into scrub areas. Today the presence of anthropologic features limits the spread of fires (Duncan and Schmalzer 2004). In addition, the presence of NASA facilities, the high visitation numbers to both the refuge and KSC, and the surrounding urbanization necessitate the immediate suppression actions be taken on unplanned wildland fire (Adrian 2003). For these reasons, it is necessary and prudent to use prescribed fire to manage scrub landscapes.

As with the natural fires, it is sometimes necessary to ignite the more flammable flatwoods and let the fire build up in intensity in order to burn the scrub areas. In other cases specialized ground ignition devices, such as the Terra Torch, can generate sufficient heat to ignite scrub directly. Due to the expanse of many of the refuge's burn units, aerial ignition is used on most burns at some point.

The height of scrub varies with time since the last fire, as one would expect. As previously mentioned, when managing the shrub landscape properly, not all of the patches of scrub oaks and scrubby flatwoods need to be, or can be, in optimal condition. Although tall scrub does hinder the jays' abilities to spot predators, small patches are acceptable in the landscape. On the other hand, recently burned, short scrub, while not providing nesting cover or mast, can still provide foraging opportunities. Scrub-jays have large territories, which is an adaptation to frequent fires in the landscape. The size of the territories increases the chance of any territory having sufficient optimal scrub in it at any one time (Breininger et al 1995).

Mechanical Treatment: Three general types of mechanical methods have been widely used for cutting scrub: rotary cutting, roller chopping, and shearing. Rotary cutters use heavy duty blades, usually attached to flywheels, that are either hydraulically or mechanically driven. These devices are usually attached to or part of rubber tired tractors. Roller choppers are steel drums of varying sizes with cutting blades mounted on them. The weight of the drum crushes the vegetation, while its rolling motion forces the blades into stems, cutting them up. Some experimentation has been done with rollers which are similar to the chopper, but lack the cutting blades. Choppers and rollers can be pulled with either tracked or rubber tired equipment. Shearing is typically done with V blades or KG blades. As its name suggests, the V blade is a triangular blade, usually with serrated cutting edges along both sides. The KG blade is an angled blade with a cutting edge along the bottom. Both are used to slice of the vegetation at ground level. Cutting blades are usually mounted on tracked equipment.

Other mechanical means of treating can vary widely. Occasionally, chainsaws have been used, but this is labor intensive and should only be used where more efficient methods are not suitable. Other mechanized equipment can include dozer blades and root rakes. These can be mounted on wheeled equipment, such as front end loaders, or tracked vehicles. Equipment designed to maintain power lines and other rights-of-way, such as the Gyro Track and the

Brontosaurus (a flail type cutting head mounted on a track hoe), have been used in various places to manipulate scrub and other brush and could proved useful in managing shrublands. Harrows and disks, pulled by farm type tractors would also have some possible applications in scrubland management.

Chemical Treatment: The use of herbicides has not been used extensively to manipulate scrub landscapes on the refuge. However the application of liquid or granular chemicals by trained personnel may well be an option in the future, especially where small openings need to be created in otherwise optimal scrub patches. Application rates can be at the level where vegetation is killed outright, or less concentrated applications can be used to slow growth rates.

Planting: The conversion of agricultural sites has been tried once on the refuge with limited success. A 10-acre abandoned citrus grove in the Shiloh SRU was selected for a scrub creation site as part of a scrub habitat compensation effort (Schmalzer et al 1994). Most of the citrus trees had been removed from the site in the middle 1980s, but some citrus did resprout from root stocks. In 1992, these citrus trees were removed along with most of the cabbage palms that were on the site. In addition, several herbicide applications were conducted in an attempt to eliminate exotic grasses and brush. Later that year, the site was mechanically planted with 1/0 seedlings of sand live oak, myrtle oak, and Chapman's oak. Planting density was about 400 stems/acre. In the summer of 1993, other scrub species, grown in one gallon pots, were planted, including saw palmetto, rusty lyonia (*Lyonia fruticosa*), shiny blueberry (*Vaccinium myrsinites*), and south Florida slash pine. Also in 1993 an additional 2,000 oaks were hand planted on the site.

This experiment was a marginal success at best. In 1999, the overall oak survival was less than 50%. Saw palmetto survived fairly well until a large portion was uprooted by feral hogs. The blueberries and *Lyonia* by 1999 were 25% and 50% respectively. In addition, the planted area did not resemble native scrub to any great extent. Many of the oak seedlings grew tall, instead of in the low bushy form that was desired. In addition exotic plants still occupied a large portion of the site and native vegetation was slow to fill in the area.

In spite of this, planting of scrub on the drier abandoned groves of the refuge is an important management alternative. Several possibilities exist for improving the overall results. First, the survival of the oaks may be enhanced by planting seedlings that have been grown in the nursery for two years. The larger seedlings would have a better chance of surviving. This especially true in the case of myrtle oaks whose 1/0 seedlings were very small. Burning of the site after several years may top kill the planted oaks causing them to resprout. This could help change them from a vertical form to a lower bushy structure. From the work done in Shiloh it is clear that stocking levels of all planted species needs to be increased. Obviously this would increase the coverage of desired species, but it may also cause the oaks to spread out. Finally, better pre-treatment of the site is needed to control exotic plants. Repeated applications of herbicide are needed, perhaps over two or more seasons to ensure that competition from exotics is reduced to an acceptable level

C-2: MANAGEMENT TECHNIQUE CONSTRAINTS

Prescribed Fire: Numerous constraints exist to using prescribed fire. These limitations are discussed in detail in the *Fire Management Plan for Merritt Island National Wildlife Refuge* (Adrian 2003). These constraints can be grouped into several categories: safety, of both

firefighters and the public; policy, including Department of Interior, Service, and refuge guidance; legal requirements, including State of Florida Division of Forestry burning regulations; smoke management; KSC operations and concerns; and last, but certainly not least, the resource objectives of the burn.

Policy can be gleaned from Department and Service manuals, along with other documents, such as the Service's *Fire Management Handbook* available on line at: http://www.fws.gov/fire/redbook/index.htm. State of Florida burning regulations are covered under Chapter 590, Florida Statutes.

Adrian (2003) describes the complexities of fire management on Kennedy Space Center in detail. The process of notifying NASA of planned burns and obtaining approval has evolved over the years to a workable, if somewhat cumbersome, process. The integrity of the notification system requires constant contact with NASA Shuttle Operations personnel, the Joint Base Operations Contract dispatcher, and the numerous payload managers. NASA is generally sensitive to the refuge's needs to burn, but sensitive payloads can shut down burning in large portions of the refuge for six or more months.

The remaining constraints are covered by fire management prescriptions which are discussed in Section C-5.

Mechanical Treatment: There are a few cautions when using mechanical treatments of scrub. One should be careful when using mechanical treatment for several reasons. All three methods of mechanical treatment with heavy equipment reduce the amount of saw palmetto on the site (Schmalzer et al 2003). Since palmetto is a major contributor to the flammability to the scrub vegetation mix, it is recommended that mechanical treatment be used only once on a broad scale. The use of repeated mechanical treatments of edges, as previously described has not yet proved to be a problem.

Additionally, when using mechanical treatment to modify the fuel bed, care should be taken to not over do it. The cutting or chopping should be just enough to alter the fuels to allow for burning under reasonable fire management prescriptions. Excessive cutting or chopping can cut fuels into very small particles and compress them, which would make burning difficult.

A third consideration when using mechanical treatment is the spread of exotic plants. Scarification of the soil provides good germination conditions for several exotic plants, most notably Brazilian pepper (*Schinus terebinthifolius*). Mechanically treated areas should be monitored carefully for the subsequent appearance of exotics and treatment of these should be immediate. Another problem is the transportation of exotics from one site to another. Equipment should be thoroughly cleaned after being used on a site where exotic plants occur.

Mechanical treatment should not be used by itself unless burning is absolutely impossible. This is true for several reasons. The first has to do with the changing flammability of cut vegetation. Immediately after mechanical treatment, and for several months thereafter, the flammability of the area is dramatically increased. The cut vegetation dries out quickly, and can be easily ignited accidentally. In addition, burning of cut scrub removed most of the biomass that is on the ground. This exposes bare soil which improves the suitability of the areas for jays and other scrub fauna. Burning also recycles nutrients stored in the cut vegetation in very short order. Finally, in many pryogenic ecosystems fire is important in the flowering and setting of seed in

many plants. Wire grass, which occurs in the palmetto flatwoods and scrubby flatwoods, is a well known example of this. In the shrub layer, palmetto seems to have better berry production in recently burned areas.

Finally, post treatment burns should be done in timely manner. As noted above, there is a dramatic increase in flammability on the site after cutting. On the other hand, cut vegetation deteriorates relatively quickly. Once these fuels have decomposed sufficiently, they absorb and hold moisture readily. Waiting longer than six to eight months after cutting to apply fire can result in a poor burn.

Chemical Treatment: The use of chemicals to manage scrub lands should be done with caution. The use of herbicides to control brushy species is commonplace, and, if the management decision is made to use them to control scrub vegetation, it would most assuredly work. However, one must remember that the vegetative community is one that provides habitat for a number of federally and state listed species. The application of herbicides should be done with this in mind and performed so that any adverse effect on these species is minimized. It should also be noted that the use of chemicals requires the development and approval of a Pesticide Use Proposal.

Planting: The constraints associated with planting scrub vegetation come down to site suitability and funding. The soil of the site should be investigated with some care. It is not advisable to expend time and money to plant scrub vegetation on soils that would not support them. Finally, managers must consider the resources required to restore these sites. The trial planting showed that restoration of scrub areas is expensive and somewhat risky.

C-3: IMPACTS TO RESOURCES OF CONCERN ASSOCIATED WITH THE IMPLEMENTATION OF PROPOSED MANAGEMENT TECHNIQUES

The scrub lands themselves have been recognized as a resource of concern. It is the purpose of the management techniques described herein to maintain, and hopefully improve, the scrub landscape. The foremost wildlife species of concern for scrub is the Florida scrub-jay. Again, the purpose of this plan is to improve the overall quality of the scrub-jay habitat to ensure the continued existence of this species at Merritt Island Refuge and to contribute to the overall survivability of the species statewide.

A species group of concern that uses the shrubland landscape is neotropical migrants. Depending on the individual species, management actions may be either beneficial or detrimental. The restoration of wet areas from hydric forests to grassy swales would obviously remove habitat for those species that require the forests, but create habitat for those whose needs include grass areas.

C-4: MANAGEMENT TECHNIQUE SELECTION

Prescribed Fire: One must consider the use of fire on two levels: whether to use it at all, and, if so, when to use it. In scrub management, the answer to the first question is straight forward. As noted above, scrub lands are pyrogenic. They evolved with fire, and, if fire is removed as a viable ecosystem force, the vegetative complex changes. When this happens, many of the fauna associated with scrub and scrubby flatwoods can no longer exist there. Many of the problems now faced when managing scrub lands can be traced back to this period of little fire.

Without periodic fire, the scrub became overgrown with heights of scrub oaks reaching 20 feet or more in places. In addition to this change in vertical structure, the horizontal structure changed as well. Sandy openings, once common in scrub land, became enclosed. These open areas are vital, not only to the Florida scrub-jay, but also to numerous other creatures that inhabited scrub lands. Much success has been experienced restoring the vertical structure of scrub by using fire. Although many areas of 15-foot and taller scrub still exist, large portions are closer to optimum heights than was the case in the early 1980s when prescribed burning began. On the other hand, 20 years of prescribed burning have not restored the horizontal structure of the scrub landscape to its previous open condition. The only area where more or less persistent openings have been created using fire is in the Shiloh area. Here, dense scrub was mechanically treated and the biomass piled prior to burning. The hot, long duration fires in these piles sterilized the soil to such an extent that the openings created have lasted for over seven years (Schmalzer and Adrian 2001). Unfortunately, the large amount of biomass needed for this technique would only be present when a scrub area is first restored. The only other examples of persistent openings in scrub are found in the TEL IV area. This was not the result of prescribed burning, but rather is the consequence of several intense wildfires during the past 20 years.

The answer to the second point, when to use fire, is more difficult to resolve. One must take into account the present structure and condition of the scrub unit that is under consideration for burning, along with various aspects of fire itself. The four elements of fire operations that need discussion here are the intensity of the fire, the frequency at which fire should be applied, seasonality and the juxtaposition, and relative flammability of vegetation types within the landscape. In addition, one must consider the objectives of the burn. In most cases, the objective of prescribed fire in scrub lands is the modification of vegetative structure to meet scrub-jay objectives.

Fire Intensity: Because scrub lands are difficult to ignite under natural scenarios, they often burned under hot, dry, windy conditions. This resulted in an intense, stand replacing fire. Although this type of fire can sometimes be used effectively to burn overgrown scrub, it can only be used infrequently. One reason is safety. High intensity head fires are difficult to control. Fires burned under these conditions can only be used in situations where there is a very non-flammable landscape on the down wind side of the burn area. The best example would be a large body of water, although in certain conditions non-fire vegetation types, such as mesic hammocks would suffice. Another reason that this type of fire should be used infrequently is that intense fires frequently do not leave unburned patches. It is likely that entire scrub-jay territories would be consumed, and this is not an ideal situation.

On the other end of the scale is a low intensity fire that burns a large portion of more flammable vegetation, such as flatwoods or swales, but only burns small portions of scrub. The difficulty here is that insufficient amounts of the scrub patches are burned. Repeated use of low intensity fires would result in much of the oak scrub and scrubby flatwoods becoming once again overgrown.

The third alternative is probably the most useful, but, unfortunately, is the hardest to accomplish. In this case, a fire is ignited that is intense enough to burn through portions of the landscape, but goes out after traveling several hundred feet into the scrub vegetation. This technique requires close attention to the details of weather, fuel conditions, and methods of ignition.

Fire Frequency: The second element that requires consideration is fire frequency. Recommended fire return intervals in scrub vary from five to 20 years, depending on which source is used. However, it is believed that the longer estimates of time between fires may be excessive for many of the scrubby flatwoods sites on the Atlantic Coast of Florida (U.S. Fish and Wildlife Service 2003). Adrian (2003) suggests that prescribed burning be considered on an interval of between four and seven years for scrub vegetation on the refuge. These intervals are good for planning purposes, but, in reality, scrub burning needs to be implemented as the result of field observations. Optimum jay habitat has been described as being between three and 10 feet in height. Therefore, when the vegetation in an area begins to approach six to eight feet in height, a burn should be planned soon.

Seasonality: The third element to take into account is the season of burn. Most of the natural lightning fires occur from late May through September. On the surface, it would seem therefore that summer burns would be the choice. However studies of shrub vegetation on the refuge have shown that, although there are some short term differences in post fire response of sprouting vegetation between winter and summer burns, after 12 to 18 months these differences disappear (Foster and Schmalzer 2003). The importance of seasonality may be more important with herbaceous plants. It is recognized that wire grass (*Aristida stricta*) flowers and sets seed more abundantly with growing season burns than when burned in the dormant season. There may well be other physiological responses of scrub vegetation related to fire seasonality that are not yet recognized. In light of this, it would be prudent to do as much burning as possible during the natural fire season.

Having said this, one must still be realistic. Managers must recognize that NASA operational concerns, potential smoke management problems, and various environmental factors can severely limit the number of available burn days. They must also be aware that the absence of fire in scrub vegetation would soon lead to the degradation of habitat. In order to apply sufficient fire to the landscape, the refuge has, in the past, burned throughout the year. This should continue with some stipulations. Exploit all burn opportunities that occur during the growing season. Where possible, burning in optimal or near optimal scrub should be avoided during jay nesting season. Care should also be taken during dry periods. Although all environmental prescription parameters can sometimes be met during periods of moderate dryness, one tends to get burns that consume the vast majority of the units. As previously mentioned, this can be tolerated from time to time, but should be used minimally.

Mechanical Treatment: There are situations where the use of fire alone is not sufficient to achieve scrub land management goals. The first of these is where an intense fire would be required to burn the scrub, but other considerations, such as the proximity to buildings, prevent the use of such a fire. In these instances, mechanical treatment can be used to modify the fuel to allow the use of more moderate weather conditions for prescribed burning.

A second example where mechanical treatment of vegetation would be useful is the treatment of edges. When prescribed burns are first ignited, the fire burns with low intensity for a short period of time. This is especially prevalent along the downwind side of the burn unit where backing fires are used to “black in” the fire line. Fuels on the surface of the ground are consumed, but the fire does not have sufficient intensity to consume shrubs until it has run 20 to 30 feet into the unit. This results in a narrow strip of tall vegetation along the fire line. This hedge presents a visual barrier, which is detrimental to scrub-jay activity. Mechanically treating

these hedge areas prior to burning not only removes them, but also provides a suitable fuel bed for black lining.

Finally, mechanical treatment shows potential in creating openings. Openings were a prominent feature in the scrub landscape, as evidenced by early aerial photography. As stated previously, repeated prescribed fires have not succeeded in reestablishing these openings. It is suspected that in order to have sufficient openings, the large amount of below ground biomass must be depleted. Since fire alone does not seem to be an satisfactory means of doing this, other techniques must be investigated. Removing vegetation with equipment is easy enough to do. The question to be asked is what area is need and what spacing is desirable? The answer to these questions must be determined through research. The ultimate test of the success of making openings would be their use by jays and other scrub animals.

Chemical Treatment: There are two situations where the use of herbicides would be useful in shrubland management. The first of these is to control exotics and other invasive plants. Mechanical treatments, and sometime even applications of fire, can result in invasive plants spreading to the site. This includes not only exotics, such as Brazilian pepper and *Melaleuca*, but also native plants, such as grape vines. Spot applications of herbicides would be an appropriate technique to control these plants.

An untried use of herbicides would be using them to create openings. The use of chemicals to kill small patches of vegetation in scrub patches would be potentially useful, but caution must be used. The system that is being managed has numerous listed species, and managers need to ensure that no long term effects on these species result from refuge management activities. As was discussed in the use of mechanical means to create openings, research needs to be conducted to determine the type and spacing of openings. Monitoring is also needed to assess any possible detrimental effects of herbicide applications.

Planting: Planting should only be used in cases where the natural vegetation has been removed from the site. The trial planting previously discussed, using an abandoned grove, is a good example. Other disturbed areas, such as old home sites, may be considered.

C-5: MANAGEMENT PRESCRIPTIONS

General Management Prescription Comments: The refuge has over 12,000 acres of scrub vegetation in the four scrub reserve units of the refuge: Within each of these areas are several prescribed fire burn units. Since fire is one of the primary tools used to manage the shrub landscape, the burn units have been the subset of the landscape used to delineate scrub conservancy activities. It would be difficult, and perhaps irresponsible, to described specific management prescriptions for this much territory in the Habitat Management Plan. Instead, a general process of deciding which potential management practices should be considered along with their possible timing and along with other policy and environmental considerations would be presented.

The end result of shrubland management is to provide habitat for the species that live there. It is assumed that if the habitat is in optimal condition for the Florida scrub-jay, then it would also be sufficient for the other wildlife species that are native to scrub areas. As noted in the description of optimal habitat, one must consider not only the patches of scrub themselves, but also the surrounding landscape. One of the impacts of this approach is that management in one

year in a specific burn unit would influence the management decisions for subsequent work planned in adjacent units. One should also keep in mind that shrubland management on the refuge has two approaches. In some areas of the refuge, restoration of scrub is needed. In the past, most restoration efforts have been directed towards mechanically treating areas where overgrown scrub vegetation exists to obtain vertical structure more in line with what is considered optimal. This has been done with excellent results on a considerable portion of the scrub lands. In many cases, however, the restoration process has not gone as far as is needed. Specifically, not much has been done to restore the horizontal structure of the landscape (i.e., the creation of the persistent open areas which are important components of optimal scrub habitat). On the other hand, where near optimal or optimal habitat conditions exist, the emphasis of management activities should be on maintaining, or perhaps making only minor modifications to the vegetation.

It is preferable that work be done each year in all four of the scrub reserve units. Likewise, annual activities should be planned in both the restoration of scrub and in the maintenance of previously managed areas. Annual surveys should be done for each of the SRUs. In these surveys, stands of scrub would be placed into either the restoration arena or into areas that may need maintenance management. Some of the specific considerations one might entertain when developing management prescriptions for those two alternative situations are detailed. An important note when developing shrubland management prescription is that in most cases fire would be a part of the management activities. If this is the case, then a Prescribed Fire Plan must also be developed for each planned burn. This increases the complexity of the management process.

Restoration Prescriptions: At the present time, most of the restoration of scrub lands done by the refuge is based on outside funding sources. The two sources of this funding have been Ecological Services (FWS) and NASA.

Obviously, dense, tall scrub should be targeted for restoration. This would usually involve cutting or roller chopping the scrub oaks and other woody vegetation, followed by the application of prescribed fire. The type of mechanical work depends in a large measure on the size of the scrub to be cut.

In scrub patches that are not overgrown, the horizontal structure must be considered. In some areas of the refuge, most notable in the TEL IV Scrub Reserve Unit, the amount of persistent openings seems to be sufficient. Unfortunately, this is not the case in most areas. Should openings be lacking, attempts to re-establish them should be considered.

Restoration of scrubland habitat would also include improving the openness of the overall landscape. In most cases this would involve manipulation of non-scrub vegetation. One of the most common deficiencies of the landscape is the presence of woody vegetation in the swales associated with scrub lands. The removal of brush and the restoration of native swale grasses in these areas should be considered. Another landscape feature that deserves attention when developing management prescriptions is the extent and density of forests. As noted previously, both mesic hammocks and pine woodlands have increased over the years. The thinning or removal of timber to approximate the coverage represented by 1940s aerial photography would be another possibility to be explored in annual prescriptions. A third consideration is the removal of hedges that are often found along roads. These present a visual barrier and should be removed by mechanical means.

Many restoration projects would require two prescriptions. The first covers the scrub chopping, timber removal, or other mechanical vegetation manipulation. The other would be a Prescribed Burn Plan to address the use of fire. Both of these may require a Section 7 Intra-Service Consultation.

Maintenance Prescriptions: In scrub land areas that are not are not overgrown nor impacted by encroachment of forests or brush areas, management activities should directed towards keeping the vegetation in near optimal condition. In most cases, this would involve the application of prescribed fire. The use of fire should be based on a field inventory, rather than on some assigned rotation. As a general rule, individual sites should be assessed two to three years after the last burn. By this time, vegetation would have recovered to the point where an evaluation can be made as to the timing of the next burn. Even in those areas where extensive restoration is not needed, there are still some landscape factors that must be considered. Foremost of these is the tendency for edges of burn units to develop a hedge effect. If present, this taller vegetation may well require mechanical treatment prior to burning.

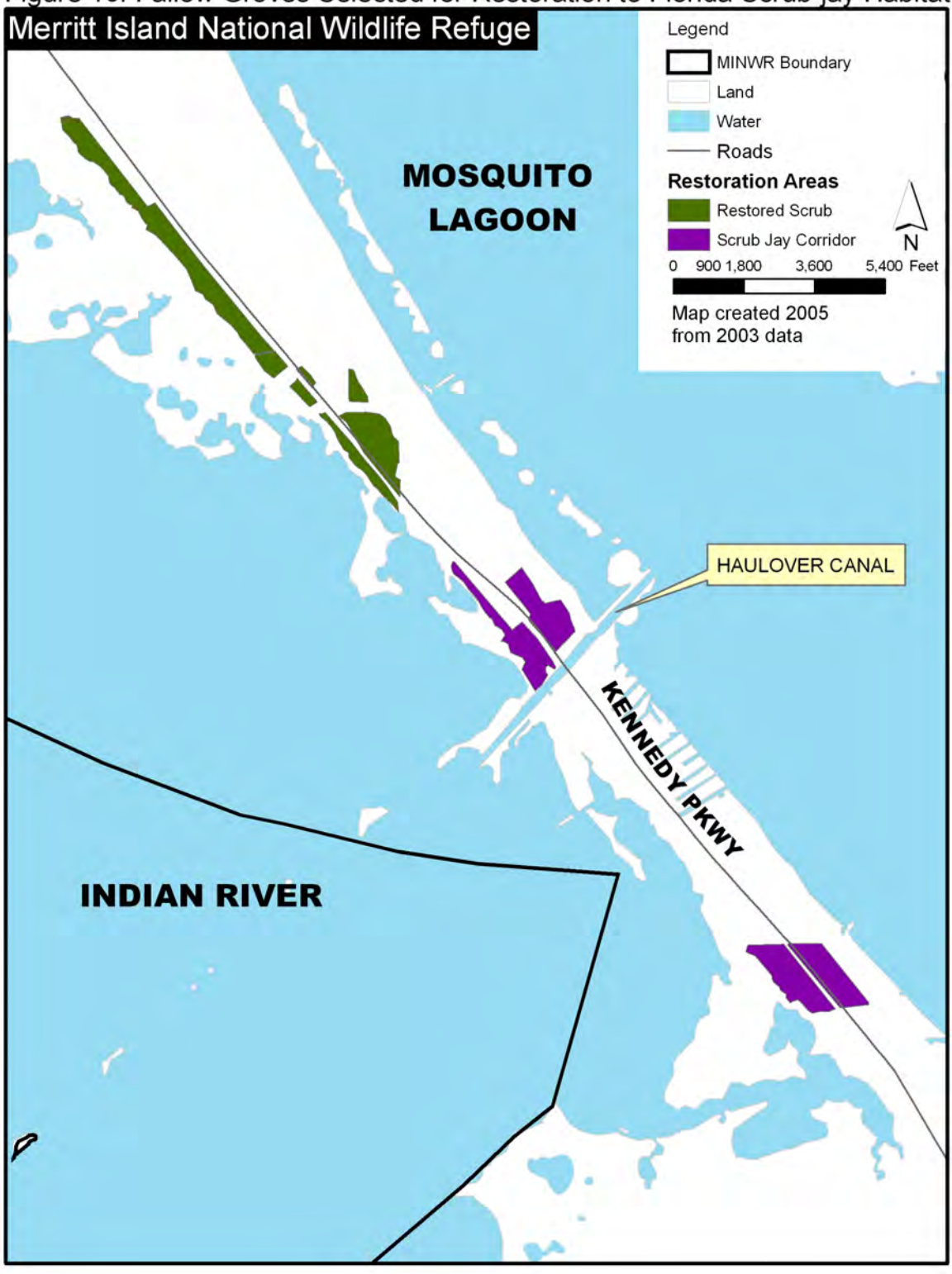
In areas utilized by scrub-jays, some consideration must be given to their territories when planning management activities. If possible, maps of territories should be developed. Since this may not be the case, the alternative is to ensure that fire prescriptions be written and executed to produce a mosaic burn. Jays need only a small patch, one to two acres out of a 20-acre territory, to maintain them until regrowth of the vegetation occurs. It is not advisable to attempt to exclude portions of territories from fire by establishing temporary fire lines.

Much of the maintenance of quality Florida scrub-jay habitat is done in conjunction with hazardous fuels reduction burns. There is a good correlation between the suitability of the scrub lands for the Florida scrub-jay and the degree of risk from hazardous fuels. As stated previously, jays do not do well when the vegetation reaches or exceeds eight to 10 feet in height. The probability of intense, rapidly spreading wildfires is also increased as fuel loadings reach this level.

Specific Management Projects: Several specific management projects have been identified, most involving the conversion of some other vegetation type the shrubland. The first of these is the restoration of several abandoned groves in the Shiloh Scrub Reserve Unit. These old groves are on the proper soils for scrub vegetation. They are also in close proximity to scrub landscapes that have been restored in the past decade. They have a reasonable chance of being colonized by scrub-jays (Figure 10).

The second project also involves old groves which are located just north of Haulover Canal (Figure 10). Rather than being completely restored to native vegetation, the groves in this venture would be altered to provide connectivity between the Shiloh Scrub Reserve Unit and the Happy Creek Scrub Reserve Unit to the south. The purpose here is to remove the citrus trees, most of the cabbage palms, and as many of the exotics as possible. Management of the area would then be directed towards keeping it in a mixture of shrubs and grasses. Although this would not provide nesting habitat for the scrub-jay, it would allow them to cross through the area to get from one SRU to the other.

Figure 10: Fallow Groves Selected for Restoration to Florida Scrub-jay Habitat



A restoration area, just south of Haulover Canal, is scheduled for completion in late 2005 or early 2006. This part of the refuge was once a canal lot residential development. There is a small area of scrub occupied by jays in the northwest corner of the unit. Scattered throughout the unit are other areas of overgrown scrub oak, some ruderal pine stands, exotics, and other assorted vegetation. Not all of this would be suitable for jay habitat, but all it can be converted to open shrubland. Fire would be used in the final stages of the restoration effort, and would be used subsequently to maintain the shrubland character of the site. This project would not only provide some additional scrub habitat, but would also help complete the corridor between the Shiloh and Happy Creek scrub reserve units.

D. MANAGEMENT DOCUMENTS

D-1: NECESSARY RESOURCES

One of the essential resources required to carry out an effective shrubland management program is personnel knowledgeable in the field of shrubland ecology and management. This is addressed in the Comprehensive Conservation Plan's staffing section with the addition of an upland Biologist, along with forestry technicians and biological science technicians. It is also essential that these positions have knowledge of fire ecology and the use of fire to manage the shrublands. It is also likely that timber removal required to restore some shrublands would be done through commercial harvesting. Other management activities, such as timber marking, chemical treatments, and planting could also be done by contracting with non-government sources. Expertise in developing these contracts and administering them would also be useful.

At the present time, the refuge has sufficient heavy equipment to accomplish most of the work that would be done force account. This would include roller chopping, shearing, and rotary cutting.

D-2: DOCUMENTATION OF SPECIAL USES

If timber removal is needed, and is to be done through commercial harvesting, it should be handled with a Special Use Permit as has been done in the past. Any research and monitoring related to shrublands management should also be under permit if they are conducted by non-refuge personnel. The permit can be used to track what information is being gathered, and can, through permit requirements, ensure that the refuge receives these data.

D-3: DOCUMENTATION OF COMPLIANCE

The Habitat Management Plan will go through the NEPA process as an appendix to the Comprehensive Conservation Plan. Therefore, no additional action of this nature would be required for forest and woodland management actions, unless major changes in management philosophy occur. However, specific prescriptions for activities, such as prescribed fires, timber removal, planting, and chemical treatments may be required. These prescriptions need to follow the policy and procedures in force at the time of their development, and be forwarded through the appropriate channels. Although not compliance per se, it is strongly recommended that all management activities are recorded in GIS for future reference. Prescriptions should also be reviewed under Section 7 (Intra-Service Consultation) of the Endangered Species Act.

CHAPTER V
FOREST & WOODLAND MANAGEMENT

A. HABITAT GOALS AND OBJECTIVES

Three goals, with subordinate objectives, listed in the Merritt Island National Wildlife Refuge Comprehensive Conservation Plan are applicable to forest and woodland management. The first addresses management of threatened and endangered species and the second addresses migratory birds, while the third concerns general wildlife and habitat diversity.

1. Rare, Threatened, and Endangered Species

WILDLIFE AND HABITAT MANAGEMENT GOAL 1: Preserve, protect, and enhance populations of rare, threatened, and endangered species of plants and animals at existing or increased levels on the refuge, and preserve, protect, manage, and restore their native east central Florida coastal and estuarine habitats occurring on the refuge to contribute to recovery goals.

Under this goal one objective pertains to forest and woodland management and concerns habitat for the bald eagle.

1.b. Bald Eagle - Flatwoods and Scrub Habitats

Wildlife and Habitat Management Objective 1.b(1): Annually maintain 11-15 successful nesting pairs of bald eagles on the refuge.

Strategies for Wildlife and Habitat Management Objective 1.b(1) are listed.

The strategy would allow managers to continue to monitor all known bald eagle nest sites on and within one-mile of the refuge on an annual basis to determine nest use and productivity.

- Continue to cooperate with the Florida Fish and Wildlife Conservation Commission (FWC) to monitor bald eagle nesting and to ensure that eagles have sufficient habitat for nesting. This may be dependent on funding for flights and may not be necessary every year.

Strategies that would address road mortality of eagles are listed.

- Educate KSC commuters and refuge visitors to be cautious when they see vultures along roads, since eagles may also be present.
- Remove road kills and decrease speeds.

Strategies that would protect existing eagle nest sites are listed.

- Continue to work with NASA Master Planning and NASA Environmental and with NASA's environmental contractor to reduce impacts on nest sites from human impacts. Incorporate federally recommended buffer zones.
- Provide man-made sites where appropriate (e.g., abandoned NASA towers and nesting platforms).
- Develop and implement burning techniques to protect nests and nest trees during prescribed fire operations.

- After sufficient fuels reduction, use growing season burns to eliminate conflicts with the eagle nesting season.

Strategies that would improve the availability of future eagle nest sites by using timber management would include the listed strategies.

- Develop stand maps of pine forests within 0.5 miles of existing and historic nest sites to determine the locations of suitable future nest areas.
- Develop natural regeneration areas within 0.5 miles of existing or historic nest sites using seed tree and/or shelterwood silvicultural methods to provide for future nest stands.
- Develop comprehensive thinning programs to manipulate existing stands within 0.5 miles of existing and historical nest sites. Favor potential nest trees during timber thinning operations.
- Provide foraging areas and perch sites for refuge's nesting eagles and for those eagles nesting on adjacent lands, but also using the refuge.
- Use commercial harvesting to maintain proper stand densities of mature trees in and around existing and historical eagle nest sites.
- Use harvesting, other mechanical removal, and chemical treatments for timber stand improvement activities to ensure health of intermediate age pine stands.
- Manage pine forests to provide 20 mature (50+ years old) stands of pine of proper density for future nest sites.

2. Migratory Birds

WILDLIFE AND HABITAT MANAGEMENT GOAL 2: Maintain and actively manage refuge coastal barrier island wetlands and uplands primarily to contribute to migratory bird priorities of the refuge and peninsular Florida physiographic area, while providing consistency with regional and national goals.

The objective associated with this goal is general in nature, and does not specifically address any forest and woodland concerns. However, several neotropical migrant species utilize the forest and woodlands landscape. Once the habitat requirements for these species become better defined, forest management activities must be reviewed to make sure that they are compatible.

2.e. Neotropical Migratory Birds

Wildlife and Habitat Management Objective 2.e(1): Within 5 years of plan approval, initiate research to determine usage and habitat requirements of neotropical migratory birds on the refuge.

Strategies for Habitat Management Objective 2.e(1) that would improve baseline knowledge of neotropical use in refuge habitats are listed.

- Encourage research projects that would determine neotropical migrant use in pine lands and hammock areas of the refuge.
- Develop additional volunteer programs to determine neotropical migrant use on the refuge and on adjacent conservation lands.
- Determine the role of Merritt Island NWR in the conservation of neotropical migrants within the overall landscape as related to other local conservation areas. This role should also be linked to efforts of the North Florida Ecosystem and any applicable

management plans at the regional and national levels.

Strategies that involve coordination with NASA to improve conditions for neotropical migratory birds are listed.

- Continue to work with NASA to identify threats or conflicts.
- Educate NASA employees to the potential impacts of their activities on neotropical migrants and recommend alternative actions as needed.

Strategies that would help protect and enhance existing neotropical migratory bird habitat are listed.

- Protect habitats that are known to be important to migratory birds, such as coastal scrub and mesic hardwood hammocks.
- Focus management considerations on Florida Priority Bird Species (Hunter 1999).
- Monitor condition of mesic hardwood hammocks. Develop management techniques to ensure their continued health and survival as necessary.

Strategies that would maintain and increase diversity of habitats are listed.

- Promote diversity of native species and community structure to provide appropriate food and cover. Examples would include promoting native species, such as palmetto, that provide fleshy fruits.
- Restore abandoned citrus groves to native habitat where applicable. Use soil types and adjacent vegetation to help determine which native species should be planted.
- Promote grassy-herbaceous ground cover through the use of prescribed fire techniques in numerous wetland swale/trough habitats and document techniques and results (e.g., for wintering Henslow's sparrows).
- In fire maintained vegetative types, use prescribed fire to mimic the natural role of fire in the ecosystem. This would include timing fires to promote the flowering and fruiting of native species and using fire to manipulate vegetative structure.

4. Wildlife & Habitat Diversity

WILDLIFE POPULATION AND HABITAT MANAGEMENT GOAL 4: Protect, manage, and enhance the natural diversity of fish, wildlife, and habitats and the important landscapes of the refuge's coastal barrier island system to ensure that refuge fish and wildlife populations remain naturally self sustaining.

Again, the objective that would relate to forest and woodland management is general in nature. However, maintaining the diversity of habitats and sustaining wildlife populations would be directly impacted by forest management actions.

4.f. Upland Habitat Diversity

Wildlife and Habitat Management Objective 4.f(1): Within the 15-year life of the plan, determine the appropriate matrix of upland vegetative communities necessary to support native wildlife diversity.

Strategies for Wildlife and Habitat Management Objective 4.f(1) that would improve baseline knowledge of resident species' use of refuge habitats include those listed.

- Encourage research projects that would determine wildlife use in shrub lands, pine lands, and hammock areas of the refuge.

- Develop volunteer programs for surveying resident wildlife on the refuge and on adjacent conservation lands.
- Determine habitat needs of resident species of high interest.

Strategies designed to use prescribed burning to keep fire as a viable ecosystem force are listed.

- In fire maintained vegetative types, use prescribed fire to mimic the natural role of fire in the ecosystem. This would include timing fires to promote the flowering and fruiting of native species and using fire to manipulate vegetative structure.
- Promote grassy-herbaceous ground cover through the use of prescribed fire techniques in numerous wetland swale/trough habitats and document techniques and results.
- Work toward more growing season burns to mimic the natural role of fire.
- Develop prescribed fire plans and use firing techniques that result in a mosaic of burned and unburned vegetation.

Strategies that would direct management towards re-creating the more open landscape shown on 1940s aerial photography are listed.

- Use timber management to develop a wide range of stand densities and age classes.
- Use mechanical and chemical means to reduce hardwood hammocks to historical size and extent.

Figure 11: Location of Forest and Woodland Vegetation

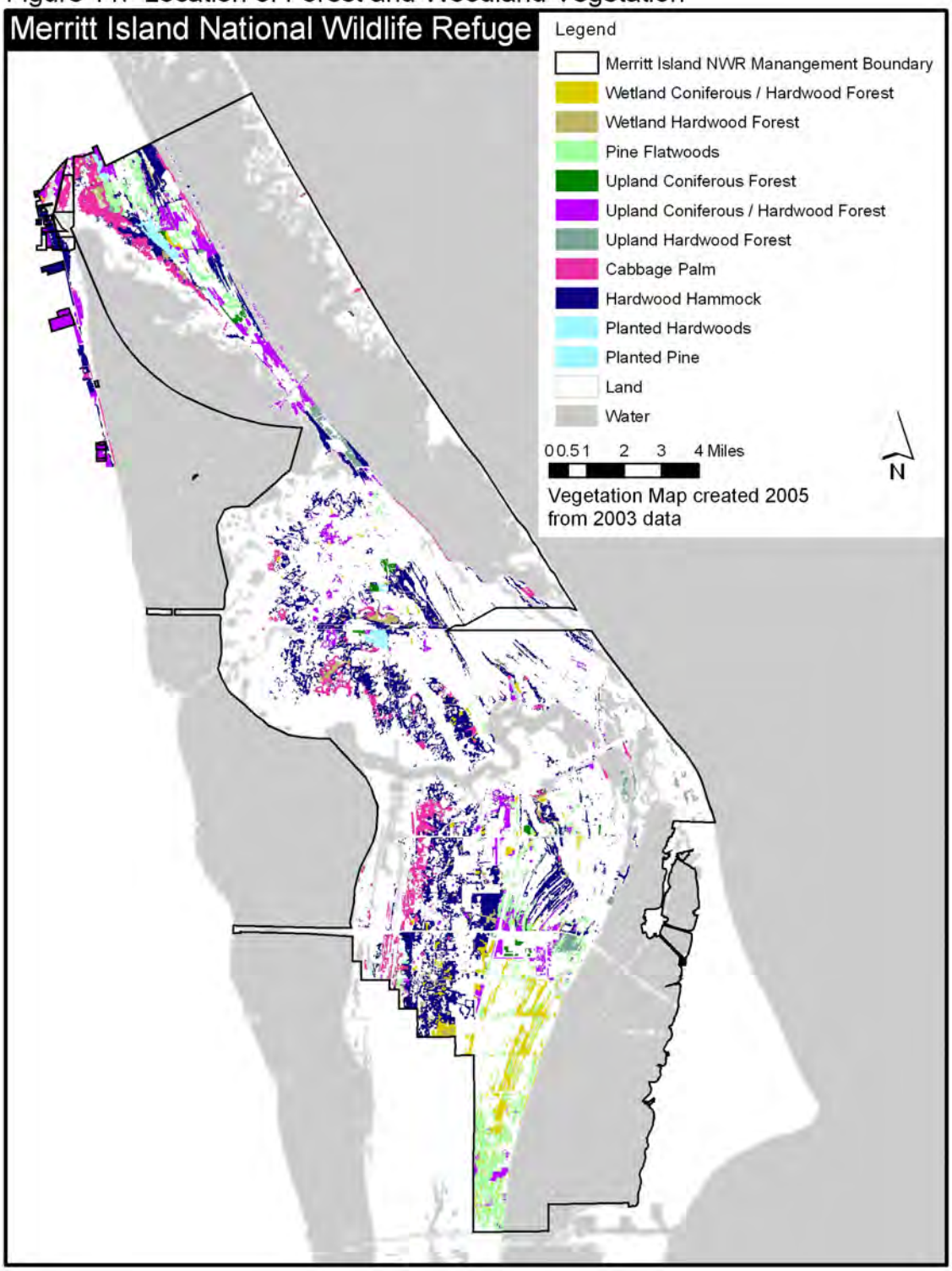
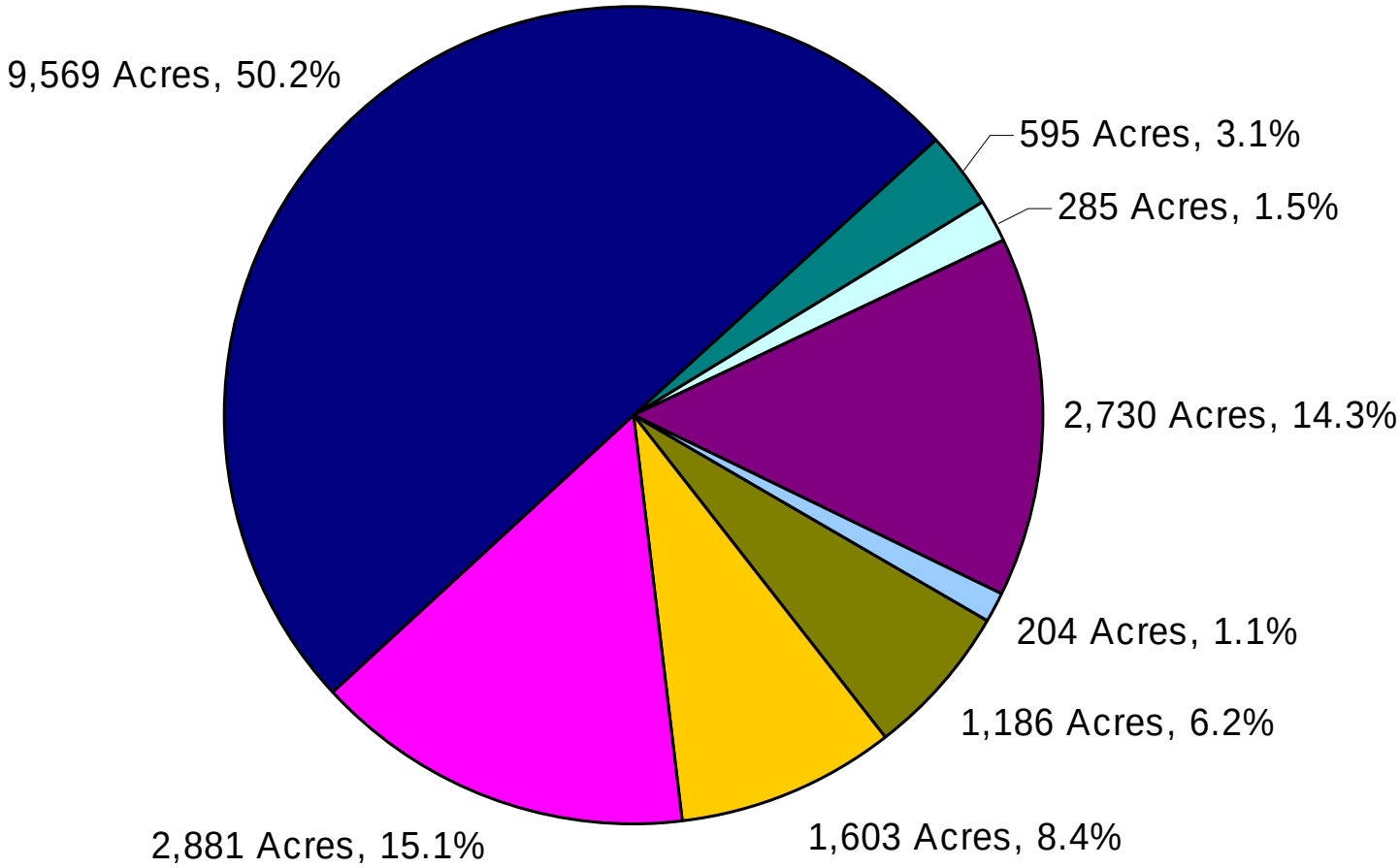


Figure 12: Forest and Woodland Distribution



B. DESCRIPTION OF THE RESOURCE

The U.S. National Vegetation Classification Standard (Federal Geographic Data Committee 1997) defines forests as areas where tree crowns overlap and crown coverage is generally between 60% and 100%. Woodlands on the other hand are open stands of trees where the crowns usually do not touch and crown closure is between 25% and 60%. The refuge has numerous vegetative communities that would meet these two definitions. For ease of discussion, and because most management activities would be the same for both, the term forests would be used when describing the refuge's timbered areas. Figure 11 shows the location of forest and woodland vegetation of the refuge, while Figure 12 gives the proportion of the various sub-types.

Forested areas of the refuge are found on sites that range from the dry sand ridges to wet low areas and include both pine and hardwood species. All of these forested areas, which are discussed in detail, exist in a landscape matrix. In its natural state, this landscape historically included the forest along with freshwater upland swales and saltwater and freshwater marshes. This landscape has been changed over the years (Duncan and Schmalzer 2004). Aerial photography from the 1940s shows that this landscape was much more open than it is now. The coverage of pine forests was scattered and open. Although stands of hardwoods existed throughout the refuge, most were small in area. The swales associated with the shrublands were grassy, with few woody species present. Although some roads were present, they were narrow and few and far between.

The open nature of the landscape and the lack of natural and human made barriers, along with the flammability of several of the vegetative communities suggest that fire played an important role in the maintenance of the landscape. Duncan and Schmalzer (2004) showed that with little human alteration to the landscape, naturally ignited fires in the 1920s and 1940s would have spread extensively. Present day observations of fires in the shrubland areas would lead us to believe that many of these fires would have been very intense (Adrian 2003).

Time, however, has changed the scene. Although some alteration of the landscape for farming and residential uses occurred in the 1940s and 1950s, the acquisition of the land by NASA for the Kennedy Space Center dramatically increased the amount of human activity on the refuge. One of the most important changes is the role of wildland fire in the ecosystem. The use of fire by humans, common for most of the time prior to the 1950s, was essentially stopped when KSC was developed. The spread of naturally ignited fires was inhibited by the increased number of roads and other infrastructure. In addition, wildfires were usually suppressed as quickly as possible due to the sensitive nature of space exploration activities.

Human alteration of the landscape was not limited to the removal of fire as an ecosystem force. The construction of roads, buildings, rights-of-way, and other infrastructure necessary for the space program fragmented once large continuous expanses of shrubland vegetation. Ditches constructed to provide drainage for agricultural endeavors, home sites, and more recently for the development of KSC infrastructure altered the natural hydrology of the areas. Ruderal areas, lands once cleared and then abandoned, not only increased fragmentation, but enhanced the spread of exotic plants.

All of this activity, or the lack of it in the case of fire use, resulted in major changes in the vegetation. With the exclusion of fire, the shrub layer in both the flatwoods became more dense

and taller. Forests and woodlands increased in both size and density. Many of the swales moved from wet grassland communities to hydric forests populated by maples and willows.

Over the last two decades, refuge management activities have been directed towards addressing some of the changes in the landscape. A fuels reduction prescribed burning program was begun in 1981, prompted by a severe wildfire season in which two refuge employees were killed during fire suppression actions. Prescribed burning of large units of the refuge continued until the early 1990s. At that time the focus of prescribed burning shifted. Although fuels management was still a priority in the burning program, more emphasis was placed on using fire as an ecological force in the ecosystem.

B-1: VEGETATIVE COMMUNITIES

Wetland Hardwood Forests and Woodlands

*Wetland Hardwood Forest***;** (ACER RUBRUM-ULMUS AMERICANA SEASONALLY FLOODED FOREST ALLIANCE; Acer rubrum - Ulmus americana Association): The hardwood swamp areas have standing water for large portions of the year. They are dominated by red maple (*Acer rubrum*) and elm (*Ulmus americana*), but may have cabbage palm and water tolerant oaks. Some of these areas were once grassy swales that have changed over time as the result of alterations in hydrology and/or the exclusion of fire.

*Cabbage Palm Hammock***;** (SABAL PALMETTO TEMPERATE FOREST ALLIANCE; Sabal palmetto Association): These hammocks are almost pure stands of cabbage palms (*Sabal palmetto*). The understory is usually open with a scattering of palmetto and other vegetation. Although cabbage palms can grow on soils with a wide range of moisture regimes, they are typically found on more or less saturated soils, such as those along the edges of impoundments. As elevation increases and the soils become better drained, the vegetation grades into the mesic oak/palm hammocks.

Cabbage palm hammocks can also be found on disturbed sites. Land that was once cleared for home sites or for agriculture would often come back as stands of exotics and cabbage palms when abandoned. This situation is especially noticeable in the case of citrus groves that have gone fallow.

Mesic Hardwood Forests and Woodlands

Hardwood Hammock; (QUERCUS VIRGINIANA-SABLE PALMETTO FOREST ALLIANCE; Quercus virginiana-Sabal palmetto Association): These hammocks are dominated by large live oaks (*Quercus virginiana*), cabbage palms, and laurel oaks (*Q. laurifolia*). The understory in some of these hammocks is palmetto (*Sabal palmetto*), while others have a mix of subtropical shrubs, such as wild coffee (*Psychotria* spp.), nakedwood (*Myrcianthes frarans*), *Ardisia* spp., and ferns along with the palmetto.

Upland Hardwood Forest; (QUERCUS VIRGINIANA-SABLE PALMETTO FOREST ALLIANCE; Quercus virginiana-Sabal palmetto Association): Although classified the same as the hardwood hammocks, the upland hardwood forest occupy slightly better drained soils. These are mixed hammocks that have not only cabbage palms and live and laurel oaks, but also elms, ashes (*Fraxinus* sp.), red mulberries (*Morus rubra*), sugar berries (*Celtis laevigata*),

and other overstory species. The understories may have nakedwood, wild coffee, and southern red cedar (*Juniperus virginiana* var. *siliciola*).

Oak-Cedar Hammocks; (QUERCUS VIRGINIANA-SABAL PALMETTO FOREST ALLIANCE; Quercus virginiana-Sabal palmetto-Juniperus virginiana var siliciola Association): These stands are similar to the upland hardwood hammocks, but have a substantial amount of southern red cedar in them. The majority of these stands are found in the Turnbull Creek area.

Planted Hardwoods; (QUERCUS VIRGINIANA-QUERCUS LAURIFOLIA FOREST ALLIANCE; Quercus virginiana-Quercus laurifolia Association): These stands were planted on old citrus groves in the northern portion of the refuge during 1991 and 1992. The original planting density was six feet within row spacing with twelve feet between rows. By 2004 crowns had closed within the rows. The understory consists mainly of exotic grasses left over from the citrus operations.

Xeric Hardwood Forest

Xeric Hammock; (QUERCUS GEMINATA-QUERCUS MYRTIFOLIA ALLIANCE; Quercus geminata-Quercus myrtifolia Association): This type is found on the Paola-Pomello-Astatula association, which is deep, well to excessively drained soils. The overstory vegetation is sand live oak (*Quercus geminate*), myrtle oak (*Q. myrtifolia*), and Chapman's oak (*Q. chapmanii*). This vegetation type is often the end result of long periods of fire exclusion. The vegetation has become a dense, almost impenetrable stand reaching heights of 30 feet and higher. The understory is sparse, consisting of clumps of palmetto. There is little in the way of an herbaceous layer. Much of this vegetation type has been restored to oak scrub. Most remaining stands are too small in area to warrant mapping.

Pine Forests and Woodlands

Pine Flatwoods; (PINUS ELLIOTTI-SERENOA REPENS ALLIANCE; Pinus elliotti-Serenoa repens Association): The pine flatwoods forests and woodlands are generally found on the poorly drained spodosols of the Myakka-Eau Gallie-Immokalee soil association. The overstory consists of two species of pines. South Florida slash pine (*Pinus elliottii* var. *densa*) pine makes up the vast majority of the pine population. Pond pine (*P. serotina*) can be found in small stands on very wet areas. Pine stands range widely in both stocking densities' age and height. The understory of the pine flatwoods would vary depending on the elevation of the site. Common to all flatwoods sites is saw palmetto. Additional understory species on the mesic sites can include wax myrtle (*Myrica cerifera*), gallberry *(Ilex glabra*), and *Lyonia* spp. As the soils become drier with increased elevation, the gallberry and wax myrtle become fewer and sand live oak, myrtle oak, and Chapman's oak begin to appear. The higher flatwoods, with a high proportion of scrub oaks, are locally known as scrubby flatwoods. The flatwoods pine forests are of special interest because they provide nesting habitat for the bald eagle (*Haliaeetus leucocephalus*). Where the pine overstory is sparse, the scrubby flatwoods can provide habitat for the Florida scrub-jay (*Aphelocoma coerulescens*).

Upland Coniferous Forests; (PINUS ELLIOTTI-SENORA REPENS ALLIANCE; Pinus elliotti-Senora repens Association): The upland coniferous forest and woodlands occur on both the Myakka-Eau Gallie-Immokalee and the Canaveral-Palm Beach-Welaka soil associations. The predominant tree species is South Florida slash pine, but there are small patches of sand pine

(*Pinus* clausa) to be found. Many of the sites occupied by these stands have been disturbed in the past. The understory has many of the same species as is found in the flatwoods, including palmetto and *Lyonia*. Shrub species favoring drier soils are also found, including sand live oak, myrtle oak, and Chapman's oak. On the disturbed sites the understory shrub layer may be absent or scattered. These areas may also contain a number of exotic grasses and forbs.

Planted Pine; (PINUS ELLIOTTII TROPICAL FOREST ALLIANCE; Pinus elliottii var densa Association): Abandoned citrus groves were planted to south Florida slash pine in the late 1980s and early 1990s. These have developed into uniform stands. The understory consists of exotic grasses left over from citrus operations.

Mixed Pine and Hardwood Forests

*Wetland Coniferous/Hardwood Forests***;** (PINUS ELLIOTTII-QUERCUS VIRGINIANA SATURATED TEMPERATE FOREST ALLIANCE; Pinus elliottii-Quercus virginiana Association): These stands con be found on the Copeland-Wabasso soil association. The overstory is predominately live oak, south Florida slash pine with some cabbage palms. Some red maple and other wetland species may exist in the mid-story. The understory can have palmetto, wax myrtle, and other moist soil species.

Upland Coniferous/Hardwood Forests; (PINUS ELLIOTTII-QUERCUS VIRGINIANA FOREST ALLIANCE; Pinus elliottii-Quercus spp. Association): These stands can be found on the Copeland-Wabasso soil association, but at a slightly higher elevation. South Florida slash pine and live oak are the predominant overstory species. Other mesic hardwoods may be in the canopy, such as elms, ashes, red mulberries, and sugar berries.

B-2: FIRE ECOLOGY

Fire has been an important ecological factor in the development of the many of the of the forest and woodland landscapes on the refuge. It is also one of the primary tools utilized in its management. It is important, therefore, to understand the role fire plays in each of the subsets of timbered vegetation. Some of the forests and woodlands are fire maintained; meaning that fire not only plays an important role in the ecological process, but also is essential to the continued existence of those vegetation types. Other portions of the forests and woodlands are fire influenced. Here, although fire may occasionally be a factor, it is not usually essential to the maintenance of the system. Finally, some forest and woodland communities exist where fire is normally not expected to play any role. A short overview of the role of fire in the forests and woodland vegetation types is given. More detail on fire and its role in refuge ecosystems can be found the refuge's Fire Management Plan (Adrian 2003).

Xeric Forests: As previously discussed, many of the xeric forests can be considered oak scrub that has not had fire in it for a number of years. The fire return interval is very long, 20+ years. When xeric forests do burn, fires are extremely intense and are of a stand replacing nature. Naturally ignited fires rarely started in the xeric forests. Rather, they ignited in the more flammable flatwoods or grassy swales and then burned into these areas.

Pine Flatwoods: The pine flatwoods community is fire maintained. The fire regime in the flatwoods consists of moderately intense fires that occur every three to five years. Experience has shown that it takes from two to three years for the vegetation to recover enough to sustain

any sort of successful prescribed burn. However, in periods of drought, it is possible that a one-year rough can support some fire. This vegetative community grows back quickly and by the time five years has passed sufficient fuel is on the site to support catastrophic fires during periods of drought. After ten years, fuel loads tend to remain constant, with decomposition approximately equaling accumulation. The heavy fuel accumulations that result from unnaturally long fire return intervals can result in intense fires that can kill the pine overstory.

Much of the understory vegetation in the palmetto flatwoods is highly flammable and easily ignited. Species, such as saw palmetto contain resins and oils, ease ignition and increase rates of spread. Head fires in this habitat can burn vigorously and backing fires also spread well, but with much lower intensity. Simulations have shown that prior to the development of the infrastructure of today, fires in the flatwoods burned large expanses if no suppression actions were taken (Duncan and Schmalzer 2004).

Mesic Hardwood Forests: The mesic hammocks are considered to be fire influenced. Fire scars on some of the older trees in the mesic hardwood areas show that fire does occasionally burn through them, but that this occurs only in periods of drought. During normal years, high moisture conditions prevent fires from burning very far into these stands. Fire does play a role in the amount of mesic forests in the landscape. Most of the mesic forests are bounded by more flammable vegetation, such as the pine or palmetto flatwoods. During wet years, reproduction from the forests would colonize the flatwoods areas. Conversely, during dry periods, fires ignited in the flatwoods would burn into the edges of the mesic forests. The ecotone between the two vegetation types would fluctuate over time, but large increases in the sizes of the hammocks were unusual. With the event of fire suppression, the mesic forests expanded in the flatwoods and other shrubland sites. Once established, these new stands of hardwoods became somewhat fire resistant.

Cabbage Palm Forests and Woodlands: Fires in the dense cabbage palm forests burn slowly and with low intensity. The primary carrier of the fire is fallen palm fronds, since typically little other fuel is available. Return intervals are probably between three and five years. In the palm woodlands, fires are more intense and can spread rapidly. These areas normally have other fuels, marsh grasses in the wetlands and palmetto and gallberry in the uplands. Return intervals are two to three years in the grassy areas and three to five years where the understory is shrubs. Although fires burn frequently in the cabbage palm forests and woodlands, they should be considered fire influenced.

Hydric Forests: Hydric forests, such as mangroves, willow swamps, and maple swamps, are not normally affected by fire. For these areas to burn, the refuge would have to experience an extended period of extreme drought. These climatic conditions occurred between 1998 and 2000, and even then, few of the hydric forests were impacted to any degree. The lack of fire during the period of fire suppression has had an important effect on these vegetation types. Much of the landscape now occupied by these types of woody vegetation was once grassy swales. Without periodic fires, forests encroached on these grassy areas. Once hardwoods were established, the process could not easily be reversed by fire alone.

B-3: IMPORTANCE TO RESOURCES OF CONCERN

The forest and woodland components of the refuge landscape provide habitat for numerous species. Of particular note is the bald eagle (*Haliaeetus leucocephalus*). Refuge pine lands

have historically provided nesting sites. In the 1930s between 15 and 24 breeding pairs of eagles were on Merritt Island. This dropped to a low of two breeding pairs in the early 1970s. It is suspected that lowered productivity due to exposure to oganochlorine pesticides was the principle cause (Hardesty and Collopy 1991). Since the control of these pesticides, the number of breeding pairs has increased to 11 in 2004.

The importance of the refuge to eagles is anticipated to increase over the next 15 years. As the human population density on the mainland increases, the amount of forests available for nesting sites would decrease. The quality of other aspects of eagle habitat, such as the availability of marshes for foraging areas, may also be impacted. It is imperative, therefore, that the pine forest of the refuge be managed to provide continued opportunities for eagle nesting. Hardesty and Collopy describe a typical eagle nest trees and stands. Nest trees were south Florida slash pine that averaged 67 feet in height about 15 feet taller than randomly selected trees. Diameter at breast height (DBH) of nest trees were also larger that randomly selected trees at 22 inches. They had shorter, wider crowns than the surrounding trees. The stands in which eagle nests occurred had about one half the stocking as random stands, 15 stems per acre as opposed to 27. Likewise the basal area (BA) was less in nest stands as compared to surrounding stands, 35 square feet per acre and 45 square feet per acre respectively.

The forests and woodlands of the refuge provide habitat for a number of other avian species, including both resident birds and neotropical migratory birds. A total of 61 species are listed as utilizing the hammocks, while 43 species can be found in the pine and scrub areas. The Florida Priority Bird species list shows seven extremely high priority or high priority species that occur in refuge's pine flatwoods, seven that occur in hammocks and other forested wetlands, and four that occur in mangroves.

Reptile species that are of concern also utilize the forests and woodlands. Of particular note would be the federally threatened eastern indigo snake (*Drymarchon couperi*). Also of interest would be the gopher tortoise (*Gopherus polyphemus*) and the Florida pine snake (*Pituophis melanoleucus mugitus*), which are listed as species of special concern by the State of Florida.

C. HABITAT MANAGEMENT TECHNIQUES

C-1: POTENTIAL MANAGEMENT TECHINQUES

Prescribed Burning: Prescribed fire is not applicable to all forest and woodland vegetation types. The use of fire presents considerable risks: to the practitioners, to the general public, and to the resource itself. The decision to use fire should be based on a good understanding of the fire ecology of the forest community to be managed. The personnel applying fire to the landscape must meet all requirements concerning training and experience. Taking those cautions under consideration, it is important to recognize that fire is essential to the continued existence of many of the vegetative communities on the refuge. Past experience has shown that without fire, many of the forest and woodland habitats would degrade and become unsuitable for the fauna that utilize them. In addition, when fire is not regularly used in some forests, the vegetation becomes so overgrown that unplanned ignitions cannot be readily suppressed and extensive harm to life and property can occur.

Once the determination is made that fire is applicable to the forest in question, then the question of how to use it arises. One must take into account the current condition of the forest or

woodland to be burned, along with various aspects of fire's role in that forest. The intensity, frequency, and seasonality of fire would vary as to the type and condition of forest or woodland to be burned. They would also vary as the objectives of each specific burn vary.

Xeric Forests: The xeric oak forests are one of the communities that depend on fire. In the natural state of things, these forests went through long periods without fire. When they eventually burned, the fire was a very intense stand replacing fire. The oaks then sprouted from the roots. It took several years to grow through the shrub stage into a new xeric forest. If the objective is to maintain the site as a xeric oak forest, then an initial fire, with or without prior mechanical treatment, should be followed by 20 to 30 years without fire. Conversely, if the objective is to convert the site to oak scrub habitat, then the return interval for subsequent fires would be much shorter, five to seven years. The season of burn seems to have little effect on the regrowth of the oaks from sprouts (Foster and Schmalzer 2003), but may have other physiological effects that are unknown.

Pine Forests and Woodlands: Fire is essential for the continued existence of the pine forests and woodlands on the refuge. In both scrubby flatwoods and palmetto flatwoods understory, fires of moderate intensity reoccurred every four to seven years. These fires burned the understory vigorously and completely, leaving few unburned patches, but typically left the overstory intact (Abrhamson and Hartnett 1990). Most of the flatwoods vegetation would resprout after the fire. The fire also removed litter from the forest floor, providing seed beds for the pines.

With the removal of fire from the ecosystem, the fuels in the understory increased dramatically. With these increased fuel loads, fires increased in intensity to the point where the pine overstory could be consumed. The other result of less fire in the ecosystem was the increase in the stocking levels of the pines. Mature south Florida slash pines are protected from fire by thick bark. Some protection is offered to young seedlings when they are in the pseudo grass stage. However, the young saplings do not have much resistance to fire. In the past, frequent fires removed many of these, but with intensive fire suppression, more trees survived to maturity.

Fire can be used to help meet two widely divergent objectives in the pine forests and woodlands. Properly managed fires can reduce heavy fuel loads, which would reduce the likelihood that wildfires would damage stands that support, or could potentially support, eagle nests. These fires would also prepare sites for pine regeneration to provide for future stands. On the other hand, more intense fires could be used to remove part of the overstory in scrubby flatwoods areas where open savannah like stands are desired to increase the suitability of the area for the Florida scrub-jay.

Mesic Forests: Since mesic forests are influenced by fire, rather than being fire maintained, fire is not the primary tool for managing them. Fire can be used to maintain the current edge of hardwood forests by burning the young reproduction that is encroaching into the adjacent flatwoods or scrub. In places where it has been deemed desirable to remove some or all of a mesic forest, fire is often used to reduce the biomass resulting from harvesting or mechanical treatment.

Palm Forests and Woodlands: Palm forests are influenced by fire. Due to the structure of the trees, fire readily reaches the crowns and consumes them. However, since the bud is well

protected and rarely burns, the crown rapidly refoliates and there is little long term effect. For this reason, fire is not a useful tool.

The palm woodlands or savannahs may be another story. Although cabbage palm seedlings are difficulty to kill with fire, anecdotal evidence suggests that repeated fires may reduce palm recruitment in certain grasses marshes.

Hydric Forests: Fire has little role in the mangrove forests. There is some use for it, however, in the freshwater swamps. When trying to restore overgrown swales to their former grassy conditions, fire has been used in two cases. First, where the hardwoods have been treated either mechanically or chemically, the resulting dead biomass can be reduced by fire. The second situation is using fire to kill the standing hardwoods outright. This can only be used rarely. The stands of hardwoods must be small both height and acreage. In addition, the conditions must be dry enough to allow fire to carry into the stands, but not so dry that other fire prescription parameters cannot be met. Using fire to kill hardwood stands in swales is best done before canopies close and the underlying grass is completely shaded.

Silvicultural Systems: A silvicultural system is a program of treatments for the life of the stand. Attention is focused on the crucial step of stand regeneration by naming the system after the method of the regeneration cutting by which the stand is replaced (Wenger 1984). Included in the program is not only the reproductive method used, but also any intermediate practices that may be used during the life of the stand. Several silvicultural systems can be used in the forests and woodlands of the refuge: clear cutting, seed tree, shelterwood, and selection. The first three generally find application in the management of intolerant species, such as pine, and produce even aged stands. The selection method works best for tolerant species, usually hardwoods, and results in an uneven aged forest.

Regeneration: It is obvious that in order to maintain the presence of forests and woodlands in the landscape, regeneration must occur periodically. Regeneration can be accomplished either by natural means utilizing existing mature trees as a seed source or through artificial planting or direct seeding. Both approaches have been used in the past. Natural regeneration is preferred over planting when possible. It has the advantage of being aesthetically pleasing, is less disruptive to the ecosystem, and has the practical advantage of being less costly than artificial regeneration. Natural regeneration has its drawbacks. First, the site to be regenerated must have a suitable seed source close at hand. The second problem is achieving the proper density of trees in the new stand. This is especially true when the management goal is to create a open woodland landscape. Often seedling recruitment in these open areas can approach 1,000 stems per acre or more. This forces managers to remove a large amount of reproduction periodically through fire or mechanical means to maintain the desired stand qualities.

Artificially regeneration of a stand through planting has several benefits. In the first place, a nearby seed source does not need to be available. Planting or seeding can be used where stands have been completely removed by fire, insect outbreak, or other causes. It can also be used to convert non-forest lands to timbered areas. An example would be the restoration of abandoned agricultural areas to native forests or woodlands. The other advantage to artificial regeneration is the control of the density of the resulting stand. Density and tree spacing is very precise when planting is used, but is less so when seeding. Artificial regeneration has it disadvantages. One problem is the unnatural appearance of a planted stand. This may not be aesthetically acceptable in some refuge applications. Another consideration is that both

planting and direct seeding require more intensive site preparation than does natural regeneration. This may cause damage the soil structure, alter drainage, or remove desirable understory vegetation. Finally, site preparation and planting can be costly.

Timber Stand Improvement (TSI): When regenerated stands reach sapling size, thinning is sometimes needed. Since the trees are so small, commercial thinning operations are not feasible. A pre-commercial thin using either mechanical or chemical means can be done at this time. Timber stand improvement would release stagnated stands and speed up growth.

Timber Removal Options: The removal of trees from any of the forest and woodland vegetation types can be a viable alternative, depending on the specific management objectives. Removal can include harvesting merchantable timber, cutting or crushing small non-merchantable woody stems, or using chemical treatment. When managing large areas of pine forests or woodlands on the refuge that are of merchantable size, the most common method is to sell the timber to a commercial forest product operator. Numerous ways exist to set up and manage a commercial timber sale. In some cases it is preferable to mark the individual cut trees prior to the sale. This gives managers the greatest degree of control as to the make up of the resulting stand. It also is costly in both time and money. The other extreme is to use a logger select approach where the harvesting crew is given limits to the number and character of the trees to be left, but is allowed to select which trees are cut during the operation. This requires less up front time and effort on the refuge staff's part, but does require close monitoring of the logging operation. If this approach is to be taken, it is highly recommended that a logger with good references or one with whom the refuge has had good prior experience is used.

When removing merchantable timber, there should be no cost to the refuge. In most cases, the contractor pays a certain amount for each unit of forest product removed. When removing small diameter, non-merchantable trees, there is usually a cost involved. The work can be done either by an outside contractor or by refuge personnel. Whichever means is chosen, several options are available as to the methods of removing these stands. These options include both mechanical and chemical means.

Mechanical Treatments: Three general types of mechanical methods have been widely used for cutting scrub: rotary cutting, roller chopping, and shearing. Rotary cutters use heavy duty blades, usually attached to flywheels, that are either hydraulically or mechanically driven. These devices are usually attached to or part of rubber tired tractors. Roller choppers are steel drums of varying sizes with cutting blades mounted on them. The weight of the drum crushes the vegetation, while its rolling motion forces the blades into stems cutting them. Some experimentation has been done with rollers, which are similar to the chopper, but which lack the cutting blades. Choppers and rollers can be pulled with either tracked or rubber tired equipment. Shearing is typically done with V blades or KG blades. As its name suggests, the V blade is a triangular blade, usually with serrated cutting edges along both sides. The KG blade is an angled blade with a cutting edge along the bottom. Both are used to slice vegetation at ground level. Cutting blades are usually mounted on tracked equipment.

Other mechanical means of treating can vary widely. Occasionally, chainsaws have been used. Other mechanized equipment can include dozer blade and root rakes. These can be mounted on wheeled equipment, such as front end loaders, or tracked vehicles. Flail choppers are another option. Specially designed equipment, such as the Gyro Track, or flail type cutting heads mounted on track hoes, has been used in various places to manipulate scrub and other

brush. Harrows and disks, pulled by farm type tractors would also have some possible applications in scrub land management.

Chemical Treatment: The use of herbicides has not been used extensively to manipulate the forest and woodland landscapes on the refuge. However, spraying unwanted stands of woody vegetation, either from the ground or aerially, has been done on a limited basis with good results. Chemical treatment has potential application in the conversion of willow and other hydric forests back to grassy swales.

C-2: MANAGEMENT TECHINQUE CONSTRAINTS

Prescribed Fire: Numerous constraints exist to using prescribed fire. These limitations are discussed in detail in the *Fire Management Plan for Merritt Island National Wildlife Refuge* (Adrian 2003). These constraints can be grouped into several categories: safety, of both firefighters and the public; policy, including Department, Service and refuge guidance; legal requirements, including State of Florida Division of Forestry burning regulations; smoke management; NASA operations and concerns; and last, but certainly not least, the resource objectives of the burn.

Policy can be gleaned from Department and Service manuals, along with other documents, such as the Service's *Fire Management Handbook* available on line at: http://www.fws.gov/fire/redbook/index.htm. State of Florida burning regulations are covered under Chapter 590, Florida Statutes.

Adrian (2003) describes the complexities of fire management on Kennedy Space Center in detail. The process of notifying NASA of planned burns and obtaining approval has evolved over the years to a workable, if somewhat cumbersome, process. The integrity of the notification system requires constant contact with NASA shuttle operations personnel, the Joint Base Operations Contract dispatcher, and the numerous payload managers. NASA is generally sensitive to the refuge's needs to burn, but sensitive payloads can shut down burning in large portions of the refuge for six or more months.

The remaining constraints are covered by fire management prescriptions, which are covered in Section C-5.

Mechanical Timber Removal: The restraints to using timber removal as a tool to achieve refuge goals and objectives include adherence to policy, environmental considerations, operational factors, future fire management, and public perception. Service policy does not prohibit, nor does it limit any of the uses or methods described. What is required is that a management prescription be developed outlining the objectives of the project and the methodology to be used. Policy also requires that a consultation with Ecological Services be conducted under the provisions of Section 7 (Intra-Service consultation) of the Endangered Species Act (ESA).

Environmental considerations are partially covered by Section 7 consultations, but involve other considerations also. Commercial logging can create soil disturbance, especially where soils are wet. Limitations as to the placement of logging roads, skid trails, and yarding and loading areas may be needed to protect the soil resource from erosion, compaction, or other damage. Another consideration is the overall soil fertility of the site. The deeper sandy soils of the refuge

tend to be low in nutrients. Even the flatwoods soils can become less productive if too many nutrients are removed. Since the vast majority of nutrients are concentrated in the foliage, provisions to scatter the tops of the trees harvested rather than piling them would help recycle nutrients throughout the operational area.

Logging operations typically cause disruption of the mid and understory of the forest or woodland. Depending on the overall objective of the timber removal operation, this can be either good or bad. If the understory is sparse and needs to be preserved to provide habitat, then restrictions should be placed in the timber sale contract requiring operators to avoid sensitive understory vegetation. On the other hand, if the mid and understory vegetation is overgrown and needs to be reduced, logging operations can do an effective job is accomplishing this task.

In addition to the operational factors discussed above, there economic and other limitations exists for logging activities that need discussion. It is important to remember that the logging contractor must either make a profit from the timber removal operation or be paid for his trouble. When planning a timber sale it should be recognized that enough timber must exist on the site to cover the expenses of moving a logging crew into the area. Managers should also be aware that if it costs more to go out and cut, skid, and load isolated trees or small stands than the amount of money the operator would get for the wood, these trees would most likely be left.

An operational limitation particular to any operations on Merritt Island NWR is the refuge's location on an active space port. Closures during launch operations and during periods of heightened security may well impact a logging operation. Likewise, badging requirements for timber operations inside the KSC security area may limit the type of timber removal crew available to do the job.

The application of prescribed fire often follows operations that removed forest and woodland vegetation. The method by which slash from these operations is disposed of on the site can effect fire management. After either a commercial sale of large timber or the mechanical treatment of smaller stems, a large amount of biomass is left on the treated area. The burning of this residue can be problematic. Scattering the debris more or less uniformly over the land not only helps with nutrient cycling as previously mentioned, but presents a more homogeneous fuel bed for burning. This prevents heavy concentrations of fuel, which produce uneven fire behavior. This can cause damage to the remaining overstory. If piles of debris are near control lines, the increased fire intensity can lead to spotting and fire control problems. Conversely, if the overall management objective of the unit calls for the creation of openings in the understory, the piling of slash can be beneficial, so long as the placement of the piles does not create the above mentioned problems. The concentrated heat pulse that results from burning piles sterilizes the soil, which, in turn, results in open areas that can persist for several years (Schmalzer and Adrian 2001).

The last constraint to timber removal as a management technique is the reaction of the public. People often are disturbed when a seemingly healthy forest is cut. In order to gain public support it is necessary to educate the public as to the reasons for altering the forest or woodland landscape. Signs and brochures giving the basic rational for the operation are a start. Media should also have contact points where additional information can be obtained. The refuge's unique association with the Kennedy Space Center offers other avenues for information dispersal. KSC's *Space Port News* and other internal communication venues can be used to

inform the refuge's closest partners as to the Service's intentions. Questions from the general public can be answered at the refuge's Visitor Information Center and by direct contact with refuge employees. Displays and brochures at the Visitor Center can also provide information on timber and other habitat management activities.

Chemical Timber Removal: The general categories of constraints discussed in the mechanical removal of forest and woodland vegetation apply to the use of chemicals with a few differences. The first of these is in the realm of policy. In addition to a management prescription for the chemical removal of woody vegetation, a Pesticide Use Proposal (PUP) must be submitted and approved by the Service's Southeast Regional Office. Should the application of the herbicide be by air, Washington Office approval would be necessary. In the past, obtaining these approvals has been free of problems. In conjunctions with the PUP, a Section 7 consultation must also be done.

While the application of herbicides reduces the environmental problem of soil disturbance, other ecological considerations exist. While some herbicides are designed to kill grasses and others to attack broadleaf vegetation, they are not species specific. In other words, the application of a broad leaf herbicide to kill willows in an overgrown marsh would most likely kill any other broad leaf species that comes in contact with it. For this reason, it is best if broadcast applications of herbicides are used on more or less homogeneous stands of undesirable vegetation. To selectively thin mixed stands of trees it is best to apply the chemicals by hand. The methods suitable here are basal applications, injection, or careful spot spraying. Other possible detrimental effects of the use of chemicals to remove unwanted woody vegetation include effects on threatened and endangered species, other aquatic plants and animals, other terrestrial wildlife and plants, and the applicators themselves. Concerns about the negative effects of chemicals on plants and animals are addressed through the use of the PUP and the Sections 7 consultation. Using trained applicators who follow the label directions supplied with the herbicides used should prevent any problems as far as humans are concerned.

C-3: IMPACTS TO RESOURCES OF CONCERN ASSOCIATED WITH THE IMPLEMENTATION OF PROPOSED MANAGEMENT TECHNIQUES

Prescribed Fire: The use of prescribed fire runs the risk of burning eagle nests or killing of the nest trees. However, techniques developed by refuge fire personnel have allowed burns to be conducted around eagle nest trees with no damage. The alternative of not burning would certainly result in an increase in fuel loads. This, in turn would lead to more intense wildfires. These wildfires pose an even greater risk of fire damage to eagle nesting sites than prescribed burning. Another potential negative effect of prescribed burning is disturbance of eagles during the nesting season. Proper timing can help prevent this. It should be said, however, that burning has been done near active nests without disruption of nesting activities. Overall, the judicious use of prescribed fire would increase the health and diversity of the pine forests, and should, therefore, provide for better eagle nesting habitat.

Another potential problem with the use of prescribed fire lies with its effect on neotropical migratory birds. This concern is limited to the pine forests, since prescribed fire is not used in the hardwood hammocks. Again, the use of prescribed fire would reduce fuel loadings. This would reduce the risk of catastrophic wildfires. Properly done, prescribed fire would leave a mosaic of burned and unburned patches in the shrub layer of the forest. The unburned areas not only provide safe haven for birds and other wildlife during the burn, but also provide cover,

food sources, and nesting sites until the burned patches recover. As is with the eagles, the long term overall health of the forest ecosystem is what is important. Fire is a natural component of the flatwoods ecosystem and its proper use should provide long term benefits.

Mechanical Timber Removal: As far as the bald eagle is concerned, one of the biggest potential dangers would be the accidental cutting of a nest tree. This can be avoided by marking the nest tree and with careful monitoring of the cutting activity. The other potential problem is disturbance during nesting activities. This too can be easily overcome through timing of treatment and/or careful monitoring of the operation.

The most likely effect of thinning timber would be improvement in the overall condition of the forest. Over stocking increases the risk of disease and insect damage. While reducing this potential hazard, potential future nest trees can be favored. Stocking can be manipulated to create a range of forest densities which would increase the chances that suitable habitat is available for different species of neotropical migrants. Thinning is also a valuable tool in reducing timber densities in the scrubby flatwoods to those suitable for the Florida scrub-jay.

Chemical Timber Removal: This option is best suited for removal of hydric forests that have developed in once grassy swales. The downside is that this habitat is removed and replaced with grass. In the case of neotropical migrants, some species would lose habitat, while others would gain habitat. The opening up of the landscape which would result from removing the hydric forests would benefit the Florida scrub-jay.

C 4: MANAGEMENT TECHNIQUE SELECTION

Prescribed Fire: When using prescribed as a management tool, three aspects of fire need to be considered. Fire intensity, frequency, and seasonality would affect the outcome of the burn.

Fire Intensity: In the natural state of things, pine forests and woodlands ignited relatively easily. This is due in part to the flammability of the understory, primarily palmetto, and in part to the presence of pine litter. Historic fires were of low to moderate intensity. Flames were seldom high enough to do serious damage to the overstory. With the increased fuel loads that exist today under many of the pine stands on the refuge, this is no longer the case. Intensities have increased. It is quite common, even after repeated fires, for both prescribed fires and wildfires to cause mortality to the pine overstory. This may not be as bad as it would first appear. In cases where the management objective is to improve the shrubland landscape for the Florida scrub-jay, the thinning of forest by fire may be acceptable. Conversely, if a more dense pine forest is desired, as would be the case in managing for eagle nesting habitat, intense fires could be detrimental. In either situation, managers must be aware of the safety considerations of such fires. Intense surface fires combined with the torching and crowning of trees can dramatically increase chances of spotting and subsequent loss of a prescribed burn. It may be better to burn these overgrown areas with less intense fires and mechanically remove unwanted timber.

Fire Frequency: The second element that requires consideration is fire frequency. Estimates of fire return intervals for the pine/palmetto flatwoods range from one to eight years (Breininger et al 2002). The fire return internal in the less flammable scrubby flatwoods would be from five to 20 years (Menges and Hawkins 1998). Practical experience suggest that prescribed fire should be applied to the flatwoods and scrubby flatwoods forests and woodlands at intervals of from

three to five years. Fires ignited in rough less than three years old would not spread as readily and are not as intense as ones ignited when the vegetation has had longer to recover. These quick turn around fires can be used to break up the continuity of fuels in areas that exhibit excessive fuel loading. If fire is withheld from flatwoods areas for more than five years, live fuel loads approach those of long unburned sites.

Seasonality: The third element to take into account is the season of burn. As discussed in Chapter IV, most of the natural lightning fires occur from late May through September. On the surface, it would seem therefore that summer burns would be the choice. However, constraints, such as weather and NASA operations, limit the number of burn opportunities during this time. In the past, fire has been applied to the refuge's forest throughout the year as prescription parameters are met.

Timber Removal: One of the strategies to provide habitat for the various species of wildlife that have occurred historically on the refuge is to begin to re-create the refuge landscapes as they appeared prior to extensive development. Since past management practices, such as the exclusion of fire, have increased the density and extent of forest over the past 80 years, it is logical that the removal of some of this woody vegetation is necessary to re-create these landscapes.

Several specific instances exist where timber removal should be used. It has been discussed previously that many of the once grassy swales are now populated with maples, willows, and other hardwoods. Where this has occurred in shrublands that are otherwise suitable habitat for the Florida scrub-jay, it is essential that these trees be removed. Herbicide application, mechanical cutting or chopping, and fire can be used in various combinations to achieve this. Special efforts should be made to take advantage of dry periods to facilitate equipment operation in these wet soils.

Some mesic hardwood hammocks have increased in size over the years. Where it can be shown that these hammocks have encroached into the shrublands or open pine woodlands, they should be reduced in acreage. In most cases it would be sufficient to remove the younger trees in the transition zone between the hammocks and the flatwoods or scrub. As in the overgrown swales a combination of chemicals, mechanical treatment, and fire can be used successfully.

At the present time there does not seem to be a need to do selective thinnings in the mesic hammocks. Natural openings, created by windfall, insects, or disease have been sufficient over the past two decades to provide regeneration sites for the trees commonly found in these stands. However, the hardwood forests should be monitored periodically to ensure that this remains the case.

Pine forests and woodlands that have a scrubby flatwoods understory become suitable habitat for the Florida scrub-jay and other scrub species. The pine stocking should be very scattered with two to three stems per acre as a target density for the final stand. Where initial stocking is heavy, a first cut, leaving from four to six stems per acre of mature pines, is advisable. This allows for mortality that sometimes occurs after a timber harvest operation. Small five to 10-acre patches of denser timber should be left for the sake of diversity.

In the pine forests where the understory is primarily palmetto, gallberry, *Lyonia* sp., and wax myrtle, the objectives are different. Here timber management should be conducted with the end result of leaving a variety of stand densities though the forest. Special consideration should be made in the vicinity of existing and historic eagle nest sites to provide the stands of large trees with stockings near 40 square feet of basal area per acre. Several thinnings throughout the life of the stand should be made to reach the desire density.

Stand Regeneration: Planting trees would normally be limited to restoration of disturbed sites. Of particular note would be abandoned citrus groves. The soil type present in these areas would, to a large measure, determine the vegetation that should be planted. Deep sands are more suitable for scrub vegetation, while the more mesic sites should be planted with forest species.

Natural regeneration in both the pine forest and woodlands and in the hardwood hammock forest has been sufficient in the past to maintain these stands. In fact, logging operations in the pine forests usually prepare the site so well that too much regeneration occurs. However, the possibility exists that specific regeneration sites may need to be created. In the pine areas, a seed tree or shelterwood cut would be sufficient. In hardwood forests, selectively removing decadent trees to provide small open areas would be needed.

C-5: MANAGEMENT TECHNIQUE PRESCRIPTIONS

General Management Prescription Comments: The refuge has over 22,000 acres of forest and woodland vegetation. It would be difficult, in most cases, to described specific management prescriptions for this much territory in the Habitat Management Plan. Instead, a general process of deciding which potential management practices should be considered along with their possible timing, along with other policy and environmental considerations would be presented.

The refuge is divided into nine management units (Figure 2), each one having several burn units within it (Figure 3). These existing geographical areas should be the basis for developing management prescriptions. The forested areas of the refuge should be inventoried periodically, perhaps on a 10-year cycle. Although a formal timber cruise would not be necessary in each case, information on stand densities, tree health, and understory vegetation species and condition should be recorded. This information should be used to determine the need for any management action.

Forest Ecosystem Maintenance: Two general classes of forest and woodland management activities need to be discussed. The first is those actions that are designed to keep the forest and woodlands in a healthy condition and thereby provide proper habitat for the wildlife that uses these areas.

Pine Forests and Woodlands: In the pinelands, the understory is the key to the overall management direction. Areas where the understory vegetation is primarily palmetto, gallberry, wax myrtle, and *Lyonia* should be targeted for eagle nesting habitat management. The silvicultural practices described above should be employed to maintain a wide range of even aged stands five to 20 acres in size. Thinnings should favor potential eagle nest trees and provisions should be made for regeneration areas. By creating a wide range of pine forest

stand densities and ages, habitat would be provided for other wildlife native to the pine flatwoods. The application of prescribed fire would give additional diversity to the ecosystem.

Mesic Hardwood Hammocks: Inventories of the mesic hammocks should pay particular attention to the presence or absence of reproduction of the overstory trees in the mid and understory. If it appears that there are sufficient younger trees to replace the mature trees that succumb to disease, wind throw, and other maladies, then no action should be required. On the other hand, if additional replacement trees are needed, prescriptions for the selective removal of overstory trees should be considered. The small openings created should be close enough to potential seed trees of the desired species to allow for natural regeneration. In the past, the mesic hammocks have not required much attention. The trees in these stands are shade tolerant and reproduction can remain in a suppressed condition for many years. The natural attrition of old trees has provided the small openings that allow the younger trees to grow into the canopy. It is likely that this sequence of events would continue.

Conversion of Forests and Woodlands to Other Vegetation Types: There are areas of the refuge where past management practices, primarily the lack of timely application of fire, have caused forests to expand or become more dense than is desired. Many of these instances occur where forest lands are adjacent to scrub. In these situations the management objective may be to remove forest vegetation to allow another habitat type to become dominant.

Pine Forests and Woodlands: Once again, the key to deciding which management option should be selected is the understory. Where the understory is predominately palmetto and scrub oak, rather than mesic flatwoods vegetation, removal of some or all of the pine overstory would help create habitat more suitable for the Florida scrub-jay. In this scenario, it would necessary to reduce the timber stocking to three to five stems per acre. A complete description of the habitat requirements of the scrub-jay can be found in Chapter IV.

Mesic and Hydric Hammocks: Where mesic hammocks have spread into scrub oak or scrubby flatwoods areas, it may be advisable to reduce them to pre fire exclusion size. In developing prescriptions for this situation, the 1940s aerial photography should be viewed to give a general idea of how much the particular stand has expanded. In addition, an onsite inspection of the contours of the ground can often indicate where the historic boundary of the hardwood stand was. The timber here is generally not merchantable. Removal would probably need to be done through mechanical or chemical means.

As has been discussed previously, fire exclusion has allowed many of the swales in and around the scrub ridges to become hydric forests. When considering the conversion of hydric hammocks to more open conditions, the early aerial photography can once again be useful. This is the best way to determine if the area in question was in fact once in grass vegetation. If this is in fact the case, the next consideration is how this particular swale fits into the landscape. If the removal of the woody vegetation can increase the suitability of the landscape for the Florida scrub-jay, removal may be a viable option. Again, the timber here would usually be non-merchantable and removal would need to be done through mechanical and/or chemical means.

Specific Forest Management Projects: There are two specific management projects that have been identified for completion during the fifteen year life of the CCP. The first of these is a timber thinning project in units 9.5, 9.6, and 9.7 (Figure 13). The understory in the western portions of these units is scrubby flatwoods and scrub, while the eastern part has a more typical

flatwoods understory. Where the understory vegetation is scrub and scrubby flatwoods, the long term objective is to manage the land for Florida scrub-jay habitat. In the more typical flatwoods areas, the objective would be to provide for eagle nesting habitat. The commercial harvesting operation would bring stocking levels in the scrubby flatwoods and scrub vegetation down to between three and five stems per acre, while the eastern portion would have a somewhat greater final stocking. Although the western part of the sale would still have some trees, it would fall into the definition of shrublands.

The other project involves the restoration of fallow citrus groves (Figure 14). Several small groves, totaling 14 acres, near the intersection of State Road 402 and Kennedy Parkway (State Road 3), along with an 86-acre tract north of Swartz Road have been selected for conversion to mesic hammock. This process would involve removing existing citrus trees, controlling exotic and invasive species, and filling old grove ditches. After site preparation, the area would be planted to native forest species. Nearby existing hardwood hammocks would be inventoried to determine the proper species mix and stocking levels. The estimated cost of this endeavor, in 2005 dollars, is between $4,000 and $5,000 per acre.

Figure 13: Areas Selected for Timber Thinning to Improve Scrub-jay Habitat

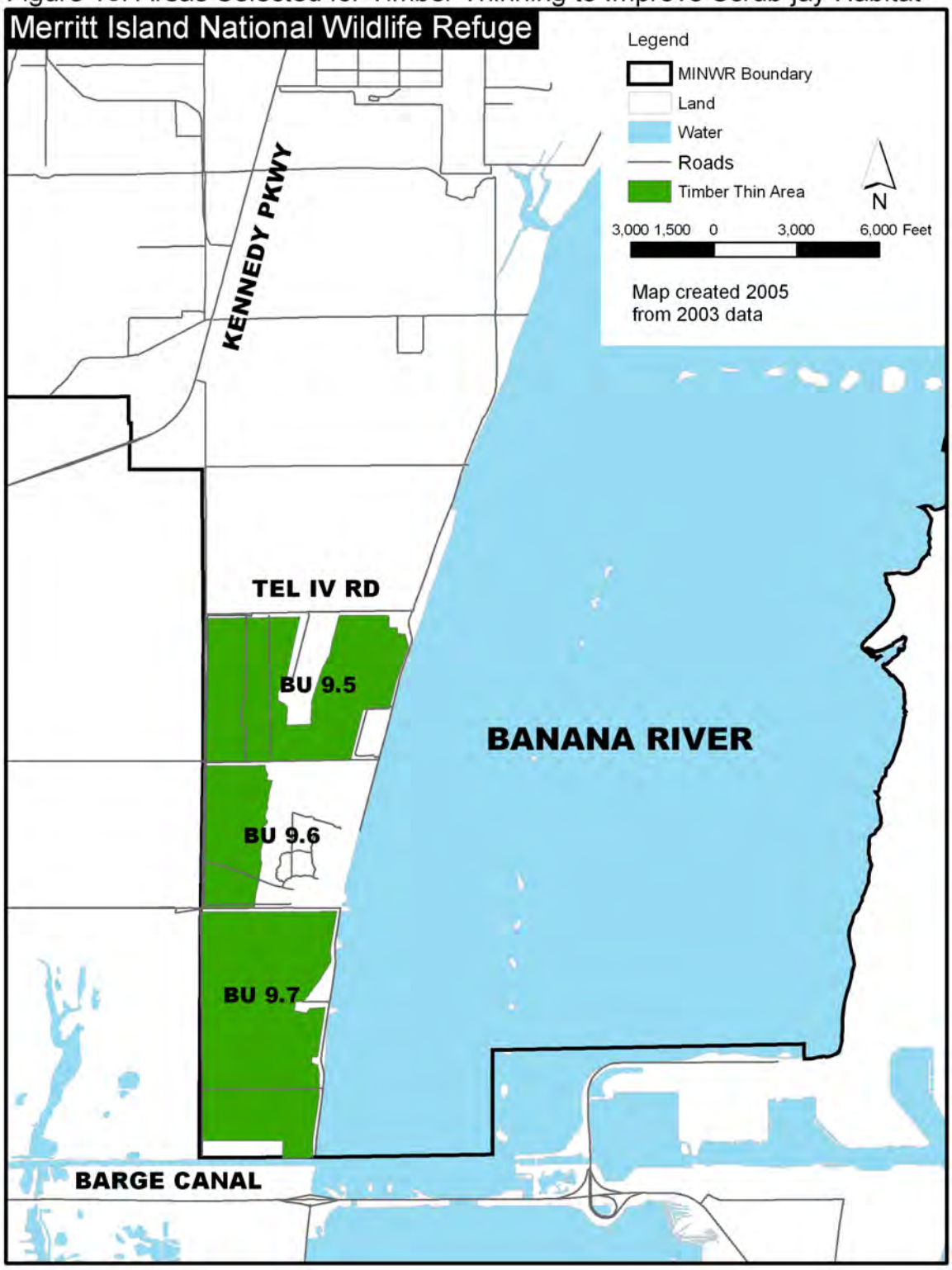
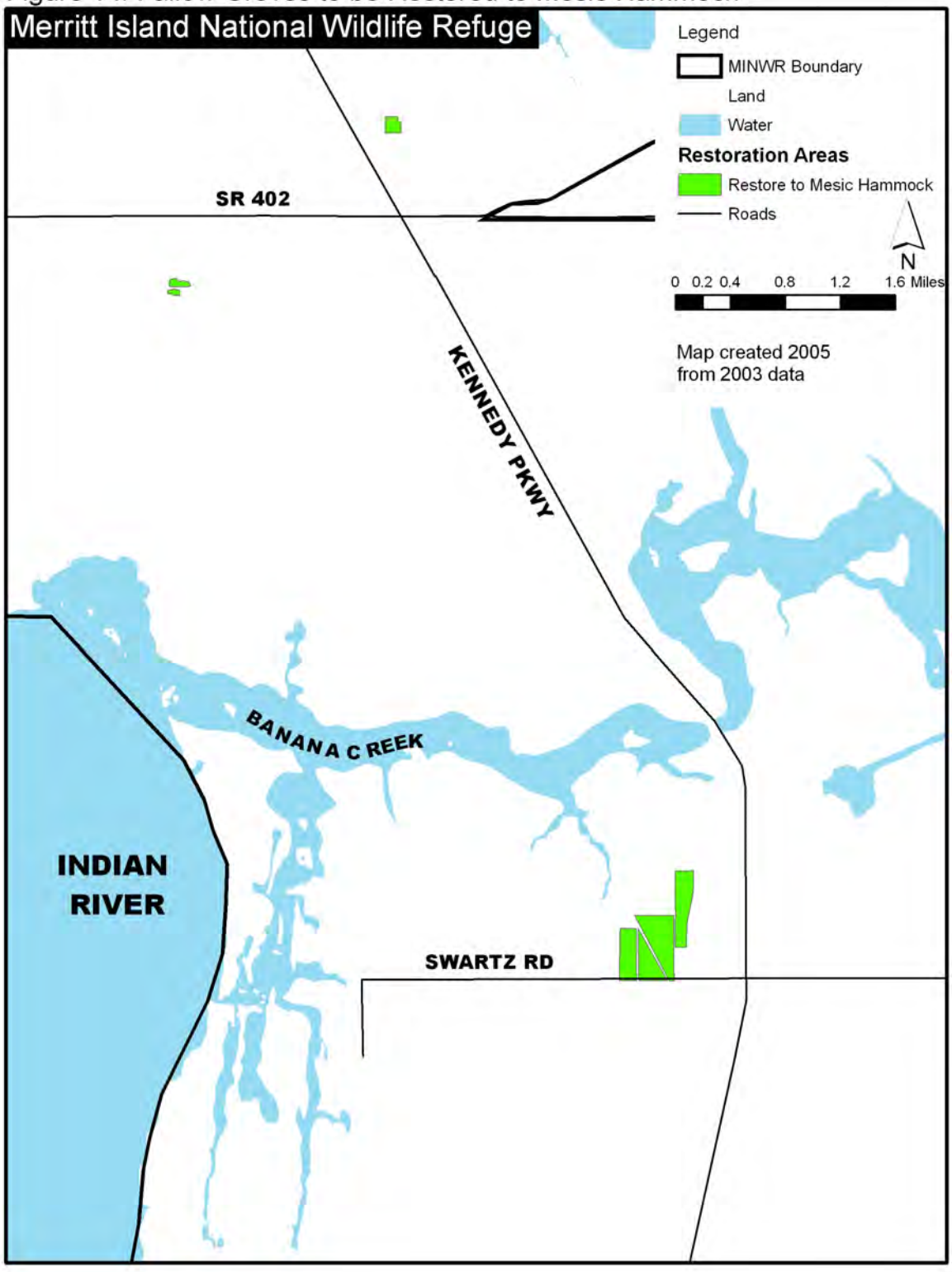


Figure 14: Fallow Groves to be Restored to Mesic Hammock



D MANAGEMENT TECHNIQUE DOCUMENTS

D-1: NECESSARY RESOURCES

One of the essential resources required to carry out an effective forest and woodland management program is personnel knowledgeable in the field of forest ecology and timber management. This is addressed in the Comprehensive Conservation Plan's staffing section with the additions of an upland Biologist and a Forestry Technician. It is also essential that these positions have knowledge of fire ecology and the use of fire to manage the pine forests and woodlands. It is also likely that timber removal would be done through commercial harvesting. Other management activities, such as timber marking, chemical treatments, timber stand improvement, and planting could also be done by contracting with non-government sources. Expertise in developing these contracts and administering them would also be useful.

At the present time, the refuge has sufficient heavy equipment to accomplish most of the work that would be done force account. This would include bull dozers, road graders, disks, harrows, and similar equipment.

D-2: DOCUMENTATION OF SPECIAL USES

Some timber management activities, such as commercial timber harvesting, have traditionally been handled under a Special Use Permit. This practice should continue. Any research and monitoring related to forest and woodlands management should also be under permit if they are done by non-refuge personnel. The permit can be used to track what information is being gathered, and can, through permit requirements, ensure that the refuge receives these data.

D-3: DOCUMENTATION OF COMPLIANCE

The Habitat Management Plan will go through the NEPA process as an appendix to the Comprehensive Conservation Plan. Therefore, no additional action of this nature would be required for forest and woodland management actions unless major changes in management philosophy occur. However, specific prescriptions for activities, such as prescribed fires, timber removal, planting, and chemical treatments may be required. These prescriptions need to follow the policy and procedures in force at the time of their development and be forwarded through the appropriate channels. Although not compliance per se, it is strongly recommended that all management activities be recorded in GIS for future reference. Prescriptions should also be reviewed under Section 7 of the Endangered Species Act.

CHAPTER VI
CITRUS GROVE MANAGEMENT

A. HABITAT GOALS, OBJECTIVES, AND STRATEGEIS

The refuge's Comprehensive Conservation Plan (CCP) provides goals, objectives, and strategies which direct management actions for the land now occupied by citrus groves. Some strategies relate directly to the manipulation of habitat and are directly relevant to an action plan, such as this. Other strategies, while important to the overall fate of the citrus groves, fall in the arena of administration, coordination, and/or research. Both types of strategies are enumerated under their associated objective. There is one goal, with subordinate objectives and strategies, listed in the refuge's CCP that is directly applicable to the citrus groves. Other goals and objectives may be supported indirectly as grove management evolves in the future.

4. Wildlife & Habitat Diversity
WILDLIFE AND HABITAT MANAGEMENT GOAL 4: Protect, manage, and enhance the natural diversity of fish, wildlife, and habitats and the important landscapes of the refuge's coastal barrier island system to ensure that refuge fish and wildlife populations remain naturally self sustaining.

Under this goal there are two objectives that pertain specifically to citrus management.

4.h. Citrus Groves
Wildlife Populations and Habitat Management Objective 4.h(1): Before 2008, evaluate the role of approximately 1,100 acres of citrus groves on the refuge to determine which groves are targeted for future restoration to native habitat and which groves are targeted for development by NASA. In the interim, the refuge will continue to manage these groves to limit the presence of exotic, invasive, and nuisance species.

Strategies for Wildlife and Habitat Management Objective 4.h(1) are listed.

- Continue the partnership with the Florida Research Center to farm groves using sustainable programs until final disposition of the groves is determined. If nothing else, this would prevent the groves from becoming overgrown with exotic plant species.
- For those groves identified by NASA for future development, require that NASA clear and maintain them as grassy field until the site is developed.
- Determine which groves would be best suited for future development areas by NASA. Work with NASA master planning and environmental planners to make determinations. Work with NASA to use former citrus groves sites as locations for their new facilities and thereby lessen impacts to undisturbed upland sites.
- Initiate research to determine the use of farmed and/or abandoned groves by neotropical migratory birds.
- Determine which groves occur in areas that would provide linkages between the several refuge Florida scrub-jay population centers.
- Identify specific groves (e.g., such as the groves north of Haulover Canal) that would be best suited to be restored and maintained as grassy fields and corridors for jays.

Wildlife and Habitat Management Objective 4.h(2): Within the 15-year life of the CCP, restore 200 targeted acres of abandoned citrus groves to native habitat: 120 acres for Florida scrub-jay habitat on sand ridge sites and 80 acres for neotropical migratory birds in the more mesic areas.

Strategies for Wildlife and Habitat Management Objective 4.h(2) are listed.

- Initiate a pilot study to accurately determine the cost of restoring abandoned citrus groves to native habitat.
- Select specific groves to be maintained in an open grass condition to provide corridors for jays and adjacent foraging areas for painted buntings along soft edge habitat.
- Develop interim annual management plans for groves to include burn cycles and mechanical manipulation**.** Include palmetto (*Sable palmetto*) removal, mowing, burning, exotic species control, and citrus tree removal as part of the planning process.
- Use soil maps, old aerial photography, and hydrological studies to determine historical vegetation on grove sites.

B. DESCRIPTION OF THE RESOURCE

B-1: HISTORY OF CITRUS GROVES ON MINWR

Citrus groves have been a part of the landscape since the 1860s when Dummitt Grove was planted. By the time NASA acquired the land for Kennedy Space Center and subsequently transferred the management of non-operational lands to the refuge in the 1960s, almost 2,500 acres of citrus were being farmed. For the first 10 years the original owners of the groves were allowed to continue operate them. In the early 1970s the individual groves were consolidated into six groups and bid out to commercial citrus interests. Under this arrangement, the government received a percentage of the gross receipts and the highest percent bid on each group determined who won the contract. The receipts were considered general revenue and did not return to the refuge for operational expenses. In addition to these payments, contractors were required to maintain ditches, replant trees, and follow citrus culture practices recommended by the University of Florida.

Freezes in the middle 1970s and early 1980s severely damaged the groves in the northern portion of the refuge. It was determined that it was no longer economically feasible to operate these groves and they were removed from production. Citrus trees were pushed out and various species of oaks and pines were planted in them during the middle 1980s. The remaining grove acreage, totaling 1,756 acres, was divided into five groups ranging in size from 230 acres to about 530 acres. These five groups continued to be farmed under contract.

In 1989 a new contract was offered for bid. Care taking of the groves including drainage and replanting trees continued much as before. However, a major change was made in the payments that came to the government. While the successful bidder continued to be determined by the highest percent of gross receipts as before, contractors were also required to spend $300.00 per acre on in kind improvements to the groves and surrounding areas. This included specific actions, such as building new grove facilities, replacing and improving pumps and drainage, and removing exotic species. Two grove operators were successful in winning the bid. One citrus company won the rights to farm groups 1, 3, 4 and 5, while Group 2 was operated by a different contractor.

In the early 1990s, the Service instituted stricter control over the types of pesticides that could be used on the refuge, and the use of Integrated Pest Management (IPM) was required. To assist the growers in implementing IPM and to find more environmentally friendly methods of citrus culture, the refuge began an association with the Kerr Center for Sustainable Agriculture in Vero Beach, Florida. The Kerr Center, which later became the Florida Research Center, worked with the contractors to reduce the amounts of both pesticides and fertilizers applied to the groves. The growers were allowed to apply a portion of the $300.00 per acre, required for in kind payments, to compensate the Kerr Center for its work.

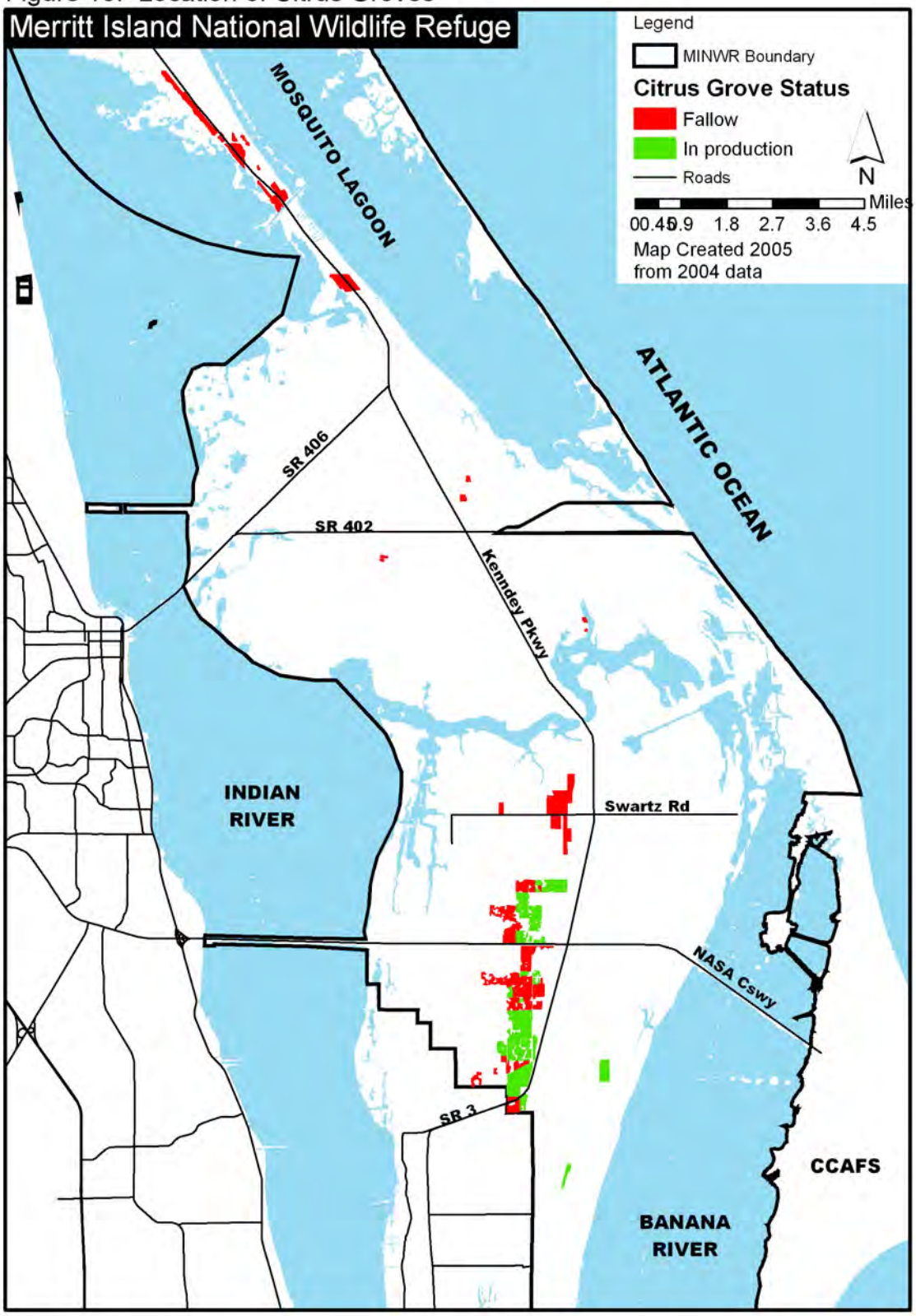
During this same period of time, two circumstances combined to eventually bring an end to commercial operation of the groves. The first of these was a severe freeze on Christmas of 1989. Damage to the citrus trees was extensive in all areas of the refuge. While the two contractors were working to overcome this calamity, competition from foreign countries caused a major drop in citrus product prices. Both contractors eventually were forced to cease operations on the refuge.

In 1996, NASA took over management of all citrus groves with the exception of Group 2. The refuge went into a partnership with the Kerr Center for Sustainable Agriculture to manage the Group 2 groves. The Memorandum of Understanding (MOU) between the Kerr Center and the refuge was originally to last for five years and tasked the Kerr Center to generate a sustainable citrus culture program which would be more environmentally friendly than existing commercial operations. This would be accomplished by reducing dependence on pesticides and other chemical inputs while still producing marketable fruit. The Kerr Center contracted with a local citrus operator to farm Group 2 under the Kerr Center's Program.

Toward the end of 1997, NASA entered into negotiations with the refuge to return groups 1, 3, 4, and 5 to the refuge. During the two years NASA was in control of the groves, little care taking had been done. By the time the refuge got the groves back, most of the citrus trees were in poor shape, and weeds and exotics had taken over most of the middles and grove perimeters. The Kerr Center agreed to expand its program into portions of these groves. Due to the poor condition of the groves, the Kerr Center decided to use groups 3 and 4, concentrating on the more profitable fruit varieties, such as navel and Valencia oranges, tangerines, and other fresh fruit varieties. Most of the grapefruit and juice orange trees were abandoned. The contractor for Group 2 took over portions of Group 1, while another subcontractor was engaged to work in groups 3 and 4. All of Group 5 was abandoned.

NASA's plans to develop the International Space Research Park began to impact grove operations in 2002. The site chosen for the park included part of the Group 2 groves and all of the Group 3 groves. This project was to be built in several phases, with the Group 3 grove area being developed first. Since the land would not be withdrawn from the refuge until later, citrus operations were allowed to continue. However, an access road, Space Commerce Way, was

Figure 15: Location of Citrus Groves



built through the middle of the Group 3 groves, impacting their economic feasibility. Most of the land that supported low value fruit in this group was allowed to go fallow. Farming was continued on 29 acres of higher value navel oranges and Minneola tangerines.

In 2004, reorganization within the Kerr Center resulted in the creation of the Florida Research Center for Sustainable Agriculture. All assets of the Kerr Center's Vero Beach research station were transferred to this new entity, including the MOU with the refuge. Since there was no change in personnel when the Florida Research Center was formed, the effects on the refuge's partnership were negligible.

B-2: PRESENT GROVE SITUATION

At the end of 2004, there were 1,751 acres of groves within the management boundary of the refuge (Figure 15). Of these, 714 acres of groves being actively farmed by the Florida Research Center, under the MOU which would be in effect until 2008. Of the remaining groves, 1,014.4 acres are fallow (Table 2) and 25 acres were taken from Group 2 for a borrow pit for NASA.

The groves that are being actively farmed are in good condition. However, the fallow groves have been rapidly overtaken with exotic plants. Of most concern is Brazilian pepper, but exotic grasses and vines are also present in great numbers.

TABLE 2. PRESENT AND FUTURE DISPSITION OF CITRUS GROVES

Group	Total Acres	Present Disposition		Future Disposition			
		Farmed	Fallow	Farmed	Restored	Return to NASA	Not Determined
1	231.9	199.5	32.4	199.5	0.0	0.0	32.4
2	285.0	262.2	22.8	262.2	0.0	0.0	22.8
3	313.4	29.0	284.4	0.0	0.0	0.0	313.4
4	369.4	223.6	145.8	223.6	0.0	0.0	145.8
5	526.0	0.0	529.0	0.0	301.5	80.1	17.4
TB*	26.3	0.0	26.3	0.0	0.0	0.0	26.3
AB**	178.9	0.0	178.9	0.0	0.0	0.0	178.9
Total	1930.9	714.3	1,219.6	685.3	301.5	80.1	737.0

*TB = Turnbull Creek Area

**AB = Acres located in the refuge's acquisition boundary, but not yet managed by the refuge

B-3: IMPORTANCE TO RESOUCES OF CONCERN

Neotropical Migrants: The citrus groves do provide open woodland habitat for some neotropical migratory bird species. Painted buntings (*Passerina ciris*) have been detected in grove areas along with other migrants. However, the open woodland habitat can be kept as part of the restoration process. Groves that occupy mesic sites could be planted with less than full stocking with native hardwoods to provide this niche.

C: HABITAT MANAGEMENT OPTIONS

C-1: POTENTIAL MANAGEMENT OPTIONS

Several options exist for the future of the citrus groves on the refuge. It is important to remember that, while the ultimate aim of the refuge is to phase out citrus management, something must be done with the groves until that can be accomplished. Past experience has shown that allowing groves to go fallow only increases the refuge's exotic plant problem.

Restoration to Native Vegetation: This option is certainly the most desirable. The native vegetation which would replace the groves depends upon the soils that are present. Some of the groves were established on deep sands on which native vegetation is usually oak scrub or scrubby flatwoods. Most of these groves are located near Haulover Canal. The groves in the center and southern part of the refuge tend to be on more loamy soils, such as the Copeland series. The native vegetation here would be mesic hardwood forests.

Restoration is expensive. Byrn and Matson (2004) reported cost of about $3,500 per acres to restore bahia grass pasture to pine flatwoods. In a similar study Bissett (2004) spent approximately $4,600 per acre. In the early 1990s the refuge, in cooperation with KSC, attempted to restore about 10 acres of abandoned grove to oak scrub (Schmalzer et al 2002a). This effort was expensive in time, money, and labor, and was, at best, marginally successful. The principle shortcomings of this experiment were inadequate control of existing exotic plants and insufficient stocking rates of the scrub species planted.

The general procedure for restoring groves would start with the mechanical removal of any remaining citrus trees, the ever present stand of cabbage palms that appear in abandoned groves, and large Brazilian pepper trees. During this phase of the restoration, since heavy equipment is already on the site, it would be best to restore, as much as possible, the natural hydrology by filling in any ditches and furrows established for grove drainage. After this, several herbicide treatments would be needed to remove smaller exotic plants, such as guinea grass and smaller pepper plants. This site preparation is likely to take from one to two years.

The next step is to establish the desired vegetation: either oak scrub on the sandy sites or mesic hardwoods on the heavier soils. Some inventory work should be done in adjacent native stands to determine the likely mix of species to plant. Planting of tree species can be done mechanically. The shrub layer was hand planted in the oak scrub restoration effort previously noted, but it is possible that seeding could be effective depending on the species planted. If the establishment of an herbaceous layer is desired, seeding is probably the best approach.

The oak scrub study did demonstrate three important points. First, good control of exotic species on the site is essential. Without this, any remaining exotic species would, at best, hinder the growth of the planted species and could overpower them. Secondly, original planting densities should take into account mortality. If too many trees survive, they can always be thinned later. Finally, use plants of sufficient size to ensure proper planting and survival. In the oak scrub planting, some species used, notably myrtle oak, were too small. It may be necessary to use seedlings that have been grown two years in the nursery.

There are a lot of unknowns here. It is suggested that the results of the oak scrub restoration effort be studied carefully and that body of knowledge be built upon for the next effort. In the case of restoring mesic sites, a small grove should be selected as an initial attempt. Partnerships with non–government organizations interested in land restoration should be sought. The present grove operator, the Florida Research Center, has expressed interest in working in this area.

It should be noted that it is possible to do a partial restoration. In this case, the citrus trees and other woody vegetation would be removed, exotics controlled to some extent and the site be maintained by a combination of prescribed burning and/or mowing. At some time in the future, full restoration could be completed.

Develop into Florida Scrub-jay Corridors: Connectivity between the scrub reserves is beneficial to the overall well being of the Florida scrub-jay (Chapter 4). Several citrus groves, now fallow, can be utilized as corridors. These groves are located immediately north of and about a mile south of Haulover Canal. In these cases, rather than fully restoring the groves to native habitat, they would instead be kept in an open condition. Grasses would be left and the area would be maintained by either burning or mowing. The scrub-jay would then be able to use these areas to migrate from the Shiloh Scrub Reserve to the Happy Creek area.

This option is similar to the partial restoration previously mentioned. The difference would be that the objective would be to keep the site in an open condition, rather than continuing the restoration process at a later date. The process would begin with the mechanical removal of old citrus trees, cabbage palms, and other tall woody vegetation. Herbicide would be used to control woody exotic plants, especially pepper. It may not be necessary to completely control exotic grasses. If all the exotic grasses are removed, some native grasses would need to be seeded or planted. The process would stop short of planting scrub species or other native overstory vegetation. Left with a mixture of native and exotic grasses, the site could be managed easily with fire as an open area.

Use as Future NASA Development Sites: The refuge encourages NASA to develop new facilities on already disturbed land, rather than impact more natural areas. Over the years several small grove tracts have been used in this manner. At the present time, NASA is planning to utilize all of the Group 3 groves and the northern half of Group 2 for the International Space Research Park, although the future of this endeavor is presently under review. Although no additional plans for using the groves exist at the present time, it is likely that groves near existing KSC facilities would be used for future development. This brings up an important point in planning the future of the groves. It would not be prudent to restore groves in these areas. As noted above, restoration to native habitat is expensive, and the refuge's resources should not be used where future NASA development is likely.

If and when the refuge is approached by NASA to use grove areas, managers should insist that KSC remove these lands from the refuge forthwith. NASA should also be encouraged to go ahead and remove the existing grove vegetation, along with any exotics, and plant grass or some other easily maintained cover crop in the interim. This would eliminate the presence of unsightly, overgrown groves, and reduce sources for the spread of exotic plants.

Continue Farming: Some of the groves that are not selected for the above mentioned uses would continue to be actively farmed. Where it is economically feasible to operate these

groves, the partnership with the Florida Research Center should be continued. Extending the MOU with the Center past the present expiration date in 2008 has several advantages. The immediate benefit to the refuge is keeping farmable groves from going fallow. This not only prevents them from becoming overgrown with exotics, but presents a more aesthetically pleasing vista than would abandoned groves. A longer term benefit falls into the realm of the refuge being a good environmental citizen in the Indian River Lagoon system watershed. By allowing the Florida Research Center to continue to develop more environmentally responsible citrus management practices, the whole of the Indian River Lagoon system benefits. One of the stated goals of the Center is to export the knowledge gained in the refuge groves to other citrus operations in the Indian River Lagoon area.

Allow Groves to go Fallow: If none of the other options are possible, the only other alternative is to allow the groves to go fallow. As noted above, once farming ceases, exotics soon take over the grove area. The dense stands of Brazilian pepper that develop in old groves have limited value for wildlife habitat. Management options in overgrown groves are limited. If burning is started before grove grasses are shaded out by pepper, fire can help keep undesirable vegetation in check. Herbicides can also be used to reduce exotic vegetation.

C-2: MANAGEMENT OPTION CONSTRAINTS

Restoration to Native Habitat: The primary constraint with this option is the expense. Over 1,700 acres of groves are on the refuge and it is unlikely that resources would become available to restore all of them. In addition to being expensive, the actual mechanics of restoration has several potential pitfalls. Experience has shown that the removal of exotic plants from old grove sites is essential to the success of a grove restoration effort. Repeated mechanical and chemical treatments would be necessary to accomplish this. Additional work may be needed to fill in grove ditches to restore the hydrology of the site.

Once the site is prepared, care must be taken to select the correct species to plant. Soils maps can be a guide, but sometimes these are inaccurate. The investigation of the soil for each potential restoration site is necessary. Analysis of the soil profile by knowledgeable people through borings or other means can identify the specific soil series. Descriptions of vegetation naturally occurring on these series can then be used as a guide for plant selection. Alternatively, inventories of adjacent native stands of vegetation can be used to help make decisions on what plants to use. Finally, the size of the seedlings to be planted is critical, as has been previously discussed.

Develop into Florida Scrub-jay Corridors: The problems here are similar to those encountered in complete restoration. Although the groves selected for this use would not necessarily be planted to native vegetation, the problems with controlling or eliminating exotics still apply. This management option also requires the long term commitment to manage the site through burning or mowing.

Use as Future NASA Development Sites: The principle constraint with this option is obviously NASA's desire to utilize the grove as a development site. Many of the groves are remote from present NASA operational areas and their use would not fit into future development plans. In the past, as was the case with the International Space Research Park, groves have been earmarked for development and farming has ceased, but little activity has occurred for several years. When this happens the groves soon become overgrown with exotics. NASA should be

encouraged to clear the groves as soon as negotiations for their use are finished. Alternatively, NASA could arrange for the grove caretaking during the period between withdrawal from the refuge and initiation of construction activities.

Continue Farming: The primary constraint to the continuation of farming is the economic viability of the groves. At the present time, fresh fruit is the only commodity that is profitable enough to warrant continued grove operation. It should be noted that the economic situation can change quickly. When the Florida Research Center first took over the groves, grapefruit was a loosing proposition and many of the grapefruit blocks managed directly by the Center were allowed to go fallow. A subcontractor of the Center decided to continue to care take some of the grapefruit in his sector. The income from these groves was at best marginal for several years. In 2004 several hurricanes damaged most of the grapefruit crop in the southern portion of the state, but spared those on Merritt Island. The resultant lack of supply increased the value of the grapefruit crop on the refuge dramatically. An increase in supply of a particular variety of citrus in another region could just as easily lower the prices of refuge fruit to a point where the groves could no longer be farmed.

This leads to a second important constraint, that of finding someone who would continue the farming operation. It is unlikely that commercial farming of the groves would ever be realistic again. Economic conditions, the large amount of groves already fallow and in poor condition, and the possibility of NASA removing groves from production for their use would prohibit this. Additionally, the refuge's cost in time and personnel to manage contracts for an operation that is not appropriate is not warranted. At the present time, the Florida Research Center, a non-profit organization, is working the groves as part of its efforts to develop environmentally friendly citrus management practices. It is conceivable that this option could disappear should the market value of the citrus crop drop significantly some time in the future.

Allow Groves to go Fallow: Allowing the groves to go fallow further reduces their ability to provide any sort of habitat for wildlife. The dense stands of Brazilian pepper and other exotics that quickly develop on groves when farming ceases also provide ready sources for the spread of these pests.

C-3: IMPACTS TO RESOURCES OF CONCERN ASSOCIATED WITH THE IMPLEMENTATION OF MANAGEMENT OPTIONS

Restoration to Native Habitat: Obviously the point of restoring groves to native habitat is to improve conditions for wildlife. The groves on the refuge are on three principle soil associations: the deep sands of the Paola-Pomello-Astatula association, the deep sands of the Canaveral-Palm Beach-Welaka association, and the poorly drained Copeland-Wabasso association. In the natural state of things, the deep sands support shrubland communities, specifically oak scrub and, on more moist sites, scrubby flatwoods. The Copeland-Wabasso Association, on the other hand, has hardwood hammocks of various types as its native vegetation. Restoring old groves to native vegetation would, therefore, benefit the oak scrub community and the hardwood forest communities. This, in turn, would benefit the wildlife that utilizes these habitats, notably the Florida scrub-jay in the scrub and various neotropical migrants in the hardwood forests.

Develop into Florida Scrub-jay Corridors: This management option is designed to improve the overall situation of the Florida scrub-jay. At present limited connectivity exists between the

four Scrub Reserve Units (SRU) on the refuge: Shiloh, Happy Creek, Swartz Road, and the Southern Woodlands. The old citrus groves in the Haulover Canal area are programmed to be kept in an open condition to provide a corridor between the Shiloh and Happy Creek SRUs.

Use as Future NASA Development Sites: The removal of citrus groves for development would remove the limited habitat benefits the groves provide. On the other hand, using marginal habitat for future NASA development, rather than undisturbed natural areas would give an overall benefit to a wide range of resources of concern.

Continue Farming: The groves would continue to provide limited habitat for neotropical migrants, as the do now. There would be little benefits to other resources of concern. However, the continued care taking of the groves would keep exotic plant species in check in these areas.

Allow Groves to go Fallow: There is practically no benefit to any wildlife species under this option. The Brazilian pepper stands that would most assuredly develop would provide a food source to certain neotropical migrants. The downside is that the birds would help spread the pepper to other areas of the refuge.

C-4: MANAGEMENT OPTION SELECTION

It is unlikely that the refuge would be able to completely phase out citrus operations during the 15 year life of the CCP. However, during this time some work would be done to restore groves to native habitat, while other groves would be returned to NASA for its use. The remainder would be either partially restored for use as Florida scrub-jay corridors; farmed; or, where no other option is feasible, allowed to go fallow. The likely fate of the grove acreages over the 15-year life of the CCP is shown in Figure 16.

Restoration to Native Habitat: There are two factors that should be looked at when considering this option. First, it is important that refuge time and money not be spent in restoration that might later be withdrawn from the refuge by NASA. This can be handled in two ways. First, groves selected for restoration should be in areas that are unlikely to be used by NASA. If it is desirable to restore groves close to existing NASA facilities, coordination with NASA should occur well in advance of any on the ground activities. Furthermore, it should be made clear to NASA that once restored, these areas would be treated as natural habitat, and the refuge would resist any moves to develop the site.

The other issue is effectiveness. Will the restoration have a reasonable chance to succeed? Furthermore, will this restored area be beneficial to the overall management objectives of the refuge? This is especially important when considering restoring old groves to scrub lands. Scrub restoration efforts on the refuge and on Cape Canaveral Air Force Station have shown that it is more likely that jays would move into the restored sites adjacent to occupied scrub areas than when remote areas are restored.

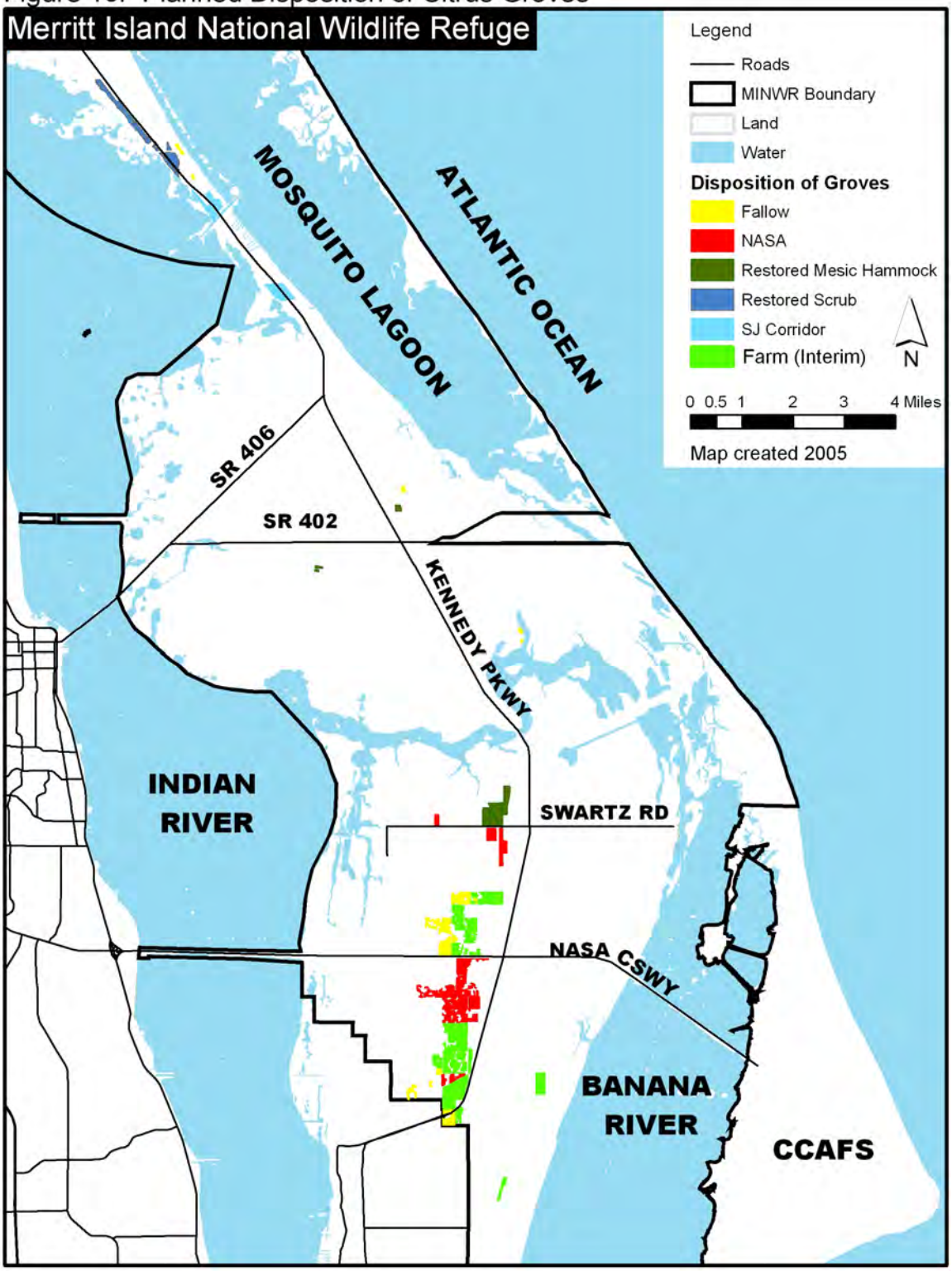
Develop into Florida Scrub-jay Corridors: The issues noted in complete restoration apply here also, especially the location of the site. It should be obvious that corridors be placed in areas where connectivity is needed.

Use as Future NASA Development Sites: History shows that the refuge's input is limited in this option, since the decision is primarily NASA's. The refuge can, and should, attempt to influence NASA decision makers to consider using the groves whenever possible.

Continue Farming: Farming of economically viable groves should continue until funding is available to restore them in some fashion. The economic viability of a particular grove is a decision that must be made by the citrus operator. Unfortunately, external supply and demand factors are the driving force here and the refuge has no control over them. Currently, the groves are managed by a non-profit organization in a quasi-research mode. Although this has some administrative problems from time to time, this arrangement should continue.

Allow Groves to go Fallow: If none of the above options is workable, then the decision to allow the groves to go fallow is made by default. As has been discussed previously, this is not a desirable situation, but is the only one left for groves that cannot be utilized elsewhere.

Figure 16. Planned Disposition of Citrus Groves



C-5: MANAGEMENT OPTION PRESCRIPTIONS

Restoration to Native Habitat: Restoration is planned for approximately 200 acres. Detailed plans for the restoration projects should be written at a later date, but a brief summary of each proposal is provided here. About 80 acres of this is in the area of the refuge north of Haulover Canal. These abandoned groves are on sandy soils suitable for oak scrub vegetation. This site is well away from most of the NASA operational areas. Although there have been some remote facilities, such as radar sites and camera pads, placed in the northern portion of the refuge in the past, development would not be expected to impact this area. The refuge should, however, ensure that NASA planners are aware of the refuge's intentions. Since this site is outside of the security zone, access is not a problem.

The other 120 acres of groves are on sites suitable for hardwood hammocks. Five of these acres are in the Bair's Hammock area. It is recommended that this small grove be the first attempt at restoring mesic hammock. Although these are in NASA's security area, the access is off of State Road 402 and the problems associated with getting access for contractors and other non-refuge personnel associated with the project access to the site should be minimal. Additionally, this area is away from most NASA operational area, with the exception of the Shuttle Landing Facility. Another advantage of using this site is that it is surrounded by hammocks. It can be assumed that the vegetation in the adjacent hammock would be similar to that which should be planted.

The remaining mesic groves are located in old Group 5, near Swartz Road. This site is much closer to NASA operations and careful coordination is essential. Access to this area by contractors might be more difficult than in the other restoration sites. On the positive side, there are some forested areas near the site that could be surveyed to help determine a proper species mix for planting.

Develop into Florida Scrub-jay Corridors: Approximately 130 acres of old groves are programmed to be used as corridors to connect sub-populations of the Florida scrub-jay. The groves in question are located near Haulover Canal. The area is outside NASA's security zone and access would not be a problem. Recent prescribed fires have helped keep exotic species in check, but they are still present and would need treatment. As is the case with the full restoration areas, a detailed plan would need to be developed.

Other Management Options: There is no need for formal plans or prescriptions for the other management options. The continued farming of the groves is handled under the Memorandum of Understanding between the refuge and the Florida Research Center. This agreement expires in 2008 and should be renegotiated prior to that time.

Coordination with NASA to site new facilities is an ongoing process. The Kennedy Space Center should be encouraged to utilize areas in Group 5 not scheduled for restoration first. This site is close to the current Vehicle Assembly Building area and the groves are fallow. Much of Group 4 can still be farmed economically, as can portions of groups 1 and 2. There are fallow groves in all these groups which could be used for future facilities.

The only thing that can be done at a reasonable cost in any of the fallow groves not otherwise obligated is to attempt to control exotics. Some success has been had in aerially spraying Brazilian pepper. As opportunities present themselves, this should be continued.

D. MANAGEMENT OPTION DOCUMENTS

D-1: NECESSSARY RESOURCES

The options that would require the most refuge resources would be the restoration of the groves and the development of the groves into corridors for the Florida scrub-jay. In both cases, much of the on the ground work could be done either by force account or through contracting. This would include removing the old citrus trees, controlling exotics, filling in ditches, and planting. The refuge has on hand the necessary heavy equipment and spray apparatus to do the job, but contracting may be more practical. The seedlings would need to be grown in a commercial nursery. To effectively plan and oversee these operations, the refuge would need personnel with expertise in soils, equipment operation, herbicide application, and tree planting.

If farming is continued in some of the groves, it would most likely be done as it is now with an non-governmental organization (NGO) or other entity doing the actual work. Refuge input would be limited to ensuring adherence to the current agreement and ensuring that any chemical applications are in accordance with FWS policy. The refuge staff member responsible for this should be familiar with Service pesticide use policy and have some working knowledge of Integrated Pest Management. Some knowledge of citrus culture would be helpful, but not essential.

D-2: DOCUMENTATION OF SPECIAL USES

The farming operations would require some sort of agreement. No formal permit is required for any of the other options.

D-3: DOCUMENTATION OF COMPLIANCE

The Habitat Management Plan will go through the NEPA process as an appendix to the Comprehensive Conservation Plan. Therefore, no additional action of this nature would be required for citrus grove management actions unless major changes in management philosophy occur. However, specific prescriptions for the restoration and Florida scrub-jay corridor options may be required. These prescriptions need to follow the policy and procedures in force at the time of their development and be forwarded through the appropriate channels. Use of the groves for NASA development would require the land to be formally withdrawn from the refuge. Chemical applications done in conjunction with any of the options would require the submission of a Pesticide Use Proposal and are subsequent approval. Prescriptions and pesticide applications should also be reviewed under Section 7 of the Endangered Species Act.

CHAPTER VII
BEACH AND DUNE MANAGEMENT

A. HABITAT GOALS AND OBJECTIVES

Two goals listed in the Merritt Island National Wildlife Refuge Comprehensive Conservation Plan relate to the management of the beach and dune systems. The first of these concerns the threatened and endangered species that utilize the beach areas, while the second addresses migratory birds.

1. Rare, Threatened, & Endangered Species

WILDLIFE AND HABITAT MANAGEMENT GOAL 1: Preserve, protect, and enhance populations of rare, threatened, and endangered species of plants and animals at existing or increased levels on the refuge and preserve, protect, manage, and restore their native east central Florida coastal and estuarine habitats occurring on the refuge to contribute to recovery goals.

Under this goal two objectives pertain to sea turtle nesting and one objective addresses habitat for the southeastern beach mouse. While each of these objectives has strategies that are specific to those species, several strategies relate to increasing the overall knowledge of the beach and dune system and/or detail activities that would provide benefits to all species that inhabit these areas.

Under Goal 1 two objectives concern the management of sea turtles and their habitats.

1.c. Sea Turtles - Beach and Estuary Habitats

Wildlife and Habitat Management Objective 1.c(1): Continue to annually maintain 6.3 miles (10 km) of refuge beach in a high quality condition for nesting leatherback, green, and loggerhead sea turtles to support an annual target of 1,250 loggerhead sea turtle nests and a bi-annual target of 210 green sea turtle nests to support sea turtle recovery efforts.

Strategies for Wildlife and Habitat Management Objective 1.c(1) are listed.

- Monitor annual trends in numbers of sea turtle nesting in the beach and dune habitat.
- Where necessary, reconstruct dune and beach areas to re-establish native plant communities and beach profiles after ocean storms or for habitat management purposes.
- Coordinate an annual beach cleanup to remove accumulated litter and debris. Any annual beach cleanup would be conducted before March 15 to reduce impacts to nesting Wilson's plovers or other colonial nesting species (Appendix D), as well as to minimize impacts to sea turtles.

Wildlife and Habitat Management Objective 1.c(2): Continue to annually maintain an annual sea turtle nest depredation rate of less than 10% to support sea turtle recovery efforts.

The strategy for Wildlife and Habitat Management Objective 1.c(2) is listed.

- Monitor annual depredation on sea turtle nests and use the most effective means to reduce depredation rates to levels less than 10% of overall nesting (e.g., trapping and removing wild hogs and raccoons).

An additional objective addresses the southeastern beach mouse and associated habitats.

1.d. Southeastern Beach Mouse - Beach and Dune Habitats
Wildlife and Habitat Management Objective 1.d(1): Continue to annually maintain about 100 acres of coastal dune community dominated by forbs and beach grass to support the southeastern beach mouse recovery efforts.

Strategies for maintaining and improving southeastern beach mouse habitat are listed.

- Encourage monitoring and research related to beach mice to show habitat needs and population trends.
- Continue to control exotic species within the dune and coastal strand habitats (see Chapter IX: Exotic, Invasive, and Nuisance Species Management).
- Work with NASA to resolve issues of erosion from storms, sea level rise, and development impacts.
- Coordinate with NASA's environmental contractor to initiate monitoring of coastal erosion rates and to project foreseeable impacts to coastal resources.
- Discourage additional development and reduce human activity, by NASA and others, on the refuge beach and dune system to protect the integrity of this natural system
- Consider dune habitat management techniques that would enhance sandy, grassy conditions and reduce dense palmetto and scrub overgrowth, such as fire, mechanical, and chemical treatments.

These strategies are applicable to the above listed objectives.

- Ensure that the 10-km Merritt Island NWR beach and dune system habitat is maintained at the highest quality and suitable for listed species, such as sea turtles, beach mice, and the piping plover.
- Ground truth existing habitat delineation of coastal habitats and monitor vegetation successional changes through continued aerial photo interpretation and on the ground plots.

2. Migratory Birds
WILDLIFE AND HABITAT MANAGEMENT GOAL 2: Maintain and actively manage refuge coastal barrier islands wetlands and uplands primarily to contribute to migratory bird priorities of the refuge and peninsular Florida physiographic area, while providing consistency with regional and national goals.

One objective under this goal pertains to beach and dune management.

2.f. Migratory Birds
Wildlife and Habitat Management Objective 2.f(1): Annually maintain about 300 acres of beach and dune habitat for migratory bird use.

In Florida, the coastal beach and dune system is exceedingly vulnerable and important to many species, including snowy and piping plovers (*Charadrius melodus* and *C. a. tenuirostris,* respectively) and colonial nesting shorebirds (Charadriiformes) (Millsap et al 1990, Johnson and Barbour 1990). In Florida, coastal habitats are one of the most attractive areas for people to live, work, and recreate. Continued loss and modification of coastal habitats augments the necessity to protect and manage the refuge's beach and dune habitat. The refuge has conducted bird surveys on the beach in accordance with the International Shorebird Survey protocol. Data suggest there are summer (shorebirds, May - October) and winter (diving birds, October - April) components to bird guilds using the beach area. Wilson's plover *(Charadrius wilsonia*) nest on the upper beach and dune system at Merritt Island NWR from April through July (Epstein 1999)**.**

Strategies that can be used to meet this objective are discussed.

- Monitor nesting plovers and other colonial nesting birds and integrate all research and monitoring activities on the beach system to avoid impacts of human activities on migrating and nesting birds.
- Coordinate activities that may affect coastal shoreline habitat, such as shoreline erosion control and monitoring, dune protection and restoration, beach refurbishment, and other projects affecting beach resource.
- Encourage research to investigate elements of coastal ecology as they reflect on active management potential for wildlife of management concern and their habitats.
- Continue to educate the KSC security force on bird use of beaches and the impact of vehicles and boats on bird use in other habitats.

Figure 17: Location of Refuge Beach-North

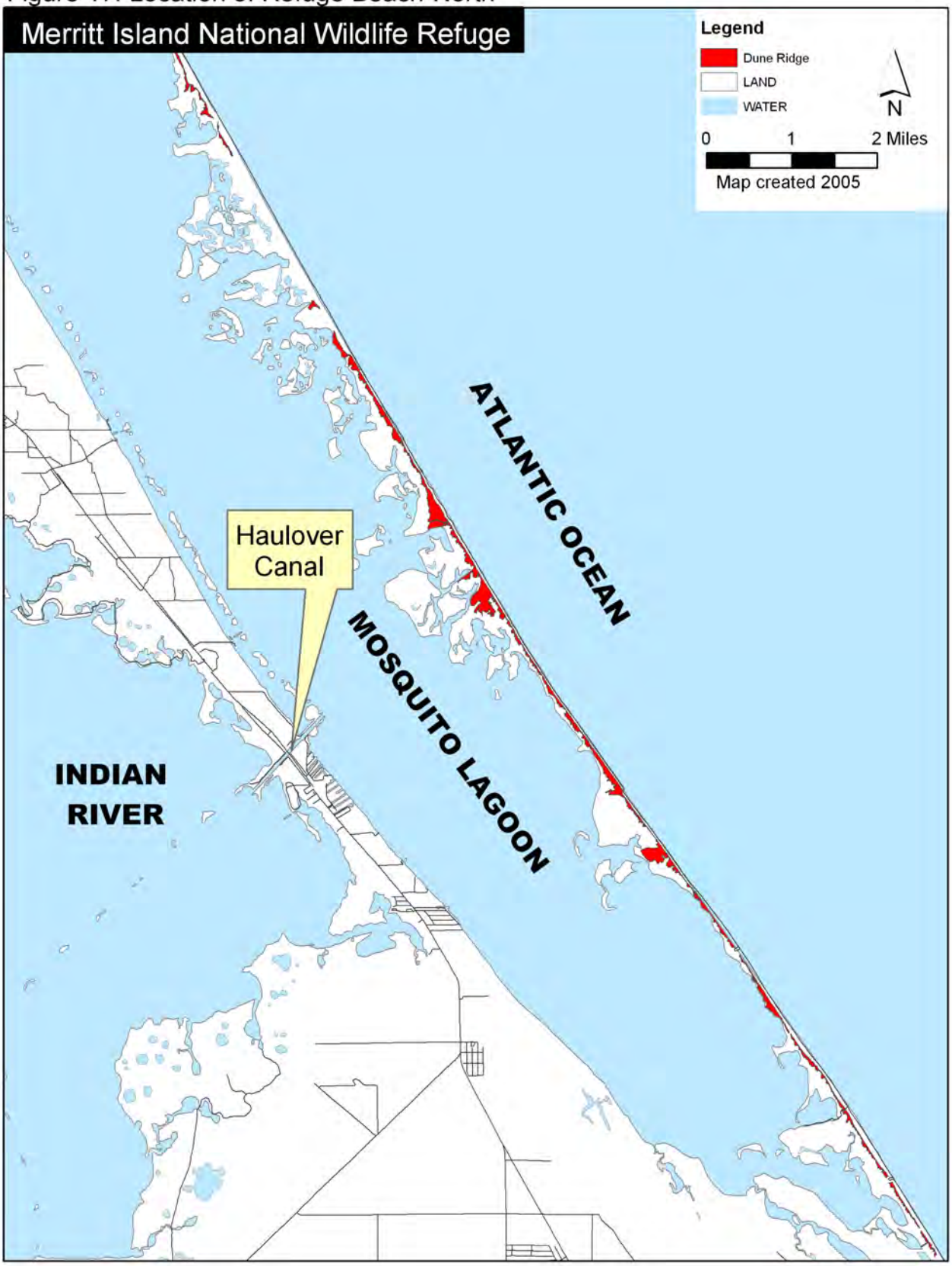
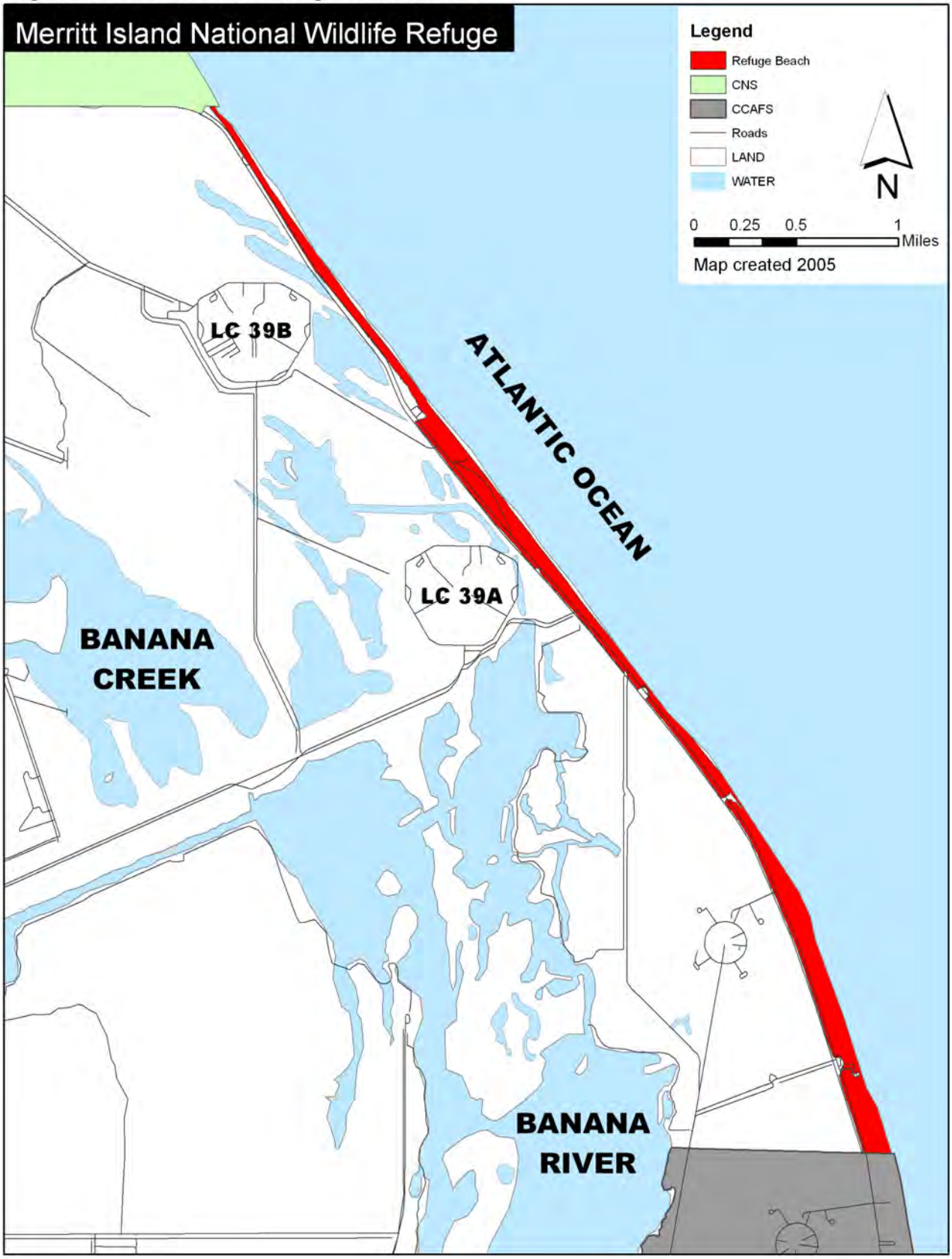


Figure 18: Location of Refuge Beach-South



B. BACKGROUND

B-1: BEACH AND DUNE MANAGEMENT UNITS

The refuge is located on Florida's east-central coastal zone. The refuge's 141,000 acres spans southeastern Volusia and northern Brevard counties. The refuge manages two separate coastal beach/dune habitats. The south refuge beach is the coastal beach and dune habitat within the NASA security area between Canaveral National Seashore (CNS) on the north and Cape Canaveral Air Force Station (CCAFS) to the south (Figure 17). The north refuge beach consists of the back barrier beach-dune habitat lying west of the CNS paved road at Playalinda Beach and the unimproved sand road that continues on to the northern boundary of the refuge in Volusia County behind Klondike Beach (Figure 18). Administratively, the refuge does not manage the front beach of the latter dune ridge area and the front beach of this area is managed as part of the Canaveral National Seashore. However, for purposes of description within this document, both systems would be described as the refuge barrier beach (figures 17 and 18).

B-2: BEACH AND DUNE SYSTEM BACKGROUND

Beach and Dune System Dynamics: The refuge beach and dune area is dynamic and can be described as a sand sharing system. This area is the transitional habitat between the ocean and the uplands, where material is constantly moving as a river of sand and water. The beach is derived from sand that is being carried along the coastline by the ocean's littoral current. The sand sharing reflects the moving of sand between the ocean and the beach. Once deposited, wind moves sand over the beach and dunes, building the system's profile. Vegetative succession assists in the beach and dune building process by stabilizing the sand. While doing this, the vegetation also provides habitat for wildlife. Periodic storms are also an important part of the processes that occur here. Increased wave action from storms can move sand great distances, create inlets and overwash fans, and set vegetative succession back to earlier stages. In addition, salt spray and sand blasting from high energy wind events cause changes in both the vegetative community and the beach and dune profile. All of these natural processes and the resultant movement of sand through the beach and dune system characterize the dynamic nature of this habitat. Where possible, the beach and dune system should be allowed to function naturally. However, it may be necessary to occasionally use active management to ensure that refuge goals and objectives are met. The management techniques that might be employed include prescribed burning in the dune vegetation, mechanically altering the dune profile, planting native vegetation, and using fencing to augment dune building.

Historic Condition: The 328-acre refuge beach (mean high tide line west to the Beach Road) is between the refuge's boundary with the CNS at State Road 402 and the south boundary with CCAFS (Figure 18). The Atlantic Ocean forms the eastern boundary of the refuge's barrier beach and dune system. Historically and prior to acquisition by the National Aeronautics and Space Administration (NASA), the beach was occupied by a residential, ocean front community.

The 342-acre dune ridge that lies north of State Road 402 is a narrow stretch of back barrier dunes that lies within the CNS-refuge joint management area (Figure 17). This narrow ridge of sandy dune and coastal strand habitat is located west of the primary dune line and a beach road (see Figure 18). The area from the primary dune line and east (i.e., generally east of the beach

road) is managed as the CNS. The southern section of this area is Playalinda Beach (in Brevard County), while the mid section is named Klondike Beach (in Brevard and Volusia counties), and the northern section is part of Apollo Beach in Volusia County. Historically, Playalinda and Klondike beaches were managed as part of the refuge. In 1975, with the establishment of the CNS, these coastal beaches were transferred to the National Park Service (NPS) as part of the Seashore. (The management authority between the FWS and NPS is outlined in Chapter I.)

Geographic and Physical Setting: The outer beach and dune system formed during the Holocene period and the interior island formed as a barrier complex with progressive dune ridges representing successive stages in growth. Therefore, the beach area is a Holocene feature that overlays the Pleistocene formations of Merritt Island. The dune ridge is part of Holocene barrier beach. The landscape profile at Merritt Island is characteristic of coastal barrier islands with an undulating ridge and trough (ancient sand dune and interdunal swale) topography that reflects the prehistoric coastal island development. Soils are of marine origin, are sand and shell, and are well drained and gently undulating. Most of these soils are in the Palm Beach and Canaveral soil series.

Current Conditions: Along the refuge's beach, all but one of the original residential homes was removed. The single home that still exists was used as an Astronaut retreat and is now used as a KSC meeting facility. Some infrastructure of the homes are still visible in the dune system, such as house pads, walkways, fence post, and the plumbing/septic systems that occasionally erode through the dune system. The CCAFS has constructed a weather/security tower on the south end of the beach inside the dune areas and a galvanized fence along the CCAFS-KSC boundary. Intermittent camera pads, the NASA Railroad, deep ditching associated with the Beach Road and the railroad, and a NASA corrosion experimental station occur within the dune and coastal strand habitats. The ditches and Railroad pose a threat to some wildlife serving as a barrier to movement and a pitfall (e.g., for beach mice, sea turtles, and gopher tortoises). On the north, NASA constructed a security observational tower known as Eagle 4. Both U.S. Air Force and NASA launch pad facilities are in close proximity to the beach. The presence of lighting on these structures poses issues of concern for disorientation of sea turtle during nesting and hatching.

The dune ridge area is in a fairly unaltered condition. Sand roads access this area from the north and south and the majority of the wetlands that border the west boundary have been impounded. No major human developments exist within this area. The area of refuge responsibility is the west side of the beach ridge, which is called the back barrier, meaning the area behind the barrier beach. The upland dunes are a transitional-scrubby habitat that typifies coastal strand vegetation with a few areas of grassy sand dune habitat.

The Merritt Island Refuge beach and dune ridge are part of the Canaveral coastal barrier complex. Only the refuge beach has an ocean-beach-dune interface. The dune ridge is the back-barrier part of the beach and is administratively separated from the ocean by land and water managed by CNS.

The refuge beach has a generally stable, low energy profile; however, the mid section receives more wave energy than the north or south ends. The higher energy section experiences erosion and the marine scarp extends to the dune face and into the transitional scrub (coastal strand) habitat. Erosion is threatening specific points of the beach and dune near the shuttle

launch pads and narrow areas along the dune ridge. Hurricane damaged dunes and overwash into the Railroad have required dune restoration activities. Beach and dune erosion monitoring was established as a coordinated effort between the refuge and KSC.

Recent erosion from oceanic storms and salt water intrusion has caused the westward migration of the beach into the coastal strand in both coastal segments, which creates open sandy dunes and returns the coastal strand habitat to early successional grass stages. The rate of beach and dune migration is being monitored by Dynamac Corporation for NASA in consultation with the refuge.

West of the refuge beach and dune system is oak scrub vegetation. Management here is focused on maintaining and improving habitat for the Florida scrub-jay The coastal strand is a scrub transitional community from the beach to back barrier habitats. The strand also serves as a buffer for protecting beach mice during storms. Hamilton (2002) provided management recommendations for the beach mouse. Threats to the beach system include litter, coastal erosion, and development of NASA and U.S. Air Force infrastructure.

The southern end of the refuge beach is a lower energy site with typical beach and dune foreshore development and with a low erosion upper beach. The upper sandy beach is largely bare with sparse vegetation, such as isolated beach plants (e.g., sea rocket, *Cakile* spp.). The dunes are vegetated primarily with sea oats (*Uniola paniculata*), morning glories (*Ipomoea* sp.), and typical dune grasses (Johnson and Barbour 1990), but do not have an extensive secondary dune field. There is a very quick transition from the primary/secondary dunes to coastal strand and a saw palmetto/scrub community.

Threatened and Endangered Species: Of the total area considered beach and dune habitat on the refuge, approximately 123 acres are primary beach and dunes. The loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), and leatherback sea turtle (*Derrmochelys coriacea*) nest on the refuge beach predominantly during April through September (Popotnik and Epstein 2002). Threats to nesting sea turtles include nesting and hatchling disorientation impacts from lighting along the beach from NASA and U.S. Air Force launch facilities, which has been documented.

The coastal beach and dune system provides important habitat for many listed species, including: threatened or endangered sea turtles and endemic species [e.g., southeastern beach mouse, (*Peromyscus polionotus niveicentris*)]. The Southeastern beach mouse, a subspecies of the old field mouse, may now be restricted to the undeveloped, contiguous beach systems of the Canaveral National Seashore, Merritt Island NWR, and the Cape Canaveral Air Force Station. The historic range of this small mammal has been reduced by approximately 80 percent. This suggests that the refuge is a core population area for this subspecies. The primary and secondary dune system is principal habitat for the Southeastern beach mouse at Merritt Island, however, recent studies have found the mouse in scrub habitat at Happy Creek (Becky Smith, personal communication). In a recent pilot study (Toombs 2001), beach mice were most often found along the primary dune line in areas where sea grape (*Coccoloba uvifera*) was abundant. In addition, Tombs noticed that beach mice were not normally found in areas of dense stands of saw palmetto, perhaps because the sand was too dense and difficult for burrowing. In many locations along the study area, small mammal communities are comprised of three species: old field mouse (*Peromyscus polionotus*), cotton mouse (*Peromyscus gossypinus*), and cotton rat (*Sigmodon hispidus*). Few beach mice appear to be

in the undisturbed beach and dune area of the CNS's northern beach and MINWR dune ridge (John Stiner, Canaveral National Seashore, NPS, personal communication). This finding, along with the observation that the cotton rat (*Sigmodon hispidus*) is most often found in the scrub areas where beach mice seemed to be excluded, may warrant further studies of the small mammal communities in this area.

Other Species: Wilson's plover (*Charadrius wilsonia*) may nest with or near other species of shorebirds using this system, but they commonly breed in single nests or scattered in loose associations with nests spread a good distance from each other (Epstein 1999). Generally, the beach is used by a diversity of species, seasonally low during the summer months and higher during fall and spring migration (Epstein, unpublished data; Stolen 1999)

C: BEACH AND DUNE MANAGEMENT

The beaches at Merritt Island National Wildlife Refuge are dynamic, being influenced by coastal storms and erosion. Overwash, salt spray, sand migration, and other natural processes assist in maintaining grassy dune fields and early succession vegetation states. In the absence of public use activities, natural forces work well to maintain this system. However, NASA will continue to protect KSC facilities along the beach and the refuge has assisted NASA with dune restoration by planting sea oats and bunch grass (*S. bakerii*) after storms caused severe erosion. The refuge also implements beach clean-up events to remove winter deposits of litter (Appendix D). Within the coastal strand, minimal management is necessary and is usually limited to exotic plant removal, prescribed fire for scrub-jay management, and secondary dune system enhancement for beach mice. To enhance beach and dune habitats, experimental habitat disturbance with a combination of mechanical chopping and fire is suggested to control the regrowth of shrubs and saw palmetto. Fire alone may not maintain a grassy dune system.

CHAPTER IX: ESTUARINE, WETLAND, AND SPOIL ISLAND HABITAT MANAGEMENT

A. ESTUARY, WETLANDS, AND IMPOUNDMENT BACKGROUND

A-1: HISTORIC CONDITIONS

The majority of the estuarine wetlands of the refuge are now impounded as a result of the original mosquito control activities conducted between early 1950 and mid 1960. Additionally, many acres of marsh islands were modified by dragline ditching and draining for the purpose of mosquito control. Between 1963 and 1993, the refuge installed as many water control structures in the impoundments as budgets would allow. In 1994, the refuge entered into a partnership with the Brevard Mosquito Control District (BMCD) and the St. Johns River Water Management District (SJRWMD) to reconnect the impoundments to the estuary by installing culverts through the dikes. The purpose of reconnecting the impoundments to the lagoon system was to enhance and restore hydrological connection. It also provided a limited means of managing water depths and vegetative community types. However, the new water control structures did not allow for complete control of water within the impoundments. The new structures could not prevent water from moving from the estuary into the impoundments when estuary water levels exceeded impoundment water depths. Additionally, over time, various agencies have installed different sized (riser) water control structures in refuge impoundments. Three or four different sized flashboard risers now exist, which has created much confusion in trying to manage these structures. The refuge standardized specifications for culvert riser widths in 1997 and the evolution of the design continues to include double riser, removable flapgates, and flashboard riser locks. The present design of flapgates incorporated the capability to adjust the height of the flapgate within the riser to lift the flapgate off of the bottom to prevent the flap from lodging in mud and debris accumulated in the structure.

Leenhouts (1982) developed the first wetland management plan for the refuge. In 1996, a plan was developed for restoration and enhancement of all impounded and modified wetlands on the refuge (Epstein 1997). This was a living document that included adaptive strategies for management of refuge wetlands. This document was modified in 1999 based on comments from BMCD (Table 3). However, this Habitat Management Plan incorporates and supersedes all previous plans.

Since 1972, the refuge has restored approximately 1,037 acres of the original marsh impoundments. As part of the recovery effort for the now extinct dusky seaside sparrow (*Ammodramus maritimus nigrescens*), a 533-acre impoundment (T-10-K) was restored in 1972. Since 1997, an additional 504 acres of impoundments have been restored to native wetlands through complete dike removal/restoration. Of these impoundments, one was located in the Banana River (i.e., T-22, U.S. Air Force Impoundment), one was located in the Indian River Lagoon (i.e., T-9), and five were located in the Mosquito Lagoon (i.e., V-1, V-2, V-5, T-45, and

Table 3. Merritt Island NWR impoundment characterization and recommendations, 2004.

[1] Featured Species Management: D = Waterfowl, S = Shorebirds, W = Wading Birds, F = Fisheries, TBR = To Be Restored, E = To Be Evaluated for Restoration

MANAGED IMPOUNDMENTS	**Featured Species[1]**		**UNDETERMINED IMPOUNDMENTS**	**Featured Species**		**UNMANAGED IMPOUNDMENTS**	**Featured Species**	
Mosquito Lagoon		***Acres***	***Mosquito Lagoon***		***Acres***	***Mosquito Lagoon***		***Acres***
T-27-A	D/S/W	1393	**Subtotal**		**0**	T-39-N	F (Restored)	29
T-27-B	D/S/W	717				T-39-S	F (TBR)	74
T-38	W	263	**Indian River**			T-41	F (TBR)	29
T-43	D/S/W	561	C-20-A	F/W (E)	898	T-42	F (TBR)	118
T-40	D/S/W	259	C-15-E	W	281	T-45	F (Restored)	40
T-44	D/S/W	260	C-20-B	F (E)	188	V-1	F (Restored)	88
V-3	D/S/W	428	T-10-M	D/W/S	1066	V-2	F (Restored)	61
V-4	D/S/W	183	T-21	D/S/W(E)	79	V-5	F (Restored)	47
Subtotal		**4064**	T-34		57	**Subtotal**		**486**
			T-37-A		10			
Indian River			Picnic Island	W	63	**Indian River**		
C-15-C	D/S/W	1463	***Subtotal***		**2642**	C-15-B	F (E)	553
T-16	S/W	893				C-15-D	F (TBR)	462
C21-36	D/S/W	404				C-20-C	F/S/W	345
T-10-B	S/W	38	**Banana River**			T-9	F (Restored)	148
T-10-F	D/S/W	137	T-25-B	S/W	110	T-10-A	F/S/W (E)	73
T-10-G	D/S/W	328	T-25-C	F	94	T-10-C	F/S/W (E)	63
T-10-I North	D/S/W	179	T-25-D		51	T-10-D	F/S/W (E)	173
T-10-I South	D/W/S	235	T-35		109	T-10-E	F/S/W	64
T-10-J	D/S/W	574	**Subtotal**		**364**	T-10-H	F/S/W	334
Triangle Pond	D/W	124				T-10-K	F (Restored)	533
T-10-L	D/S/W	716				T-17	F (E)	360
T-24-A	S/W/D	121				T-18-A	F (TBR)	200
T-24-B	D/S/W	217				T-18-B	F (TBR)	93
T-24-C	D/S/W	210	**Pad Impoundments**			T-37-B		58
T-24-D	D/S/W	2851	T-27-D		576	T-37-C	F (TBR)	28
Gator Creek	D/W	544	T-29-A		140	SHILOH 1 South A	F	65
Moore Creek	D/W	579	T-29-B		163	SHILOH 1 South B	F/S/W	184
Shiloh 1 North	D/S/W	375	T-33-A	S	86	**Subtotal**		**3737**
Shiloh 3	D/S/W	323	T-33-B		102			
Shiloh 5	D/S/W	910	T-33-C		221			
Subtotal		**11221**	**Subtotal**		**1288**	**Banana River**		
						C-21-B	(E)	433
						C-21-C North	F (E)	260
Banana River			**Featured Species**			C-21-C South	F (TBR)	39
T-25-A	D/S/W	357	Waterfowl Acres	Total	15685	C-21-D	F (TBR)	95
T-28-B	D/S/W	213	Shorebird Acres	Total	2512	T-28-A	F/S/W (E)	28
Subtotal		**570**	Wader Acres	Total	1505	T-30	F (TBR)	78
			Fishery Acres	Total	5013	Air Force A		47
			Undetermined	Total	1967	Air Force B	F	970
			Subtotal		**26682**	Air Force C	F	305
			To Be Restored	Total	1216	Air Force Restored	F (Restored)	56
			Restored	Total	-1002	**Subtotal**		2311
Managed			**Undetermined**			**Unmanaged**		
Total Acres		**15855**	**Total Acres**		**4294**	**Total Acres**		**6533**
			GRAND TOTAL	**25680**		**Total Restored**		-1002

T-39). Additional impoundment wetlands have been partially restored through efforts to improve Shiloh area dike roads in 2004 (approximately 35 acres were restored, including the removal of interior dikes within shilohs 3 and 5).

A-2: CURRENT CONDITIONS

The refuge manages 90,917 acres in the estuary, wetlands, and impoundments. Managing NASA lands and waters at the Kennedy Space Center (KSC), which includes a national wildlife refuge and mosquito control activities, requires a highly coordinated effort. Managing wetlands for multiple objectives (e.g., public use, fisheries, endangered species, shorebirds, wading birds, and waterfowl) with multiple partners (e.g., SJWMD, BCMCD, KSC, and Ducks Unlimited) may distract from the refuge's primary migratory bird management objectives. The refuge and NASA are working together to protect wetlands by minimizing and coordinating NASA developments and by restoring and enhancing wetland resources (National Aeronautics and Space Administration 2001). If all NASA considerations have been addressed (e.g., mosquito control activities to protect KSC workers), then the primary resource focus of wetland management would integrate refuge goals and objectives and would include mosquito control programs as necessary. Annual coordination efforts are necessary to integrate these sometimes conflicting programs. However, other agencies may expect that their management philosophies should be the wetland management program at MINWR (Brockmeyer et al 1997). The refuge has recognized these conflicts and incorporated multiple objectives into a wetland management program (Epstein 2001, Epstein and Lloyd 2001) that meets the requirements of multi-species management. Refuge management focuses on the vision, mission, goals, objectives, and purposes of the refuge, Refuge System, and the National Wildlife Refuge System Improvement Act (1997).

B. ESTUARINE LAGOON WATERS BACKGROUND

B-1: GEOGRAPHIC SETTING

The refuge's estuarine lagoon habitat encompasses a total of 53,069 acres, including waters in the Indian River Lagoon, Mosquito Lagoon, and Banana River. Collectively, the waters of the estuary form part of the northern Indian River Lagoon system, which extends 156 miles from Ponce Inlet to Jupiter Inlet on Florida's east coast. The estuary habitats on and near the refuge have special state and federal designations, including: Merritt Island National Wildlife Refuge (U.S. Fish and Wildlife Service), Canaveral National Seashore (National Park Service), Estuary of National Significance (Environmental Protection Agency and SJRWMD), Essential Fish Habitat (National Marine Fisheries Service), candidate Marine Protected Area (National Marine Fisheries Service), Outstanding Florida Waters (State of Florida), and aquatic preserves (State of Florida).

B-2: PHYSICAL SETTING

The waters of the estuary are characterized by generally large, shallow, saline to brackish basins that do not have a direct, nearby connection to the ocean. The closest inlets to the ocean are Ponce Inlet (20 miles north) and Sebastian Inlet (40 miles south). And, Port Canaveral is located just to the south of the refuge. The lagoon waters of the refuge experiences very little daily tidal amplitude. The lagoon waters are affected by the seasonal

tidal amplitude, produced by the equinoxes (sun and moon gravitational affects that produce spring tides), which raise the waters of the lagoon system in spring and fall. The fall amplitude brings the highest water level conditions to the lagoon waters and to refuge wetlands. However, wind speed and direction directly affects daily lagoon amplitude. A strong southerly wind will push water northward in the lagoon and increase water levels or river amplitude in the northern Indian River Lagoon and Banana River. At the same time, this wind could lower river amplitude in the Mosquito Lagoon as the water is pushed to the north. The inverse would hold true as well: northerly winds blow water south in the Mosquito Lagoon and in the Indian River Lagoon. Salinity is largely a factor of seasonal rainfall. The Atlantic Intracoastal Waterway (ICW) traverses the refuge through the lagoon waters through Mosquito Lagoon, Haulover Canal, and the Indian River Lagoon.

B-3: HISTORIC CONDITIONS

Historically, the lagoon waters were largely undisturbed systems that fluctuated with natural conditions. The Mosquito Lagoon became connected to the Indian River Lagoon by means of early settlers digging a shallow channel, later called Haulover Canal, between the two systems for the purpose of moving their boats across the narrow upland bridge of Merritt Island that separated the two water bodies. Except for the Intracoastal Waterway that was developed between the early and middle 1900s, the lagoons were generally shallow flats that support highly productive seagrass beds. Extensive submerged beds of seagrasses form the vegetative nursery and bases for an aquatic community of oysters, clams, shrimp, crabs, and hundreds of species of fish that thrive in the warm, shallow waters. The construction of the ICW was a national effort (ca. 1930s) to provide an interior navigational waterway system. By the 1950s and 1960s, the U.S. Army Corps of Engineers assisted Kennedy Space Center, NASA and the Cape Canaveral Air Force Station, U.S. Air Force in developing a waterway system within the KSC boundary for navigational needs to transport equipment and materials to support the space program. Most of these lagoon alterations were confined to the Banana River and contiguous waterways. Additionally, development of the infrastructure of KSC and CCAFS (e.g., roads, launch pads, and area facilities) required extensive dredge and fill operations that extensively modified some of the Banana River lagoon bottoms and isolated Banana Creek and Happy Creek from the Banana River.

As a result of these activities, deep borrow pits exist in the northern Banana River; deepened waterways exist throughout the lagoon system; and dredge spoil islands are found throughout the Mosquito Lagoon, Indian River Lagoon, and Banana River systems. The spoil islands follow the waterway channels and many have become important bird rookery areas. Various restrictions to public access into the north Banana River by the Service, NASA, and the U.S. Air Force has created an important fish and wildlife sanctuary area.

Mosquito Lagoon is considered developmental habitat for sub-adult loggerhead and green sea turtles (Mendonca et al 1982) and once supported vast numbers of wintering juvenile sea turtles. Mosquito Lagoon was thought to have supported thousands of sea turtles at one time (Ehrhart and Yoder 1978). A sea turtle fishery that persisted into the 1960s was thought to contribute to the worldwide declines in sea turtle populations.

Juvenile sea turtles may remain in the Mosquito Lagoon until maturity. Turtles wintering in the lagoon system are plagued by winter freezes, which can cold stun the animals and can cause mortality. The refuge has developed a plan to coordinate the handling of cold stunned turtles

and prevent mortalities (Epstein 2001, Provancha et al 2005). Monitoring of wintering sea turtles in the Mosquito Lagoon in the mid 1970s (Ehrhart and Yoder 1978) found higher numbers than presently found (Provancha et al 2002). Today more sea turtle fibropapillomas and higher numbers of green sea turtles are found in Mosquito Lagoon then previously reported.

B-4: CURRENT CONDITIONS

Based on 1999 aerial imagery, the refuge consisted of a total of 27,065 acres of seagrass beds, including in Banana River (10,306.42 acres), the Indian River Lagoon (5,278.68 acres), and Mosquito Lagoon (11,479.85 acres) (Joe Beck, St. Johns River WMD, personal communication). The refuge's seagrass beds are some of the highest quality in the lagoon system, presumably from the undeveloped nature of the upland landscape surrounding the lagoon waters (Virnstein 1999). Four species of seagrasses are common to the refuge: shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), turtle grass *(Thalsssia testudinum*), and widgeon grass (*Ruppia maritima*). For the most part, the seagrass meadows have remained unchanged over the past 55 years in refuge waters (Virnstein 1999), except for widespread prop-scaring from outboard motors in the shallow waters of the Mosquito Lagoon. In 2001 the refuge brought this issue forward during the refuge's Wildlife and Habitat Management Review (U.S. Fish and Wildlife Service 2003). The issue of public opportunities for high quality fishing on the refuge was coupled with concern regarding prop scarring and wildlife and habitat disturbance. What later developed into the Mosquito Lagoon Pole/Troll Zones was segregated from the CCP as an independent element due to growing concern about the loss of habitat and reduced quality of fishing and aquatic resources. As a result, the refuge took immediate action to develop a phased approach to improve the quality of the fishing experience and to enhance habitat protection by creating poling and trolling only zones in the north Mosquito Lagoon (around Tiger Shoals and WSEG boat ramp). Additional areas may be added in subsequent years to increase the quality of the fishing experience and to provide needed habitat protection.

Water quality and clarity are critical components in the distribution patterns of the seagrass beds. The shallow lagoon waters are considered important seagrass habitat with a logical connection to the density of many fish and macrofaunal invertebrates using the refuge's estuarine waters. This designated Essential Fish Habitat (Magnuson-Stevens Act, 16 U.S.C. 1801 et seq). has an estimated fisheries economic impact of about $12,000 per acre per year (Virnstein and Morris 1996). Based on this estimate, the 27,000 acres of seagrass within refuge boundaries contribute over 300 million dollars per year to the area in fisheries resources. The seagrass communities are presently being mapped and monitored by the SJRWMD and KSC. The refuge's seagrass community represents 40% of the grass beds in the entire Indian River Lagoon. Refuge efforts to protect and restore seagrass habitat is consistent with local, state, regional, and national goals.

The Indian River Lagoon system is characterized by high biodiversity and productivity and is ranked as one of the most diverse systems in the world. There are 132 fish species identified in the lagoon waters of the refuge (Paperno 2001). The horseshoe crab (*Limulus polyphemus*) generally inhabits estuarine systems and was very common in refuge waters. In recent years, researchers have noticed a steep decline in the numbers of horseshoe crabs (Jane Provancha and Gretchen Ehlinger, personal communications). The reason for the decline in horseshoe crabs is presently unknown. Horseshoe crabs serve as a keystone species in the lagoon and influence species diversity and productivity. Horseshoe crabs and their eggs are a vital prey

component of numerous species, including the threatened loggerhead sea turtle, migrating shorebirds, and many species of fish.

Very large numbers of migratory and resident waterbirds use the estuary waters in and around the refuge for feeding and loafing. Within the Atlantic Flyway, no other site winters such large numbers of lesser scaup - - a waterfowl species well below national levels/goals of the flyways and the U.S. Fish and Wildlife Service. The refuge is an area of national importance, harboring up to 62% of all Atlantic Flyway wintering scaup and 15% of the continental population (Herring 2003). However, scaup populations wintering at the refuge have declined over the last six years. The refuge lagoon waters also harbor important colonial wading bird nesting rookeries and roost sites. Natural marsh and spoil marsh islands are used extensively by several key wading bird species, Florida mottled ducks, Wilson's plover, and other shorebirds for nesting and loafing.

The open water estuary habitat has some of the most renowned sport fishing sites in the world (Roberts et al 2001). This system also serves as a wintering area for federally listed sea turtles, sustains resident manatee populations and overwintering migratory bird populations, and supports one of the riches fisheries in the south Atlantic. This system is essential to several interjurisdictional and economically important fishes, including snook, tarpon, red drum, black drum, spotted sea trout, and striped mullet. Maintaining the biological integrity and diversity of this system, while providing fish and wildlife-oriented recreation where appropriate and compatible is a National Wildlife Refuge System mandate.

The refuge faces threats and impacts from an ever increasing human population and the associated demands for recreational and commercial use of the refuge. Refuge management is hampered by a lack of information regarding the resources protected by the refuge and the management actions necessary to adequately sustain viable fish and wildlife populations into the future. Recreational and commercial harvesting activities have increased and expanded in refuge waters to include fin fishes, mollusks, and crustaceans. Recreational and commercial boating activities have damaged seagrass beds through prop dredging and may also disrupt wildlife populations.

Contiguous estuarine wetlands on the refuge were largely impounded for mosquito control as previously mentioned. However, a small amount of remnant salt marshes remain that were not impounded and some areas that were modified remain un-impounded. These estuarine marshes are characteristically high marsh (above mean high water) wetlands and vegetated mostly by glasswort, saltwart, salt grass, sea purslane, mangrove, bunch grass, and other species (Montague and Wiegert 1990). The refuge has been very active in identifying diked or draglined ditched marshes that can be restored towards a natural state.

Merritt Island National Wildlife Refuge is moving forward to meet the challenge of biological conservation at ecosystem levels. The National Wildlife Refuge System (NWRS) Improvement Act of 1997 provided a Wildlife First mandate for refuges, which includes all fish, wildlife, and plants as priority considerations. The refuge provides habitats for endangered species, waterfowl, migratory birds, and fish, as well as opportunities for public use and enjoyment. Multiple landscape issues, such as NASA development at KSC and mosquito control, as well as listed species, migratory birds, exotic species control, public access and use, ecosystem restoration, and biological integrity are addressed within this document. Refuge management activities are consistent with local and regional goals and national policy (e.g., Endangered

Species Act, NWRS Improvement Act, Essential Fish Habitat, National Estuary Program, endangered species' recovery plans, North American Waterfowl Management Plan, and Partners in Flight). As leaders in natural resource conservation, the Service is obligated to confront these issues and consider management alternatives. The Merritt Island National Wildlife Refuge is working with others to accomplish goals, adapting new concepts and meeting the challenge of national mandates.

C. MERRITT ISLAND NATIONAL WILDLIFE REFUGE BIOLOGICAL PROGRAM

Specific wildlife and habitat goals and objectives are detailed in the CCP and later in this Chapter.

C-1: RESOURCES OF INTEREST

Interior Wetland Characterization

The wetlands of the refuge are largely determined by the characteristics of the coastal geological formation and soil types. Deposition of materials under maritime conditions created ridge and trough topography that profiles sandy ridges and wet, inter-ridge (dune) swales. The ridge and trough topography is a distinct landscape feature on the refuge. Much of the refuge's wetlands lie interior of the estuarine boundaries and interspersed within the upland habitats as trough or swale marshes, or ephemeral wetlands. The depth of these wetlands varies and many are ephemeral, but have characteristic wetland plants in a grassy state (e.g., *S. bakerii*) or a mixture of grasses and shrubs (e.g., *Salix spp*.). Some of the deeper swales have floating-leaved aquatic plants. The wetlands are highly interspersed throughout the refuge's landscape and include forested, freshwater woody wetlands with hydric hammocks of oaks (*Quercus* spp., cabbage palmetto, and maple (*Acer spp*.). Many man-made or modified features exist, such as borrow pits, ditched areas, and impoundments (National Aeronautics and Space Administration 2001). (Wetlands impounded for mosquito control are described in the next section).

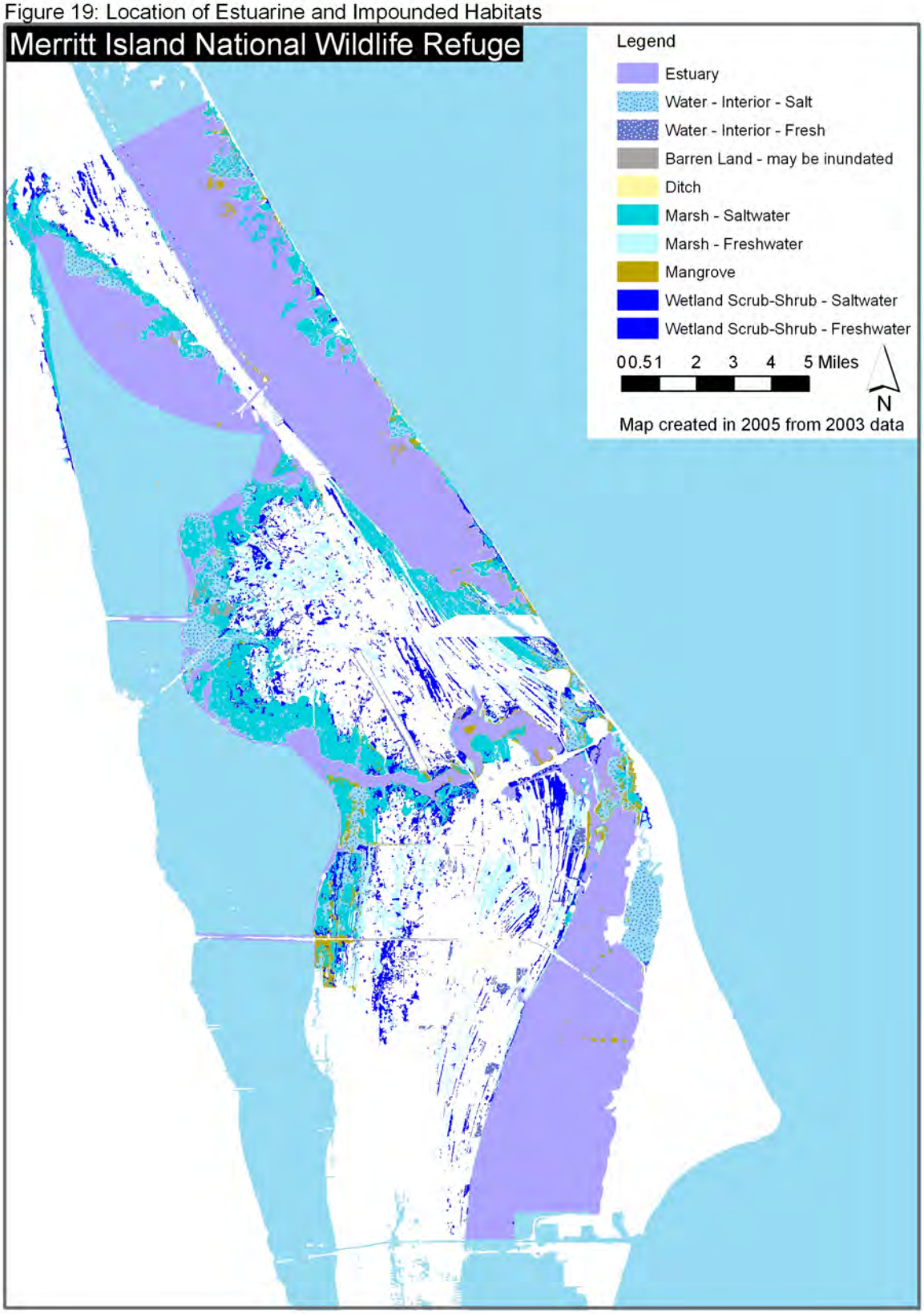
The interior wetlands are a key ecological feature of the refuge's landscape due to the coastal ridge and swale topographic and physical profile. The majority of these wetlands are not a part of wetland manipulations, but are managed passively within the confines of the upland blocks or the refuge's burn units, as integrated landscape features. Where hydrology has been altered and/or fire suppression has caused the wet swales to succeed to woody vegetation, mechanical manipulation or herbicides may be used for vegetation restoration. These wetlands would primarily be managed as part of the contiguous upland landscape. Where altered, efforts to restore natural features would be made to mimic natural functions. (Additional information on interior wetlands is located in Chapter IV, Shrubland Management and in Chapter V, Forest and Woodlands Management, of this HMP.) The locations of wetland and estuarine habitats are shown in Figure 19.

Impounded Wetland Characterization

The characterization of impounded wetlands is based on management and organized by both location and management type. Impoundments were evaluated for their potential for wetland wildlife management, fisheries management (including reconnecting and managing as open), or full restoration (see Table 3). A recent evaluation of the impoundments was conducted by the MINWR staff as part of the CCP planning process in 2004. The impoundment designations

were refined to include: Managed Impoundments which are essential to the mission of the refuge, Undetermined Management, a flexible option for wildlife-aquatic management, Rotational Impoundment Management [RIM], available for restoration or enhancement, or Unmanaged which are available for complete restoration (see Table 3 for designations). Impoundments are further defined by the featured species of management or primary action influencing management.

Figure 19: Location of Estuarine and Impounded Habitats



C-2: IDENTIFICATION OF HABITAT REQUIREMENTS

Primary management (actively managed) impoundments are those that have the greatest potential for management to meet the habitat requirements for wetland wildlife, particularly migratory birds. Habitat requirements include the daily, seasonal, or annual manipulation of water depths for the primary purpose of providing specific wildlife habitat conditions (e.g., providing specific water depths, vegetative community, and cover types to serve migratory birds). This includes multiple species consideration for desirable interspersion of open water areas for waterfowl, shorebirds, wading birds, other wetland wildlife, and fisheries, as well as for mosquito control. Primary management impoundments would not be considered for restoration activities due to their contributions to wildlife. Featured species management is a designated focus on a species group; however, the management provides integrated multiple species use and benefits. For example, an impoundment designating fishes as the featured species may also provide specified wildlife benefits for wading birds.

Impoundments that have marginal management potential or those that are not critical to the mission of the refuge are included in the Undetermined Management category. However, the undetermined designation also denotes that there could be issues (e.g., mosquito control concerns or other landscape consequences) associated with restoration (see Table 3). Impoundments designated as Unmanaged were impoundments that had few to no consequences for restoration, had already been restored, were already identified to be restored, or had a high potential for restoration and fisheries. Restoration involves the full removal of the dike system and restoration of a natural-like shoreline to provide full hydrological connectivity to the estuary.

All refuge impoundments were evaluated for their resource management and restoration potential. When deciding whether to restore or reconnect (i.e., add culverts to) an impoundment, the refuge worked with BCMD. If the BMCD was concerned that restoration would create a mosquito production issue, the site was included in the undetermined category. An unmanaged impoundment is one that is kept open and flowing (i.e., the water control structures are left open, if present or reconnected) and features fisheries as the primary management. If a reconnected impoundment produces unacceptable levels of mosquitoes, then the water control structures (WCS) could be used to flood the unit for mosquito control. If an impoundment has been designated as unmanaged with open WCS and does not produce mosquitoes, it could be reconsidered for restoration at a later date. However, open impoundment management is a management regime that is also used as a means to manipulate vegetative communities or rejuvenate bottom sediment conditions in actively management units that are not designated for restoration.

Impoundments characterized for restoration were determined not to be manageable for wildlife for various reasons and were approved for restoration by BMCD. For these impoundments, restoration means dike removal and the restoration of a natural shoreline based on pre-impoundment conditions. This effort was recommended to benefit fisheries management and as an estuary enhancement endeavor. The refuge is working with KSC to develop restoration plans for the estuary and interior wetlands (National Aeronautics and Space Administration 2001).

Impoundment Management

About 75 marsh impoundments are managed either passively (which means they are managed as open) or actively as a complex of wetlands. Including the eight impoundments that have been completely restored, this mix provides a diversity of habitats for multiple species. Impoundments may be restored, managed as open units with open culverts, or actively manipulated to provide variation in seasonal water depths. Some impoundments have little or no connection to other impoundments or to the estuary (e.g., impoundments around the shuttle launch pads). Actively managed impoundments mimic natural systems to a large degree, depending on the primary management objectives of a particular impoundment. Brackish water management requires a balance between fresh and saline water, but emulates natural environmental cycles to promote desirable (suitable) native plant communities. Suitable habitat in actively managed impoundments (low marsh wetlands) is the interspersion of open water and vegetative communities that have desirable species composition (e.g., Ruppia spp., *Najas spp*., or *Chara spp*.) and seed producing emergents (e.g., *Seteria spp., Scurpus spp*., or *Echinochloa spp.*). Suitable habitat avoids monotypic stands of vegetation (e.g., *Typha spp., Salix spp*., or *Distichlis* spp.) and enhances the diversity of habitats and species richness. Wetlands are deemed unsuitable for many species with rank stands of undesirable or exotic vegetation, or it lacks the desired interspersion or ratio of open areas to vegetative cover or because they could lack proper water depth conditions. Wetland management directs vegetative succession to produce the desired conditions (e.g., using drawdowns, employing extended flooding, or providing preferred seasonal water depths). However, management is geared to improve habitat conditions and once habitats are suitable, water depths are then manipulated seasonally for wildlife. In the high marsh wetlands, such as where the bottom elevation of the marsh is high and does not support submerged vegetation and where extensive stands of *Spartina bakerii* predominate, water level management is secondary to prescribed fire in controlling undesirable species (e.g., encroaching brush and other shrubby vegetation). Prescribed fire is used to direct vegetative succession to maintain the grassy *S. bakerii* wetlands (high marsh wetlands).

Rainfall is the single most important abiotic feature to influence impoundment management and it is the only source of freshwater regulating salinity. Rainfall patterns naturally vary (see Figure 20), especially with hurricanes (Figure 21). Observed monthly rainfall commonly varies outside monthly averages, either higher or lower. Months of highest precipitation are usually between June and October (see Figures 22 and 23). Capturing rainfall during this time is necessary to maintain desirable salinities and preferred vegetative responses. However, August, September, October, and November can be characterized by tropical storms and hurricanes, which can account for 10-15% of annual rainfall (Mathews et al 1980; see Figure 21). Rainfall for these months averages 43% of annual rainfall for the refuge (see Figure 22). Periods of extreme high or low precipitation patterns can raise or lower salinities within the entire lagoon system. During 1998, for example, conditions were extremely dry (see Figure 23), resulting in hyper saline conditions in the lagoon system. Drought conditions persisted until a tropical storm event in 1999. Periods of extensive rainfall during tropical cyclones may cause flooding in impoundments and cause dike washouts. Most impoundments have an upper limit of one and three quarters to two-feet above mean sea level before they begin to drain across dike spillways. Many dikes will overwash when water level exceeds two feet mean sea level. Precautions to drain the impoundments by approximately six inches or more below these elevations before the arrival of a tropical cyclone is prudent, however, management actions may depend on the predicted precipitation.

Wetland vegetation and plant succession is altered by drought conditions and the recovery of aquatic plant productivity may take several years. Precipitation patterns highly influence how impoundments can be managed and rainfall is the primary source of freshwater. Therefore, close attention to seasonal precipitation patters is important to coordinate wildlife and habitat objectives with water management, salinity, and water depth objectives. For example, drawdowns (for drying) can be most effective during periods of low rainfall.

The seasonal tidal fluctuation in the lagoon system follows a seasonal trend (at the equinoxes) (see Figure 24). There is virtually no daily tide. However, the daily and monthly mean levels can and do vary depending on wind speed, wind direction, and rainfall. There are short term opportunities to capture wind tides. Wind effect can dominate tidal amplitude.

Figure 20: Variability in monthly precipitation patterns, Merritt Island NWR, 1986-2005

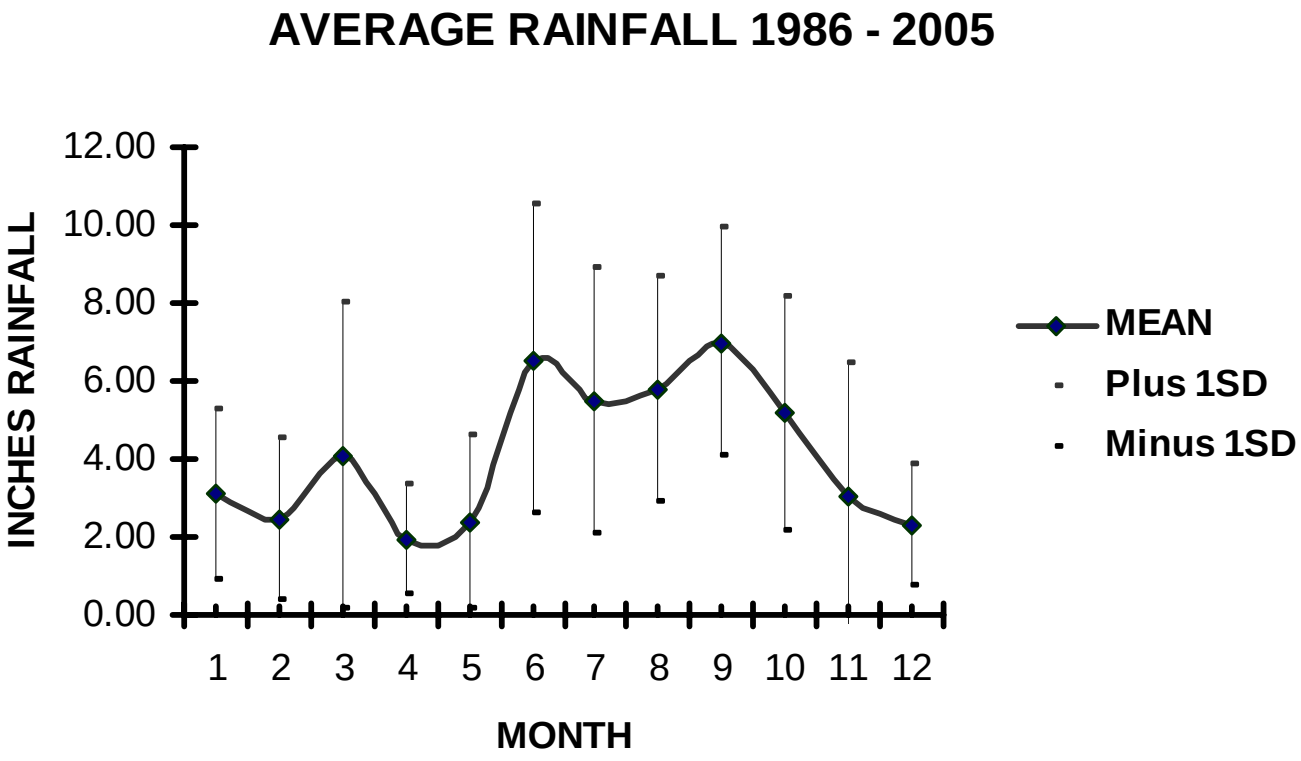
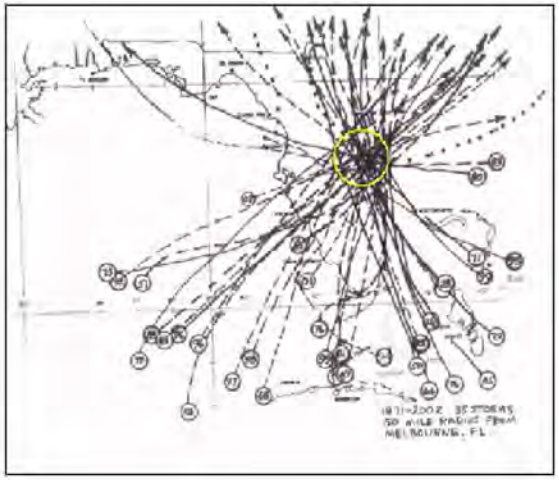


Figure 21: Tropical clclone tracks in the vicinity of Melbourne, Florida (Left) (Used by permission of JohnWilliams.
Percent of total precipitation resulting from tropical cyclones 1931-1960 (Right) (After Mathews et. al. 1908)



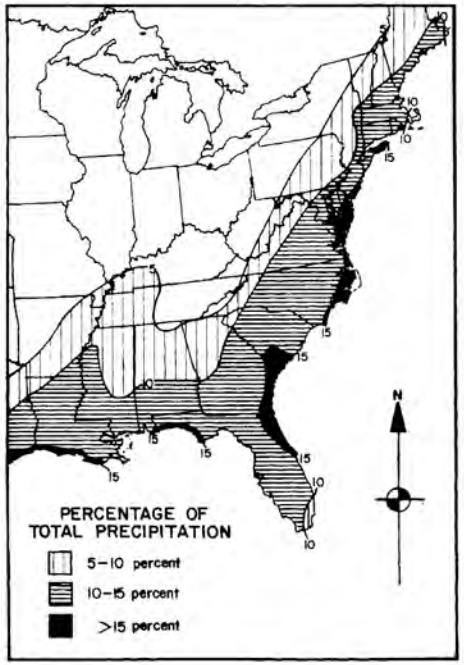


Figure 22: Seasonal variation in annual precipitation for Merritt Island NWR, 1986 - 2004. Tropical (hurricane season) includes the months of June, July, August, September, October, and November).

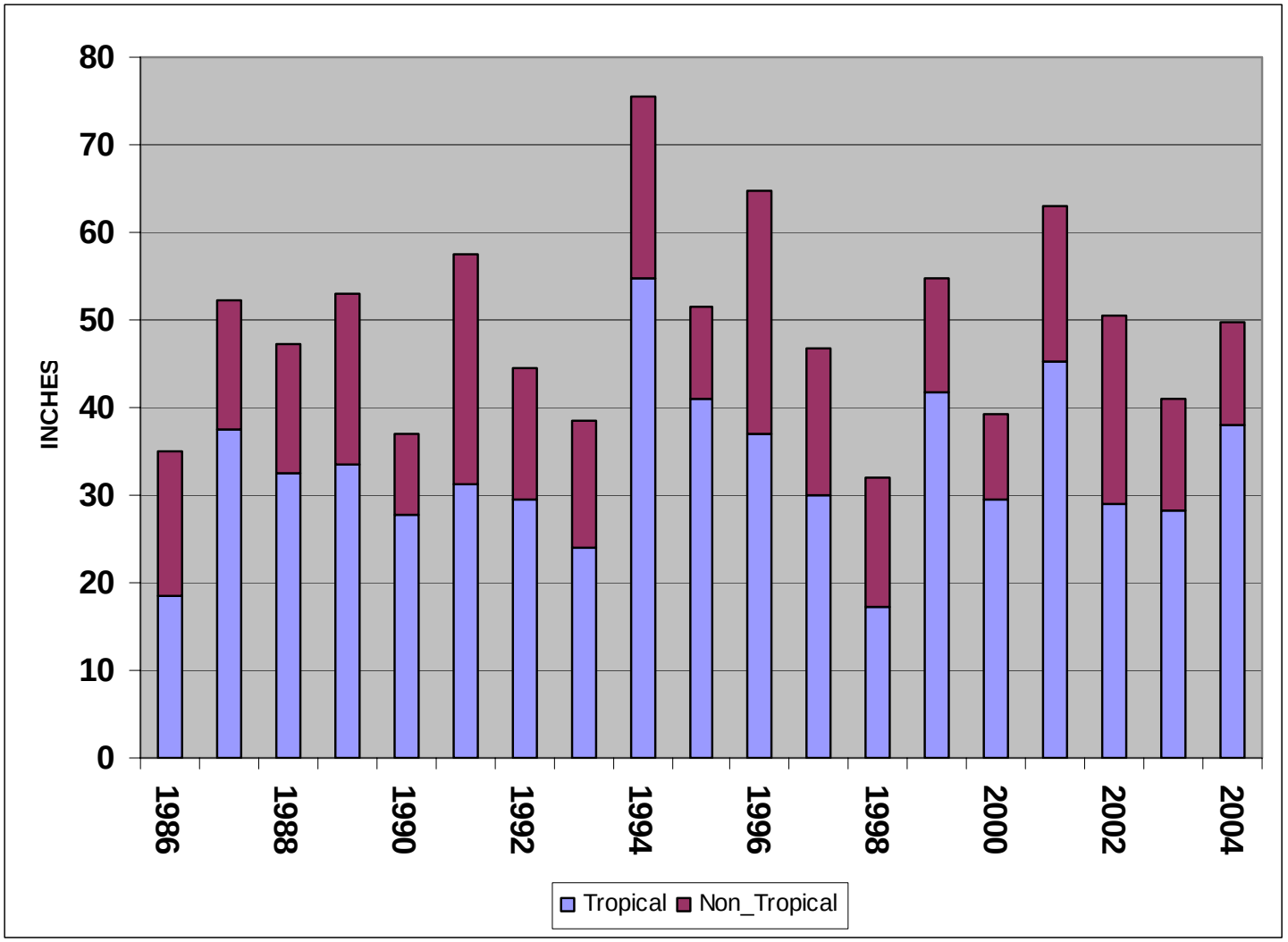


Figure 23: Monthly total and average precipitation 1986 through 2005, Merritt Island NWR. Average rainfall is shown as a repeating mean the period 1986-2005.

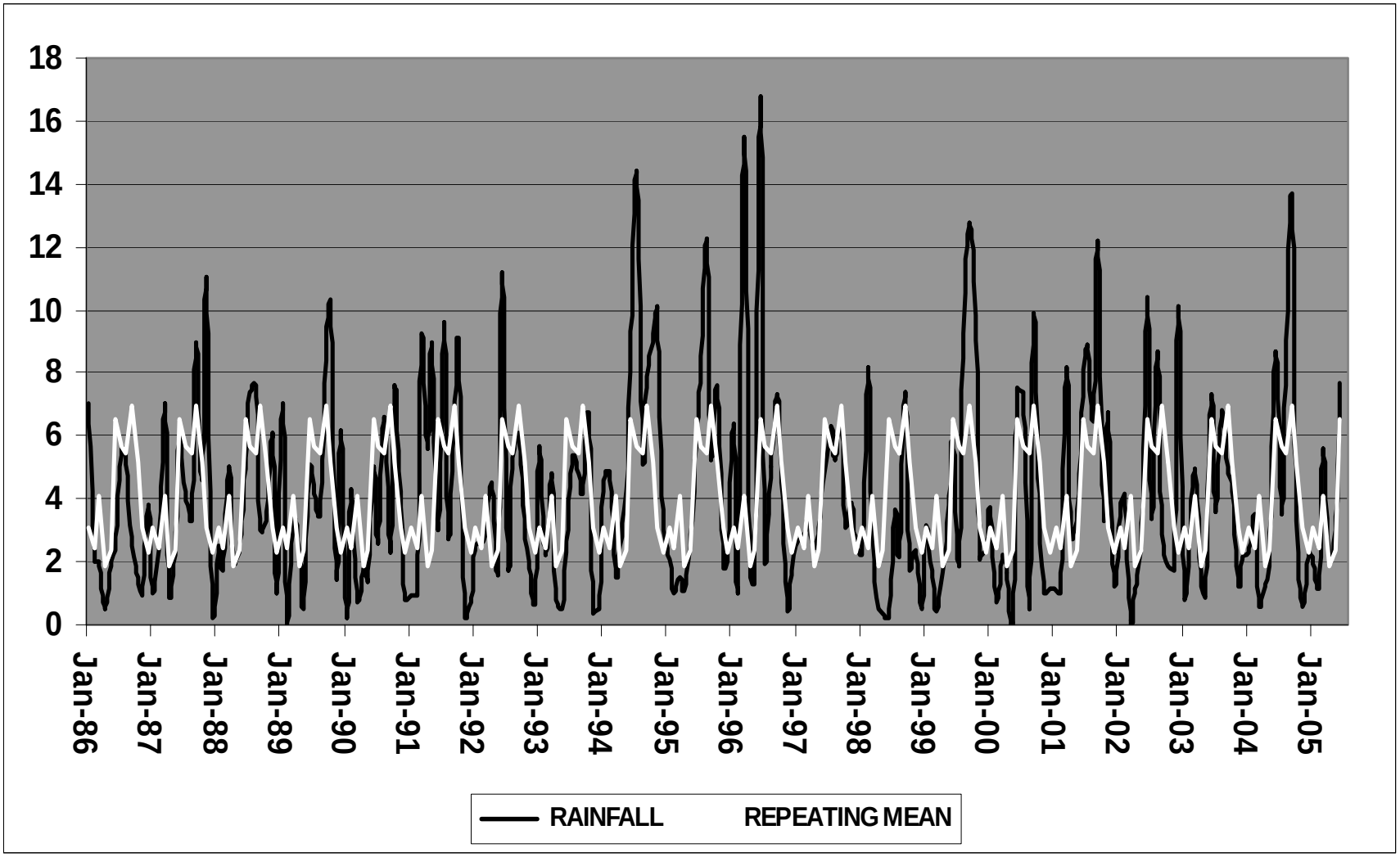
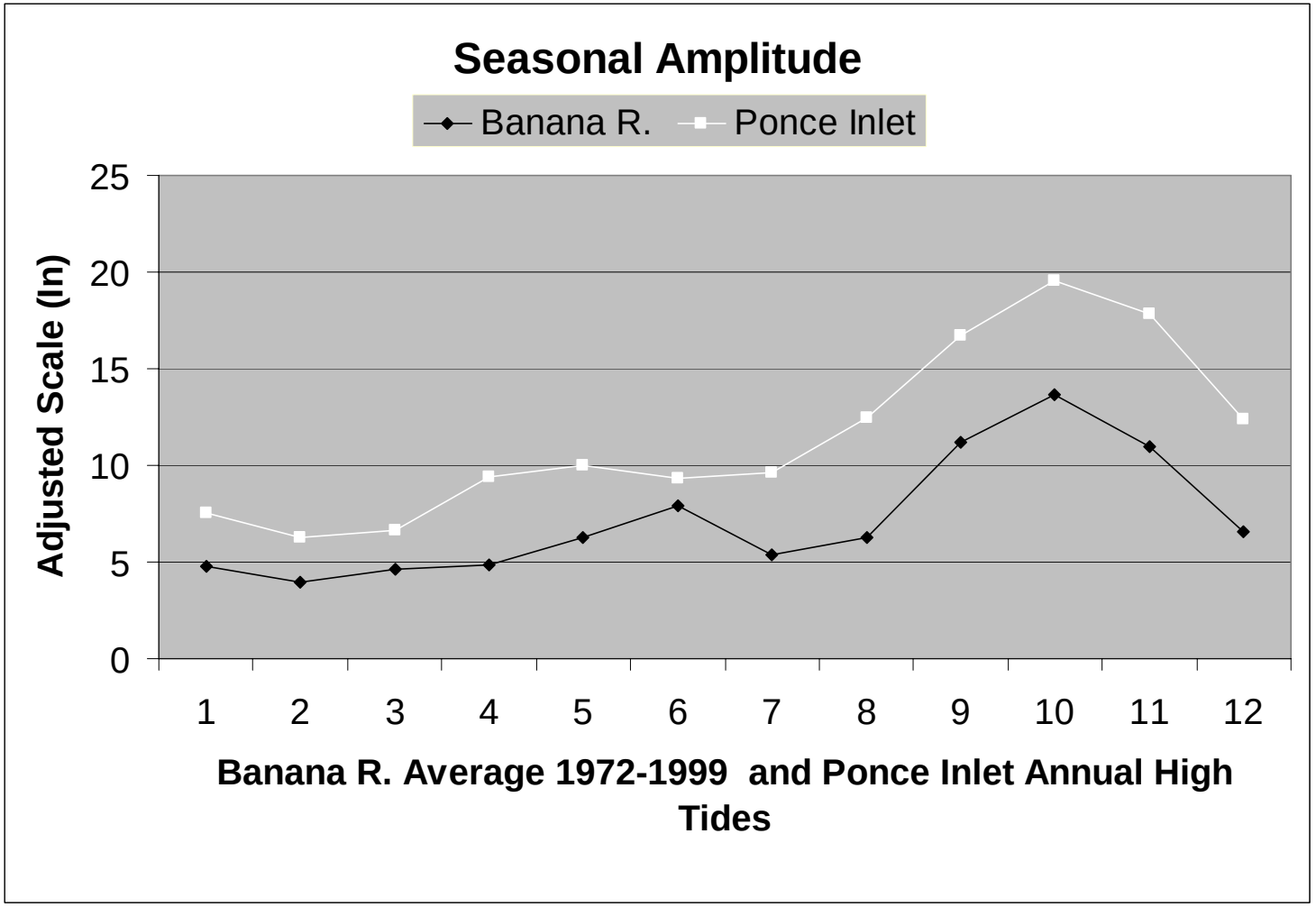


Figure 24. Monthly and seasonal tidal amplitudes in the Banana River and Port Orange, FL . Banana River data reflects monthly water level readings (inches above MSL) (BMCD 1972-1999). Port Orange data reflects monthly, mean high tide range (National Ocean Service 1995).



D: GOALS, OBJECTIVES, AND STRATEGIES

The Merritt Island National Wildlife Refuge CCP outlines goals, objectives, and strategies which include management actions related to the impounded wetlands, interior wetlands, and habitats of the estuary. The CCP outlines three goals that are applicable to impounded wetlands management: Goal 1. Rare, Threatened, and Endangered Species; Goal 2. Migratory Birds; and Goal 4. Wildlife and Habitat Diversity. Interior wetlands are addressed under Goal 4. Wildlife and Habitat Diversity. Three goals address habitats of the estuary: Goal 1. Rare, Threatened, and Endangered Species; Goal 2. Migratory Birds; and Goal 4. Wildlife and Habitat Diversity.

D-1: GOALS, OBJECTIVES AND STRATEGIES ADDRESSING IMPOUNDED WETLANDS

1. Rare, Threatened, and Endangered Species

WILDLIFE AND HABITAT MANAGEMENT GOAL 1: Preserve, protect, and enhance populations of rare, threatened, and endangered species of plants and animals at existing or increased levels on the refuge and preserve, protect, manage, and restore their native east central Florida coastal and estuarine habitats occurring on the refuge to contribute to recovery goals.

1.f. Wood Stork

Wildlife and Habitat Management Objective 1.f(1): Within the 15-year life of the CCP, re-establish wood stork nesting on the refuge to support wood stork recovery efforts.

Wood storks historically used Merritt Island, but did not start breeding on the refuge until 1972 in the Moore Creek impoundment (Clark and Lee 1982). The Moore Creek impoundment (579 acres) is one of the former, large wood stork nesting colonies on the refuge, but wood storks have also been recorded breeding on Bird Island (in Mosquito Lagoon) (Clark and Lee 1982), Blue Bill Creek in the north Banana River, Peacocks Pocket Island, and Mullethead Island (U.S. Fish and Wildlife Service 1996).

The Moore Creek wood stork rookery was the largest and most consistent of the wood stork rookeries, where nest numbers peaked in 1980 (at 350 nests) and varied in number until 1986. A severe freeze occurred in 1985-86 that destroyed all of the mangrove nest sites. Although there were 250 nests in 1986, the storks abandoned the rookery and no confirmed nesting has occurred at this site since 1986. In 1997, 25 wood stork artificial nest structures were constructed and installed at the former rookery area in hopes of restoring the rookery. However, great blue herons are the only bird to use the structures to date. Approximately 200 to 300 wood storks currently using the refuge for feeding and roosting, with the highest densities occurring in winter.

Strategies related to Objective 1.f(1) are listed.

- Within 15 years, evaluate the management options to restore the historic breeding wood stork populations on the refuge.
- Continue to evaluate the 25 artificial nest structures installed to encourage wood stork nesting in former rookeries.
- The artificial nest structures are designed to be removed if the program does not attract nesting storks. The nest structures can then be used on other sites/refuges if not productive at this site.

- Develop water management schedules to enhance feeding and nesting opportunities.
- Consider improving wood stork feeding habitat in C-15-E.

2. Migratory Birds

WILDLIFE AND HABITAT MANAGEMENT GOAL 2: Maintain and actively manage refuge coastal barrier island wetlands and uplands primarily to contribute to migratory bird priorities of the refuge and Peninsular Florida Physiographic Area, while providing consistency with regional and national goals.

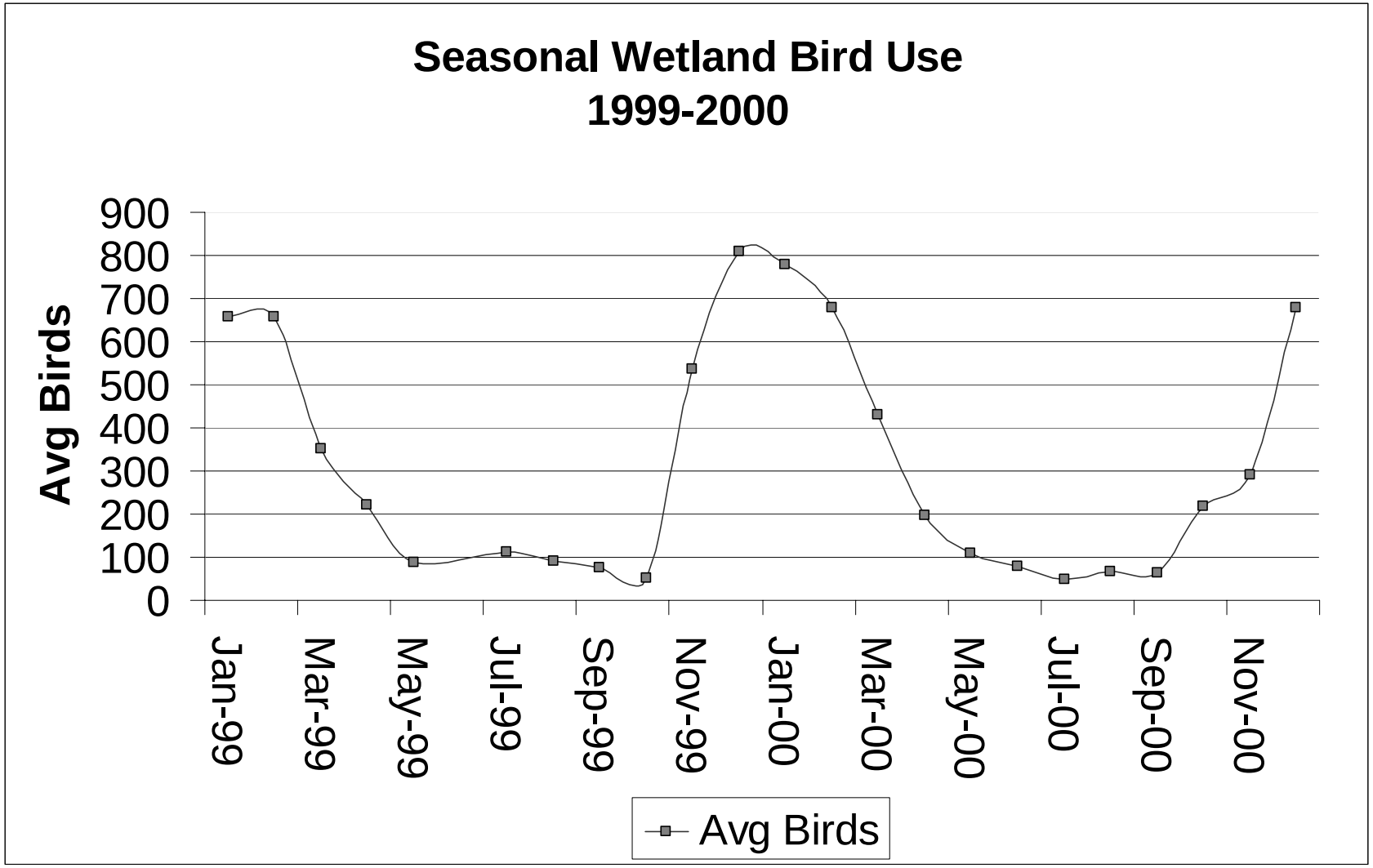
Under this goal, several objectives are pertinent to management of the refuge's wetland areas. These cover management actions concerning waterfowl, shorebirds, and wading birds, along with the construction and maintenance of water control structures. Therefore, the strategies are not species specific, but are listed collectively to reflect the management of wetlands for multiple species and featured species groups (Epstein 1997, Epstein 2002). The wetland management program is geared towards habitat management and not species specific management. The refuge's annual impoundment management and habitat monitoring program identifies specific impoundment water management and habitat objectives. The monitoring process would help guide evaluation of the water management program (Lyon and Epstein 2005).

Seasonal Wildlife Use Patterns

Monitoring Bird Use - Use of wetland habitats by migratory birds, including seasonal shifts in resident species, reflects the chronology of migration of species groups and habitat conditions. In 1999, the refuge enlisted about 12 volunteers from local nature groups to monitor birds using refuge impoundments. The volunteer bird monitoring program enlists volunteers and assigns them each to a specific marsh impoundment. Volunteers count the birds in their assigned areas at their convenience on the 10^{th}, 20^{th}, and 30^{th} of each month, plus or minus two to three days before or after these count days. During 1999 and 2000, over 630 observations counted 184,887 wetland birds among 14 sites (see Figure 25). This program continues to monitor wetland birds. The present database exists for the years 1999-2005 and is being analyzed with the assistance of the USGS Cooperative Fish and Wildlife Unit at North Carolina State University.

These data have provided insight into the seasonal patterns of birds using the refuge. The data are being further broken down by species groups and correlated with environmental data. The refuge is now able to depict seasonal migratory use patterns by species groups, such as waterfowl, waders, divers, raptors, shorebirds, and rails. The data can be further broken down to the species level to show the predominance of some species using an area over others. It provides important information. For example, shorebirds are the primary user group on a system managed for waterfowl, while dunlins are the one dominant species. The data also provide insight into seasonal migratory variation of these species, their responses to different water level conditions, and long-term management insights.

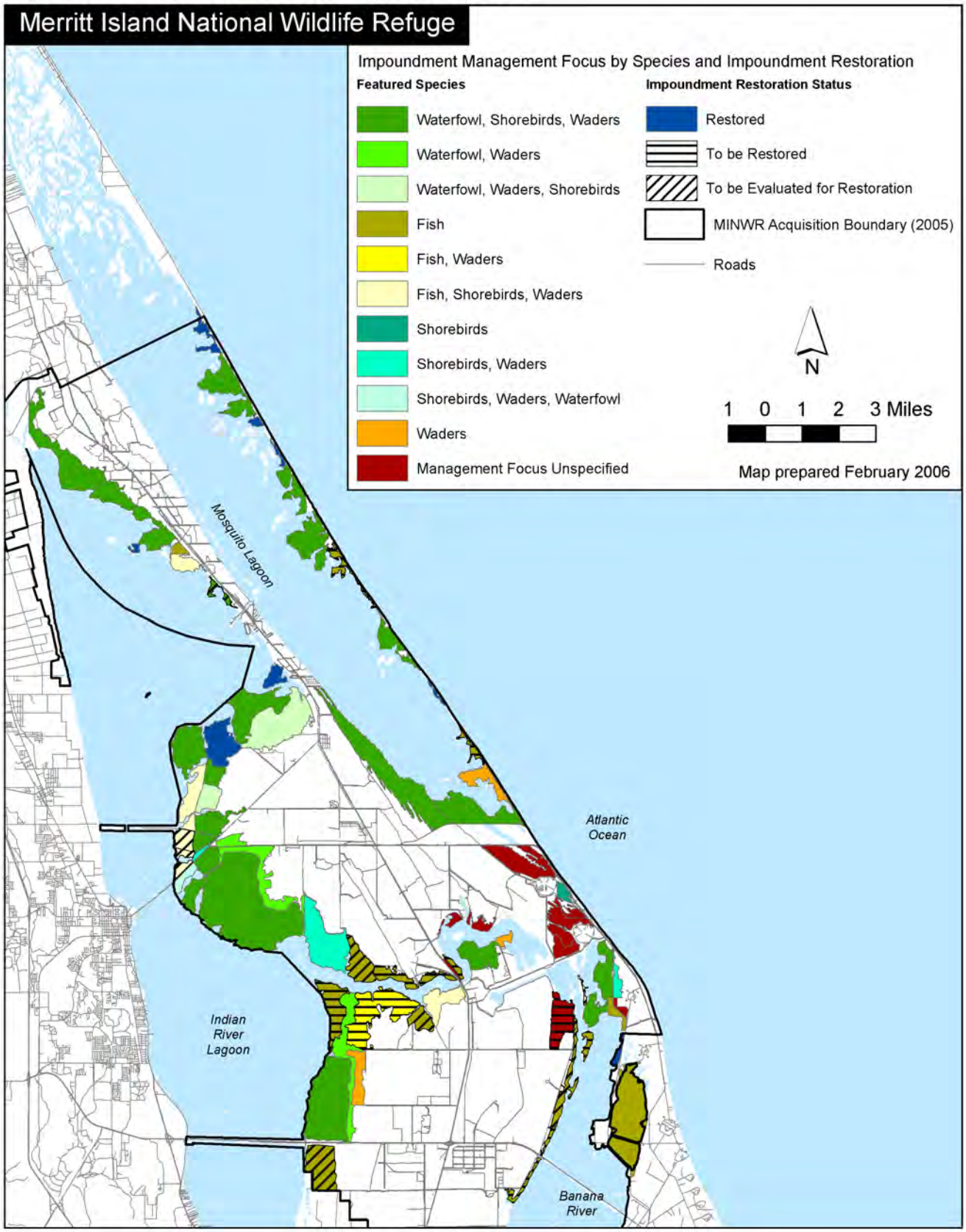
Figure 25: Seasonal bird use patterns on Merritt Island NWR, 1999-2000. Data based on 634 observations among 14 impoundments.



Featured Species Management

The use of featured species management of wetlands identifies a primary species or species group for which a particular wetland is to be managed. Under this process, a wetland is manipulated to enhance habitat and resources for the featured species or species group. However, under this type of management, the manipulations can be geared to accommodate multiple species. The management must have a habitat first approach, meaning that the habitat must be in prime condition for the featured species before manipulations for multiple species are considered. If the habitat is not suitable for the featured species, manipulations should progress towards improving the habitat for the featured species or species group. Featured species management for waterfowl accommodates multiple species, including waterfowl, shorebirds, wading birds, and fish. Figure 26 shows the management focus and species priorities of the individual impoundments on the refuge.

Figure 26. Impoundment Management Focus



2.a. Waterfowl
Wildlife and Habitat Management Objective 2.a(1): Maintain 15,000-16,000 acres within impounded wetlands with a primary management focus on waterfowl from August to January of each year.

The strategies that would help meet this objective are listed.

- Within 5 years of the plan approval, develop a wetland management plan with the framework to designate individual impoundments best suited for waterfowl, but that also includes consideration of shorebirds and wading birds.
- Evaluate impoundments suitable for intensive water management and those not suitable for wildlife/aquatic management within 5 years of the plan approval.
- Evaluate and determine the need for rotating water management among impoundments, whereby some impoundments are managed in a open flowing condition to assist with bottom sediment rejuvenation, marsh detrital building, and habitat diversity.

Wildlife and Habitat Management Objective 2.a(3): Support an average annual breeding population target of 250 pairs of mottled duck.

The Florida mottled duck (*Anas fulvigula fulvigula*) is unique to peninsular Florida. It is also highly prized as a game bird and has an intrinsic aesthetic value. Rapid changes in south Florida's landscape resulting from agricultural and urban development raised concerns about the status of these habitats and the wildlife that depend on them, including the mottled duck. The refuge provides an important habitat base for mottled ducks in the rapidly developing east-central portion of the state. Management that emphasizes high-quality, dense upland nesting cover in close proximity to shallow, emergent aquatic habitat is recommended (U.S. Fish and Wildlife Service 2003). Providing relatively large blocks of dense nesting habitat would help minimize depredation. Additionally, the close proximity of shallow, emergent aquatic habitat would enhance duckling and female survival. Mottled ducks and broods frequently use the managed impoundment habitats for feeding, loafing, and breeding. Suitable spoil island habitats are used for breeding and nesting. Mottled duck abundance has been observed to be higher in impoundments managed in the lower target salinities under the featured species management program.

The strategies that would help meet this objective are listed.

- Provide a stable habitat base for Florida mottled ducks. Continue to work with the FWC on habitat suitability requirements for Florida mottled ducks on MINWR.
- Determine mottled duck habitat production needs among wetlands and spoil islands.
- Identify impoundments having an upland/wetland interface or those that could otherwise be important for mottled duck production.
- Evaluate wetland management schedules to ensure that a minimum number of units are available for mottled duck nesting and brood rearing from March through August in any given year.

2.b. Shorebirds
Wildlife and Habitat Management Objective 2.b(1): Annually maintain a minimum of 2,500 acres of impounded wetlands with a primary management focus on migratory shorebird habitat.

The strategies that would help meet this objective are listed.

- Annually provide seasonal water depth conditions that are suitable for the diversity of shorebirds that use refuge wetlands.
- Within 5 years of the plans approval, evaluate specific manipulations that would benefit fall and spring shorebird migrations.
- Use existing monitoring data to evaluate effects of different management regimes on shorebirds.

2.c. Wading Birds

Wildlife and Habitat Management Objective 2.c(1): Annually maintain a minimum of 1,500 acres of impounded wetlands with a primary management focus on wading bird habitat.

Strategies are listed below collectively for multi-species and featured species management in lieu of species specific management strategies. Bird population numbers have been monitored on selected wetlands since 1999, as previously mentioned, and would assist in management evaluation.

The strategies needed to fulfill objectives 2.b(1) Shorebirds and 2.c(1) Wading Birds are listed.

- Annually evaluate the potential of individual impoundment habitats to seasonally provide for multiple species groups, such as wading birds.
- Ensure management emphasizes achieving desired habitats first and then provides for consideration of seasonal manipulations for wildlife to meet multi-species management goals and objectives. For example, habitat management considerations would supersede public use management priorities and additional wildlife management priorities (e.g., habitat management must be prioritized to maintain productive and healthy wetland systems to serve the featured species of management).
- Within the featured species program, emphasize multi-species use of impounded wetlands through water level management by decreasing water depths in winter to spring to accommodate arrival and use by shorebirds, wading birds, diving birds, and other species groups, as appropriate.
- Within 1 year of the CCP approval, maintain the existing level of diversity and species richness of plants and animals through wetland management and habitat availability that corresponds to seasonal use patterns and species migration. (See Table 3 for the listing of impoundment and species group management designations.)
- Provide appropriate migratory bird habitats and preferred water depths during seasonal migratory patterns using natural cycles of tidal amplitude and precipitation.
- Alternate management regimes to maintain habitat diversity among impoundments for multi-species use. Consider rotating impoundment management priority to include migratory shorebirds and wading birds.
- Within 5 years of the CCP approval, evaluate the effectiveness of current management activities to meet the needs of migratory waterfowl, wading birds, and shorebirds. Adapt new management as necessary to meet annual, seasonal, or long-term objectives.
- Manage wetlands to encourage a diverse mosaic of natural plant communities interspersed with open water and mudflats using seasonally fluctuating water depths, salinity, and/or extended flooded conditions as required.
- Encourage preferred emergent vegetation, including annual and perennial seed producing native species (e.g., *Scirpus spp.*, *Echinochloa* spp., *Eleocharis* spp., *Leptochloa* spp., *Setria* spp., and *Sesuvium* spp.), submergents (e.g., *Ruppia maritima,*

Chara hornemannii, Najas spp., and *Potamogetom* spp.), and cover species (e.g., *Distichlis* sp., *Spartina* spp., and *Juncus* sp.). Determine the direction of management based on the condition of the habitat. Transitional succession between fresh and saline marshes is desirable.

- Maintain desirable water quality conditions with target salinities between 8 and 15 parts per thousand (ppt) and desirable dissolved oxygen levels at or greater than 3 mg/l within primary management impoundments.
- Conduct summer and fall flooding, as appropriate, for suitable habitat and water quality conditions and also to minimize and control mosquito production.
- Develop integrated mosquito control and migratory bird management practices. Continue to coordinate with the mosquito control districts to review proposed mosquito management within impounded wetlands to determine how to decrease potential adverse impacts to plants and animals.
- When necessary for mosquito control purposes, water control structures would be closed and impoundments maintained in a flooded state (i.e., RIM). Protocol for mosquito control manipulations would follow the guidelines of the refuge's mosquito control agreement with the BCMCD.
- Use prescribed burning, as needed, to promote desirable vegetative community changes, reduce hazardous fuel buildup, and increase resource availability by removing rank biomass and by opening dense vegetation. This would be particularly useful in maintaining grassy wetlands and controlling scrub encroachment in the high marsh impoundments that are dominated by *Spartina bakerii*.

2.d. Water Control Structures

Wildlife and Habitat Management Objective 2.d(1): Within 1 year of the CCP approval, develop a standardized riser size and a tamper-proof design for all water control structures to be installed in refuge impoundments, as replacement or installation is necessary.

The refuge needs the ability to fully control water within and among the impoundments. At present, some water control structures allow uncontrolled flow of estuarine water into the impoundments, which disrupts water management objectives in impoundments with set seasonal water depth goals. Having water control structures that provide better water level management capabilities would help limit the stress on habitat, waterfowl, and shorebirds during water level changes (e.g., changes in lagoon height). Improved water control structures would enhance management by providing the means to stop, manage, or allow water flow within and among impoundments based on the stated goals of the impoundment.

Strategies for improving water control structure management are listed.

- Develop a standard water control structure design and flashboard riser size (with an inside width of 47 $^{3/8}$ inches) for all water control structures to be installed in refuge impoundments.
- Install water control structures that would allow total control over water management and that would maximize the capability to correctly manage wetland habitats, including double flapgates. Continue to evaluate new water control structures to determine the best ones for the refuge.
- Use and maintain dikes and appropriate water control structures to conduct water management options as necessary to achieve desired wetland community types.

Impoundment Management

Active management of impounded wetlands would be performed on those best suited for management. The refuge has certain state exemptions for maintenance and restoration of impoundment dikes (i.e., the St. Johns River Water Management District's exemption for maintaining mosquito control structures) and mangrove trimming (Florida Department of Environmental Protection 1996; SJRWMD 2001, 2003). New water control structures have the capability to provide a number of options, as listed. The predominant management regimes are: Wildlife/Aquatic (i.e., widgeongrass management), Open, Natural Systems, and Flooded (Appendix E).

Wildlife/Aquatic - Wildlife-aquatic management is a brackish water management regime with an emphasis on wildlife, but that also has an aquatic phase of management. This type of management provides seasonally fluctuating water depths to restore or maintain native plant and wildlife communities. Seasonal manipulations include late winter lower water depths and periodic summer drawdowns. Lower water depths in winter to spring allow for shorebird migration and use of wetlands. Periodic drawdowns allow mudflat exposure for bottom sediment oxidation and rejuvenation. Oxidation of accumulated organic matter and bottom sediment consolidation provides a suitable substrate for productive submergent vegetative communities. Seasonal dewatering consistent with natural tidal amplitude and precipitation patterns coincides with use by wetland neotropical birds and waterfowl. Flooding would be provided by natural tidal amplitude and precipitation, as well as by pumping. Enhanced water exchange through new water control structures would augment nutrient exchange and circulation. Salinity can be regulated to control undesirable communities. Optimal salinities in the impoundments under the Wildlife/Aquatic management regime are between 8 and 15-ppt ($\pm$5 ppt). This program is consistent with mosquito control by allowing the area to be flooded during the mosquito breeding period where prolonged flooding with deep, freshwater may be necessary to control certain vegetative communities. Increasing water depth is beneficial to many wading birds and fishes. Under ideal conditions, water levels are gradually allowed to increase from late spring through summer and fall. Water depths are gradually decreased from winter through spring to meet resource needs of migratory waterfowl and shorebirds. Gradually lowering water depth concentrates prey species, which are quickly exploited by wading birds and other wetland wildlife (e.g., osprey, eagles, alligators, and otters). Exposed mudflats during spring are essential for migratory shorebirds. If bottom sediments become unconsolidated and too mucky for good production of submergent plants, periodic spring/summer drawdowns are provided for oxidation and consolidation of accumulated organic materials, allowing for the recycling of nutrients. If vegetative communities shift (expand) to reduce the ratio of open water to vegetation, prescribed burning and/or flooding are used to create openness and mudflat areas. Conversely, if a habitat shift creates too much openness or mudflat areas, corrective manipulations to allow the unit to re-vegetate should be taken. This would primarily be to manage the unit as an open system in open flowing condition with the lagoon until the desired interspersion of vegetation is accomplished.

Figure 27. A conceptual water management regime with habitat conditions at an optimal state (e.g., wildlife aquatic).

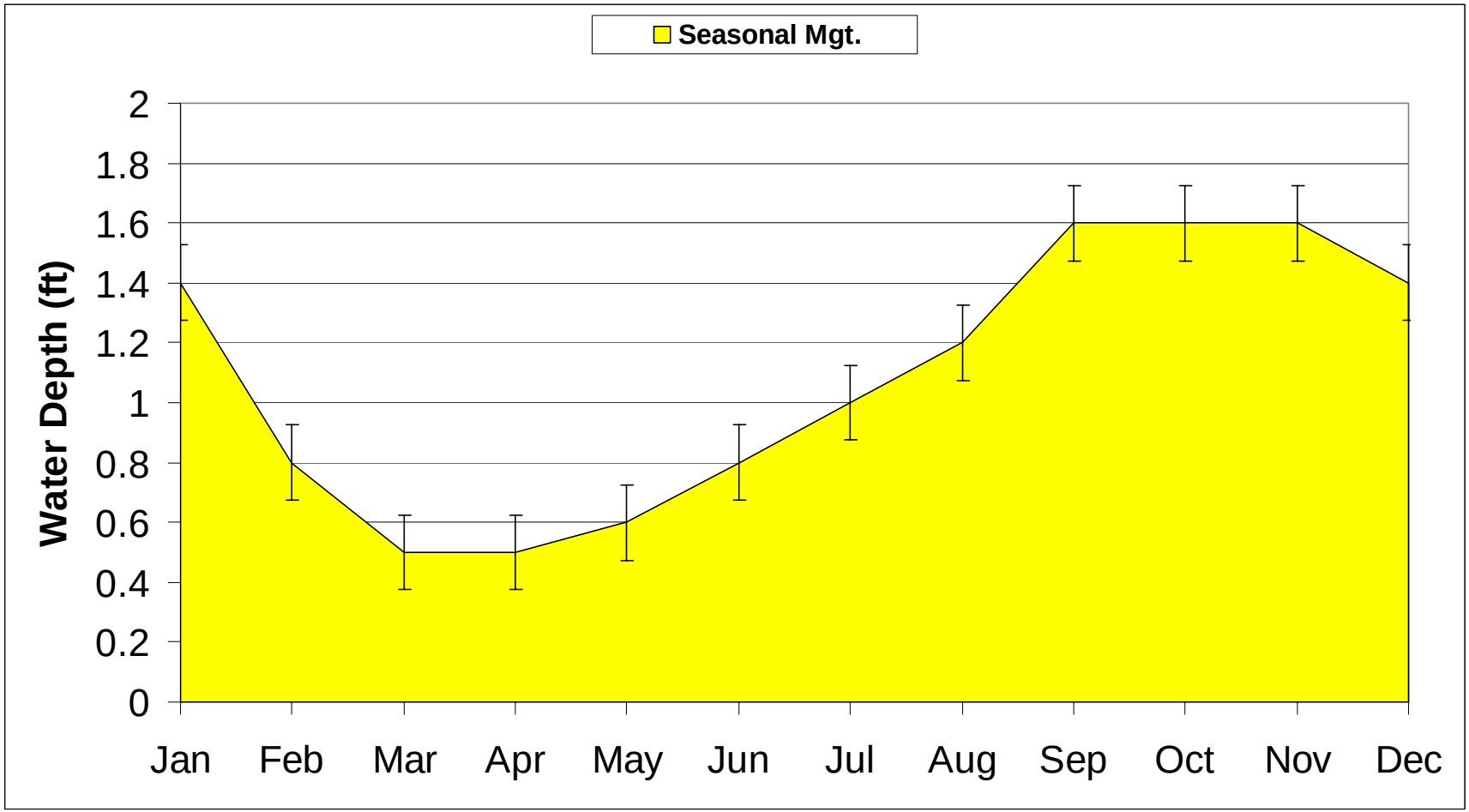
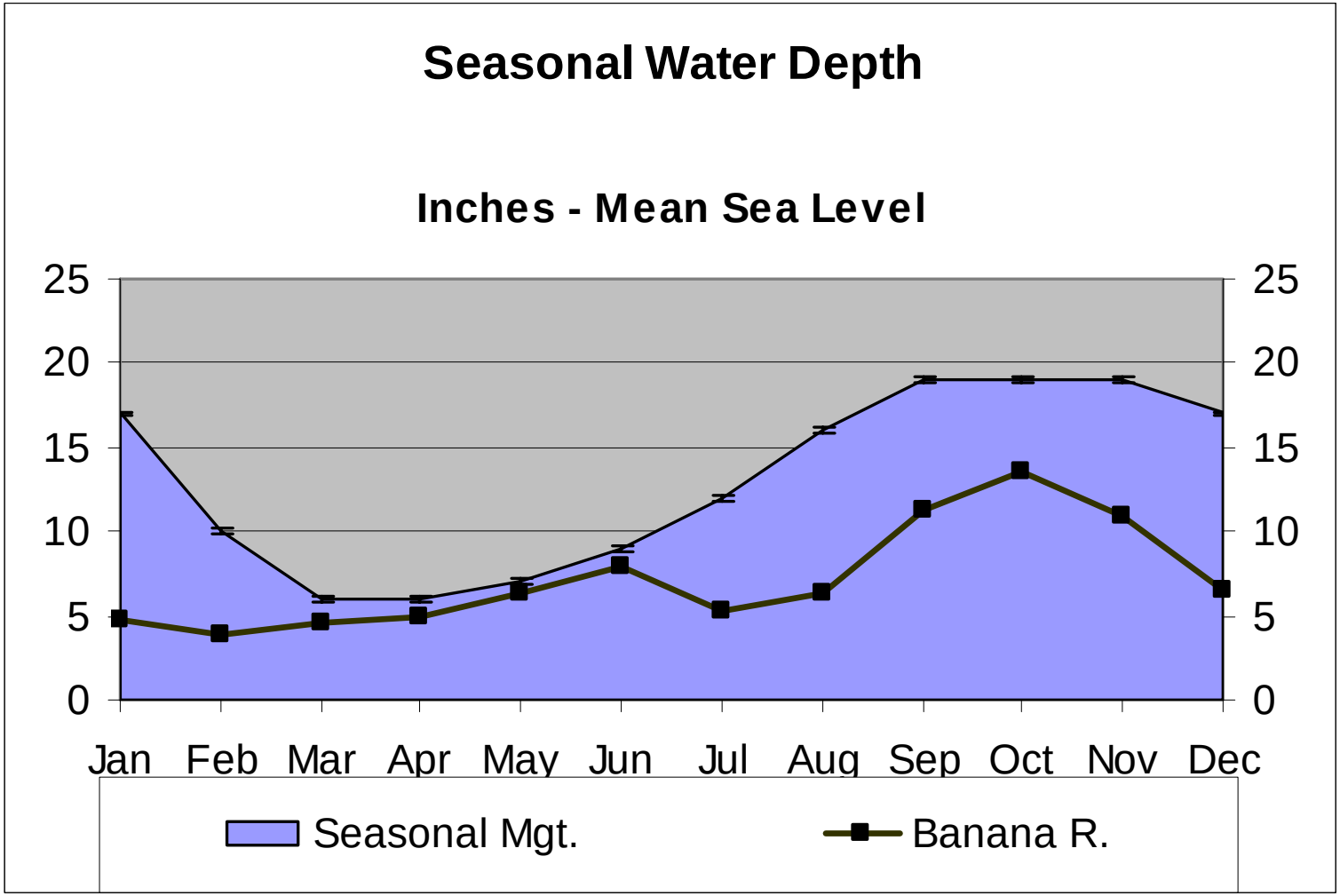


Figure 28. Conceptual seasonal water management and tidal amplitude. Tidal amplitude illustrates seasonal flux from the Banana River (BMCD 1972-1999) showing high and low amplitude (not drawn to scale). Figure 28 illustrates seasonal amplitude dynamics, which correlate with seasonal equinoxes and are highly influenced by wind direction and speed (e.g., wind tides).



Summer Drawdown - Moist Soil/Aquatic - This is a freshwater management regime that would produce an abundance of mostly annual seed producing plants (e.g., smart weeds *Polygonum*, spp.), wild millets (*Echinochloa* spp.), foxtail grasses (*Seteria* spp.), sea purslane (*Sesuvium* spp.), and bearded sprangletop (*Leptochloa* fascicularis). If moist soil management is used in brackish impoundments consistently over years, it may result in undesirable vegetation changes (e.g., continuous moist soil management in brackish systems would shift vegetative communities towards salt marsh). It can be used infrequently and as an alternative when conditions are fresh, to provide seasonally fluctuating water depths and to restore bottom sediments or maintain native plant and wildlife communities. The moist soil management regime provides moist soil conditions (through drawdown) in spring and summer, and/or through fall. Spring and summer drawdown conditions allow moist soil plants to germinate and grow. Moist soil conditions are maintained through summer and fall or plants are gradually flooded in fall and into winter. Late summer/early fall flooding with target salinities between 8-15 ppt may also produce submergent plant communities (e.g., *Ruppia* and *Chara*). From winter into spring, water depths are gradually lowered. Exposed mudflats during spring are essential for migratory shorebirds and concentrates prey for waders. This management regime is typical of freshwater systems, but may be conducted periodically in brackish systems to rejuvenate bottom sediments and remove rank plant communities.

Flooded - Water levels in the impoundments are kept elevated above estuarine levels. Water level can be maintained as flooded in brackish or fresh condition for several years or until a prescribed need to fluctuate to control undesirable vegetation or rejuvenate bottom sediment conditions. Flooded impoundments may be used to drown undesirable vegetation or to allow fresher habitat to advance prior to restoring seasonally fluctuating water depths. Submergent and aquatic vegetation can respond positively under this regime.

Open Impoundment Management - Water levels within the impoundment are allowed to fluctuate with estuarine water levels and precipitation patterns. All water control structures are left in a free flowing condition. This regime is used for managing fisheries, flushing impoundments, controlling rank fresh marsh vegetation, and managing modified natural systems. Water control structures are present for mosquito control or an alternate management regime.

Summer Drawdown - Water levels in the impoundments are drawn down in spring/summer, as previously mentioned. If undesirable plants (e.g., willows, cattails, and/or Brazilian pepper) have established beyond acceptable levels, burning combined with inflow of saline water (>20 ppt) would be allowed during August - October to control undesirable plants. After desirable vegetative communities have been established, suitable water depths and salinities between 8-15 ppt would be encouraged to enhance wigeongrass, *Chara*, and preferred emergent vegetation production. This regime is similar to Moist Soil Management, however, the goal is slightly different.

Rotational Impoundment Management (RIM) - This is primarily a mosquito control regime. Water levels within the impoundments are allowed to fluctuate with the estuary from the end of the mosquito breeding season to the beginning of the next breeding season (i.e., flood in May-June and open in October). This is suitable for fall shorebird migration. Re-flooding depths need only to cover the majority of the flats with shallow water for mosquito control.

Modified RIM - Water levels are maintained high until the end of the wintering waterfowl season (March) and water levels are then allowed to fluctuate with estuarine conditions until May or June. In May or June, the impoundment is closed and re-flooded. Re-flooding depths need only to cover the majority of the flats with shallow water for mosquito control.

Shorebird Management - Water control structures are set to allow a gradual water depth decline to support spring shorebird migration (north migration), providing abundant shorebird and wading bird feeding opportunities. Impoundment management continues in moist soil or wildlife-aquatic, depending on the primary objectives of management and the condition of the impoundment. Late summer and fall manipulations would include shallow water or declining water depth conditions starting in August or September to serve the migratory birds in south migration.

Wildlife Aquatic and Mosquito Control - Impoundments are flooded in early summer/late spring for mosquito control purposes and/or for widgeongrass management. Ideally, impoundments are flooded slowly through summer, allowing wigeongrass to germinate and grow with deepest water depths by October. Late summer flooding must consider the fall tropical storm season and try to accommodate unpredictable storm events. Use of summer and fall high precipitation is useful to maintain lower salinities.

Restored - Natural Systems - This regime is used on wetlands that have had its dikes completely removed and the hydrology reflects whatever exists in the adjacent natural system. Restoration management has been applied to a number of systems that were deemed not suitable for refuge management purposes. Restoring an impoundment endeavors to restore the natural shoreline by placing the dike into the perimeter ditch system and emulating pre-impoundment conditions.

Combined/Graduated Regimes

Combination - uses a mix of the above mentioned regimes among all the impoundments. The principle is that not all impoundments would be managed under the same regime, creating diversity among the impoundments and maximizing diversity in habitats. Additionally, water depths would be managed and staggered among the impoundments, such that some would be dewatered sooner than others. This also would allow a diversity of habitats among impoundments so that some are deep, some are shallow, and others have moist soil conditions. This regime (managed wetland complex) is a normal sequence in impoundment management application and part of the annual manipulations.

Adaptive Management - includes site specific manipulations for short-term responses to changing (from desirable to undesirable) conditions and takes advantage of existing circumstances (e.g., precipitation patterns, salinity, tropical storms, and mosquito production) to enhance management options. Feedback from monitoring protocols would be used to determine best management practices.

Impoundment Water Quality Monitoring

The refuge has adapted a water quality and vegetation monitoring system that records a series of environmental and abiotic data and also uses established photo-stations to monitor vegetative responses. The monitoring is conducted on selected impoundments to develop a

record of water quality conditions and biological responses gained through other monitoring programs. General observations of fish and wildlife responses to management are recorded as well (Lyon and Epstein 2005).

Water Quality Monitoring Strategy

- Monitor selected abiotic factors that influence plant and animal communities and environmental health of managed wetlands.

1) Water depth, dissolved oxygen, and salinity measurements are collected monthly in primary and/or flexible management impoundments (Table 3).

Generally, dissolved oxygen decreases as water temperature and salinity increase. The cooler the water temperature and the fresher it is, the more dissolved oxygen it can hold. Dissolved oxygen levels are naturally lowest at night, mornings, and on cloudy days. Therefore, readings are best taken before 9 am. Under emergency sampling, the time of day would not be important. With fish kills, take readings for at least 1 day after the event. See Table 4 for guidelines related to desired oxygen levels.

Table 4. Guidelines For Average Dissolved Oxygen Levels (mg/L)

≤1	**Very Poor Condition, Fish Kills Can Occur**
2-4	**Biological Stress, Watch Closely, Notify Staff**
4-5	**Fair to Ok Condition**
≥5	**Good Condition**
Salinity targets within managed systems are 8-15 parts per thousand	

2) If water quality conditions become poor, corrective management actions would be considered. Any manipulations that would increase flow and circulation (e.g., pumping or opening water control structures) would be corrective actions to assist in low water quality situations.

3) Precipitation information is collected by coordinating with NASA's KSC Shuttle Landing Facility. Monthly rainfall is averaged and compared to long-term patterns.

Wetland Monitoring Using Photographic Stations to Document Vegetation Changes

Beginning in June and July of 2004 a series of photographic stations were established on 10 primary impoundments to document changes to vegetation in those impoundments (Lyon and Epstein 2005) (see Table 5).

Procedure: From one to five photographic stations were established on each of the selected impoundments. All stations were on impoundment roads and were oriented to the inside of the impoundment. Generally, larger impoundments would have a greater number of stations, with a greater distance between stations. Photographic stations were placed in areas where changes in vegetative cover are likely to occur as a result of management actions. Large areas with relatively deep, open water or dense, elevated vegetation were avoided, as these areas are unlikely to experience a large change as a result of current management practices. Stations are visited once quarterly and a photograph is taken at each station. The following equipment and procedures were used:

- digital camera with wide angle lens, approximately 35mm;
- Silva compass;
- Garmin 12xl global positioning system (GPS) receiver; and
- Adobe Photoshop Elements.

A global positioning system (GPS) coordinate was established at each station and a compass bearing (magnetic north) was taken for the direction of a properly exposed photograph. The scene was composed with the camera zoom set to full wide angle (equivalent to a 37mm lens on 35mm still camera). Data included the date, location information (impoundment name and station number), and impoundment water level for each photograph.

Photographs were saved as JPEG files at the highest quality resolution with minimal compression. These were later imported into Adobe Photoshop Elements. Additional image information (camera used and settings) was entered into the sidebar caption section of file information (File > File Info). Subsequent, quarterly photographs are taken at the same locations. To insure photographic consistency, prints of photographs made during the initial station visit were used to assist image composition on subsequent plot visits.

Table 5. Wetland impoundment monitoring photo-stations.

Impoundment	Station Establishment Date	Photo Station Number	Coordinates N	Coordinates W	Azimuth	Way Point	Notes
T-24A	7/26/04	1	28.62497	80.78414	333	164	
T-24A	7/26/04	2	28.62708	80.78318	302	163	
T-24A	7/26/04	3	28.63150	80.77927	8	162	
T-24A	7/26/04	4	28.63615	80.77727	230	165	
T-24B	7/26/04	1	28.63555	80.77627	70	159	
T-24B	7/26/04	2	28.63423	80.76972	350	160	
T-24B	7/26/04	3	28.63843	80.76641	273	161	
T-24D	6/17/04	1	28.60731	80.73640	275	154	From southeast
T-24D	6/17/04	2	28.60326	80.75696	2	155	
T-24D	6/17/04	3	28.60641	80.75929	280	156	
T-24D	6/17/04	4	28.61197	80.76842	310	157	
T-24D	6/17/04	5	28.61353	80.77286	330	158	
V-3	6/22/04	1	28.82289	80.77291	19	170	
V-3	6/22/04	2	28.82202	80.76641	41	171	
V-3	6/22/04	3	28.82150	80.75704	312	10	at riser
V-4	6/22/04	1	28.81388	80.75622	296	14	at riser
T-43	6/22/04	1	28.76770	80.72789	44	172	
T-43	6/22/04	2	28.76679	80.72815	230	173	at flaps
Shiloh 1N	6/23/04	1	28.77409	80.80483	120		
Shiloh 1N	6/23/04	2	28.76515	80.80051	103	169	
Shiloh 3	6/23/04	1	28.78241	80.82272	130		
Shiloh 3	6/23/04	2	28.78041	80.82296	328		
Shiloh 3	6/23/04	3	28.77824	80.81254	6		
Shiloh 5	6/18/04	1	28.80028	80.84569	2	147	From north
Shiloh 5	6/18/04	2	28.79702	80.83861	102	166	
Shiloh 5	6/18/04	3	28.78372	80.83403	52	167	
Shiloh 5	6/18/04	4	28.78326	80.82864	43	168	at WCS
T-10J	10/25/04	1	From obs tower	at binocular stand	290		
T-10J	10/25/04	2	From obs tower	at binocular stand	341		
T-10J	10/25/04	3	From obs tower	at binocular stand	48		

D-2: GOALS OBJECTIVES AND STRATEGIES ADDRSSING INTERIOR WETLANDS
Restoration of altered interior wetlands are addressed under Goal 4 Wildlife and Habitat Diversity and Objective 4.e(1).

4. Wildlife and Habitat Diversity
WILDLIFE AND HABITAT MANAGEMENT GOAL 4: Protect, manage and enhance the natural diversity of fish, wildlife and habitats and the important landscapes of the refuge's coastal barrier island system to ensure that refuge fish and wildlife populations remain naturally self sustaining.

4.e. Interior Wetlands
Wildlife and Habitat Management Objective 4.e(1): Within the 15-year life of the plan, evaluate and restore altered freshwater wetlands as integral parts of the landscape to mimic natural hydrologic function.

Strategies related to this objective are listed.
- Identify, enhance, and/or restore interior freshwater systems to a more natural-like system by filling ditches, re-establishing hydrological conditions, and restoring native plant communities in altered sites (e.g., citrus groves).
- Continue to work with NASA and other agencies on planned restoration of freshwater systems on the refuge.
- Plug or fill drainages as necessary.
- Target overgrown swales in the shrub/scrub landscape for restoration to enhance scrub-jay habitat.

D-3: *GOALS OBJECTIVES AND STRATEGIES ADDRESSING HABITATS OF THE ESTUARY*
Estuarine habitats, including open waters, seagrass beds, natural and spoil islands, and those supporting fisheries are addressed under the outlined objectives within three different goals: Goal 1. Rare, Threatened, and Endangered Species; Goal 2. Migratory Birds; and Goal 4. Wildlife and Habitat Diversity.

1. Rare, Threatened, and Endangered Species
WILDLIFE AND HABITAT MANAGEMENT GOAL 1: Preserve, protect, and enhance populations of rare, threatened, and endangered species of plants and animals at existing or increased levels on the refuge and preserve, protect, manage, and restore their native east central Florida coastal and estuarine habitats occurring on the refuge to contribute to recovery goals.

1.e. West Indian Manatee – Estuary Habitats
Wildlife and Habitat Management Objective 1.e(1): Continue to annually maintain and protect 50,000 acres of refuge estuarine habitat to support an anticipated spring peak population target of 500 or more West Indian manatees.

Strategies related to this objective are listed.
- Continue to protect these species through NASA and CCAFS closed areas and through the refuge's no motor zone in the Banana River.
- Coordinate with NASA and FWC on annual manatee aerial surveys.
- Coordinate with FWC regarding all sick or injured manatees.

- Coordinate with NASA and SJRWMD regarding monitoring primary seagrass beds as important habitat for manatees and regarding protecting manatee feeding areas.
- Provide effective law enforcement in areas designated for manatee and manatee habitat protection
- Provide all security officers and others utilizing the manatee sanctuary (e.g., KSC and CCAFS) manatee awareness training.
- Encourage research into life history needs.
- Promote the use of new technologies to protect manatees by FWS, researchers, KSC, CCAFS, and others.

2. Migratory Birds
WILDLIFE AND HABITAT MANAGEMENT GOAL 2: Maintain and actively manage refuge coastal barrier island wetlands and uplands primarily to contribute to migratory bird priorities of the refuge and Peninsular Florida Physiographic Area, while providing consistency with regional and national goals.

2.a. Waterfowl
Wildlife and Habitat Management Objective 2.a(2): Continue to annually maintain and protect 50,000 acres of refuge estuarine habitat to support an average annual migration of 60,000 lesser scaup.

Strategies related to this objective are listed.

- Continue to protect vital staging and feeding areas from disturbance and impacts.
- Provide public information and increase appreciation of the importance of the lagoon to migratory lesser scaup to augment awareness of the ecological needs of scaup.
- Continue to encourage research and monitoring of scaup using refuge resources.

4. Wildlife & Habitat Diversity
WILDLIFE AND HABITAT MANAGEMENT GOAL 4: Protect, manage and enhance the natural diversity of fish, wildlife and habitats and the important landscapes of the refuge's coastal barrier island system to ensure that refuge fish and wildlife populations remain naturally self sustaining.

NATURAL AND SPOIL ISLAND HABITATS

Many spoil islands that were created with the dredging of the Atlantic Intracoastal Waterway and the KSC barge canals on the refuge have been documented to subsequently be important rookeries sites for colonial wading birds, shorebirds, and mottled ducks (e.g., Parnell and Soots 1978, Baker 1979, Smith 1997). Similarly, many natural marsh islands within the refuge boundary are rookery sites for many wading birds and/or shorebirds. Vegetative succession has advanced over many of the islands, which have become forested with mangrove, oaks, palmetto, and exotic species. Many of the forested islands are now used by colonial nesting birds as breeding areas.

However, on some of the spoil islands, advanced succession has made them unsuitable for ground and shoreline nesting birds. The refuge has attempted, when funding was available, to clear some islands and restore sandy habitats for gulls, terns, plovers, and mottled ducks (see Appendix F). However, some islands may warrant additional restoration and management for breeding birds (see Figure 29). When newly created, these spoil islands provided bird habitat (Erwin et al 1994, Erwin et al 2003). The refuge remains open to using these sites for controlled dredge-spoil deposition for habitat restoration. Some natural marsh islands that were historically drag-lined ditched for mosquito control have been identified for wetland restoration.

4.a. Natural and Spoil Islands

Wildlife and Habitat Management Objective 4.a(1): Within 5 years of plan approval, evaluate and characterize all spoil, altered natural, and natural marsh islands for restoration and management.

Strategies pertaining to evaluating natural and spoil islands are listed.

- Identify and protect spoil and natural marsh islands that have a high intrinsic value for wildlife (see Figure 29).
- Identify natural marsh islands that historically have been altered and work with state and federal partners to conduct habitat restoration.
- Re-evaluate and use the existing Banana River Spoil Island Management Plan as a guide for refuge marsh island management.

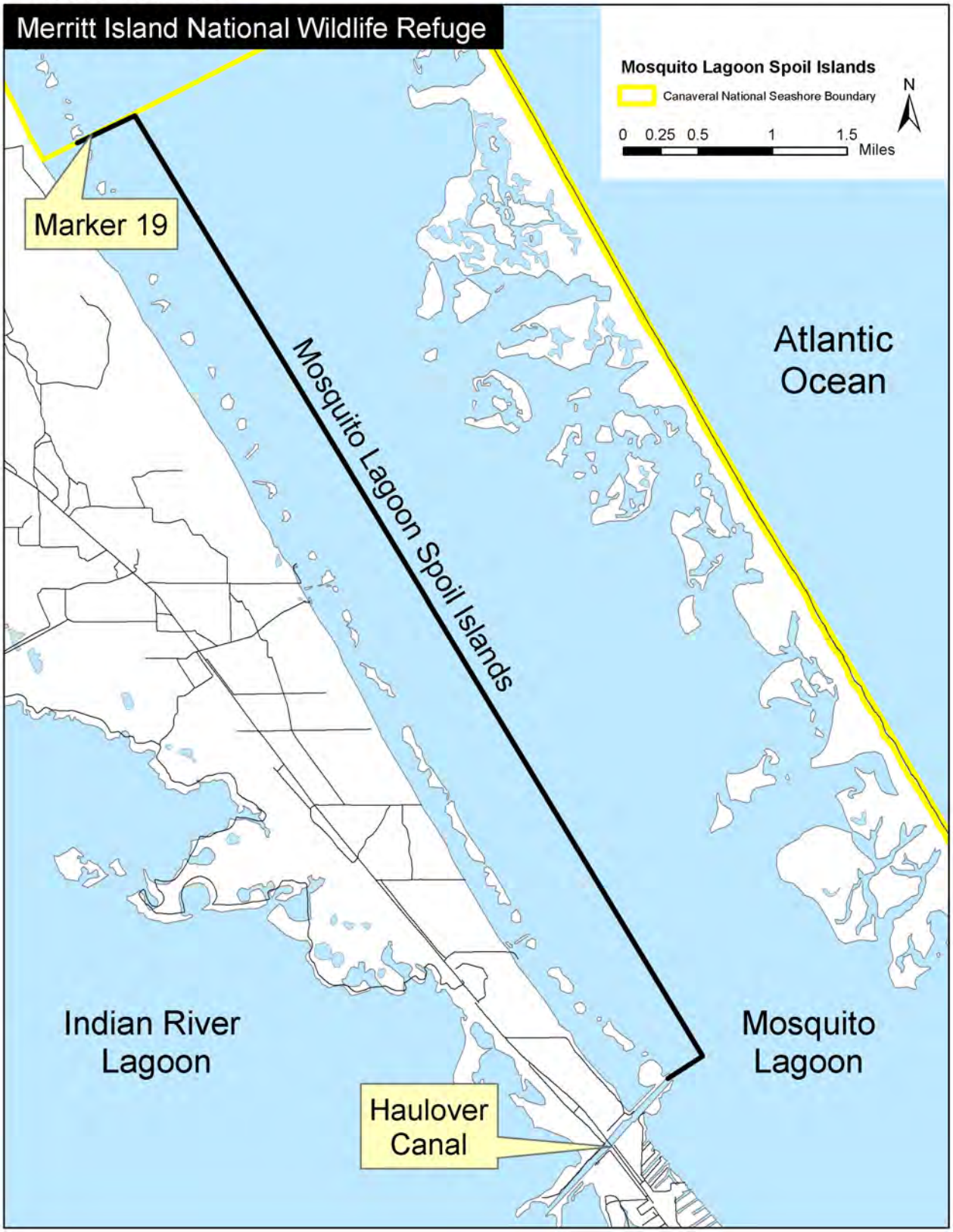
Wildlife and Habitat Management Objective 4.a(2): Within the 15-year life of the plan, restore to native vegetation seven altered natural islands in Mosquito Lagoon.

Strategies for restoration of altered islands in Mosquito Lagoon are listed.

- Select islands that have been historically altered and restore those islands to provide for piping plover wintering habitat and breeding areas for Wilson's plovers, as well as to include a mix of bare ground, grass, and shrub habitats.
- Where appropriate, consider the reuse of dredge spoil island materials at needed locations (e.g., old canals, impoundments, or other islands).

Consideration for restoration of the spoil islands along the western boundary of the Mosquito Lagoon and the Intracoastal Waterway would be given (see Figure 29). These islands have not been recorded as wildlife use areas. During the Indian River Lagoon North Feasibility Study (part of the Comprehensive Everglades Restoration Project) (U.S. Army Corps of Engineers, *in prep.*), refuge personnel suggested using some of these islands and U.S. Army Corps of Engineers' environmental restoration project funding for the beneficial re-use of qualifying spoil island material. Materials could be used to fill historically dredged channels south of Haulover Canal, to fill in other degraded sites, to fill eroded island areas, and/or to create habitat. These islands could be completely removed to restore native seagrass bottoms or scraped down to salt marsh elevation levels for wetland creation.

Figure 29. Locaton of Spoil Islands in Mosquito Lagoon that may be Considered for Wetland Restoration



Wildlife and Habitat Management Objective 4.a(3): Within 10 years of plan approval, select, clear, and maintain three islands down to the sand/shell substrate within the Banana River for terns and other ground nesting birds.

Strategies for preparing islands for nesting sites for terns and other ground nesting birds are listed.

- Identify spoil islands that can be restored for ground nesting birds.
- Seek funding for annual restoration projects and, where possible, seek federal and state approval to use controlled spoil deposition to restore habitats.
- Develop operational plans for island restoration to include exotic species control, vegetation removal, substrate preparation, monitoring, and other logistical issues.

Three spoil islands in the Banana River (island numbers 13, 26 and 27) were tentatively identified as potential sand-surface restoration sites (see Figure 30). Selection was based on a review of the historic species use, logistics and accessibility of heavy equipment needed to perform mechanical removal of vegetation, and the absence of existing wading bird rookeries. All islands would be surveyed to determine if any active wading bird rookeries are present prior to project implementation. If active rookeries are discovered, alternative islands would be selected for restoration. Historical royal tern (*Sterna maxima*) use was a main criteria in island selection, however, other species have also nested on these islands in the past, including gull-billed terns (*Sterna nilotica*), black skimmers (*Rynchops niger*), laughing gulls (*Larus atricilla*), American oyster catchers (*Haematopus palliatus*), willets (*Catoptrophorus semipalmatus*), and mottled ducks (*Anas fulvigula*) (Schroeder 1980, Leenhouts 1986). Past mechanical vegetation removal was used on each of these islands. In 1992, a small bulldozer with an attached tiller was barged to spoil islands 26 and 27 to remove herbaceous and woody vegetation from the southwest portion of each island. In 1998, spoil island 13 underwent similar treatment, with vegetation removed from much of the island. Personal observation and aerial photography show that vegetation, exotic or otherwise, would quickly reestablish on these islands if not maintained.

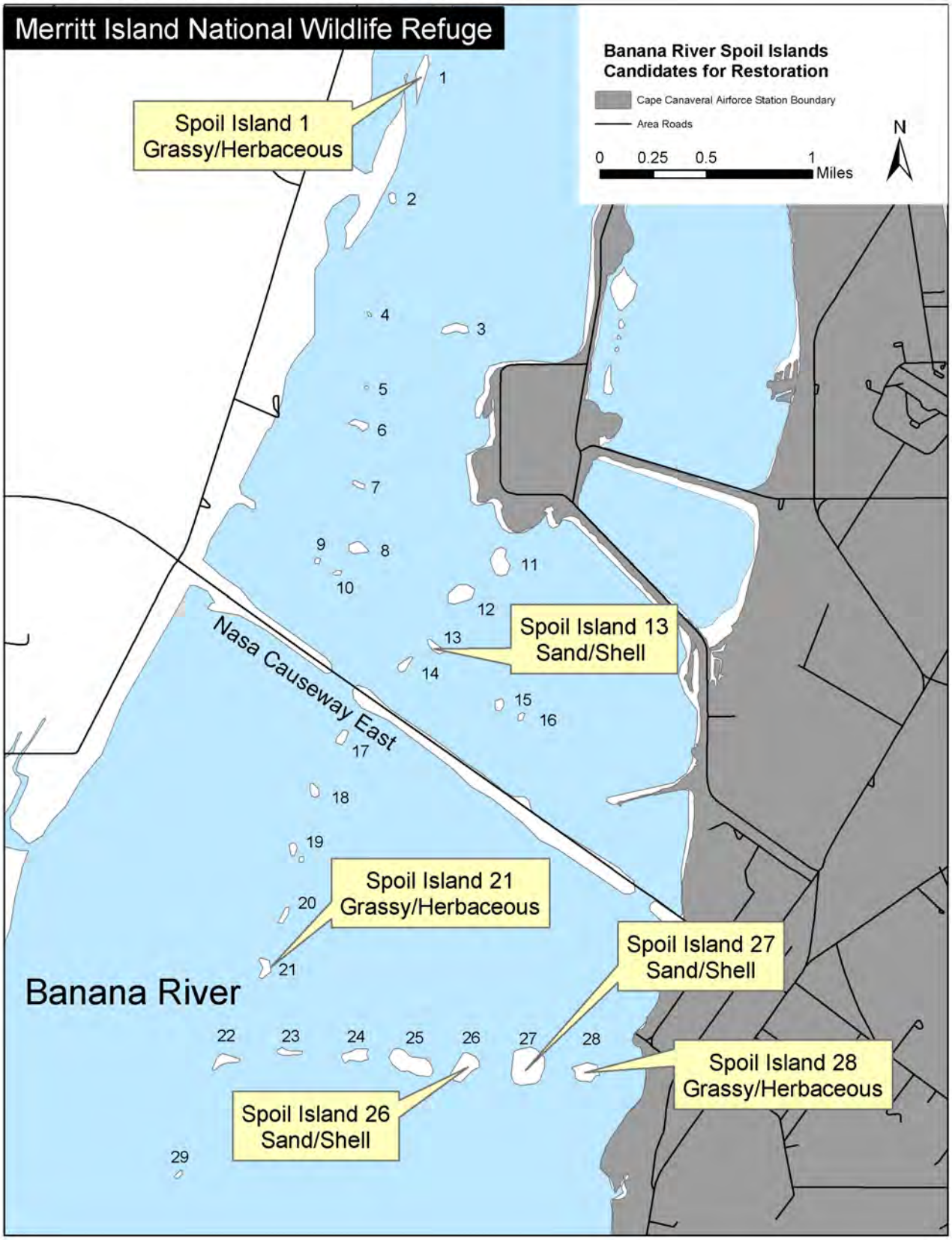
Wildlife and Habitat Management Objective 4.a(4): Within 10 years of plan approval, select, clear, and maintain two to three islands down to grassy and herbaceous cover within the Banana River for mottled ducks and other grass nesting birds.

The strategy for this objective is listed.

- Identify spoil islands that can be restored for other ground nesting birds and seek funding for annual restoration projects. Where possible, seek federal and state approval to use controlled spoil deposition to restore habitats

Three spoil islands in the Banana River (see Figure 30; spoil islands 1, 21, and 28) were tentatively identified as potential grassy/herbaceous restoration sites. The islands were specifically chosen because there is no known history of nesting by terns or wading birds (Schroeder 1980, Leenhouts 1986). Nesting by willets (*C. semipalmatus*) on islands 1 and 21, and by laughing gulls (*L. atricilla*) on island 28 was noted in 1980 (Schroeder 1980). None of these islands have previously been cleared. Aerial photographs from 1999 show that each island possess some areas of grassy/herbaceous cover, although spoil islands 21 and 28 were shrubby.

Figure 30: Location of Selected Spoil Islands in the Banana River to be Considered for Restoration



Wildlife and Habitat Management Objective 4.a(5): Within 5 years, evaluate the options for shoreline stabilization of Tank and Mullethead islands to ensure continued existence of these important rookeries.

A strategy for determining options for shoreline stabilization is listed.

- Work with local experts and partners to establish baseline data on erosion rates and stabilization options.

Wildlife and Habitat Management Objective 4.a(6): Establish buffers of 300 to 450 feet for nesting and roosting islands, including Bird, Little Bird (Preacher's), Pelican, Tank, and Mullethead islands.

Strategies for protect rookeries on these islands are listed.

- Continue to protect these islands as important breeding sites for colonial nesting birds through proper posting with no flushing from nesting and loafing sites from adjacent public use activities. Flush distances, and therefore minimum buffer distances, vary by species and by the type of disturbance (Rodgers and Smith 1995, Rodgers and Smith 1997, Rodgers and Schwikert 2000). Conduct surveys to monitor the effectiveness of the established buffers.
- Use published recommendations and/or other information to set posting distances for mixed-species colonies tolerances to disturbance (e.g., set-back distance of 300 feet for wading bird rookeries and up to 500 feet for ground nesting shorebirds). Special operations (e.g., airboat use by KSC Security and biological researchers) would require specific coordination. Water depth may inhibit posting at some sites.
- Annually survey rookery islands and ensure proper posting and compliance.

ESTUARINE FISHERIES AND WILDLIFE MANAGEMENT

Increasing boater use of the estuarine habitats by vessels that are adapted to shallow water has increased disturbance to aquatic habitats on the refuge. The shallow water flats are productive areas for many species of lagoon fish (Roberts et al 2001), waterfowl, wading birds, and other water birds. Advances in boat hull designs over the last ten years have allowed fishermen access to many shallow waters that were formerly inaccessible. The new flats boats have the ability to run at high speeds (greater than 40 mph) through waters that are less than one foot in depth. This new boat hull technology brings new issues for resource managers. To compound the problem, over this same period, fishing pressure in Mosquito Lagoon has increased boater use density, negatively impacting the quality of fishing.

Prop scarring to the submerged aquatic plants and soft bottom prop-dredging in the Mosquito Lagoon was recently identified (U.S. Fish and Wildlife Service 2003). Seagrass scarring was mapped by the Florida Fish and Wildlife Conservation Commission (Sargent et al 1995). Light scarring is defined as those areas where less than 5% of the seagrass was scarred. Moderate scarring had polygons from 5-20% scarred. And, severe scarring is defined as those areas having greater than 20% scarring. Sargent et al (1995) reported that vessel registration increased from 235,294 in 1970 to 829,971 in 2000 in Florida. Currently, over 900,000 recreational boats are registered in Florida and an additional 400,000 seasonal recreational boats that visit Florida (personal communication, 2005, Shelly Gurr, Florida Fish and Wildlife Conservation Commission). The shallow water flats are productive areas for many species of lagoon fish, waterfowl, wading birds, and other water birds. Although no direct links are

documented on the refuge to report declines in wildlife (Herring 2003) or fish (Ehlinger and Tankersley 2003, Ehlinger 2001, Ehlinger 1999), maintaining habitat and water quality is primary to the refuge mission.

4.b. Seagrass Beds

Wildlife and Habitat Management Objective 4.b(1): Work with the partners to maintain the current level of approximately 27,000 acres of seagrass beds on the refuge.

Strategies for seagrass bed management are listed.

- Continue to work with NASA, Dynamac Corporation, SJRWMD, FWC, NPS, and other organizations that monitor water quality and seagrass communities within the refuge's boundaries.
- Do not allow activities that would cause any degradation of existing seagrass beds below current acreages based on existing seagrass cover estimates (Joe Beck and Robert Virnstein, SJRWMD, personal communication, 2004).

Wildlife and Habitat Management Objective 4.b(2): Within the 15-year life of the plan, decrease prop scarring to levels at or below FWC's established definition of light scarring.

Strategies for reducing prop scaring are listed.

- Evaluate the Mosquito Lagoon pole/troll zones and determine the effectiveness of the zones to reduce seagrass impacts.
- If the zones prove effective, expand the pole/troll zones to other areas of the Mosquito Lagoon or refuge where needed.
- Work with state and local agencies and organizations to develop a monitoring protocol to judge the effectiveness of the pole/troll zones

4.c. Fisheries

Wildlife and Habitat Management Objective 4.c(1): Within five years of plan approval, develop an inventory of the baseline estuarine fisheries resources of the refuge and then every fifth year thereafter re-inventory to evaluate management actions necessary to maintain population levels.

The Indian River Lagoon is characterized by high productivity and believed to harbor the greatest species diversity of any estuary in North America, including alligators, finfishes, sharks, manatees, dolphins, sea turtles, and an extremely diverse invertebrate fauna. There are 132 fish species identified in the lagoon waters of the refuge (Paperno 2001). The horseshoe crab, *Limulus polyphemus*, generally inhabits estuarine systems and was very common in refuge waters. In recent years, researchers have noticed a large decline in the numbers of crabs (Jane Provancha and Gretchen Ehlinger, personal communication). The reason for the decline in horseshoe crabs is presently unknown. Horseshoe crabs serve as a keystone species in the lagoon and influence species diversity and productivity. Horseshoe crabs and their eggs are a vital prey component of numerous species, including the threatened loggerhead sea turtle, migrating shorebirds, and many species of fish.

Diked marsh impoundments are generally managed for mosquito control or to enhance habitat for migratory birds. However, multi-species management adapts alternative management strategies to address different fish and wildlife species groups. Impoundments can be very productive microcosms of the estuarine system, provided water quality remains satisfactory.

Fish and crab populations can flourish within these systems. Biologists have tried to design water control structures and water management strategies that would allow the release of fishes back to the estuary. Conceptual impoundment designs have been proposed using small interconnecting ponds and pumps to create a counter current flow, which would attract fish into smaller units that could be later released to the estuary. Additionally, concepts need to be developed using alternative means, such as volunteers, that could assist with gill nets, capture and release, and/or special public use programs (e.g., fishing events) that would help in the capture and release of fish to the adjacent estuary.

Strategies for developing baseline information on refuge fisheries are listed.

- Continue to work with the partners (e.g., FWC, SJRWMD, and Dynamac) and use existing plans (e.g., Waters et al 2001 and SWIM Plan of the SJRWMD) to identify monitoring efforts to help develop baseline inventories.
- Conduct and encourage monitoring and research of species that represent the native biological diversity of refuge waters and encourage monitoring of any resources that may indicate serious ecological disturbance within the estuarine waters, such as horseshoe crabs.
- Use inventory and monitoring data to protect and maintain habitats and critical life history periods that would allow important Mosquito Lagoon fishery species, such as red drum, spotted sea trout, and black drum, to effectively reproduce and recruit.
- Develop and implement programs for impoundment fisheries based upon scientifically sound resource assessment and monitoring, applied research, technology, public education, and technical assistance.
- Develop concepts for fish passage using best available technology and fish release programs.
- Develop volunteer and/or public use programs that would foster an environmentally beneficial fish capture and release program.

Natural Systems Management

Natural systems management is directed towards restoration of altered systems or to maintain existing habitats as close as possible to the original landscape by allowing the natural forces of nature to direct native habitat cover types. However, management would be used as a tool to assist in maintaining or enhancing these conditions.

The refuge has elevated the importance and the value of having more natural-like habitats with very ambitious upland and wetland restoration and enhancement programs. Over 550 wetland acres have been completely restored since 1996. The wetland restoration program has coordinated closely with the FWS Division of Fisheries, local mosquito control districts, NASA, and the St. Johns River Water Management District to accomplish restoration projects.

4. Wildlife and Habitat Diversity

WILDLIFE AND HABITAT MANAGEMENT GOAL 4: Protect, manage and enhance the natural diversity of fish, wildlife and habitats and the important landscapes of the refuge's coastal barrier island system to ensure that refuge fish and wildlife populations remain naturally self sustaining.

4.d. Estuarine Wetlands

Wildlife and Habitat Management Objective 4.d(1): Within the 15-year life of the plan, restore approximately 1,200 acres across 10 targeted impounded wetlands to mimic natural hydrologic function.

Wildlife and Habitat Management Objective 4.d(2): Within the 15-year life of the plan, evaluate the potential to restore approximately 3,100 acres across 11 targeted impounded wetlands to mimic natural hydrologic function.

Wildlife and Habitat Management Objective 4.d(3): Within seven years of plan approval, re-evaluate management of all impounded wetlands to ensure that best management practices are being used among impoundment habitats.

Wildlife and Habitat Management Objective 4.d(4): Within the 15-year life of the plan, restore approximately 200 acres across six targeted dredge impacted wetlands in the Mosquito Lagoon to mimic natural-like hydrologic function, and evaluate and identify an additional 100 acres of degraded ditched wetlands on other parts of the refuge that require restoration.

Strategies for the restoration and natural-like hydrological functions of estuarine wetlands are listed.

- Within 1 year of CCP approval, identify those impoundments best suited for non-intense water manipulation and encourage wet prairie cover types best suited for rail and neotropical species groups.
- Within 1 year of CCP approval, identify those impoundments best suited for natural-like systems and/or that have both fish and wildlife management potential and provide recommendations for restoration or open management.
- Promote native plant communities and natural-like hydrological management by maintaining impoundment water control structures in an open, flowing condition, allowing impoundment hydrology to emulate daily/seasonal tidal amplitude, except for mosquito control purposes. This management can use RIM or OPEN procedures, as appropriate.
- Maintain approximately 2,300 acres of impoundments as primary fisheries habitat with potential for multi-species wildlife objectives.
- To promote native plant communities and natural hydrological fluctuations, identify impoundment wetlands, dikes, and other altered wetlands that can be completely restored to a natural-like or enhanced condition.
- Consider restoring impoundments to natural-like systems that are not actively managed for wildlife and/or do not pose a mosquito production issues

Strategies for restoring impounded wetlands are listed.

- Use Table 3 as a guide to identify impoundments targeted for wetland restoration.
- Use Table 3 as a guide to identify impoundments that require additional evaluation for restoration and coordinate planning to include these wetlands as primary restoration areas.

CHAPTER IX
EXOTIC, INVASIVE, AND NUISANCE SPECIES

A. HABITAT GOALS AND OBJECTIVES

One goal in the Merritt Island National Wildlife Refuge's Comprehensive Conservation Plan addresses exotic, invasive, and nuisance species. Supporting this goal are five objectives, each with several strategies.

3. Exotic, Invasive & Nuisance Species
WILDLIFE AND HABITAT MANAGEMENT GOAL 3: Control and eliminate, where possible, exotic, invasive, and nuisance species on the refuge to maintain and enhance the biological integrity of the refuge's native coastal and estuarine habitats of east central Florida.

The first objective concerns inventorying the exotic plant problem and developing the ability to track efforts to control it.

3.a. Exotic Plants
Wildlife and Habitat Management Objective 3.a(1): Within two years of plan approval, develop and annually thereafter maintain a refuge-wide baseline exotic plant database.

Strategies for Wildlife and Habitat Management Objective 3.a(1) are listed.

- Within one year of plan approval, complete a baseline inventory, including a GIS database, of all refuge lands to determine the number of exotic plant species present and the coverage and stocking level for each species identified.
- Within one year of the initial exotic plant survey, complete an operational plan identifying the level of control efforts outside of the treatment areas identified in Objectives 3.a(3) and 3.a(4) for Brazilian pepper (*Schinus terebinthifolius*) and other exotic species not identified in Objective 3.a(2).
- Every five years, re-survey all refuge lands to identify infestations of new exotic plant species and to determine the coverage and stocking level for all exotic plant species in order to assess the effectiveness of control efforts and, as needed, re-direct on going control efforts.
- Update the exotic plant GIS database at least every five years, in conjunction with re-surveys.
- Partner with Dynamac and NASA for GIS assistance.
- Seek funding for contractors to do exotic plant surveys.
- Seek funding to hire a Biological Science Technician to complete the surveys and the operational plan and to oversee the exotic plant control program.
- Seek funding to help support a GIS Specialist for the refuge (to also support a variety of refuge programs).

The second objective identifies several exotic plant species where the potential to totally eradicate them from the refuge exists.

Wildlife and Habitat Management Objective 3.a(2): Within five years of plan approval, eliminate all known Old World climbing fern (*Lygodium microphyllum*), Australian pine (*Casuarina* spp,) Melaleauca (*Melaleuca quinquenervia*), cogongrass (*Imperata cylindrical*), kudzu (*Pueraria montana*), bamboo (*Bambusa* spp.), and *Eucalyptus* spp. from the refuge and annually maintain a level of no infestation of these seven species on the refuge.

The only exception to total elimination will be Australian pine around actively farmed citrus groves. These Australian pines will remain until the groves are restored.

Strategies for Wildlife and Habitat Management Objective 3.a(2) are listed.

- Seek funding to hire staff to conduct removal of exotic plants.
- Utilize trained volunteers to kill exotic plants.
- Utilize USDA approved biological control agents which are appropriate for refuge habitats.
- Continue to apply for grant funding from the Florida Department of Environmental Protection's Division of Invasive Plant Management for contract removal of exotics.
- Annually conduct an aerial survey of all refuge interior wetlands during spring or fall for *Melaleuca* spp., while in bloom, to treat all known sites.

The third and fourth objectives relate to exotic plants in cases where elimination from the refuge is unlikely due to their present infestation levels and their high propagation rates. These objectives address the incorporation of exotic plant control into other refuge management activities.

Wildlife and Habitat Management Objective 3.a(3): Integrate the exotic plant program into all refuge resource management programs to annually treat 30% of the refuge to control and, where feasible, eliminate exotic plants, including Brazilian pepper and Guinea grass (*Panicum maximum*).

Strategies for Wildlife and Habitat Management Objective 3.a(3) are listed.

- Annually define target areas for new treatments.
- Annually retreat the previous year's treatments.
- Integrate exotic plant control activities into the fire prescriptions.

Wildlife and Habitat Management Objective 3.a(4): Annually spray along the perimeter of all dikes, firebreaks, public use roads, and other public use areas to treat these target areas for exotic plants.

Strategies for Wildlife and Habitat Management Objective 3.a(4) are listed.

- To the extent possible utilize current staff.
- Seek funding to hire staff or contractor(s) to conduct control of exotic plants.
- Utilize volunteers to kill exotic plants.
- Verify success of initial field treatments through field inventories.
- Maintain good records concerning application, location, timing, and herbicide used.
- Revisit treated sites annually to determine if retreatment is required.

The fifth and final objective concerns pest animals, specifically feral hogs (*Sus scrofa*)

3.b. Feral Hogs

Wildlife and Habitat Management Objective 3.b(1): Within two years of plan approval and for three consecutive years thereafter, annually remove a minimum of 4,000 feral hogs from refuge lands. After these three years, evaluate the estimated hog population and adjust the target take to continue to lower the feral hog population on the refuge.

Strategies under Wildlife and Habitat Management Objective 3.b(1) are listed.

- Utilize contract trappers to remove hogs.
- Seek funding to hire a staff member to remove hogs by trapping and ground and aerial shooting.
- Utilize public hunting to remove hogs.

B. DESCRIPTION OF PROBLEM

B-1 BACKGROUND

The occurrence of exotic plant and animal species has been identified by staff and inter-governmental partners as one of the major management issues facing Merritt Island National Wildlife Refuge. Nuisance native animal species are also known to have negative impacts on threatened and endangered species, native wildlife of management concern, and on human safety. See Table 6 for selected exotic species on the refuge.

The listed definitions would be used for this plan.

- Exotic species - A species introduced outside of its native range.
- Invasive species - An exotic species capable of sustaining itself outside of its native range having the potential to invade and disrupt native plant and animal communities.
- Nuisance species - A native species requiring population controls due to negative impacts on threatened and endangered species, native wildlife of management concern, or on human health and safety.

Table 6. Selected Exotic Species Occurring on Merritt Island National Wildlife Refuge

Scientific Name	Common Name(s)	Category[1]
Plants		
Albizia julibrissin	Mimosa, Silk Tree	1
Abrus precatorius	Rosary Pea	1
Bambusa spp.	Bamboo	N/A
Bruhinia variegate	Orchid Tree	1
Casuarina spp.	Australian Pine	1
Dioscorea bulbifera	Air-Potato	1
Eichhornia crassipes	Water-Hyacinth	1
Enterolobium cyclocarpum	Costa Rica Ear Tree	N/A
Eucalyptus spp.	Eucalyptus	N/A
Ficus spp.	Fig	1
Imperata cylindrical	Cogangrass	1
Lygodium microphyllum	Old World Climbing Fern	1
Melaleuca quinquenervia	Paper Bark Melaleuca	1
Melia azedarach	Chinaberry Tree	2
Nephrolepis cordifolia	Boston Fern/Erect Sword Fern	1

Scientific Name	Common Name(s)	Category[1]
Panicum maximum	Guinea Grass	2
Psidium spp.	Guava	1
Pueraria Montana	Kudzu	1
Rhynchelytrum repens	Natal Grass	1
Ricinus communis	Castor Bean	2
Ruellia brittoniana	Mexican Petunia	1
Sapium sebiferum	Chinese Tallow Tree	1
Senna pendula	Christmas senna	1
Sporoblus indicus	Smut Grass	N/A
Schinus terebinthifolius	Brazilian Pepper	1
Animals		
Sus scrofa	Feral Hog	N/A
Felis domesticus	Feral Cat	N/A
Perna viridius	Green Mussel	N/A
Pterygoplithys spp.	Armored Catfish	N/A

1. Exotic Plant Council Category

In Florida, almost one-third of the plants occurring in the wild are exotic. And of the estimated 1,200 exotic species in Florida, approximately 11 percent are invasive in natural areas. Schmalzer and others (2002b) reported over 50 invasive exotic plants in and around the refuge. These are listed in Appendix G. Although no comprehensive survey of exotic plants has been conducted on the refuge itself, 25 of these have been observed by refuge personnel on refuge lands (Table 6). Control efforts by refuge staff have historically been uncoordinated and typically focused on controlling exotic plants in public use areas and along selected roads and dikes. The refuge currently receives no dedicated funding for exotic plant control. All exotic plant control efforts have been funded out of limited operations' monies and through partnerships. In 2000, the refuge began participation in a Florida Department of Environmental Protection (FDEP) program where public land management agencies could submit proposals for exotic plant control project funding. To date, the refuge has had eight projects funded with a value of $775,110.00. In addition, Canaveral National Seashore (Seashore) has completed five projects in cooperation with FDEP within the joint refuge/Seashore area. The FDEP projects have focused on protecting native plant diversity and protecting wildlife habitat. The refuge would continue to seek invasive plant control project funding from FDEP.

Extensive information on invasive plants and invasive plant control techniques can be found at www.fleppc.org, the website of the Florida Exotic Pest Plant Council.

Two invasive animal species are known to occur on the refuge, feral hogs and feral house cats. Hogs are an invasive species which are present in large numbers in all upland and marsh habitats. Hogs cause extensive habitat damage and it is suspect they also negatively impact wildlife through direct mortality and competition for food. Hogs are also a safety hazard due to impacts with vehicles. And they cause economic damage through vehicle collisions and through destruction of landscaped areas and road shoulders by rooting. Estimates of the hog population on the refuge have varied from 5,000 to 12,000. Current control efforts include trapping by permittees and shooting by refuge staff to remove approximately 2,500 hogs from the refuge each year. The number of feral house cats occurring on the refuge is small and is usually associated with refuge and NASA facilities. It is assumed that all feral house cats occurring on the refuge are released by the public. In the past, KSC employees were known to feed feral house cats at some KSC facilities. Supposedly these practices have stopped.

B-2: PROBLEM STATEMENT

A total of 29 invasive and nuisance plant and animal species are known to occur on the refuge. These species have invaded all refuge wetland and upland habitats, as well as disturbed sites. Invasive species have negative impacts to natural plant diversity and to wildlife habitat. Invasive animal species also cause direct mortality to native wildlife and compete with native wildlife for food resources. Invasive species can also have negative economic and public health and safety impacts.

The infestation of invasive plants and feral hogs is extensive on the refuge and without control efforts, the level of infestation would continue to increase, resulting in even greater negative impacts to refuge habitats and wildlife populations. The steps necessary to implement a methodology to control invasive species on Merritt Island Refuge are discussed.

C. INDIVIDUAL SPECIES, CURRENT SITUATION, HISTORY AND MANAGEMENT TECHINQUES

C-1 EXOTIC AND INVASIVE PLANTS

The first step in managing invasive plants on the refuge is to complete a database, including a GIS database, of all refuge lands. This database, as it now stands, identifies a number of exotic/invasive plant species present on the refuge and the coverage and stocking level for each species identified. This database would be updated and maintained annually.

The refuges uses a database to record the known locations of Old World climbing fern, Australian pine, *Melaleuca*, cogongrass, kudzu, bamboo, eucalyptus, air potato, and other invasive plant species. Treatment dates and history for each location are also recorded in the refuge's exotic plant database.

C1-1: Melaleuca

Level of Infestation: Currently 90 *Melaleuca* infestation sites are recorded on the refuge, ranging in size from a single tree to sites of scattered infestations of close to 50 acres. A number of other known, but undocumented infestation sites exist and new sites are discovered regularly by staff working on unrelated field operations. *Melaleuca* occurs from the southern refuge boundary at the barge canal to the northern most site in Burn Unit 2.3A. The majority of infestations occur in marshes and swale wetlands. Many of the infestation sites are difficult to access.

Past Control Efforts: *Melaleuca* has been treated by both refuge staff and contractors. Staff efforts have been concentrated in the Management Unit 9 and in T-24-D. Until recently staff control efforts were uncoordinated with no record of treatment dates and locations. Current staff control efforts are documented in a database. Contractors have treated *Melaleuca* at various locations in burn units 6.1, 6.2, 7.1, 7.2, 8.1, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, and 9.7. Due to various constraints, no efforts to accomplish re-treatments of previously treated sites have been conducted.

Level of Control: All *Melaleuca* located on the refuge would be killed each year. Each known *Melaleuca* location would be visited every year to check for and treat any living trees. Known *Melaleuca* locations would be considered not infested after 10 years with no re-growth.

Control Techniques: Seedlings would be hand pulled. Any *Melaleuca* too large to be pulled by hand would be cut using limb cutters or a chainsaw. The cut stumps would be immediately sprayed with a 20 percent solution of imazapyr in water using a hand or backpack sprayer.

Biological control agents are being released south of the refuge by the U. S. Department of Agriculture. It is expected that within a few years these biological control agents would spread to the refuge and infest *Melaleuca* there. The biological control agents feed on the leaves and buds of the host which causes stress. The stressing of the *Melaleuca* results in reproduction failure.

C1-2 Brazilian Pepper

Level of Infestation: Brazilian pepper has invaded almost all habitat types throughout the entire refuge. Infestations are most severe on disturbed sites, along roads and dikes, on marsh and wetland fringes, and on the edges of elevated sites in the marsh.

Past Control Efforts: Brazilian pepper has been treated by both refuge staff and contractors. Staff efforts have concentrated on roads, dikes, fire breaks, and public use areas. Until recently staff control efforts were uncoordinated with no record of treatment dates and locations. Current staff control efforts are documented in a database. Contractors have treated Brazilian pepper along both sides of State Road 402 from the western refuge boundary to State Road 3 and along the dikes of impoundments C-20-A, C-20-B, C-20-C, C-15-C, C-15-D, T-25-A, T-25-D, T-28-A, and T-28-B. Contractors working on Seashore projects have treated Brazilian peppers in Burn Unit 3.2, in all the impoundments surrounding Mosquito Lagoon, and on the beach ridge from the security area boundary north to the refuge boundary. Re-treatments of previously treated areas have occurred, especially along dikes, roads, and public use areas, but these efforts have been inadequate to maintain control of Brazilian peppers in previously treated areas.

Level of Control: Each year, all Brazilian pepper within the operational range of a power sprayer along the perimeter of dikes, public use roads, firebreaks, and public use areas would be sprayed with herbicide. Additionally, Brazilian pepper on 30 percent of the refuge would be treated annually utilizing the full range of refuge resource management programs, including mechanical cutting and removal, prescribed burning, and aerial and ground application of herbicides.

Control Techniques:

Mechanical Treatment - In select locations, Brazilian pepper would be cut with mowing equipment or uprooted and piled using an excavator equipped with a thumb device.

Herbicide Treatment - Brazilian pepper would be treated by either foliar or basal bark application of herbicides. Foliar treatment would consist of applying a one percent solution of triclopyr amine mixed in water to leaf surfaces until the leaf surfaces are wet. Basal bark treatment would consist of applying a five percent solution of triclopyr ester mixed in spray oil to wet the lower 12-18 inches of basal bark. Foliar applications are typically made using ground or aerial equipment. Ground applications utilize a truck or tractor mounted power sprayer. Aerial applications utilize a helicopter mounted power sprayer. Basal bark treatments are typically made using a hand sprayer.

C1-3: Cogongrass

Level of Infestation: Cogongrass has been documented at 43 sites on the refuge. All cogongrass infestation sites are one acre or less in size. A number of other known, but undocumented infestation sites exist and new sites are discovered regularly by staff working on unrelated field operations. Cogongrass infestation sites occur throughout the refuge and are most common along the edges of roads or dikes.

Past Control Efforts: All control of cogongrass has been by refuge staff and all control efforts have been within the past four years. In 2003 and 2004, all documented cogongrass sites were treated with glyphosate. Recent control efforts have been documented in a database.

Level of Control: All cogongrass known to occur on the refuge would be killed each year. Each known cogongrass location would be visited every year to check for and treat any live plants. Known cogongrass locations would be considered not infested after 10 years with no re-growth.

Control Techniques: Cogongrass would be treated by applying a two percent solution of glyphosate mixed in water as a foliar application. Glyphosate would be applied using a truck or tractor mounted power sprayer. Mowing cogongrass infestations 10 to 12 weeks before herbicide treatment may contribute to a better kill by removing dead plant material and exposing new growth to the herbicide.

C1-4: Old World Climbing Fern

Level of Infestation: Old World climbing fern is known to occur on at least four sites on the refuge. One site is in Burn Unit 9.4 along the north side of Center Road adjacent to a dredge spoil disposal site. A second site is in Burn Unit 9.6 immediately north of the KARS Park shooting range. The other two sites are in impoundment C-21/36 and Burn Unit 6.1B.

Past Control Efforts: The first occurrence of Old World climbing fern was documented in Burn Unit 9.4 in 2001. This infestation was treated in 2001, retreated in 2002, and has been checked for re-growth each year since. The other sites have not been treated.

Level of Control: All Old World climbing fern known to occur on the refuge would be killed each year. Each known Old World climbing fern location would be visited every year to check for and treat all living plants. Known Old World climbing fern locations would be considered not infested after 10 years with no re-growth.

Control Techniques: Old World climbing fern would be treated by making two applications each year of a two percent solution of glyphosate mixed in water as a foliar spray using a truck mounted power sprayer. The second application should be made approximately 12 to 16 weeks after the initial application.

C1-5: Kudzu

Level of Infestation: Kudzu is known to occur at only one site on the refuge. This site is approximately one acre in size and is located in an abandoned citrus grove on the east side of State Road 3 in Burn Unit 1.5.

Past Control Efforts: Kudzu at the only known site on the refuge was treated by piling all the vines into a single pile using a loader equipped with a root rake. The kudzu sprouts that

occurred after clearing and piling the vines and any living vines were treated with glyposate applied as a foliar spray.

Level of Control: All kudzu known to occur on the refuge would be killed each year. Each known kudzu location would be visited every year to check for and treat all living kudzu plants. Known kudzu locations would be considered not infested after 10 years with no re-growth.

Control Techniques: Kudzu would be treated by applying a two percent solution of glyphosate mixed in water as a foliar spray using a power sprayer.

C1-6: Australian Pine

Level of Infestation: Australian pines occur throughout the refuge as isolated stands of trees. These stands range in size from a few trees up to several acres. Australian pines are more abundant south of State Road 402 because of past FDEP contract control efforts north of State Road 402 and because of the abundance of Australian pines associated with citrus groves on the southern portion of the refuge. Most Australian pines occur on disturbed sites or on sites associated with past human habitation, such as old home sites. Australian pine infestation is extensive in and around active and abandoned refuge citrus groves where many of the roadsides and ditch banks are lined with a solid stand of mature Australian pines.

Past Control Efforts: Australian pine has been treated by both refuge staff and contractors. Staff efforts have been minimal, consisting of using an excavator to pull trees and roots along short lengths of ditch bank and at random locations along dikes and roads as they are encountered while doing other work with an excavator. Staff control efforts have been uncoordinated with no record of treatment dates and locations. Contractors have treated all known Australian pine infestation sites north of State Road 402. Contractors have also killed Australian pine as encountered while working on control projects for other species. Due to various constraints no efforts to accomplish re-treatments of previously treated sites have been conducted.

Level of Control: All Australian pines known to occur on the refuge would be killed each year. Each known Australian pine location would be visited every year to check for and treat all living trees. Known Australian pine locations would be considered not infested after 10 years with no re-growth.

Control Techniques: Depending upon size and location of the trees, Australian pines would be treated in a variety of ways. Small seedling and sapling sized trees may be treated by either foliar application of a one percent solution of triclopyr amine in water or basal bark application of a five percent solution of triclopyr ester mixed in spray oil. Larger trees would be killed primarily using basal bark application of triclopyr ester. Larger trees may also be cut and the stump treated with a one percent solution of triclopyr amine in water. Sapling and larger sized Australian pines may also be mechanically removed using an excavator to pull up the tree and the root system. Large Australian pines near roads, fire breaks, and public use areas would be pulled or cut down and the stump would be treated with triclopyr to prevent safety hazards and physical obstruction caused by falling dead limbs and trees.

C1-7: Air Potato

Level of Infestation: Air potato has been documented at five sites on the refuge. Infestation sites are generally small in size, however, one site on the north end of the refuge is believed to be over one acre in size. All infestation sites are adjacent to roads or historic public use sites.

Past Control Efforts: Only one site has been treated thus far. The potatoes have been physically collected and removed to the Brevard County landfill. In 2004, the vines at this site were treated with gyphosate. This site has not received a follow-up treatment and other sites have not been treated.

Level of Control: All air potato known to occur on the refuge would be killed each year. Each known air potato location would be visited every year to check for and treat all living air potato plants. Following initial herbicide treatment of a site, all potatoes should be physically collected and removed to the Brevard County landfill. Known air potato locations would be considered not infested after 10 years with no re-growth.

Control Techniques: The potatoes would be collected by hand and placed in plastic bags and the bags removed to the Brevard County landfill. Air potato vines would be treated by applying a two percent solution of glyphosate mixed in water as a foliar spray using a power sprayer. The vines in small infestations may be treated with hand sprayers using a two percent solution of glyphosate mixed in water or a five percent solution of triclopyr ester mixed in spray oil as a foliar spray. Air potatoes may also be controlled by cutting the vines and treating the cut surface with a two percent solution glyphosate in water or a five percent solution of triclopyr in oil.

C1-8: Other Invasive Plants

Level of Infestation: Other invasive plants which would receive control efforts include bamboo, mimosa (*Albizia julibrissin*) E*ucalyptus* spp., and guava (*Psidium spp*). Each of these species has low infestation levels and they typically occur as isolated single plants or small stands.

Past Control Efforts: There have been no staff efforts to control other invasive plants. Contractors have killed bamboo and eucalyptus at all known infestation sites north of State Road 402. Contractors have also killed mimosa and eucalyptus as encountered while working on control projects for other species.

Level of Control: All bamboo, mimosa, eucalyptus, and guava known to occur on the refuge would be killed each year. These species would be treated primarily as they are encountered while treating other invasive plants.

Control Techniques: Bamboo would be killed by cutting larger stems and by treating cut stems and sprouting stems with a two percent solution of glyphosate mixed in water. Small mimosa, eucalyptus, and guava may be treated with foliar applications of a one percent solution of triclopyr amine in water. Mimosa and guava of any size may also be treated by basal bark application of a five percent solution of triclopyr ester in spray oil. Large eucalyptus would be treated by cutting and treating the stump with triclopyr.

C2: EXOTIC ANIMALS

C2-1: Feral Hog

Description: Feral hogs on Merritt Island National Wildlife refuge are free-ranging morphs of the domesticated pig. Being descendents of the domesticated pig, the feral hog shares the basic physical characteristics. However, the body of a feral hog is usually much leaner and the face is more elongated, while the males often have protruding tusks. The coat color is also highly variable among feral hogs. The predominate coat color of feral hogs on MINWR is black. Other coat colors including red, white, spotted, tan, and orange have been observed. Though males are generally larger and heavier than females, weights are highly variable. The largest hogs have estimated weights in the hundreds of pounds. Feral hogs have poor eyesight, but a well-developed sense of smell, which they use to great advantage to locate food.

Feral hogs are social and forage in groups, usually consisting of females and their offspring. Male feral hogs of breeding age are typically solitary and only join these groups to breed. Females may breed as early as seven months of age. The gestation period is almost four months. Breeding occurs year-round with females producing an average of 1.8 litters per year (Strand 1976). Litters range in size from five to 12.

Feral hogs are omnivorous and feed on a variety of foods available on Merritt Island NWR. Acorns, tubers, hickory and pecan nuts, palmetto and cabbage palm berries, and commercial citrus are available to the hogs seasonally. Feral hogs also eat small reptiles, amphibians, and insects. They often root along public roadways and on refuge dikes, destroying large tracts of grass and native vegetation. They also root extensively in shallow seasonally flooded wetlands. They are most active at night; however they may continue to forage during daylight hours, especially during periods of extended rain, cloud cover, and/or cool temperatures.

Background: Feral hogs were first introduced to Florida, and to North America, in 1539 by Spanish colonizers in the form of 13 free ranging domestic pigs in Lee County (Mayer et al 1991). The pigs were used by early settlers as a source of food. Feral hogs have undoubtedly hybridized with free ranging pigs in the area over the last four centuries. Since their introduction, feral hogs have been documented in every Florida county.

Feral hogs have been documented in all areas of the refuge. To control feral hog numbers, the refuge started a feral hog removal program in 1972. Special use permits were issued for hog hunting during the first few years. In August 1974, the Florida Fish and Wildlife Conservation Commission (then the Florida Game and Freshwater Fish Commission) contracted with John Tanner to live trap and relocate feral hogs from the refuge to state game management areas for public hunting. Of those he trapped, Mr. Tanner provided the state with half of the hogs, while he kept the other half. This continued until 1989, when Mr. Tanner started trapping hogs as a volunteer, keeping all the hogs he caught. In 1995, the feral hog removal program was changed to a competitive bidding process with an annually renewed, multi-year permit. The refuge was divided into three hog removal units and three contractors were selected. The contractors mainly used dogs to assist with capturing hogs. Several of the contractors used traps to some extent. In 2004, after two competitive bidding cycles, the refuge changed the process to a random draw with the mandatory use of traps. Another essential component of the feral hog removal program is direct control by refuge staff. In addition to trapping, refuge staff members destroy hogs on sight, especially near major roadways.

Damage by feral hogs has been observed in almost all refuge habitats. Feral hogs do immense damage to native plant communities. Their rooting of the soils provides a means for invasive plants to spread. The hogs present a direct threat to sea turtle nests, where their keen sense of smell allows them to locate and predate visually hidden nests. Their olfactory skills also allow them to locate buried and covered mast, such as acorns and nuts, which reduces the amount of these foods available to native wildlife. Feral hog rooting can be seen along roadways and dikes. Each year, numerous vehicle accidents involve hogs. Feral hogs also compete with native wildlife for food and upset the balance of the ecosystem.

Management Objectives and Strategies: Feral hogs are so adaptable and the refuge so large and remote that total eradication is not believed to be economically feasible. Even if a way were found to remove all feral hogs from the refuge, there would be no viable way to prevent feral hogs from re-colonizing the refuge from adjoining properties. Therefore, feral hog control would be a continuing process requiring constant effort. Feral hog control efforts would focus on:

1. Reducing risk and maintaining low risk to public safety from vehicle collisions;
2. Preventing depredation on sea turtle nests and maintaining low predation levels;
3. Reducing rooting impacts to roads, levees, and landscaped public areas;
4. Maintaining low populations levels;
5. Preventing the spread of feral hogs off-refuge; and
6. Reducing habitat and native wildlife impacts.

Hog trapping on the refuge is conducted under permit (Appendix H). In April of 2004, four permit trappers were enlisted to control feral hogs on the refuge. Including assistant trappers, up to 54 people may be involved in removing feral hogs from the refuge. The new permits require trappers to set (activate) a minimum number of traps for nine days each month during the hog trapping season: September through April. The minimum number of traps required in each unit is listed.

Unit	Number of Traps
1	8
2	10
3	27
4	7

C2-2: Feral House Cat

Description: Feral house cats on Merritt Island National Wildlife refuge are any free-ranging morph of the domesticated housecat. Feral cats vary in size, weight, and coloration, depending on the predominant breed of the cat. The cat's eyesight and sense of hearing are well developed. Cats use these senses in hunting prey.

Feral cats become reproductively mature between seven and 12 months. A breeding female can be in estrus up to five times a year. Feral cats can have two or more litters per year. Domestic cats live 15 to 17 years. Feral cats typically live four to five years.

Background: Feral cats likely existed on the refuge when it was established in 1963. Several homesteads were located on what is now refuge property and they most likely had free-ranging cats that escaped into the refuge. However, most feral cats on the refuge today were probably

abandoned by their owners. No known concentrations of feral cats exist on the refuge. Historically, the largest concentration of feral cats was in a colony supported by NASA employees and located in an abandoned NASA building known as the cathouse of West Schwartz Road. Since this colony was housed inside a NASA building, they were not technically located on refuge property. This colony no longer exists. Small colonies are associated with several boat ramps on the refuge. These colonies are thought to feed on fish parts or bait discarded near the boat ramps by fishermen. Feral cats are occasionally observed at the Visitor Center and along State Road 402 near the west boundary of the refuge, presumably these are feral cats abandoned there by their owners.

Feral cats affect a range of native animal species. They prey on small reptiles, amphibians, mammals, and birds. They represent a threat to several federally threatened and endangered species on the refuge, including the Florida scrub-jay; southeastern beach mouse; and hatchlings of green, leatherback, and loggerhead sea turtles. In addition, they may serve as a vector for disease into native refuge wildlife, such as bobcats and raccoons.

Management Objectives and Strategies: To minimize the threat to native wildlife, especially to federally and state listed species, the refuge destroys all observed feral cats. The objective of the refuge is the removal of all feral cats from the refuge to maintain the refuge free from feral cats. Since the total number of feral cats is relatively small and since they usually occur in areas associated with people (e.g., Visitor Center and boat ramps), they can be effectively controlled by destroying individual animals as they are observed. Particular attention should be paid to controlling feral cats that are observed in or near Florida scrub-jay habitat, or on the beach where they could impact southeastern beach mouse or sea turtle hatchlings.

C2-3: Other Exotic/Invasive Animals

On rare occasion exotic animal species other than feral hogs and feral house cats are encountered on the refuge. When these exotic animals are encountered they would be removed or destroyed as soon as possible. The exception is aquatic exotic animals, such as the green mussel (*Perna viridius*) and the armored catfish (*Pterygoplicththys* spp.), which currently receive no control efforts.

C3: NUISANCE ANIMALS

C3-1: Raccoon

Description: Raccoon coats can range in color from reddish-brown to almost black. They have dark markings around their eyes and four to seven dark bands on their bushy tails. Male raccoons are generally larger than female raccoons. Raccoons have a short, stocky, bear-like body. Their feet and forepaws have five fingers/toes and are dexterous.

Raccoons are almost exclusively nocturnal and have excellent hearing and night-vision. They are omnivorous and have a highly variable diet, including insects, fruits, vegetables, acorns, seeds, fish, and small mammals. Raccoons typically have one litter of two to seven babies per year after a 63-day gestation.

Background: Raccoons are a native species and are a well-adapted, essential component of the coastal Florida ecosystem. However, during the sea turtle nesting season (April through October), these animals prey on federally threatened and endangered sea turtle eggs and hatchlings.

The refuge maintains 10 kilometers of beach for nesting sea turtles. Refuge staff monitors and reports the number of sea turtle nests and nesting success. This beach is part of a statewide network of index beaches used to monitor the overall success of nesting sea turtles. In the past, predation rates were as low as six percent. To accomplish this low predation rate on sea turtle nests, raccoons are trapped on the sea turtle nesting beach and euthanized. This is the most effective and efficient means of protecting sea turtle nests from raccoons. In recent years, the National Park Service and Cape Canaveral Air Force Station, which manage sections of beach to the north and south of the refuge, have also initiated raccoon trapping programs to protect sea turtle eggs and hatchlings.

Management Objectives and Strategies: The refuge would continue to trap and euthanize raccoons to protect sea turtle nests and hatchlings. Currently, the refuge uses up to 15 baited traps spaced along the 10-kilometer section of refuge managed beach. These traps are baited and set before the sea turtle nesting season in April and trapping continues through the end of sea turtle hatchling emergence in October. The traps are checked during sea turtle crawl surveys. Any raccoons caught are euthanized immediately. The carcasses are buried in the sand. The objective of the raccoon trapping program is to maintain sea turtle nest predation rates below 10 percent.

C3-2: Nuisance Animals On Kennedy Space Center Property

As part of the agreement between the Service and NASA, Kennedy Space Center contracts the refuge to remove certain nuisance animals from industrial areas, buildings, launch pads, and visitor facilities. The refuge responds to calls for nuisance birds, reptiles, and mammals other than raccoons and opossums. The refuge responds to each nuisance animal by the least intrusive means. Nuisance animals in this instance include only native species, since exotic animal species would be removed or destroyed as previously described.

Birds: Refuge personnel responding to birds nesting on active launch pads or similar areas attempt to postpone the planned human activity until after fledging has occurred. If the activity cannot be postponed, then the nest is moved intact or the eggs are relocated to an animal rehabilitation facility for incubation. As a last resort, depending upon the NASA operations, the nest or eggs may have to be destroyed. In an attempt to reduce conflicts with nesting birds, refuge personnel work proactively with NASA employees to schedule outdoor maintenance activities before or after nesting season and to configure facilities so they are not attractive to nesting birds.

Refuge personnel responding to other nuisance bird inquires, such as birds damaging facilities or causing a hazard to traffic, attempt to repel the birds from the area or exclude the birds from the facility. Refuge personnel remove the attracting feature, install predator decoys, or use sub-lethal harassment methods to cause the birds to avoid the area, depending on the specific situation. Birds trapped inside of a building or facility are captured and released.

Alligators: Refuge personnel responding to reports of nuisance alligators go to the site to assess the situation. If the alligator presents a threat to humans and is small enough for refuge personnel to safely handle, the refuge relocates it to a suitable site far from NASA facilities. If the alligator can't be safely handled by refuge personnel (e.g., it is too large or no experienced staff is available), the state nuisance alligator trapper is called to handle the alligator. The trapper either relocates the alligator to a suitable site on the refuge or it is harvested.

Other Wildlife: Occasionally the refuge receives calls about various other nuisance wildlife, including armadillos, rattlesnakes, and small mammals. These animals are captured and relocated to suitable sites on the refuge away from NASA facilities.

In all cases, injured nuisance native wildlife would be captured and transported to a rehabilitation facility. Individual animals judged to be injured to the point of not being able to survive in a rehabilitation facility would be euthanized by authorized refuge personnel.

Appendix A: Literature Cited

Abrhamson W. G. and D. C. Hartnett. 1990. Pine flatwoods and dry prairies. In: Ecosystems of Florida. R. L. Myers and J. J. Ewel ed. University of Central Florida Press. Orlando, FL.

Adair, R. C. Jr. 2003. The Sustainable Citrus Program at the Merritt Island National Wildlife Refuge Citrus Groves: Annual Report 2003. Florida Research Center. Vero Beach, FL. 89 pp.

Adrian, F. W. 2003. Fire management in the Intergalactic Interface, or 30 years of fire management on Merritt Island National Wildlife Refuge/Kennedy Space Center. In: Proceedings of the second international wildland fire ecology and fire management conference. American Meteorological Society. Published on CD ROM and at http://www.ametsoc.org.

Baker, James L. 1974. Spoil island nesting investigations. Unpublished report. U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge. 7 pp.

Bissett, N. 2004. Reedy Creek mitigation bank restoration: seven years of progress from bahia pasture to flatwoods. In: 24th annual conference of the Florida Native Plant Society. (Abstract)

Breininger, D. R., B. W. Duncan, and N. J. Dominy. 2002. Relationships between fire frequency and vegetation type in pine flatwoods in east central Florida, USA. Natural Areas Journal 22:186-193.

Breininger, D. R., M. J. Barkaszi, R. B. Smith, D. M. Oddy, and J. A. Provancha. 1994. Endangered and potentially endangered wildlife on John F. Kennedy Space Center and faunal integrity as a goal for maintaining biological diversity. NASA Technical Memorandum 109204. John F. Kennedy Space Center, FL.

Breininger, D. R., V. L. Larson, B .W. Duncan, and R. B. Smith. 1998. Linking habitat suitability to demographic success in Florida scrub-jays/ Wildl. Soc. Bull. 26(1):118-128.

Breininger, D. R., V. L. Larson, B .W. Duncan, R. B. Smith, D. M. Oddy, and M. F. Goodchild. 1995. Landscape patterns of Florida scrub-jay habitat use and demographic success. Conservation Biology 9(6)1442-1453.

Breininger, D. R., V. L. Larson, R. Schaub, B. W. Duncan, P. A. Schmalzer, D. M. Oddy, R. B. Smith, F. W. Adrian, and H. Hill. 1996. A conservation strategy for the Florida scrub-jay on John F. Kennedy Space Center/Merritt Island National Wildlife Refuge: an initial scientific basis for recovery. NASA-TM-111676. Kennedy Space Center, FL.

Brockmeyer, R. E. , Jr., J. R. Rey, R. W. Vernstein, R. G. Gilmore, and L. Earnest. 1997. Rehabilitation of impounded estuarine wetlands by hydrologic reconnection to the Indian River Lagoon, Florida (USA). Special Issue: Hydrologic Restoration of Coastal Wetlands, Wetl. Ecol. & Manage. 4(2):93_109.

Byrn, M. and C. Matson. 2004. New techniques of seed preparation and seed drilling for understory restoration: bahia pasture to flatwoods. In: 24th annual conference of the Florida native plant society. (Abstract)

Campbell, T. 2000. Analysis of the Effects of an Exotic Lizard (Anolis sagrei) on a Native Lizard (Anolis carolinensis) in Florida, Using Islands as Experimental Units. Ph.D. University of Tennessee. 336 pp.

Campbell, T. and A.C. Echternacht. 2002. Character release and body sizes of introduced lizards in their native and invaded lands. Institute of Biological Invasions. pp 67.

Clark, E. Scott and Robert C. Lee, Jr. 1982. History and Status of Wood Stork Nesting on Merritt Island National Wildlife Refuge, Florida 1972-1981. U.S. Fish and Wildlife Service.

Clark, Edward E. Engineers-Scientists, Inc. 1987. KSC Ground Water Survey. Kennedy Space Center, Florida.

Duncan, B.W. S. Boyle, P.A. Schmalzer, and D.R. Breininger. 1996. Spatial quantification of historic landscape change within tow study sites on John F. Kennedy Space Center. Proceeding of the Sixteenth annual ESRI users Conference.

Duncan, B. W. and P. A. Schmalzer. 2004. Anthropogenic influences on potential fire spread in a pyrogenic ecosystem in Florida USA. Landscape Ecology. 19:153-165.

Duncan, B. W., S. Boyle, D. R. Breininger, and P. A. Schmalzer. 1999. Coupling past management practice and historic landscape change on John F. Kennedy Space Center, Florida. Landscape Ecology 14:291-309.

Duncan, B. W., V. L. Larson, and P. A. Schmalzer. 2004. Historic landcover and recent landscape change in the North Indian River Lagoon watershed, Florida USA. Natural Areas Journal 24:198-215.

Ehlinger, Gretchen S. 2001. Spatial and Temporal Patterns of Spawning and Larval Hatching by the Horseshoe Crab, Limulus polyphemus, in a Microtidal Costal Lagoon. Florida Institute of Technology. 36 pp.

Ehlinger, Gretchen S. 1999. Progress Report on the Population and Recruitment Variability of the Horseshoe Crab (*Limulus* polyphemus) in the Indian River Lagoon, Florida. Florida Institute of Technology. Melbourne, FL. 8 pp.

Ehlinger, Gretchen S. and Richard A. Tankersley. 2003. Larval hatching in the horseshoe crab, *Limulus polyphemus*: facilitation by environmental cues. Journal of Experimental Marine Biology and Ecology. Vol. 292. pp. 199-212.

Ehrhart, L. M. and R. G. Yoder. 1978. Marine Turtles of Merritt Island National Wildlife Refuge, Kennedy Space Center, Florida. Proceedings of the Florida Interregional Conference on Sea Turtles, July 1976. Florida Marine Research Publications, No 33.

Epstein, Marc B. 2002. Managing wetlands for multiple objectives: Atlantic Flyway.. Waterfowl habitat restoration, enhancement and management in the Atlantic Flyway, 4th Ed. Environmental Management Committee, Atlantic Flyway Council, Tech. Sect.

Epstein, Marc B. 2001. Wetland restoration and enhancement: Merritt Island NWR. Tech. Bull. FL Mosquito Control Assoc. 4th Workshop on Salt Marsh Management and Research Vol 3: p. 11-12. (Abstract)

Epstein, Marc B. 1999. Incidental impact to nesting Wilson's plovers during the sea turtle nest monitoring season. FL Field Nat. 27(4): 173-176.

Epstein, Marc B. 1997. Conceptual wetland management plans for NASA mitigation projects. USFWS/Merritt Island NWR. Unpublished report. 10pp.

Epstein, M and B. Blihovde. 2006. Listed species of the Merritt Island National Wildlife Refuge. US Fish and Wildlife Service, Merritt Island National Wildlife Refuge. Titusville, FL. 13 pp.

Epstein, Marc B. and Ralph Lloyd. 2001. Draft Wetland Management Plan: Merritt Island National Wildlife Refuge. Unpublished report. U.S. Fish and Wildlife Service. 26pp.

Erwin, R. Michael, D.H. Allen, and D. Jenkins. 2003. Created versus natural coastal islands: Atlantic waterbird populations, habitat choices, and management implications. Estuaries 26(4A):949-955.

Erwin, R. Michael, Jeff S. Hatfield, and Thomas J. Wilmers. 1994. The Value and Vulnerability of Small Estuarine Islands for Conserving Metapopulations of Breeding Waterbirds. Biological Conservation, Vol 71.

Federal Geographic Data Committee. 1997. National Vegetative Classification Standard. Federal Geographic Data Committee Secretariat. U.S. Geological Survey. Reston VA.

Florida Department of Environmental Protection. 1996. Mangrove Trimming and Preservation Act. Tallahassee, FL. 9 pp.

Foster, T. E. and P. A. Schmalzer. 2003. The effect of season of fire on the recovery of Florida scrub. In: Proceedings of the second international wildland fire ecology and fire management conference. American Meteorological Society. Published on CD ROM and at http://www.ametsoc.org.

Gilmore, R. Grant. 1995. Enveronmental and Biogeographic Factors Influencing Ichthyofaunal Diversity: Indian River Lagoon. Bulletin of Marine Science Vol 57. pp 153-170.

Gurr, Shelly. 2005. Boat Registrations and Seasonal Boat Use. Florida Fish and Wildlife Conservation Commission. Personal communication.

Hamilton, S. 2002. Suggestions for a Revision of the Recovery Plan Anastasia Island Beach Mouse and Southeastern Beach Mouse. U.S. Fish and Wildlife Service. 23 pp.

Hardesty, J. L. and M. W. Collopy. 1991. History, demography, distribution and habitat use of the southern bald eagle (*Haliaeetus l. leucocephalus*) on Merritt Island National Wildlife Refuge, Florida. Department of Wildlife and Range Sciences, School of Forest Resources and Conservation, University of Florida. Gainesville, FL. 179p.

Herring, G. 2003. Assessing nutrient reserves and local population dynamics of wintering lesser scaup in east-central Florida. MS Thesis. North Carolina State University. Raleigh, NC. 80pp.

Hunter, C. 1999. Florida WatchList (Priority Bird Species). DRAFT October 31, 1999. 6pp. unpublished.

Johnson, A. F. and M. B. Barbour. 1990. Dunes and maritime forest. Pages 429_480 *in* Myers, R. L. and J. Ewel (eds.), Ecosystems of Florida. University of Central Florida Press. Orlando, FL. 765pp.

Leenhouts, William P. 1986. Colonial nesting birds -1986. Unpublished report. U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge. 6 pp.

Leenhouts, William P. 1982. Marsh and water management plan, MINWR. U.S. Fish and Wildlife Service. Unpublished report. Merritt Island National Wildlife Refuge.

Lyon, James and Marc Epstein. 2005. Merritt Island National Wildlife Refuge Impoundment Monitoring and Management 2004. U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge. Titusville, FL. 64 pp.

Mathews, T.D., F.W. Stapor, Jr., C.R. Richter, et al. 1980. Ecological characterization of the Sea Island coastal region of South Carolina and Georgia. Vol. I: Physical features of the characterization area. USFWS, OBS, Washington, DC. FWS/OBS_79/40. 212pp.

Mayer, John J., Brisbin, and I. Lehr. 1991. Wild Pigs of the United States, Their History, Morphology, and Current Status. The University of Georgia Press. 313 pp.

Mendonca, M. T. and L. M. Ehrhart. 1982. Activity, Population Size and Structure of Immature Chelonia mydas and Caretta caretta in Mosquito Lagoon, Florida. Copeia (1):161-167.

Menges, E.S. and C.V.Hawkins. 1998. Interactive effects of fire and microhabitat on plants of Florida scrub. Ecological Applications 8:935-946.

Millsap, B. A., J. A. Gore, D. E. Runde, and S. I. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildl. Mono. 111. 57 pp.

Montague, C. L. and R. G. Weigert 1990. Salt Marshes. Pages 481-516 in R. L. Myers and J. J. Ewel, Ecosystems of Florida. University of Central Florida Press.

Myers, R. L. 1990. Scrub and high pine. In: Ecosystems of Florida. University of Central Florida Press. Orlando, FL. Pages 150-193.

Myers, R.L. and J.J. Ewel. 1990. Ecosystems of Florida. Univ. of Central Florida Press. Orlando, Florida. 765 pp.

National Aeronautics and Space Administration. 2001. Wetland restoration plan. Regulatory permit application. March 2001. Kennedy Space Center, FL. 148pp.

National Aeronautics and Space Administration. 1984. Master Plan. John F. Kennedy Space Center. Titusville, FL.

National Ocean Service. 1995. Tide tables 1996: high and low water predictions east coast of North and South America including Greenland. NOAA and International Marine. McGraw Hill Company. Blacklick, OH. 308pp.

National Weather Service. 2005. <http://www.srh.noaa.gov/mlb/ltgcenter/ltgmain.html> National Weather Service Office, Melbourne, FL.

Paperno, R. 2001. Estuarine Fish Species List for Merritt Island National Wildlife Refuge. Florida Fish and Wildlife Conservation Commission. Personal communication.

Parnell, James F. and Robert F. Soots Jr. 1978. The Use of Dredge Islands by Wading Birds. Wading Birds Research Report No. 7, National Audubon Society. pp. 105-111.

Patrick Air Force Base. 2004. Operational climatic data summary KTTS. https://www.patrick.af.mil/45OG/45ws/data/SLFclimo.htm.

Popotnik, G. J. and M. B. Epstein. 2002. Characterization of sea turtle nesting and depredation at the Merritt Island NWR, Kennedy Space Center. 22nd Annual Symp. on Sea Turtle Bio. and Conserv. Miami, FL. (Abstract)

Provancha, J. A., M. J. Mota, K. G. Hollway-Adkins, E. A . Reiyer, R. H. Lowers, D. M. Scheidt, and M. Epstein. 2005. Mosquito Lagoon sea turtle Cold stun event of January 2003, Kennedy Space Center/Merritt Island National Wildlife Refuge, Florida. Vol 86(2):114-121.

Provancha, J.A, M.J. Mota, R. Lowers, D. Scheidt, and E. Reyier. 2002. Relative abundance and distribution of marine turtles inhabiting mosquito lagoon summary of 2001 surveys. 3rd Biennial Mosquito Lagoon Conference, U.S. Fish and Wildlife Service and National Park Service. Titusville, FL. (Abstract)

Randazzo, A.F. 1997. The Sedimentary Platforms of Florida: Mesozic to Cenozoic: *In* Randazzo, A.F. and D. S. Jones (eds). The Geology of Florida. University Press of Florida. Gainesville, FL. pp 39-56.

Roberts, C.M., J.A. Bohnsak, F. Gell, J.P. Hawkins, and R. Goodridge. 2001. Effects of Marine Reserves on Adjacent Fisheries. Science 294: 1920-1923.

Rodgers, James A. Jr., and Henry T. Smith. 1997. Buffer Zone Disturbances to Protect Foraging and Loafing Waterbirds from Human Disturbances in Florida. Wildlife Society Bulletin. 25(1): 139-145.

Rodgers, James A., Jr., and Henry T. Smith. 1995. Set-back Distances to Protect Nesting Bird Colonies from Human Disturbance in Florida. Conservation Biology, Vol 9

Rodgers, James A Jr. and Stephen T. Schwikert. 2002. Buffer Zone Distances to Protect Foraging and Loafing Waterbirds from Disturbance by Personal Watercraft and Outboard-powered Boats. Bureau of Wildlife Diversity Conservation, Florida Fish and Wildlife Conservation Commission. Conservation Biology, 16, No. 1. pp. 216-224.

Salata, Larry. 1979. Least tern census and nesting survey. Unpublished report. USFWS, Merritt Island NWR. 10 pp.

Sargent, F. J., T. J. Leary, D. W. Crewz, and C. R. Kruer. 1995. Scarring of Florida's Seagrasses: Assessment and management options. Florida Department of Environmental Protection, Florida Marine Research Institute Technical Report TR-1. 46pp.

Schmalzer, P. A. and C. R. Hinkle. 1992. Species composition and structure of oak-saw palmetto scrub vegetation. Castanea 57(4): p. 220-251.

Schmalzer, P. A., D. R. Breininger, F. W. Adrian, R Schaub, and B. W. Duncan. 1994. Development and implementation of a scrub habitat compensation plan for Kennedy Space Center. Technical memorandum 109202. Kennedy Space Center, FL.

Schmalzer, P. A. and F. W. Adrian. 2001. Scrub restoration on Kennedy Space Center/Merritt Island National Wildlife Refuge. In D. Zattau (Ed.) Proceedings of the Florida Scrub Symposium 2001. U. S. Fish and Wildlife Service. Jacksonville, FL.

Schmalzer, P. A., M.A. Hensley, and C.A. Dunlevy. 2001. Background Characteristics of Soils of Kennedy Space Center, Merritt Island, Florida: Selected Elements and Physical Properties. FL. Sci. Vol. 64, No. 3. pp. 161-190.

Schmalzer, P.A., S.R. Turek, T.E. Foster, and F. W. Adrian. 2002a. Reestablishing Florida scrub in a former agricultural site: Survival and growth of planted species and changes in community composition. Castanea 67:146-160.

Schmalzer, P.A., T.E Foster, and B.W. Duncan. 2002b. Revised list of flora and list of threatened and endangered plants for the John F. Kennedy Space Center area, Florida. NASA/TN-2002-21175. Kennedy Space Center, FL.

Schmalzer, P. A., T. E. Foster, and F. W. Adrian. 2003. Responses of long-unburned scrub on the Merritt Island/Cape Canaveral barrier island complex to cutting and burning. In: Proceedings of the second international wildland fire ecology and fire management conference. American Meteorological Society. Published on CD ROM and at http://www.ametsoc.org.

Schroeder, Barbara A. 1990. Banana River Spoil Island Management Plan. Unpublished management plan. U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge. 50 pp.

Schroeder, Barbara A. 1981. Banana River spoil island survey, Unpublished report. U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge. 11 pp.

Schroeder, Barbara A. 1980. Least Tern Nesting Survey. Unpublished report. U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge. 6 pp.

Seigel, R.A.,and D.A. Pike. 2003. Continued Studies on Amphibians and Reptiles of the Kennedy Space Center, Merritt Island National Wildlife Refuge, and Canaveral National Seashore. Annual Report. Towson University. 29 pp.

Seigel, Richard A. and Nadia A Siegel. 2000. Inventory and Monitoring of Herpetological Communities on the Kennedy Space Center/Merritt Island National Wildlife Refuge/Canaveral National Seashore: Annual Report. Southeastern Louisiana University. Unpublished Report to Merritt Island National Wildlife Refuge. Lafayette, LA.

Smith, Henry T. and Elsa M. Alvear. 1997. Recent Breeding Reports of the Gull-Billed Tern in Florida...Status Undetermined? Florida Naturalist, Spring.

Soil Survey Staff. 1974. Soil survey of Brevard County, Florida. U.S. Department of Agriculture, Soil Conservation Service. Washington, D.C. 123 pp.

St. Johns River Water Management District. 2003. Chapter 40C-4, FAC. Environmental resource permits: surface water management systems. Palatka, FL.

St. Johns River Water Management District. 2001. Chapter 40C-400, F.A.C. Noticed General Environmental Resource Permits. Palatka, FL. 27pp.

Stevens, T. and G. Knight. 2003. Status and distribution of the Florida scrub-jay (*Aphelocoma coerulescens*) at Cape Canaveral Air Force Station, Florida, Annual Report 2002-2003. 45th CES/CEV. Patrick Air Force Base, FL.

Stolen, E. D. 1999. Occurrence of birds in beach habitat in east-central Florida. FL. Field Nat. 27(3):77-88.

Strand, Deborah Kay. 1980. Reproductive Ecology and Behavior of the Florida Feral Hog (*Sus scrofa*) . Florida Institute of Technology. Melbourne, FL.

Toombs, A.K. 2001. Pilot study of the Southeastern Beach Mouse, *Peromyscus polionotus niveiventris* at Merritt Island National Wildlife Refuge. Titusville, FL. Ann. Res. Rept. for Merritt Island NWR. (Abstract)

U.S. Fish and Wildlife Service. 2003. Merritt Island National Wildlife Refuge Wildlife and Habitat Management Review (Biological Review). Titusville, FL.

U.S. Fish and Wildlife Service. 2002. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, Virginia. 99 pp. [Online version available at http://migratorybirds.fws.gov/reports/bcc2002.pdf]

U.S. Fish and Wildlife Service. 1999. Merritt Island 1999 Annual Narrative. USFWS, Merritt Island National Wildlife Refuge. Titusville, FL.

U.S. Fish and Wildlife Service. 1998. Merritt Island 1998 Annual Narrative. USFWS, Merritt Island National Wildlife Refuge. Titusville, FL.

U.S. Fish and Wildlife Service. 1996. Merritt Island 1996 Annual Narrative. USFWS, Merritt Island National Wildlife Refuge. Titusville, FL.

U.S. Fish and Wildlife Service. 1992 Spoil Islands. Unpublished notes. USFWS Merritt Island National Wildlife Refuge. Titusville, FL. 3 pp.

U.S. Fish and Wildlife Service. 1988. Merritt Island 1988 Annual Narrative. USFWS Merritt Island National Wildlife Refuge. Titusville, FL.

U.S. Fish and Wildlife Service. 1987. Merritt Island 1987 Annual Narrative. USFWS Merritt Island National Wildlife Refuge. Titusville, FL.

U.S. Fish and Wildlife Service. 1986. Merritt Island 1986 Annual Narrative. USFWS Merritt Island National Wildlife Refuge. Titusville, FL.

U.S. Fish and Wildlife Service. 1980. Merritt Island 1980 Annual Narrative. USFWS Merritt Island National Wildlife Refuge. Titusville, FL.

Virnstein, R.W. 1999. Seagrass Meadows: Fish and Wildlife Factors. Florida Naturalist. 72(2): 18-19.

Virnstein, R. W. and L. J. Morris. 1996. Seagrass Preservation and Restoration: A Diagnostic plan for the Indian River Lagoon. Tech. Memo. 14, SJRWMD. Palatka, FL. 43 pp.

Waters, L., A. Roman, J. Stiner, and D. Weeks. 2001. Water resources management plan: Canaveral National Seashore, FL. National Park Service. 224pp.

Wenger, K. E. 1984. Forestry Handbook 2nd Edition. John Wiley & Sons. New York, New York, 1,335 pp.

White, W. A. 1970. The geomorphology of the Florida peninsula. Geological bulletin No. 52. Bureau of Geology, Florida Department of Natural Resources, Tallahassee, FL. 164 pp.

Appendix B: Habitat Management Plan Authorship

CHAPTER	AUTHOR(S)
Chapter I	Fred Adrian[1], Marc Epstein[2], and Ralph Lloyd[3]
Chapter II	Fred Adrian and James Lyon[4]
Chapter III	Fred Adrian and Marc Epstein
Chapter IV	Fred Adrian
Chapter V	Fred Adrian
Chapter VI	Fred Adrian
Chapter VII	Marc Epstein and James Lyon
Chapter VIII	Marc Epstein and James Lyon
Chapter IX	Ralph Lloyd

1. Fred Adrian, Refuge Forester, MINWR, USFWS

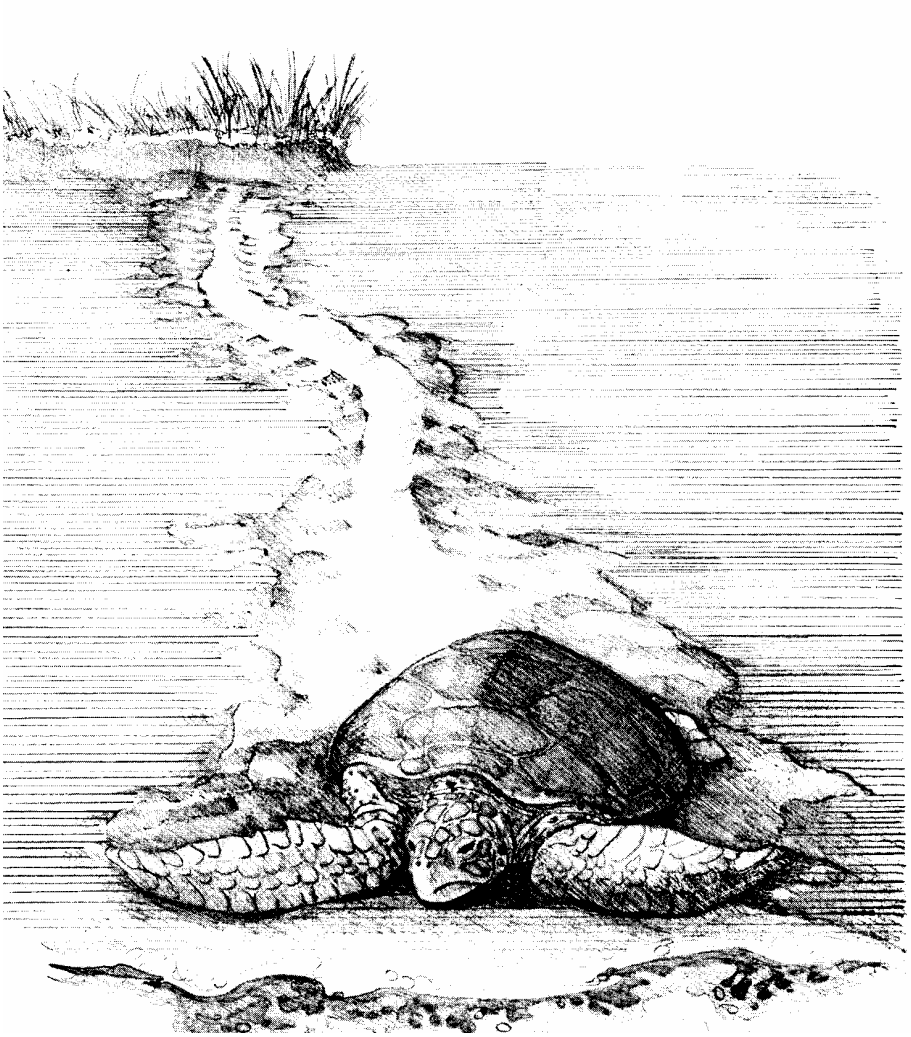
2. Marc Epstein, Supervisory Refuge Biologist, MINWR, USFWS

3. Ralph Lloyd, Deputy Project Leader, MINWR, USFWS

4. James Lyon, Biological Science Technician, MINWR, USFWS

C.

LISTED SPECIES OF THE MERRITT ISLAND NATIONAL WILDLIFE REFUGE



Compiled by:
Marc Epstein and Boyd Blihovde
US Fish and Wildlife Service
Merritt Island National Wildlife Refuge
February 2006

LISTED SPECIES OF THE MERRITT ISLAND NATIONAL WILDLIFE REFUGE

Listed species are plants or animals that have been listed by a State and/or Federal agency with special protection or conservation designations. Included on this list are species designated by non-governmental agencies that do not provide regulatory protection (see below). Those species with regulatory protection are protected by law, such as State and Federal Endangered and Threatened species. State Species of Special Concern (SSC) and Commercially Exploited are afforded special protection, recognition, or consideration (Florida Administrative Code 39-1.004 and Chapter 5B-40). Birds of Conservation Concern are those migratory and non-migratory bird species (not already listed as Federally Threatened or Endangered) with the highest conservation priority (USFWS 2002). Brief explanations of species designations are listed below. Definitions of species designations and status are listed in Appendix 1.

Types of Designations Used in this List:

Agencies and Organizations Listing Species

Florida Fish and Wildlife Conservation Commission **(FWC)**
Florida Department of Agriculture and Consumer Services **(FDA)**
US Fish & Wildlife Service **(FWS)**
Florida Natural Areas Inventory **(FNAI)**
Florida Committee on Rare and Endangered Plants and Animals **(FCREPA)**

Listing Designation

Similarity of Appearance T(S/A) means the species is similar in appearance to a threatened taxon. The American alligator in this case with the American crocodile, but the alligator is not a threatened species under the meaning or intent of the threatened designation.

Endangered (E) means "without special management efforts, these species are considered rare enough to become extinct." (Federal and State)

Threatened (T) means "without special management efforts, these species are likely to become endangered in the foreseeable future." (Federal and State)

Species of Special Concern (SSC) means that the species warrants special protection because of concern that it could become threatened. (State; see Sullivan 2004))

Birds of Conservation Concern (BCC) replaced the Nongame Birds of Management Concern (SMC). These birds have the highest conservation concern for the US Fish and Wildlife Service (other than the birds listed as Federally Threatened or Endangered) (Federal; see USFWS 2002).

Rare (R) means the species is considered rare by the Florida Committee on Rare and Endangered Plants and Animals (non-government).

Commercially Exploited (C) means plants that are protect due to Commercial Exploitation.

Rare (R) means the species is considered rare by the Florida Committee on Rare and Endangered Plants and Animals (non-government).

FNAI means that the species has been ranked by the Florida Natural Areas Inventory (non-government).

FCREPA means the species is listed by Florida Committee on Rare and Endangered Plants and Animals (non-government).

This list is based on species with a Federal, State, or non-government designation; it is not a comprehensive list of species for the refuge. There are 124 unique species included under this list: 1 amphibian, 10 reptiles, 69 birds, 6 mammals, and 38 plants. There may be species in Florida that are protected but not listed here because the species either has not been confirmed or has been extirpated from the refuge. This list includes species that are considered "rare" and do not occur on the refuge every year or there have been incidental reports (see Literature Cited section). The total number of "listed" species presently known to exist or regularly occur on the Merritt Island NWR are categorized (Tables 1 and 2).

Among the 124 species listed here, 50 are listed as State or Federal Threatened or Endangered plants and animals (21 animals and 28 plants) and 5 are plants that are listed by the State as "Commercially Exploited" (Table 3). There are no known Federally listed plants on the refuge and all listing for plant are State designations. Of the total listed animal species, 17 are Federally listed. However, 7 of these species (American alligator, Kemp's ridley sea turtle, Hawksbill sea turtle, Atlantic salt marsh snake, snail kite, Audubon's cara cara and roseate tern) either have a special listing (i.e., alligator) or have rarely been recorded on the refuge. This brings the actual number of State or Federally-listed species that presently occur on the refuge to 41; 10 Federal and 31 State species (excludes alligator; includes 28 plant species) (Table 2). There are 10 Federally and 3 State listed animal species (13 total State or Federal) that presently occur on the refuge. A total of 93 species that presently occur on the refuge have a Federal or State designation (i.e., T, E, BCC, SSC, or C). Annotated species records of rare sightings (16 species) are included on this list, however, these rare species may not actually be a functional component of the wildlife community on the refuge and may only be the results of incidental sightings. Additionally, rare non-federally listed species, such as the Florida black bear, Limpkin, Roseate tern, and others are also listed but may have limited distribution or activity on the refuge. Species that are rare or have only had incidental sightings are footnoted to this effect. They are removed from the final calculation.

There are 55 animal species designated as species of "Special Concern" by State or Federal agencies (designated BCC or SSC). There are 33 plant species listed by the State as Threatened, Endangered, or Commercially Exploited. Included in the list are 22 additional plant species that have special designations (e.g., UR, FNAI, CITES, or FCREPA). Some plant species may have both a State and special designation.

Table 1. State or Federally designated plants and animals that have been recorded on Merritt Island National Wildlife Refuge.

T & E Species Presently Occurring	**Fish**	**Amphibians**	**Reptiles**	**Birds**	**Mammals**	**Plants**	**TOTAL**
Number of Federal	0	0	4	4	2	0	10
Number of State and Federal	0	0	4	7	2	28	41

Table 2. Number State and Federally Threatened and Endangered species that presently occur on the Refuge.

Species	**Federal**			**State**			**Commercially Exploited Plants**
	E	T	BCC	E	T	SSC	C
Fishes	0	0	0	0	0	0	0
Amphibians	0	0	0	0	0	1	0
Reptiles	4	4	0	5	2	3	0
Birds	2	5	42	3	8	12	0
Mammals	1	1	0	1	2	1	0
Plants	0	0	0	17	11	0	5
Total Recorded	**7**	**10**	**42**	**26**	**23**	**17**	**5**

Table 3. Listed Species of the Merritt Island National Wildlife Refuge.

Scientific Names	Common Names	Agency Status			
		FWC	FWS	FCREPA	FNAI
Amphibians (1)					
Rana capito	Gopher frog	SSC	*	T	G3G4S3
Reptiles (10)					
Alligator Mississippiensis	American alligator [1]	SSC	T(S/A)	*	G5S4
Caretta caretta	Loggerhead	E	T	T	S3
Chelonia mydas	Green turtle	E	E	E	S2
Dermochelys coriacea	Leatherback	E	E	R	S2
Lepidochelys kempi	Kemp's ridley [3, 5]	E	E	E	S1
Eretmochelys imbricata	Hawksbill [3, 5]	E	E	E	S1
Gopherus polyphemus	Gopher tortoise	SSC	*	T	S3
Pituophis melanoleucus mugitus	Florida pine snake [4]	SSC	*	SSC	G5T3S3
Nerodia clarkii taeniata	Atlantic saltmarsh snake [2, 5]	T	T	E	G4T1S1
Drymarchon couperi	Eastern indigo snake	T	T	SSC	G4T3S3
Birds [6, 7] (69)					
Spizella pusilla	Field sparrow	*	BCC	*	*
Ammodramus henslowii	Henslow's sparrow [5]	*	BCC	*	*
Aimophila aestivalis	Bachman's sparrow	*	BCC	*	G3S3
Passerina ciris	Painted bunting	*	BCC	*	G5S3
Sturnella magna	Eastern meadowlark	*	BCC	*	*
Dolichonyx oryzivorous	Bobolink	*	BCC	*	*
Dendroica discolor	Prairie warbler	*	BCC	*	G5T3S3

Scientific Names	Common Names	Agency Status			
		FWC	FWS	FCREPA	FNAI
Dendroica pensylvanica	Chestnut-sided warbler	*	BCC	*	*
Lymnothylpis swainsonii	Swainson's warbler [5]	*	BCC	*	*
Vireo altiloguus	Black-whiskered vireo	*	BCC	R	G5S3
Lanius ludovicianus	Loggerhead shrike	*	BCC	*	*
Cistothorus platenis	Sedge wren	*	BCC	*	*
Hylocichla mustelina	Wood thrush	*	BCC	*	*
Catharus fuscescens	Veery	*	BCC	*	*
Colaptes auratus	Northern flicker	*	BCC	*	*
Aphelocoma coerulescens	Florida scrub-jay	T	T	T	G2S2
Aramus guarauna	Limpkin [5]	SSC	BCC	SSC	G5S3
Charadrius melodus	Piping plover	T	T	E	G3S2
Botaurus lentiginosus	American bittern	*	BCC	*	*
Ixobrychus exilis	Least bittern	*	BCC	SSC	G5S4
Egretta caerulea	Little blue heron	SSC	*	SSC	G5S4
Egretta rufescens	Reddish egret	SSC	BCC	R	G4S2
Egretta thula	Snowy egret	SSC	*	SSC	G5S3
Egretta tricolor	Tricolored heron	SSC	*	SSC	G5S4
Eudocimus albus	White ibis	SSC	*	SSC	G5S4
Polyborus plancus audubonii	Audubon's crested caracara [5, 7]	T	T	T	G5S2LTLT
Falco peregrinus	Peregrine falcon	E	*	E	G4S2
Rosthrhramus sociabilis	Snail kite [5, 7]	E	E	E	G4G5T2S2
Elanoides forficatus	Swallow-tailed kite	*	BCC	T	G5S2
Circus cyaneus	Northern harrier	*	BCC	*	*
Grus canadensis pratensis	Florida sandhill crane	T	*	T	G5T2T3S2S3
Haematopus palliatus	American oystercatcher	SSC	*	T	G5S2

Scientific Names	Common Names	Agency Status			
		FWC	FWS	FCREPA	FNAI
Mycteria americana	Wood stork	E	E	E	G4S2
Gavia immer	Common loon	*	BCC	*	*
Pelecanus occidentalis	Brown pelican	SSC	BCC	T	G4S3
Laterallus jamaicensis	Black rail	*	BCC	R	G4S2
Rynchops niger	Black skimmer	SSC	*	SSC	G5S3
Sterna antillarum	Least tern	T	BCC	T	G4S3
Sterna dougallii	Roseate tern [5]	T	T	T	G4S1
Chilidonias niger	Black tern	*	BCC	*	*
Tyto alba	Barn owl	*	BCC	*	*
Asio flammeus	Short-eared owl	*	BCC	*	*
Haliaeetus leucocephalus	Bald eagle	T	T	T	G4S3
Caprimulgus carolinensis	Chuck-will's-widow	*	BCC	*	*
Puffinus Iherminieri	Audubon's shearwater [5]	*	BCC	*	*
Fregata magnificens	Magnificent frigatebird [5]	*	BCC	T	G5S1
Melanerpes erythrocephalus	Red-headed woodpecker	*	BCC	*	*
Falco sparverius paulus	Southeastern American kestrel [5]	T	BCC	T	G5T4S3
Dendroica petechia (only gundlachi sub spp.)	Yellow warbler	*	BCC	R	G5T4S3
Dendroica dominica	Yellow-throated warbler	*	BCC	*	*
Numenius phaeopus	Whimbrel	*	BCC	*	*
Ammodramus maritimus	Seaside sparrow	SSC	BCC	SSC	G4TS
Calidris canutus	Red knot	*	BCC	*	*
Calidris pusilla	Semipalmated sandpiper	*	BCC	*	*
Limnodromus griseus	Short-billed dowitcher	*	BCC	*	*

Scientific Names	Common Names	Agency Status			
		FWC	FWS	FCREPA	FNAI
Sterna nilotica	Gull-billed tern	*	BCC	*	G5S2
Sterna hirundo	Common tern	*	BCC	*	*
Casmerodius albus	Great egret	*	*	SSC	*
Nycticorax nycticorax	Black-crowned night-heron	*	*	SSC	*
Nycticorax violacea	Yellow-crowned night-heron	*	*	SSC	*
Plegadis falcinellus	Glossy ibis	SSC	*	SSC	*
Accipiter cooperii	Cooper's hawk	*	*	SSC	*
Recurvirostra americana	American avocet	*	*	SSC	*
Sterna fuscata	Sooty tern [5]	*	*	SSC	*
Sterna maxima	Royal tern	*	*	SSC	*
Sterna sandvicensis	Sandwich tern	*	*	SSC	*
Sterna caspia	Caspian tern	*	*	SSC	*
Picoides villosus	Hairy woodpecker [5]	*	*	SSC	*
Cictothorus palustris	Marsh wren	SSC	*	SSC	*
Mammals (6)					
Peromyscus polionotus niveiventris	Southeastern beach mouse	T	*T*	*T*	*G5T1S1*
Podomys floridanus	Florida mouse	SSC	*	T	G3S3
Trichechus manatus	West Indian manatee	E	E	E	G2S2
Ursus americanus floridanus	Florida black bear [5]	T	*	T	G5T2S2
Neofiber alleni	Round-tailed muskrat	*	*	SSC	*
Mustela frenata peninsulae	Florida weasel [5]	*	*	R	*
Plants [8] (38)					
Asclepias curtissii	Curtiss milkweed	*	E	*	G3, S3
Avicennia germinans	Black mangrove	*	*	SSC	*

Scientific Names	Common Names	Agency Status			
		FWC	FWS	FCREPA	FNAI
Calamovilfa curtissii	Curtiss reedgrass	*	T	*	G1G2,S1S2
Calopogon multiflorus	Many-flowered grass pink	*	E	*	*
Chamaesyce cumulicola	Sand dune spurge	*	E	*	G2,S2
Chrysophyllum oliviforme	Satinleaf	*	T	*	*
Encyclia tampensis	Butterfly orchid	*	C	*	*
Epidendrum canopseum	Greenfly orchid	*	C	*	*
Harrisella filiformis	Threadroot orchid	*	T	*	*
Hexalectris spicata	Crested coralroot	*	E	*	*
Lantana depressa var. *floridana*	East coast lantana	*	E	*	G2T2, S2
Lechea cernua	Nodding pinweed	*	T	*	G3, S3
Lechea divaricata	Pine pinweed	*	E	*	G2, S2
Lilium catesbaei	Catesby lily	*	T	*	G4, S3
Myrcianthes fragrans	Nakedwood	*	T	*	G4T3, S3
Nemastylis floridana	Celestial lily	*	E	*	G2, S2
Ophioglossum palmatum (= Cheiroglossa palmata)	Hand fern	*	E	E	G5, S2
Opuntia stricta	Shell mound prickly-pear	*	T	*	*
Osmunda cinnamomea	Cinnamon fern	*	C	*	*
Osmunda regalis var. *spectabilis*	Royal fern	*	C	*	*
Pavonia spinifex	Yellow hibiscus	*	*	*	G4G5, S2S3
Peclumula plumula (=Polypodium plumula)	Plume polypody	*	E	*	*
Peperomia humilis	Peperomia	*	E	*	G5, S2

Scientific Names	Common Names	Agency Status			
		FWC	FWS	FCREPA	FNAI
Peperomia obtusifolia	Florida peperomia	*	E	*	G5, S2
Persea borbonia var*. humilis*	Scrub bay	*	*	*	G3, S3
Pogonia ophioglossoides	Rose pogonia	*	T	*	*
Pteroglossaspis ecristata (= Eulophia ecristata)	False coco	*	T	*	G2G3, S2
Remirea maritima (=Cyperus pedunculatus)	Beach-star	*	E	*	*
Rhizophora mangle	Red mangrove	*	*	SSC	*
Scaevola plumieri	Scaevola	*	T	*	*
Sophora tomentosa	Necklace pod	*		*	G4, S3
Spiranthes laciniata	Lace-lip ladies'-tresses	*	T	*	*
Tephrosia angustissima var. curtissii	Narrow-leaved hoary pea; coastal hoary pea	*	E	*	G1T1, S1
Tillandsia fasciculata	Common pine	*	E	*	*
Tillandsia utriculata	Giant wild pine; giant air plant	*	E	*	*
Verbena maritima (= Glandularia maritima)	Coastal vervain	*	E	*	G2, S2
Verbena tampensis (=Glandularia tampensis)	Tampa vervain	*	E	*	G1, S1
Zamia umbrosa (= Zamia pumila)	East coast coontie	*	C	T	*

1 (S/A) means species was listed due to "similarity of appearance" with the American crocodile. The species is not listed in regards to regulatory actions of Section 7 of the Endangered Species Act and is not in danger of becoming extinct (D. Palmer, FWS, personal communication)
2 Within species home range area, not officially recorded on the Refuge (Moler 1992, Blihovde 1996, Seigel and Seigel 2000).
3 see Ehrhart (1983
4 R. Seigel (personal communication)
5 Species which have been recorded on the Refuge but are rarely seen. These species may not be a functional component of the vertebrate wildlife on the refuge
6 US Fish and Wildlife Service, 2002
7 Merritt Island NWR, unpublished data
8 Plants list after Schmalzer et al. 2002

9 Florida Natural Area Inventory. 2002

Appendix 1: FNAI - Florida Natural Areas Inventory Ranking and Status Definitions

UPDATED OCTOBER 2002

Florida Resources and Environmental Analysis Center
1018 Thomasville Road, Suite 200-C
Tallahassee, Florida 32303
Phone: (850) 224-8207 http://www.fnai.org/data.cfm

FNAI GLOBAL RANK DEFINITIONS

G1 = Critically imperiled globally 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.

G2 = Imperiled globally because of rarity (6 to 20 occurrences or less than 3000 individuals) or because of vulnerability to extinction due to some natural or man-made factor.

G3 = 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 from other factors.

G4 = Apparently secure globally (may be rare in parts of range)

G5 = Demonstrably secure globally

GH = Of historical occurrence throughout its range, may be rediscovered (e.g., ivory-billed woodpecker)

GX = Believed to be extinct throughout range

GXC = Extirpated from the wild but still known from captivity or cultivation

G#? = Tentative rank (e.g., G2?)

G#G# = Range of rank; insufficient data to assign specific global rank (e.g., G2G3)

G#T# = Rank of a taxonomic subgroup such as a subspecies or variety; the G portion of the rank refers to the entire species and the T portion refers to the specific subgroup; numbers have same definition as above (e.g., G3T1)

G#Q = Rank of questionable species - ranked as species but questionable whether it is species or subspecies; numbers have same definition as above (e.g., G2Q)

G#T#Q = Same as above, but validity as subspecies or variety is questioned.

GU = Due to lack of information, no rank or range can be assigned (e.g., GUT2).

G? = Not yet ranked (temporary)

FNAI STATE RANK DEFINITIONS

S1 = Critically imperiled in Florida 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 Florida because of rarity (6 to 20 occurrences or less than 3000 individuals) or because of vulnerability to extinction due to some natural 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 from other factors.
S4 = Apparently secure in Florida (may be rare in parts of range)
S5 = Demonstrably secure in Florida
SH = Of historical occurrence throughout its range, may be rediscovered (e.g., ivory-billed woodpecker)
SX = Believed to be extinct throughout range
SA = Accidental in Florida, i.e., not part of the established biota
SE = An exotic species established in Florida may be native elsewhere in North America
SN = Regularly occurring, but widely and unreliably distributed; sites for conservation hard to determine

FEDERAL LEGAL STATUS

Provided by FNAI for information only.

For official definitions and lists of protected species, consult the relevant federal agency. Definitions derived from U.S. Endangered Species Act of 1973, Sec. 3. Note that the federal status given by FNAI refers only to Florida populations and that federal status may differ elsewhere.

LE Endangered: species in danger of extinction throughout all or a significant portion of its range.
LT Threatened: species likely to become Endangered within the foreseeable future throughout all or a significant portion of its range.
E(S/A) Endangered due to similarity of appearance to a species which is federally listed such that enforcement personnel have difficulty in attempting to differentiate between the listed and unlisted species.
T(S/A) Threatened due to similarity of appearance (see above).
PE Proposed for listing as Endangered species.
PT Proposed for listing as Threatened species.
C Candidate species for which federal listing agencies have sufficient information on biological vulnerability and threats to support proposing to list the species as Endangered or Threatened.
XN Non-essential experimental population.
MC Not currently listed, but of management concern to USFWS.
N Not currently listed, nor currently being considered for listing as Endangered or Threatened.

STATE LEGAL STATUS

Provided by FNAI for information only.

For official definitions and lists of protected species, consult the relevant agency.

Animals: Definitions derived from "Florida's Endangered Species and Species of Special Concern, Official Lists" published by Florida Fish and Wildlife Conservation Commission, 1 August 1997, and subsequent updates.

LE Endangered: species, subspecies, or isolated population so few or depleted in number or so restricted in range that it is in imminent danger of extinction.

LT Threatened: species, subspecies, or isolated population facing a very high risk of extinction in the future.

LS Species of Special Concern is a species, subspecies, or isolated population which is facing a moderate risk of extinction in the future.

PE Proposed for listing as Endangered.

PT Proposed for listing as Threatened.

PS Proposed for listing as Species of Special Concern.

N Not currently listed, nor currently being considered for listing.

Plants: Definitions derived from Sections 581.011 and 581.185(2), Florida Statutes, and the Preservation of Native Flora of Florida Act, 5B-40.001. FNAI does not track all state-regulated plant species; for a complete list of state-regulated plant species, call Florida Division of Plant Industry, 352-372-3505 or see:
http://www.doacs.state.fl.us.

LE Endangered: species of plants native to Florida that are in imminent danger of extinction within the state, the survival of which is unlikely if the causes of a decline in the number of plants continue; includes all species determined to be endangered or threatened pursuant to the U.S. Endangered Species Act.

LT Threatened: species native to the state that are in rapid decline in the number of plants within the state, but which have not so decreased in number as to cause them to be Endangered.

PE Proposed for listing as Endangered.

PT Proposed for listing as Threatened.

C Commercially Exploited

N Not currently listed, nor currently being considered for listing.

---

[9] **Explanations and definitions to the ranking system were copied from the Florida Natural Areas Inventory (FNAI) website. For additional information on FNAI species status and ranking, please contact FNAI or see http://www.fnai.org/data.cfm.**

Literature Cited:

Anonymous. Birds: Merritt Island NWR. National Wildlife Refuge Brochure. Unknown date.

Blihovde, William Boyd. 1996. Distribution of the *Nerodia clarkii* Complex in Volusia, Brevard, and Indian River Counties, Merritt Island National Wildlife Refuge Complex and Canaveral National Seashore. UnPubl. Report to Merritt Island NWR.

Ehrhart, Llewellyn M. 1983. Marine Turtles of the Indian River Lagoon System. Florida Scientist, Vol 46.

Florida Fish and Wildlife Conservation Commission. 1997. Florida's endangered species, threatened species and species of special concern: official list. Florida Game and Freshwater Fish Commission.

Florida Natural Areas Inventory. 2002. List of vertebrates. Unpublished data.

Humphrey, S. R. (Editor). 1992. Rare and endangered biota of Florida: Vol. I. Mammals. Univ. Press Fl., Gainesville, 392pp.

Moler, P. E. (Editor). 1992. Rare and endangered biota of Florida: Vol. III. Amphibians and reptiles. Univ. Press Fl., Gainesville, 291pp.

Office of Migratory Bird Management. 1995. Migratory nongame birds of management concern in the United States: the 1995 list. USFWS, Washington, DC. 22pp.

Schmalzer, P.A., T.E. Foster, and B.W. Duncan. 2002. Revised flora and list of threatened and endangered plants for the John F. Kennedy Space Center Area, Florida. NASA Technical Memorandum NASA/TM-2002-211175. Kennedy Space Center, Florida. 75 p.

Seigel, Richard A., and Nadia A. Seigel. 2000. Inventory and Monitoring of Herpetological Communities on the Kennedy Space Center/Merritt Island National Wildlife Refuge/Canaveral National Seashore: Annual Report. Southeastern Louisiana University. UnPubl. Report to Merritt Island NWR.

Sullivan, D. J. 2004. Florida's endangered species, threatened species, and species of special concern. Florida Fish and Wildlife Conservation Commission. 6 pp.

U.S. Fish and Wildlife Service. 2002. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, Virginia. 99pp. [Online version available at http://migratorybirds.fws.gov/reports/bcc2002.pdf]

ACKNOWLEDGEMENTS: We thank Jim Lyon (FWS), Becky Smith (Dynamac Corp.), Paul Schmalzer (Dynamac Corp.) and Cheri Ehrhardt (FWS) for making helpful comments to the draft document.

Appendix D: Beach Cleanup Plan March 2000

The purpose of this plan is to provide a template to use to organize beach cleanup activities. The joint Refuge-NASA employee beach cleanup preformed in 2000 was very successful and provided a means to interact directly with NASA employees in an environmental hands-on activity.

I. BEACH CLEANUP: Depending on the number of people signing up, one or two afternoons will be designated as "Spring Beach Cleanup Day."

A) If 100 people or less sign up _

1) Friday March 22nd will be the afternoon for the cleanup: 1-4:30 PM

2) Friday March 29th will be the rain day: 1- 4:30 PM

B) If more than 100 people sign up, a two day approach can be used to allow all center employees an opportunity to assist with the cleanup (or limit the number of people?): same dates: March 22nd and 29th.

II. COORDINATION NEEDS:

1. Transportation of employees to/from beach.
2. Area Permits
3. Sign up: telephone sign up sheets. Questions, which day are you available? Name and contact number
4. Equipment (Dump Truck, 4x4 Pickup Trucks, ATVs, garbage bags, gloves?)
5. Areas of focus: depends on if there are 1 or 2 days, conduct beach survey to prioritize sections of the beach to work on; ensure good access points.
6. Refuge employees to serve as team leaders.

III. BEACH CLEAN UP ACTION LIST

- Busses: Contact NASA Environmental or Public Affairs to arranged for 3 NASA busses to be at the Public Affairs Turn Basin site for pick up (Action - Biologist and Manager).

- Mapped Area: A GIS map of access and pickup sites, created sign-up sheets, small notice-posters to place in NASA facilities (See Fig. A-1; Action - Biologist).

- Equipment: Biotech to check refuge ATVs and trailers, aluminum plank for crossover south of eagle-4, trucks, trailers, marsh master, and any other equipment (Action – Biological Science Technician).

- NASA Coordination: Public Use Ranger to write news release. Manager to coordinate with NASA Headquarters for the day, time, and place. Options to be put into place if necessary due to shuttle rollout (Action – Manager and Public Use Supervisor and Manager).

- NPS: Biologist to contact NPS for additional equipment needs (e.g., ATV*s and one trailer that is beach ready (Action - Biologist).

- Pelican Island NWR: Biologist to contact manager for additional equipment needs (e.g., ATV and beach-ready (Action - Biologist).

- NASA - A second news release through NASA email if necessary, depending on the number of people signed up for activity (Action - Public Use Ranger).

- Logistic: Garbage bags, water and coolers on-site; What time and where to pick-up and leave; grouping people into teams. Larger groups to areas between Beach House and Corrosion Experimental Facility. Call corrosion control site manager to let them know we are going to walk through their area. (Action – Biological Science Technician).

- Information and instructions to be given to clean-up volunteers; (Action Public Use Ranger and Biologist).

Importance of beaches to turtles, shorebirds, beach mice, etc.; trash being eaten by wildlife; sea turtles ingesting balloons, plastic; birds being tangled by line and trash; obstructions to nesting turtles, don't climb into dune faces to collect trash but walking over flat sandy overwash areas is ok. Do not pick up jelly fish and Portuguese Man-O-War, look like purple balloons

- Deputy/Assistant Manager to coordinate MINWR personnel to see who will be helping and what they will do; need team leaders, beach bag picker-uppers, loaders at the truck; drivers or team leader to drop-off/pick-up volunteers, a water boy or girl (Deputy Manager and Assistant Manager).

- Team Meeting – Refuge personnel to meet and Biologist to present the work flow from start to finish to the team; issue team assignments and materials (See Figure A-2) (Action – Biologist).

- What have we forgot? (Other items).

ASSIGNMENTS:

ATVs: North Beach = Volunteer (trailer) & Maintenance Supervisor (water/bags)
South Beach = FMO (trailer) & Biotech (water/bags)

PICK UP TEAMS		MIN. NUMBER PEOPLE	PICK UP POINT	DISTANCE
Bus 1	Eagle 4/Shop	4 to work south to	Point 3	0.7 miles
Bus 1	Point 3/Biotech Point 2/	10 to work south, Meeting & Pick Up Pickup Truck	n/a Point 2	1.4 miles
Bus 1	Parking Area North Public Use Supervisor	6 to work north to	Point 2	0.9 miles
Bus 2	Parking Area South	5 to work south to	Corrosion Facility	1.2 miles

	Shop			
Bus 2	Camera Pad / Planner	6 to work south to	Point 1	1.2 miles
Bus 2	Corrosion/Fire /Fire	12 to work south to Pickup Truck	Point 1	0.6 miles
Bus 3	Point 1 / Manager / Shop	12 to work in local area Dump Truck	Point 1	Local Area
Bus 3	Beach House/NPS	11 to work north to	Point 1	1 mile
Bus 3	Air Force Line	4 to work north to	Point 1	1.4 miles

PRIORITY ORDER TO FILL TEAMS By Location: Point 1, Beach House, Camera Pad, Parking Area South, Parking Area North, Point 3, Air Force Line and Eagle 4.
Area Passes Escorts: Six refuge personnel
1) Water in coolers, extra bags, Biotech and Shop Forman
2) Beach Trailers, FMO and other Fire Employee
3) First Aid Kit, Biologist
4) Sign-up Sheet (for NASA employees)

Name	Telephone #	Mail Stop	Area Permit (yes or no)

Example Sign-up Sheet for NASA Employees

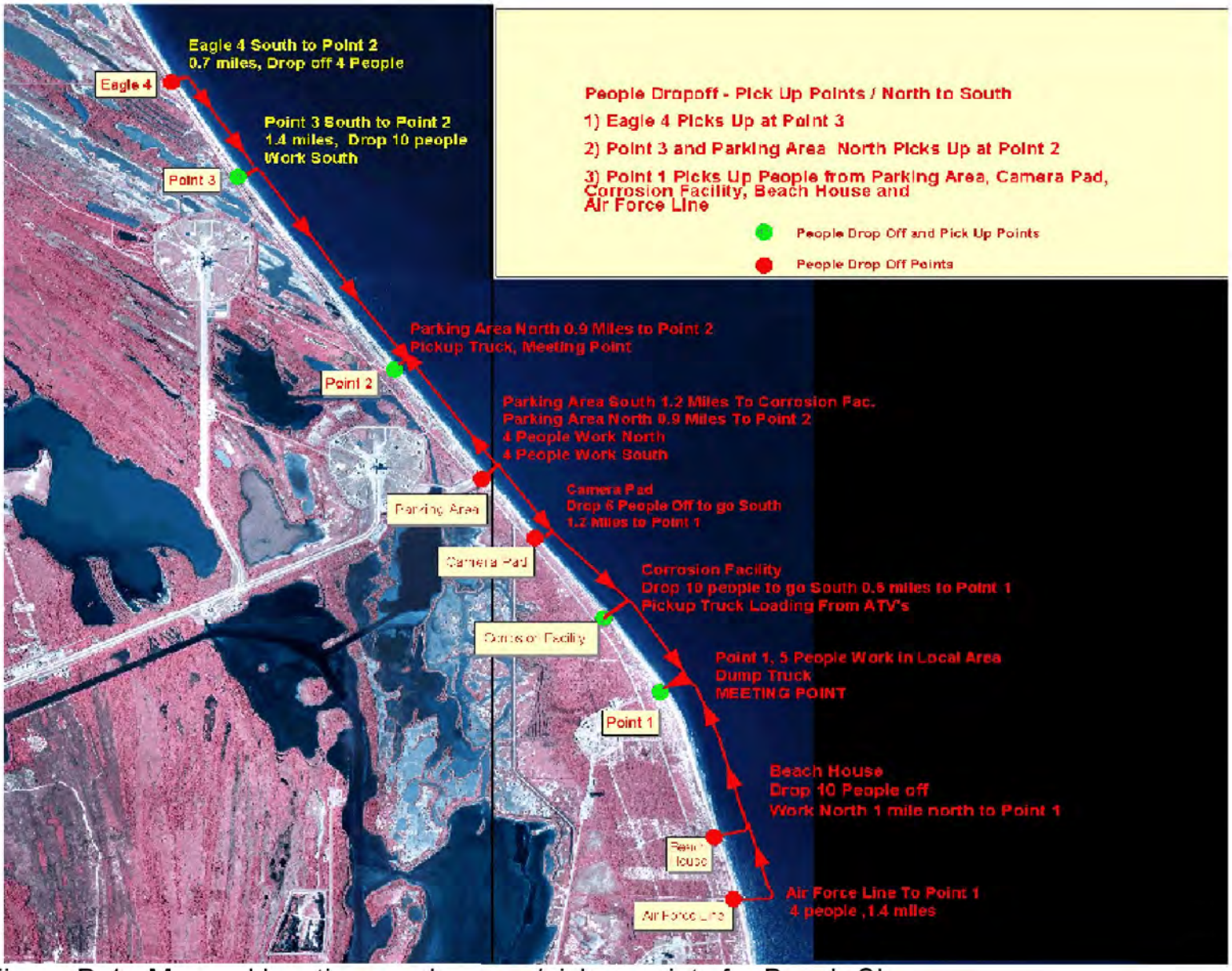
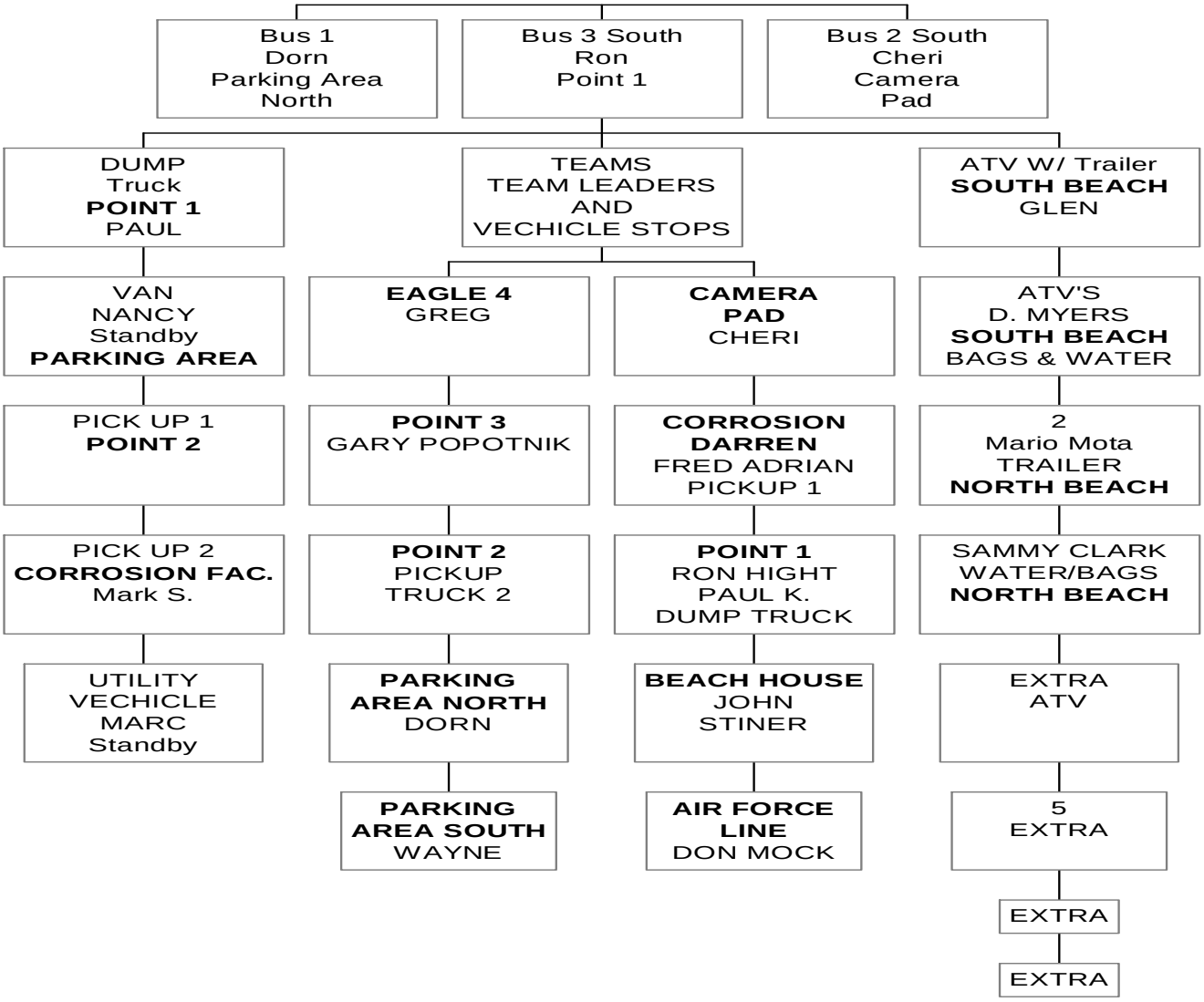


Figure D-1. Mapped locations and access/pickup points for Beach Clean-up.

Figure D-2. Example beach clean up teams and personnel assignments (teams from 2000 beach cleanup, 2000).



Appendix E: Three to five year objectives for selected primary, management flexible, and restoration impoundments, Merritt Island National Wildlife Refuge, Florida. [1]

Impoundment	Mgt. Regime	Primary Objectives
T-24-D	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Maintain flooded or seasonally manage water depths to control cattails; target salinities 8-15ppt; maintain brackish communities; encourage/maintain open water areas throughout for abundant Ruppia/Chara growth.
T-24-A	Wildlife-Aquatic Shorebirds/Waders/ Ducks	Seasonally manage water depths for shorebirds, waders, and waterfowl. Maintain target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
T-24-B	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Maintain flooded w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth; can take to the point of fresh marsh system before manipulating to control cattails.
T-24-C	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Maintain flooded w/target salinities 8-15ppt; change salt marsh to brackish communities; can take to the point of fresh marsh system before manipulating to control cattails. Encourage open water areas north end and throughout rank Salt Grass and for abundant Ruppia/Chara growth. Use fire when possible.
T-10-A	Unmanaged/ Fisheries Shorebirds/Waders	Multiple Species/Objectives, Open, RIM, Mosquito Control, Evaluate for Restoration.
T-10-B	Wildlife-Aquatic Shorebirds/Waders	Maintain target salinities 8-15ppt; flooded seasonally w/Jan-April gradual water declines for migratory shorebirds birds. Encourage/maintain open water areas throughout for abundant Ruppia/Chara growth.
T-10-C	Unmanaged/ Fisheries Shorebirds/Waders	Manage as Open or RIM.
T-10-D	Unmanaged/ Fisheries Shorebirds/Waders	Manage as Open or RIM.
T-10-E	Unmanaged/ Fisheries Shorebirds/Waders	Manage as Open or RIM; Alternate to wildlife aquatic management for habitat enhancement.

Impoundment	Mgt. Regime	Primary Objectives
T-10-F	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Maintain target salinities 8-15ppt; flooded seasonally w/Jan-April gradual water declines for migratory shorebirds if salinity targets can be maintained. Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
T-10-G	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Maintain flooded w/target salinities 8-15ppt; maintain brackish communities; can take to the point of fresh marsh system before manipulating to control cattails. Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth. Late season water declines for migratory birds only if salinity targets can be maintained.
T-10-H	Unmanaged/ Fisheries Shorebirds/Waders	Manage as open; Multiple Species/Objectives; primary shorebirds/waders.
T-10-I South	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
T-10-I North	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
T-10-J	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
T-10-L	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth; change salt marsh to brackish communities; can take to the point of fresh marsh system before manipulating to control cattails.
T-10-M	Undetermined Management Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
T-21	Undetermined Management Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
Shiloh 1 South-A	Unmanaged/ Fisheries	North end of Shiloh 1 South B; Manage as OPEN or RIM or Restore.

Impoundment	Mgt. Regime	Primary Objectives
Shiloh 1 South-B	Unmanaged/ Fisheries Shorebirds/Waders	Manage Open or RIM - Multiple Species/Objectives for shorebirds and waders.
Shiloh 1N	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
Shiloh 3	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
Shiloh 5	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
V-3	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth. Beach impoundment - extra attention to lower salinities is required.
V-4	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth. Beach impoundment - extra attention to lower salinities is required.
T-44	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Maintain flooded w/target salinities 8-15ppt; encourage brackish communities, open water areas throughout for abundant Ruppia/Chara growth. Beach impoundment - extra attention to lower salinities is required.
T-43	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Maintain flooded w/target salinities 8-15ppt; encourage brackish communities, open water areas throughout for abundant Ruppia/Chara growth. Beach impoundment - extra attention to lower salinities is required.
T-42	Unmanaged/ Fisheries	Manage Open or RIM - Multiple Species/Objectives for fisheries and waterbirds; To Be Restored.
T-40	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth. Beach impoundment - extra attention to lower salinities is required.

Impoundment	Mgt. Regime	Primary Objectives
T-38	Wildlife-Aquatic Waders	Maintain flooded w/target salinities 8-18ppt; change salt marsh to brackish communities; can take to the point of fresh marsh system before manipulating to control cattails. Encourage/maintain open water areas throughout for abundant Ruppia/Chara growth.
T-27-B	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth. May require pumping for mosquito control.
T-27-A	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth. May require pumping for mosquito control.
C-21:36	Wildlife- Aquatic Moist Soil Management Ducks/Shorebirds/ Waders	Provided low salinity conditions of <8ppt can be maintained, moist soil management with summer drawdown for moist soil plants. If cattails re-establish, manage w/higher salinities and drawdowns for control. If salt marsh dominates, maintain flooded w/target salinities 8-12ppt; change salt marsh to brackish communities; can take to the point of fresh marsh system before manipulating to control cattails. Encourage/maintain open water areas throughout for abundant Ruppia/Chara growth. Seasonally fluctuate for migratory birds.
Jack Davis T-25-A	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
T-25-B	Undetermined	East of railroad tracks. No connection.
T-25-C	Undetermined/ Fisheries	Manage Open or RIM - Multiple Species/Objectives for fisheries and waterbirds.
T-25-D	Undetermined	East of railroad tracks. No connection.
T-28-B	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
T-28-A	Open/RIM Fisheries/ Shorebirds/ Waders	Manage Open or RIM - Multiple Species/Objectives for fisheries and waterbirds; Evaluate for Restoration.

Impoundment	Mgt. Regime	Primary Objectives
C-15-C	Wildlife-Aquatic Ducks/Shorebirds/ Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
C-20-A	Undetermined Fisheries/Waders	Manage Open or RIM - Multiple Species/Objectives for fisheries and waterbirds; evaluate for restoration.
Moore Creek	Wildlife-Aquatic Ducks/Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth.
T-16	Wildlife-Aquatic Shorebirds/Waders	Seasonally managed w/target salinities 8-15ppt; Encourage emergent - open water interspersion areas throughout and Ruppia/Chara growth. Maintain open mudflat areas for migratory shorebirds; alternate to WAM for habitat enhancement.
Gator Creek	Wildlife-Aquatic Ducks/Waders	Can be used as a reservoir for the T-24 units. Maintain flooded w/target salinities 8-15ppt; can take to the point of fresh marsh system before manipulating to control cattails. Encourage/maintain open water areas throughout south end and for abundant Ruppia/Chara growth. Encourage late season water declines for migratory birds only if salinity targets can be maintained.

[1] See Table1 for impoundment listings. Once an objective is reached, it is not necessary to continue a manipulation even if it is prior to the 3-5 year projected time frame. Once the objective is accomplished, reevaluate the impoundment, and develop a new objective(s).

Appendix F. A description of spoil island habitat, historic bird nesting use, and management.

Spoil Island No.	Approx. Acreages	Habitat Description (Based on 1999 aerial photos)	Historic Nesting Species (AOU Codes*)	Historic Habitat Management
1	11.6	Herbaceous cover, some shrubs.	WILL (Schroeder 1981)	
2	3.5	Heavy shrub cover, close mainland.	None	
3	6.6	Shrub cover.	LAGU, BLSK (Schroeder 1981)	Portion cleared (Salata 1979)
4	3.1	Dense shrub cover, some bare beach.	None	
5	0.4	Mostly submerged.	None	
6	5.8	Shrub cover, small bare spit.	LAGU, GBTE, BLSK (Schroeder 1981) MODU, WILL, LAGU (Leenhouts 1986)	Portion cleared (Salata 1979)
7	1.5	Very narrow spit, some shrub cover.	None	
8	4.6	Herbaceous/shrub cover, large cleared areas, some bare substrate.	LAGU, GBTE, WILL, BLSK (Schroeder 1981) BNST, LAGU (Leenhouts 1986) Gulls, terns, BLSK,ROTE (USFWS 1987) AMOY, LAGU (USFWS 1999)	Cleared (USFWS 1998)
9	0.8	Bare sand spit, some shrub cover.	BLSK (Schroeder 1981)	
10	1.5	Shrub cover.	WILL (Schroeder 1981)	
11	8.1	Heavy shrub cover, close to mainland.	WILL (Schroeder 1981)	Portion cleared (Salata 1979)
12	8.5	Heavy shrub cover, small bare sand spit.	WILL, BLSK (Schroeder 1981)	Portion cleared (Salata 1979)
13	2.7	Bare sand beaches, some shrub cover, internal water.	GBTE,WILL (Schroeder 1981) MODU, GBTE, ROTE, BLSK (Leenhouts 1986) AMOY, LAGU (USFWS 1999)	Portion cleared (Salata 1979) Cleared (USFWS 1998)
14	6.6	Heavy shrub cover, interior water, small bare sand spits and beaches, close to NASA causeway.	GBTE (Leenhouts1986) Gulls, terns, ROTE (USFWS 1987, 1988)	Portion cleared (Salata 1979)
15	0.4	2/3 shrub covered, bare sand beach.	BLSK (Schroeder 1981) SNEG, GBHE, DCCO (Leenhouts 1986)	

Spoil Island No.	Approx. Acreages	Habitat Description (Based on 1999 aerial photos)	Historic Nesting Species (AOU Codes)	Historic Habitat Management
16	0.4	Submerged.	None	
17	4.2	Heavy shrub cover, close to NASA causeway.	LAGU, GBTE (Schroeder 1981)	Portion cleared (Salata 1979)
18	2.3	Mostly bare sand, some herb/shrub cover.	LAGU, ROTE (Schroeder 1981), ROTE (USFWS 1980) BLSK (2000)	Portion cleared (Salata 1979) Cleared (USFWS 1996)
19	2.7	Mostly submerged, thin sand spit.	WILL (Schroeder 1981)	
20	2.3	Submerged.	None	
21	4.2	Shrub cover, some bare sand beach, herbaceous cover in island center.	WILL (Schroeder 1981)	Portion cleared (Salata 1979)
22	3.1	Shrub cover, bare sand spit.	WILL (Schroeder 1981), evidence of heron nesting (Schroeder 1990)	50' x 100' area cleared (USFWS 1992)
23	2.3	Mostly submerged.	None	
24	4.6	Herbaceous cover, small sand spit, interior water.	LAGU, BNST (Leenhouts 1986) Stick nests (Schroeder 1990)	
25	11.2	Heavy shrub cover, some small sand beaches.	GREG, SNEG, CAEG, REEG, WHIB, GLIB, TRHE, DCCO (Leenhouts 1986)	
26	7.7	Herb/shrub cover, some areas of open sand, no beach.	LAGU (Schroeder 1981) LAGU, BLSK (Leenhouts 1986)	Portion Cleared (USFWS 1986) SW portion cleared (USFWS 1992)
27	21.6	Herb/shrub cover, sand beaches.	LAGU, ROTE (Schroeder 1981) LAGU, ROTE (Leenhouts 1986) Heron Nest (1) (Schroeder 1990)	Areas cleared SW portion of Island (USFWS 1992)
28	1.5	Herb/shrub cover, no beach, nearshore.	LAGU (Leenhouts 1986)	
29	1.5	Mostly bare sand.	WILL (Schroeder 1981) BLSK, LAGU (2000)	
30		Shrub cover, sand spit and beach.	LAGU (USFWS 1999)	Cleared (USFWS 1996)

APPENDIX G: INVASIVE EXOTIC PLANTS REPORTED FROM KENNDY SPACE CENTER, MERRITT ISLAND NATIONAL WILDLIFE REFUGE, CANAVERAL NATIONAL SEASHORE, CAPE CANAVERAL AIR FORCE STATION AND VICINITY [1]

Family	Scientific Name	Common Name	Category[2]
Pteridophytes			
Nephrolepidaceae	*Nephrolepis cordifolia* (L.) Presl	Tuberous sword fern	EPPC-CI
Schizaeaceae	*Lygodium microphyllum* (Cav.) R. Br.	Old world climbing fern	EPPC-CI
Angiosperms			
Acanthaceae	*Asystasia gangetica* (L.) T. Anders	Chinese violet	EPPC-CII
Acanthaceae	*Ruellia tweediana Griesb.* (=*R. brittoniana*)	Mexican bluebell	EPPC-CI
Agavaceae	*Agave sisalana* Perrine	Sisal hemp	EPPC-CII
Amaranthaceae	*Alternanthera philoxeroides* (Mart.) Griesb.	Alligatorweed	EPPC-CII
Anacardiaceae	*Schinus terebinthifolius* Raddi	Brazilian pepper	EPPC-CI
Araceae	*Colocasia esculentum* (L.) Schott	Wild taro	EPPC-CI
Araceae	*Pistia stratiotes* L.	Water lettuce	EPPC-CI
Araceae	*Syngonium podophyllum* Schott	American evergreen	EPPC-CI
Arecaceae	*Phoenix reclinata* L.	Senegal date palm	EPPC-CII
Asparagaceae	*Asparagus aethiopicus* L.	Sprenger's asparagus-fern	EPPC-CI
Asteraceae	*Sphagneticola trilobata* (L.) Pruski [=*Wedelia trilobata* (L.) Hitchc.]	Creeping oxeye	EPPC-CII
Caprifoliaceae	*Lonicera japonica* Thunb.	Japanese honeysuckle	EPPC-CI
Casuarinaceae	*Casuarina cunninghamiana* Miq.	River sheoak	EPPC-CII
Casuarinaceae	*Casuarina equisetifolia* L. ex J.R. Forst. & G. Forst.	Australian pine	EPPC-CI
Casuarinaceae	*Casuarina glauca* Sieb. ex Spreng.	Gray sheoak	EPPC-CI
Crassulaceae	*Kalonche pinnata (Lam.) Pers.*	Cathedral bells	EPPC-CII
Dioscoreaceae	*Dioscorea bulbifera* L.	Air-potato	EPPC-CI
Euphorbiaceae	*Ricinus communis* L.	Castorbean	EPPC-CII
Euphorbiaceae	*Sapium sebiferum* (L.) Roxb.	Chinese tallowtree	EPPC-CI
Fabaceae	*Abrus precatorius* L.	Rosary pea	EPPC-CI
Fabaceae	*Albizia julibrissin* Durazz.	Mimosa	EPPC-CI
Fabaceae	*Albizia lebbeck* (L.) Benth.	Woman's tongue	EPPC-CI
Fabaceae	*Bauhinia variegata* L.	Orchid tree	EPPC-CI
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit.	White leadtree	EPPC-CII
Fabaceae	*Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.)	Kudzu	

Family	Scientific Name	Common Name	Category[2]
	Maesen & S.M. Almeida		
Fabaceae	*Senna pendula* (Humb. & Bonpl. ex Willd.) H.S. Irwin & Barneby var. *glabrata* (Vogel) H.S. Irwin & Barneby	Valamuerto	EPPC-CI
Fabaceae	*Sesbania punicea* (Cav.) Benth.	Rattlebox	EPPC-CII
Hydrocharitaceae	*Hydrilla verticillata* (L.f.) Royle	Waterthyme	EPPC-CI
Lauraceae	*Cinnamonum camphora* (L.) Nees & Eberm.	Camphortree	EPPC-CI
Malvaceae	*Hibiscus tiliaceus* L	Mahoe	EPPC-CII
Malvaceae	*Urena loabta* L.	Caesarweed	EPPC-CII
Moraceae	*Broussonetia papyrifera* (L.) Vent.	Paper mulberry	EPPC-CII
Myrtaceae	*Eugenia uniflora* Smith	Surinam cherry	EPPC-CI
Myrtaceae	*Melaleuca quinquenervia* (Cav.) Blake	Punktree	EPPC-CI
Myrtaceae	*Psidium cattleianum* Sabine	Strawberry guava	EPPC-CI
Myrtaceae	*Psidium guajava* L.	Guava	EPPC-CI
Myrtaceae	*Syzygium cumini* (L.) Skeels	Java plum	EPPC-CI
Myrtaceae	*Syzygium jambos* (L.) Alston	Malabar plum	EPPC-CII
Oleaceae	*Jasminum sambac* Ait.	Arabian jasmine	EPPC-CII
Poaceae	*Imperata cylindica* (L.) Beauv.	Cogongrass	EPPC-CI
Poaceae	*Panicum maximum* Jacq.	Guineagrass	EPPC-CII
Poaceae	*Panicum repens* L.	Torpedograss	EPPC-CI
Poaceae	*Pennisetum purpureum* Schum.	Napiergrass	EPPC-CI
Poaceae	*Rhynchelytrum repens* (Willd.) C.E. Hubb.	Natalgrass	EPPC-CII
Poaceae	*Urochloa mutica* (Forssk.) R.D. Webster	Paragrass	EPPC-CI
Polygonaceae	*Antigonon leptopus* Hook. & Arn.	Coral vine	EPPC-CII
Pontederiaceae	*Eichhornia crassipes* (Mart.) Solms	Water hyacinth	EPPC-CI
Ruscaceae	*Sansevieria hyacinthoides* (L.) Druce	Bowstring hemp	EPPC-CII
Verbenaceae	*Lantana camara* L.	Shrubverbena	EPPC-CI

[1] Sources:

Schmalzer, P.A., T.E. Foster, and B.W. Duncan. 2002. Revised flora and list of threatened and endangered plants for the John F. Kennedy Space Center Area, Florida. NASA Technical Memorandum NASA/TM-2002-211175. Kennedy Space Center, Florida. 75 p.

Schmalzer, P.A. and T.E. Foster. 2005. Flora and threatened and endangered plants of Canaveral National Seashore. Final report to National Park Service. Dynamac Corporation, Kennedy Space Center, Florida.

2. Florida Exotic Pest Plant Council (http://www.fleppc.org)

FERAL HOG TRAPPING PERMIT

MERRITT ISLAND NATIONAL WILDLIFE REFUGE

1. BACKGROUND

Merritt Island National Wildlife Refuge is a barrier island that contains over 140,000 acres of open water, marshes, and uplands. Approximately 69,000 acres of the refuge consists of land areas—alternating upland ridges, intermittent wet swales, impoundments, saltwater marshes, hardwood hammocks, pine flatwoods, and palmetto-oak scrub habitat. Alligators, eastern diamondback rattlesnakes, pigmy rattlesnakes, and cottonmouth snakes are frequently encountered. Mosquitoes can be extremely heavy at times, and may carry West Nile Virus. Briars, thick vines, saw palmetto, and poison ivy are very thick in parts of the refuge and can restrict travel.

The feral hog population on the refuge has been estimated to be between 10,000 and 15,000. Their rooting behavior damages road shoulders, dikes, firebreak roads, orange groves and public recreation areas. These damages require constant maintenance by refuge staff. The feral hogs also compete with native wildlife for food and destroy nests of endangered sea turtles and other wildlife. In addition, feral hogs pose a safety hazard to vehicles traveling on refuge roadways.

During the 1970s and 1980s, the refuge administered the feral hog trapping program as a volunteer effort with a single volunteer. In 1995, the feral hog trapping program shifted to a qualified, high bid, annually renewed, 5-year contract with three units. Each high bidder was assisted by 10 others, for a total of 33 hog trapping personnel. All current contracts expire on March 31, 2004.

In 2004, the hog trapping program at Merritt Island NWR will change from a qualified, high bid contract to a qualified, lottery draw for contractors. The contract period will last 5 years, with annual renewal requirements. The refuge will be divided into 4 feral hog trapping units. Specific refuge and NASA regulations will apply to each unit. Some units may be more restricted than others. Units located within the NASA security area will require trappers to pass a background investigation. NASA may implement additional restrictions with little or no notice. Merritt Island NWR works with NASA on changes to security policy or operations but NASA has the final authority.

The goal of the feral hog trapping program is to eradicate feral hogs from Merritt Island National Wildlife Refuge. The use of traps will be required in all units. All applicants must be at least 21 year old and have at least 3 years experience trapping feral hogs. Applications with supporting documents must be received by May 7, 2004.

2. LOCATION OF REFUGE

Merritt Island NWR is located on Merritt Island between the Indian River Lagoon and Mosquito Lagoon and between the Indian River Lagoon and Banana River Lagoon. The northern boundary lies south of Oak Hill and the south boundary lies to the north of State Road 528.

3. DESCRIPTION OF UNITS AND OPERATIONAL CONDITIONS

UNIT 1
Approximately 8,159 acres located north of Haulover Canal between Indian River Lagoon and Mosquito Lagoon. This unit may be subject to public hunting for white-tailed deer and feral hogs during part or all of the State hunting season for these species. The Comprehensive Conservation Plan (CCP), which is currently in progress at Merritt Island NWR, will determine details on public hunting in this area. The CCP is expected to be completed in 2005. Public hunting, if implemented, would likely not occur until the 2006-2007 hunting season.

UNIT 2
Approximately 16,555 acres located south of Haulover Canal between Indian River Lagoon and Mosquito Lagoon and north of State Road 402. Black Point Wildlife Drive, one of the most popular refuge attractions, is located within this unit. Part or all of Unit 2 is subject to closure by NASA for security precautions during launches, landings, or during high threat conditions.

UNIT 3
Approximately 39,413 acres located south of State Road 402 to Jerome Road on the east side of State Road 3 and refuge property south of 402 and west of State Road 3. The western boundary is the Indian River Lagoon. The eastern boundary is Banana River. See map for details. The Merritt Island NWR visitor center, NASA launch pads and NASA's Shuttle Landing Facility are located within this unit. This unit is located within the permanent security area of Kennedy Space Center. This unit is subject to closure by NASA for security precautions during launches, landings, or during high threat conditions. All trappers in this area are required to submit to a security background investigation in order to access areas within the permanent security area of KSC. **Due to NASA security concerns and the sensitive nature of working within NASA's industrial, operational, and launch facilities, this unit is not open for application at this time.**

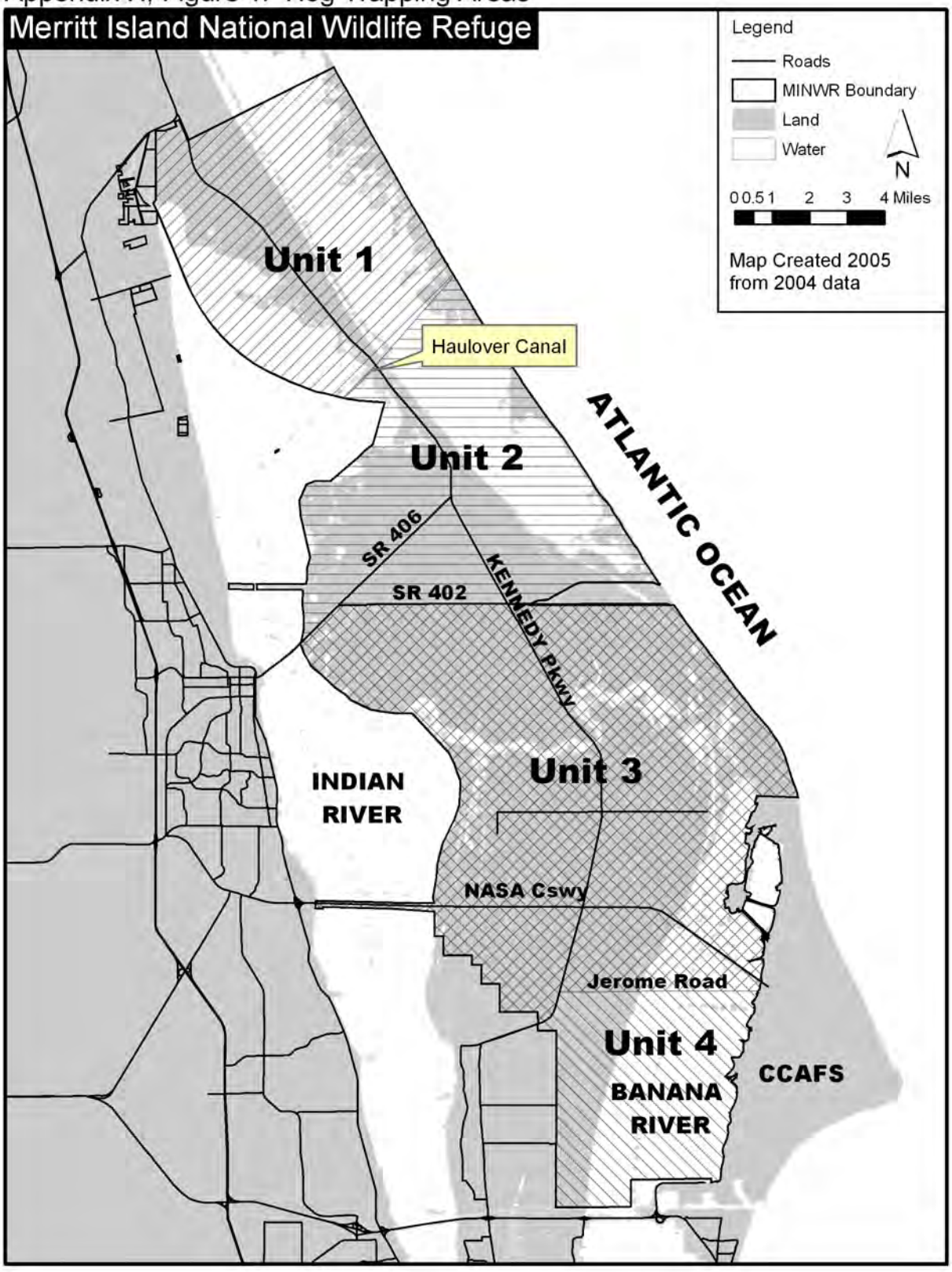
UNIT 4
Approximately, 4,662 acres located east of State Road 3 and south of Jerome Road. The southern boundary is the southern boundary of the refuge. This unit is includes NASA's KARS Park, a recreational area used by employees of KSC. This unit is adjacent to a residential subdivision. This unit is within the permanent security area and subject to closure by NASA for security precautions during launches, landings, or during high threat conditions. In addition, trappers in this area are required to submit to a

security background investigation in order to access areas within the permanent security area of KSC.

ALL UNITS

Roads or highways establish borders between several units. Each unit begins at the edge of the pavement or dirt road closest to the respective unit. The roadways and median, if present, are open to trappers from either adjacent unit.

Appendix H, Figure 1. Hog Trapping Areas



4. TRAP QUOTAS

Trapping of feral hogs is required in all units. Traps will be baited with corn or other suitable bait. Baiting must occur for several days prior to and during setting of traps to attract the greatest number of feral hogs. The number of traps and the minimum number of days each trap must be set during each month is detailed below. These trapping quotas must be met each month from October 1st through April 30th. Trapping during the summer is allowed, however it is not required. The trapping quota represents a minimum effort. To effectively remove feral hogs from the refuge trapping efforts should exceed the minimum required for some or most of the year.

The primary hog trapper for each unit must install at least the minimum number of traps and the refuge must verify these traps before the trapping season begins on October 1, 2004.

UNIT	MINIMUM NUMBER OF INDIVIDUAL TRAPS	MINIMUM NUMBER OF SET DAYS PER MONTH
Trap Unit 1	8	9
Trap Unit 2	10	9
Trap Unit 3	27	9
Trap Unit 4	7	9

5. PERSONNEL AND OPERATIONS

UNITS 1 AND 2

The hog trappers for Units 1 and 2 will be allowed to designate up to 10 authorized assistant trappers. In addition, 5 guest passes will be provided for each unit. This pass may be used to bring additional guests to assist with the removal of feral hogs. However, the guest must be in possession of the guest pass, valid photo identification, and must be accompanied by the primary trapper or an authorized assistant trapper at all times. Assistant trappers or guests in these units must be at least 14 years old.

UNIT 2

The primary hog trapper and up to one authorized assistant trapper may be required to meet NASA badging requirements to continue trapping operations during short-term security restrictions associated with space shuttle launches and landings. These restrictions are infrequent and last only a few days. However, without access badges, trapping activities would be interrupted.

UNIT 3

The primary hog trapper in this unit will be allowed to designate 20 assistant trappers. All trappers and assistant trappers must meet NASA badging requirements and pass a background security check. Failure to meet and maintain the requirements set by

NASA to access the security area will result in removal from consideration or removal from the feral hog trapping program.

UNIT 4

All trappers and assistant trappers must meet NASA badging requirements and pass a background security check. The hog trappers will be allowed to designate up to 10 authorized assistant trappers. No guest passes will be issued due to NASA security badging requirements. Failure to meet and maintain the requirements set by NASA to access the security area will result in removal from consideration or removal from the feral hog trapping program.

UNITS 1, 2, 3 AND 4

The primary trapper in each unit must submit a list of authorized assistant trappers to the refuge for approval at least 2 weeks prior to the contract start date. This list will include name, address, social security number, and phone numbers and will be kept on file at the refuge. This list must be updated annually by the primary trapper. Only authorized assistant trappers on this list will be allowed to participate in hog removal activities on Merritt Island NWR.

The primary trapper is responsible for his assistant trappers and guests. All trappers and guests must have medical insurance. **It is the responsibility of the primary trapper to ensure ALL trappers and guests have medical insurance**. The trapper must provide proof of medical insurance covering all trappers and guests each year before the contract start date and/or anytime a new trapper is added or insurance coverage changes.

All vehicles used in connection with feral hog trapping activities on Merritt Island NWR must be properly licensed and insured, as required by the State of Florida. The primary hog trapper must submit a list of all vehicles that will be used for feral hog trapping activities to the refuge 2 weeks prior to the contract start date. This list must include make, model, color, tag number and the person to whom the vehicle is registered.

Because of the close affiliation and working relationship between the feral hog trappers and the refuge, the refuge reserves the right to conduct background investigations on any primary hog trapper, assistant hog trapper, and any guests. Any individual with outstanding warrants, repeated game violations, or similar violations will not be allowed to participate in the hog trapping program.

All primary hog trappers are required to report the location of each trap on a map prior to the start of the trapping season and notify the refuge prior to relocating traps. **The location description must be of sufficient detail to be able to locate the trap without further directions**. The traps will be numbered and the number of the trap will be clearly displayed on the trap. The primary trapper must notify the refuge at least 1 business day prior to initiating baiting, setting or moving any trap. This notification must occur by email (preferred) or by fax.

6. REPORTING REQUIREMENTS

UNITS 1, 2, 3 AND 4

The primary hog trapper for each unit will submit two reports to the refuge each month detailing the past month's hog trapping activities. One report will contain sex, est. weight, how the hog was captured (trap/dog), trap number, and date of capture. The second report will describe trap setting activities: trap number, date baiting started, date(s) set, etc… All reports must be submitted to the refuge by the tenth day (or first business day following) of the next month. The refuge will provide the primary hog trapper with a paper and electronic copy of templates for these reports.

All primary hog trappers are required to report the location of each trap on a map prior to the start of the trapping season and notify the refuge prior to relocating traps. The location description must be of sufficient detail to allow refuge staff to locate the trap without further directions. The traps will be numbered and the number of the trap will be clearly displayed on the trap. The primary trapper must notify the refuge at least 1 business day prior to initiating baiting, setting or moving any trap. This notification must occur by email (preferred) or by fax.

ADDITIONAL REQUIREMENTS FOR UNITS 1 AND 2

The primary hog trappers in Units 1 and 2 must also submit a report listing any guests assisting with trapping activities. The report will include name, phone number, address, social security number, and the date of the visit. All reports must be submitted to the refuge by the tenth day (or first business day following) of the next month. The refuge will provide the primary hog trapper with a paper and electronic copy of templates for these reports.

ADDITIONAL REQUIREMENTS FOR UNIT 3

The primary hog trapper in Unit 3 will provide the refuge with a dated list of all persons participating in hog trapping activities on the refuge on a monthly basis. This report must be submitted to the refuge by the tenth day (or first business day following) of the next month.

7. LABOR, EQUIPMENT, TRANSPORTATION, AND SUPPLIES

HOG TRAPPER

The primary hog trapper will furnish all labor, equipment and supplies required to accomplish the effective trapping and removal of feral hogs from Merritt Island NWR. Each primary hog trapper will provide the refuge with a phone number to contact for day and night. A cell phone is preferred.

The primary hog trapper will provide personal information on persons needing access to the security area in a timely manner. The badging process can take several days or more to complete.

MERRITT ISLAND NWR

The refuge will provide combination locks for barricades, maps of the trapping units, and a paper and electronic template for required reports. The refuge will provide access to NASA badges and refuge hog trapping program identification badges.

In addition, as time and budget constraints allow, the refuge will provide assistance to hog trappers in the form of additional traps, bait, or other means.

8. SPECIAL RESTRICTIONS AND REQUIREMENTS – UNITS 1, 2, 3 AND 4

APPLICATION REQUIREMENTS

Prospective primary hog trappers must submit written proof of their hog trapping experience (use of traps). This proof must include a clear, legible narrative statement detailing number of years trapping and dogging, estimated hours per month/year doing each, and estimated hogs captured with use of traps and with dogs per month/year. Trapping experience includes building traps, selecting trap locations, or selecting trap type. Removing hogs and re-baiting existing traps is NOT considered trapping experience. In addition, each application must include three letters of reference verifying the applicant's experience and dates of experience. The three letters of reference should not overlap time frames and may not be from a family member. In addition, the letters of reference must be included in the envelope with your completed application. Letters of reference sent separately will not be considered. Applications received without three letters of reference or without a legible narrative statement will not be considered. Hog trappers will only be awarded one trapping unit. Any exaggeration or false statement provided on the application or in letters of reference may disqualify the applicant.

OPERATIONAL REQUIREMENTS

Hog trappers must check traps daily, bait traps for several consecutive days before setting traps, and respond to problem areas quickly. To do this requires a considerable investment of time on the part of the hog trapper. Therefore, **hog trappers must reside within 75 miles of the refuge**. Due to this requirement, applications from prospective trappers outside this area will not be considered.

All hog trappers will use humane means to remove feral hogs from Merritt Island NWR. If dogs are used, they must also be treated in a humane manner. The dogs shall be trained or controlled to pursue only hogs and not other refuge wildlife. Dogs that pose a threat to the public or refuge will not be permitted. All dogs must have collars with the owner's name, address, and phone number attached. Dogs without attached identification found on the refuge will be removed to the nearest available animal shelter.

All primary hog trappers are responsible for the actions of their authorized assistant trappers and guests. Any violation of State or Federal law, refuge regulation or contract condition by the primary or assistant trappers or guests may result in immediate cancellation of the contract and forfeiture of funds. Violation of the following conditions may result in immediate cancellation of the contract:

- Trappers may only trap in their assigned area.
- Possession of firearms is prohibited.
- All terrain vehicles (ATVs and dirt bikes) and air boats are prohibited.
- Damage to facilities, theft, or misuse of government supplies or equipment is prohibited.
- Toxic substances (poisons or drugs) for hog capture are prohibited.
- Building camps or structures other than traps is prohibited.
- All set traps must be checked daily and must be marked with the trapper's name and the assigned trap number.
- All captured hogs become property of the trapper and may be disposed of in any manner in accordance with all local, State, and Federal laws. All hogs must be removed from the refuge alive. Hogs may not be killed, slaughtered, or field dressed on the refuge.

Use of the refuge for feral hog trapping does not permit the trapper any special privileges not afforded to the general public.

Hogs are considered invasive feral animals by the U.S. Fish and Wildlife Service and may be destroyed by authorized refuge personnel at anytime. However, efforts will be taken to allow the hog trapper to remove the hogs before refuge personnel take direct action.

Period of use, time of entry, route of travel, techniques used, and other special regulations are subject to approval of the Refuge Manager. Special restrictions apply to trapping activities during daylight hours near Black Point Wildlife Drive, the Hammock Trails area and other public use facilities.

The refuge reserves the right to change the minimum trap requirements, or other contract details to respond to changes in feral hog populations or levels of activity. These changes may increase or decrease the trapping effort required. Any significant changes will occur during annual contract renewals.

Successful applicants will pay an annual hog trapper fee of $500, due the first day of the contract period—April 1. If payment is not received within 30 days of this date, the contract will be cancelled.

9. SPECIAL RESTRICTIONS AND REQUIREMENTS – UNIT 3

The primary hog trapper, or designee, for this unit must be available for call-out on a 24 hour basis, seven days a week. All hog trappers will be required to work in secured areas of NASA's Kennedy Space Center and will be required to meet and maintain security requirements for badging.

10. PERMIT ADMINISTRATION

The Refuge Manager has overall responsibility for the administration of this permit. He alone, without delegation, is authorized to take actions on behalf of the government to

amend, modify, or deviate from the contract terms, conditions, requirements, specifications, details, or other items. His word is final in any disagreement within or between hog trappers. However, he may delegate certain other responsibilities to his authorized representative.

The authorized representative for this contract is:

Ralph Lloyd
U.S. Fish and Wildlife Service
Merritt Island National Wildlife Refuge
P.O. Box 6504
Titusville, Florida 32782
(321) 861-0667 phone
(321) 861-1276 fax
ralph_lloyd@fws.gov

All official correspondence regarding this permit should be sent to the person and address listed above.

11. GOVERNMENT INSPECTION OF WORK PERFORMED

The refuge will monitor trapping efforts and results throughout the year. Any trapping which is not considered satisfactory will be brought to the attention of the hog trapper immediately. If unsatisfactory performance continues without correction it will be considered grounds for cancellation of the permit and forfeiture of all fees.

12. BASIS FOR AWARD

The permit for each unit will be awarded based on a qualified, random drawing. Applicants must meet the following qualifications to be considered for the random draw:

1. Applicant's residence is within 75-mile limit.
2. Applicant must be at least 21 years of age upon submitting a completed application.
3. Applicant possesses at least 3 years of experience in the use of traps to capture feral hogs. Trapping experience may include building traps, selecting traps locations, or selecting trap type. Removing hogs and re-baiting existing traps is NOT considered trapping experience. Applicant submitted a clear, legible narrative statement detailing number of years trapping and number of years dogging, estimated hours per month/year, estimated number of hogs captured with use of traps and with dogs per month/year. Narrative statement must be enclosed with the application.
4. Applicant submitted 3 letters of reference detailing the applicant's experience in the use of traps to capture hogs. All letters of reference must be enclosed with the application.

The refuge will draw from all qualified applications at random. The first application drawn will be awarded their first preferred unit as marked on the application. The second application drawn will be awarded their most preferred unit as marked on their application. This will continue until all units have been awarded. The refuge will record the names and preferred units of each of the remaining applicants as they are randomly drawn. Any hog trapping units made available within the permit period will be offered to the other applicants in the order they were drawn. Hog trappers will only be awarded one trapping unit.

13. PAYMENT

Prior to beginning work, the hog trapper shall provide to the address listed in Item 10 above a certified check or money order made out to the United States Fish and Wildlife Service in the amount of $500.

I,_____, HAVE READ AND UNDERSTAND THE ABOVE REGULATIONS, AND CONDITIONS AND REALIZE THAT FAILURE TO COMPLY MAY RESULT IN TERMINATION OF THE AGREEMENT AND/OR CRIMINAL CHARGES.

_____ _____
Signature Date

APPLICATION FOR FERAL HOG TRAPPING

MERRITT ISLAND NATIONAL WILDLIFE REFUGE

NAME _____ DATE OF BIRTH_____, 19___

ADDRESS_____ PHONE_____

I agree to provide management, supervision, labor, materials, supplies, and equipment, and shall plan, schedule, coordinate and assure effective performance of all services described herein at Merritt Island National Wildlife Refuge.

SIGNATURE _____ DATE_____

Permit Period:
The permit period is from April 1, 2004 through March 31, 2005. An option for annual renewal exists at the end of each permit year and is extendible for 4 years for a total of 5 years. Both parties must annually agree to renew the permit for an extension to occur. The hog trapper or the refuge can fail to renew the permit without cause and without recourse. (Due to application process, initial permit start date will be June 14, 2004)

Permit Amount:
The hog trapper agrees to pay the refuge $500.00 on an annual basis, due the first day of the permit period.

Trapping Units:
Indicate the order of preference for each unit in the box beside the unit name. Mark 1 for your first choice, 2 for your second choice, etc…:

☐ Unit 1

☐ Unit 2

☐ Unit 4

Check Your Enclosures:

☐ I have enclosed a clear, legible narrative statement of my hog trapping experience, which includes at least 3 years of experience using traps to capture feral hogs.

☐ I have enclosed three letters of reference verifying my experience using traps to capture feral hogs.

APPLICATION MUST BE RECEIVED AT REFUGE BEFORE 4:30 PM MAY 7, 2004