



# Endangered and Potentially Endangered Wildlife on John F. Kennedy Space Center and Faunal Integrity as a Goal for Maintaining Biological Diversity

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## ABSTRACT

Buffer zones for space operations provide for a wildlife diversity unsurpassed among most federal facilities in the continental U.S. demonstrating the coexistence possible with one of man's greatest technological achievements. This document ranks 119 resident or migratory wildlife species that are endangered or declining. The ranking system herein was based on species' vulnerability to extinction and the relevance of Kennedy Space Center (KSC) for maintaining populations in the U.S. and Florida. One amphibian, 19 reptiles, 80 birds and 19 mammals were considered endangered or declining. KSC is an integral area for regional species diversity being the focus of the Merritt Island/Cape Canaveral/Turnbull Ecosystem which is part of the Indian River Lagoon watershed, an estuary of national significance. Many species that use this system also use the nearby St. Johns River Basin ecosystem. These two ecosystems are biological corridors between temperate Carolinian and tropical/subtropical Caribbean biotic provinces. Threats to biological diversity on KSC were also reviewed. Traditional environmental assessments, resulting from environmental regulation guidelines, focus on environmental contaminants and habitat lost due to construction. However, this review suggested that small population sizes, isolation of populations, ecosystem and habitat fragmentation, road mortality, and other edge effects may represent more critical threats to biological diversity than the traditional topics.

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## 1.0 INTRODUCTION

This document updates the status of endangered and potentially endangered wildlife (amphibians, reptiles, birds, and mammals) on KSC. Species considered include endangered, threatened, and species of special concern listed under federal and state statutes. Species that have not yet been listed by agencies but are recognized by the scientific community to be declining or of concern are also included. Many species that are not yet listed by agencies are indicators of environmental quality because they are particularly sensitive to change or their habitat is declining at a rapid rate. Since preparation of the previous list for KSC (Breininger et al. 1984), several candidate species (e.g., Florida Scrub Jay and Southeastern Beach Mouse) have been federally listed as threatened or endangered.

Legal requirements of federal agencies for protecting wildlife are not only restricted to endangered or threatened species (Salwasser et al. 1983). Reliance on the Endangered Species Act alone is not biologically sound or cost effective (Scott et al. 1987, Campbell 1991, Rohlf 1991). Once species reach the endangered status, great monetary costs are incurred yet there is no insurance of species' survival. Polls show that increased regulation and public involvement is expected regarding the conservation of wildlife, given the overwhelming public support and willingness for greater expense to protect Florida's wildlife (Duda 1987). Conservation of biological diversity has become one of the most important agency goals regarding natural resources (Thomas and Salwasser 1989). Active management has become recognized as a necessary approach for the conservation of biological diversity (Frankel and Soule 1981).

### 1.1 BIOLOGICAL DIVERSITY

Biological diversity refers to ecosystem, community, species, and genetic

diversity at global, national, regional, and local levels (Office of Technology Assessment 1987). Although numerous state laws and regulations already relate to biological diversity (Table 1), maintenance of biological diversity will be the subject of increased environmental regulation for federal agencies. Proposed federal regulation includes requiring agencies to review programs, prepare reports, and insure actions are consistent with the goal of conserving biological diversity (Blockstein 1989). This includes evaluations of biological diversity in the environmental impact assessment process.

Federal lands in the U.S. are a crucial element in achieving the goal of conserving biological diversity (Thomas and Salwasser 1989; Brussard, 1991). Although natural resource managers recognize that legislation and regulation to maintain biological diversity already exist, maintenance of biological diversity is often inadequately addressed (Thomas and Salwasser 1989). Federal conservation efforts have been largely reactive, aimed at the recovery of single species already on the verge of extinction, rather than prevention of future losses (Office of Technology Assessment 1987). The Endangered Species Act is analogous to Superfund as a way to mitigate against harm already done. Biological diversity legislation is analogous to the Toxic Substances Control Act and the Resource Conservation and Recovery Act which are designed to prevent the need for future Superfund expenditures (Blockstein 1989).

Diversity is a common ecological measurement used in different contexts pertaining to scale and application (Samson and Knopf 1982, Schroeder 1986, Murphy 1989). Alpha diversity refers to species richness (the number of different species) and the equitability (relative abundance among the species). For example, consider two sites occupied by the same number of species and individuals. The site where many species are common is more diverse than the site where a few species comprise most of the individuals.

Table 1. Federal and state laws relating to maintenance of biological diversity and integrity.

Federal Laws	Code
Lacey Act of 1900	16 U.S.C. 667,701
Migratory Bird Treaty Act of 1918	16 U.S.C. 703-711
Migratory Bird Conservation Act of 1929	16 U.S.C. 669 et.seq.
Fish and Game Sanctuary Act 1934	16 U.S.C. 694
Fish and Wildlife Coordination Act 1934	16 U.S.C. 694
Wildlife Restoration Act of 1937	16 U.S.C. 668 et.seq.
Bald Eagle Protection Act of 1940	16 U.S.C. 668-668d
Fish and Wildlife Act of 1956	15 U.S.C. 713 et.seq.
National Wildlife Refuge System Administration Act of 1966	16 U.S.C. 742 et.seq.
Pelly Amendment to the Fishermen's Protective Act of 1967	16 U.S.C. 668dd et.seq.
National Environmental Policy Act of 1970	22 U.S.C. 1978
Federal Water Pollution Control Act of 1972	42 U.S.C. 4231-4347
Marine Mammal Protection Act of 1972	33 U.S.C. 466 et. seq.
Marine Protection, Research and Sanctuaries Act of 1972	16 U.S.C. 1361-1407
Endangered Species Act of 1973	16 U.S.C. 1431-1434
Whale Conservation and Protection Study Act of 1976	33 U.S.C. 1401,1402, 1411-1421, 1441-1444
Federal Land Policy and Management Act of 1976	16 U.S.C. 1531
Fish and Wildlife Conservation Act 1980	16 U.S.C. 915 et.seq.
<u>State Laws</u>	7 U.S.C. 1010-1012
Florida Endangered and Threatened Species Act	16 U.S.C. 5,79,420, 460,478,522, 523,551,1339
Florida Panther Protection Act	16 U.S.C. 2901 et.seq.
Florida Manatee Sanctuary Act	Florida Statutes Sec. 372.072
Marine Turtles Protection Act	Florida Statutes Sec. 372.671
Feeding or Enticement of Alligators or Crocodiles Act	Florida Statutes Sec. 370.12
Poaching of Alligators Act	Florida Statutes Sec. 370.12
	Florida Statutes Sec. 372-667
	Florida Statutes Sec. 372.663

Management for high levels of alpha diversity can result in the loss of species with specific habitat requirements not met under conditions favoring high alpha diversity (Noss and Harris 1986, Murphy 1989). Forest edges, for example, can be inhabited by a very diverse assemblage of birds characteristic of two different plant communities and birds that prefer edges. Yet, many species exist only within large forests away from the edges (Forman et al. 1976, Robbins 1979, Whitcomb et al. 1981). These interior species have declined as forests have become increasingly fragmented. Unwise management for alpha diversity can result in a less diverse, increasingly homogeneous, and "weedy" landscape (Noss and Harris 1986). As landscapes become increasingly fragmented, opportunistic and "weedy" species account for a misleadingly higher diversity, which is clearly not the goal of conservation (Verner 1986). Examples of "weedy" species include the European Starling (*Sturnus vulgaris*), House Sparrow (*Passer domesticus*), Northern Mockingbird (*Mimus polyglottos*), Brown-headed Cowbird (*Molothrus ater*), Virginia Opossum (*Didelphis virginiana*), and Raccoon (*Procyon lotor*). Maintenance of biological diversity is not managing for high diversity at individual sites but managing for diversity across the regional scale (Murphy 1989). Regional species diversity is measured as the number of species in all available habitats within a given region (Samson and Knopf 1982, Schroeder 1986).

The significance of the loss of one species is dependent on its interaction (e.g., as an important predator, symbiont, or mutualist) with other species (Estes et al. 1989). Results range from few changes in community composition to conspicuous changes (Paine 1980). Local extinction of an important predator can have a cascading influence on the ecosystem due to the release of some consumers (Terborgh and Winter 1980, Estes et al. 1989). The precipitating loss of species, referred to as "faunal collapse," has been documented in many ecosystems (Diamond 1972; Terborgh 1975; Case 1975; Soule et al. 1979, 1988; Frankel and Soule 1981, Burgess and

Sharpe 1981; Whitcomb 1981; Lynch and Whigham 1984; Wilcove et al. 1986).

The rates of "natural or background" extinctions are perhaps 1/100 to 1/1000 of the rates caused by man (Ehrlich and Ehrlich 1981, Soule and Simberloff 1986, Myers 1989). Since vertebrate speciation is a process that often takes thousands to millions of years, the result of the currently high extinction rates is an alarming decline in biological diversity. Species that are endangered or threatened no longer just include highly restricted forms. Only a subset of the native fauna, which was once widespread and common, is found in many landscapes.

## 1.2 OBJECTIVES AND SCOPE

The scope of biological diversity has not been completely defined (Office of Technology Assessment 1987). Maintenance of faunal integrity has been recommended (Harris 1990) as a specific goal for reversing the trend of declining biological diversity. Fauna here refers to the list of animals that naturally occur in an area (Harris 1984). Consideration of only native fauna is important because 67 exotic wildlife species have been introduced in Florida and 15 native species have become extinct (Badger 1990). Integrity is more difficult to quantify (Noss 1990). One defines integrity as "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a specific species composition and functional organization comparable to that of natural habitat of the region" (Karr and Dudley 1991). Indicator species of integrity include the presence of top predators such as large mammals and raptors (Gosselink and Lee 1989). Goals of biological diversity protection should also include ecological health (Karr 1990). Measures of ecological health include (relative) stability, capacity for self-repair when perturbed, and the need for minimal external support (Karr et. al. 1986).

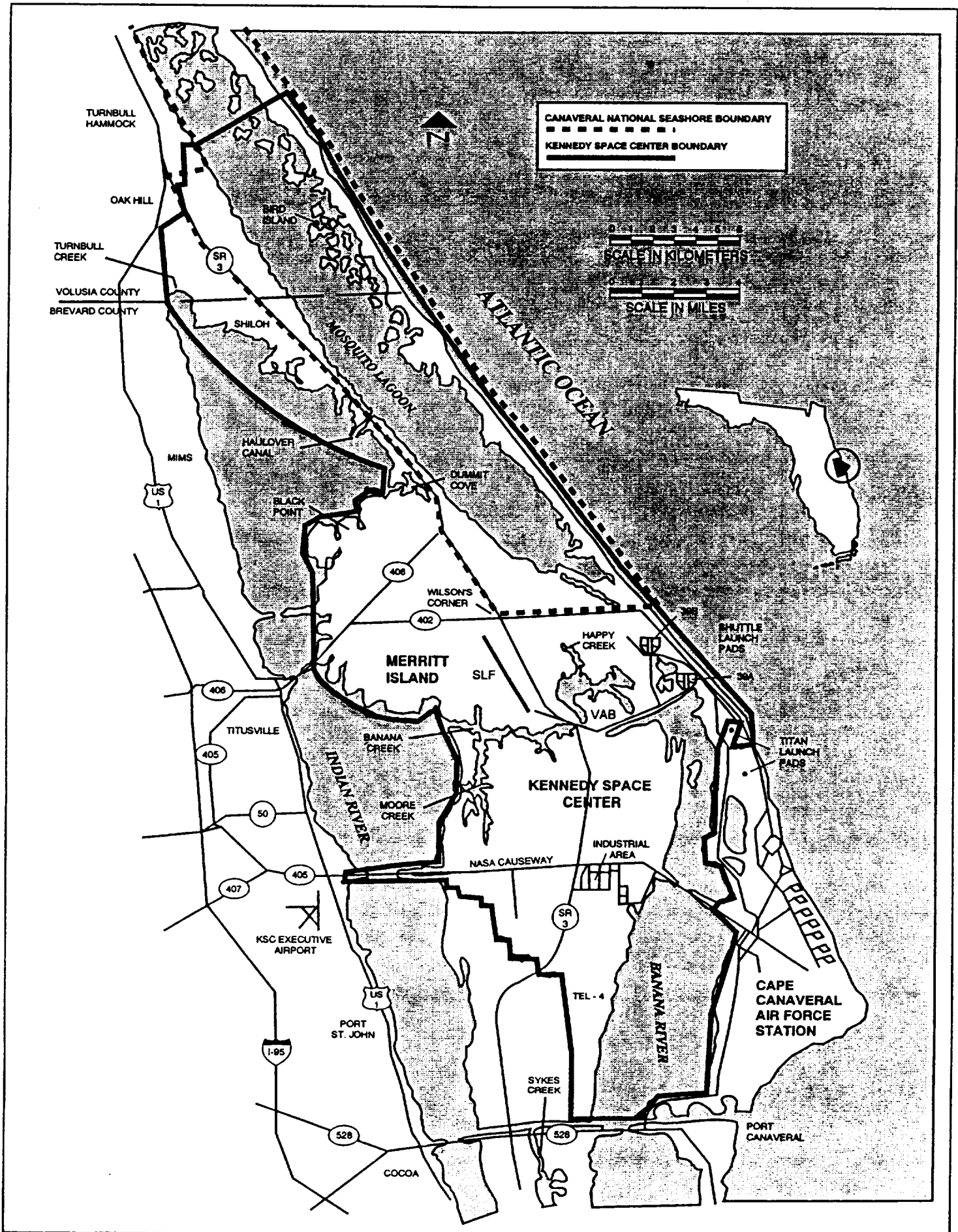
This document can not plan how to preserve biological diversity because interagency collaboration is needed to develop goals and approaches. Rather, the scope was to focus on the endangered and potentially endangered wildlife that might serve as an umbrella for maintaining most wildlife populations on KSC.

The objectives of this document are to:

1. Identify endangered and potentially endangered species on KSC as an initial step towards developing an approach for maintaining biological diversity and native faunal integrity,
2. Rank species according to their degree of endangerment and the significance of KSC in maintaining their population in the U.S. and Florida,
3. Identify factors influencing the viability of these populations on KSC (especially those related to KSC operations),
4. Review the roles of habitat and management in the conservation of endangered and potentially endangered species,
5. Identify monitoring efforts needed to maintain these species on KSC.

### 1.3 DESCRIPTION OF KENNEDY SPACE CENTER AND ITS RELATION TO THE MERRITT ISLAND\CAPE CANAVERAL\TURNBULL ECOSYSTEM

Lands and lagoons of KSC comprise 57,000 ha in Brevard and Volusia counties located along the east coast of central Florida. Most of KSC is on northern Merritt Island forming a barrier island complex with the adjacent Cape Canaveral (Figure 1). KSC occurs within a biogeographical transition zone, having faunal and floral assemblages derived from both temperate Carolinian and tropical/subtropical Caribbean biotic provinces (Robertson 1955, Boyles 1966, Ehrhart 1976, Sweet et al. 1979, Greller 1980, Snelson 1976, Stout 1979, Gilmore et al. 1981, Provancha et al. 1986, Virnstein and Campbell 1987, DeFreese 1991). KSC occurs within a zone of



moderate amphibian diversity, high reptilian diversity, low breeding land bird diversity, and low mammalian diversity within the continental U.S. (Simpson 1964, MacArthur and Wilson 1967, Harris 1984). Vertebrate diversity generally declines from north to south down the Florida peninsula. These distributions occur due to physiographic barriers that limit tropical species colonization, and peninsular conditions, in which continental species are poorly adapted (Robertson 1955). Glacial chillings and less severe climatic cold periods may also have limited the establishment of species adapted to the subtropical climate (Neill 1957, Brooks 1972). Swamping of genetic adaptations of local breeding bird populations by migrating birds having northern range centers may further reduce local adaptation (Emlen 1978). Breeding land bird diversity in Florida declines more rapidly along the coast than down the peninsula, resulting in a low number of landbirds that nest on KSC (Robertson 1955, Robertson and Kushlan 1974, Emlen 1978, Hirth and Marion 1979, Breininger 1990, Breininger and Schmalzer 1990). In contrast to landbirds, Florida supports a high diversity of waterbirds (Robertson and Kushlan 1974) which are especially abundant on KSC (Breininger and Smith 1990). Several species of conservation concern that occur on the Florida mainland do not occur on KSC (Ehrhart 1976, Larson 1992). The diversity of wildlife on KSC is attributable to the variety of upland and wetland habitats, proximity to the coast, and migratory birds.

Fluctuating sea levels with alternating glacial-interglacial cycles have shaped the barrier island complex comprising KSC. The Merritt Island landscape probably began forming 24,000 years ago, although most sediments are not that old (Brooks 1972). Cape Canaveral probably dates <7000 years before present as does the barrier strip separating Mosquito Lagoon and the Atlantic Ocean. The barrier beach along Mosquito Lagoon is gradually regressing landward by seaward erosion and washover, in contrast to Cape Canaveral which represents a progradational series of beach deposits (Mehta and Brooks 1973). The beach width and steepness vary



considerably along this shoreline.

The Indian River Lagoon system contains one of the richest and productive estuarine faunas in the continental U.S. (Gilmore 1985). This complex of the Mosquito Lagoon, Banana River, and Indian River lagoons and watersheds extends 250 km along Florida's east coast (Stewart and VanArman 1987). Parts of all three lagoons are contained within KSC. The nearest inlets to the Atlantic Ocean are Ponce De Leon to the north and Sebastian to the south, except for locks between Banana River and Port Canaveral. Water movement in the lagoons surrounding KSC is wind driven and nontidal. The average water depth is 1 m. Salinities vary from 35 ppt to nearly fresh water at drainage outfalls and some creeks. No fresh water creeks occur on KSC.

Topography on KSC is marked by a series of swales and ridges, (which represent relict dunes) ranging from sea level to 3 m. A narrow strip of dune and coastal strand occurs adjacent to the Atlantic Ocean. Surficial deposits are of Pleistocene and recent ages and consist primarily of sand and sandy coquina (Schmalzer and Hinkle 1990). Well drained habitats comprise about 2% of all KSC lands (Breininger et al. 1991). Detailed vegetation maps show scrub and pine flatwoods as the dominant upland communities (Provancha et al. 1986). Fresh and salt marshes occur adjacent to the estuary and in low areas interspersed in scrub and pine flatwoods (Schmalzer and Hinkle 1985). Forests occur on higher areas among marshes and lower areas among scrub and pine flatwoods.

The climate is warm and humid. Mean daily maximum temperatures range from 21C in January to 31C in July. Mean daily minimum temperatures range from 11C in January and 23C in July (Mailander 1990). Freezes seldom occur for more than three consecutive nights (Mailander 1990); Merritt Island had 44 days with freezing temperatures over its 47 year record, whereas mainland Titusville had 351 days with freezing temperatures for a 93 year period (Mailander 1990). There is a seven percent

chance that hurricane force winds (121 km/hr) will reach the 80 km stretch of KSC/CCAFS coastline during hurricane season (August through November) (Simpson and Lawrence 1971, as cited in Bradley 1972). KSC has one of the highest frequencies of lightning strikes in the world with  $1400 \pm 840$  cloud to ground strikes per month during the summer (Eastern Test and Missile Center 1989). Annual normal rainfall ranges from 54 to 56 inches depending on location with nearly 70% occurring between June and September (Mailander 1990). Rainfall is relatively clean but may range to a low pH of 4.5 to 4.7 (Madsen et al. 1992). Water levels are often lowest in spring due to low rainfall combined with high evapotranspiration (Schmalzer and Hinkle 1990).

Indigenous human occupation in the region occurred from 8000 BC to 1705 AD and there was some clearing, the use of fire in wildlands, and building of shell middens (e.g., Turtle Mound) (Davidson and Bratton 1986). Spanish colonization until 1762 involved free-ranging cattle, annual burns in the St. Johns watershed, and some citrus planting; however, disturbance was probably minor on KSC. English colonization and Spanish retrogression involved some draining and diking, limited live oak and pine logging, and some plantation farming. With early Florida statehood (1845-1861) came extensive live oak logging and some town establishment around citrus groves, followed by abandonment. After the Civil War, railroad establishment led to permanent towns associated with the citrus industry. Logging of virgin pine became prevalent. From 1900-1962 there was repeated logging of pine, burning for free-ranging cattle, and the draining and diking of wetlands for mosquito control (Davidson and Bratton 1986). Brevard County was predominantly rural prior to 1950. From 1950 to 1960, the population grew from 23,500 to 111,500, largely due to the arrival of military personnel ( U.S. Air Force [USAF] 1990). The population was estimated to be 338,000 in Brevard County in 1985 and now is greater than 400,000. Employment at KSC peaked during 1968 when there were nearly 26,000 employees

associated with the Apollo program. After the Apollo program ended, the KSC workforce declined to 8,500 in 1976 and later rose to 18,500 by 1990 to support the space shuttle program (Edward E. Clark Engineers-Scientists, Inc. 1993).

Prior to NASA acquisition, there were some small towns, fish camps, citrus groves, and other human establishments on KSC. Although much of the land was not extensively developed, it was altered by drainage practices, mosquito control impoundments, grazing, timbering, hunting, and roads (Trost 1968, Davidson and Bratton 1986). Beginning in the 1950's, Allan D. Cruickshank played a major role in popularizing bird watching in Florida and brought much fame to the area now known as KSC (Kale 1988). In 1962, NASA began acquiring KSC property. Merritt Island National Wildlife Refuge (MINWR), managed by the U.S. Fish and Wildlife Service (USFWS), was established in 1963 to manage lands and waters not being used directly by the space program. Canaveral National Seashore (CNS), managed by the National Park Service (NPS), was established in 1975. NASA remains the landowner and lands are occasionally removed from the refuge or seashore as needed by the space program (NASA 1979, Edward E. Clark Engineers-Scientists, Inc. 1986). Some NASA facilities are on the adjacent Cape Canaveral Air Force Station (CCAFS) and some CCAFS facilities are located on KSC. CCAFS is part of the USAF Eastern Space and Missile Center (44th Wing). The USAF has habitat management responsibility on CCAFS.

Several other federal agencies have regulatory roles on KSC, including the U.S. Army Corps of Engineers, National Oceanic and Atmospheric Administration (NOAA), and U.S. Environmental Protection Agency (EPA). Brevard County Mosquito Control District (BCMCD) and Volusia County Mosquito Control District are non-federal agencies that have management roles on KSC. Eight other state and local government agencies also have regulatory roles (Edward E. Clark Engineers-Scientists, Inc. 1986, KSC Ecological Program Plan 1991).

Environmental monitoring objectives on KSC, as administered by the NASA Biomedical Operations and Research Office at KSC, include operation and construction monitoring, long-term ambient monitoring, and ecological research (Ecological Program Plan 1991). Environmental management and permitting are the responsibility of the Environmental Management Office within the NASA Engineering Development Directorate. One of eight overall goals of KSC is to enhance and protect KSC's unique environment (KSC Strategic Plan 1991). The KSC Strategic Plan identifies the need to apply new and existing techniques, processes, and materials to preserve the environment. Initiatives related to wildlife include minimizing effects attributed to new facilities, enhancing workforce awareness, minimizing environmental risks, and enhancing prediction and analysis capability to enhance environmental management.

KSC and CCAFS are the largest public lands along Florida's Atlantic coast. Some of CNS extends north of the KSC property line. Turnbull Hammock is adjacent to KSC and is partly owned by the St. Johns River Water Management District (SJRWMD). There is potential for acquisition of much of this large forested wetland which is nearly 11 km in length and one km wide and includes a direct connection to KSC (SJRWMD 1991). The resulting connection of public lands can be referred to as the Merritt Island/Cape Canaveral/Turnbull Ecosystem.

Connection of KSC to the St. Johns River would be beneficial because much of the area along the St. Johns River is public land already or may be acquired (SJRWMD 1991). Acquisition would result in a large protected area bordering a river that stretches several hundred kilometers from north to south. The St. Johns River basin is connected to many other public lands (e.g., Ocala National Forest, St. Johns National Wildlife Refuge, Tosahatchee State Preserve). Currently, the stretch near the Brevard/Volusia County line between KSC/Turnbull and the St. Johns River is not extensively developed. Turnbull and a possible connection to the St. Johns are the

last potential land corridor between KSC and the mainland because, most other areas surrounding the Merritt Island/Cape Canaveral/Turnbull Ecosystem are urban (Larson 1992).

## 2.0 METHODS

The endangered and potentially endangered species list in this document was developed by updating previous lists for KSC (Ehrhart 1976, NASA 1979, Breininger et al. 1984) using state lists (Wood 1991), federal lists (50 CFR 17.11 and 17.12), and the scientific literature (e.g., Florida Committee for Rare and Endangered Plants and Animals [FCREPA]). Scientific literature was used to add species whose populations might be endangered or potentially endangered on KSC, although these species might not be listed by USFWS or FGFWFC.

A review of potential resident species (Ehrhart 1976, Lee 1983, and Breininger 1985) identified additional species that may be endangered on KSC because they approach minimum viable population size (MVP). MVP models represent population sizes that have chances for remaining viable at particular levels of risk for specific time periods. An estimate of 500 individuals is often used for populations under carefully monitored natural conditions (Frankel and Soule 1981, Salwasser et al. 1983, Noss et al. 1986, Shaffer 1981). Populations approaching 500 adults or less on KSC were included if they were potentially isolated. Population size estimates were unavailable for many species on KSC. The application of acreages of suitable habitat with estimates of densities, territory sizes, or momerange sizes (derived from the scientific literature) were used to estimate population size for many species.

Reviews of recent scientific literature and agency reports were used to provide a general background of the species' ecology, distribution, habitat requirements, vulnerability, population size, dispersal ability, and relations to environmental impact

and habitat management topics. Habitats used by each species were identified using references on species/habitat associations. Scientific literature on habitat requirements was used to estimate the importance of habitat types to particular species. Habitat types designated as essential were defined as those habitats that supported most of the KSC population. A small fraction of the population could still possibly exist (at least temporarily) without these types. This approach was used because the goals of conservation need not only maximize the chance of species persistence for long periods, but also to provide opportunity to adapt/evolve to environmental change and to be ecologically functional (Frankel and Soule 1980, Harris 1984, Woodruff 1989, O'Connor 1986).

A point system was used to rank species according to: (1) their vulnerability to extinction throughout their range and on KSC, and (2) their relevance. Relevance included the importance of KSC for maintaining their populations in the U.S. and Florida and the species role in faunal integrity (Figure 2). The biological vulnerability score from Millsap et al. (1990) was used as one measure of vulnerability. Millsap's score was derived from the population size across the species' range, the population trend over the last two decades, the size of the species' range, the change in distribution since European settlement, the degree of population congregation or seasonal aggregations at specific locations, average offspring produced per female per year, minimum age at which females typically reproduce, dietary specialization, reproductive specialization, other ecological specializations, and supplemental variables. Supplemental variables included the systematic significance of the species (i.e., their genetic uniqueness), the percent of the species' total range within Florida, the population trend in Florida, the percent of the time a species spends in Florida (permanent resident, seasonal breeder, wintering, transient), and the harvest status (Millsap et al. 1990).

Figure 2. Ranking methods for determining priority species on John F. Kennedy Space Center.

① Determine the Total Points for Each Species Based on Vulnerability and Relevance:

Vulnerability Measures

- a) Millsap et al. (1991) biological vulnerability score (# points)
- b) Status according to the U.S. Fish and Wildlife Service (USFWS), Florida Game and Fresh Water Fish Commission (FGWFC), and Florida Natural Areas Inventory (FNAI):
  - (30 pts.): listed as endangered or critically imperiled by one or more agencies
  - (20 pts.): listed as threatened or imperiled by one or more agencies
  - (10 pts.): listed as a species of special concern or vulnerable by one or more agencies
- c) Species were assigned 30 points if the population on KSC was isolated from other large populations.
- d) Species were assigned points depending on the size of the KSC resident population:
  - 30 pts.  $\leq 500$
  - 20 pts. 501-5,000
  - 10 pts.  $> 5,000$

Relevance Measures

- a) Species has a keystone role in faunal integrity (30 pts.)
- b) KSC is a population center for the species in Florida (30 pts.)
- c) KSC is a population center for the species in the U.S. (30 pts.)

② The following were considered low priority species:

- a) Whales
- b) Extinct species
- c) Rare visitors
- d) Species that require stocking to reestablish a population on KSC. These species (i.e., Wild Turkey, Grey Fox, and White-tailed Deer) were assumed not to be a NASA priority for preserving faunal integrity but may be of relevance to other agencies.
- e) Species with doubtful residency.

③ Species were arranged into four priority categories based on their accumulated of points:

Priority #1	187-125
Priority #2	124-82
Priority #3	81-39
Low Priority	38-6

The second criterion for scoring points was whether the species was listed by USFWS, FGFWFC, or FNAI. This provided another measure of vulnerability relevant to federal agency management directives that require special consideration for endangered and threatened species. Species classified as endangered or critically imperiled were given 30 points. Species classified as threatened or imperiled were given 20 points. Species of special concern or vulnerable were given 10 points.

Isolation increases vulnerability for small populations and represented a third criterion. Amphibians and reptiles are typically most sensitive to isolation, followed by mammals, permanent resident birds, and finally migratory birds (Harris 1984). Common isolating features relative to KSC include large water bodies, human developments, and highways (Oxley et al. 1974, Harris and Eisenberg 1989). Species that were isolated at KSC were given 30 points.

The population sizes of residents were used to estimate vulnerability and represented the fourth criterion used to rank vulnerability. Population sizes of permanent, nesting, or wintering populations on KSC were used as final factors to estimate vulnerability. Species with resident population sizes  $\leq 500$  were considered most vulnerable (Frankel 1980, Frankel and Soule 1981) and were assigned 30 points, species with resident populations of 500-5000 were assigned 20 points, and species with  $>5000$  residents were assigned 10 points. Species whose populations are vulnerable only along the edge of their range should not receive the same consideration as residents that are vulnerable across their range (see Knopf 1986, 1989). A number of species that are declining elsewhere (FCREPA, Hunter 1990, Noss and Labisky in press) reach the edge of their breeding range in north Florida and do not reproduce on KSC. Although representatives of these species migrate through KSC, the migrants are not necessarily from the declining populations.

Three criteria were then used to determine the relevance of species to KSC. Native endangered and potentially endangered species that may play a keystone role



in maintaining faunal integrity were given 30 points. The loss of one or more of these species could disrupt community balance and result in secondary extinctions of other species (Wilcove et al. 1986). Predators such as Bobcats, owls, hawks, and large snakes may perform a regulatory role on populations of smaller omnivorous species like Raccoons, Opossums, Grey Squirrels, and Blue Jays (Matthiae and Stearns 1981, Whitcomb et al. 1981, Wilcove et al. 1986). Omnivores in turn prey on a variety of smaller vertebrates and eggs or young of larger vertebrates. Species, such as the Gopher Tortoise, whose burrows are important to many species (Landers and Speake 1980, Eisenberg 1983, Cox et al. 1987, Witz et al. 1992), were given 30 points. Some species may play a keystone role but were not included, such as the White Ibis which may perform important roles due to their probing of marsh sediments (Bildstein 1991) but was not assumed essential for maintaining faunal integrity.

Significant populations of several species are supported by habitats on KSC. If KSC provided habitat for  $\geq 10\%$  of the entire U.S. population of a species, the species was assigned 30 points. If KSC could provide for  $\geq 10\%$  of the Florida population, the species was assigned another 30 points. Judgments concerning the relevance of KSC were needed due to marginally accurate population estimates and movements associated with migratory populations. The relevance of KSC was discussed with state, federal or university researchers to determine if it was reasonable to assume that KSC represented a significant area for a particular species. Some species (e.g., shorebirds) are represented by both wintering and transient populations. The winter population for some species was estimated to be 5-8% of the Florida population. However, it was suspected that a larger portion of the Florida population used KSC during migration. A common approach for shorebirds was to compare Christmas Bird Count (CBC) data for MINWR with the totals from all Florida CBCs to estimate the percent of the wintering population. Records for large sightings on KSC (e.g., Cruickshank 1980) were compared with the total Florida wintering population size

estimated from the total found from all CBCs conducted in Florida. Maximum counts on KSC were also compared with sightings regarded as noteworthy in regional reports (e.g., American Birds). Other common sources to determine significance included colony counts (e.g., Nesbitt et al. 1982, Clapp et al. 1983), estimates of the habitat acreage on KSC compared to acreages of habitat in Florida, range maps, and FCREPA accounts. See individual species accounts (Appendix A) for further information.

Points from all of the above sources were totaled for each species. The highest score was divided by four to develop four levels of decreasing priority. Species were placed into the four levels according to their scores. Those in the three highest levels were considered high or moderate priority species. Whales, extinct species, extirpated species, and rare visitors were considered low priority regardless of their scores. Species common in the southeastern U.S. but nearly extirpated from KSC were considered low priority species (e.g., White-tailed Deer, Grey Fox, and Wild Turkey) unless they had important roles in maintaining faunal integrity.

### 3.0 GENERAL OVERVIEW OF ENDANGERED AND POTENTIALLY ENDANGERED WILDLIFE ON KENNEDY SPACE CENTER

One amphibian, 19 reptiles, 83 birds and 19 mammals (representing a total of 119 species) are considered endangered or potentially endangered and may occur on KSC (Tables 2, 3, 4). These represent 1/20 of the amphibians, 1/5 of the reptiles, 1/4 of the birds, and 1/2 of the mammals that occur or may occur here. Sixteen species are federally listed as endangered and nine as threatened. A total of 14 federally listed species is derived by excluding species that no longer occur or seldom occur on KSC property (e.g., whales, Atlantic Hawksbill, Kirtland's Warbler, Red-cockaded Woodpecker, and the Florida Panther). There are 16 species that occur or sometimes

Table 2. Protected status of endangered and potentially endangered wildlife on John F. Kennedy Space Center.

	FGFWEFC	USFWS	CITES	FCREPA	Global Rank	FNAI	State Rank
<b>Amphibians and Reptiles</b>							
American Alligator	SSC	T (S/A)	II	SSC	G5	S4	S4
Loggerhead Sea Turtle	T	T	I	T	G3	S3	S3
Atlantic Green Turtle	E	E	I	E	G3	S2	S2
Eastern Diamondback Rattlesnake							
Leatherback Turtle	E	E	I	R	G3	S2	S2
Eastern Indigo Snake	T	T		SSC	G4T3	S3	S3
Atlantic Hawksbill Turtle	E	E	I	E	G3	S1	S1
Gopher Tortoise	SSC	C2		T	G3	S3	S3
Mole Kingsnake				R	G5	S4S3	S4S3
Eastern Kingsnake*				R			
Atlantic Ridley Turtle	E	E	I	E			
Eastern Coachwhip*							
Florida East Coast Terrapin*							
Atlantic Salt Marsh Water Snake	T	T		E	G4T1	S1	S1
Florida Pine Snake	SSC	C2		T	G5T3	S3	S3
Gopher Frog	SSC	C2		T	G3	S3	S3
Florida Scrub Lizard		C2		T	G3	S3	S3
Dusky Pygmy Rattlesnake*							
Florida Crowned Snake*							
Coastal Dunes Crowned Snake*							
<b>Birds</b>							
Cooper's Hawk				SSC	G4	S3	S3
Mottled Duck*							
Bachman's Sparrow		C2		R	G3	S3	S3
Roseate Spoonbill	SSC				G5	S2S3	S2S3
Dusky Seaside Sparrow	E				G4TX	SX	SX
Florida Scrub Jay	T	T			G5T3	S3	S3
Limpkin	SSC			SSC	G5	S3	S3
Burrowing Owl	SSC		II	SSC	G5T3	S3	S3

Table 2. (continued)

	FGFWFC	USFWS	CITES	FCREPA	Global Rank	FNAI	State Rank
American Bittern*							
Great Horned Owl*							
Red-shouldered Hawk*							
Red-tailed Hawk*							
Broad-winged Hawk*		C2					
Swainson's Hawk							
Semipalmated Sandpiper*							
Red Knot*							
Sanderling*							
Western Sandpiper*							
Pectoral Sandpiper*							
Great Egret*	T			SSC	G5		S4
Piping Plover		T		SSC	G3		S2
Wilson's Plover*							
Northern Harrier			II				
Common Ground Dove*							
Florida Prairie Warbler*					G5T3		S3
Kirtland's Warbler	E	E			G1		S1
Pileated Woodpecker*							
Little Blue Heron	SSC			SSC	G5		S4
Reddish Egret	SSC	C2		R	G4		S2
Snowy Egret	SSC			SSC	G5		S4
Tricolored Heron	SSC			SSC	G5		S4
Swallow-tailed Kite		C2		SSC	G5		S2S3
White Ibis	SSC			SSC	G5		S4
Merlin			II	SUD	G4		SU
Arctic Peregrine Falcon	E	T	I	E	G3		S2
Southeastern American Kestrel	T	C2	II	T	G5T3T4		S3?
Eastern American Kestrel			II				
Rothschild's Magnificent Frigate Bird*				T	G5		S1
Common Loon*							
Florida Sandhill Crane	T		II	T	G5T2T3		S2S3
American Oystercatcher	SSC			T	G5		S3

Table 2. (continued)

	FGWFC	USFWS	CITES	FCREPA	Global Rank	FNAI	State Rank
Southern Bald Eagle	T	E	I	T	G3		S2S3
Worm-eating Warbler*				SSC	G5		S1
Black-necked Stilt*							
Yellow-breasted Chat*		C2					
Migrant Loggerhead Shrike		C2		SVD	G4?		S3?
Black Rail*							
Whimbrel*							
Least Bittern*				SSC	G5		S4
Red-headed Woodpecker*							
Wild Turkey*							
Wood Stork	E	E		E	G4		S2
Short-billed Dowitcher*							
Marbled Godwit*							
Black-crowned Night-heron*				SSC	G5		S3?
Yellow-crowned Night-heron*				SSC	G5		S3?
Kentucky Warbler*							
Osprey			II	T	G5		S3S4
Brown Pelican	SSC				G4		S3
Red-cockaded Woodpecker	T	E			G2		S2
Hairy Woodpecker*				SSC	G5		S3?
Glossy Ibis*				SSC	G5		S2
Black-bellied Plover*							
King Rail*							
American Avocet*				SSC	G5		S1S2
Black Skimmer				SSC	G5		S3
Louisiana Waterthrush*				R	G5		S3
American Redstart*				R	G5		S3
Brown-headed Nuthatch*							
Field Sparrow*							
Least Tern	T			T	G4		S3
Roseate Tern	T	T		T	G3		S1
Sooty Tern*				SSC	G5		S1
Caspian Tern*				SSC	G5		S2?

Table 2. (continued)

	FGFWFC	USFWS	CITES	FCREPA	Global Rank	FNAI	State Rank
Gull-billed Tern*							
Royal Tern*				SSC	G5	S3	S3
Sandwich Tern*				SSC	G4	S2	S2
Barred Owl*							
Common Barn Owl*							
Black-wiskered Vireo*				R	G5	S3	S3
Hooded Warbler*							
Mammals							
Sperm whale	E	E		E			
Right whale	E	E	I	E			
Sei whale	E	E	II	E			
Finback whale	E	E	II	E			
Florida Panther	E	E	I	E	G4T1	S1	S1
Gray Fox*							
River Otter			II				
Bobcat			II				
Florida Long-tailed Weasel		3C		R	G5T3	S3?	S3?
Indiana Bat	E	E		E	G2	SA	SA
Round-tailed Muskrat		C2		SSC	G3	S3	S3
Red Wolf		E					
Florida Mouse	SSC	C2		T	G3	S3	S3
Southeastern Beach Mouse	T	T		T	G5T1	S1	S1
Southeastern Big-eared Bat		C2		R	G4	S3?	S3?
West Indian Manatee	E	E	I	E	G2?	S2?	S2?
White-tailed Deer*							
Florida Black Bear	T	C2	III	T	G5T2	S2	S2

Table 2. (continued)

Species listed in alphabetical order by scientific name as they appear in 50 CFR 17.11, Wood (1991), and FNAI (1991). See Table 3 for scientific names.

- FGWFC = Florida Game and Fresh Water Fish Commission  
 USEWS = U.S. Fish and Wildlife Service  
 CITES = Convention of International Trade of Endangered Species  
 FCREPA = Florida Committee for Rare and Endangered Plants and Animals  
 FNAI = Florida Natural Areas Inventory  
 E = Endangered Species  
 T = Threatened Species  
 R = Rare Species  
 SSC = Species of Special Concern  
 C2 = A candidate for listing, with some evidence of vulnerability, but for which not enough data exist to support listing.  
 I = Appendix I Species  
 II = Appendix II Species  
 \* = Species listed as endangered or potentially endangered in scientific literature or has low population size on KSC.

FNAI Codes

- G = Global Rank  
 S = State Rank  
 1 = Critically imperiled  
 2 = imperiled  
 3 = very rare or local, or otherwise vulnerable to extinction  
 4 = apparently secure  
 5 = demonstrably secure  
 T = subspecies rank  
 Q = questionable whether it is subspecies or species  
 X = believed to be extinct  
 ? = Tentative rank or not yet ranked  
 U = No rank assigned  
 H = Historical occurrence, may be rediscovered  
 SA = Accidental in Florida, i.e., not part of established biota.  
 3C = Candidate species, Category 3C. Taxa that have proven to be more abundant or widespread than was previously believed and/or those that are not subject to any identifiable threat.

Table 3. Scientific and common names of endangered and potentially endangered wildlife on John F. Kennedy Space Center.

Amphibians and Reptiles

Alligator mississippiensis  
Caretta caretta caretta  
Chelonia mydas mydas  
Crotalus adamanteus  
Dermochelys coriacea coriacea  
Drymarchon corias couperi  
Eretmochelys imbricata imbricata  
Gopherus polyphemus  
Lampropeltis calligaster rhombomaculata  
Lampropeltis getulus getulus  
Lepidocheilus kempii  
Masticophis flagellum flagellum  
Malaclemys terrapin tequesta  
Nerodia fasciata taeniata  
Pituophis melanoleucus mugitus  
Rana areolata aesopus  
Sceloporus woodi  
Sistrurus miliaris barbouri  
Tantilla relicta neilli  
Tantilla L. pamllica

American Alligator  
Atlantic Loggerhead Turtle  
Atlantic Green Turtle  
Eastern Diamondback Rattlesnake  
Leatherback Turtle  
Eastern Indigo Snake  
Atlantic Hawksbill Turtle  
Gopher Tortoise  
Mole Kingsnake  
Eastern Kingsnake  
Atlantic Ridley Turtle  
Eastern Coachwhip  
Florida East Coast Terrapin  
Atlantic Salt Marsh Water Snake  
Florida Pine Snake  
Gopher Frog  
Florida Scrub Lizard  
Dusky Pygmy Rattlesnake  
Florida Crowned Snake  
Coastal Dunes Crowned Snake

Birds

Accipiter cooperii  
Anas fulvigula  
Aimophila aestivalis  
Ajaja ajaja  
Ammodramus maritimus nigricens  
Aphelocoma coerulescens coerulescens  
Aramus guarava

Cooper's Hawk  
Mottled Duck  
Bachman's Sparrow  
Roseate Spoonbill  
Dusky Seaside Sparrow  
Florida Scrub Jay  
Limpkin



Table 3. (continued)

<i>Athene cunicularia floridana</i>	Burrowing Owl
<i>Botaurus lentiginosus</i>	American Bittern
<i>Bubo virginianus</i>	Great Horned Owl
<i>Buteo lineatus alleni</i> and <i>extimus</i>	Red-shouldered Hawk
<i>Buteo jamaicensis borealis</i> and <i>umbrinus</i>	Red-tailed Hawk
<i>Buteo platypterus platypterus</i>	Broad-winged Hawk
<i>Buteo swainsoni</i>	Swainson's Hawk
<i>Calidris alba</i>	Sanderling
<i>Calidris canutus rufa</i>	Red Knot
<i>Calidris fuscicollis</i>	White-rumped Sandpiper
<i>Calidris mauri</i>	Western Sandpiper
<i>Calidris pusilla</i>	Semipalmated Sandpiper
<i>Casmerodius allbus egretta</i>	Great Egret
<i>Charadrius melodus</i>	Piping Plover
<i>Charadrius wilsonia wilsonia</i>	Wilson's Plover
<i>Circus cyaneus hudsonius</i>	Northern Harrier
<i>Columbina passerina</i>	Common Ground-dove
<i>Dendroica discolor paludicola</i>	Florida Prairie Warbler
<i>Dendroica kirtlandii</i>	Kirtland's Warbler
<i>Dryocopus pileatus pileatus</i>	Pileated Woodpecker
<i>Egretta caerulea</i>	Little Blue Heron
<i>Egretta rufescens rufescens</i>	Reddish Egret
<i>Egretta thula thula</i>	Snowy Egret
<i>Egretta tricolor ruficollis</i>	Tricolored Heron
<i>Elanoides forficatus forficatus</i>	American Swallow-tailed Kite
<i>Eudocimus albus</i>	White Ibis
<i>Falco columbarius columbarius</i>	Merlin
<i>Falco peregrinus tundrius</i>	Arctic Peregrine Falcon
<i>Falco sparverius paulus</i>	Southeastern American Kestrel
<i>Falco s. sparverius</i>	Eastern American Kestrel
<i>Fregata magnificens rothschildi</i>	Rothschild's Magnificent Frigate Bird
<i>Gavia immer</i>	Common Loon
<i>Grus canadensis pratensis</i>	Florida Sandhill Crane
<i>Haematopus palliatus palliatus</i>	American Oystercatcher
<i>Haliaeetus leucocephalus leucocephalus</i>	Southern Bald Eagle

Table 3. (continued)

<u>Helminthos vermivorus</u>	Worm-eating Warbler
<u>Himantopus mexicanus mexicanus</u>	Black-necked Stilt
<u>Icteria virens</u>	Yellow-breasted Chat
<u>Lobrychus exilis exilis</u>	Least Bittern
<u>Lanius ludovicianus</u>	Loggerhead Shrike
<u>Laterallus jamaicensis jamaicensis</u>	Black Rail
<u>Limnodramus griseus griseus</u>	Short-billed Dowitcher
<u>Limosa fedoa</u>	Marbled Godwit
<u>Melanerpes erythrocephalus erythrocephalus</u>	Red-headed Woodpecker
<u>Meleagris gallopavo osceola</u>	Wild Turkey
<u>Mycteria americana</u>	Woodstork
<u>Numenius phaeocopus hudsonicus</u>	Whimbrel
<u>Nycticorax nycticorax hoactli</u>	Black-crowned Night Heron
<u>Nycticorax violaceus violaceus</u>	Yellow-crowned Night Heron
<u>Oporomis formosus</u>	Kentucky Warbler
<u>Pandion haliaetus carolinensis</u>	Osprey
<u>Pelecanus occidentalis carolinensis</u>	Brown Pelican
<u>Picoides borealis</u>	Red-cockaded Woodpecker
<u>Picoides villosus auduboni</u>	Hairy Woodpecker
<u>Plegadis falcinellus falcinellus</u>	Glossy Ibis
<u>Pluvialis squatarola</u>	Black-bellied Plover
<u>Rallus elegans elegans</u>	King Rail
<u>Recurvirostra americana americana</u>	American Avocet
<u>Rynchops niger</u>	Black Skimmer
<u>Seiurus motacilla</u>	Louisiana Waterthrush
<u>Setophaga ruticilla ruticilla</u>	American Redstart
<u>Sitta pusilla pusilla</u>	Brown-headed Nuthatch
<u>Spizella pusilla pusilla</u>	Field Sparrow
<u>Sterna antillarum antillarum</u>	Least Tern
<u>Sterna dougallii</u>	Roseate Tern
<u>Sterna fuscata</u>	Sooty Tern
<u>Sterna caspia</u>	Caspian Tern
<u>Sterna nilotica</u>	Gull-billed Tern
<u>Sterna maxima</u>	Royal Tern
<u>Sterna sandvicensis</u>	Sandwich Tern

Table 3. (continued)

*Strix varia*  
*Tyto alba pratincola*  
*Vireo altiloquus*  
*Wilsonia citrina*

Barred Owl  
 Common Barn-owl  
 Black-wiskered Vireo  
 Hooded Warbler

Mammals

*Balaena glacialis*  
*Balaenoptera boreals*  
*Balaenoptera physalus*  
*Canis rufus*  
*Eptescius fuscus fuscus*  
*Felis concolor coryi*  
*Lasiurus intermedius floridanus*  
*Lutra canadensis vaga*  
*Lynx rufus floridanus*  
*Mustela frenata peninsulæ*  
*Mustela vison lutensis*  
*Myotis sodalis*  
*Neofiber alleni*  
*Odocoileus virginianus*  
*Podomys floridanus*  
*Peromyscus polionotus niveiventris*  
*Plecotus rafinesquii macrotis*  
*Physeter catodon*  
*Tadarida brasiliensis cynocephala*  
*Trichechus manatus latirostris*  
*Urocyon cinereogentens*  
*Ursus americanus floridanus*

Right Whale  
 Sei Whale  
 Finback Whale  
 Red Wolf  
 Big Brown Bat  
 Florida Panther  
 Northern Yellow Bat  
 River Otter  
 Bobcat  
 Florida Long-tailed Weasel  
 Florida Mink  
 Indiana Bat  
 Round-tailed Muskrat  
 White-tailed Deer  
 Florida Mouse  
 Southeastern Beach Mouse  
 Southeastern Big-eared Bat  
 Sperm Whale  
 Brazilian Free-tailed Bat  
 West Indian Manatee  
 Gray Fox  
 Florida Black Bear

Table 4. Vulnerability and relevance scores for endangered and potentially endangered wildlife used to determine priority species for John F. Kennedy Space Center.

Species: Taxon	Vulnerability Scores					Relevance Scores				Total Score
	Biological Vulnerability (Millsap et al. 1990*)	Status (USFWS, FGFWFC, FNAI)	Degree of Isolation	Size of Resident Population	Role Faunal Integrity <sup>3</sup>	Florida Population Center	U.S. Population Center			
<b>PRIORITY #1 SPECIES:</b>										
Florida Scrub Jay	30	20	30	20		30	30		160	
Atlantic Green Turtle	32	30		30		30	30		152	
West Indian Manatee	32	30		30		30	30		152	
Southeastern Beach Mouse	31	20	30	10		30	30		151	
Southern Bald Eagle	26	30		30	30	30	30		146	
Wood Stork	23	30		30		30	30		143	
Eastern Indigo Snake	25	20	30	30	30	30	30		135	
Roseate Spoonbill	25	20		30		30	30		135	
Reddish Egret	23	20		30		30	30		133	
Florida Long-tailed Weasel	18	20	30	30		30	30		128	
Atlantic Salt Marsh Snake	37	30	30	30	30				127	
<b>PRIORITY #2 SPECIES:</b>										
Florida Pine Snake	24	10	30	30	30				124	
Florida East Coast Terrapin	32	20		30		30	30		122	
Atlantic Loggerhead Turtle	20	20		20		30	30		120	
Royal Tern	26	10		20	30	30	30		116	
River Otter	26	30	30	30	30				116	
East. Dmndbk Rattlesnake	24	30	30	30	30				114	
Arctic Peregrine Falcon	24	30	30	30	30				114	
Gopher Tortoise	24	20	30	10	30	30	30		114	
Gull-billed Tern	21	30		30					111	
Florida Gopher Frog	25	20	30	30					105	
American Avocet	14	30		30		30	30		104	
Black Skimmer	24	20	30	30	30	30	30		104	
Bobcat	14	20	30	30		30	30		104	
Eastern Brown Pelican	24	20	30	30		30	30		104	
Least Tern	24	20	30	30		30	30		104	
Eastern Kingsnake	13	30	30	30	30				103	
Eastern Coachwhip	13	30	30	30	30				103	
Black Rail	31	10	30	30		30	30		101	
Caspian Tern	21	20	30	30		30	30		101	
Sandwich Tern	19	20	30	30		30	30		99	
Mole Kingsnake	16	20	30	30	30				96	
Glossy Ibis	15	20	30	30		30	30		95	
Florida Prairie Warbler	30	30	30	30		30	30		90	

Table 4. (continued)

Species: Taxon	Vulnerability Scores				Relevance Scores				Total Score
	Biological Vulnerability (Millsap et al. 1990*)	Status (USFWS, FGFWFC, FNAI)	Degree of Isolation	Size of Resident Population	Role Faunal Integrity <sup>3</sup>	Florida Population Center	U.S. Population Center		
Osprey	17	10		30	30			87	
White Ibis	13	20		20				83	
Round-tailed Muskrat	22	10	30	20		30		82	
<b>PRIORITY #3 SPECIES:</b>									
Black-necked Stilt	18			30		30		78	
Barn Owl	18			30	30			78	
Pileated Woodpecker	18			30	30			78	
Snowy Egret	17	10		20		30		77	
Tricolored Heron	17	10		20		30		77	
Short-billed Dowitcher	26			20		30		76	
Western Sandpiper	26			20		30		76	
Marbled Godwit	26			20		30		76	
Red-shouldered Hawk	16			30	30			76	
Cooper's Hawk	15			30	30			75	
Northern Harrier	15			30	30			75	
Wilson's Plover	14			30		30		74	
Black-bellied Plover	24			20		30		74	
Barred Owl	14			30	30			74	
Florida Mouse	22	10	30	10				72	
Merlin	10			30	30			70	
American Oystercatcher	29	10		30				69	
Dusky Pygmy Rattlesnake	9		30	30				69	
Great Horned Owl	8			30	30			68	
American Alligator	17	N/A		20	30			67	
Whimbrel	34			30				64	
Red-tailed Hawk	4			30	30			64	
Little Blue Heron	23	10		30				63	
Eastern American Kestrel	10			20				60	
Black-whiskered Vireo	18	10		30	30			58	
Red Knot	26			30				56	
Common Loon	25			30				55	
Black-crowned Night-heron	13	10		30				53	
Loggerhead Shrike	18			30				48	
Common Ground-dove	17			30				47	

Table 4. (continued)

Species: Taxon	Vulnerability Scores				Relevance Scores				Total Score	
	Biological Vulnerability (Millsap et al. 1990*)	Status (USFWS, FGFWFC, FNAI)	Degree of Isolation	Size of Resident Population	Role Faunal Integrity <sup>3</sup>	Florida Population Center	U.S. Population Center			
Least Bittern	15			30				45		
Sanderling	24			20				44		
Piping Plover	24	20						44		
King Rail	22			20				42		
Great Egret	19			20				39		
<b><u>LOW PRIORITY SPECIES:</u></b>										
<b><u>Low point accumulation</u></b>										
Louisiana Waterthrush	8			30				38		
Bachman's Sparrow	12	20						32		
Limpkin	22	10						32		
Pectoral Sandpiper	28							28		
Semipalmated Sandpiper	26							26		
Hairy Woodpecker	17	10						27		
White-rumped Sandpiper	26							26		
Red-headed Woodpecker	20							20		
Field Sparrow	19							19		
American Bittern	18							18		
Broad-winged Hawk	14							14		
Worm-eating Warbler	11							11		
Brown-headed Nuthatch	10							10		
Hooded Warbler	8							8		
Kentucky Warbler	8							8		
Yellow-breasted Chat	7							7		
American Redstart	6							6		
<b><u>Visitors only</u></b>										
Atlantic Ridley Turtle	32	30						62		
Atlantic Hawkbill	30	30						60		
Roseate Tern	28	30						58		
Atlantic Leatherback	26	30						56		
Kirland's Warbler	24	30						54		
Florida Sandhill Crane	33	20						53		
Sooty Tern	15	30						45		
Southeastern Kestrel	23	20						43		
Magnificent Frigatebird	13	30						43		
Great White Heron	15	20						35		
Burrowing Owl	20	10						30		
Swallow-tailed Kite	30							30		

Table 4. (continued)

Species: Taxon	Vulnerability Scores					Relevance Scores			
	Biological Vulnerability (Millsap et al. 1990*)	Status (USFWS, FGFWFC, FNAI)	Degree of Isolation	Size of Resident Population	Role Faunal Integrity <sup>3</sup>	Florida Population Center	U.S. Population Center	Total Score	
Swainson's Hawk	21							21	
Yellow-crowned Night-heron	21							21	
<del>Apparently secure regionally</del>					30			95	
Gray Fox	5		30	30				70	
Wild Turkey	10		30	30				68	
White-tailed Deer	8		30	30				68	
Mottled Duck	19		30	30	30			49	

1 The ranking system is provided in Figure 3.

2 Score for endangered species (Millsap et al. 1990)

Score for threatened species (Millsap et al. 1990)

Score for species of special concern (Millsap et al. 1990)

≥ 33

≥ 29-32

≥ 28-24

3 Refers to role as top predator or keystone role for other wildlife species

N/A Not applicable for taxon listed due to similarity of appearance or because the edge of taxon's breeding range overlaps Florida elsewhere.

occur on KSC that are being reviewed for federal listing. There are 44 state-listed species that occur on KSC.

The Merritt Island/Cape Canaveral/Turnbull Ecosystem is one of a few important areas for the global survival of two, perhaps four taxa (Table 4). Scrub and pine flatwoods on KSC support the largest population of the Florida Scrub Jay (Cox 1987, Breininger 1989) and the largest population of the Southeastern Beach Mouse (Humphrey 1987, Paradiso 1989). Some of the salt marshes along the eastern shore of Mosquito Lagoon may support a population of the Atlantic Salt Marsh Snake (Kochman 1978). KSC may support the largest remaining population of the East Coast Diamondback Terrapin (Seigel 1979). KSC provides habitat for significant populations in the U.S. for 12 species and significant populations in Florida for 29 species (Table 4).

Figure 3 presents the 72 high and moderate priority species. Several species received high ranks but are not listed by the USFWS, FGFWFC, or FNAI, similar to findings by Millsap et al. (1990). Nine of the 11 species that received the highest ranking for KSC are listed by both state and federal agencies. Some species not listed by agencies are candidates for future listing. Some rare species, such as the Wilson's Plover, may not yet be listed by agencies due to little information on their status (T. Below, R. Paul., and H. Kale, pers. comm.). Extinctions of largely unnoticed species (e.g., several subspecies of small mammals) have already occurred in Florida. The identification of additional imperiled species is anticipated following public education concerning their status (Humphrey 1990). Many species may not yet be endangered in the U.S. or Florida but are becoming endangered in many local landscapes (e.g., Bobcat and River Otter) (Harris and Gallagher 1989).

Table 5 lists the habitats associated with various high and moderate priority taxa. Estuarine waters, open water impoundments, salt marsh, cattail, and graminoid marshes are habitats used by the largest number of priority species; broad leaved



Figure 3. Endangered and potentially endangered wildlife on John F. Kennedy Space Center, Florida (priority #1, 2 and 3 species 1992).\*

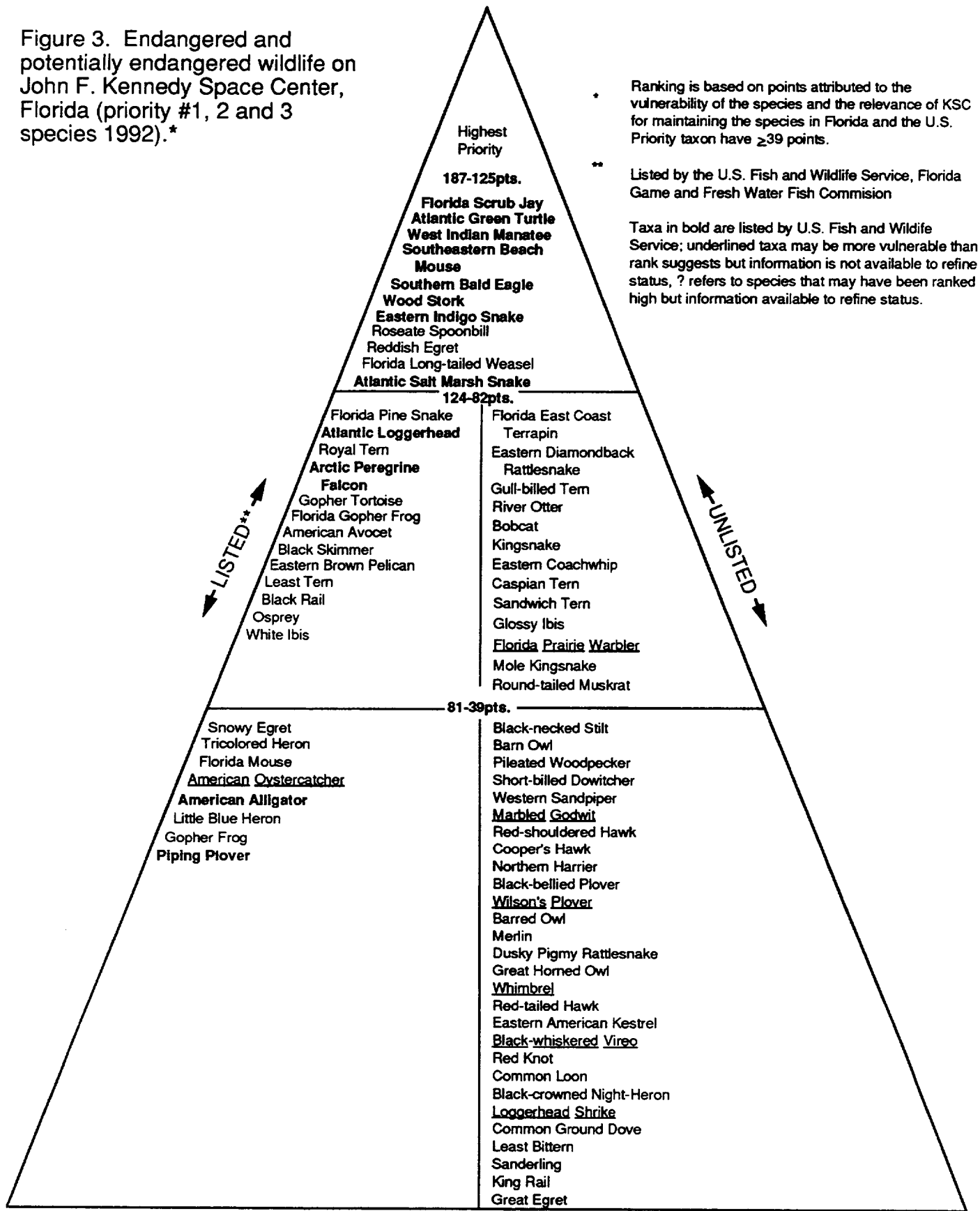


Table 5. Habitats occupied or required by priority species listed in decreasing priority.

HABITAT TYPE

Priority Species	Estuarine Waters and Edge	Impounded Open Water & Mud Flats	Salt Marsh	Cattail & Graminoid Marshes	Coastal Dune & Strand	Ocean Beach	Scrub & Slash Pine	Broad-leaved Forests	Miscellaneous Disturbed (e.g. citrus, Brazilian Pepper)	Islands	Ditches & Canals	Ruderal Grass
Florida Scrub Jay					2		4		1			F2
Atlantic Green Turtle	F4					B4						
West Indian Manatee	4											
Southeastern Beach Mouse					4		2 <sup>r</sup>					
Wood Stork	F2	F4	F2	F2						B4	F2	
Southern Bald Eagle	F4	F4	F2	F2	F1	F1	B4F1	F1	F1	F1	F2	F2
Eastern Indigo Snake		F2	F2	F3	3		4	1	2		F2	F2
Roseate Spoonbill	F4	F4	F1							B4F1 <sup>r</sup>	F1 <sup>r</sup>	
Reddish Egret	F4	F4	F1							B4F1 <sup>r</sup>	F1	
Florida Long-tailed Weasel	F1	F1	2	2	2	F1	2	2	2		2	F2
Atlantic Salt Marsh Snake	2	F1 <sup>r</sup>	4	1 <sup>r</sup>						4 <sup>r</sup>	F1 <sup>r</sup>	
Florida Pine Snake					4		4		2			1
Florida East Coast Terrapin	F4	1	F2		B1				B4	B4	B3	
Atlantic Loggerhead	F4					B4						

Table 5. (continued)

Priority Species	Estuarine Waters and Edge	Impounded Open Water & Mud Flats	Salt Marsh	Cattail & Graminoid Marshes	Coastal Dune & Strand	Ocean Beach	Scrub & Slash Pine	Broad-leaved Forests	Miscellaneous Disturbed (e.g. citrus, Brazilian Pepper)	Islands	Ditches & Canals	Ruderal Grass
Royal Tern	F3	L2				L2				B4		
River Otter	F3	F3	4	3				2	2		2	
Eastern Diamondback Rattlesnake		F1	F1	F2	3	F1	4	2	2		F2	F2
Arctic Peregrine Falcon	F4	F4	F2	F1	F2	F2	F1		F1	F2	F2	F2
Gopher Tortoise				F2 <sup>r</sup>	3		4	1	2			2
Gull-billed Tern	F3	F4	F4	F3			F1			B4	F2	F1
Florida Gopher Frog				B4 <sup>r</sup>			F4		F2 <sup>r</sup>			
American Avocet	F1	F4	F1 <sup>r</sup>							F1 <sup>r</sup>	F1 <sup>r</sup>	
Black Skimmer	F4	F4				L2				B4	F2	
Bobcat	F1	F2	F2	F2	F2	F2	4	4	2		F1	F2
Eastern Brown Pelican	F4	F2								B4	F1	
Least Tern	F4	2	1 <sup>r</sup>			L2				B4	F2 <sup>r</sup>	B1 <sup>r</sup>
Eastern Kingsnake				F2			1	4	1		F2	F1
Eastern Coachwhip				F1	2		4	1	2		F1	F1
Black Rail			4	2 <sup>r</sup>							F2 <sup>r</sup>	
Caspian Tern	F3	L2				L2				B4		

Table 5. (continued)

HABITAT TYPE

Priority Species	Estuarine Waters and Edge	Impounded Open Water & Mud Flats	Salt Marsh	Cattail & Graminoid Marshes	Coastal Dune & Strand	Ocean Beach	Scrub & Slash Pine	Broad-leaved Forests	Miscellaneous Disturbed (e.g. citrus, Brazilian Pepper)	Islands	Ditches & Canals	Ruderal Grass
Sandwich Tern	F3	L2				L2				B4		
Mole Kingsnake					1		4	1	2			2
Glossy Ibis	F1	F4	F2	F2						B4F2 <sup>r</sup>	F2	F2
Florida Prarie Warbler			4 <sup>r</sup>							4 <sup>r</sup>		
Osprey	F4	F2					B4			B2		B2 <sup>r</sup>
White Ibis	F2	F4	F2	F2				F2 <sup>r</sup>		B4F2 <sup>r</sup>	F2	F1
Round-tailed Muskrat			4	3							3	
Black-necked Stilt	F4	F4	4	3						3		
Barn Owl	F1	F2	F3	F2	F3	F2	F2	B4	F2		F2	3
Pileated Woodpecker							3	4	1			2 <sup>r</sup>
Snowy Egret	F2	F4	F2	F2						B4F1 <sup>r</sup>	F2	
Tricolored Heron	F2	F4	F2	F2						B4F2 <sup>r</sup>	F2	
Short-billed Dowitcher	F4	F4	F1			F1				F1 <sup>r</sup>		
Western Sandpiper	F4	F4	F1			F1				F1 <sup>r</sup>		
Marbled Godwit	F4	F4	F1			F1				F1 <sup>r</sup>		

Table 5. (continued)

## HABITAT TYPE

Priority Species	Estuarine Waters and Edge	Impounded Open Water & Mud Flats	Salt Marsh	Cattail & Graminoid Marshes	Coastal Dune & Strand	Ocean Beach	Scrub & Slash Pine	Broad-leaved Forests	Miscellaneous Disturbed (e.g. citrus, Brazilian Pepper)	Islands	Ditches & Canals	Ruderal Grass
Red-shouldered Hawk			F2	F3			F2	4	F2		F2	F2
Cooper's Hawk			F1	F1	F1		3	4	2			F2
Northern Harrier	F2	F4	F4	F4	F2	F1	F2		F2	F1	F2	F1
Wilson's Plover	F3	4				4				2 <sup>r</sup>		
Black-bellied Plover	F4	F4				F4				F2 <sup>r</sup>		
Barred Owl		F2	F2	F3 <sup>r</sup>	F1		F2	4	F2		F1	F2
Florida Mouse					3		4		1			
Merlin	F3	F4	F4	F2	F3	F4	F3		F2	F2	F2	F3
American Oystercatcher	F4					F1				B4		
Dusky Pygmy Rattlesnake			1	F4	3		4	2	2		F3	F3
Great Horned Owl		F1	F1	F2	F1		4	2	F1		F1	F2
American Alligator	F2	F2	3	4					L1	L2	3	
Whimbrel	F4	F4	F3			F1				F1 <sup>r</sup>		
Red-tailed Hawk		F2	F2	F2	F2		4	1	1		F2	F2
Little Blue Heron	F3	F4	F4	F4						B4F2 <sup>r</sup>	F2	

Table 5. (continued)

HABITAT TYPE

Priority Species	Estuarine Waters and Edge	Impounded Open Water & Mud Flats	Salt Marsh	Cattail & Graminoid Marshes	Coastal Dune & Strand	Ocean Beach	Scrub & Slash Pine	Broad-leaved Forests	Miscellaneous Disturbed (e.g. citrus, Brazilian Pepper)	Islands	Ditches & Canals	Ruderal Grass
Eastern American Kestrel	F1	F4	F4	F2	F3	F1	F4		F3	F3	F3	F4
Black-whiskered Vireo			4 <sup>r</sup>						1	4 <sup>r</sup>		
Red Knot	F4	F4	F3			F3 <sup>3</sup>				F1 <sup>r</sup>		
Common Loon	F4					L1						
Black-crowned Night-heron	F4	F4	F2	F2						B4F2 <sup>r</sup>	F1	
Loggerhead Shrike		F1	F2		F1		F3B4		F2			F4
Common Ground-dove	F1	F1	F1	F1	4	F1	1		3			F2
Least Bittern			4	4						3 <sup>r</sup>	F1	
Sanderling	F4	F2	F2			F4				F1 <sup>r</sup>		
Piping Plover	F2	F2				F4				F1 <sup>r</sup>		
Great Egret	F4	F4	F2	F2						B4F1 <sup>r</sup>	F2	
King Rail			3	4							F2 <sup>r</sup>	

Table 5. (continued)

HABITAT TYPE

Priority Species	Estuarine Waters and Edge	Impounded Open Water & Mud Flats	Salt Marsh	Cattail & Graminoid Marshes	Coastal Dune & Strand	Ocean Beach	Scrub & Slash Pine	Broad-leaved Forests	Miscellaneous Disturbed (e.g. citrus, Brazilian Pepper)	Islands	Ditches & Canals	Ruderal Grass
Total Number of Priority Taxon Requiring this Habitat	24	26	13	7	3	7	15	7	1	22	0	2
Total Number of Priority Taxon using this Habitat	47	48	48	38	25	27	31	20	28	41	40	30

B = Breeding Habitat

F = Feeding Habitat

L = Loafing or Roosting Habitat only

Blank column = Habitat probably not used

1 = Habitat rarely used

2 = Habitat commonly used

3 = Habitat heavily used so that elimination of habitat could reduce species population in the general area

4 = Habitat critical for continuation of the species on KSC

r = Species highly restricted to areas with particular characteristics within this type (i.e. restricted to salt water, restricted to wetlands, restricted to man-made structures for nesting, restricted to coastal scrub)

forests are used by the fewest priority taxa. Islands are required nesting habitat for many priority taxa (Tables 4, 5). Estuarine waters and open water impoundments are required by many priority taxa as feeding habitat. Salt marsh, scrub, and pine flatwoods are required by the most priority taxa because these species are dependent on these habitats. Although ditches, ruderal, and miscellaneous disturbed habitats are used by a large number of priority taxa, they are only required by a few species. Only a subset of disturbed areas is critical to these species; this subset is important habitat due to the disruption of native landscape structure. Estuarine waters comprise 38% of KSC (Table 6). Less than 1% of KSC is comprised of beach, coastal dune and strand. Nearly 13% of KSC lands, excluding roads and facilities, are not native plant communities. A few thousand acres of habitat are under direct NASA operational control rather than managed by the MINWR or CNS (Edward E. Clark Engineers-Scientists, Inc. 1986). NASA is liable for management of endangered and threatened species in these areas (White 1991).

Most priority taxa having low feeding habitat availability also rely on the same habitat for nesting (Tables 7). These include the Atlantic Salt Marsh Snake, Eastern Kingsnake, Black Rail, Barred Owl, Common Ground Dove, Black-whiskered Vireo, Florida Prairie Warbler, Southeastern Beach Mouse, and Florida Mouse. An exception is the Wood Stork which is limited by separate feeding and nesting habitats. Priority taxa that faced a much lower availability of nesting habitat than feeding habitat were colonial nesting birds that nest on islands. Habitat types with the lowest availability are bare or sparsely vegetated islands, mangroves, mudflats, beaches, coastal dune, coastal strand, well-drained scrub and pine flatwoods, open pine stands with large trees, and large unfragmented forests with large trees (Appendix A).

Most isolated priority taxa were reptiles and mammals. Nearly 54 of the priority taxa had low population sizes, nearly 12 had moderate population sizes, and only four had large populations (Table 8). The Atlantic Salt Marsh Snake, Eastern Indigo



Table 6. Acreage of habitat and vegetation types.

	<u>Hectares</u>
Estuarine Water	21599
Open water Impoundments	3578
Salt Marsh (Includes some Island habitat):	
Salt Marsh Cordgrass	23
Black Mangrove	1069
Mixed Grass/Sedge	44
Black Mangrove/Saltwort/Glasswort	40
Saltwort/Glasswort	251
Mixed Salt Tolerant Grasses	951
White Mangrove/Mixed Mangrove	485
Dead Mangrove	81
Sea Oxeye	121
Mixed Grass Sedge	44
Mudflats	115
Totals	3224
Broad-leaved Forests:	
Coastal Live Oak Woods	131
Live Oak/Cabbage Palm Hammock	826
Red Bay/Laurel Oak/Live Oak	1266
Cabbage Palm Hammock	719
Southern Red Cedar/Live Oak	73
Southern Red Cedar	36
Willow Swamp	728
Hardwood Swamp	443
Totals	4222
Cattail and Graminoid Marshes:	
Cattail Marsh	1478
Graminoid Marsh	4225
Cabbage Palm Savannah	2180
Totals	7883
Coastal Dune & Strand:	
Coastal Dunes	148
Coastal Strand	255
Totals	403
Ocean Beach	174

Table 6. (continued)

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Scrub + Slash Pine:

Mixed Oak/Saw Palmetto	6512
Disturbed Scrub	453
Slash Pine	3540
Sand Pine	1
Totals	10506

Exotic (Includes some Island habitat):

Wax Myrtle/Brazilian Pepper	534
Australian Pine	188
Shrub/Herb Spoil Vegetation	107
Citrus	1088
Dikes	938
Totals	2855

Ruderal Grass 1189

Ditches, Canals, Inland Waters:

Ditches, Borrow Pits	212
Inland Waters	85
Totals	297

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Table 7. Habitat specificity and availability for priority species listed in decreasing priority.

	# Habitats Used For Feeding	# Habitats Used For Reproduction	# Habitats Essential For Feeding	# Habitats Essential For Reproduction	Availability of Essential Habitat For Feeding	Availability of Essential Habitat For Reproduction	Opportunity for Dispersal
Florida Scrub Jay	4	3	1	1	M	M	L
Atlantic Green Turtle	1	1	1	1	M	M	H
West Indian Manatee	1	1	1	1	M	M	H
Southeastern Beach Mouse	2	2	1	1	L	L	L
Southern Bald Eagle	12	1	2	1	M	L	M
Wood Stork	5	1	1	1	M	L	M
Eastern Indigo Snake	9	4	1	1	H	M	L
Roseate Spoonbill	5	1	2	1	H	M	H
Reddish Egret	5	1	2	1	H	M	H
Florida Long-tailed Weasel	11	7	0	0	H	H	L
Atlantic Salt Marsh Snake	6	4	2	2	L	L	L
Florida Pine Snake	4	4	2	2	L	L	L
Florida East Coast Terrapin	3	5	1	2	M	L	M
Atlantic Loggerhead	1	1	1	1	M	M	H
Royal Tern	1	1	0	1	H	L	H

Table 7. (continued)

	# Habitats Used For Feeding	# Habitats Used For Reproduction	# Habitats Essential For Feeding	# Habitats Essential For Reproduction	Availability of Essential Habitat For Feeding	Availability of Essential Habitat For Reproduction	Opportunity for Dispersal
River Otter	7	5	1	1	L	M	L
Eastern Diamondback Rattlesnake	10	4	1	1	H	H	L
Arctic Peregrine Falcon	11	N/A	2	N/A	M	N/A	H
Gopher Tortoise	6	5	1	1	H	M	L
Gull-billed Tern	7	1	2	1	H	L	H
Florida Gopher Frog	2	1	1	1	L	M	L
American Avocet	5	N/A	1	N/A	M	N/A	H
Black Skimmer	3	1	2	1	M	L	H
Bobcat	11	3	2	2	H	H	L
Eastern Brown Pelican	3	1	1	1	H	M	H
Least Tern	4	4	1	1	H	L	H
Eastern Kingsnake	6	3	1	1	L	L	L
Eastern Coachwhip	7	4	1	1	M	M	L
Black Rail	3	2	1	1	L	L	H
Caspian Tern	1	1	0	1	H	L	H
Sandwich Tern	1	1	0	1	H	L	H

Table 7. (continued)

	# Habitats Used For Feeding	# Habitats Used For Reproduction	# Habitats Essential For Feeding	# Habitats Essential For Reproduction	Availability of Essential Habitat For Feeding	Availability of Essential Habitat For Reproduction	Opportunity for Dispersal
Mole Kingsnake	5	5	1	1	M	M	L
Glossy Ibis	7	1	1	1	H	M	H
Florida Prairie Warbler	2	2	2	2	L	L	H
Osprey	2	3	1	1	M	M	H
White Ibis	8	1	1	1	H	M	H
Round-tailed Muskrat	3	3	1	1	L	L	L
Black-necked Stilt	5	3	3	1	M	L	H
Barn Owl	10	2	0	1	M	L	H
Pileated Woodpecker	4	4	1	1	M	L	H
Snowy Egret	6	1	1	1	H	M	H
Tricolored Heron	6	1	1	1	H	M	H
Short-billed Dowitcher	5	N/A	2	N/A	M	N/A	H
Western Sandpiper	5	N/A	2	N/A	M	N/A	H
Marbled Godwit	5	N/A	2	N/A	M	N/A	H

Table 7. (continued)

	# Habitats Used For Feeding	# Habitats Used For Reproduction	# Habitats Essential For Feeding	# Habitats Essential For Reproduction	Availability of Essential Habitat For Feeding	Availability of Essential Habitat For Reproduction	Opportunity for Dispersal
Red-shouldered Hawk	7	1	1	1	L	L	H
Cooper's Hawk	7	3	1	1	M	L	H
Northern Harrier	11	N/A	3	N/A	H	N/A	H
Wilson's Plover	4	3	2	2	L	L	H
Black-bellied Plover	4	N/A	3	N/A	M	N/A	H
Barred Owl	9	1	1	1	H	M	H
Florida Mouse	3	3	1	1	L	L	L
Merlin	11	N/A	3	N/A	H	N/A	H
American Oystercatcher	2	1	1	1	M	L	H
Dusky Pygmy Rattlesnake	8	5	2	1	M	M	L
Great Horned Owl	9	2	1	1	H	M	H
American Alligator	5	3	1	1	M	M	H
Whimbrel	5	N/A	2	N/A	M	N/A	H
Red-tailed Hawk	9	3	1	1	H	M	H

Table 7. (continued)

	# Habitats Used For Feeding	# Habitats Used For Reproduction	# Habitats Essential For Feeding	# Habitats Essential For Reproduction	Availability of Essential Habitat For Feeding	Availability of Essential Habitat For Reproduction	Opportunity for Dispersal
Little Blue Heron	6	1	3	1	H	M	H
Eastern American Kestrel	11	N/A	4	N/A	M	N/A	H
Black-whiskered Vireo	3	3	2	2	L	L	H
Red Knot	5	N/A	2	N/A	M	N/A	H
Common Loon	1	N/A	1	N/A	H	N/A	H
Black-crowned Night-heron	6	1	2	1	M	M	H
Loggerhead Shrike	6	1	1	1	H	N/A	H
Common Ground-dove	9	3	1	1	L	L	H
Least Bittern	4	3	2	2	M	M	H
Sanderling	5	N/A	2	N/A	M	N/A	H
Piping Plover	4	N/A	1	N/A	L	N/A	H
King Rail	3	2	1	1	M	M	H
Great Egret	6	1	2	1	H	M	H

N/A = Species does not nest on KSC

L = Low

M = Medium

H = High

Table 8. Seasonal abundance, population size, and measures of endangerment of priority species.

	Breeding Season	Seasonal Abundance on KSC				Estimated Population Size on KSC	Autecology Characteristics (Noss and Labisky in press)
		Spring	Summer	Fall	Winter		
Florida Scrub Jay	Feb-June	C	C	C	C	2,100	1 R <sub>1</sub> DLUFH
Atlantic Green Turtle	April-Sept.	C	O	C	C	150	
West Indian Manatee	All Year	C	C	C	R	< 300	
Southeastern Beach Mouse	All Year	C	C	C	C	> 5000	
Southern Bald Eagle	Dec-April	U	U	U	U	20	2/3 R <sub>2</sub> W L C
Wood Stork	Feb-July	C	C	C	C	0-600	
Eastern Indigo Snake	All Year	C	C	C	C	< 500	
Roseate Spoonbill	Mar-July	U	C	U	R	400	
Reddish Egret	Mar-July	O	O	O	O	20	
Florida Long-tailed Weasel	Nov-Feb	R	R	R	R	< 500	2 R <sub>1</sub> R <sub>2</sub> WL
Atlantic Salt Marsh Snake	Mar-Sept.	R	R	R	R	< 500	
Florida Pine Snake	Mar-Sept.	R	R	R	R	< 500	2/3 R <sub>2</sub> NFHE
Florida East Coast Terrapin	Mar-Sept.	R	R	R	R	400-500	
Atlantic Loggerhead Turtle	April-Sept.	L	C			1,200	



Table 8. (continued)

	Breeding Season	Seasonal Abundance on KSC				Estimated Population Size on KSC	Autecology Characteristics (Noss and Labasky in press)
		Spring	Summer	Fall	Winter		
Royal Tern	Mar-June	C	C	C	C	4,000	
River Otter	All Year	O	O	O	O	< 500	2 R <sub>2</sub> W I E
Eastern Diamondback Rattlesnake		O	O	O	O	< 500	2 R <sub>2</sub> W N E
Arctic Peregrine Falcon	N/A	R		O	O	< 10	
Gopher Tortoise	Mar-Sept.	C	C	C	C	18,000	2 L N F H E
Gull-billed Tern	May-July	R	O	R	R	< 300	
Gopher Frog	Mar-Oct.	R	R	R	R	< 500	
American Avocet	N/A	O	O	C	C	400	
Black Skimmer	May-June	C	C	C	C	200	
Bobcat	All Year	U	U	U	U	< 500	2 W E
Eastern Brown Pelican	Feb-Aug	C	C	C	C	500-1,000	
Least Tern	April-July	C	C	C		0-1,000	
Eastern Kingsnake		R	R	R	R	< 500	2/3 R <sub>2</sub> N E
Eastern Coachwhip		C	C	C	C	< 500	2 W N F H E
Black Rail	Apr-Aug	R	R	R	R	< 500	
Caspian Tern	Mar-June	U	O	C	C	200	

Table 8. (continued)

	Breeding Season	Seasonal Abundance on KSC				Estimated Population Size on KSC	Autecology Characteristics (Noss and Labasky In press)
		Spring	Summer	Fall	Winter		
Sandwich Tern	Mar-June	O	R	O	O	200	
Mole Kingsnake	May-July	R	R	R	R	< 500	2 R <sub>1</sub> R <sub>2</sub> NE
Glossy Ibis	Mar-June	C	C	C	C	400	
Florida Prairie Warbler	May-Aug	R	R	R		< 100	
Osprey	Mar-June	C	C	C	C	60	3 R <sub>2</sub> WL
White Ibis	Mar-July	C	C	C	C	3,000	
Round-tailed Muskrat	All Year	O	O	O	O	500-5000	
Black-necked Stilt	Apr-July	U	U	U		30-300	
Barn Owl	Nov-April	R	R	R	R	< 500	
Pileated Woodpecker	Feb-June	U	U	U	U	< 500	3 W
Snowy Egret	Mar-July	C	C	C	C	800	
Tricolored Heron	Mar-July	C	C	C	C	800	
Short-billed Dowitcher	N/A	C	O	C	C	< 500	
Western Sandpiper	N/A	C	O	C	C	> 5000	
Marbled Godwit	N/A	O	O	O	O	< 500	

Table 8. (continued)

	Breeding Season	Seasonal Abundance on KSC				Estimated * Population Size on KSC	Autecology Characteristics (Noss and Labasky in press)
		Spring	Summer	Fall	Winter		
Red-shouldered Hawk	Mar-June	U	U	U	U	10-100	3 WLI
Cooper's Hawk	Mar-May	O	O	O	O	10-100	3 R <sub>2</sub> WLI
Northern Harrier	N/A	C		C	C	< 500	
Wilson's Plover	April-July	R	R	R	R	< 500	
Black-bellied Plover	N/A	C	O	C	C	< 500	
Barred Owl	Nov-Apr	O	O	O	O	10-100	3 WLI
Florida Mouse	All Year	C	C	C	C	> 5000	2 R <sub>1</sub> UFH
Merlin	N/A	R		O	O	< 500	
American Oystercatcher	Mar-June	R	R	R	R	0-100	
Dusky Pygmy Rattlesnake		R	R	R	R	< 500	2/3 NE
Great Horned Owl	Nov-May	U	U	U	U	10-100	4
American Alligator	Mar-Sept.	C	C	C	C	3,000	
Whimbrel	N/A	O		O	O	< 500	
Red-tailed Hawk	Mar-June	C	C	C	C	10-100	4
Little Blue Heron	Mar-July	C	C	C	C	40	

Table 8. (continued)

	Breeding Season	Seasonal Abundance on KSC				Estimated * Population Size on KSC	Autecology Characteristics (Noss and Labasky in press)
		Spring	Summer	Fall	Winter		
Eastern American Kestrel	N/A	C		C	C	< 500	2 R <sub>1</sub> W F U H
Black-whiskered Vireo	May-Sept.	R	R	R		< 100	
Red Knot	N/A	O		O	O	< 500	
Common Loon	N/A	O		O	C	< 500	
Black-crowned Night-heron	Mar-June	U	U	U	U	50	
Loggerhead Shrike	Mar-June	U	O	U	U	< 100	
Common Ground-dove	Mar-Aug	O	O	O	O	< 500	2 N F E
Least Bittern	Mar-Aug	O	O	O	C	< 100	
Sanderling	N/A	C	C	C	C	500-5000	
Piping Plover	N/A	R		R	R	< 500	
King Rail	Mar-Aug	O	O	O	O	500-5000	
Great Egret	N/A	O	O	O	O	500-5000	

\* Population estimates vary from actual data to estimations; see species accounts for more information.

Footnotes for Seasonal Abundance

- C = common, usually seen in suitable habitat
- O = occasional, often seen in suitable habitat
- R = rare, infrequently seen in suitable habitat

Table 8. (continued)

blanks = species not usually present during the season  
N/A = species does not nest on KSC

Footnotes to Noss and Labisky (in press)

- 1 - extremely vulnerable; severe population decline or local extinction highly probable
- 2 - very vulnerable; local extinction fairly probable; population decline highly probable
- 3 - moderately vulnerable; local extinction possible; population decline fairly probable
- 4 - possibly vulnerable; population decline possible, but species appears to be tolerant of most impacts
- 5 - not vulnerable; species tolerant, persisting or even thriving in anthropogenic habitats

R<sub>1</sub> - rarity due to limited or patchy geographic distribution (i.e., narrow, endemic, or disjunct population)

R<sub>2</sub> - rarity due to low local population density

G - low level of genetic variation (e.g., inbred, homozygous, etc.)

D - low dispersability (low vagility or mobility; low colonization or recolonization potential)

W - wide ranging (area-dependent; large territory or home range)

L - low fecundity (low I or reproductive rate)

U - dependent on unpredictable, seasonal, or patchy resources (including specificity to rare habitat patches, or extreme ecological specialization)

V - great temporal variation (fluctuations) in population size

C - congregates in large groups for breeding, foraging, or other purposes (high sociality or coloniality)

M - long-distance migrant

N - nests on or near the ground (susceptibility to ground predators)

I - confined to or preferring forest interior habitat (edge-avoiding)

F - dependent of fire-maintained habitat, or vulnerable to alteration (e.g., seasonality) of fire regime

H - specializing on, or distributed primarily in, habitat prone to development or human disturbance

E - vulnerable to exploitation for meat, skins or pet-trade; or persecution due to cultural bias (e.g., snakes, bats)

Snake, Eastern Kingsnake, Eastern Diamondback Rattlesnake, Dusky Pygmy Rattlesnake, Eastern Coachwhip, Florida Pine Snake, River Otter, and Bobcat had low population sizes and were either isolated or were susceptible to isolation. Nearly 23 priority bird species nested on KSC and had low population sizes. The extent of interactions between KSC populations and nearby populations is poorly understood (Appendix A). Sixty priority species are permanent residents. Many of these include permanent and seasonal residents, and transients (e.g., Ospreys, Red-shouldered Hawks, Red-tailed Hawks, Barred Owls, Great Horned Owls, Wilson's Plover). Some wintering shorebird species do not nest on KSC but include nonbreeding vagrants in summer (Cruickshank 1980). Nearly all priority taxa were present in spring and fall; a few were not present in summer or winter.

Noss and Labinsky (in press) summarized likely causes of population decline and local extinction for upland species in northern peninsular Florida. Many upland priority taxa on KSC are vulnerable to extinction due to low fecundity, susceptibility to ground predators, low population densities, large homerange requirements, human persecution, and large area requirements (Table 8). These priority taxa included at least 22 species that are likely to suffer further population declines and local extinctions in Florida.

Range maps suggest that the Coastal Dunes Crowned Snake and Florida Crowned Snake may occur on KSC. Although there were no records for these species on KSC, surveys have not been sufficient to establish their absence. Some range maps suggest that the Florida Scrub Lizard occurs on KSC; however, field studies have probably been sufficient to assume their absence. KSC was once a population center for the now extinct Dusky Seaside Sparrow. Other species that probably occurred on KSC and became extinct were the Carolina Parakeet (Conuropsis carolinensis), West Indian Monk Seal (Monachus tropicalis), and perhaps the Ivory-billed Woodpecker (Campephelius principalis). The Red-cockaded

Woodpecker, Florida Black Bear, Florida Panther, and Red Wolf (the Florida subspecies is extinct) no longer occur on KSC but occur elsewhere. There are many unconfirmed Panther sightings which may actually be Bobcats or Jaguarundis (Felis yagouaroundi) that are mistakenly identified.

Nearly half of the birds and reptiles that are federally listed as endangered or threatened in Florida occur on KSC. Geographic patterns in vertebrate vulnerability revealed that the Atlantic coastline was the most vulnerable area for reptile populations and one of the most vulnerable areas for birds (Millsap et al. 1990). This coastline also has been designated as having high vulnerability for mammals (Millsap et al. 1990). Florida's Atlantic coast not only has high biological diversity but also has some of the highest human population growth rates in the U.S. KSC is the largest protected area for wildlife using the Indian River Lagoon system. Little information is available on most biological resources of this highly diverse ecosystem (DeFreese 1991). Manatees are one of the few species for which distribution was investigated (Beeler et al. 1988). The location and composition of wading bird colonies are available for some years (Nesbitt et al. 1982; Kale 1988; Maxwell and Kale 1974, 1977; Runde et al. 1991). KSC and Pelican Island National Wildlife Refuge supported most of the colony sites for wading birds. Spoil island surveys provided minimal information on spoil island bird use along the Indian River Lagoon (DNR 1990).

Quantifying the relevance of KSC (and other areas along the lagoon) for wildlife species dependent on the estuary and its watershed is not readily achieved. This poor state of knowledge is surprising since management of the estuary and its watershed involves 112 interacting governmental agencies (Panico and Barile 1986). Attention has been focused on the deterioration of specific areas associated with discharges of sewage effluent, stormwater, and agricultural runoff. Fisheries received considerable agency attention since commercial and recreational values approached \$83 million in 1984 (Yingling 1987). There is a need to investigate, monitor, and manage the

biological diversity of the Indian River Lagoon rather than just focusing on contaminated sites (DeFreese 1991).

Many waterbirds that use KSC also use marshes of the upper St. Johns River, although little information was available to quantify the significance of the areas to one another (Clark and Lee 1982, D. Cooley pers. comm.). Nearly 80% of the St. Johns Basin has been converted to agriculture, silviculture, pasture, or housing (Lowe et al. 1984). Waterfowl (FGFWFC 1981) and presumably wading birds (Lowe et al. 1984) have declined to nearly 25% of their original numbers. Impoundments along the Indian River probably support many of the wading birds that once used the St. Johns marshes (Kale 1988). Some of the St. Johns basin was recently restored and additional restoration is planned (SJRWMD 1991).

#### 4.0 THE DISRUPTION OF NATURAL PROCESSES AND THREATS TO BIOLOGICAL DIVERSITY

Species are dependent on management in an unprecedented fashion, constituting a huge responsibility for decision makers because their decisions effect species survival. The rationale for biological conservation is to provide opportunity for a globally diverse assemblage of wildlife which would not be possible without management (Frankel and Soule 1981, Soule 1989, Vrijenhoek 1989, Woodruff 1989, Shaffer 1981). This does not suggest that sufficient knowledge exists to manage most populations in a human altered landscape, but that management is an inevitable necessity. Most of KSC has potential to provide habitat for an abundant and diverse assemblage of wildlife. Section 4.0 justifies the need for management, disputing the notion that nature should be left alone to take care of itself. Even large public lands such as the Greater Yellowstone Ecosystem no longer function naturally (Craighead 1979, Chase 1987, Christensen et al. 1989, Anderson 1991, Berger 1991,



Mattson and Reid et al. 1991).

Management decisions affecting wildlife on KSC are made by several government agencies and include traditional habitat management directed towards wildlife, ongoing operational activities, or the siting and construction of new facilities. Whenever possible, emulating and providing opportunity for natural processes should be provided where possible; such objectives are beyond the scope of this document. Topics in this section are divided into three subsections concerning environmental impacts, habitat management, and extrinsic factors.

#### 4.1 ENVIRONMENTAL IMPACTS

##### 4.1.1 Habitat Loss

The majority of habitat loss occurred before the 1970s when most KSC and CCAFS facilities were established. A moderate loss of habitat occurred during construction of the space shuttle landing facility in the 1970s. Most other facilities used to support the space shuttle program were modified from the Apollo program. Thus, most areas were developed prior to the institution of environmental regulations. Most new construction occurs in uplands, particularly scrub and pine flatwoods, due to strong wetlands and floodplains protection. Development in existing citrus groves is likely to be minimal given past leasing agreements and the strong political influence of the citrus industry. Environmental regulation of uplands is mostly influenced by stormwater discharges or the occurrence of federally listed species. Previous land development on KSC was influenced primarily by the presence of Bald Eagle nests. Subsequent listing of the Florida Scrub Jay as threatened mandated a new era of development on KSC. Nearly all native habitat on KSC is inhabited by federally listed species, or is subject to wetland and floodplain regulations.

Habitats are heterogeneous and vary spatially with respect to vegetation, water table, soils, habitat structure, and importance to wildlife. Long term environmental monitoring objectives aim at identifying habitat characteristics necessary for maintaining populations. New facility construction is anticipated. A worst case scenario for the next three years is that new facilities could result in a loss of 90 ha of scrub and pine flatwoods, which is nearly 1% of the total acreage of these habitats on KSC. A scrub/pine flatwoods restoration and creation program, in collaboration with MINWR, has been implemented to compensate for effects of projected facility construction.

#### 4.1.2 Ecosystem fragmentation, road mortality, boundary effects, and corridors.

Large populations must be maintained to avoid inbreeding, survive epidemics and catastrophies and have sufficient genetic information and opportunity to adapt and evolve (Frankel and Soule 1981). Concepts of conservation biology are used below to identify specific threats to biological diversity; however, the significance of these threats is still poorly understood on KSC. These are as relevant to environmental assessment and monitoring as traditional environmental concerns relating to habitat loss and environmental contamination.

#### Habitat Fragmentation

Species often live within patches of habitat surrounded by less suitable habitat where the species is rare or absent (Stamps et al. 1987). Movement between patches is influenced by characteristics of their surroundings. Some areas represent an impenetrable boundary which dispersing individuals never cross; other barriers have different degrees of permeability (Stamps et al. 1987). The degree of isolation is a continuum that is species specific and related to the biology of a species and the

environmental conditions (Harris 1989). Obvious barriers for many species include large water bodies or urban areas (Harris 1984). Other barriers are behavioral when they are comprised of habitat that species will not enter (Yahner 1983). Where a population is partially isolated, it is interconnected by patterns of gene flow, extinction, and colonization and is said to be a metapopulation, or a population made up of subpopulations (Lande and Barrowclough 1988). Some habitat patches cannot support isolated, self-sustaining local populations and are doomed to local extinctions without persistent immigration because they are too small or they are of marginal quality (Thompson and Nolan 1973, King and Mewaldt 1987). Reproductive rates in some patches ("sources") exceed mortality rates, providing a source of new individuals to a metapopulation (Boorman and Levitt 1973, Buechner 1987, Wiens and Rotenberry 1981, Pulliam 1988, Pulliam and Danielson 1991, Howe et al. 1991). The term "rescue effect" has been coined (Brown and Kodric-Brown 1977) to describe the influence of self-sustaining populations on non-sustaining (sink) populations.

Several features fragment ecosystems. The lagoon and ocean waters surrounding most of KSC obviously impede movements for some species. Haulover Canal, which provides for the passage of boats between the Mosquito Lagoon and Indian River, is an estuarine connection that was not a feature in the recent historical landscape. It may be an impermeable barrier for some terrestrial species and a corridor for some aquatic species. Human growth on the Florida east coast is rapidly isolating populations (Larson 1992). The areas comprising KSC, CCAFS, Turnbull Hammock, and the St. John's River Basin are patches of "natural communities" in a surrounding landscape that is becoming increasingly urbanized. The outer barrier island north of the CNS becomes increasingly urbanized until Daytona Beach is reached, forming a barrier for movement of many plants and animals. Large areas of north Merritt Island were converted into citrus groves. The connection between KSC and the Florida mainland was historically an open landscape of mostly scrub and pine

flatwoods. It is becoming increasingly forested with pines and hardwoods due to the disruption of natural fire patterns and the planting of pines and hardwoods. The southern end of Cape Canaveral is urban, as is most of central Merritt Island. The mainland is increasingly becoming urban in Brevard and Volusia Counties although a stretch of low intensity agriculture and relatively undeveloped land still occurs between the St. Johns River and the Merritt Island/Cape Canaveral/Turnbull Ecosystem. This area, however, is segmented by roads and two large highways (I-95 and U.S. 1). The connection between KSC and CCAFS is largely intact, although roads, launch pads, and the lack of fire threaten the function of this corridor.

Fragmentation is not only isolating the Merritt Island/Cape Canaveral/Turnbull Ecosystem from the Florida mainland but is also isolating populations within the ecosystem. Fine scales of fragmentation impact habitats and many organisms (Lord and Norton 1990). Fragmentation can be more degrading to wildlife than the original loss of habitat (Harris and Gallagher 1989). Fragmentation disrupts ecological relationships (Gilbert 1980, Terborgh and Winter 1980) and leads to additional or "secondary extinctions". Inbreeding reduces species vigor, fecundity, and the ability to adapt to changing conditions (Frankel and Soule 1980, Harris 1984). As fragmentation increases, patches become isolated and inhabited by only samples of the native fauna. This process is referred to as insularization (Wilcox 1980). Some insularization has already occurred at KSC due to the development of roads, canals, facilities, citrus groves, and alteration of habitat structure.

#### Road Impacts

Heavily traveled roads have an isolating effect on some small mammal, snake, turtle, frog, and other small vertebrate populations (Frankel and Soule 1980, Oxley et al. 1974, Mader 1984). Cursorial (non-flying) animals are less likely to disperse

across such inhospitable terrain (Frankel and Soule 1980). Traffic can kill 50-100% of the amphibians that attempt to cross roads (Reh and Seitz 1990). Populations fragmented by roads sometimes have altered genetic composition (Reh and Seitz 1990). Some species are attracted to roadsides and other edges that can become "ecological traps" (Dickerson 1939, McClure 1951, Gates and Gysel 1978, Fitzpatrick et al. 1991, Dreschel et al. 1991). Mortality rates can exceed reproductive rates along roads so that roadside populations are supported by immigration (Fitzpatrick et al. 1991). The width of the roadside sink may be influenced by homerange size. Given the large homerange of an Indigo Snake and the attraction to disturbed sites (Kehl et al. 1991), much of the population may succumb to road mortality. Road mortality on KSC has been a concern for other snakes, Florida Scrub Jays, Bobcats, and River Otters (Ehrhart 1976, Seigel 1977, Dreschel et al. 1991).

Road mortality can contribute to local extinction of large predators and other species with low population size on KSC. Four dead Bobcats were found in separate locations along KSC roads on 06 November 1991; several other Bobcats were found within a month of this event. Many dead and injured snakes have been found on roads including Eastern Indigo Snakes, Eastern Diamondback Rattlesnakes, and Eastern Coachwhips. Relating mortality to impacts on snake populations is difficult given problems in censusing reptilian populations (Dodd et al. 1989). Endangered and potentially endangered birds documented as road kills include the Bald Eagle, Eastern American Kestrel, Wood Stork, Snowy Egret, White Ibis, Brown Pelican, and Cooper's Hawk.

Measures can reduce road mortality (Harris and Gallagher 1989). River Otters often follow watercourses and move across land using short cuts to other watercourses (Melquist and Hornocker 1983, Mason and Macdonald 1986). Dead otters can be frequently be found at the same location on roads over time (Channin and Jefferies 1978). Culverts and underpasses can provide corridors for movement in

areas having high road mortality. Dead River Otters on KSC are periodically found along NASA Causeway between the KSC Industrial Area and the Banana River, and along Playalinda Beach road.

#### Other Boundary Effects

Fragments have less suitable habitat to sustain populations than should be provided by their size due to edge effects (Laurance and Yensen 1991). Populations within fragments are influenced by size, shape, and position of areas in the landscape (Saunders et al. 1991). Core areas within habitat fragments maintain some populations (Wilcove et al. 1986, Temple 1986). Edges are frequented by predators such as Blue Jays (Cyanocitta cristata), Raccoons (Procyon lotor), Gray Squirrels (Sciurus carolinensis), Common Grackles (Quiscalus quiscula), Boat-tailed Grackles (Q. major), and Fish Crows (Corvus ossifragus) (Wilcove et al. 1986). Competitors, such as European Starlings which compete with cavity nesting birds, are also abundant along edges and have negative effects on native fauna (Whitcomb et al. 1976).

Natural landscapes allowed fires to burn through large regions, but fragmentation minimizes such occurrences. Alteration of fire patterns and the associated habitat structure effects, also represent serious edge effects. Some fragments, particularly those adjacent to facilities, have remained unburned for long periods. Nearly 10% of the scrub and pine flatwoods is located in habitat fragments outside MINWR fire management units (FMUs) (Breininger et al. 1991). Fires often do not burn through fragments within FMUs and within disturbed areas (Breininger and Schmalzer 1990). These areas enhance habitat for nest predators and competitors and interfere with the ability of Florida Scrub Jays to spot avian predators in a landscape that is naturally open (Woolfenden and Fitzpatrick 1984, McGowan and

Woolfenden 1989).

Increasing amounts of edge could enhance Cowbird population expansion (Cruz et al. 1989) and represent a future threat to faunal integrity. Cowbirds are nest parasites that lay their eggs in the nests of other species which expend resources raising cowbird chicks and not their own. The Brown-headed Cowbird, Shiny Cowbird (*Molothrus bonariensis*), and Bronzed Cowbird (*M. aeneus*) are expanding their range and may soon become established on KSC (Hoffman and Woolfenden 1986, Kale and Maehr 1990). The effects may vary according to which cowbird species become established. Cowbirds have significantly impacted bird populations elsewhere (Payne 1973, Clark and Robertson 1981, Hanka 1984, Folkers and Lowther 1985). There is a large population of possible hosts on KSC offering potential for establishment of cowbird populations. Large populations of cowbirds could impact several priority species that are less common. The Florida Prairie Warbler and Black-wiskered Vireo are at particular risk (Hoffman and Woolfenden 1986).

Abiotic edge effects also occur causing relevant changes in microclimate (Harris 1984, Saunders et al. 1991). Frost sensitive plants are vulnerable along the edges of hammocks. Noise associated with construction and operations is greater along edges and influences mating, predator detection, and prey location (Brown et al. 1990). High noise levels are associated with road traffic, aircraft at the shuttle landing facility, construction projects, sandblasting, and a variety of other causes (Edward E. Clark Engineers-Scientists, Inc. 1986). Tall buildings, towers, and smokestacks cause bird mortality during migration (Crawford 1980, Maehr et al. 1983, Taylor et al. 1983, Crawford and Stevenson 1984, Taylor and Kershner 1986). Electrocution of raptors was a national conservation issue in the 1970s (Yoakum et al. 1980). Power lines and ground wires cause avian mortality either because birds fly into them or are electrocuted (Crivelli et al. 1988). Mortality is often represented by isolated events of little significance; however, mortality rates may be more severe depending on location

and the configuration of the powerlines (Faanes 1987). Mitigative methods include minimizing structures in certain habitats and enhancing the visibility of powerlines and/or ground wires (Faanes 1987, Morkill and Anderson 1991).

### Corridors

Local extinctions occur frequently in small isolated populations (Whitcomb et al. 1976, Fritz 1979). Natural landscapes are becoming less interconnected so that corridor planning is now needed to link biota on coarse and fine landscape scales (Noss 1983, 1987; Soule et al. 1988; Adams and Dove 1989). Corridors can provide safe passage of wildlife between larger blocks of habitat. Narrow "token" strips provide food and cover requirements only for weedy species and can become ecological traps due to edge effects (Gates and Gysel 1978, Wilcove et al. 1986). Research is needed to better define optimal linkage strategies (Noss 1987, Brown et al. 1990a, b). Large scale integration of subpopulations comprising the Merritt Island/Cape Canaveral/Turnbull Ecosystem, Indian River Lagoon, and St. Johns River basin is needed. The Environmentally Endangered Land Selection Committee in Brevard County has proposed acquisition of a corridor to the St. Johns River (Swain et al. 1993).

Linkages between landscape fragments on KSC are also important to maintain. Many wildlife species use more than one habitat type to obtain their requirements. Many amphibians and reptiles use different habitats for breeding, feeding, and cover requirements (Speake et al. 1978, Weller 1978, Moler and Franz 1987). Small mammals that occupy seasonally flooded wetlands often move back and forth across upland and wetland habitats (Smith and Vrieze 1979). Corridors to connect significant wetlands need to be >200m wide (Brown et al. 1990). Forested corridors should be at least 100 m wide (Kautz 1984). The width of an average Florida Scrub Jay territory



(300 m) should be the minimum corridor width in scrub and pine flatwoods. Corridor development must consider the road mortality issue to function properly.

#### 4.1.3 Ditches and the Alteration of Drainage Patterns

Many wetlands on KSC have been altered by ditches; most roads are bordered by ditches which lower the water table within a few hundred meters of the ditch (Edward E. Clark Engineers-Scientists, Inc. 1987 a,b,c). Some ditches drain or dump water into ephemeral wetlands and connect ephemeral wetlands to permanent waters (Moler and Franz 1987, Laney 1988, Pechmann et al. 1989). Permanent water within ephemeral wetlands provides access and refugia for fish and large frogs that prey upon and compete with the young of amphibians that require ephemeral wetlands. Steep ditch banks decrease landscape connectivity for some amphibians (Laan and Verboom 1990). Some ditches may be beneficial by connecting habitat fragments and providing corridors under roads (Reh and Seitz 1990). Canals and ditches provide habitat for waterbirds (Smith and Breininger in preparation) and herpetofauna such as Indigo Snakes (Kehl et al. 1991).

Ditches are occasionally dredged and receive frequent herbicide application to keep them free of vegetation, thereby increasing stormwater runoff. Stormwater impacts to the Indian River system include eutrophication due to nutrient loadings, "muck" deposition associated with upland erosion, and the buildup of toxins and pathogens in the biota (Steward and Van Arman 1987). Some conclusions concerning runoff may be largely anecdotal due to failure to document cause and effect relationships (Bennett et al. 1991). No recent studies have investigated whether significant damage to the estuary has occurred from stormwater discharges on KSC or whether ditches provide significant habitat for some estuarine organisms. Elsewhere, sewage treatment plants, marinas, and fresh water creeks discharge large amounts of

contaminants into the estuary.

Because waters from some ditches run directly into the estuary, toxins can be carried to another ecosystem. Herbicide spraying elsewhere has been associated with a decline in habitat use by Manatees (Tiedemann 1983). Mechanical clearing of vegetation from ditches may cause direct wildlife mortality, removal of food and cover, increased silt, and decreased water quality. Regulatory statutes are resulting in the construction of structures to retain stormwater runoff and presumably minimize impacts to the estuary; however, these may increase groundwater tables, thereby impacting other habitats. Research is needed to design and maintain ditches and canals that provide proper drainage but also provide good wildlife habitat and benefit the estuarine biota. (Note that impoundment of salt marshes is discussed below).

#### 4.1.4 Environmental Contaminants

Historically, many habitats were affected by contamination; currently contamination is local in distribution. Identifying sources of bioaccumulation in animals is confounded by their movements and a poor understanding of fates and effects of contaminants in the natural environment.

##### Pesticides

Pesticide bioaccumulation may once have significantly impacted sensitive wildlife populations on KSC. Large amounts of DDT and other pesticides were used to control mosquito populations. Use declined after impoundment of salt marshes and the ban of DDT and related pesticides. Howell (1937, 1941, 1949, 1954, 1958, 1962, 1968, 1973) documented a substantial decline in breeding site occupancy of Southern Bald Eagles on KSC and its surroundings. He noted that much of the decline resulted from habitat loss and harassment. Continued population declines on KSC after 1950

paralleled declines associated with reduced productivity caused by DDT and DDE contamination (Broley 1947, 1958; Hardesty and Collopy 1991). Recovery of the population is now partially hampered by a low population size (Hardesty and Collopy 1991).

Minor pesticide contamination was found in Brown Pelicans from KSC in the 1970s. Studies in the 1970s suggested that Brown Pelicans were not under the stress from pollutants such as DDT and its metabolites, dieldrin, and polychlorinated biphenyls, that affected species in California (Thompson et al. 1977, Nesbitt et. al. 1981). Wading birds were sampled on KSC in 1977 to investigate pesticide contamination (Lee 1977). Pesticide levels were not alarmingly high although DDE, DDT, dieldrin, mirex, oxychlorane, cis-nonachlor, and PCB as arcolor 1254 were detected. Some fish samples had contamination by DDD, DDE, and PCB (Lee 1977). Fish samples were collected from the stomachs of wading birds and from Mullet (Mugil cephalus) and Spotted Weakfish ("Sea Trout") (Cynoscion nebulosus). The highest pesticide contamination was associated with the fish sample taken from the Indian River in an area (source undescribed) not believed to be subject to contamination from KSC. Pesticide levels in birds were reported as similar to results using eggs shells collected on KSC in 1973 (Ohlendorf et al. 1974). Within the Indian River system traces of DDT, DDE and other pesticides have been found in hard clams and oysters, but amounts were below FDA standards (Bates 1977, Muse 1977). Later, concentrations of organochlorine were low or undetectable in Manatees using the Indian River (O' Shea et al. 1984).

Documentation of recent pesticide use is provided elsewhere (NASA 1979, Clark Engineers and Scientists, Inc. 1986). Citrus groves are the management responsibility of MINWR where records are kept concerning the pesticide use. The BCMCD uses larvacides and adulticides to control mosquitos. Spraying of malathion is performed around NASA and USAF facilities to reduce mosquitos. Pigeon

(Columba livia) control poisons (i.e., Rid-a-bird 1100 Perch solution, 11% Fenthon-oil) are used in hangars on CCAFS. Because it takes a few days for birds to die from these poisons, workers occasionally report sick, moribund, or dead birds in hangars and adjacent areas. For example, a poisoned Great Horned Owl was recently found. Poisoned animals are easy prey for predators.

### Lead

The ingestion of lead shot caused the death of thousands of waterfowl in North America over several decades (Bellrose 1951, Eisler 1988). Bald Eagle mortality, due to swallowing lead shot embedded in prey, was frequent in Florida (Eisler 1988). Mortality has often been reported for coots and rails and occasionally for shorebirds, gulls, hawks, quail, and rarely for owls. Lead shot concern is a concern due to direct ingestion because wetland plants do not accumulate high levels of lead (Behan et al. 1979). One of the most popular waterfowl hunting areas in the southeastern U.S. occurs north of the security zone on KSC (mostly north of Route 402). Lead shot has been banned on MINWR since 1976, however, large levels have accumulated in impoundments (Hardesty and Collopy 1991). Changes in water management practices (e.g., water level drawdown) can periodically expose animals to lead and result in mortality (Anderson 1975).

Lead from motor vehicles is a contaminant along roadsides but its significance to wildlife is influenced by the traffic volume and distance from the roadside (Scanlon 1979). Several studies failed to find toxic levels in wildlife (Grue et al. 1984, 1986) along roadsides. Rarely, high lead concentrations temporarily show up in surface water quality samples on KSC (C. Hall pers. comm.). Lead solubility and bioavailability are greater at low pH, low organic content, low concentrations of suspended sediments, and low concentrations of several salts (Eisler 1988) so it is not

very available in coastal waters at KSC. However, lead can be mobilized in the sediments (Eisler 1988). Environmental burdens will probably decline because legislation limits lead content in paints, gasoline, and the use of lead shot nationwide.

### Air Quality

Air quality monitoring since 1977 has shown that air quality is relatively good except for ozone (Drese 1992). Most toxic air discharges are minor and are associated with scattered facilities (Edward E. Clark Engineers-Scientists, Inc. 1986). Much expense is undertaken to reduce toxic emissions. The proximity to the coast, air masses from the Florida mainland and northern states, and locally generated air emissions result in occasionally high ozone levels (Drese 1987). Sulphur and nitrogen dioxide are frequently detected from plumes generated by Florida Power and Light and Orlando Utilities power plants (Drese 1987). Levels of nitrogen oxides increase during rush hour traffic and on launch days when several thousand visitors enter KSC to view launches (J. Drese unpublished data). Locally high levels of carbon monoxide, nitrogen oxides, and ozone occur from prescribed burns and wildfires on KSC and the Florida mainland (Coffer et al. 1990, Drese in preparation). (The short term and small spatial area effects of launches are discussed below).

### Water Quality

Long term ground and surface water quality monitoring is performed on KSC (Edward E. Clark Engineers-Scientists, Inc. 1986, EG&G 1991) and adjacent estuarine waters (Windsor and Steward 1987). The upper Indian and Banana Rivers, and Mosquito Lagoon have been regarded as the cleanest, healthiest, and most productive waters in the Indian River (Windsor and Steward 1987). Banana Creek once connected the Banana River and Indian River, but this connection has been

blocked by Shuttle crawlerways between launch pads and the assembly areas (e.g., VAB). Circulation in Banana Creek is poor and fish kills occasionally occur during low oxygen and high temperature periods on cloudy days after heavy rains. Banana Creek once had anoxic bottom water and sediment attributed to a sewage discharge that has since long been eliminated (Daggett 1973). All direct discharges from KSC to the estuary, except stormwater, have been eliminated. Water quality regulatory standards are rigorous since surface waters on KSC are classified by the Florida Department of Environmental Regulation as Outstanding Florida Waters. Groundwater standards are rigorous even though very little of the water is suitable for human consumption due to the coastal influence (Edward E. Clark Engineers-Scientists, Inc. 1987 a,b,c). Stormwater quality on KSC is comparable to data in other urban areas (Jones 1986, Bennett 1989, Ryan and Goetzfried 1988).

Heavy metals in KSC estuarine waters are believed to be at natural background levels (Tower 1975). Sporadic violations of water quality standards have been detected within the estuary, groundwater, ditches, or other inland waters. Most exceedences are from natural constituents of coastal waters or products of natural decomposition. Violations are investigated using repeated sampling to determine the source. Occasionally pH, total dissolved solids, sulphates, chlorides, fecal coliform, PCB's, mercury, lead, copper, tin, zinc, iron, aluminum, cadmium, chromium, and mercury exceed regulatory standards. Only silver and phenols are often above state standards (C. Hall, pers. comm.). Silver levels are not found in toxic concentrations and are similar to levels found in treated and untreated drinking water across the U.S. (Fowler and Nordberg 1979). Opportunities for silver bioaccumulation are low because once absorbed, silver is tightly bound over a wide range of pH and enzymatic conditions and is likely to be excreted (Connell et al. 1991). The phenols are those resulting from natural decomposition.

Treated sewage effluent is discharged to land at one site and a wetland at

another site on KSC. Studies of terrestrial wildlife have not found heavy metal accumulation at toxic levels within areas subject to sewage sludge or effluent; some studies have found increased quality or quantity of food production (e.g., Anthony and Kozlowski 1982; Anderson 1983, 1985). Sewage effluent discharge occurs in "Molly Pond" which is a small impoundment (T-37-B) north of the Vehicle Assembly Building (VAB). Marsh ecosystems on KSC have considerable ability to assimilate heavy metals so that they are of little threat to fish and wildlife (Mion et al. 1986, 1989). There are, however, other potential detrimental effects to wetland disposal. Treated ponds can serve as population sinks for amphibians (Harris 1984) and can become sources for diseases and parasites (see below). Vegetation changes have occurred in impoundment T-37-B ("Molly Pond") since it has received treated sewage effluent. Open water frequently used by wading birds, was replaced by water hyacinth (Eichhornia crasipes) and cattails (Typha spp.) which also replaced native salt marsh vegetation. This impoundment is now rarely used by wading birds.

Wildlife species that are mobile can acquire heavy metal and pesticide burdens on and off KSC property. Estuarine waters near Titusville and Cocoa have been contaminated due to wastewater discharge and urban runoff (Hand et al. 1986, Holm and Windsor 1986). Nearby Sykes Creek has been the subject of environmental concern and controversy because of fish kills, algal blooms, and foul odors that resulted from rapid urban growth, sewage discharge, and septic systems (Grizzle 1979, Windsor and Steward 1987). Elevated levels of anthracene, phenanthrene, flouranthene, pyrene, chrysene, beza(a)pyrene, copper, mercury, lead, zinc, cadmium, and iron have been found in sediments and hard clams (Mercenaria mercenaria) at Port Canaveral (Trefry et al. 1983, Steward et al. 1980, Pogban 1984, Pogban and Windsor 1984, Kouadio 1984). In 1980, approximately 100 large red drum died in north Indian River and Mosquito Lagoon (Cardeihac et al. 1981). Based on stomach content it was reported that copper, zinc, and arsenic were responsible for their death.

The food source for contamination has not been adequately resolved (Windsor and Steward 1987).

Recently, some mercury contamination has been found in fish taken from KSC (D. Whitmore, pers. comm.) and additional sampling will be performed (R. Hight, pers. comm.). Mercury has become a significant concern in Florida where it has been detected in many wildlife and fish. At least some of the increase in Mercury results from the alteration of hydrology (e.g., drainage) resulting in the oxidation of thousands of years of peat accumulation. Mercury has globally increased several times its natural level due to human activities and is very toxic to most wildlife (Eisler 1987). Sources of mercury on KSC include atmospheric and marine transport, antifouling paints, agricultural chemicals, incinerators, and other forms of waste disposal involving electrical equipment and lighting. Many sublethal effects (e.g, reproductive impairment) are possible at low concentrations (Eisler 1987, Scheuhammer 1991). Predatory species associated with aquatic food chains, especially fish eaters (e.g., Bald Eagles, Ospreys, and River Otters) accumulate more mercury than those associated with terrestrial food chains (Scheuhammer 1991).

Extensive groundwater studies on KSC revealed that background water quality in many areas is influenced by seawater intrusion and the decay of vegetative matter (Edward E. Clark Engineers-Scientists, Inc. 1985, 1987a,b,c.). Natural decay produces organic compounds such as benzene, chloroform, and toluene in concentrations as high as 300 ug/l (Cleary 1985). Groundwater from the KSC surficial aquifer has a dark color from natural decay processes although there are areas that are of good quality.

Groundwater contamination easily occurs given the low elevation and sandy substrate; nearly all the uplands are within a few feet of the water table. To comply with hazardous waste and other environmental regulations, approximately 51 sites have been investigated for contamination because of past or ongoing operations



(NASA 1992). Nine sites have concerns involving fuel oil leaks or spills. Other sites with contaminants have solvents, acids, and metals. Volatile organic compounds occur at Wilson's Corner which was used to clean and degrease parts in the 1960s. Trichloroethylene (TCE) and its natural breakdown products vinyl chloride (VC) and trans 1,2 dichloroethylene (TCDED), contaminated three ha. Concentrations are not believed to be harmful to wildlife (NASA 1991a). A treatment and monitoring system at the site is used to achieve state drinking water standards (NASA 1991b).

The Ransom Road landfill is an old landfill (6 ha) in an area of poor ambient groundwater quality contaminated with metals and solvents that represent a violation of state standards but not necessarily a hazard to wildlife. The leachate plume of the Schwartz Road landfill has low toxicity and occupies a 24 ha site. The Flight Crew Rescue and Training Area is contaminated with low levels of TCE and other solvents and probably will require corrective action (NASA 1992). Contaminants (1,1-dichloroethene, trichloroethene, chromium, cadmium, and copper) were found in two ditches near the Converter Compressor Facility where further study and corrective actions are likely. Chromium has been discharged to an isolated wetlands near the Printed Circuit Board Shop where further study and corrective action is being evaluated. Several sandblasting sites have elevated levels of chromium, cadmium, lead, iron, manganese, and sodium and will be further investigated for possible corrective action (NASA 1992). Another 76 oil/water separators exist on KSC and are being investigated to determine whether any release of hydrocarbons occurred (NASA 1992).

Some hydrocarbon spills have occurred including a small spill in Banana Creek caused by an outside construction contractor. This resulted in little apparent damage and no oiled animals were found. In general, most biota recovers in an area that has been subject to a spill if the area is not re-oiled within months or years (Olsen et al. 1982). The initial exposure to a spill is usually the most devastating (Olsen et al.

1982). Earlier space operations resulted in small spills of hydrazine fuel which have high toxicity even in low concentrations (Kane and Williamson 1983). Most of these compounds are very reactive and have low residency once released. Unsymmetrical dimethyl hydrazine is of the most concern due to its breakdown into monomethyl amine. Most other fuels breakdown rapidly into non-toxic components. Extreme measures to prevent releases are undertaken due to the immediate severe threat to human lives.

Dredging is a maintenance operation that temporarily degrades water quality and requires the disposal of dredged material. Water birds are attracted to disposal sites and can concentrate contaminants that accumulate in sediments (White and Cromartie 1985). The availability of sediments to the biota is poorly understood (Olsen et al. 1982).

#### Trash and Litter

Much trash generated elsewhere washes onto KSC and CCAFS beaches and accumulates. Annual beach clean-ups by volunteers show that activities at Port Canaveral and boats using the Port are the primary source of trash, especially plastics (R. Parkinson, pers. comm.). Insidious impacts of debris, especially plastics, have profound effects on birds and marine turtles. Marine birds, especially members of the order Procellariiformes, are impacted due to ingestion and the inability to regurgitate ingested plastics, which result in many physiological impacts (Azzarello and Vleet 1987). Brevard County has had the highest rates of entanglement of Manatees in crab traps (Beeler et al. 1988). Fishing gear entanglement of Manatees may also be high in Brevard (Shane 1983) as is entanglement of waterbirds.

## Parasites and Disease

Domesticated animals are sources of new diseases to native wildlife. Feral Hogs (*Sus scrofa*) and House Cats (*Felis domesticus*) are reservoirs for diseases. Elsewhere nutrient enrichment (e.g., sewage effluent) has been associated with a parasitic nematode that has deleterious impacts on wading bird colonies. No surveys on KSC have yet been conducted for this parasite. Although many adult birds can withstand some parasitic burdens, heavy infestation often occurs in nestlings and can greatly impact reproductive success of a colony (Spalding 1991). Concentrations of birds in impoundments could result in a higher incidence of disease. Avian botulism has been documented in phosphate settling ponds in Florida at least twice (Forrester et al. 1980, Marion et al. 1983). This disease and others associated with aggregations of waterbirds can kill large numbers, but the incidence of such diseases (except nematode parasitism) in Florida is low (Friend 1987).

## Launch

Launches and associated operations on KSC and CCAFS are hazardous, thereby justifying the purchase of a large buffer area to protect the public from accidents. More than ten years of launches have resulted in impacts to few areas (Schmalzer et al. 1993). The largest space vehicles used today on KSC and CCAFS are Space Shuttles and Titan IV rockets. Two solid rocket engines and three shuttle main engines are used to launch a Space Shuttle (NASA 1979). Main engines use liquid propellants that leave relatively clean exhaust products. Nearly all controversy attributed to environmental effects is associated with the use of solids; much of this relates to minor and temporary changes to the ozone layer and the effects of the aluminum propellants (NASA 1989). Each solid rocket booster contains 498,950 kg of propellant that produces 2,650,000 pounds of thrust at sea level. The propellant is

16% aluminum powder fuel and 69.6% ammonium perchlorate. A sound suppression system includes a 1,135,550 liter tank that dumps a large quantity of water during launch to protect the orbiter and payloads. Nine seconds before launch the main engines are ignited and their exhaust is directed to the south by flame trenches. The solid rocket motors are ignited at launch time and their exhaust is directed to the north by another flame trench at a velocity of nearly 85 meters per second. A large ground cloud forms in the first 10-12 seconds, and rises and moves away from the launch site depending on prevailing winds. Concentrations and deposition of the cloud are predicted by a Rocket Exhaust Diffusion Model. Nearfield areas surround the pads and extend several hundred meters north of the flame trench. Farfield areas occasionally receive launch deposition depending on atmospheric conditions and include most of KSC. Nearfield deposition of fine particulates results from depositional settling forces (Dreschel and Hall 1985, 1990). Aerosol measurements suggest that the ground cloud is of little concern once it has moved away from the launch area (Pellet et al. 1983, Sebacher et al. 1984). The most environmental damage on KSC from launches is from hydrochloric acid (HCl) deposition. Nearly 3,400 kg of HCl are deposited in nearfield areas, depending on humidity, temperature, and wind (Dreschel and Hinkle 1984). Heavy deposition areas include a 65 ha area north of 39A and 53 ha area north of 39B (Duncan and Schmalzer in press). Nearfield deposition results in temporary lowering of pH and depletion of bicarbonate buffering capacity in shallow water. Small fish kills often occur in shallow water immediately north of the pads due to gill damage associated with a rapid decrease in pH (Knott et al. 1982, Milligan and Hubbard 1982, Hawkins et al. 1984). These are temporary and are not a long term threat due to the buffering capability of the system. Fish species encountered in surveys of fish kills are small (e.g., Poecilia latipinna, Gambusia affinis, and Cyprinodon variegatus). Occasionally, a few dead or injured amphibians, reptiles, birds, or mammals are found in front of the flame trench after launches. Video tapes

show that most birds take flight when the main engines start and that some are overtaken by the exhaust from both the main engines and solid rocket motors. Shuttle exhaust emissions have some potential to affect insects (Heck et al. 1980) and avian embryos by accelerated moisture loss from the egg (Stout et al. 1976); however, sufficient concentrations required to cause damage seldom occur except temporarily in nearfield areas.

HCl deposition causes acute vegetation and soils damage in nearfield areas, a loss of sensitive species, and an increase in weedy species (Schmalzer et al. 1985, 1993). Damaged areas include disturbed mesic shrubs and salt marsh. Damage outside of this area depends on climate but is minor except for moderate damage that occasionally occurs along a narrow band (e.g., 100 m) for  $\leq 1.2$  km from the pad (Schmalzer et al. 1985, 1986). Although moderate damage occasionally occurs to a narrow band of coastal strand and dune, no community changes have occurred. A total of 18,148 ha of KSC has received deposition from shuttle launches; 68% of this has received deposition only once; 92% of the area has received deposition less than three times in ten years (Duncan and Schmalzer in press). Typical results of deposition in these areas include a sparse spotting on leaves of aluminum oxide with rare acid spotting. Even moderate damage from three launches have not produced long term changes in vegetation composition.

Nearly 7300 kg of particulates, mostly aluminum oxide, are deposited in the nearfield areas after launch (Dreschel and Hall 1990). Some zinc and iron are also found as well as trace amounts of cadmium, lead, chromium, copper, manganese, and nickel (Drese in preparation). Leachate from microcosms in the nearfield area at 39A showed significant increases in aluminum, copper, iron, and zinc (Hinkle et al. 1986). Concentrations of zinc and aluminum were elevated in sediments near pad 39A in 1986; elevated levels of aluminum were also found in fish in nearfield areas (Rydene 1987).

Aluminum oxide is the most abundant shuttle exhaust product. It is a naturally abundant element at KSC in soils (Schmalzer and Hinkle 1987, 1991), groundwaters (Edward E. Clark Engineers-Scientists, Inc. 1985, 1987a, b, c), and surface waters (C. Hall unpublished data). Humans and wildlife are exposed to large amounts of aluminum, because it is a major constituent of many soils, it is common in ground and surface water, and is used in antiperspirants, laxatives, and antacids. Gastrointestinal absorption of all forms of dietary aluminum is low and excretion is efficient without loss of kidney dysfunction (Scheuhammer 1991). Aluminum can disrupt the absorption and metabolism of calcium and phosphorous (Scheuhammer 1987). Aluminum was claimed to be a cause of impaired breeding in birds in Europe (Nyholm and Myhrberg 1977, Nyholm 1981). Other studies failed to demonstrate similar results attributed to aluminum (Carriere et al. 1986, Ormerod et al. 1988). Low calcium availability in the environment was suspected to be the cause for the results observed by Nyholm and Myrberg (Scheuhammer 1991). Aluminum was found in patients with Alzheimer's disease, but it is believed to be an effect of the disease and not an indication of environmental toxicity (Pearl and Brody 1980, Wegman 1981, Shore and Wyatt 1983). In humans, pulmonary fibrosis was an occupational disease caused by aluminum exposure in bauxite miners and abrasive compound workers before precautionary measures minimized exposure. Aluminum is one of the least soluble elements, being soluble at pH values less than 3.5. It is a soluble ion in organic acids which form organo complexes. However, transport is short due to the abundance of anions (Huang and Keller 1972). Bacteria, algae, and fungi accumulate aluminum; however, effects on growth are minimal at low concentrations, although nitrogen fixation can be effected (Petterson et al. 1985, Petterson et al. 1986, and Folsom et al. 1986, Roth et al. 1987). Elevated levels of Aluminum have been associated with waterfowl tissue and food items in phosphate-mine wetlands but no evidence of unhealthy populations were observed (O'Meara et al. 1987).

Bioaccumulation of aluminum through vegetation is unlikely due to the natural pH and buffering capacity of soils, ground waters, and surface waters. Low pH values are found in a small area for only a few hours after launch. Given the high levels within the vegetation in the nearfield areas, ingestion and inhalation of aluminum is possible. Because the flesh of fish, birds, and mammals maintains low aluminum concentrations, piscivorous wildlife and top predators should not bioaccumulate aluminum in high levels (Scheuhammer 1991). Insectivorous birds that feed on aquatic invertebrates could be at the greatest risk if calcium and phosphorous were not abundant in the nearfield area. Terrestrial species of wildlife with small territories or homeranges may be at risk in nearfield areas due to particulate inhalation.

There is potential for the gradual accumulation of other metals in the nearfield areas. The buffering ability and pH of soils, sediments and the waters, and the abundance of organic matter reduce the chance for widespread bioaccumulation. However, the fate of many toxic metals is poorly understood in most natural systems (e.g., Eisler 1985, 1986). Toxic impacts from smelters to terrestrial and aquatic wildlife have been documented elsewhere in the U.S. (Blus et al. 1987, Meyer 1988). Waterbirds have been shown to accumulate pesticides and heavy metals within contaminated water bodies elsewhere in the U.S. and Europe (King et al. 1980, White et al. 1980, White et al. 1984, Goede and Voogt 1985, White and Cromartie 1985, King and Cromartie 1986, King and Krynitsky 1986, Goede et al. 1989). Not only is the severity of contamination much greater in those areas than in nearfield areas, but contamination occurs over much larger areas. Although some priority species occur within nearfield areas, these areas are insignificant relative to the available habitat on KSC.

Noise effects of Shuttle launches have been measured outside the nearfield area and no long term effects have been found (Knott et al. 1982). Peak noise levels do not exceed 120 decibels outside a two kilometer radius of the pads. Peak launch

sound of 144 decibels has been measured from above ground stands in nearfield areas. These levels appear to be under levels that cause physiological damage to birds (Cogger and Zegarra 1980). Small mammals are more sensitive to physiological hearing damage. Damage has been documented to the inner ears of small mammals from impulse sounds near 144 decibels (Chappel 1980) but these levels may not occur in the burrows of small mammals. Presumably, small mammals are within their burrows during launch except for the occasional night launch. Southeastern Beach Mice are currently being investigated in nearfield Shuttle and Titan areas. Most noise studies are related to long term exposure and humans. Damage is related to frequency and intensity; laboratory studies often use weighted means and do not report frequencies so that comparison with launch noise becomes difficult.

Concern for noise occurred when Wood Storks began nesting within 2 km of pad 39A in 1988 at the Bluebill Creek colony. Occasionally launches occur during the nesting season. Video photography revealed a startle response of wading birds during launches when they briefly took flight from their nests and returned within minutes. This provides opportunity for some loss or damage to eggs or nestlings from startled adults or predation by Fish Crows during the short duration adults are away from the nest. Pre- and post launch studies of selected nests of wading birds suggested that no mortality of nestlings occurred at the Bluebill Creek Colony from launches at 39B. Most Wood Stork nests successfully produced 1-3 young and the number of breeding pairs increased between 1988 and 1990. There were 28 nests in 1988, 81 in 1989, and 110 in 1990 (Smith and Breininger unpublished data). This nesting success contrasted with nesting failures in south Florida. The first launch from 39A during the nesting season occurred in 1991. Rising water levels during the breeding season and degradation of mangroves from previous freezes probably resulted in abandonment of the nesting colony by Wood Storks prior to launch. Because of the recent freezes, no further Wood Stork nesting is expected there in the



near future. Other wading bird species nesting at the time of the launch from 39A did not show any obvious deleterious effects. Nestlings present before launch were present after launch.

Titan launches do not produce extensive wet acid deposition but do produce dry deposition and high intensity noise. Shuttle pads are surrounded by a large perimeter (>300 m) mowed grass areas whereas Titan pads are surrounded by smaller perimeters (150 m mowed area) (USAF 1990). Thus, native habitats are closer to the impact zone at Titan launch pads. Demographic studies of colorbanded Florida Scrub Jays are being conducted in the impact areas of both Titan launch pads. No direct mortality has occurred. Reproductive success and mortality are comparable to areas on KSC not subject to launch effects (Breininger et al. 1991).

Shuttle launches and landings produce sonic booms that are greater in pressure and duration than produced by conventional aircraft. On KSC these occur over the Atlantic Ocean during launch and over the St. Johns River during landing. Many studies were performed due to the anticipated focusing of sonic booms occurring over the Channel Islands in California where many seabird and marine mammal rookeries are found (Cooper and Jehl 1980). Studies in California provided useful information concerning potential noise effects. No significant effects from sonic booms were found from launches or landings at KSC (Knott et al. 1982, Potter 1983).

Although mortality and injury to wildlife has occurred in the immediate launch vicinity, few individuals are involved relative to their populations. To date, only two endangered or threatened animals have been found dead or injured in 44 shuttle launches. One American Alligator was found dead in a sound suppression water holding pond inside the pad perimeter. Another American Alligator was found just outside the perimeter fence in a lethargic state but appeared to recover by the following day. Other priority species found dead included a Red-tailed Hawk and a Dusky Pygmy Rattlesnake found inside the pad perimeter fence. Habitats impacted

are a small percent of the total of each habitat type found on KSC (Duncan and Schmalzer in press). Effects may increase from the anticipated use of advanced solid rocket motors that have nearly 20% additional propellant (NASA 1989). Thus, endangered and potentially endangered populations are little effected by launches, particularly in comparison to other factors influencing their populations. The possible exception may be the Southeastern Beach Mouse.

### Lighting

Lighting from launch pads along the beach is a threat to hatchling marine turtles which become disoriented by the bright lights. Monitoring marine turtles is required to inform the Florida Department of Natural Resources and USFWS if disorientation of hatchlings is observed. Pads 39A and B have been implicated in the disorientation of several clutches. This trend appears to be increasing relative to these two structures (Lowers et al. 1991). However, the bulk of the disorientation events recorded for KSC nests so far have occurred at the southern end of KSC near the CCAFS boundary, reportedly caused by CCAFS pads 40 and 41. The USAF has been under section 7 consultation with the USFWS and is actively pursuing the rectification of this problem. Opportunities exist to reduce impacts based on the use of different light sources. Low-pressure sodium vapor luminaries, which emit only yellow light, appear to minimally impact Loggerhead Turtles (Witherington and Bjorndal 1991).

#### 4.2 Habitat and Population Management

Management for natural conditions and processes is advantageous since presumably most species and natural communities are best adapted to these conditions. One can challenge whether "natural" should model conditions before the arrival of Europeans or whether it should model conditions before Homo sapiens (e.g.,

Diamond 1986, Chase 1987). However, given the low elevation and past sea level rise and other changes that decrease the potential to achieve natural conditions, management goals obsessed with natural conditions are unreasonable (see Diamond 1986).

#### 4.2.1 Loss of Large Predators and Release of Mesopredators

Predators link ecosystem components and play a keystone role in determining the composition and diversity (Hansonn 1977, Noss and Harris 1986). Predator removal can lead to dramatically altered, less diverse communities (Terbough 1976, Estes and Palmisano 1974, Paine 1966, Paine and Vadas 1969, Zare and Paine 1973). Large predators tend to undergo demise in fragmented or otherwise human altered landscapes (Terbough 1976, Diamond 1976, Noss and Harris 1986). The Florida Panther and the Florida Red Wolf once inhabited KSC as well as the Florida Black Bear, a large omnivore. These species were recorded as being very abundant along the barrier islands of Florida's Atlantic Coast (Motte 1837). Bobcats and River Otters still are common on KSC, but population sizes are probably low and vulnerable to local extinction.

Results of Red Wolf reintroduction studies have identified that even a few wolves can greatly affect Raccoons (R. Seigel, pers. comm.). The loss of large, dominant predators often permits population explosions of smaller omnivores and predators (Eisenberg et al. 1979, Terbough and Winter 1980, Glanz 1982, Pacala and Roughgarden 1984, Schoener and Spiller 1987) which is referred to as "mesopredator release" (Soule et al. 1988). Populations of Raccoons, Skunks, Opossums and Armadillos are serious predators of ground-nesting birds, small mammals, and turtles (Harris and Gallagher 1989). Some mesopredators benefit from other human produced changes. Dikes made marshes more accessible to Raccoons.

Marine Turtle nest predation by Raccoons reached 62% on KSC beaches and 90% on CCAFS prior to predator control and nest screening (Provancha et al. 1984). Other examples of species populations impacted by Raccoon predation are discussed in Appendix A.

#### 4.2.2 Disruption of Natural Fire Patterns

Reliance on wild fires is no longer an option due to habitat fragmentation (see section 4.1.2), NASA and USAF facilities and operations, and the presence of urban areas located to the east and south. Aerial photography from 1943 shows that scrub and pinelands were dominated by shrubs but there was an abundance of openings in contrast to current conditions where many areas have become forested and few openings remain (Breininger 1992). Past turpentine, timbering, grazing and drainage practices also altered the structure of pinelands (Davidson and Bratton 1986). Twenty years of fire suppression resulted in a buildup of heavy fuel load. This was followed by a period of intense wildfires in 1981 and nearly a decade of a frequent prescribed fires aimed at fuel reduction in some areas. Some very intense fires occurred in areas with high fuel levels or when prescribed fires occurred during dry conditions. Some pines were eliminated in areas that historically had Bald Eagle's nests (J. Hardesty, pers. comm.). However, based on historical accounts and aerial imagery, and the lack of stumps, it appears that large areas were naturally devoid of pines (Breininger 1992).

All KSC researchers believe scrub was the common native habitat before the arrival of Europeans but a few outside biologists believe otherwise. Some believe scrub replaced pinelands that were mostly grass due to fire suppression while others believe scrub replaced live oak savannahs due to logging. Historical records suggest that a shrubby understory was present in many pinelands in central Florida before fire

suppression practices were widely established (Harper 1921). In 1773, Bartram noted that there was a variety of pine habitats where he saw Florida Scrub Jays, Loggerhead Shrikes and many Rufous-sided Towhees (Jackson 1988). The presence of Loggerhead Shrikes suggests a much more open habitat than currently occurs at KSC. The presence of Florida Scrub Jays and an abundance of Rufous-sided Towhees suggests a significant shrub layer (Breininger 1981, Breininger and Schmalzer 1990, Breininger and Smith 1992). Pinelands with a palmetto understory were common in Florida (Harper 1921; Maehr and Marion 1985; Woolfenden and Fitzpatrick 1984; Robertson 1955; Hough 1965, 1981; Hough and Albin 1978; McNab et al. 1978). Saw palmettos do not invade most scrub on KSC rapidly. In 1837, near Haulover Canal, an expanse of two to four feet tall "prairies" of scrub and saw palmetto was reported (Motte 1837).

Davidson and Bratton (1986) suggested that scrub grew up from planted fields that formerly were hammock or live oak savanna especially near Haulover Canal area. They noted that Debrahm's map (1735) did not show scrub because it was of no use to colonists. Disturbed areas are noted by the conspicuous absence of saw palmetto and the abundance of tall oaks; saw palmettos show no sign of widespread invasion on historical aerial photography even after 30 years since a site has been cleared (Breininger and Schmalzer 1990). Indian settlements may have been associated with oak groves which provided a food source (Larson 1980). Impacts of Indians could have favored the growth of large oak trees with little understory (Davidson and Bratton 1986) favoring the development of oak woodlands in sites near Haulover. The Haulover area is commonly described in the historic records because it represented a narrow isthmus frequently crossed and readily identifiable. Indians may have changed "natural" plant communities in the Haulover Canal area but not necessarily across all of KSC and CCAFS.

Traditional natural fires occur in summer (Komarek 1965, Robbins and Myers

1989). Fires during the rainy, humid growing season are often patchy and regrowth occurs quickly (Christman 1983, Robbins and Meyers 1989). Growing season burns occur in dry (spring) and wet months (summer); with the transition between them representing the height of the fire season (Robbins and Meyers 1989). Prescribed fires during spring drought differ greatly from fires during wet seasons when fuel moisture levels are high and the only fuels available are primarily living volatile vegetation such as wiregrass, saw palmetto, and gallberry holly. Fires caused by humans on KSC have occurred throughout the year but have been especially common in the winter (Davidson and Bratton 1986). Scrub burns readily in winter when fuel moisture levels are lowest due to low rainfall and humidity. Winter fires are not natural to native vegetation (Davidson and Bratton 1986).

Much of the original salt marsh on KSC was comprised of a fire maintained medium-dense cordgrass which provided habitat for the extinct Dusky Seaside Sparrow (Trost 1968, Sweet 1976). Fire and natural hydrological patterns reduce many shrubs such as groundsel-tree (Baccharis halmifolia), wax myrtle (Myrica cerifera), Brazilian pepper (Schinus terebinthifolius), black mangrove (Avicennia germinans), and white mangrove (Laguncularia racemosa) (Leenhouts and Baker 1982). Since the construction of impoundments, shrubs extended their distribution into salt marshes, especially along dikes (Leenhouts and Baker 1982; H. Kale pers. comm.). Flatwoods marshes are also maintained by periodic fire (Kushlan 1990) that eliminates dead vegetation, makes nutrients available for new growth, and enhances habitat for many marsh birds (Vogl 1973). Hardwoods, especially wax myrtle, willow, and red maple, have invaded these marshes where there is the long exclusion of fire and alterations in hydrology (Schmalzer and Hinkle 1985). The woody invasion of swale marshes can influence surrounding habitats, particularly scrub and slash pine, by fragmenting a previously open landscape (Breininger 1992). Woody vegetation

replaces flammable marsh vegetation so that fires may no longer carry into the surrounding areas.

#### 4.2.3 Impoundment and salt marshes alteration

Mosquito control involved pesticide spraying, ditching, drainage, and impoundment. Most salt marshes in Brevard County were diked in the 1950s and 1960s for mosquito control. The salt marsh mosquito, Aedes taeniorhyncus, must lay its eggs on exposed substrate, so flooding the marsh during mosquito breeding season (summer) is an effective, non-toxic means of control (Provost 1967, 1969). Earthen dikes were built around salt marshes to hold the water, and water-control structures were used to provide access to the estuary. Flooding was accomplished by pumping water from the estuary, estuarine inflow, and rainfall. Permanent flooding and associated water depths killed much of the original salt marsh vegetation resulting in large expanses of open water. Management techniques have diversified over the years and many impoundments can be flooded and still retain salt marsh vegetation. After the mosquito breeding season, most impoundments on KSC are kept flooded until March to support a large wintering waterfowl population.

Marsh impoundment had beneficial and negative effects for wildlife. The loss of marsh vegetation for nesting contributed to the demise of the Dusky Seaside Sparrow, and reduction in other bird populations that depended directly on marsh habitat, such as the Clapper Rail (Rallus longirostris) (Trost 1968) and Black Rails (P. Sykes, pers. comm.). Some people believe that fisheries in the nearby estuaries have suffered from the loss of marshes as nursery habitat, but sufficient data are lacking to support this claim (Montague et al. 1985). The original salt marsh on KSC was nontidal and dry for most of the year (Provost 1967). Many impoundments not only enclosed the original marsh but also unnecessarily enclosed several narrow brackish water

embayments (termed "creeks"). Isolating impoundments from the estuary for mosquito control normally occurs when transient fish use of high salt marsh is minimal (Gilmore 1987, Rey et al. 1990). Perimeter ditches, created by the removal of material for dike construction, surround much of the inside of impoundments (Rey et al. 1990). These serve as refuges for fish and other organisms during dry periods and may actually increase the amount of flooded habitat for such organisms in a significant manner (Gilmore 1987).

Unbroken expanses of high salt marsh were reported to have low bird densities but impoundment of these marshes has been associated with increased use by many waterbirds (Trost 1968, Provost 1969). Data collected on KSC show that large numbers of wading birds (Ciconiiformes) use these impoundments (Breininger and Smith 1990) and greatly prefer open water over other cover types (Smith and Breininger unpub. data). As Florida's human population continues to grow, the demands for safe, economical mosquito control will continue. New techniques called open-marsh water management allow the return of most of the marsh to natural water regimes (Montague and Wiegert 1990). Mosquito breeding areas are controlled by ditching. These methods require several years of testing to determine their effects on mosquitos and wildlife. Current legal restrictions may prevent the development of open-marsh water management (Montague and Weigert 1990). Environmental and commercial fishery concerns have led to the opening of impoundments in several areas of the Indian River Lagoon system. Some organizations would like to see dikes removed from all impoundments along the Indian River. Agencies charged with managing impoundments have the unenviable task of balancing mosquito control, the differing needs of wildlife, duck hunters, recreational and commercial fisherman, and requests by "naturalists" to return salt marshes to their natural condition. To further complicate the competing interests, there are little reliable data to quantify the effects of the different management actions (Breininger and Smith 1990).



These impoundments not only influenced marshes but they probably impacted water table depths in adjacent habitats including scrub (D. Bennett pers. comm.). Potentially, this increase could approach 1 m during some seasons. The relationship between water table and vegetation is clearly linked on KSC (Schmalzer and Hinkle 1987, 1991) so that changes in the composition and structure of scrub may also be due to water level management.

#### 4.2.4 Alteration of Nesting Habitats for Colonial Waterbirds

Human landscape alterations have destroyed nesting habitat of colonial waterbirds in the southeastern U.S. and resulted in human disturbance, increased predator populations, and improved access to the nesting areas by predators. Spoil islands created from dredging operations decades ago have replaced natural nesting habitat for many species and may have resulted in changes in the distribution of some species. Many spoil islands on KSC have since become overgrown with woody vegetation due to natural successional processes and are not suitable for species that prefer bare substrates such as Least and Royal Terns (Schreiber and Schreiber 1978). Rooftops, runways, and other artificial nesting substrates have been substituted for natural areas by Least Terns and other species. Nesting has been discouraged at the Shuttle Landing Facility by changing the color of overruns to black. Success of rooftop nesting is species specific and dependent on roof structure and disturbance (Appendix A).

#### 4.2.5 Proliferation of Exotics

Several species of exotic plants are well established on KSC, including Australian pines, Brazilian pepper, and Melaleuca thereby changing community structure. Attempts are made to control them in some areas.

Feral Pigs are an abundant exotic and are destructive to the natural environment (Ralph and Maxwell 1984, Singer et al. 1984). MINWR supports one of the highest concentrations of Feral Pigs in Florida (Frankenberger and Belden 1976). They impact vegetation, ground dwelling animals, especially snakes, by both direct consumption and habitat alteration. Changes in composition of ground predators may explain why some snakes that were previously reported as common (Ehrhart 1976) are seldom or never seen (pers. obs.). Feral Pigs are also reservoirs for diseases that can threaten other wildlife populations (Harris and Eisenberg 1989). Davidson and Bratton (1986) suggested Feral Pigs may have caused a shift in hammock structure due to their consumption of live oak acorns following a historical period of extensive live oak logging. The number of Feral Pigs removed from KSC per year has increased from 91 in 1975 to 1,617 in 1989, but no data are available on population trends during this time. A number of Feral Pig studies were conducted in the 1970s (Baber 1977, Peck 1978, Poffenberger 1979, Antonelli 1979, Strand 1980) estimating the presence of one Feral Pig for every 12.5 ha of habitat. Thus, many (e.g., 14) Feral Pigs may live within the homerange of one Indigo Snake.

The Nine-banded Armadillo (*Dasyus novemcinctus*) is another abundant exotic on KSC that may influence populations of birds, snakes, and other ground-dwelling species although insects are their most abundant dietary component (Fitch et al. 1952, Nesbitt et al. 1978, Sikes et al. 1990). A population of House Cats has become established here; at least 20-30 animals are believed to occupy the Contractor's Road area (MINWR pers. comm.). Some KSC employees release and feed cats and reject the need for control efforts. House Cats, from nearby houses, also use KSC near the property boundary. House Cats not only have direct effects on native amphibians, reptiles, birds, and small mammals by predation, but also provide a reservoir for alien diseases that can impact native mammals, especially Bobcats.

#### 4.2.6 Human Disturbance

The detrimental effects of road mortality have already be mentioned. Most of the traffic at KSC results from employees at KSC and CCAFS, and visitors of CNS, MINWR, and KSC. The new Playalinda Beach Access Road has provisions to minimize vehicle speeds through the adjacent scrub. Public access to wildlife drives influences waterbirds feeding immediately adjacent to these areas. Disturbance increases during the hunting season. Public beach access also interferes with birds that feed and loaf on the beach. Recreational access to spoil islands impacts colonial waterbirds. Within the NASA security zone south of State Route 402, there is no public access, but some disruptions are associated with maintenance, construction, security patrols, and researchers.

#### 4.3 Extrinsic Factors

##### 4.3.1 Changes Beyond Kennedy Space Center Boundaries

Urbanization in areas adjacent to KSC is impacting local wildlife populations (Larson 1992). Deforestation in the tropics is a threat to several birds that use KSC for nesting (Terborgh 1989). The number of ducks using the Indian River and associated wetlands has declined substantially due to the loss of breeding habitat in the prairie pothole area of the U.S. and Canada. The northern enhancement of wintering waterfowl habitat has "short-stopped" many migrants (Kale 1988). The surrounding waters of Brevard County are known to have the most Manatee deaths attributed to boat traffic in Florida, and the population is seriously endangered due to this mortality.

##### 4.3.2. Catastrophic Events

Accidents may include explosions and the release of toxic materials such as

hydrazine, monomethylhydrazine, and nitrogen tetroxide. Most accidents are not expected to effect areas outside of the site boundaries (NASA 1978, 1979, 1990). Extreme safety measures are taken to avoid accidents due to the potential for injury or loss of human life. A catastrophic accident could impact endangered and potentially endangered species, but this effect would be limited to a relatively small area on KSC and would be of minor influence to most or all populations. One option is to discourage waterbirds from nesting on islands immediately adjacent to hazardous operations.

A direct hit by a major hurricane could devastate KSC impacting many endangered and potentially endangered species. Damage from major hurricanes influence some communities more than others and for longer periods of time. Impacts in salt marshes are less severe and shorter than impacts to forests (Michener et al. 1991). Strategies to lessen impacts to endangered and threatened species in areas subject to hurricanes include the dispersion of populations (Hooper et al. 1990). Many individuals of a population can survive catastrophes, but it is important to have sufficient genetic diversity available in subsequent founder populations (Frankel and Soule 1980, Harris 1984, Griffith et al. 1989, Leberg 1990). KSC should never be instituted as the only remaining major population center for a species, and the maintenance of large population sizes should be considered an important objective. Although KSC is regarded as having large, and apparently viable populations of the Southeastern Beach Mouse and Florida Scrub Jay, it should not be used as the only preserve for coastal populations. Small, scattered populations, having questionable long term viability without special management, may become important after a catastrophic event.

### 4.3.3 Sea Level Rise

Sea level rise is an influence on biological diversity that requires planning (Brinson and Moorhead 1989). About 15,000 years before present (YBP), sea levels were 130 m below present level and rapidly rose at about 1.3 cm/year until 7,500 years ago when the sea level was about six meters below present level (Wanless and Parkinson 1989). Sea level migrated landward at a rate of 1km/100 years across the west Florida shelf; the narrow southeastern Florida shelf was only inundated more towards the latter part of this period (Wanless and Parkinson 1989). Between 7,500 and 5,500 the rise slowed to 0.5 cm/year; between 5,500 and 3,200 years the rate slowed to 0.2 cm/year. Between 3,200 and now the rate slowed to less than 0.04 cm/year (Wanless and Parkinson 1989). World records suggest the sea level has been rising 0.01-0.02 cm/year in the last 100 years (Edgerton 1991). Geologic studies suggest that Florida Mangrove communities have been controlled greatly by the rate of sea level rise (Snedaker and Parkinson 1991, Parkinson and Meeder 1991). The ability of wetland systems to adapt to sea level rise is dependent on the rate of rise. Salt marshes can move landward with slow increases in sea level rise providing the rate (i.e, 0.04-0.06 cm/yr [Titus 1988]) allows the accretion of sediment. Sea level rise is further influenced by land subsidence which is much more severe on Florida's Gulf coast compared to the Atlantic coast (Neil 1957). The partial submergence of shell middens and mounds on the east coast is attributable to postglacial rise of sea level (Goggin 1948, Rouse 1951). Sediments in the Indian River show an ascending sequence which consists of: (1) depauperate marsh muds, (2) restricted marine fauna, and finally (3) a more normal marine fauna (Bader and Parkinson 1990). The sea level was probably near the bottom elevation of the Indian River a few thousand years ago; natural changes in sea level have recently resulted in a dominance of

seagrasses and estuarine organisms inhabiting the lagoon (Virnstein 1988, Gilmore 1988).

The increase in atmospheric CO<sub>2</sub> associated with the burning of fossil fuels and deforestation may result in increased surface temperatures, a wetter climate in Florida, and rapidly increasing sea levels. The increase may impact the hydrological functions of scrub resulting in structural changes in communities (R. Hinkle pers. comm.). This is a severe threat to biological diversity due to rate of change and landscape fragmentation, resulting from human development, that no longer allows large shifts in biological communities (Peters and Darling 1985, Reid and Trexler 1991). The Environmental Protection Agency estimates a global sea level rise of 0.26-0.39 m rise by 2025 and a 0.91-1.37 m rise by 2075 (Edgerton 1991). Planning must consider the expected rise and the uncertainty associated with the sea level rise estimates (Reid and Trexler 1991). Species differ in susceptibility (Bildstein et al. 1991). Wetlands may extend landward unless the rise is too rapid (Reid and Trexler 1991). Sea level rise has consequences for coastal marshes and uplands on KSC given the low topography. Studies are planned to study KSC peat accretion in relation to water management practices. This can provide data needed to mitigate accelerated sea level rise (R. Parkinson, pers. comm.). A serious consequence is anticipated for coastal strand and xeric habitats if there is an accelerated rise in sea level within 50-100 years. These habitats comprise only a small portion of KSC but are especially important for the contribution of KSC to global biological diversity. Populations of great risk are the Florida Scrub Jay and Southeastern Beach Mouse. Other populations of Florida Scrub Jays occur on the Lake Wales Ridge and Ocala National Forest which are relatively high in elevation. Less opportunity for species preservation may occur for the Southeastern Beach Mouse.

## 5.0 THE ROLE OF HABITAT TYPES ON KENNEDY SPACE CENTER IN MAINTAINING BIOLOGICAL DIVERSITY

Several approaches are used to protect biological diversity based on habitat. A common method, referred to as a coarse-filter strategy, is to preserve sufficient amounts of all habitat types occurring in an area, assuming that most species would thereby be protected. The amount of habitat must provide for enough individuals to guarantee a high probability of survival (Soule and Simberloff 1986). Large amounts of most habitats types are protected on KSC to offer protection for most species. However, many approach minimum population sizes or require more specific habitat features, so that protecting examples of all habitats is not sufficient. A fine filter approach is used for endangered species or others that "fall through the pores" of the coarse filter.

Three classes of additional considerations are needed to refine the coarse and fine filter approach to habitat protection and management (Noss 1987). The first two include: 1) the disturbance and regeneration needs of habitat types, and 2) the functional combinations of habitat types and successional stages. Some are adapted to a fire maintained habitat by occupying larger areas than needed because only a portion of the area is at an optimal successional stage from fire (Woolfenden and Fitzpatrick 1984, 1991). Thus, frequency, patch size, and distribution of fires become important management objectives. Some species require two different habitat types adjacent to each other (Moler and Franz 1987). A third class is landscape context which occurs at various scales. Habitat subunits must be sufficiently large and connected to provide for a viable population and must be configured to minimize deleterious edge effects including road mortality. There is the need to minimize the possibility that a single catastrophic event could impact an entire population.

Habitat types often refer to vegetation cover types and not the individual needs

of the wildlife species using a habitat. For example, the Eastern Diamondback Rattlesnake is associated with many habitats but this species is not necessarily a habitat generalist and required habitat features may be uncommon in the landscape (R. Seigel pers. comm.). The Florida herpetofauna responds to specific habitat characteristics and not necessarily habitat nomenclature (Campbell and Christman 1982). Not all species (e.g., Bobcats) are associated with a particular habitat type but require enough suitable habitat within a landscape. Several raptors (e.g., Red-tailed Hawk, Eastern American Kestrel, Northern Harrier, Merlin, Barn Owl) use many habitats but prefer open areas and may be partially limited by prey availability.

Conservation of biological diversity is broader than considered in this document. For example plant, fish, and invertebrate species also need to be considered. Not all wildlife species have been addressed. Endangered and potentially endangered species have been emphasized herein as an umbrella for maintaining native wildlife populations on KSC since nearly 1/3 of the wildlife species found on KSC are considered endangered or potentially endangered. However, KSC provides habitat for other species (e.g, Bats and several Snakes) that are rare or not easily observed but not identified as declining or having a low population size. Many species are declining throughout much of the southeast but are not necessarily endangered across Florida (Hunter 1991). Many overwintering species spend more time in Florida than they spend on their northern breeding grounds (Keast 1980). The winter ranges of many migrants are small relative to breeding ranges, and thus they occur in much greater densities on their wintering grounds (Cox 1985). Thus, KSC habitats are important for many species that nest elsewhere although they may not be endangered or threatened. Many of these species and their associated habitats are summarized in Appendix B. The following describes the habitat types as communities and summarizes the relevance of each habitat type for conservation of biological diversity. Management influences to biological diversity specific to these habitat types



are mentioned below but are discussed more extensively in section 4.0. More detailed reviews of species considerations are provided in Appendix A.

## 5.1 Estuarine Waters and Shoreline

Estuarine habitat has the most acreage (21,600 ha) of all habitat types, representing 39% of KSC. The diversity, productivity, and the presence of MINWR has resulted in parts of the estuary being designated an Estuary of National Significance, a Florida Outstanding Waterway, and an Aquatic Preserve. The northern limit on the east coast for subtropical seagrass meadows in lagoon waters occurs in the vicinity of KSC. Seagrass beds have undergone change associated with sea level fluctuations and the opening and closing of inlets (Virnstein 1988). Dominant submerged aquatic vegetation includes manatee grass (Syrinodium filiforme), shoal grass (Halodule wrightii), Ruppia (Ruppia maritima), and a macroalgae (Caulerpa prolifera) that recently became unusually common in some areas. Submerged aquatic vegetation supports a wide array of vertebrates and invertebrates including species of recreational and commercial importance (Rathjen and Bolhassen 1988). Much of the lagoon was once bordered by salt tolerant grasses such as Distichlis spicata, Spartina bakeri, and S. alterniflora, and other low halophytes (i.e., Salicornia spp., and Batis maritima) (Gilmore 1988). Within the last forty years, some marshes in the lagoon have been replaced by mangroves (Gilmore 1988). Many changes in fish populations have occurred in the last several thousand years due to sea level changes, opening and closing of inlets, and changes due to European occupation (Gilmore 1988). The estuary is the southern limit of many temperate (northern) fish and the northern limit of many tropical (southern) fish (Snelson 1976, Provanca et al. 1986, Gilmore 1987).

Most wildlife studies within the Indian River Lagoon system have been conducted on marine mammals, marine turtles, and colonial nesting birds (Virnstein

1987). Many endangered and potentially endangered species use estuarine habitat. Two large herbivores (Atlantic Green Turtle and West Indian Manatee) feed in the estuary; both are endangered. The Green Turtle is rarely found in the Banana River but is common in Mosquito Lagoon (Ehrhart 1980, 1988). The estuary, particularly Mosquito Lagoon, provides a developmental habitat for immature Green Turtles (post-yearling to subadults). The lagoon probably represents the northern-most winter range for this species. Mendonca and Ehrhart (1982) estimated this population to be about 135 animals. Witherington and Ehrhart (1989) speculated that this population was growing, based on data from cold stunning events. During the winter of 1989, 209 Green Turtles were found stunned in Mosquito Lagoon after a cold weather period (Schroeder et al. 1990). The estuarine habitat on KSC is (or once was) important for maintaining populations of the East Coast Diamondback Terrapin which should be listed as endangered or threatened (Millsap et al. 1990). Recent surveys support listing (R. Seigel, unpublished data). Except for a few studies on KSC (Seigel 1979, 1980 a, b), essentially nothing is known concerning its ecology, abundance, and distribution.

Many wading birds, including Wood Storks, Little Blue Herons, Roseate Spoonbills, Tricolored Herons, White Ibises, Snowy Egrets, and Great Egrets use estuarine waters but are not dependent on these waters (Smith and Breining in preparation). Wading birds use shallow areas in the estuary which are typically located along shorelines. Least Terns, Royal Terns, Caspian Terns, and Sandwich Terns rely upon the estuary and ocean waters for feeding. Populations of Reddish Egret, Southern Bald Eagles, Arctic Peregrine Falcons, and Black Skimmers are at least partially dependent on the estuary for feeding, although they also use impoundments. Bald Eagles appear to be associated with areas where impoundments occur adjacent to the estuary, perhaps due to the types and abundance of foods characteristic of both habitats (Hardesty and Collopy 1991). Arctic

Peregrine Falcons also capture prey in ocean beach and some upland habitats. Black-bellied Plovers, Western Sandpipers, Short-billed Dowitchers, and other shorebirds use very shallow areas, mudflats, or edges of the estuary; they also use open water impoundments (Cruickshank 1980, Breininger and Smith 1990). Estuarine edge may historically supported large populations of migrating or wintering shorebirds but impoundment of adjacent marshes appears to have greatly modified estuarine borders based on historical imagery. White Pelicans (Pelecanus erythrorhynchos) are experiencing declines in the western U.S.; many hundreds winter in the estuary surrounding KSC, Pelican Island National Wildlife Refuge, and Everglades National Park (Chapman and Loftus 1986). The importance of the estuary to the River Otter has not been investigated, but the edges are assumed to be important and River Otters are occasionally seen along its edges (Breininger pers. obs.).

It is difficult to quantify the significance of KSC to bird populations of the entire Indian River Lagoon system because consistent and intensive surveys have rarely been conducted. This is remarkable given the diversity and abundance of birds using this system and the recognition of the importance of the system to avian populations in Florida (Kale 1988). Virnstein (1978) concluded that requirements of bird populations using the Indian River are largely unknown. Surveys (e.g. Osborn and Custer 1978, Schreiber and Schreiber 1978, Nesbitt et al. 1982), colony studies (Williams and Martin 1971; Maxwell and Kale 1974, 1977; Clark 1979; Girard and Taylor 1979) and compilations (Cruickshank 1980, Kale 1988) indicate that KSC combined with Pelican Island National Wildlife Refuge, are the most important areas regionally for most wading birds and Brown Pelicans. Pelican Island, which represents America's first National Wildlife Refuge, is located in vicinity of the proposed Archie Carr National Wildlife Refuge. KSC appears to be the most important area for nesting Royal Terns and Black Skimmers using the Indian River Lagoon whereas American Oystercatchers

are most abundant from south Brevard to Martin County (see Appendix A).

The West Indian Manatee has received the most study in the Indian River Lagoon system and perhaps is the most endangered. Winter mortality due to cold exposure is a serious problem (Irvine 1983, O' Shea 1985). The warm effluents of nearby power plants attract large numbers of Manatees during the winter and represent the most heavily used part of the Indian River during January and February (Shane 1983, Beeler et al. 1988). These warm water discharges may compensate for habitat loss in southern Florida; however, they alter historical migratory patterns and render large numbers susceptible to death from cold periods if discharges fail (Shane 1983). Large aggregations of Manatees are sighted on KSC as animals migrate away from winter refuges (Shane 1983). Unprecedented numbers (200-300) have recently used the north Banana River during spring (Provancha and Provancha 1988). These aggregations can reduce the cover of manatee grass by 90% (Provancha and Hall 1991). Manatee use of Mosquito Lagoon is low although they are frequently sighted moving through Haulover Canal (Beeler et al. 1988). Canals and dredged channels have enhanced the availability of some feeding habitat (Beeler et al. 1988). Other factors influencing Manatee distribution include an attraction to fresh water which is provided in two areas on KSC to aid USFWS researchers that study the animals.

Aerial surveys of Bottlenose Dolphins (Tursiops truncatus) in the Indian River Lagoon suggest a population of a few hundred individuals (Leatherwood 1982, Shane 1983). Scott (et al. 1990) suggested that seasonal changes in numbers are attributed to an ocean influx of animals. However, there is evidence that there is a distinct population of inshore Dolphins (Hersch and Duffield 1990) and that little movement through inlets occurs by resident inshore Dolphins (Leatherwood 1982). Dolphins are common in estuarine waters on KSC (Shane 1983).

Most wildlife using the estuary are mobile and adapted to patchy resources so that management of these populations must consider large areas of the Indian River

Lagoon. The influences of NASA on the estuary are related to occasional boat and barge traffic, occasional maintenance dredging, and stormwater runoff into ditches that enter the estuary. The widespread use of herbicides to control aquatic vegetation in ditches is of concern. Herbicides, fertilizers, suspended matter, and other contaminants are suspected to influence submerged aquatic vegetation. Emergent ditch vegetation have been reduced by herbicides and ditch dredging practices. Emergent vegetation provides filtering and nutrient uptake that help protect estuarine quality. Many storm water structures are being constructed on KSC that should minimize these impacts. The restricted waters of the upper Banana River greatly reduces the amount of boat traffic and influences of fishermen.

## 5.2 Impounded Open Water and Mudflats

Impoundments on KSC are a significant environmental resource on central Florida's Atlantic coast (Rey et al. 1991). There are nearly 3,700 ha (9,143 ac) of open water impoundments and mudflats on KSC. Submerged vegetation (Chara and Ruppia) is abundant during fall and winter when water level and temperature is optimal for such vegetation (Joanen and Glasgow 1965). These high water periods provide a large area for fish populations to develop (Snelson 1976). The dominant fish populations in impoundments are common food for wading birds (Willard 1977, Kushlan 1979) and fish production in impoundments is an order of magnitude higher than in nearby seagrass beds (Schooley 1980). These impoundments are used by a large number of endangered and potentially endangered species and are required by more species than any other habitat except islands. American Alligators are conspicuous reptiles in these impoundments. At least some of these impoundments are used by Indigo Snakes even when flooded. Indigo Snakes also use dikes, roadsides, and saw palmetto scrub islands within impounded landscapes.

Avian species are the most visible and diverse taxa associated with impoundments and consequently provide recreation opportunity along Black Point and Max Hoeck Creek Wildlife Drives. Birders from all over the world visit these spectacular birding locations. The impoundments are regarded as a popular waterfowl hunting resource in the southeastern U.S. Historically, Florida was one of the most important states for wintering waterfowl in the Atlantic Flyway (Chamberlain 1960), but in recent times many waterfowl are "short-stopped" in refuges to the north for hunting (Kale 1988). KSC includes one of Florida's largest wintering waterfowl populations (Goodwin 1979). Maximum monthly counts of nearly 140,000 ducks and 40,000 coots have been recorded in recent years on KSC (MINWR unpublished data). The replacement of original salt marsh vegetation with submergents increased the quantity and quality of waterfowl foods (Bailey and Titman 1984, Goodwin 1979). Although emergent vegetation represents high quality waterfowl food elsewhere (Chabreck 1975, Landers et al. 1976), most species of emergents that dominate KSC marshes are poor quality food (Neely and Davidson 1966).

Wood Storks, Reddish Egrets, Roseate Spoonbills, and eight other wading birds are common in these impoundments (Smith and Breininger in preparation). Numerous raptors, shorebirds, terns, and other birds commonly use impoundments and mudflats for feeding and/or loafing (Cruickshank 1980, Breininger and Smith 1990). A few raptors such as the Southern Bald Eagle, are attracted to these impoundments because prey (i.e., coots, ducks, shore birds, and wading birds) are seasonally abundant (Hardesty pers. comm.). For many impoundments, water levels are highest during winter when most waterfowl are present. These high water periods are followed by spring drawdown that concentrates food items for nesting wading birds (Breininger and Smith 1990). Many, perhaps hundreds of thousands, of shorebirds commonly feed in impoundments on exposed mudflats during spring drawdown (Breininger and Smith 1990). Impoundments in the vicinity of Launch Pad 39B have

been implicated as one of a few primary areas in Florida for the migratory American Avocet (Ehrhart 1976, DeGange 1978). These impoundments are also significant for the Black-necked Stilt (Howell 1932, Sprunt 1954, Lesman unpublished data). The River Otter and Bobcat also feed in impoundments.

NASA operations impact less than 1% of the total area of open water impoundments. Areas near 39A and 39B are impacted by temporary effects from shuttle launches; Molly Pond is impacted by sewage effluent. Management of open water impoundments is primarily the responsibility of the MINWR and the Brevard County Mosquito Control District. Isolation from the estuary of most impoundments for mosquito control occurs when transient fish use is minimal (Gilmore 1987; Rey et al. 1987, 1990). Most impoundments are managed for waterfowl after the mosquito season. Impoundments interrupt the exchange of biota and other materials between marsh and estuary (Harrington 1961, Gilmore et al. 1986). Nearly 75% of the Indian River wetlands were impounded (Virnstein and Campbell 1987). Reconnection of impounded marshes to the Indian River system is a high priority for ecosystem restoration and enhancement (DeFreese 1991). Reconnection does not necessarily require dike removal. Releases of impounded water can allow production and export of resources to the estuary (Montague et al. 1986) and perhaps excesses of organic matter. Periodic drawdowns are needed to maintain productivity of waterfowl food resources (Morgan et al. 1975) and provide habitat for wading birds and shorebirds. Impoundments provide opportunity for spatial and temporal management that can achieve numerous resource objectives, including mosquito control. They may also provide a mechanism to minimize impacts of sea level rise.

### 5.3 Salt Marshes

Salt marshes on KSC are nontidal, most are impounded, and their structure and

composition is dynamic due to water level management and geographic location. Salt marshes are dominated by almost pure stands of Spartina alterniflora, sand cordgrass (S. bakerii), black rush (Juncus roemerianus), salt grass (Distichlis spicata), and other low salt tolerant grasses. Often areas have been termed "scrub marshes" (Provost 1967, 1969) because they are comprised of shrub-sized mangroves, Batis maritima, Salicornia, and salt grass. Some marshes were invaded by mangroves after impoundment (H. Kale, pers. comm.) especially along dikes (Leenhouts and Baker 1982). KSC is a transitional zone between grassy marshes to the north and mangrove swamps to the south due to climatic differences and the intolerance of mangroves to hard freezes (Provost 1967, 1969; Trost 1968; Bidlingmayer 1982). Mangroves occurred on KSC before impoundment; frost-killed mangroves were noted by Motte in 1837 (Davidson and Bratton 1986). Longstreet found the Florida Prairie Warbler associated with small mangroves near Turtle Mound in Mosquito Lagoon in 1925 (Howell 1932). Some areas have been dominated by a tree canopy of mangroves. Black mangrove ranges as far north as St. Augustine. The northern range of white mangrove is located at KSC except for a small disjunct area near Daytona Beach. Red mangrove (Rhizophora mangle) extends just north of Daytona Beach (Little 1978). After many years without severe freezes, mangroves achieve tree stature. Mangroves are reduced greatly by occasional freezes (e.g., in 1944 [Davidson and Bratton 1986], 1983 and 1985 [Provanha et al. 1987] and 1989). Mangroves are sometimes reduced to a scrubby stature (i.e., freezes of 1983 and 1985). The 1989 freeze was devastating to mangroves on KSC. Many areas that were once dominated by mangroves trees are now dominated by salt grass, Salicornia, or Batis especially in Mosquito Lagoon. Some mangrove propagules have survived and sprouted after the freeze in the Moore Creek and Dummitt Cove; however, it will be several years before mangroves reach the stature suitable to support Wood Stork nests.



Historically, salt marsh landscapes were unflooded for most of the year except for scattered creeks and ponds (Trost 1968). A large number of endangered and potentially endangered species require or at least use salt marsh habitat. Some are specialized to use low salt tolerant vegetation, others require mangroves, and others require open water within the habitat (see below). Some species are less specialized and use all three habitat components. The most likely areas on KSC for the Atlantic Salt Marsh Snake, if they are present, are salt marshes dominated by Salicornia, Batis maritima and salt grasses along the east shore of Mosquito Lagoon. Salt marshes on KSC and adjacent marshes along the St. Johns River once provided habitat for the extinct Dusky Seaside Sparrow. Impoundment, fires, highway construction, and other activities contributed to its extinction (Kale 1988). Further north, the extinct Smyrna Seaside Sparrow (A. m. pelonata) was characteristic of open salt marshes dominated by salt grass and Salicornia. The "northward invasion" of mangroves displaced the species so that the sparrows were nearly gone by 1948 (Nicholson 1950). The Black-wiskered Vireo and Florida Prairie Warbler are dependent on mangrove vegetation. The dynamics of these populations are uncertain, especially given recent freezes. The Black-wiskered Vireo still is common in a few areas (D. Cooley, MINWR, pers. comm.) and Florida Prairie Warblers can be heard singing in spring on some spoil islands where there are few or no mangroves (Breininger and Smith pers. obs.). Black-wiskered Vireos were not historically as common along the Atlantic coast as they were along the Gulf coast (Howell 1932). Salt marsh vegetation is important to Least Bitterns but essentially nothing is known about their distribution, population size, or dynamics on KSC. The Black Rail is very dependent on low salt marsh vegetation such as Distichlis and Salicornia. The status of this species is poorly known on KSC. The species was once a common breeding bird prior to impoundment (Sykes 1978; P. Sykes pers. comm.). Areas in the vicinity of KSC were important for this species at least in winter (Root 1988). Impoundment was detrimental to rails (Trost 1968), but this

effect was not quantified. Clapper Rails (Rallus longirostris) are still common along edges of salt marshes in impoundments. The Round-tailed Muskrat is also abundant in some salt marshes dominated by salt grass.

NASA's influence on most species that inhabit salt marshes is minor. The area near LC 39B has significant nesting by Black-necked Stilts (Lesman and Smith unpublished data). Changes, potentially associated with the discharge of sewage effluent, to "Molly Pond" were discussed in Section 4.0. Originally, the depth of water maintained for mosquito control resulted in the loss of much of the original salt marsh vegetation. Later, impoundment management practices were altered to keep some areas sufficiently flooded during the mosquito breeding season (May-October) to prevent mosquito egg-laying but keep the marsh shallow enough so that much of the original vegetation could survive (Provost 1969). Many marshes have been converted to fresh water and are dominated by cattail (Provancha et al. 1986). Much cattail conversion has continued since 1978 which was the date of imagery used to map KSC vegetation (Smith unpublished data). Other marshes have had low salinity but presumably the soils have remained sufficiently saline to maintain salt tolerant vegetation (P. Schmalzer pers. comm.).

#### 5.4 Cattail and Graminoid Marshes

This habitat includes areas mapped as cattail marsh, graminoid marsh, and cabbage palm savanna (Provancha et al. 1986b). These commonly occur as isolated wetlands interspersed among other vegetation types, especially scrub and slash pine flatwoods, or as large impounded marshes near estuarine lagoons. Cattail marsh is dominated by Typha domingensis and T. latifolia (Schmalzer and Hinkle 1985). Cattail marshes often characterize disturbed areas with deeper fresh water and longer hydroperiods than other graminoid marshes (Kushlan 1990).

Cabbage palm savanna has an open or scattered canopy of cabbage palm and an understory of sand cordgrass and other graminoids. Some shrubs such as wax myrtle and groundsel also occur. Cabbage palm savanna occurs in isolated swales and areas transitional between brackish and upland communities (Schmalzer and Hinkle 1985). Areas mapped as graminoid marsh (Provancha et al. 1986b) include swale marsh and sand cordgrass-black rush marsh (Schmalzer and Hinkle 1985). Swale marshes commonly occur among scrub and slash pine flatwoods. Most of these are isolated wetlands unless they are connected to other areas by ditches or canals. Shallow swales or shallow edges of deeper swales are typically dominated by several species of beard grass (Andropogon spp.). Some swales are dominated by Curtiss reedgrass (Calamovilfa curtissii) which is under review for federal listing (Schmalzer and Hinkle 1990). KSC supports the largest populations in public ownership and the only confirmed populations of this plant on the east coast of Florida; other known populations are in the Florida panhandle (Johnson and Blyth 1988, Schmalzer and Hinkle 1990). In marshes with longer hydroperiods, sand cordgrass dominates. Deeper marshes are dominated by sawgrass (Cladium jamaicense) or occasionally flag marshes (Sagittaria lancifolia). Other common plants in these marshes include swamp fern (Blechnum serrulatum), maidencane (Panicum hemitomon), and bloodroot (Lachnanthes caroliniana) (Schmalzer and Hinkle 1985). Bloodroot is a common food item of Feral Hogs that cause much damage to KSC marshes by their rooting activities. Swale marshes have elsewhere been termed flatwoods marshes (Kushlan 1990). Flooding is often seasonal, although some remain flooded for the entire year. Lowest water levels are typically in April and May when transpiration is high but summer rains have not begun. Sand cordgrass-black rush marshes typically occurred near brackish lagoons but have been impounded for mosquito control (Provost 1967, 1969; Trost 1968). Some sand cordgrass and most black rush marshes can be classified as salt marsh habitat.

Graminoid marshes are used by many endangered and potentially endangered species but are required habitat for only a few (Table 5). Isolated graminoid marshes have important roles in community structure within the scrub and slash pine flatwoods landscape. Several amphibian species breed in these ponds but live their adult lives in the uplands. Many reptiles characteristic of scrub and pine flatwoods, such as Eastern Indigo Snakes and some of their prey items (i.e., Black Racers [Coluber constrictor]), feed heavily upon frogs from isolated wetlands (Moler and Franz 1987). Amphibians have an important role in the flow of biomass between the marshes where they breed and terrestrial systems where they live as adults (Burton and Likens 1975, Gosz et al. 1978). Small, isolated marshes support a diverse assemblage of species that are different from those found in larger more permanent bodies of water (Moler and Franz 1987). Many of the species breed primarily or exclusively in wetlands that are ephemeral and often small. Isolated wetlands in scrub and slash pine flatwoods probably have a more important role in their influence on the herpetofauna rather than as avian habitat (Breininger 1992). Some marshes that are adjacent to deeper permanent water provide habitat for the American Alligator.

Some Florida isolated wetlands are important habitat for several wading birds including Wood Storks. On KSC, however, it appears that few such wetlands are used significantly by most wading birds (Breininger 1992, Smith and Breininger in preparation). A few priority species such as King Rails and perhaps Least Bitterns nest within these marshes. River Otters use graminoid marshes (Ehrhart 1976) but almost nothing is known about the importance of these marshes to River Otters.

Some future NASA facilities may be located within swale marshes, but the acreage developed will probably remain small. Sewage discharge occurs in some of this habitat and there have been proposals to use marshes for stormwater management (Bennett 1989; Bennett et al. 1991). Drainage patterns were dramatically altered by the development of space program facilities prior to the

environmental legislation that has made it very difficult to develop and alter marshes. The majority of marshes on KSC are now influenced by fire and water management practices of the USFWS and the BCMCD. Fire in marshes has a critical role in limiting the invasion of woody plants and peat accumulation (Leenhouts and Baker 1982, Kushlan 1990). Woody species temporarily invade some marshes as patches of shrubs during dry years and die in later years when rainfall patterns return to normal. Hardwoods, especially wax myrtle, willow, and red maple, invade these marshes where there is the long exclusion of fire and alterations in hydrology within the scrub and slash pine flatwoods landscape (Schmalzer and Hinkle 1985). Aerial imagery show an increasing invasion of graminoid marshes by woody vegetation. Some cordgrass and rush marshes have been converted to open water impoundments or cattail marshes by increased flooding associated with impoundment. The loss of emergent vegetation had negative consequences for species that preferred such vegetation. Impoundments with nearly continuous flooding and not open seasonally to the brackish estuary often are dominated by cattails. Cattail marshes are not very productive habitat for most wading bird species (Trost 1968, Smith and Breininger unpublished data). Outside management organizations are funding (i.e., SWIM) culvert installation to reconnect most impoundments to the estuary. The success of these operations on KSC is uncertain because cattail peat accumulation may have raised the original surface of the marsh.

#### 5.5 Coastal Dune, Coastal Strand, and Coastal Scrub

The KSC, CNS, and CCAFS coastline represents the longest stretch of coastal dune and coastal strand along the east coast of Florida (Johnson et al. 1990). Much of the coastal habitats from Brevard to Dade County have been developed or are in a highly fragmented condition except on KSC and CCAFS (Johnson et al. 1990).

Coastal dunes are dominated by sea oats (Uniola paniculata) and other grasses including slender cordgrass (Spartina patens) and beach grass (Panicum amarum). Small shrubs include beach berry (Scaveola plumeri), marsh elder (Iva imbricata), and Croton (Croton punctata). Common herbs include beach sunflower (Helianthus debilis), railroad vine (Ipomea pes-caprae), and camphorweed (Heterotheca subaxillaris) (Schmalzer and Hinkle 1985). Coastal strand occurs immediately behind the coastal dunes. It is often dominated by saw palmetto (Serenoa repens) although other common shrubs occur such as Rapanea (Rapanea punctata), naked wood (Myrcianthes fragrans), tough buckthorn (Bumelia tenax), hercules club (Zanthoxylum clava-hercules), bay (Persea borbonia and snowberry (Chiococca alba). Proceeding westward, a dwarf variety of live oak (Quercus virginiana undescribed variety) is found that forms a coastal scrub or coastal woodlands community. This coastal scrub includes many of the above hardwoods and tends to occur on alkaline soils with greater abundance of many nutrients in contrast to more interior scrub (P. Schmalzer and A. Johnson, pers. comm.). The outer coastal strip is often narrow and salt marsh vegetation, especially mangroves, border the coastal strand with few or no oaks.

The coastal strand may be important for the Florida Pine Snake on KSC but virtually nothing is known about this species. Coastal dunes and strand support large numbers of the Gopher Tortoise (Logan 1978). Eastern Indigo Snakes also use these habitats. Coastal strand is used by Florida Scrub Jays when adjacent to scrub oaks (Breininger 1981) and coastal live oak woodlands (Simon 1986). Coastal dune and coastal strand on KSC and CCAFS provide most of the protected habitat for the largest population of the Southeastern Beach Mouse (Paradiso 1989). These areas are essential for maintaining this unique mammal. The Florida Mouse is also abundant in this habitat. Little construction occurs on the coast. Some of these habitats do receive Shuttle launch cloud deposition, which occasionally defoliates areas (Schmalzer and Hinkle 1986). A small amount of habitat is located in Titan launch impact areas where

Florida Scrub Jay reproductive success and survival studies are being studied (Breininger et al. 1990). Lighting from launch pads covers a large area; the effects of these lights on small mammals has not been investigated. Studies of the Southeastern Beach Mouse have recently been undertaken (Provancha and Oddy unpublished data). Historically, records suggest that lightning caused fires were common in this habitat (Davidson and Bratton 1986). The authors have observed that most coastal scrub species sprout rapidly from fire and grow quickly at least within coastal areas that remained unburned for long periods. These areas have been subject to few prescribed fires in the recent past, although a few lightning and accidental fires have burned small areas.

## 5.6 Ocean Beaches

There are 175 ha of ocean beach present along KSC and the combined KSC-CCAFS stretch of beach is 58 km. This is the largest undeveloped stretch of beach on Florida's Atlantic coast. More than half of this beach has public access; the remaining areas are within security zones of KSC and CCAFS. Beach habitat is comprised of unstable sands that accumulate on the beach during the spring and summer and erode during storms in fall and winter. Because of this instability, the few plants that grow on the actual beach are extensions of dune plants. Few wildlife species are permanent residents.

The KSC and CCAFS beach is a primary rookery for the Loggerhead Turtle in the southeastern U.S. (Carr and Carr 1977, Ehrhart 1976, Provancha et al. 1984, Provancha and Ehrhart 1987) and is part of the largest rookery in the western hemisphere (Carr et. al. 1982). Nesting is not uniform along the beach; the distribution of nests is correlated with width and slope (Provancha and Ehrhart 1987). Nearly all hatchlings produced on KSC are females due to sex determination resulting from

warm sand temperatures (Mrosovsky and Provancha 1989). Beaches further north (Georgia, South Carolina, and North Carolina) have more equal sex ratios. Nest predation by Raccoons reached 62% on KSC beaches and 90% on CCAFS (Provancha et al. 1984). Predation control practices have been implemented and have been, in most cases, very effective. Feral Pigs also depredate nests. The number of Green Turtles that nest on these beaches is much lower than Atlantic Loggerheads, but represents a significant portion of the Florida population (Ehrhart 1976). Some disorientation of hatchlings due to lighting has occurred on KSC and CCAFS beaches (section 4).

These beaches provide habitat for a wintering population of shorebirds such as Sanderlings, and are used during migration by many other shorebirds. Although the Piping Plover occasionally is sighted in the area, few or none winter here. The Wilson's Plover occurs in low numbers on KSC and in Florida. Successful nesting occasionally occurs on beaches (D. Cooley pers. comm.). The Wilson's Plover is especially endangered on KSC. Royal, Caspian, Sandwich, and Least Terns use the beaches for loafing. The American Oystercatcher is often associated with beaches elsewhere, but on KSC it typically occupies spoil islands and is rarely observed on the beaches. The impacts to this habitat include the effects of trash that wash onto the beach, public access, and lighting in operational areas.

#### 5.7 Scrub and Pine Flatwoods

Scrub and pine flatwoods on KSC have similar shrub layers, but pine flatwoods differ by having an open overstory of slash pine (*Pinus elliotii*) and occasionally pond pine (*P. serotina*). Scrub oaks (*Quercus myrtifolia*, *Q. geminata*, *Q. chapmanii*) dominate drier sites, while saw palmetto *Serenoa repens* dominates the wetter end of the scrub (Schmalzer and Hinkle 1987, 1991, 1992; Breininger et al. 1988; Breininger



and Schmalzer 1990). On most sites, a mixed oak/palmetto shrub layer occurs. Scrub, except saw palmetto scrub, is often a term used to describe an excessively drained desert-like habitat (Woolfenden and Fitzpatrick 1984). Most scrub and pine flatwoods on KSC differ by having a water table that is close to the surface for much of the year (Breininger et al. 1988). Well drained ridges occur as a series of long narrow strips formed on relict dunes oriented north-to-south. These comprise only 14% of the scrub and slash pine flatwoods; however, scrub oaks are abundant within patches in at least half of the remaining scrub and pine flatwoods (Breininger et al. 1991).

There are no records of longleaf pine/wiregrass or longleaf pine/turkey oak ("sandhill") occurring on KSC in the recent past. Sandhill may have occurred in some excessively drained areas north of Haulover Canal where an occasional turkey oak (*Q. laevis*) can be found. The few scattered stands of sand pine scrub on KSC are small and have a very open tree canopy. A few small stands of scrub hickory (*Carya floridana*) occur on KSC; this is probably the most limited plant association on KSC. Some scrub is mapped as disturbed scrub, which was oak/palmetto scrub that was cleared and has revegetated (Breininger and Schmalzer 1990).

No other habitat has more endangered or potentially endangered wildlife species that are permanent residents. Many of the amphibians found in scrub and slash pine flatwoods use nearby marshes for reproduction. Amphibians are part of the food chain for numerous species inhabiting scrub and slash pine, particularly the Eastern Indigo Snake which uses Gopher Tortoise burrows as den sites and marshes for hunting. Indigo Snakes use all habitats within the scrub and pine flatwoods landscape and may occur far from well drained areas (Kehl et al. 1991). The average homerange has been nearly 121 ha for males and 31 ha for females (Kehl et al. 1991). Homerange boundaries have shown little overlap among males; however, female boundaries may overlap homeranges of one or more males. Male Indigo Snakes may exclude other males from their homerange but not females. Thus, individual Indigo

Snakes require large amounts of habitat, and the population size may be of special concern given the frequency of road mortality.

Gopher Tortoises also have a wide distribution, using nearly all scrub and pine flatwoods (Breininger et al. 1988, 1991; Giovanetto 1988). Telemetry studies have shown that Gopher Tortoises readily use flooded burrows even when unflooded burrows are nearby (Smith and Breininger in preparation). Gopher Tortoises prefer more frequent fire than Florida Scrub Jays (Breininger et al. 1988). However, Gopher Tortoise densities are not significantly lower within preferred Scrub Jay habitat when compared to other areas. Recruitment of Gopher Tortoises into the population also occurs in preferred Florida Scrub Jay habitat (Breininger et al. 1994). Eastern Diamondback Rattlesnakes and Eastern Coachwhips are abundant in scrub and pine flatwoods, but there are no data on their ecology.

KSC once supported one of the most dense concentrations of Bald Eagles in North America; today less than 10 pairs nest on KSC (Hardesty and Collopy 1991). The population on KSC has not recovered as it has elsewhere in Florida for reasons that are unclear. Bald Eagles appear to select for large supercanopy or codominant trees with stands having an open canopy of 25-47 trees/ha (Hardesty and Collopy 1991). Individual trees of the stature used as Eagle nest sites are rare on KSC due to past logging activities, a fire suppression policy that allowed heavy levels of fuels to accumulate, and subsequent wild and prescribed fires. Most nest sites for the Bald Eagle are in poorly drained slash pine or within the grassy swales interspersed in these areas (J. Hardesty pers. comm.). It is unclear whether these sites provide optimal conditions for pine growth or whether they serve as refugia for pine regeneration and survival in a landscape subject to periodic fires.

Fifty percent of the slash pine that is of current or recent historical importance to Bald Eagles (defined as all slash pine within 0.8 km of a nest site) overlaps 12% of areas identified as Florida Scrub Jay population centers (Breininger et al. 1990). This

suggests Bald Eagle management should take priority over Florida Scrub Jay management in the areas of overlap. Some additional areas should be located for Bald Eagle nest site management. Florida Scrub Jay densities decline with increasing slash pine density between 25-50 trees/ha (Breininger unpublished data) which is tree density that is common in at many Eagle nest sites. Habitat management does not need be performed for either species in a manner that is detrimental to the other. Stands used for nesting by Bald Eagles do not need to be large. There is overlap in suitability with respect to pine density, and pine stands will most likely occur in poorly drained areas, whereas Scrub Jays prefer well-drained areas.

Nearly 80% of the Florida Scrub Jay population occurs within 300 m of well drained areas. Florida Scrub Jays have the highest densities in areas with 20-50% of the area comprised of open sand or sparse herbaceous vegetation, >50% of the shrub layer comprised of scrub oaks,  $\leq$  15% pine canopy cover,  $\geq$ 100 m of a forest, and a shrub height of 120-169 cm (Breininger 1992). Average territory size has ranged from 3-7 ha in some optimal scrub habitat (Breininger and Smith 1989 a,b) to 10 ha in pine flatwoods (Breininger et al. in prep.). Habitat suitable for Florida Scrub Jays is suitable for most scrub and pine flatwoods birds on KSC except for special requirements for Bald Eagles described above and for the Downy Woodpecker (Picoides pubescens). Populations of this woodpecker are apparently maintained by an abundance of snags in recently burned pine flatwoods (Breininger and Smith 1992). The historical importance of pinelands to the Loggerhead Shrike is unclear. Most pinelands on KSC have a dense shrubby layer and Loggerhead Shrikes are rare. If KSC habitats were historically important to Loggerhead Shrikes, native pinelands might have been important and an open structure would probably have been found.

Bobcats are top common predators within scrub and pine flatwoods on KSC (Ehrhart 1976). The authors observe at least one successful litter produced each year in the Happy Creek scrub study site. The Florida Mouse populations may be

sustained within well-drained areas, but they do at least occasionally occur within some poorly drained areas (Stout 1980). Long term research at Archbold Biological Station suggests habitat suitable for Florida Scrub Jays is suitable for small mammal species within well-drained scrub and pine flatwoods since small mammals have a broader successional tolerance and are divided into groups that prefer older or more recently burned areas (Layne 1990). Many herpetofauna that occupy scrub also use the middle successional phase that is preferred by Florida Scrub Jays (Campbell and Christman 1982). Gopher Frogs require ephemeral marshes to breed.

Information suggests that the management indicator species to maintain biological diversity within scrub and pine flatwoods should be the Gopher Frog, Eastern Indigo Snake, Southern Bald Eagle, Florida Scrub Jay, Downy Woodpecker, Florida Mouse, Bobcat, and possibly the Loggerhead Shrike. Habitat potential varies across the landscape for many of these species and only a fraction of the total habitat available has potential to be optimal. There may be potential to reestablish a Red-cockaded population as pinelands mature.

A small amount of habitat is developed each year, but cumulative loss of habitat could become significant within a few decades without compensation. Loss is being compensated by creating scrub in abandoned citrus groves and restoring degraded, unburned scrub. A fire suppression policy was in effect on KSC from 1963 until 1975, when the USFWS began a limited prescribed fire program. After severe wildfires during 1981, a more extensive prescribed fire program was instituted to reduce fuel levels and of wildfires. However, scrub oaks have reached tree stature in some areas so that fires have little influence. This is especially true along edges and some disturbed areas. Revegetation of areas subject to mechanical clearing of shrubs and disturbance to the soil layer often results in a fuel structure that burns poorly even after 20 years (Breiningner and Schmalzer 1990). Other areas adjacent to NASA facilities or Eagle's nests are especially overgrown and have accumulated fuel levels that will

make fires especially difficult to control. The objective of restoration is to modify these areas so that they can once again be maintained by fire (Schmalzer et al. in preparation). However, restoration is expensive and is currently funded as only a small portion of the acreage where restoration is needed.

In 1981, a three year fire rotation was implemented to reduce fuels that had accumulated during a twenty year period of fire suppression. Some believed that shrubs had invaded the KSC landscape during the period of fire suppression and all native Florida pinelands should be mostly pines and wiregrass. It is unlikely that previous fire suppression practices resulted in the invasion of shrubs into the pinelands on KSC given the predominant vegetative reproduction characteristic of scrub species and relatively short (20 year) period of fire suppression which followed an open range period. Several large areas of primary scrub habitat were burned extensively 3-4 times in the last twelve years. Such a rotation is detrimental to Florida Scrub Jays (Cox 1984, Gipe 1987, Breininger et al. 1988, Fitzpatrick et al. 1991). Short burning rotations of extensive fires can eliminate pines and perpetuate saw palmetto (Wade et al. 1980). However, these provide opportunity to determine whether a few frequent fires can restore native landscape conditions. The amount of frequent and extensively burned scrub is small compared to the amount of scrub that needs more frequent burning.

## 5.8 Broad-leaved Forests

Broad-leaved forests on KSC include subtropical and temperate species (Schmalzer and Hinkle 1985, Provancha et al. 1986b) because KSC is a transition zone between a temperate broad-leaved evergreen forest and tropical forest (Greller 1980). Cypress swamps do not occur on KSC. Four major broad-leaved forests occur on KSC. Oak-cabbage palm hammock has a canopy typically dominated by live oak

(Quercus virginiana), but cabbage palm (Sabal palmetto), laurel oak (Q. laurifolia), elm (Ulmus americana), and red mulberry (Morus rubra) also occur. Shrubs of tropical affinity typically dominate the understory (Schmalzer and Hinkle 1985). Red bay-live oak-laurel oak hammock (RBL) has a canopy dominated by live or laurel oak, but red bay (Persea borbonia) often occurs. The understory is dominated by saw palmetto (Serenoa repens). Hardwood swamps are typically dominated by deciduous species, especially red maple (Acer rubrum); elm and persimmon (Diospyros virginiana) may be common. These swamps often include evergreen taxa such as laurel oak and cabbage palm. Ferns are often abundant in the understory (Schmalzer and Hinkle 1985). Willow swamps are dominated by the deciduous Carolina willow (Salix caroliniana). However, red maple and wax myrtle (Myrica cerifera) are often present. The understory is dominated by aquatic plants such as arrowhead (Sagittaria stagnorum). Willow swamps occur in deeper water and on sites with longer hydroperiods than other hardwood swamps (Schmalzer and Hinkle 1985). Coastal woodlands also occur in patches along the coastline (Johnson et al. 1991), especially in areas not subject to recent fire either due to man-made or natural landscape features.

Avian and small mammal studies, but no quantitative herpetological studies, have been performed in this habitat. Indigo Snakes occasionally use this habitat (Kehl et al. 1991). Elsewhere, Indigo Snakes were found to use buttresses of trees as winter den sites within woodlands (open tree canopies that did not have interlocking tree canopy) but they appeared to avoid forests (Moler 1987). Eastern Kingsnakes are thought to use broad-leaved forests (see Appendix A). Broad-leaved forests are important for the maintenance of regional populations of the Red-shouldered Hawk, Cooper's Hawk, Barred Owl, Pileated Woodpecker and possibly Black Vulture (Coragyps atratus) and Turkey Vulture (Cathartes aura) (Breininger 1990). These species occupy large feeding territories (Schoener 1968), occurring in low densities

(Breininger 1990), and occupying higher trophic levels. The Red-shouldered Hawk and Barred Owl may require large forested tracts (Craighead and Craighead 1956, Hamel et al. 1982). Several large forests occur on KSC; it is important that these large tracts remain intact for preservation of faunal integrity. Many areas mapped as this habitat type include small sized forests and lack old, large trees. These forests may occasionally be important to many migrating warblers and other neotropical migrants (see Appendix B). Neotropical migrants that are area-sensitive breeders in large forests (Robbins 1979, 1980; Whitcomb et al. 1981; Hamel et al. 1982) do not breed on KSC. River Otters and Bobcats use hardwood forests (Gosselink and Lee 1989). On KSC, these habitats are typically not associated with deep standing water (such as rivers) although ditches are sometimes within or adjacent to these areas. Bats appear to be associated with hammocks in central Florida (Jennings 1958).

Little NASA construction occurs in these forests except in habitat fragments. Many of these fragments were once scrub, pine flatwoods, or marshes that became isolated by facility development and have undergone vegetation structural changes as oaks grew into large trees. Native forests on KSC are typically wetlands or are interspersed with forested wetlands. Habitat compensation to create new forested wetlands is difficult to achieve and extremely expensive. Recent habitat loss of native forests has been associated with line of sight clearing at the Shuttle Landing facility (SLF). The amount of forested habitat on KSC has dramatically increased since the 1940s; this trend is clearly observed using aerial photography. The increase of forested habitat is likely to increase as habitat fragments of scrub and marshes continue to remain unburned. Forests occasionally are subject to fire as evident from fire scars, but fires have little influence on composition and structure of most native forests (P. Schmalzer pers. comm.). Except for red bay/live oak/laurel oak hammocks, which often have a saw palmetto understory, and some late successional marshes that still have an abundance of marsh grasses, forests burn poorly. This is not true for

some coastal woodlands that can be converted to scrub communities (at least temporarily) by hot fires; this may be a natural process. Other native forests on KSC are not maintained by periodic fire, and few fires have any influence on the habitat. The interruption of natural drainage patterns, however, can impact these forests by either increasing or decreasing the hydroperiod.

### 5.9 Miscellaneous Disturbed Habitats

These habitats are dominated by herbaceous plants, shrubs, and/or trees and comprise old fields (some areas mapped as ruderal), citrus groves, dikes, and other areas with wax myrtle, Brazilian pepper, Melaleuca, Australian pine (Casuarina). This habitat category excludes impoundments, ditches, disturbed scrub and pine flatwoods, spoil islands, and ruderal grass. Brazilian pepper is most abundant where there was soil disturbance although scattered individuals can be found in some mesic and hydric areas. Brazilian Pepper and Australian pine are not common in disturbed scrub and pine flatwoods except where planted, or areas with dredge spoil material, or in disturbed coastal scrub. The invasion into native habitats may be limited by periodic freezes because these exotics tend to be sensitive to frost. Many native herbaceous plants, wax myrtle, groundsel, grape vine (Vitis), and cabbage palms are common in disturbed areas. Some abandoned citrus groves have been invaded by cabbage palms and grape vines that cover nearly all of the area. Historical aerial photography suggests this vine community, once established, allows the establishment of few other plants since the vines are capable of covering all other vegetation. This vine habitat occurs on a variety of sites and has the ability to spread into other undisturbed habitats. Vines can have a negative impact on other vegetation and be responsible for little recruitment of other species resulting in a perpetual vine community (e.g., Whigham 1984).



Some disturbed areas are used by many endangered and potentially endangered species but are required by few or none. Some dikes, particularly the Shiloh dike, have recently been important for nesting by Diamondback Terrapins (R. Seigel pers. comm.). Most disturbed types support fewer endangered and potentially endangered species than the native habitat that originally occurred on these sites. Brazilian pepper stands, for example, have a less diverse and lower density of native birds than undisturbed habitats (Curnutt 1989, Breininger unpublished data). Gopher tortoises are sometimes very abundant in disturbed areas as are Common Ground Doves.

Control of exotic vegetation, especially Melaleuca and Australian pine, is being performed by MINWR. Brazilian pepper is difficult, if not nearly impossible to control. These disturbed habitats are recommended sites for future development and some are recommended sites for habitat restoration and creation. Much citrus agriculture occurred on Merritt Island prior to NASA purchasing the land, and historical agreements have allowed many citrus groves to remain. Past freezes devastated citrus groves on north Merritt Island and these have been abandoned. These abandoned groves are extensive and, in contrast to groves within the NASA security area, occur on well drained soils. Many were probably scrub but some turkey oak is present so that some small amounts of sandhill vegetation may also have occurred there. Much, or perhaps nearly all, of the vegetation and fauna native to sandhill areas can be restored on abandoned citrus groves sites (Humphrey et al. 1985). We believe that scrub can also be restored on these sites, at least in a manner that provides good quality habitat for many species of concern. This has been recommended as one of the actions to offset construction in scrub habitat elsewhere on KSC. Otherwise, hundreds of acres of abandoned groves may become rapidly overtaken by cabbage palms and grape vines.

## 5.10 Islands

This habitat includes natural islands that are dominated by salt marsh vegetation and spoil islands that are man-made. Most occur in the Indian and Banana Rivers, Banana Creek, or Mosquito Lagoon, as well as natural salt marsh islands within Mosquito Lagoon, Banana Creek, and Moore Creek. Moore Creek, although impounded, was once an estuarine embayment located along Banana Creek. Island habitat, as termed in this document, does not refer to patches of marsh, swamp, or upland habitat located within impoundments where open water surrounds the original salt marsh vegetation due impoundment. Island habitat refers to permanent islands surrounded by deeper water where islands were present before impoundment. There are many natural islands within Mosquito Lagoon. These were dominated by mangroves in the 1970s and much of the 1980s, but subsequent freezes have converted them back into salt marshes (e.g., salt grass, Salicornia, Batis maritima). Spoil islands are made of material dredged from the estuary to provide channels for water navigation. They were constructed between 1937-1974 and range in size from 0.04-13.2 ha. They range from barely emergent shell and sand bars to islands with 15 m tall Australian pines. There are 75-100 spoil islands on KSC property or immediately adjacent to KSC. Most are in public access areas where they are heavily utilized; large bird colonies in these areas are posted off limits and are under jurisdiction of the USFWS. Some spoil islands are in the north Banana River and eastern Banana Creek within the NASA security area and closed to public access.

Several surveys of vegetation and bird use of spoil islands in Florida have been conducted (Schreiber and Schreiber 1978, Lewis and Lewis 1978, DNR 1990). These surveys did not include all islands on KSC used by colonial nesting birds. Natural islands in Mosquito Lagoon and spoil islands in Banana Creek and Banana River were excluded. The following summarizes typical succession patterns on spoil

islands. Marsh species, including mangroves, colonize the intertidal area within a few years. Other grasses and herbaceous plants typically become established within 3-5 years. Low woody shrubs become established within 5-50 years. Subsequently, Australian pine, cabbage palm, Brazilian pepper, or Southern red cedar (Juniperus silicicola) may eventually dominate (Lewis and Lewis 1978). Some portions of islands may remain bare.

Some islands may be important for the East Coast Diamondback Terrapin (Seigel 1979, 1980 a,b) although habitat features important to Terrapins are largely unknown. Islands on KSC are used for roosting, loafing, nesting, and feeding by many resident and migratory waterbirds (Ehrhart 1976, Schreiber and Schreiber 1978, Clark 1978, Osborn and Custer 1978, NASA 1979, Girard and Taylor 1979, Nesbitt et al. 1982, Clark and Lee 1982, DNR 1990). Schreiber and Schreiber (1978) classified three habitat types that are characterized by different assemblages of nesting birds. The "clear, sandy-rocky beach, berm and open area habitat", hereafter referred to as "mostly bare habitat", is needed by the Least Tern, Black Skimmer, and Wilson's Plover. Only two Wilson's Plovers were seen on one spoil island in Florida by Schreiber and Schreiber (1978). This island was located near KSC in the Indian River. None were seen in a recent survey (DNR 1990). "Sparsely vegetated areas of grass, with few low shrubs", hereafter referred to as "sparse grassy habitat", is used by the American Oystercatcher, Royal Tern, Gull-billed Tern, Caspian Tern, Black-necked Stilt, and Sandwich Tern.

Mostly bare and sparse grassy habitat are the two most limiting habitat types on spoil islands due to successional processes. Many spoil islands have bare and grassy patches but they also include many trees and large shrubs (Lewis and Lewis 1978, Provanca et al. 1986) which may provide cover and perch sites for predators. Spoil islands on KSC were described as one of two primary nesting sites for Royal Terns in Florida (Clapp et. al. 1983). There are many years when no Royal Tern

nesting was reported on KSC for unknown reasons. Least Terns have nested in many NASA operational areas perhaps because there are few suitable islands that remain. Nesting on roof tops, causeways, runways, impoundments, and construction sites has been noted, but no large colonies have been reported on islands or along the ocean beaches. Except for those on rooftops and islands, nesting Least Terns are extremely susceptible to ground predators and often have poor or no reproductive success. The population of Least Terns on KSC was once estimated to be 300-400 birds (NASA 1979).

Mostly bare and sparse grassy spoil islands have long been recognized as important for the conservation of biological diversity. Management recommendations for spoil islands made by Schreiber and Schreiber (1978) are summarized below. We repeat these because persistent and widespread implementation of these recommendations would remove the most important factors that have been limiting several endangered and potentially endangered species:

1. Human disturbance of islands used for nesting by waterbirds should be limited or completely prohibited. Designate colony sites as sanctuaries and post them.
2. Mammalian predators (rats, mice, dogs, cats, raccoons) should be prevented from accessing islands and should be removed if they gain access (implies monitoring).
3. Modify islands to control erosion where necessary and attain desired successional stages for selected islands and maintain them.
4. Create new islands specifically for bird use where appropriate.

In the spring of 1991, MINWR personnel cleared two islands in Banana River in an attempt to provide nesting habitat for certain colonial nesting shorebirds. On 11 June 1991, there were 50 Black Skimmer nests on one island, as well as 79 Black Skimmers, two Laughing Gulls (Larus), and two Willets; no birds were on the other

island (K. Whaley, R. Hight, MINWR, pers. comm.). Other agencies recommend planting native trees and shrubs on spoil islands (DNR 1990).

Islands that have shrubs and trees are used by Wood Storks, Brown Pelicans, White Ibises, Snowy Egrets, Tricolored Herons, Great Egrets, Glossy Ibises, Little Blue Herons, Roseate Spoonbills, Reddish Egrets, Black-crowned Night Herons, and Ospreys (Table 9). A few other species such as the Florida Prairie Warbler and Black-wiskered Vireo use mangrove islands.

Several Wood Stork studies have been funded by NASA. Early research included colony studies (Clark 1978); recent work has included studies of feeding habitat and nesting locations (Smith and Breininger unpublished data). The nesting population on KSC can be expected to fluctuate considerably depending on local and regional conditions. The number of Wood Storks in central and northern Florida has nearly doubled since 1960 (Ogden 1991). Within any location there is considerable yearly variation in the number of nesting pairs (Rodgers et al. 1987). Poor nesting success during recent years in south Florida suggests that populations in central Florida may become increasingly important to the species' survival. Dead mangroves, killed in recent freezes, have become too weak to support nests, and it is likely to take many years for them to regrow to sufficient stature. Wood Storks elsewhere use a variety of vegetation for nesting including man-made nesting sites (Ogden 1991), so nesting on other spoil island vegetation on KSC should be possible. All known Wood Stork nesting on KSC has been restricted to mangroves. It is possible to plant mangroves or at least encourage the successful colonization by propagules (R. Paul pers. comm.) should it become desirable to enhance the development of mangrove islands in selected locations.

Table 9. Estimates of wading bird nests on KSC, 1976-1990.

	1976 <sup>a</sup>	1977 <sup>a</sup>	1978 <sup>a</sup>	1979	1980 <sup>b</sup>	1981 <sup>b</sup>	1982 <sup>b</sup>	1983 <sup>b</sup>	1984 <sup>b</sup>	1985 <sup>b</sup>	1986 <sup>b</sup>	1987 <sup>c</sup>	1988 <sup>c</sup>	1989 <sup>c</sup>	1990 <sup>c</sup>
Great Blue Heron	36	155	30		+ 100			+ 20	170	145		79	69	106	155
Great Egret	145	170	150		830		x		460	504		417	304	420	592
Snowy Egret	515	0	+ 300		+ 483				336	300		428	273	320	1224
Little Blue Heron	142	100	+ 1		+ 15			1		130		65	11	12	60
Tricolored Heron	625	100	+ 700		+ 378			+ 13		153		452	188	407	733
Reddish Egret	0	0	1		2	x	x	x		1	x	16	12	9	14
Cattle Egret	2300	875	1000		+ 1100		x			1700		301	164	115	450
Green-backed Heron	12	0	0		+ 10					4		12	0	5	7
Black-crowned Night-heron	0	0	12		+ 30					25		30	10	3	13
Yellow-crowned Night-heron	0	0	0							5		x <sup>d</sup>	0	0	0
White Ibis	333	800	500		1260		x	+ 200	500	820		801	715	1454	7226
Glossy Ibis	36	x	20		x			+ 200		90		150	50	133	423
Roseate Spoonbill	0	0	0		0					0		1	4	4	6
Wood Stork	250	600	0		410	0	50	250	300	235	250	0	45	122	121
Total estimated nests	4394	+ 2800	+ 2713		+ 4618	x	+ 50	+ 684	1766	4112	+ 250	2751	1845	3110	11024
Number of colonies	4	3	+ 2		6	6	x	x	4	6	4	7	4	7	6

Missing values indicate no survey was done

+ low estimate; on some colonies, presence was noted, but not quantified  
x no estimate; presence noted

a Nesbitt et al. 1982

b MINWR Annual Narratives

c Smith & Breininger, unpublished.

d Rich Paul, pers. comm.

## 5.11 Ditches and Canals

The function of ditches is to store and carry water from roads and facilities and provide fill for dike construction, roads, firebreaks, and other similar purposes. There are nearly 560 km of ditches on KSC. The physical characteristics of the ditches and canals on KSC vary greatly. Widths range from 2-20 m and slopes range from gradual to sharp drops adjacent to the bank. Depths vary from <1 m to several meters, so that some of the ditches hold water year-round and others are wet only during rainy periods or storm events. Vegetation within the ditches includes emergents such as willows and cattails, and submergents such as widgeon grass, and Chara. Ditches near roads and facilities are often contiguous with mowed grass or sand. Ditches within impoundments are adjacent to salt marsh vegetation, open water, or have overhanging mangroves or Brazilian pepper. Many ditches are adjacent to other native vegetation such as scrub, pine flatwoods, or forests.

Twenty-nine species listed in Table 8 use ditches and canals for some aspect of their biology. Data from several radiotagged Indigo Snakes on KSC suggest that they use ditches and the surrounding vegetation as feeding areas (Kehl et al. unpublished data). American Alligator, Round-tailed Muskrat, and River Otter populations might decline if ditches were eliminated or altered in a manner which made them unsuitable. American Alligators feed and rest in the water, and dig dens to lay eggs in the banks where the young Alligators spend their first several weeks. Round-tailed Muskrat nests have been found in the canals along SR 3 with trails leading to the grassy road shoulders where they presumably feed (L. Ehrhart pers. comm.). Most of the other species listed in common in the ditches along roads and impoundments. Wading birds seem to prefer the shallow water/vegetation interface along the edge instead of the deeper open water in the center of the ditches (Smith and Breininger unpub. data). Impacts to ditches occur due to frequent herbicide application, occasional dredging, and spills of environmental

contaminants. Most ditches lead directly to the estuary which may be adversely affected. Ditches not only perform drainage and stormwater functions but also are important wildlife habitat and can function as filters.

#### 5.12 Ruderal Grass

This habitat is comprised of periodically mowed grass dominated by bahia (*Paspalum notatum*). It typically occurs adjacent to roads, facilities, power lines, and other structures. There are nearly 267 km of roads. Ruderal habitat is used by many species, particularly the Gopher Tortoise, Barn Owl, Great Horned Owl, Eastern American Kestrel, Red-tailed Hawk, Red-shouldered Hawk, Merlin, and Loggerhead Shrike, White Ibis, Glossy Ibis, and Florida Scrub Jay. This habitat may be necessary for Kestrels, Loggerhead Shrikes, and Barn Owls especially given the less open structure of scrub and pinelands that now occurs on KSC. The use of a ruderal site often depends on surrounding habitat. Barn Owls nest in some old buildings on CCAFS particularly adjacent to coastal grasslands (M. Mercadante pers. comm.). Nearly 314 ha of ruderal habitat occurs adjacent to oak scrub within Scrub Jay population centers (Breininger et al. 1991). Many species can be influenced by management practices including pesticide use and the frequency of mowing operations. Shrikes are not only influenced by pesticide use, but fertilizer use can also impact Shrike populations due to impacts on prey populations (R. Yosef, H. Swain, pers. comm.).

### 6.0 RECOMMENDATIONS FOR MANAGEMENT AND MONITORING

The following identifies information gaps which may be important for maintaining endangered and potentially endangered wildlife populations on KSC. No attempts were made to distinguish management and monitoring responsibilities among agencies because such attempts quickly produce a convoluted series of



issues. Thus, interagency collaboration is essential for those involved in most aspects of the management and monitoring of the Merritt Island/Cape Canaveral/Turnbull Ecosystem.

The need for management was justified in section 4.2. The importance of long term monitoring is provided in the following paragraphs. Proper management of environmental resources requires direct biological monitoring (Karr 1987). This is important because in many cases, neither theory nor short term data are sufficient to predict impacts. Animals and their habitat operate as a functional unit so that monitoring one without the other will fail to determine cause and effect relationships (Salwasser et al. 1983). Monitoring is a legal mandate to assure mitigative measures and other commitments associated with federal projects are carried out and have the intended effects (Salwasser et al. 1983).

Successful monitoring programs provide ecologically and statistically valid information that is adequately sensitive to detect trends or changes. Not all programs are successful. Unsuccessful programs seldom publish in peer reviewed journals and the data are of short term nature or cannot be compared with other monitoring studies (Hirst 1983). Monitoring programs need carefully formulated objectives designed to answer questions of management and maintain sustainable and reliable funding. Publishing monitoring results for periodic outside review is important to establishing and maintaining the proper, accepted management activities (Hirst 1983).

Most short term studies provide only a glimpse of events at a point in time. Several years of data are needed to determine true trends in population and habitat structure. One study which exemplifies the misleading properties of short term data and the need for long term studies was conducted by Gill et al. (1983) on newts in South Carolina. In this study, Red-spotted Newts were marked for identification and surveys were conducted for six years to relocate the marked newts. Results led to the conclusions that breeding populations were derived from ponds that were far away

because marked newts did not appear to return to their breeding pond. Marked newts finally began appearing in the seventh year. It took a long term study to determine the length of time for newts to reach maturity and return to breeding grounds.

This section is structured to identify gaps in knowledge about the ecology of KSC and areas of information needed to complete the understanding of KSC's role in regional and global biodiversity. Section 4 of this document details each topic and it is suggested that the details provided in section 4 be read in addition to these lists. Additional information is provided throughout the document and in the species accounts found in Appendix A. Not all gaps have been identified. Obvious critical gaps in information were chosen to produce a list of questions.

#### 6.1 Review of Historical Literature

Thorough literature reviews help create a base for formulating natural processes and assess the results of recent studies in a perspective of long term trends. Details concerning the use of historical literature are provided in sections 1.0 and 1.3. Areas with information gaps include: 1) the historical distribution and numbers of wading birds using KSC, particularly bird use before and after impoundment of salt marshes; 2) the locations of nesting sites for colonial nesting waterbirds and shorebirds before, during and after spoil island creation; 3) the fire history of various KSC habitats and use of these habitats by species of concern throughout the fire history; and, 3) the background levels of measurements in environmental quality.

#### 6.2 Habitat Fragmentation and Landscape Linkages

One of the most critical concerns in conservation today is the extent of habitat fragmentation. Habitat fragmentation isolates populations of species and, in turn, weakens genetic health, reduces the opportunity to evolve and adapt to changing

conditions, diminishes the ability to withstand catastrophic events, and increases the rate of extinction (Gilpin and Soule 1986). Planning and providing landscape linkages may lessen the detrimental effects of fragmentation by allowing the exchange of genetic information over an effectively larger area and allowing movement to better habitat conditions. A detailed account of the importance of these issues is provided in sections 4.1.2. A few of the information gaps and possible management strategies are offered below; however, the list is not exclusive and an understanding of the problem of habitat fragmentation is critical to filling the information gaps and making management decisions.

Information needs for KSC include: 1) identifying the distribution of existing habitat fragments on a local and regional scale, 2) assessing the consequences of fragmentation on native flora and fauna on KSC, 3) finding possible landscape linkages between fragments across human and natural barriers 4) identifying how KSC fits into these linkages and 5) investigating the significance of Haulover Canal as a barrier to terrestrial species and a corridor to aquatic species. Some of the management goals for KSC would include: 1) developing corridors between KSC and Turnbull hammock; KSC and St John's River; KSC and the Atlantic Coastal Ridge; and KSC and CCAFS, 2) focusing scrub restoration and creation along these corridor systems, 3) reducing road mortality, especially along possible animal use corridors and 4) reestablishing an open, periodically burned landscape of scrub and slash pine flatwoods along State Road 3.

### 6.3 Minimum Viable Population Size

The minimum viable population (MVP) is an estimate of the number of individuals needed to sustain a species at different levels of risk to extinction (Soule 1986). Additional information about the species such as the number of reproductive

individuals, mortality and natality rates, gender ratios, behavioral limitations, and movement patterns are needed to investigate risks for extinction. Some risk assessment needs are provided in sections 4.3.1, 4.3.2 and Appendix A. The ultimate goal should be to establish population sizes for species on KSC that are ecologically functional on both the local and regional levels. Some steps to obtain this long term goal are 1) identify the species which have less than 500 individuals on KSC and have a low exchange rate with other populations in the region, 2) perform ecological risk evaluations using population models, 3) gather demographic, genetic, and other information on selected species to investigate inbreeding and other problems associated with low population numbers, and 4) determine the need for relocating individuals and monitoring their success.

#### 6.4 Environmental Contaminants

Environmental contaminants can range from physical pollutants such as plastics to increased noise or lighting which alter a species' behavior. Contaminants are a global problem and are of concern on KSC. Recently, attempts have been made to identify areas on KSC which may be contributing to lower environmental quality. The details about these areas are discussed in section 4.1.4. Three specific areas which need further investigation are 1) the fate and effects of heavy metals and pesticides on KSC (especially in citrus groves), 2) the effects of lighting on species such as the Beach Mouse and colonial waterbirds which may be vulnerable around heavily lighted facilities, and 3) developing a protocol for reducing light-related turtle mortality already occurring on KSC.

#### 6.5. Stormwater

Florida's average rainfall, weather patterns, low relief and increasing human

habitation make stormwater management practices a major conservation issue. Water diverted from natural flow patterns can eliminate wetlands, decrease salinities, increase turbidity and nutrient loads at discharge points, and reduce aquifer recharge. Details concerning stormwater practices are provided in sections 4.1.3 and 5.11. Many of Florida's development, pollution, wildlife and habitat problems involve the use/misuse of water. Like the rest of Florida, KSC has altered water patterns which effect wildlife in a variety of ways. One goal should be to gather information about water management practices and how they effect the native fauna and flora on KSC. For example, it would be beneficial to identify possible linkages between critical habitats via stormwater structures and identify the type of habitat provided by the structures and their resultant water flow. Also, it is important to identify the fates of pesticide applications via stormwater structures and their effects on groundwater and the estuary. Management goals could include alternative varying drainage strategies which enhance native populations.

## 6.6 Habitats

Understanding the ecology of habitats on KSC is important in order to understand the role which KSC plays in the regional preservation of faunal integrity. Each habitat must be understood in the perspective of all other habitats in order to establish a functional ecosystem. The information gaps identified for each habitat type provide some of the basic research and management needs; however, these lists are not all-inclusive.

### Forest Habitats

Details about this habitat are provided in 5.8 and individual species accounts in appendix A. Some of the information needs concerning forests include: 1) GIS files to

categorize forest types, 2) determining the size and habitat characteristics of forests which support nesting Red-shouldered Hawks and Barred Owls. An initial management goal for the region would be to develop linkages between forests for species which are dependant on that habitat.

### Scrub and Pine Flatwoods

The scrub habitat of Florida has been severely degraded through altered fire regimes, fragmentation, and human habitation. The high degree of endemism and habitat specificity make scrub and pine flatwoods some of the most critically imperiled habitats in Florida. These habitat types are discussed in detail in sections 4.2.2 and 5.7. Additionally, the individual species accounts in Appendix A provide information on the species' associations within the habitat. A better understanding of the ecology of all parts of the system is needed. The gaps presented merely scratch the surface of the needs that should be addressed for a full understanding. Basic ecological studies are needed for the herpetofauna and small mammals found in scrub and pine flatwoods. Identifying the demographics of these populations and monitoring the success of habitat restoration/creation for species of concern is particularly important. Specific information is needed concerning 1) Gopher Tortoise reproductive success based on habitat characteristics, 2) recruitment patterns of Indigo Snakes, 3) fire and restoration effects on Indigo Snakes and Scrub Jays, 4) the source/sink structure of Scrub Jay metapopulations and the effects of nest predation on source populations, 5) the generation of Bald Eagle nesting habitat, and 6) quantifying the landscape impact of infrequent fire.

### Impoundments and Salt Marshes

The beneficial and detrimental effects of salt marsh impoundments have been

widely debated. Some arguments for both sides have been based on very little data and research. A great deal of information is missing about function and most species using or effected by impoundments. Details concerning salt marsh and impoundment habitat are provided in sections 4.2.2, 4.2.3, 5.1, 5.2, 5.3 and individual species accounts in Appendix A. It is important to study the pros and cons of estuarine function associated with impoundment for each individual species as well as for the ecosystem as a whole. Some species are more sensitive to changes in function than others and information needs to be gathered on these species. The existence and distribution of the Atlantic Salt Marsh Snake needs to be determined, particularly along the eastern shore of Mosquito Lagoon; the foraging success by wading birds based on habitat type and water level needs to be studied; feeding locations of Wood Storks need to be identified; and basic ecological studies on the Black Rail need to be conducted. Other management questions in impoundments include: 1) the management strategies needed to maintain wading bird populations, 2) managing impoundments for larger prey items preferred by Wood Storks, 3) the significance of KSC to Florida wading birds as nesting success decreases in south Florida, 4) evaluating impacts of water level management activities on round-tailed muskrats and peat accumulation, 5) actions to enhance fisheries such as culvert installation, 6) detrimental impacts of culvert installastion (such as impacts to oligotrophic habitats), and 7) consequences of dike removal.

## 6.7 Specific Taxa of Concern

### Colonial Nesting Water Birds

Colonial waterbirds include both shrub/tree nesting and ground nesting species. Each of these groups have specific habitat needs for roosting and nesting. Specific details about waterbirds are provided in sections 4.2.4 and 5.10 and in the

individual species accounts in Appendix A. Colonial waterbirds have been declining throughout the region especially in south Florida. Many ground nesting waterbirds require open sandy areas with sparse to no vegetative cover. Many of these species historically nested on beaches and sand spits. These areas have become increasingly developed and used for recreational purposes; therefore, these species have been forced to use alternative nesting habitats. On KSC, these alternative nest sites have included gravel roof tops, parking lots and runways, all of which have logistical concerns. Tree nesting waterbirds have also been impacted by development and recreation; however, may have benefited from the overgrowth of vegetation on spoil islands which provides some nesting and roosting habitat. Some of the management needs for ground nesting species include: performing surveys of nesting activity on spoil islands and around facilities, encouraging nesting elsewhere on KSC rather than on or near facilities, managing for more bare or sparsely vegetated spoil islands, and identifying methods to generate and maintain spoil islands in early successional stages.

Some of the research needed for all colonial waterbirds include: identifying the habitat characteristics associated with successful reproduction and nest site selection, generating quantitative data on the number of breeding and non-breeding water birds and defining the demographic parameters that limit the water bird population including survivorship of juvenile and adult birds.

## Shorebirds

Shorebirds use KSC in various ways. Many migrants use KSC beaches and mudflats as stop-overs for resting and feeding sites which enable them to complete migration. KSC is important for overwintering shorebirds. A few shorebirds use KSC for nesting. This presents an array of concerns for management and research on



shorebirds using KSC. More information on how shorebird species use KSC is provided in section 5.10 and in the individual species accounts in Appendix A. Some specific research goals for KSC include: 1) monitoring migratory and wintering shorebirds; 2) determining the size of wintering, migrating and nesting populations; 3) identifying spatial and temporal distributions, habitat preferences, foraging success and feeding sites, 4) surveying mudflats for feeding and nesting shorebirds and 5) collecting baseline ecological data on the following species:

Black-necked Stilt	Wilson's Plover
American Oystercatcher	Sanderling
Black-bellied Plover	Whimbrel
Western Sandpiper	Marbled Godwit
Short-billed Dowitcher	Red Knot
Pectoral Sandpiper	

#### Upper Trophic Level Species

Predators in an ecological food web are often at great risk to population decline. They typically have low natural population numbers, low reproductive output, large homeranges or territories, and are particularly susceptible to environmental contaminant accumulation. Details concerning upper trophic level species can be found in section 4.1.2 and in the individual species accounts in Appendix A. Some of the research needs for the upper level species using KSC are: 1) identify the winter locations for transient predatory birds such as the Peregrine Falcon, and the Merlin; 2) standardize a survey along roads, waterways, firebreaks, ruderal areas, citrus groves and beaches for upper level species; 3) identify the food habits, prey base and potential for bioaccumulation of environmental contaminants; 4) assess the role in which herpetofauna, particularly snake species, play in the food chain in maintaining

faunal integrity; 5) investigate the two remaining large mammalian predators on KSC, the River Otter and Bobcat, to examine their role in structuring faunal integrity, particularly when in competition with mesopredators and "weedy" species such as the Raccoon and Armadillo; and 6) examine the demographics in relation to the effects of road mortality on the population patterns of predators and prey.

#### Exotics, Parasites, and Mesopredators.

Introduced species, species which invade human altered habitats, and species whose natural predators have been extirpated are a growing problem in Florida and throughout the United States. Exotics can eliminate populations by out competing native flora and fauna. Parasitic species such as cowbirds benefit from increased edges and decrease the nesting success of other species. The elimination of large predators has allowed increases in mesopredators such as Raccoons. These omnivores can severely deplete native species. Details concerning the various types of species which pose a threat to natural conditions is provided in sections 4.1.3, 4.2.1, and 4.2.5. On KSC, it is important to investigate the extent and the effects of these species because, due to the isolation of the Center, its species are more vulnerable to invading populations. Some of the goals for KSC should include examining eradication opportunities and estimating the population size, distribution and reproductive success of species which are exotics, parasites or mesopredators. Assessing the potential future rate of cowbird parasitism on the Florida Prairie Warbler and Black-whiskered Vireo is one of the specific needs which should be addressed. The impacts to wading birds from nematodes associated with nutrient enriched waters affiliated with fecal matter needs study.

## Other Animals of Special Concern

Little to no information is available for many species like the East Coast Diamondback Terrapin, King Rail, Least Bittern, Loggerhead Shrike, and Round-tailed Muskrat on KSC. KSC may play a role in the survival of the East Coast Diamondback Terrapin. Collecting ecological data, especially population data, is needed for many species. The role that KSC has in biological diversity is greater than providing habitat for endangered and potentially endangered species. Other animals of concern, in addition to those described as endangered or potentially endangered, are mentioned in Appendix B.

## APPENDIX A: SPECIES ACCOUNTS

Accounts are provided for priority species in the order listed within Table 4 which corresponds to their points accumulated during the ranking process. Other species are lumped into several categories provided below. An index is provided below.

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## APPENDIX A: SPECIES ACCOUNTS

Accounts are provided for species in the order listed within Table 4 which corresponds to their points accumulated during the ranking process.

### Florida Scrub Jay (*Aphelocoma coerulescens coerulescens*)

The Florida Scrub Jay is referred to as a disjunct race of Scrub Jay which is widespread in the western U.S. and Mexico. Recent genetic studies have shown that the Florida Scrub Jay should be considered a separate species (J. Fitzpatrick and D. MacDonald, pers. comm.). Its population has declined by at least 50% (Cox 1987) and perhaps at least 80% (J. Fitzpatrick pers. comm.). Decline is due to habitat loss and degradation; most remaining populations are vulnerable to extinction due to low population size, habitat fragmentation, and degradation (Fitzpatrick et al. 1991).

The diet consists of insects and small vertebrates throughout most of the year. Acorns are necessary in winter when insect numbers are low. Nesting season ranges from late February to early June. Unlike the western Scrub Jay, the Florida Scrub Jay has a cooperative breeding system. Young jays remain in their natal territory as non-breeders for at least one year, assisting the breeding pair with territory defense, predator identification/mobbing, and nestling care (Woolfenden and Fitzpatrick 1984). A family will occupy the same territory for many years although boundaries often change slightly from one year to the next (Breininger et al. in preparation). The number of birds occupying a territory ranges from two to as high as eight; group size may vary with habitat type. The average dispersal distance from a natal territory is 0.3 km for males and 1.2 km for females (Woolfenden and Fitzpatrick 1984). The significance of this small dispersal range is important because it has an isolating influence on populations.

The largest population of Florida Scrub Jays occurs on KSC. This population is one of only three that comprise nearly 80% of the entire population. (Cox 1984, 1987; Breininger 1989). The best estimate of the KSC population is 700 territories; approximately 86% of these individuals are located within a few population centers (Breininger et al. 1991). These centers are defined as primary habitat and secondary habitat within 308 m of primary habitat. Primary habitat includes well drained scrub and slash pine; secondary habitat includes poorly drained scrub, slash pine, and coastal strand.

Territory sizes vary with habitat conditions. Average territory size ranges from 2.4 ha in disturbed well drained scrub containing abundant openings to at least 7 ha in well drained scrub containing few openings (Breininger and Smith 1989a). Territory sizes in poorly drained slash pine flatwoods average 10 ha (Breininger et al. 1992). Myrtle oak is the most commonly used shrub for nesting on KSC except near the beach where tough buckthorn is often used. Neither reproductive success or survival are uniform across the KSC landscape. Florida Scrub Jay densities and habitat characteristics on KSC have been estimated at nearly a hundred locations (Breininger 1981, 1992). These data have been used to develop a habitat suitability model which is being tested and refined using reproductive success and survival studies of colorbanded birds at ten locations on KSC (Breininger, Larson, Smith, Barkazii, Oddy, Schaub, unpublished data). The highest densities of Florida Scrub Jays occur in areas with high scrub oak cover (approximately 1.5 m in height) with adjacent areas of mowed grass or with numerous open sandy areas and only a few tall trees (Breininger 1981, Breininger and Schmalzer 1990, Breininger 1992).

Florida Scrub Jays are one of the most habitat specific birds in North America; although they occupy a broad range of habitat conditions at KSC, occupation in these areas may not be sustainable without immigration of Scrub Jays from optimal habitat. For example, the population has declined from 1988 through 1992 at Happy Creek,

which is one of the largest population centers, largely because pairs without helpers are producing too few young (Breininger, Larson, Smith, Barkazii unpublished data). This may result from habitat degradation, which began during the fire suppression period, that is not readily reversed by frequent fires (Schmalzer et al. in preparation). This partially prompted the restoration program which is a collaborative effort with MINWR where intensive management is coupled with research. The KSC Tel 4 study area is the only (relatively) long term study population in Florida where reproductive success has exceeded the mortality rate (Breininger et al. unpublished m.s.).

Ruderal areas within Scrub Jay population centers have been identified on GIS maps. Pesticide use in such areas should be restricted. These GIS files also show transportation corridors through population centers. Although roadside edges can represent optimal habitat, they also have a high potential for mortality (Dreschel et al. 1990). Roads where traffic exceeds 35 mph can have Scrub Jay mortality rates that exceed reproductive rates (Fitzpatrick et al. 1991). Stringent wetland and floodplain regulations drive industrial development into potential Scrub Jay habitat on KSC. Loss of habitat associated with facility construction has potential for long-duration cumulative effects. Minimizing development in optimal habitat and providing corridors linking optimal areas can minimize impacts of further development. Recently NASA has been required to offset losses of habitat by creating habitat in abandoned orange groves and restoring tall, unburned habitat.

Eleven percent of primary habitat is found outside Fire Management Units (FMUs); this habitat will become unsuitable without fire. There are several thousand acres of suitable habitat outside FMUs that are becoming unsuitable due to a lack of fire associated with landscape fragmentation and fire suppression. One third of the FMUs contain 96% of all primary habitat. These FMUs are responsible for the viability of the population and should be managed accordingly. Primary habitat is typically less than 1/3 of the area within an FMU. Most FMUs are comprised of vegetation types that

may naturally burn more frequently than primary habitat (Breininger et al. unpublished m.s.). A long term threat on KSC is potentially rising sea level, particularly if the rate of sea level rise is accelerated by global warming and decreasing habitat quality.

#### Atlantic Green Turtle (Chelonia mydas)

The Green Turtle is a primarily tropical species commercially valued for its meat, eggs and calipee (the cartilagenous portions of the shell) (Lund 1978a). Until the 1970s, the harvesting of Green Turtle eggs in Brevard County was not uncommon. The Florida fishery for immature Green Turtles did not become illegal until 1974. Nineteenth century reports indicate that the Green Turtle fisheries in the region began in 1878 and the species was severely effected during a 17 year period of exploitation (Provancha et al. 1991). Fisheries data for the Mosquito Lagoon in the 1800's indicate that 150 greens were exported in 1879 (Gilmore, in press). By 1895 captures of estuarine Green Turtles declined dramatically.

Within KSC boundaries there are two habitats used by Green Turtles, the estuary and the beach. The estuary, particularly Mosquito Lagoon, provides a developmental habitat for immature Green Turtles (post-yearling to subadults). The lagoon probably represents the northernmost winter range for this species. Mendonca and Ehrhart (1982) estimated this population to be about 135 animals. Witherington and Ehrhart (1989) speculated that this population was growing, based on data from cold stunning events. During the winter of 1989, 209 Green Turtles were found stunned in Mosquito Lagoon after a cold period (Schroeder et al. 1990).

The behavior and distribution of this species is affected by cold temperatures that are common in the KSC area during January and February. When lagoon water temperatures drop to 8-10 degrees (C), Turtles become lethargic and float to the surface. During the winter period they roam greater distances and in unpredictable

patterns within the lagoon when compared to summer activities. The atypical movements during winter are assumed to be attempts to leave the lagoon which, due to its configuration, acts as a trap (Mendonca 1983).

The KSC beach provides nesting habitat for Green Turtles although their numbers are low relative to Loggerhead Turtles. Green Turtles accounted for about 2 % of the marine turtle nests deposited at KSC over the last 8 years. The numbers of nests laid each season on the KSC secured beach (10 km) range from 6 to 55. Individual Green Turtles may nest every 3 years. Some years have higher nesting densities. Except for some hatchling disorientation (section 4.0), NASA/CCAFS operations have little impact on the population.

#### West Indian Manatee (Trichechus manatus)

The West Indian Manatee has been listed as endangered since 1972. All members of the order which it belongs (Siernia) are either threatened or endangered. Manatees are basically a riverine species in Florida although they are occasionally seen along the oceanside beaches. Manatees have wide-ranging migratory habits. They are found throughout Florida and southeastern Georgia and on rare occasions along coastal states further north and west. Individuals can range in excess of 820 km; some spending the coldest periods as far south as Miami and then travelling to Jacksonville or Georgia in the spring and summer (Reid et al. 1991). Manatees can be found on KSC year round with the exception of the very coldest periods.

The general trend in abundance at KSC is described by two peaks: one sharp peak in spring which drops off by summer followed by another slight increase in the fall (Shane 1983). The abundance and distribution patterns on KSC have not been static over the last 13 years of monitoring; the "population" has changed considerably, particularly when the spring peak numbers are compared. A five-fold increase in

Manatees using KSC waters in spring has been documented. The spring peak in recent years has included over 300 Manatees in the KSC boundaries of the Banana River (Provancha and Provancha 1988).

The increased numbers of Manatees appear to reflect the changes in the estuary outside KSC where the habitats are being more rapidly affected by human activities. It is likely that the increases at KSC represent a shift away from previously used areas outside the property. Statewide mortalities of manatees have increased alarmingly. Good quality habitat outside KSC has been severely marred by human development, and boating activities have been a major cause of direct mortality.

All open waters on KSC with depths in excess of one meter are potential habitat for these marine mammals, but large aggregations of Manatees are generally found where extensive seagrass beds are bordered by deep basins. Freshwater sources often attract Manatees and some researchers believe freshwater to be a requirement. The animals are frequently found in the vicinity of the Hangar AF boat basin where the Solid Rocket Booster retriever ships are docked. Another location often used by large numbers of manatees, particularly during the spring, is just north of the NASA Causeway. The waters just west of the Air Force rocket vehicle assembly buildings are frequented by Manatees during this period as well. Pepper Flats, located at the northern terminus of the Banana River near the Crawlerway and the entrance to the VAB turning basin, is an area traditionally used by Manatees and is still popular at the time of this writing (Provancha unpublished data).

#### Southeastern Beach Mouse (*Peromyscus polionotus niveiventris*)

Five subspecies of beach mice have been listed as endangered or threatened. The Southeastern Beach Mouse formerly occurred on the Atlantic Coast from Ponce Inlet in Volusia County south to Hollywood Beach in Broward County (Humphrey

1987). The Atlantic coast has been extensively developed. It is believed that KSC and CCAFS will be the major area remaining as a sustainable population, if managed properly (Paradiso 1989). The most current surveys suggest that the population has undergone a decline in much of its range (Humphrey 1987, Robson 1989).

Provancha and Oddy (in prep.) performed four quarterly surveys for Beach Mice on KSC in 1990 and 1991. A line transect method of trapping was employed in several vegetative zones in the KSC coastal strand, yielding 3937 trapnights with an overall capture rate of 13.8%. The overall capture rate increased to 15.8% when data from transects that were unoccupied by Beach Mice were deleted. These capture rates are high when compared to recent surveys from other areas along the Florida coast. Robson (1989) reported an overall Beach Mouse capture rate of only 0.7% for 5 study sites located from Brevard to Palm Beach County. His highest yield was 2.2% for Sebastian.

The Southeastern Beach Mouse is nocturnal and mostly limited to sand dunes behind the sea oats (Uniola paniculata) and dune panic grass (Paspalum amarulum), and adjacent coastal strand (Humphrey and Barbour 1981, Humphrey 1987). Stout (pers. comm.) found them in scrub and firebreaks nearly 2 km inland on Cape Canaveral. Humphrey (1987) suggested that the dune grassland habitat on Cape Canaveral was extensive, excellent habitat with high densities of Beach Mice but that the more narrow single dune at Canaveral National Seashore had lower densities. Extine and Stout (1987) suggested that the sea oats zone was marginal when compared to the adjacent interior zone dominated by clumps of saw palmetto, sea grape (Coccoloba uvifera), and the dense coastal strand just inland of the zone dominated by saw palmetto, sea grape, and wax myrtle.

There are no long-term studies for the Southeastern Beach Mouse (Stout 1979). Populations were sampled for several years in a beach grid and dune scrub grid on Cape Canaveral by Stout (1979). Beach Mice, like most small mammals, often



undergo considerable seasonal and yearly fluctuations. Populations are often lowest in summer and highest in winter and spring (Stout 1979). The beach grid was established near LC41 and extended from the high tide line into the dense scrub zone, but not as far inland as oak scrub. The dune scrub grid was comprised of a nearly complete shrub layer that included scrub oaks, saw palmetto, *Lyonia* spp., spanish plum (*Ximenia americana*) The study also included the only extensive stand of rosemary (*Ceratiola ericoides*) known on CCAFS.

Stout (1979) found that the overall minimum average for Beach Mice was 24.5 animals per grid on the beach and 10.0 per grid in dune scrub. Monthly averages were typically higher on the beach grid than on the dune scrub grid (Stout 1979). Reproductive peaks coincided with summer and fall and extended into winter for some years. Juveniles and subadults were found throughout the year but were most abundant August-January. The mean distance between successive recaptures was about 20 m, except for females on the dune scrub grid where the distance was over 30 m. Although Provancha and Oddy's study (in preparation) only encompassed one year, they observed that lactating and pregnant females were most abundant in late fall and winter. Males were in reproductive condition throughout the year but lowest numbers were in spring and the highest in winter.

Beach grasses and sea oats are the most utilized food plants (Blair 1951) although invertebrates are also eaten (Smith 1966, Layne 1978b). Food use may change seasonally since seeds are scarce in late spring and early summer. Beach Mice often dig their own burrows; individuals may use many burrows within their homerange, including ghost crabs burrows for temporary cover (Myers 1983).

Breeding activity is most evident from November through January when many juveniles are present. Litter size averages four; they reach reproductive maturity as early as 6 weeks of age. A female in the laboratory can produce 80 young during her lifetime with litters occurring about every 26 days (Bowen 1968). Potential predators

include Raccoons Skunks, Snakes, Hawks, Owls, and Great Blue Herons (Myers 1983). In human-altered landscapes, Dogs and House Cats are potential predators and the House Mouse (Mus musculus) may be a potential competitor. Provancha and Oddy (in preparation) found no signs of House Mice or House Cats in the vicinity of the Beach Mouse transects on KSC.

The influences of Shuttle launch deposition, security lighting, and launch-related noise have not been fully studied. Areas near the pads receive launch deposition which is sometimes heavy enough to severely injure sensitive vegetation found along the dunes near the pads (Schmalzer et al. 1986). These plants may then become unavailable, at least temporarily, for food and cover for Beach Mice. In some cases this could be significant particularly given that most individuals are assumed to have very small "homeranges". The buffering capability of the nearby soils is sufficiently high to maintain a pH that provides little opportunity for uptake of deposition from soils by vegetation. However, the influence of inhalable particulates and the ingestion of material that coats the vegetation is unclear. Aluminum oxide is believed to be relatively harmless, but some evidence suggests that some other metals may accumulate in a few nearfield areas (Drese et al. in preparation). Noise from launches approaches levels that have caused damage in small mammals which are especially sensitive to hearing loss or damage from loud sounds. Measured noise levels in nearfield areas are just below levels that have caused damage in other species. Large areas receive light from the pads and may increase predation or illicit changes in behavior of Beach Mice and other nocturnal mammals. The Endangered Species Office has recently required surveys and monitoring surrounding CCAFS Pads 40 and 41.

Construction in or disturbance of the coastal habitat could potentially fragment the Beach Mouse population. Much of the optimal habitat around the the launch pads and on the east coast of Mosquito Lagoon is narrow and vulnerable to ocean surges

from storms. Natural disturbances such as hurricanes could threaten the already precarious position of the Southeastern Beach Mouse.

#### Southern Bald Eagle (Haliaeetus leucocephalus leucocephalus)

The genus Haliaeetus includes eight species of "fish or sea eagles" in the world; only one is found on this continent (Amadon 1983). Two subspecies, the Northern and the Southern Bald Eagle, occur in North America. The Southern Bald Eagle ranges throughout Florida and along the coasts of California, Texas, Louisiana, and the south Atlantic states (Peterson 1980). Bald Eagles are listed as endangered in the U.S., except in five states where they are listed as threatened. The number of nesting pairs of the Bald Eagle has been reduced to <1500 pairs outside Alaska (Erlich et al. 1988). The number of nesting pairs of the southern race once numbered several thousand; recent estimates are only 350-375. Most of the southern race nests in Florida (Robertson 1978a). The decline of Bald Eagles was attributed to several factors: rapid clearing of land for agriculture, especially citrus groves, and housing (Howell 1958, Robertson 1978a), accumulation of pesticides and heavy metals which reduce reproductive success (Laycock 1973, Erlich et al. 1988), reduction of food supplies due to water pollution (Chamberlain 1973), nest site disturbance (Kale and Maehr 1990), and disturbance of roosting and feeding locations (Stalmaster and Newman 1978, Craig et al. 1988).

Live prey includes small mammals, water birds, and fish (Broley 1947). Eagles can live in the wild for at least 15 years and probably do not start breeding until they are 4-6 years old. Eagles arrive at KSC during late summer and leave for the north in late spring (Broley 1947, Cruickshank 1980). They move to nest sites in October and November and lay one to three eggs in November or December. The young fledge from February to April. Nest trees in Florida are usually pine, although cypress

(Taxodium spp.) and mangroves are occasionally used (Howell 1937, Broley 1947, Nesbitt et al. 1975). Nest sites are often within 8 km of salt water (Howell 1937). Nests are often reused, but territories may include several nests that have been used during previous seasons. A single nest may be used by a pair for 5-10 consecutive years, while other pairs have used five nests over such a period (Howell 1937). Reasons for the construction of a new nest are not always apparent, but the distance between nests is typically less than 2 km (Howell 1937). Occasionally nests are taken over by Great Horned Owls (Shroeder 1980); once such an event occurs it may be very difficult for eagles to regain the use of the nest (Broley 1947). In some areas, a territory of a km in diameter from the nest is defended and a pair will chase other eagles from this area (Broley 1947). Even once a previous nest site is destroyed, there is a close attachment to the territory (Broley 1947). This has been noted on Merritt Island, even with nearby housing and industrial activity (Howell 1958).

The breeding population on Merritt Island was one of the most concentrated of any in Florida (Howell 1932) and perhaps of any large raptor on earth (Peterson 1978). There may have been 30-100 nests within KSC and west to the St. Johns River (Hardesty and Collopy 1991). Since 1950, the population on Merritt Island has suffered a remarkable decline (Howell 1968, Cruickshank 1980) comparable to other areas in Florida (Broley 1958, Nesbitt et al. 1975). Eagle occupancy on KSC declined even after the acquisition of the property by NASA and controls imposed on public access (Howell 1973). Some evidence suggests that the heavy use of DDT and other pesticides, prior to the banning of DDT and its relatives, may have influenced populations although demographic patterns associated with low population size may also have been responsible (Hardesty and Collopy 1991). After 1973, a gradual increase in reproductive success occurred on KSC (Hardesty and Collopy 1991). Increases of nesting pairs and reproductive success on KSC have been lower than increases in adjacent populations for uncertain reasons (Hardesty and Collopy 1991).

Prey populations, loss of suitable nest sites to fire, low population size, the presence of lead shot from historical uses, and other factors could explain the slow increase occurring on KSC. The relationship of KSC populations to populations in the vicinity of the St. Johns River is poorly understood. Bald Eagles from KSC may, at least sporadically, use the St. Johns River during the nonbreeding season.

Bald Eagles select the largest pines as nest sites on KSC and most appear to select relatively open stands far from occupied buildings (>1500 m) and roads (>150 m) and near water (600-1700 m) (Hardesty and Collopy 1991). The nest immediately adjacent to State Route 3 has often been successful and much food is acquired from road kills. The tolerance of these individuals may not be representative of the rest of the population. Most pine trees on KSC are currently 30-40 years old due to the last logging period in the 1950's. Nesting trees are typically 70-100 years old so that many pine trees will not reach the preferred size class for at least another 30-40 years. Feeding site selection suggests a preference for the juxtaposition of impoundments and estuary, although a better understanding of feeding habitat requirements for the population is needed (Hardesty and Collopy 1991). There are currently 8-9 breeding pairs; the estimated goal for the KSC population should be a minimum of 15 pairs for the near future (Hardesty and Collopy 1991). Past wild fires and prescribed fires burned down several Eagle nest sites and other potential stands. These fires occurred after a 20 year accumulation of fuels associated with suppression practices of the 1960s and 1970s. One of the areas that was historically used by several nesting pairs and in need of serious management for future use as a nest site is west of State Route 3 and north of Schwartz Road. Unfortunately, a gun range has been constructed in this region, probably one of the worst possible locations (J. Hardesty pers. comm.).

Active and recently active nests are identified as GIS files for planning and environmental assessment purposes. NASA construction projects are unlikely to occur in the immediate vicinity of active nests due to regulations. Inactive and

historical nest sites also should be avoided as sites for future facility development, although regulatory agencies are primarily interested in active sites. It would be useful to use historical site locations and a knowledge of spatial landscape characteristics of Eagle nest site requirements to establish management zones for increasing the nesting population. Management and monitoring objectives for KSC and nearby populations are provided by Hardesty and Collopy (1991). Management actions include:

1. Educating the work force that Bald Eagles frequently feed on carrion along roads, especially October-November and February-April, and that they can be mistaken for Vultures.
2. Relocation of roadkills to minimize Bald Eagle mortality.
3. Research of the causes of mortality.
4. Increase primary management zones to a 1 km radius, secondary zones to a 2 km radius.
5. Limit human access within 1 km of nests (August 15- April 30, and within 1 km of foraging areas (October 1- April 30).
6. Establish management areas for existing, historical, and potential nest sites.

#### Wood Stork (Mycteria americana)

The Wood Stork ranges from Mexico through Central America to Argentina and from southern Georgia throughout Florida to the Everglades National Park. It is a very specialized wading bird that catches fish by groping in water 15 to 25 cm deep and snapping up prey that touches its bill. This feeding style is dependent on water levels suitable to concentrate prey items, and Wood Storks are more susceptible to changes in the hydroperiod or drainage patterns than other waders (Ogden 1976). Habitat destruction and alteration have resulted in the 1984 federal listing of the Wood Stork

as an endangered species (Federal Registry 49:7332-7335). Reproductive success is closely tied to the ability to acquire food before and during the nesting season and varies considerably from one year to the next. Sufficiently high water levels that allow prey populations to increase must be followed by declining water levels that concentrate the prey and make them available to the Wood Storks (Ogden 1978a). Decreased reproduction has been attributed to rising water levels caused by heavy rainfall once nesting has been initiated (Clark 1978). Wood Storks are colonial waterbirds; 5 to 25 pairs will often nest in a single tree. An average of two young per nest represents a successful year for a colony. Annual adult mortality approaches 20%, whereas juvenile mortality is approximately 40% during the first year (Ogden 1978a). Wood Storks rarely breed before 4 years of age. Habitat destruction and alteration of natural drainage patterns in marshes, particularly in the Everglades, caused several years of reduced nesting success or failure in south Florida. The breeding range of the Wood Stork has expanded northward and now includes several substantial colonies in Georgia and South Carolina (D. Connely, T. Murphy pers. comm.). Nest sites are usually located over standing fresh or brackish water. A variety of large trees or shrubs are used, such as swamp hardwoods, willows, Australian pine, Brazilian pepper, and prickly pear cactus. In Florida, cypress trees are typically used in fresh water habitats and mangroves are used in coastal areas, such as KSC.

The number of Wood Storks in central and northern Florida may have doubled since 1960 (Ogden 1991). Although the overall populations may be stable in this region, there is great yearly variation in the number of nesting pairs at any one time (Rodgers et al. 1987). The stability and reproductive success characteristic of these areas is in contrast to the poor success characteristic of the larger populations in south Florida. This suggests populations in central Florida may become increasingly important for species survival.

Wood Storks primarily feed in fresh water habitats (Ogden 1978a), preferring the larger fish found there (Ogden et al. 1976). Recent studies suggest that Wood Storks can successfully feed on fresh water fish that are more dispersed than previously believed given certain conditions (Coulter et al. 1992). They will eat the small fish that are abundant (Snelson 1976, Schooley 1980, Gilmore et al. 1982) in the brackish water lagoons, impoundments, and ditches such as those on KSC (Trost 1968, Leenhouts 1983, Breininger and Smith 1990, Smith and Breininger unpub. data). Wood Storks have good soaring abilities and will fly great distances over land to acquire food.

Wood Storks were found feeding in estuarine lagoons on KSC during visits by early birders (Howell 1932). Wood Storks were first recorded to nest on KSC in 1972 (Clark and Lee 1982; Table 13). The most significant colony was at Moore Creek. Between 1972 and 1980, the number of successful nests there varied between 35 and 325. There were no nests in 1981 (Clark and Lee 1982), and from 50 to 300 nests between 1982 and 1986 (Rodgers 1985, MINWR Annual Narratives). A smaller colony was located on Bird Island in Mosquito Lagoon, with approximately 11 nests observed each year in 1979 and 1980, and no nesting in 1981 (Clark and Lee 1982). Freezes in 1983 and 1985 severely damaged mangroves on KSC (Provanha et al. 1986) and by 1987, the mangroves at Bird Island and Moore Creek were too weak or too low to support wading birds nests. No Wood Storks nested on KSC during 1987 (Smith and Breininger unpub. data). Two new colonies were established in 1988 on mangrove islands that had not been as extensively damaged by freezes as Moore Creek and Bird Island. The Peacock's Pocket colony in the Indian River Lagoon had 17 nests in 1988, 41 in 1989, and 11 in 1990. The Bluebill Creek colony in the Banana River lagoon had 28 nests in 1988, 81 nests in 1989, and 110 nests in 1990 (Smith and Breininger unpublished data). Reproductive success at the Bluebill Creek colony was good in 1988 and 1989, with 1-2 young/nest, and excellent in 1990 with 2-3 young in



most nests. A freeze in December 1989 severely damaged the mangroves at both colonies and the potential for future nesting is uncertain. Wood Storks have successfully nested in altered wetlands and artificially created wetlands in a variety of exotic vegetation (Ogden 1991). This suggests Wood Storks could use other spoil island vegetation.

Sightings of Wood Storks tagged at the Moore Creek colony have occurred throughout portions of central Florida including the west coast down into south Florida (Ehrhart 1976). The nesting population on KSC can be expected to vary considerably depending on water level fluctuations across the region. The St. Johns River west of KSC is believed to be an important feeding area for the KSC population during the breeding season (Clark 1979). Regurgitation collected from 75 Moore Creek Wood Stork chicks indicated that fresh water fish were 66% of the biomass of the diet, while brackish water species constituted 7% and the remaining 27% was unidentified (Ogden pers. comm. in Clark and Lee 1982). Wood Storks have been attracted to dredging material disposal sites on KSC and elsewhere in Brevard County to consume fish species discharged from dredge pipes (Leenhouts 1987a).

It was once believed that shuttle launches might acidify or otherwise contaminate impoundments in the vicinity of the pads. Although Wood Stork use of the impoundments is occasional, the abundance and frequency of use is low (Breininger and Smith 1990). This prompted aerial surveys to determine the importance of these impoundments relative to the total habitat available. Four years of such surveys have shown that these impoundments have little significance to the population (Smith and Breininger unpublished data). Furthermore, acidification appears unlikely due to groundwater flow into the impoundments that provides sufficient buffering capacity.

Another launch-related concern for KSC Wood Storks is the close proximity (<1 km) of the Bluebill Creek colony to LC 39A. Detrimental launch effects attributed to high noise levels, panic response of adults and fledglings, and deposition of launch

products were the major concerns. No data specific to Wood Storks (or other wading birds) exist to evaluate potential effects. It was determined through Section 7 consultation with the USFWS Endangered Species Office (ESO) that direct mortality of or visible harm to adults, young, or eggs should be used to quantify effects and develop a Biological Opinion. During the 1989 and 1990 nesting seasons, no launches occurred from LC 39A; however, there were two launches from LC 39B and one from Titan Pad 41. Surveys of individual Wood Stork nests before and after these launches revealed no mortality or visible harm. The ESO concurred with the finding of no significant effect (unpub. memo, D. Wesley, USFWS, 12 Sep 1990). In 1991, a launch occurred from LC 39A during the nesting season. The Wood Storks that were using Bluebill Creek at the beginning of the season had deserted the colony shortly before the launch took place, presumably because of the deteriorating condition of the mangroves from freezing weather in 1989. Other species of waders that were nesting during the launch showed no ill effects. A major concern would be in the event of an accident at either Shuttle or Titan pads that could have catastrophic effects. It will probably be many years before the mangroves on Bluebill Creek have recovered enough to support nesting Wood Storks.

#### Eastern Indigo Snake (*Drymarchon corias couperi*)

The Eastern Indigo Snake is the largest nonpoisonous snake in North America. It was federally listed as a threatened species in 1978. They historically occurred throughout Florida (including the Keys), Alabama, Georgia, Mississippi, and South Carolina. Because Indigo Snakes are notoriously good natured, the commercial pet trade took a heavy toll on wild populations before federal protection (Kochman 1978a). Human exploitation combined with habitat loss and degradation now restrict the species mostly to Florida. Early habitat accounts emphasized the association of

Eastern Indigo Snake with xeric sand ridge habitats and their dependence on Gopher Tortoise burrows for overwintering (Wright and Wright 1957, Mount 1975, Lawler 1977, Speake et al. 1978, Landers and Speake 1980, Speake and McGlincy 1981, USFWS 1982, Diemer and Speake 1983). Indigo Snakes are largely restricted to sandhill and adjacent habitats in Georgia and perhaps (Diemer and Speake 1983). Telemetry studies there revealed that sandhills were used in winter, but that during the summer many individuals make long range seasonal movements away from xeric habitat into agricultural fields and stream bottom thickets that are interspersed within the sandhills (Speake et al 1978). Studies in the Gulf Hammock area showed that Indigo Snakes are not restricted to xeric habitats in northern Florida (Moler 1986). In southern Florida, Indigo Snakes used many habitats including canal banks (Lawler 1977), dry glades, tropical hammocks, and muckland fields (Carr 1940). Indigo Snakes are widely distributed in the Everglades National Park occupying many habitats, but pinelands and hammocks appear used most frequently (Steiner et al. 1983). The Indigo Snake is a top predator of a variety of prey including birds, young turtles, frogs, and other snakes, including rattlesnakes (Mount 1975, Ashton and Ashton 1981).

Habitat loss, degradation, and fragmentation are the greatest threats to the Indigo Snake (Lawler 1977, Diemer and Speake 1981, USFWS 1982, Moler 1986). Conditions that favor suitable prey populations and provide opportunity for prey capture may be important. Gopher Tortoise burrows are used by many potential prey items and Indigo Snakes capture prey, such as other snakes, in these locations (Judy Rodda pers. obs.). Fire suppression has a negative influence on Gopher Tortoises (Auffenberg and Franz 1982) and possibly Indigo Snakes. Indigo Snakes use active burrows but may prefer inactive and abandoned burrows (Speake et al. 1978). Gopher Tortoise burrows are important in xeric habitats; humid retreats may be important since Indigo Snakes are vulnerable to desiccation (Bogert and Coules 1947). Solution holes serve as retreats for Indigo Snakes in pinelands and hammocks

in the Everglades (Steiner et al. 1983). Other den sites include windthrows and hollow root channels of large live oaks (Speake et al. 1978, Moler 1986). Indigo Snakes frequently use disturbed areas where clearing has occurred and where debris piles remain (Speake et al. 1978, Moler 1986, Kehl et al. 1991). Other features such as shallow marshes, for hunting, may be necessary for an area to be suitable (Speake et al. 1978).

Indigo Snakes were believed to be largely restricted to the central scrub belt on KSC, based on road kill information and the early literature (Ehrhart 1976). The range of the species on KSC was mapped (NASA 1979) to extend outward from the central ridge and include the coastal strand. Later studies elsewhere (Steiner et al. 1983, Moler 1986) and on KSC (Kehl et al. 1991) revealed that the Indigo Snake is not as habitat specific as initially believed and that many other areas on KSC may represent suitable habitat. Gopher Tortoise burrows are important for the population. Den sites are often in well-drained scrub and pine flatwoods which comprise only about 2% of KSC lands. There is little information to know if Indigo Snakes can use a flooded burrow as winter den sites without suffering unhealthy consequences (Paul Moler and Jim Layne pers. comm.). Indigo Snakes have used den sites on poorly drained soils types in scrub and slash pine in the winter of 1988-1989 (Smith and Breininger unpublished data), but these burrows were unflooded for much of their length. During some winters all burrows have been flooded in scrub and slash pine except in the well-drained areas (Breininger et al. 1988). In contrast to other studies, Indigo Snakes on KSC sometimes move considerable distances during warm periods in winter. Indigo Snakes are capable of movements outside den sites on sunny days when the outside temperature is  $>55^{\circ}$  F (P. Moler pers. comm.). This provides opportunity to move to different den sites in winter. It is unknown how Indigo Snakes fair when extended cold periods follow heavy rains which flood burrows, as occurred in 1985-1986. There is a need for studies over many years to derive adequate

information. Well drained scrub and pine flatwoods are important for Indigo Snakes during the winter. If these ridges are necessary for much of the population during some years, they may limit the population.

Studies of Indigo Snake habitat use on KSC have been conducted using radio telemetry. Ten adult Indigo Snakes have been implanted with radio transmitters, released and tracked between 1989 and 1991. Each snake was tracked 2-3 times per week for periods ranging from 2-18 months. Locations were marked on aerial photographs and digitized on LANDSAT maps. Habitat characteristics, time of day, and weather conditions were recorded for each tracking event. GIS analysis was used to determine homeranges based on a convex polygon. The average homerange estimates were 279.4 ha for males and 99.8 ha for females (Kehl et al. 1991). The habitats used by these snakes included well-drained soils, hammocks, swales, ditches and ruderal areas. There appeared to be little overlap in the homeranges of males, but male and female homeranges overlapped.

A population estimate of 750 individuals on KSC occurs in a report prepared by the USFWS (NASA 1979). If homerange sizes from recent studies (Kehl et al. 1991) are used, a population of 300 animals is approximated. This is derived from the acreage of scrub and slash pine, multiplied by two to compensate for marshes and other habitats used within the scrub and slash pine flatwoods landscape, and assuming that there is little or no overlap in homeranges among individuals of the same sex, and assuming that male and female ranges overlap. Certainly, many unproven assumptions are associated with this estimate, but it indicates that the population may be near the minimum size acceptable for sustaining a population. Thus, maintenance of viable populations of this top predator is of concern given the lack of information on demographics, a relatively low fecundity rate, potential for high predation of eggs and young, and road mortality.

Most proposed construction projects occur within potential habitat for this protected species. It is unlikely, given sufficient scrub and slash pine, that the number of den sites would be limiting considering the large homerange of the snake and the hundreds to thousands of burrows that would be in a homerange (Breininger et al. 1988). Habitat management that benefits Gopher Tortoises may benefit Indigo Snakes but Indigo Snakes may require additional considerations. Fragmentation of habitat, even by low density development, is a potential threat given their susceptibility to road mortality (Moler 1986). Some road mortality has been intentional, even on KSC which encompasses a National Wildlife Refuge (pers. obs.). Road mortality to Indigo Snakes could be reduced by an education program informing employees about its protected status, beneficial roles, and generally gentle disposition towards humans.

#### Roseate Spoonbill (*Ajaia ajaja*)

Roseate Spoonbills are primarily coastal, nesting in mangroves in association with other waders (Bent 1929). The Spoonbill feeds by waving its distinctive spatulate bill through shallow water capturing insects, crustaceans, and small fish. The minimum age to breeding is three years; the clutch size is 2-3 eggs per year (Allen 1942). Historically, Roseate Spoonbills ranged throughout central and south Florida, coastal Texas and Louisiana to South America. The largest colonies occurred in south Florida, particularly in Florida Bay (Ogden 1978b); 2,000 to 2,500 birds nested there in 1974. In the mid-1800s the Roseate Spoonbill was an abundant nesting bird on Pelican Island (currently Pelican Island National Wildlife Refuge). One hunter was reported to have shot 60 there in one day (Howell 1932). During the late 1800s and early 1900s, historical accounts of as many as 150 birds were reported feeding in Mosquito Lagoon (Allen 1942). At least one pair was believed to have nested near Cocoa Beach in the early 1900s (Allen 1942). The North American population was

hunted to near extinction by plume fanciers in the late 1800s and their recovery has been very slow. The U.S. population was at its all time low at end of the last century (Allen 1942). Florida experienced continued decline in contrast to Texas and Louisiana (Allen 1942). The population in Florida Bay has been steadily declining to an average of 450 pairs for 1983-1985 and much fewer for any year since (R. Bjork pers. comm.). Loss of feeding habitat has continued to occur in the Florida Bay region (Bjork and Powell 1989).

New colonies have been reestablished in central Florida, and since 1988 there has been scattered nesting on KSC (Smith and Breininger 1988). Hundreds of Spoonbills are sometimes found on KSC although few nest here (Smith and Breininger unpublished data). Many of these are immature birds. Summer flocks of immature birds from Cuba have historically used Florida from late March through September (Allen 1942). Little is known of the origin of most Roseate Spoonbills on KSC. The largest concentrations occur in July, August, and September (Smith and Breininger unpub. data).

The shallow water impoundments and edges of the estuaries provide good feeding habitat and will probably remain protected. This species occasionally uses impoundments north of Pad 39B (Breininger and Smith 1990), but this use is low relative to other areas on KSC (Smith and Breininger unpublished data). Ditches are rarely used. Many individuals roost at Bluebill Creek colony located one kilometer south of Pad 39A. However, present NASA operations probably have potential for only minor influences on the Roseate Spoonbill populations when compared to water management actions and the influence of severe freezes on mangroves which are used for nesting.

## Reddish Egret (*Egretta rufescens*)

After nearly complete extirpation from the U.S. by plume hunters at the turn of the century, the Reddish Egret has been slowly recovering and reoccupying its former range (Paul et al. 1979). It occurs along the Pacific coast from Baha, California to Central America, the Gulf coast of Texas, Louisiana, and Florida, and the Atlantic coast north to central Florida (Robertson 1978b). Historical accounts of the species indicate its presence in the late 1800s near Dummitt Cove (Howell 1932). There are currently 2,000 resident pairs in the U.S., 300 of which breed in Florida (R. Paul pers. comm.). Reddish Egrets nest in colonies with other species of wading birds, using mangroves almost exclusively as nest sites. They feed on small fish, aquatic invertebrates, and small vertebrates. Reddish Egrets have a distinctive "dancing" feeding style that consists of quick steps made while the wings are spread above the head.

In the 1960s, Reddish Egrets were rarely seen in local surveys (Trost 1968), but are now seen feeding in open water impoundments and regularly along the edges of the estuary in small numbers (Breininger and Smith 1990; unpub. data). The Haulover Canal colony on KSC was recognized as the most significant area for reoccupation of the central Florida east coast (Paul et al. 1979, Paul 1986, Toland 1991) where as many as 41 fledglings have been counted in one year (Paul 1986). Pelican Island National Wildlife Refuge has also been recently recolonized (Rodgers and Schwikert 1986). The number of pairs nesting on colonies on KSC in years when surveys were made was:

1985 1 (MINWR Annual Narratives)

1987 16 (Smith & Breininger)

1988 12 (Smith & Breininger)

1989 9 (Smith & Breininger)

1990 14 (Smith & Breininger)



If the Reddish Egret continues to recover and expand its range, the feeding and nesting areas on KSC may become increasingly important as unprotected habitat in the rest of Florida disappears and given that a hurricane could wipe out other colonies. Certainly in the recent past, the success of the Haulover Canal colony has made a contribution toward the recovery of the east coast population. Although they occasionally occur in NASA operational areas, NASA has little influence on the species. Few Reddish Egrets rarely occur in the impoundments near shuttle pads (Breininger and Smith 1990), and a few individuals occasionally use an isolated fragment of the estuary known as Cochran Cove southeast of 39A (Breininger unpublished data).

#### Florida Long-tailed Weasel (Mustela frenata peninsulae)

The Long-tailed Weasel is one of Florida's rarest carnivores. They are predators on all types of small animals. It is restricted to the southern two-thirds of the Florida peninsula but is probably absent from the Everglades and Gold Coast (Brown 1978b). The Long-tailed Weasel population is chronically low. There were only 196 occurrence records of the Long-tailed Weasel in Florida; none were captured during 4,493 trap nights in a Florida status survey (Hovis 1992). Habitat requirements derived from known records makes identification of critical habitats difficult. The Weasel has been found in pinelands, hardwood forests, swamps, tropical hammocks and sand pine scrub. This species is vulnerable to local extinction, and a population decline is probable due to its low local population density, its limited and patchy geographic distribution, wide-ranging (area-dependent) habits and low fecundity (Noss and Labisky in press). Two recent roadkills have been found on KSC and several possible sightings have recently occurred near Happy Creek (Larson, Oddy, and Breininger, pers. obs.). There are several records for Brevard County (FGFWFC

1976). One record is for north of Melbourne where an individual was sighted exiting saw palmetto scrub (Moore 1945). During the mammal studies done by Ehrhart (1976), no Weasels were trapped; however, Ehrhart (pers. comm.) recommends a refuge-wide survey for the Weasels. This may be the most endangered mammal on KSC.

#### Atlantic Salt Marsh Snake (Nerodia fasciata taeniata)

Federally listed as threatened in 1977, this subspecies has a range that was believed to include Volusia, Brevard, and Indian River counties (Kochman 1978b, Stevenson 1976). A feature of N. f. taeniata that distinguishes it from other closely related water snakes is two dorsal stripes running the length of its body. N. f. taeniata may be a relict population of hybrids between the Mangrove Water Snake N. f. compressicauda and the Gulf Salt Marsh Snake (N. f. clarki), whose ranges overlapped during the Pleistocene, but have since been separated and have diverged due to sea level changes (Kochman 1978b). The taxonomic status of the Atlantic Salt Marsh Snake has been questioned, and a few researchers feel that it is not unique enough to distinguish it as a subspecies distinct from the Mangrove Water Snake (Dunson 1979). Since the original discovery by Cope in 1895 and subsequent specimens collected by Carr and Goin (1942), few if any specimens have been collected on KSC (Herbard and Lee 1981). Carr and Goin (1942) suggested that N. f. taeniata may have never occurred as far south as Merritt Island. Sampling methods and identification problems could be the reason for failure to find this snake on KSC.

Disturbance to the marsh such as ditching and impoundment can integrate freshwater and salt marsh habitats, allowing the freshwater Florida Water Snake (N. f. pictiventris) to occupy areas where it had not previously been found. Increased genetic exchange between the two subspecies has the potential to obliterate the N. f.

taeniata phenotype with the much larger N. f. pictiventris gene pool (Kochman 1978b). Atlantic Salt Marsh Snakes have recently been found in Volusia County.

Suitable habitat was described as brackish water habitat including tidal creeks, salt marshes, and a possible association with fiddler crab burrows (Kochman 1978b). If the Atlantic Salt Marsh Snake does occur on KSC, the best habitat is on the east side of Mosquito Lagoon (P. Moler pers. comm.). Such areas could provide habitat for one of the few population centers of the taxon. Given the habitat present, the population size would probably be fragmented by human landscape alterations (e.g., causeways and impoundments) and the patchy distribution of mangroves. The snake probably does not occur near NASA operations. Water management and mosquito control practices could effect the population. Surveys are needed to determine whether any populations occur on KSC and research and monitoring will be needed if populations are located.

#### Florida Pine Snake (Pituophis melanoleucus mugitus)

The Florida Pine Snake ranges from southern Alabama, Georgia, South Carolina and throughout Florida to the Everglades (Ashton and Ashton 1981). The Pine Snake feeds mainly on Pocket Gophers and other small mammals as well as a few birds and lizards. Habitat for the Pine Snake is sandy, dry areas often in stands of longleaf pine and turkey oak (Ashton and Ashton 1981). Annual home ranges have been found to range between 28.5- 92.8 ha (Franz 1984).

Pine Snakes spend little of their time above ground (Franz 1984). They construct some of their own burrow systems, contrary to most other snakes which do not dig burrows and use existing underground formations or other animal burrows (Burger et al. 1988). Pine snakes also use logs and occur under leaves (Burger and Zappalorti 1989). They may select openings or areas with sparse cover that allow

sunlight to penetrate for most of the day. Pine Snakes select soft, moist sandy areas and excavate nest sites and may be the only snake to dig burrows for nesting (Burger and Zappalorti 1991). They often nest communally, often in the same site for consecutive years, perhaps because suitable sites are limiting habitat features (Burger and Zappalorti 1991).

The Florida Pine Snake is a candidate for federal listing but without data on the degree of vulnerability to extinction. Florida Pine Snakes are vulnerable to population decline, and local extinctions are probable throughout much of northern Florida (Noss and Labisky in press). Its rarity is probably due to its low local population, ground nesting, dependence on a fire-maintained habitat, occurrence mainly in habitat that is prone to human development, and persecution due to cultural bias.

There are few records of the Florida Pine Snake on KSC. Specimens were found by D. Whitmore (pers. comm.), R. Seigel (unpublished data), and M. J. Brakazii. Several roadkills have been found on CCAFS (M. Mercadante, D. George pers. comm.) and on KSC (Seigel unpublished data). Although this snake can be associated with Gopher Tortoise burrows (FGFWFC 1976), it more often is associated with Pocket Gopher burrows (Funderburg and Lee 1968, R. Franz, pers. comm.) which do not occur on KSC. The species also may be associated with Beach Mice burrows (S. Sweet pers. comm.), which may explain the presence of roadkills near the beach (M. Mercadante and D. George, pers. comm.). It has also been found in burrows of the Florida Mouse (Lee 1968). The lack of frequent sightings is partly because this snake spends most of its time underground (R. Seigel pers. comm.). There is a need to perform surveys for Pine Snakes on KSC, identify important habitat, and estimate the size and distribution of the population.

## Florida East Coast Terrapin (Malaclemys terrapin tequesta)

Diamondback Terrapins occupy brackish waters from Massachusetts to Texas including both coasts of Florida (Stevenson 1976). The Florida East Coast subspecies may have been distributed along Florida's Atlantic coast exclusive of Nassau and Duval counties and the Florida Keys. Although not listed by federal or state agencies, available information suggests it should be considered a threatened species (Millsap et al. 1990). Evidence suggests that the degree of endangerment of M. t. tequesta could be greater than other species listed as threatened.

In contrast to other subspecies that have been noted to nest on sand dunes, this east coast race has been observed nesting on dike roads but not sand dunes (Seigel 1980). Breeding aggregations on KSC occurred in canals, adjacent to a spoil islands, and along Banana Creek (Seigel pers. comm.). Clutch size ranges from 5-10 with an average of 6.7 (Seigel 1980a). Gravid females have been found May-July and mean incubation time is approximately 60-73 days (Seigel 1980). Terrapins are long-lived species that probably survive for 20 years (Seigel 1984). Females of the Florida east coast subspecies grow faster than northern subspecies and probably require 3-5 years to mature (Seigel 1984) instead of 7-9 years as reported for northern subspecies (Hildebrand 1932 cited in Bishop [1983]). Egg laying occurs from through July during the middle of the day (Seigel pers. comm). The sex ratio is very skewed towards females (Seigel 1984). Hatchlings on KSC are often deperadated by Raccoons (R. Seigel pers. comm.) and elsewhere are subject to high predation by birds (Burger 1976). Young Terrapins spend much time underneath dense mats of vegetation and other debris (Lovich et al. 1991). Molluscs are the predominant food item for adults (Seigel pers. comm.).

Species threats have included heavy human exploitation for food, habitat manipulation, Raccoons, crab trap mortality (Bishop 1983), and perhaps low

population size. The Diamondback Terrapin was one of the nations most prestigious commercial species in the late 1800s and early 1920s (Bishop 1983). Captures of Terrapins in the Indian River system were estimated by the barrel (Seigel pers. comm.). Incidental capture of Diamondback Terrapins in crab traps can be significant (Bishop 1983) but mortality can be reduced if traps are checked daily (Bishop 1983). Nearly 3/4 of the Terrapins collected from the Indian and Banana Rivers were infested with barnacles (Balanus eburneus, Chelonibia manati, C. testudinaria). The effects of such infestation included interference with reproductive activity and shell erosion; erosion can be fatal (Seigel 1982).

KSC is in the center of a distribution that involves only a few counties along the lagoon (Iverson and Etchberger 1989). Much of what is known about this taxon was learned on KSC, the only location where significant populations are known to occur. KSC provide the largest known protected area for this unique turtle (Seigel pers. comm.) although few recent surveys have been conducted on KSC. Surveys of areas with previous aggregations in 1991 on KSC revealed only one individual (Seigel unpublished data). Thus the population may have crashed. The KSC distribution was patchy during the 1970s for unknown reasons and there may have only been 400-600 individuals (R. Seigel pers. comm.). Previous harvests may have eliminated much of the population. Recovery could only occur slowly due to the high potential for predation of nests, young, and adults and relatively low fecundity. Seigel (pers. comm.) has evidence for low dispersal between subpopulations. Evidence from Seigel's studies indicated that the Banana River population suffered from low recruitment and/or high mortality rates. Much of the salt marsh on KSC has been eliminated so that this turtle is confined to lagoons and brackish water impoundments (Siegel 1980a) and some canals and ditches (Siegel 1980b). Since KSC may be the most important area for maintaining this species, there may be a great deal of regulatory interest in the future. Raccoons have been observed attacking Terrapins

along a dike road on KSC and 24 freshly killed individuals were found with convincing signs of raccoon predation (Seigel 1979). Dikes may have improved access for predators within the marshes. Other human caused changes probably resulted in larger Raccoon populations.

There is a need to intensively survey the KSC population. Data on movements and demographics is needed. Some NASA activities have occurred in the few areas that have breeding aggregations (R. Seigel pers. comm.). The site of the largest aggregation along the Shiloh dike appears eroded. The significance of crab trapping in estuaries on KSC is unknown but it is of concern (Seigel pers. comm.). This subspecies may have already reached such a critical status that only extreme efforts may be possible for its recovery.

#### Atlantic Loggerhead (Caretta caretta)

The Loggerhead Turtle, a threatened species, is found in temperate and subtropical oceans throughout the world. Animals are seen in estuaries as far north as New England and the Canadian Maritime Provinces. Nesting is common north through North Carolina but the majority are in Florida. The second largest nesting colony in the world is along Florida's east coast. It is a highly mobile species with no clear home-ranges defined to date. The existence of this species has been severely threatened in recent times by incidental death during fishing operations, particularly shrimp trawls.

As with the Green Turtle, KSC provides two habitat types for two different life stages of this species, the ocean beach (reproductively mature females) and the estuary (subadults and juveniles). Nesting occurs on the KSC beaches each summer between April and September. About 98 % of all marine turtle nests on KSC are Loggerheads. Over the last eight years, seasonal nest estimates for the secured

stretch of KSC beach (10 km) ranged from 888 nests in 1984 to 1791 nests in 1990. The total reproductive potential, disregarding actual hatch success, during the last eight years is about 1 million hatchlings. Females are estimated to nest 3 times per season.

A continuing threat to the clutches deposited at KSC is predation by Raccoons and to a lesser degree, Feral Pigs. The levels of predation vary with the area and predator control methods. The general ecological effects of removing a native predator from the beach zone, such as the Raccoon, are unknown. Each of the three local agencies, CCAFS, MINWR and CNS have their own approaches to dealing with this issue. Documentation in the late 1970s and early 1980s (Provancha et al. 1983) indicated predation rates of 60-99% were common. Since that time, at least on KSC, MINWR has been able to remove enough Raccoons from the beach to drop predation rates dramatically to the 1-2% level. CCAFS uses methods similar to MINWR with good success although pigs are a greater problem there. CNS generally used methods involving screening and occasional predator removal with varying levels of success. The CNS is logistically difficult to control due to its vast size.

Another problem faced by the species in this locale is disorientation of hatchlings. Disorientation is believed to be the confusion of newly emerged turtles whereby they avoid a dark background and head for the brighter horizon. On undisturbed beaches this brighter horizon would be the ocean and the darker areas would be the dune or land mass. The lights from pads 39A and B have been implicated in a few disorientation events, but most of the events that effect KSC hatchlings have been those from nests at the southern end and in response to lighting at CCAFS pads 40 and 41. It is not clear why the KSC pads have not caused the level of problems that the CCAFS pads have caused. The intensity and level of lighting at times is quite high on 39A and B but the dune structure (i.e. height and angle) along most of this beach may provide a screen for the turtles. It is not clear whether



hatchlings are distracted by such lighting once they enter the water.

The estuarine population of Loggerheads in KSC's Mosquito Lagoon is composed of subadult animals, 50 to 80 cm straight line carapace length (Ehrhart 1983). Netting surveys in the late 1970s and various cold-stunning episodes (see Green Turtle account) have yielded basic data about the population (Witherington and Ehrhart 1989). The Loggerheads display some degree of residency in Mosquito Lagoon, but appear to migrate more than the Greens. Mendonca and Ehrhart (1982) indicated their best estimate of this lagoon population of 253 individuals was probably low.

#### Royal Tern (*Sterna maxima*)

The Royal Tern feeds almost entirely on small fish caught by plunge-diving into estuarine and ocean waters. This old world tern has a wide distribution. The Royal Tern, like most other terns, have specific habitat requirements for nesting. Buckley and Buckley (1972) list these requirements as: 1) absence of quadruped predators, 2) general inaccessibility and good visibility of surroundings, 3) extensive areas of adjacent shallows for feeding, and 4) location at or very near an inlet between bay and ocean. The Royal Tern was listed as a species of special concern by FCREPA in 1978. Concern for this species has stemmed from habitat loss along the coasts, human disturbance, and predation by introduced and domestic animals.

The Royal Tern occurs in the Merritt Island area year round and nests on natural or man-made islands. One of the earliest records of peak concentrations of nesting Royal Terns in this area was in 1913 with 2500-3000 individuals in Mosquito Inlet (Clapp et al. 1983). Recent nesting areas on KSC have not been associated with inlets. On Bird Island, a large colony was established in 1968 (MINWR Annual Narratives). In 1970, 1000 nests and 200 young were counted in the Bird Island

colony and in 1974, 2000 nests were counted on the island. In 1991 a large breeding colony was established there (Breininger and Smith pers. obs.). Spoil island nesting in the Banana River has been reported since 1973 and seems to be the preferential nesting habitat to date. In 1973 and 1977, 93% and 92% of North Carolina's breeding population occurred on spoil islands (Clapp et al. 1983). In 1980, a total of 2100 nests were found in the Banana River (MINWR Annual Narratives). In 1980, 1500 nests were estimated to have produced 150 chicks on one of the spoil islands that was partially cleared in 1980 (Schroeder 1980). Many Royal Terns abandoned the colony possibly due to human disturbance since the island was outside the security zone (Schroeder 1980). During March of 1981, six spoil islands in the Banana River were mechanically cleared of vegetation to encourage shorebird nesting. Activity on the islands began in April with at least 200 Black Skimmers, 1000 Royal Terns and 1500 Laughing Gulls nesting. No follow-up surveys were done for these islands during that year. Royal Terns continued nesting on study spoil islands through 1989 with the following survey results:

- |      |   |
|------|---|
| 1982 | No data   |
| 1983 | No data   |
| 1984 | 239 nesting pairs   |
| 1985 | 520 counted on Banana River Spoil Island (BRSI) #26.  |
| 1986 | 1035 counted on BRSI #27. A portion of BRSI #26 had been cleared earlier in the spring but no nesting took place in that area by any other gull/tern species. |
| 1987 | Reported nesting (but not counted) on BRSI #13 and #14.   |
| 1988 | Reported nesting (but not counted) on BRSI #13.   |
| 1989 | Reported nesting (but not counted) on BRSI #13.   |

Nesting populations in Florida have occurred in only a few locations (Clapp et al. 1983, Toland and Gilbert 1987). Nesting on KSC has been estimated as representing at least half of all Royal Terns nesting in Florida (Clapp et al. 1983) making KSC one of the most important areas in Florida. The population nesting on KSC was only a small percent of the population in the eastern U.S. (Clapp et al. 1983).

Royal Terns, outside the breeding season, are common along Florida's coastline. Besides adequate nesting habitat, Royal Terns require habitat for feeding and loafing. The estuarine and ocean waters surrounding KSC make ideal feeding areas, while the relatively undisturbed beaches, islands and impoundment mudflats provide loafing habitat. The following counts were made by MINWR personnel along the refuge beach and the mudflats of Black Point Wildlife Drive:

- 1986 survey of the refuge beach between October 1985 and December 1986 (14 months); average 47 Royal Terns per survey for a total of 2,112.
- 1987 survey of Black Point Drive July-December; average 1 Royal Terns per survey.
- 1988 survey of Black Point Drive; average 2 Royal Terns per survey.
- 1989 survey of Black Point Drive; average 4 Royal Terns per survey.

Recommendations regarding the Royal Tern are to maintain and perhaps increase current nesting and loafing areas. Active habitat management of the vegetated spoil islands is suggested as a means to provide suitable, undisturbed nesting locations. Absolute isolation from human intrusion and protection from rats, cats, dogs and other potential egg/chick predators is necessary. This management would not only benefit the Royal Tern but would be beneficial to at least five other species of colonial shorebirds.

## River Otter (Lutra canadensis)

The River Otter ranges through Alaska and most of Canada south to northern California and from Newfoundland on the east, south through Florida. It is absent from the Southwest and has been extirpated from most areas of the Midwest. Humphrey and Zinn (1982) suggested that River Otters in south Florida mate around the end of the wet season (late Autumn). This seasonal pattern may relate to the concentration of food resources that occur when water levels decline. The size of a home range depends on habitat and prey availability. Many home range estimates are in kilometers, instead of hectares, because River Otters often inhabit linear features such as rivers and streams. Estimates of homerange have ranged from 8-78 km (Melquist and Hornocker 1983, Mason and Macdonald 1986). Males and family groups (mother and young) may defend territories although spacing patterns are difficult to determine given the nocturnal activity patterns. A density estimate for Idaho has been 1 otter/3.9 km of waterway (Melquist and Hornocker 1983). Density estimates for marshes have ranged from 1 otter/86 ha to 1 otter/509 ha of marsh (Shirley et al. 1988).

The River Otter is one of the few remaining large carnivores in Florida and could be important for maintaining faunal integrity. The River Otter is a top predator in wetland communities. Sea Otters (Enhydra lutris) have been more extensively studied and are known to have profound influences on several herbivores upon which they feed (Ebert 1968, Wendell et al. 1986, Wild and Ames 1974). They are keystone species because they regulate sea urchin populations, allowing a luxuriant development of kelp which are mainstays of primary production over much of the U.S. Pacific coastline (Duggins 1980, Estes et al. 1978, Ostfield 1982). The influence of River Otters on community structure and function in the U.S. has received little study. Perhaps without justification, River Otters have been persecuted because of suspected effects on fisheries (Mason and Macdonald 1983); they also can have significant

predation effects on Storm Petrel colonies (Quinlan 1983). River Otters have high food intake that is a result of a metabolic rate which is 20% higher than expected based on the mammalian standard curve relating basal metabolic rate to body weight (Iverson 1972). Common food items include fish, amphibians, reptiles, and crayfish (Cooley et al. 1983). Omnivores such as the Raccoon and Opossum have experienced recent population explosions (Harris and Gallagher 1989) and may be competitors. The River Otter is very vulnerable to local extinction, and a population decline across much of northern Florida is highly probable (Noss and Labisky in press). Its vulnerability is due to its wide-ranging (area-dependent) habits and the fact that it is still exploited as a furbearer. The Otter is a legally trapped furbearer in Florida and it is internationally listed in Appendix II of CITES. River Otters are endangered over much of Florida due to road mortality and habitat fragmentation (Harris and Gallagher 1989).

The River Otter is largely aquatic and is found in marshes, ditches, canals, impoundments, and the estuary on KSC. Ehrhart (1976) reported that the River Otter was abundant on KSC based on the frequency of sightings and roadkills and the profusion of tracks and droppings in and around the suitable habitats. There may be 14,200 ha of potential habitat (marshes, ditches, inland waters, impoundments) on KSC, CNS, and CCAFS based on vegetation maps. This suggests a potential population size of 28-165 Otters using home range estimates from above. The edge of estuaries including estuarine creeks provide additional habitat especially where ditches surrounding impoundments are located outside the dikes along the estuarine edge (Breininger pers. obs). Turnbull Creek supports some River Otters. Otters use roadside canals and commonly cross roads to get from one body of water to another. Ehrhart (1976) estimated that an average of 10 Otters are killed on KSC roads each year making road mortality one of the biggest threats to the survival of Otters on KSC.

A suitable corridor is needed for River Otters between Turnbull and KSC and between the Merritt Island\Cape Canaveral\Turnbull Ecosystem and the St. Johns

River. Riparian and wetland corridors are most important to the River Otter. Areas between water must be easily traversed, have a fair amount of vegetative cover, and be free of hazards such as automobiles. The addition of a linkage to the St. Johns River basin to other large areas such as Ocala National Forest and the Econolockhatchee River could provide for a large connected population. Translocation of River Otters may be viable management technique (Erickson and McCullough 1987). Passage ways or tunnels under existing and planned roads can provide for movement between bodies of water.

#### Eastern Diamondback Rattlesnake (Crotalus adamanteus)

The Eastern Diamondback is the largest rattlesnake in North America, living on the southeast coastal plain from North Carolina and Louisiana to the Florida Keys (Carr 1940, Stevenson 1976). Although they commonly reach 2 m in length, they more often retreat than become aggressive when disturbed. Eastern Diamondbacks live in scrub, sandhills, palmetto flatwoods, dry pinelands, and ruderal areas (Ashton and Ashton 1981). Other rattlesnakes (e.g., C. horridus) have very specific habitat requirements so that observations in some habitats may represent individuals passing through and not use of that habitat for feeding (Seigel pers. comm.). Gravid females of other rattlesnakes have been shown to prefer edges, particularly along roads which are frequently crossed (Reinhert and Zappalorti 1988). Little published information is available on the Eastern Diamondback Rattlesnake in Florida although Bruce Means has performed several years of study and his results are anxiously awaited. Rattlesnakes use natural and man-made debris piles and Gopher Tortoise burrows as refugia. The Eastern Diamondback Rattlesnake is an ambush hunter that spends most of its time in specific sites used for prey capture (Timmerman 1990). The diet changes with age and includes smaller prey such as amphibians and lizards to larger prey,

particularly smaller mammals (Wallace and Diller 1990). An adult Diamondback was recently observed consuming an adult Northern Bobwhite within oak/palmetto scrub on KSC (Breininger pers. obs.). Activity areas probably range from 30-100 ha (Timmerman 1990). Rattlesnakes have delayed reproduction; the first attempt occurring within 6-11 years for several species (Brown 1991). Females do reproduce every year (often not for every 3-4 years) and generally do not feed when gravid (Reinhart and Zappalorti 1988). A female may have only 3-5 lifetime reproductive attempts since a lifespan may range from 16-22 years in the wild (Brown 1991). These demographic constraints are responsible for very slow recovery of depleted populations once protected.

They are considered to be very vulnerable to development because they have low local population density, need large areas of habitat, are susceptible to ground predators, and are particularly persecuted by humans (Noss and Labisky in press). They also have low fecundity and take years to reach reproductive age. Road mortality can have significant effects on Rattlesnake populations (Seigel 1986). Numerous sightings of Eastern Diamondback Rattlesnakes in many areas indicate that they are common on KSC (authors pers. obs.) although not abundant (Seigel unpublished data). Numerous snakes have been found by the authors on several roads; these individuals were found with missing heads and rattles. Such collecting is illegal on MINWR. No estimates are available on the KSC population size but the population was conservatively assumed to be low. They are assumed important for maintaining faunal integrity since they are a large predator.

Arctic Peregrine Falcon (*Falco peregrinus tundrius*)

The Peregrine Falcon is an endangered species with a nearly world-wide distribution. Three subspecies are recognized. The Pacific coast subspecies and the

American Peregrine Falcon once ranged over much of the U.S., but apparently not as far south as Florida (Woodward 1980). The Arctic subspecies nests in the high Arctic and has a wintering range that includes Florida. Many individuals pass through Florida down the Atlantic Coast Flyway to the West Indies and South America (Snyder 1978a). On KSC, the Peregrine is a regular but uncommon transient in fall, a rare winter resident, and is rare in spring (Cruickshank 1980). First arrivals occur in August, although the largest numbers are seen in October and November; most depart in April (Cruickshank 1980). Birds are their chief food and Peregrines typically winter where there is an abundance of waterfowl and shorebirds (Snyder 1978a). Migratory birds that are wounded, tired, or crippled are especially vulnerable to Peregrines in Florida. They can have a significant influence directly and indirectly on prey populations within an area near their nests (Paine et al. 1990). Indirect effects have occur because Peregrines prey on crows and decrease crow-related nest predations on other nesting birds.

The Peregrine requires a plentiful and dependable supply of birds for food and perches on which to roost and feed. Florida's coastal areas provide wintering habitat especially in regions where mangroves are regenerating with dead stubs along scattered ponds and sloughs where ducks, herons, coots and gulls abound. Impoundments and marshes lakes may also attract Peregrines.

Once abundant, Peregrine populations became precariously low due to DDT, PCB, and other organochlorine insecticides in the 1950s (Woodard 1980). A contributing factor to the Peregrine Falcon decline was the interest in falconry that led to nest-robbing for trade and captive breeding. The Peregrine has been making a slow comeback in recent years due to intensive conservation efforts that have involved a propagation and stocking program of captive-reared birds. The Peregrine has not, however, recovered across its former range (Woodward 1980).



Observations on KSC by MINWR personnel show the following results (Clark 1979, Breen 1980, MINWR Annual Reports):

- 1978 - 0.2 per hour of observation.
- 1979 - Total of 30 seen or 0.3 per hour of observation.
- 1980 - Total of 21 seen or 0.3 per hour of observation.
- 1981 - No official survey but scattered sightings were reported.
- 1982 - No information available.
- 1983 - No information available.
- 1984 - 0.6 per hour of observation.
- 1985 - Total of 12 seen or 0.3 per hour of observation.
- 1986 - Total of 46 seen or 0.1 per hour of observation.
- 1987 - Total of 49 seen or 0.1 per hour of observation.
- 1988 - Total of 51 seen or 0.2 per hour of observation.
- 1989 - Total of 63 seen or 0.10 per hour of observation.

As more wetlands and coastal areas are developed along the Atlantic coast, KSC may become an increasingly important area during migration. KSC provides habitat for a few wintering birds (Cruickshank 1980). Individuals have been seen several times in the Pad 39B area and occasionally perched on bleachers along NASA Causeway East for several recent, consecutive winters (Breininger pers. obs.). No information is available to evaluate what factors limit the wintering population on KSC and it was impossible to establish the percent of Florida population that uses KSC. Given its rarity during winter, KSC was not assumed to be a population center.

A collaborative effort between NASA, the Indian River Audubon Society, and Cornell Laboratory of Ornithology was proposed in 1977 to establish a breeding population of Peregrine falcons on KSC. The proposed effort was rejected by the

USFWS for reasons that included a low captive population available to provide donors, other priorities, and questions regarding suitable genetic stock. KSC was not within the former breeding range of the Peregrine Falcon. Some project initiators believed that the project might be possible at a later date as donors became more readily available.

Concerns for KSC include the use of pesticides, mainly chlorinated hydrocarbon pesticides. Management of wetlands to maximize shorebird and waterfowl numbers and law enforcement against shooting of raptors is under the jurisdiction of the USFWS.

#### Gopher Tortoise (Gopherus polyphemus)

The Gopher Tortoise is one of four tortoises that occur in North America and is the only one east of Texas. It ranges from extreme southern South Carolina and eastern Louisiana through much of mainland Florida. The population living west of the Tombigbee and Mobile Rivers in Alabama was federally listed as threatened in 1987 (52 CFR 25380). The Florida population is listed by the FGFWFC as a species of special concern (Wood 1992) and by the FCREPA as threatened (Auffenberg 1978). It has been estimated that the Florida population will be reduced nearly 70% by 2000 A.D. and could be eliminated from all but protected lands by 2025 A.D. (Auffenberg and Franz 1982). A combination of habitat destruction, predation by humans and other animals, and biological characteristics of the tortoise have placed its existence in jeopardy over most of its range.

Estimated life span of the Gopher Tortoise ranges between 40-60 years (Landers 1980) to as long as 150 years (Cox et al. 1987). The age at reproductive maturation, which is dependent upon size of the animal and varies with geographic location and genetics (Landers et al. 1982), is 10-15 years in north Florida (Iverson

1980) and 19-21 years in Georgia (Iverson 1980). Reproduction occurs from February (Dietlein and Franz 1979) to September, with the peak in May and June (Diemer 1986). The nest site is excavated by the female in an open sandy spot with direct sunlight; the Gopher Tortoise's burrow mound will often be used if it is not heavily shaded (Landers and Buckner 1981). Average clutch size is 6 eggs (Diemer 1986), but ranges from 3 to 11 (Dietlein and Franz 1979). One clutch is laid per season (Diemer 1986), and female Gopher Tortoises may not reproduce every year (Lohoefener and Lohmeier 1984). Incubation takes from 80 days in the southern part of the range (Iverson 1980) to 110 days (Wright 1982) in the north. Most eggs laid never hatch because of mammalian predators such as Raccoons, Opossums, foxes, and Armadillos (Landers et al. 1980, Auffenberg and Iverson 1979). Hatchling Gopher Tortoises are also very vulnerable to a host of mammals, birds, and snakes (Cox et al. 1987). It is estimated that of every 100 eggs laid, only 1-3 survives to become a reproductive adult (Landers 1980). All of these biological characteristics result in a low reproductive rate that makes the Gopher Tortoise susceptible to development or disturbance. The depletion of a Tortoise population on a site may not be obvious because many long-lived adult tortoises are present, but are not reproducing enough to replace themselves (Abercrombie 1981).

The distribution of the Gopher Tortoise was thought to be limited by their sensitivity to cold climates, the availability of deep, well-drained sandy soils, and a sparse canopy of shrubs and trees (Landers and Speake 1980, McRae et al. 1981, Auffenberg and Franz 1982, Diemer 1986). Most research used to define these habitat requirements was conducted in sandhill, which was considered to be the principal habitat. Subsequent research in other habitats has shown that Gopher Tortoises occupy a variety of conditions. Low densities were reported from mature sand pine scrub (Auffenberg and Franz 1982). Disturbed, altered, and ecotonal habitats within pine flatwoods and scrub have also been found to support populations

of Gopher Tortoises (FGFWFC Cross Florida Barge Canal Study 1976).

All tortoises in temperate regions dig some type of burrow (Auffenberg and Iverson 1979), but none use the burrow as consistently as the Gopher Tortoise (Deitlein and Franz 1979). Much of its time is spent within the burrow (Ernst and Barbour 1972) and the burrow serves as a focal point for many above ground activities (Auffenberg and Iverson 1979, McRae et al. 1981). Radio-tracked Gopher Tortoises were rarely seen outside the burrow, and retreat into the burrow when approached (Smith and Breininger unpub. data). The burrow provides refuge from fires, predators, and harsh climatic conditions, not only for Gopher Tortoises, but also for at least 39 invertebrate and 42 vertebrate species, several of which are federally or state listed (Speake 1981, Cox et al. 1987). This is a minimum number of species; others will be added as equipment to examine burrows improves. The sandy mound outside the mouth of many burrows also provides habitat for two species of skinks (Cox et al. 1987) and the Scrub Mint (*Dicerandra frutescens*), a federally listed threatened plant (Wood 1986). The Gopher Tortoise is considered a "keystone species" (Eisenberg 1983) because it provides a significant element to habitat structure that greatly influences the community.

KSC is the largest area of protected habitat for this species along the Atlantic coast of Florida. Studies on KSC (Breininger et al. 1988, Giovanetto 1988, Breininger et al. 1991, Breininger et al. 1994, Smith and Breininger unpub. data) have shown that Gopher Tortoise densities are highest where herbaceous cover is the highest, and densities tend to decrease with increasing cover of oaks, shrubs, and pines. Recently burned areas typically have more tortoises than unburned areas in undisturbed scrub. Disturbed scrub, not necessarily pinelands, had the highest densities of Gopher Tortoises, but they were not abundant in all disturbed scrub sites. These areas are typically dominated by a diverse cover of herbaceous plants (Breininger and Schmalzer 1990), which is the principal food of Gopher Tortoises (Landers 1980,

MacDonald 1987). Higher densities occurred in poorly drained scrub and slash pine than in well drained scrub and slash pine on KSC (Breininger et al. 1988, 1991), perhaps because food is more abundant in poorly drained areas (Breininger et al. 1988). Tortoises will spend time in flooded burrows (Means 1982, Breininger et al. 1988, Smith and Breininger unpub. data). Occupied burrows occur in areas with 100% shrub cover (Breininger et al. 1988, Smith and Breininger unpub. data). High burrow densities have been found in coastal strand (Logan unpublished), spoil areas (Speake 1983, Breininger unpub. data), and areas dominated by grape vines (Vitis rotundifolia) (Speake 1983) on KSC.

Total burrow densities in KSC scrub and slash pine range between 17.5-32.2 burrows/ha, with an average density of 1.3 animals/ha (Breininger et al. 1988). Correction factors are used to extrapolate from a known number of burrows to the estimated number of Gopher Tortoises in an area. There are several problems associated with the use of correction factors. Tortoise burrows often vary in states of maintenance, i.e. actively being used by a tortoise; inactive at the present time, but still intact; or abandoned. A burrow may be inactive, but appear active after a "visit" from a Gopher Tortoise, which often occurs with small males (Smith and Breininger unpub. data). Some burrows are used by more than one tortoise for a period of time, and most Gopher Tortoises use several burrows (Smith and Breininger unpub. data). Snakes, armadillos, or other animals may make a burrow appear as though it is being used without carefully scrutiny. A correction factor developed in sandhill habitat (Auffenberg and Franz 1982) was widely used to estimate Gopher Tortoise densities in other habitat types. In KSC scrub and slash pine flatwoods, it was found that during much of the year, the number of active burrows can be multiplied by 0.28 to get an estimate of the average number of tortoises (Breininger et al. 1988, 1991). This correction factor was determined using a camera system to survey burrows and

emphasizes that correction factors are dependent on habitat and season, and should be applied with caution.

#### Gull-billed Tern (*Sterna nilotica*)

This tern has a nearly cosmopolitan breeding distribution (Clapp et al. 1983). The species was once common along the southeastern coast of the U.S., but plume hunting and perhaps habitat destruction caused a population decline (Clapp et al. 1983). In 1976, it was estimated that there were 3,500 Gull-billed Terns in the U.S. (Clapp et al. 1983). Habitats for roosting and nesting include beaches, salt or freshwater marshes, and sandy or grassy islands; these habitats are especially susceptible to development and/or alteration that makes them unsuitable for nesting terns. Their breeding habitats now include agricultural and urbanized areas. Gull-billed Terns feed over a variety of habitats including ruderal habitats (Rowher and Woolfenden 1968), marshes, and scrub (Cain 1933). These terns eat insects, spiders, frogs, small mammals and crustaceans depending on prey abundance (Clapp et al. 1983). Feeding habitats on KSC have included *Spartina alterniflora*, *Spartina bakerii*, mangroves (Breininger pers. obs.), and open water impoundments (Breininger and Smith 1990).

The U.S. population of Gull-billed Terns seems to be declining due mainly to habitat destruction, but egg collection and the plume trade also had an impact (Erich et al. 1988). Howell (1932) found few records of this species in Florida and suggested its presence may be of recent origin. They were once common in Brevard County, especially in the spring and summer (Cruickshank 1980). The construction of spoil islands may have altered their abundance and distribution. During wintering bird surveys on MINWR, no Gull-billed Terns have been seen between 1985 and 1989 (MINWR Annual Narratives), but they have been seen on six MINWR Christmas Bird

Counts between 1970 and 1989 (Stuckey et al. 1990). KSC was once regarded as one of a few significant nesting populations for the species in Florida (Clapp et al. 1983). Nearly 300 pairs were reported in the Banana River in the mid 1970s (Schreiber and Schreiber 1978). Eighteen nests were observed in 1980 (Schroeder 1980), 20 nests in 1985, and four nests in 1986 (MINWR Annual Narratives). Nest success was not reported during most surveys. Schroeder reported that nests in 1980 appeared unsuccessful. Two nests occurred on spoil islands north of NASA Causeway in the Banana River in 1989 (Breininger and Smith pers. obs.). They prefer nearly bare or sparsely vegetated areas (Schreiber and Schreiber 1978, Clapp et al. 1983). Spoil islands have become dominated by trees and shrubs which may explain the loss of the KSC population. KSC spoil islands have potential to be significant breeding areas for regional populations of colonial nesting birds as unprotected breeding grounds elsewhere disappear or are subject to increasing human disturbance. Improvement of spoil islands for shorebird nesting should be a management priority.

#### Gopher Frog (*Rana areolata aesopus*)

The Gopher Frog is a commensal that uses Gopher Tortoise burrows (Franz 1984) and other refugia (Seigel pers. comm.) such as Mouse burrows, stump holes and mouths of crawfish holes. It feeds on insects and other small animals. Except for the use of breeding ponds, habitat associations are believed to be similar to the Gopher Tortoise. Gopher Frogs use temporary ponds for reproduction (Gibbons and Bennett 1974, Moler and Franz 1987) to avoid predators or competitors of tadpoles. Gopher Frogs may travel at least two kilometers to breeding ponds (Franz et al. 1988). Peak migration to breeding ponds occurs in late winter and is correlated with rainfall and warm night temperatures (Bailey 1990). Gopher Frog egg masses contain 1700

eggs or more are attached to emergent or submergent plants (Bailey 1990). Appropriate habitat for the Florida Gopher Frog can be found in xeric habitats from south Georgia through much of the Florida peninsula, excluding the Everglades (Carr 1940, Mount 1975, Stevenson 1976).

The Gopher Frog is vulnerable to local extinctions and a population decline is probable due to limited or patchy distribution, dependence on fire-maintained habitats, tendency to congregate in large breeding groups, its ecological specialization, and the vulnerability of its habitat to human development (Noss and Labisky in press). Although suitable habitat occurs on KSC, the Gopher Frog does not appear common. It only has been discovered on KSC north of Haulover Canal in 1992 and along Tel 4 road in 1994. It is uncertain whether the Gopher Frog occurs in a few areas or why the Gopher Frog has gone undetected in other areas of KSC. It is unusual that it appears so rare given the intensity of Gopher Tortoise studies on KSC. Nearly all Tortoise study areas were south of Haulover until 1992.

#### American Avocet (*Recurvirostra americana*)

The American Avocet feeds on plants and animals in shallow water and mudflats by swinging its bill back and forth below the water surface or fine-grained mud. They breed from eastern Washington, central Alberta and southern Saskatchewan to southern California, northern Utah and southern Texas. Wintering birds are found from central California and southern Texas to Guatemala and Florida. The American Avocet is more abundant during winter in California and along the Gulf coast of Texas, Louisiana, and Mississippi than in Florida (Root 1988). Accounts suggest that the American Avocet has historically been uncommon or rare in Florida (Howell 1932). The American Avocet is listed as a species of special concern by the FCREPA. They feed in shallow bays, mudflats, and open water impoundments in



Florida during migration and winter. Data collected during 1970-1974 Christmas bird counts indicate that approximately 500 Avocets winter in Florida in four locations, of which only two (including KSC) are protected (DeGange 1978). The Avocet is a regular wintering bird at Port Canaveral and KSC (DeGange 1978). These two locations comprised nearly all the sightings during Christmas Bird Counts in Florida for 1991. Avocets are not known to breed in Florida; copulating birds have been observed at Port Canaveral as late as June (Cruickshank 1989), but no nests have been found. They were observed at low densities (0.03-0.78 birds/ha) in April, August, October, and November 1984 and in February and March 1985 in mosquito control impoundments near Pads 39A and 39B on KSC (Breininger and Smith 1990).

#### Black Skimmer (Rhynchops niger)

The Black Skimmer has been listed as a species of special concern by FCREPA and FGFWFC. The Skimmer feeds by flying close to the water's surface and allowing the large lower mandible to dip into the water where it "skims" just below the surface catching small fish or crustaceans. This specialized behavior involves heavy energetic demand; the need for prey to be present in sufficient abundance in the appropriate places to allow capture may make food acquisition a limiting factor in some areas (Erwin 1977). Black Skimmers have narrow feeding habitat tolerances, but little information is available to quantify habitat characteristics (Black and Harris 1983). The Skimmer is found on ocean beaches and salt water bays from Cape Cod to South America and winters mainly in the Southeast. It is also common on the west coasts of the Americas (Clapp et al. 1983). Most nesting is in coastal areas with a few inland exceptions that may be associated with declines in suitable coastal nesting habitats due to human activities (Langridge and Hunter 1986). Preferred winter feeding habitat on Florida's Gulf coast is within 2 m of a land/water interface in shallow

(10-20 cm) smooth water where there is much interspersed open water and mudflats (Black and Harris 1983). Black Skimmers nest on isolated, sparsely vegetated substrates including coastal beaches, sandbars, shell banks, islands and gravel roof tops. Skimmers tend to nest in large colonies and are often associated with other terns and gulls, in particular Least Terns. Schreiber and Schreiber (1978) reported that Black Skimmers have the poorest nesting success among colonial birds that use dredge spoil islands due to human disturbance. Human development has reduced the number and quality of nest sites (Barbour 1978, Kale and Maehr 1990). Nest sites will often be abandoned if they are disturbed; a slight human disturbance can cause a reduction in the reproductive success of a colony (Erlich et al. 1990). Skimmers are sensitive both early and late in the nesting season; chicks that run due to disturbance can be killed by territorial adults (Safina and Burger 1983). Black Skimmers readily change colony sites from year to year (Clapp et al. 1983). Shifts from spoil island to rooftop nesting could have important conservation consequences for this species. Studies indicate that Black Skimmers that use rooftops for nesting routinely fail (Greene and Kale 1976, Fisk 1978, Gore 1987). If roof-nesting becomes common, studies of productivity on such areas will be especially critical.

Black Skimmers are present on KSC year-round; local nesting populations may be supplemented by migratory birds especially in fall (Cruickshank 1980). As many as 1166 birds have been sighted at one time on KSC (Cruickshank 1980). Although the numbers on KSC are only a small percent of the population in the eastern U.S., KSC is one of the most important areas on the Atlantic coast of Florida (Clapp et al. 1983). The nesting population on KSC was once the largest in the Indian River (Schreiber and Schreiber 1982). The 1991 Christmas Bird Count revealed that KSC had only about 2% of the sightings in Florida. Surveys done by MINWR personnel on refuge spoil islands reported 246 nests and 50 young in 1980 (Schroeder 1980). In 1981, three spoil islands in the Banana River were mechanically cleared to encourage

colonial bird nesting (see Royal Tern summary). The results after this clearing are as follows:

1981	200 Skimmers seen on spoil islands.
1982	Young reportedly seen on spoil islands.
1983	No data
1984	86 nesting on spoil islands.
1985	120 nesting on spoil islands.
1986	110 nesting on spoil islands.
1987	38/survey seen nesting on BRSI #13.
1988	41/survey seen nesting on BRSI #13 and #14
1989	49/survey seen nesting on BRSI #13 and #14

Relatively low numbers of Black Skimmers were found in Indian River spoil island surveys conducted between 1987-1989 (DNR 1990). It appears that a population decline has occurred on KSC. Approximately 386 nests of Black Skimmers were reported in a recent publication for northwest Florida (Gore 1991). The nesting population size in Florida might approach 2000 pairs (R. Paul 1991 Coastal Nongame Workshop). Thus, it is reasonable to assume that KSC once represented a significant nesting population center in Florida. More consistent and intensive surveys are needed to locate and monitor success of Black Skimmer colonies on KSC. Spoil island management practices probably have the most significant influence on local populations. Roof top nesting by Black Skimmers needs evaluation.

#### Bobcat (Lynx rufus)

The Bobcat is found only in North America where it is the most common wild cat. It ranges throughout North America excluded only from the corn belt (Deems and

Pursley 1978). One to four kittens are usually born in the spring, although females in Florida may have a second litter later in the year. Bobcats are primarily nocturnal and crepuscular but are sometimes active during the day. Males are almost 80% heavier than females (Anderson 1987). There is considerable variation in habitat relationships, movement patterns, population demographics, and several other ecological characteristics across the species range (Wassamer et al. 1988). Cottontails (Sylvilagus spp.) are the predominate prey item across North America (Anderson 1987). Cottontails (S. floridanus), Marsh Rabbits (S. palustris), and Cotton Rats (Sigmodon hispidus) accounted for most of the prey consumed at Archbold Biological Station (ABS) (Wassamer et al. 1982). Average distance movements during a day were 1.6 km at ABS (Wassamer et al. 1982). Disease played a very important role in Bobcat demographics at ABS. Of 17 radiocollared cats, nine died during a 32 month period; 73% of these deaths were due to disease (Wassamer et al. 1988). This suggests that high mortality rates due to feline panleucopenia and Notoedric mange may have serious consequences for small populations. Homeranges include many habitats; the proportion of a habitat that is used often varies from the proportion of its availability, suggesting that some habitats are preferred and some are avoided. Bobcats in Florida may prefer habitat types with considerable cover, although they will frequently use firebreaks, trails, and similar features within these habitats (Progulske 1982, Wassamer et al. 1988). Den sites at ABS were often in thick patches of scrub. Males typically have larger homeranges than females; the home range of members of the same sex seldom overlap but homeranges of different sexes often overlap extensively (Wassamer et al. 1988). Homeranges for the Bobcat from studies in the southeastern U.S. have ranged from 100-6000 ha (Anderson 1987).

Fur trade and predator control have been responsible for the species decline across much of North America. Additional pressures now result from habitat loss and

fragmentation. These factors combined with road mortality make the Bobcat one of the most endangered animals in Florida (Harris and Gallagher 1989). The Bobcat is very vulnerable to local extinction and population decline across northern Florida is highly probable (Noss and Labisky in press). The vulnerability is due to its need for large amounts of habitat, its wide-ranging habits, its exploitation as a furbearer and game animal, and persecution (Noss and Labisky in press). It is a legally trapped furbearer and listed in Appendix II of CITES.

The Bobcat is a permanent resident of KSC. Observations by Ehrhart (1976) suggested that the Bobcat was common in scrub and all but the wettest habitats. They at least sometimes use salt marshes and impoundment dikes for hunting and raising young (Breininger pers. obs.). In one week's time, over 60 collections of Felis scat was made along the railroad track southeast of Playalinda Beach (Ehrhart 1976). One litter was found in a Gopher Tortoise burrow during camera surveys (Breininger et al. 1988).

Homerange estimates from populations other than KSC suggest that the Bobcat is the widest-ranging terrestrial animal on KSC. KSC has 34,000 ha of uplands and wetlands, much of which could be used by Bobcats. Although this seems like a large amount of acreage, the lands of KSC alone may not be large enough to support a viable population that could survive several centuries if not linked to other areas. Using minimum and maximum density estimates from studies in the southeastern U.S. (Anderson 1987, Wassamer et al. 1988) and assuming all habitat is occupied, one derives an estimate of the KSC population from 20-400 individuals. Given its geographic location, KSC not only supports a significant population, but serves as a corridor linking CCAFS and Turnbull Hammock. There is a loose linkage of KSC and Turnbull Hammock to areas of the St. Johns River Water Basin, which is linked to the Ocala National Forest. Thus, there is a major potential network for the movement of such mammals. KSC and CCAFS represents one of the few Atlantic coastal

components of the Bobcat population in Florida. Corridors elsewhere in Florida are being planned to prevent the extinction of Florida's larger mammals. Unfortunately there is no publicly owned land for a mile stretch between KSC and the St. Johns River Basin but this area may not necessarily need to be publicly owned depending on its land use. The KSC population of feral House Cats may serve as an additional reservoir for disease and may facilitate distribution of diseases. Feral House Cat populations should be eliminated due to their potential to disrupt faunal integrity, since native animals are not adapted to these exotic predators.

#### Eastern Brown Pelican (*Pelicanus occidentalis carolinensis*)

The Eastern Brown Pelican is one of two Pelican species which occur in the U.S. The Brown Pelican was listed as endangered in 1970 but was removed from the federal list in Florida and Alabama in 1985; it remains endangered over the rest of its range. Although the Florida population is relatively stable, some areas of Florida have experienced a decline for reasons that are unknown (Jacobs 1985). Some regional populations of Brown Pelicans suffered crashes or dramatic declines in reproductive success that were attributed to organochlorine pesticides (Anderson and Hickett 1970, Blus et al. 1979a, b). A ban on DDT and restricted use on Endrin were implemented in the early 1970s. Environmental residue concentrations of these pesticides have since decreased in most areas and pesticide levels in eggs have steadily decreased (Blus 1979a,b; Scriber 1980). There has been a corresponding increase in eggshell thickness and reproductive success for the Pelican and other avian predators such as the Bald Eagle and the Peregrine Falcon which were also affected by pesticides (Jacobs 1985).

Brown Pelicans feed primarily on fish by plunge diving in coastal waters. Typically, they do not feed in fresh water or far out at sea. Weather can influence

feeding and reproductive success. High winds or waters can destroy nests and make sighting prey difficult. Cold snaps can contribute to the death of eggs and nestlings, and periodic food shortages can result in decreased nesting or fewer young produced (Schreiber 1979). Pelicans normally choose nest sites which are free from most mammalian predators; however, avian predators such as gulls and Fish Crows are also a threat. Besides overall habitat loss throughout the Pelican's range, recreational fishing can cause a substantial portion of mortality; human-induced injuries in the population are common, particularly in Brevard County (Jacobs 1985). They are vulnerable to fishing gear and are often found entangled or hooked by such gear. Brown Pelicans can be seen dead almost every week along Route A1A adjacent to Port Canaveral (Breininger per. obs.). This is a four lane highway and although it is not on KSC property, KSC employee traffic could contribute to mortality since many of the dead birds are seen immediately adjacent to the road. Brevard County employees have inquired about increased mortality believed to occur during shuttle launches. If there is increased mortality, an increase in traffic associated with launch periods may be an explanation. Other causes of such mortality are also possible. For example, power lines occur along the highway, which is nearly surrounded by estuarine or port waters used by Pelicans; powerlines have been clearly established elsewhere as significant causes of mortality (Crivelli et al. 1988). The entire area of Port Canaveral is undergoing rapid commercial development. For several decades the port area has been known for loafing and feeding shorebirds, pelicans, and other waterbirds (Cruickshank 1980). It has been said that port expansion will displace many birds with the assumption that the birds will move to the adjacent MINWR. No studies have been conducted to determine the ability of MINWR to absorb such an influx.

Brown Pelicans nest primarily within mangroves (Schreiber 1978a) but will use other trees and shrubs including Australian pine, red cedar, live oak, red bay, and sea grape. On KSC, Brown Pelicans once nested only on Bird Island in Mosquito Lagoon

(Breen 1980). Nesting chronology of the Bird Island Colony was poorly understood but the information available suggests that nesting began as early as February (Breen 1980). Bird Island was devastated by freezes in 1983 and 1985 resulting in a nesting decrease at that location. Nesting occurred at the Haulover Canal Colony in the Indian River, Bluebill Creek Colony in the Banana River, and Bird Island during 1988-1990 (Breininger and Smith pers. obs.). From 1978 through 1990, there has been a thirteen-year average of 419 Brown Pelican nests per year, ranging from 250-625 nests with no obvious trends over the period (Williams and Martin 1970, Nesbitt et al. 1977, Breen 1980, Sasser and Lee 1981). KSC has contributed to nearly 10% of the Florida population during this time period. Accurate estimation of nesting success is difficult considering the prolonged and asynchronous nesting season (Breen 1980).

Feeding primarily occurs in the ocean and lagoons, neither which are greatly influenced by NASA operations. They are vulnerable to some powerline mortality and subject to some disturbance. Given their historical susceptibility to environmental contaminants, Brown Pelican population trends should be considered measures of environmental quality.

#### Least Tern (*Sterna antillarum*)

The Least Tern is the smallest North American tern and ranges along the coast from Maine to central Texas, along large rivers in the central U.S., and on the southwest coast of California (Carreker 1985). The American Ornithologist's Union recognizes three subspecies of the Least Tern in the U.S.: the California Least Tern (*Sterna antillarum brownii*), the interior subspecies (*S. a. anthalossos*), and the eastern subspecies (*S. a. albifrons*) which inhabits KSC. The California and interior subspecies are federally listed as endangered (USFWS 1980, Whitman 1988) and the eastern Least Tern is listed as threatened (Kale and Maehr 1990). Some researchers (Massey



1976) have argued that the eastern and California Least Terns should be considered the same subspecies. Data suggest that eastern Least Tern populations declined by 80% between 1940 and the mid-1970s (Fisk 1975), and they still may be declining (Clapp et al. 1983, Erlich et al. 1988). There are approximately 25,000 birds in the southeastern U.S., and the total number in Florida appears to be nearly 5000 birds (Clapp et al. 1983). Least Terns winter in South America (Clapp et al. 1983).

Least Terns feed primarily on small fish and aquatic invertebrates taken from a variety of habitats that include freshwater lakes and rivers, borrow pits, ditches (Smith pers. obs.), canals, brackish impoundments, lagoon estuaries, and ocean waters (Kale and Maehr 1990, Carreker 1985). Colonies are usually close to permanent water, although foraging may take place up to 5 km away (Lohrer and Lohrer 1973, Thompson and Slack 1982, Clapp et al. 1983).

In Florida, Least Terns arrive on breeding grounds in late March or early April and most depart by late August (Cruickshank 1980). Adult plumage is acquired by the second year and some birds nest then, but most wait until their third year (Massey and Atwood 1981). Least Terns live for up to 21 years (Clapp et al. 1983). Egg laying takes 10-14 days and clutches of 2-3 eggs are produced. Incubation takes 21 days and precocial young fledge within 17-20 days (Massey and Atwood 1981, Lohrer and Lohrer 1973, Clapp et al. 1983, Thompson and Slack 1984). A colony often includes pairs at different stages of reproduction since Least Terns will reneest after failure, and 2-year-old birds may nest later than experienced birds (Lohrer and Lohrer 1973, Massey and Atwood 1981). Occasionally, in warmer climates, a pair will raise two clutches in one breeding season.

Historical nesting sites in the eastern U.S. were sandy beaches, sand spits, sand bars, and other areas with a light-colored substrate of sand, coarse shell, or gravel. These sites have been replaced by roofs, spoil islands (Fisk 1975, Greene and Kale 1976, Erwin 1980, Gochfeld 1983, O'Meara and Gore 1988), road embankments,

and parking lots (O'Meara and Gore 1988). Substrates typically are <20% shell and 80-90% sand with sparse, short vegetation cover that is important to provide shade and wind protection for chicks, but not provide concealment for terrestrial predators (Thompson and Slack 1982, Gochfeld 1983, Kotliar and Burger 1986).

Threats to colonies include habitat destruction, human disturbance, predation, and vegetation succession. Although loss of habitat has been responsible for a decline of Least Terns, increased recreational use of beaches has been a primary cause of shifts to alternative nesting areas (Erwin 1980, Gochfeld 1983). Disturbance can result in reduced reproductive success or abandonment of a colony. Eggs can overheat when adults are chased off their nests, and eggs and young are so cryptic that they are easily stepped upon. Least Terns are infamous for their diving and defecating and attacking nest predators during the day, but they have no defense against nocturnal predators (Jackson et al. 1982, Burger 1984). Raccoons that thrive in human-altered landscapes can reduce reproductive success at colonies (Kotliar and Burger 1986). Least Terns display some site tenacity when choosing their nesting areas (Carreker 1985); they apparently select colony sites based on previous reproductive success at the site, substrate, and proximity to feeding habitat, without considering the danger from terrestrial predators. Flooding due to extreme high tides or other storm events can be a problem for some sites.

With the disappearance of natural nesting areas, roof tops are increasingly being used as colony sites. They are typically flat or slightly pitched, with light gravel or crushed shell over tar with structures to provide shade (Fisk 1975, 1978a). Mammalian predators and vegetation succession are not problems on roofs, but some roofs are subject to flooding, human disturbance, and strong winds (Fisk 1975, 1978a; Gore 1987). Chicks can fall off, be washed down drains, or become stuck in tar (Fisk 1975). Consequently, management recommendations have been prepared for roof top nest sites (Greene and Kale 1987, O'Meara and Gore 1988) that include

scheduling maintenance activities to avoid the nesting season, fencing roof edges, screening drains and gutters, and providing structures for shade and flood prevention.

It was suggested that half of the Least Tern colonies in Florida occurred on KSC (Leenhouts 1986 in Edward E. Clark Engineers-Scientists, Inc. 1986); this is unlikely based on historic colony locations (Clapp et al. 1983). It appears, based on Clapp et al. (1983), that the population on KSC could approach 10%. Nesting data on KSC are scattered in a variety of references. In 1978, there was a spring population of 100-300 birds, a summer population of 300-400 birds, and a fall population of 50-100 birds (USFWS data cited in NASA 1979). Between 1977 and 1979, there were 2-5 unsuccessful colonies and 0-3 successful colonies. During the same time period, the number of unsuccessful nests ranged from 35-58 and there were 0-95 successful nests (unpublished USFWS report cited in Ehrhart 1978). There were four unsuccessful colonies in 1980 (Schroeder 1980). Of 30 nesting attempts, 21 that were located in parking lots failed due to human disturbance and the remaining 9 were depredated by Raccoons (MINWR Annual Narrative 1980). Nesting failure of KSC colonies has also been attributed to aircraft operations, flooding, and predation by Fish Crows and Laughing Gulls (Salata 1979, Schroeder 1980). In 1983, Least Terns were reported nesting in parking areas of the VAB and LC 39B. Only ten chicks were fledged and all other nests were abandoned (MINWR Annual Narrative 1983).

Ten spoil islands in the Banana River were cleared of vegetation in 1981 and 1982 in order to encourage shore bird nesting (MINWR Annual Narrative 1981, 1982). No data are available for the islands for 1981-1983. There were 21 Least Tern nests in 1984, 31 nests in 1985, and 31 in 1986 (USFWS cited in Edward Clark Engineers-Scientists 1986, MINWR Annual Narratives 1984, 1985, 1986). Least Terns were absent from the spoil islands after 1986, although other shorebirds (Laughing Gulls, Royal Terns, and Black Skimmers) were reported nesting on three of the islands (MINWR Annual Narratives 1987, 1988, 1989). Least Terns were observed nesting in

several locations in impoundments north and southwest of Pad 39B in May 1985 (Breininger pers. obs.). Nesting north of 39B occurred within the heavy launch deposition zone, however, no launches occurred during the nesting period. No nesting has been observed in this area since. Presumably this is a poor nesting area because it offers little protection against ground predators due to shallow (<15 cm) water. Least Tern colonies on KSC were not reported in the FGFWFC status survey of central Florida Atlantic beaches (O'Meara 1987).

Nesting was observed on both SLF overruns in 1982 and 1983. Mitigative measures were taken by painting the overruns, but the paint deteriorated by 1983 on the south end. The ecological monitoring staff, MINWR, and FGFWFC receive frequent calls from KSC employees concerning Least Tern nesting in KSC operational areas, most recently roof tops. These concerns are difficult to respond to due to the general lack of information on the KSC population. Least Tern nesting was noted on two buildings on KSC in 1989 and 1990 (Kershner pers. comm., Kehl pers. obs.).

Recommendations for increasing the KSC Least Tern population include the management of vegetation and erosion control on Banana River spoil islands (Salata 1979, Schroeder 1980). Least terns can be encouraged to use such areas by the employment of decoys (Kotliar and Burger 1984). Spoil islands are typically less prone to flooding than coastal sites and are isolated from mainland predators (Jackson et al. 1979, Erwin 1980, Burger 1984, Kotliar and Burger 1986). Because they are within the NASA and CCAFS security areas, the islands are protected from disruption by boaters that often occur in public waterways (Fisk 1978b). Without management, spoil islands gradually revegetate and will eventually become unsuitable for nesting. Such management would benefit several species of special concern besides Least Terns (Burger 1984, Thompson and Slack 1982, Kotliar and Burger 1986, O' Meara and Gore 1988).

### Kingsnake (Lampropeltis getulus)

The subspecies L. g. getulus occurs throughout much of the eastern U.S. from New Jersey to central Florida (Stevenson 1976). The Florida Kingsnake (L. g. floridana) occupies the remainder of Florida including Brevard County (Carr 1940). The snake is long-lived and can grow to larger than 2 m. They have aquatic tendencies and are often found near pond margins, swamps, hammocks and other wet areas (Carr 1940). Eastern Kingsnakes are diurnal except during the hotter months when they will hunt at night. They are powerful constrictors that eat other snakes (including poisonous ones), frogs, salamanders, lizards, mice, birds, and eggs (Carr 1940). The Eastern Kingsnake is vulnerable to local extinctions; population decline across its range in Florida is likely due to its small population size, habitat fragmentation, large area requirements, susceptibility to ground predators and disturbance, and human harassment and exploitation (Noss and Labisky in press).

KSC is near the southern end of the range of the Eastern Kingsnake and the northern range of the Florida Kingsnake (Stevenson 1976). Three museum specimens of the species have been collected from this area, one from Merritt Island in 1955, one from Playalinda Beach in 1973, and one from MINWR in 1979 (R. Seigel unpublished). KSC is only a small portion of the range of the Florida Kingsnake. Little development occurs in its preferred habitats. It is, however, affected by road mortality.

### Eastern Coachwhip (Masticophis flagellum)

This predator hunts for invertebrates, lizards, snakes, birds, and small rodents during the day, covering a large homerange. It is believed to be a significant nest predator of the Florida Scrub Jay (Woolfenden and Fitzpatrick 1984) and has been observed capturing juveniles. Coachwhips prefer dry habitats (Bogert and Cowles 1947, Campbell and Christman 1982) and are common in sandhills, scrub, and

occasionally flatwoods (FGFWFC 1976). The ability to use xeric environments during the day is attributed to its resistance to desiccation (Bogert and Cowles 1947). They range from North Carolina to southern Florida, west to Texas, Oklahoma, and Kansas, but are absent from the lower Mississippi River valley.

This snake is very vulnerable to local extinctions and a population decline is highly probable for much of Florida (Noss and Labisky in press). Eastern Coachwhips are vulnerable to human development because they have large homeranges, require much suitable habitat to maintain a minimum viable population, are subject to road mortality, are susceptible to predators such as feral pigs, and are persecuted by humans. Other threats across their range include their dependence on xeric habitats that are maintained by fire which are prone to development, fragmentation, and disruption of natural fire patterns. Road mortality is a significant threat on KSC (Seigel 1977). Because most of KSC is undeveloped, and there is much unfragmented suitable habitat that is managed by prescribed fire, the population is not threatened by the severity of factors that threaten the maintenance of viable populations over much of its range in Florida. Although occasionally observed, a low population size was assumed given their large homeranges and insufficient knowledge concerning their population.

#### Black Rail (Laterallus jamaicensis)

The Black Rail is the smallest rail occurring in the U.S. In the eastern U.S., the Black Rail breeds along the coasts of Massachusetts to Florida and winters in the southern U.S. to the Antilles (Kale and Maehr 1990). The Black Rail is listed on the California list of endangered species. Although the Black Rail occupies a wide variety of marshes, it apparently has a preference for tidal salt marshes especially where Salicornia or Scirpus occurs (Grinnell and Miller 1944, Manolis 1978). It is unclear

whether the association with such vegetation is a preference for high salt marshes or the particular form of vegetation (Manolis 1978). At least in California and perhaps New York, there is a preference for tidal marshes and not diked marshes due to greater food availability (Post and Enders 1969, Manolis 1978). Black Rails along the Colorado River are also associated with high, shallow marshes that have little annual or daily fluctuations in water levels (Repking and Ohmart 1977). The Black Rail feeds on isopods, insects and arachnids on moist soil and nests on the ground in the dense upper marsh vegetation. Due to its extremely secretive habits, very little is known about the biology or demography of this small Rail. The presence of this bird is often determined from auditory records rather than actual sightings. The male and female have different songs and will become quite vocal during the breeding season, providing some opportunity to census individuals. However, this method can be inexact and difficult for people unfamiliar with the variety of songs produced by Rails. The population of the Black Rail is either alarmingly low or unknown for much of the U.S. (Eddleman et al. 1988). Recent surveys have shown that California Black Rail (L. J. coturniculus) populations in the western U.S. are much lower than expected and are vulnerable to stochastic extinction; models predict coastal and interior coast populations to be tenuous (Evens et al. 1991). Since almost nothing is known about populations in Florida, one can question whether a similar situation exists here.

The Black Rail breeds from May through September and is a year-round resident on KSC. Breeding populations are probably supplemented by northern migrants in winter (Sykes 1978). Black Rails pass through KSC during spring and fall migration as evident from bird kills at the VAB (Cruickshank 1980, Taylor and Kirshner 1986). Typical habitat on KSC is dense Distichlis and Salicornia stands (Sykes 1978) and the species was once common here (Paul Sykes pers. comm.). Suitable habitat was abundant but it has since been fragmented and greatly reduced by impoundment. Black Rails have been sighted during the breeding season in two separate locations

within impoundments in the Pad 39A and 39B vicinity (Breininger pers. obs.). Both locations were along the edge of a ditch within mixed vegetation that included Borrichia, Distichlis, and Salicornia. It is not possible to quantify the importance of KSC for maintenance of regional populations of the Black Rail because no information is available on its status on KSC. Brevard County appears to be one of the most important counties based on sightings that have been compiled (Sykes 1978, Loftin et al. 1991). The area has been reported to have the densest and most regular wintering populations in the U.S. (Root 1988); however, these data are nearly 20 years old. Recent published breeding season surveys include the nearby St. Johns National Wildlife Refuge where a maximum of 4-6 Black Rails were detected (Runde et al. 1990). Several have also been found in the Turnbull Marshes (R. Cheney, pers. comm.). Scattered breeding records for the Black Rail exist for other coastal counties in Florida (Sykes 1978, Loftin et al. 1991).

Most salt marsh habitat is impounded on KSC. Black Rails occur in appropriate vegetation within impoundments but abundance, reproductive success, and mortality rates are unknown. No data are available before or after impoundment (Trost 1968, Provost undated) perhaps because the species is seldom detected even where present. Spartina alterniflora is a common cover type outside impoundments, but water levels are probably too deep for Black Rails. NASA has little direct impact on this species, except perhaps in the vicinity of shuttle launch pads where only a small portion of the potential available habitat is found. An indirect NASA impact could be associated with its influence on mosquito control practices. Unimpounded salt marshes occur along Turnbull Creek in the north end of the Indian River Lagoon. Efforts being made to acquire these marshes for conservation appear to have good chances of success (R. Hinkle pers. comm.).



### Caspian Tern (*Sterna caspia*)

The Caspian Tern distribution is cosmopolitan; it occurs throughout much of North America but is most abundant along the coasts of Virginia, South Carolina, Texas, and Louisiana. These terns nest on isolated, sparsely vegetated islands and they nest singly or in small to large colonies (Clapp et al. 1983). Caspian Terns feed mainly on small to medium-sized fish that are captured by plunge-diving into the water. Howell (1932) noted that the Caspian Tern was an uncommon migrant and winter resident in Florida. Sprunt (1954) suggested its presence in Florida may be of recent origin. In Florida, the terns are present in small numbers throughout the year along the Atlantic coast, but few nest here (Clapp et al. 1983). In 1976, surveys found no nesting Caspian Terns. In 1978, nesting was reported in Florida, and it is speculated that this was due to an increase in nesting habitat provided by the dredge spoil islands (Schreiber and Schreiber 1978). In 1979, Herb Kale reported a maximum of 31 pairs nesting on dredge-spoil islands on KSC, which represented the only breeding site on Florida's Atlantic coast (Clapp et al. 1983). Surveys by MINWR personnel reported: 1 nest but no young in 1980; 2 nesting (1/survey) in 1986; 4/survey in 1987; 8/survey in 1988; and 8/survey in 1989. Wintering surveys of Caspian Terns utilizing the refuge have shown numbers ranging from 8 in 1978 to 22 in 1976. Wintering Caspian Terns on KSC represented one of the largest wintering populations in Florida (Clapp et al. 1983). The major concern for maintaining this tern is the maintenance of spoil islands. Management of spoil islands for nesting Royal Tern and Least Terns could benefit wintering and nesting Caspian Terns.

### Sandwich Tern (*Sterna sandvicensis*)

The cosmopolitan Sandwich Tern requires bare sand on isolated spits, sandbars, barrier beaches, and sparsely vegetated dredge-spoil islands for nesting

and loafing. In the U.S., this species breeds along the coasts of the Carolinas, north Florida, and Louisiana (Clapp et al. 1983). There have been nesting records from St. George Island near Jacksonville, Clearwater, John's Pass (St. Petersburg), Charlotte Harbor, Cape Sable, the Florida Keys and the Dry Tortugas. Since 1974, nesting has been reported only on Bird Island in Nassau Sound (near Jacksonville). Royal and Sandwich Terns are often found nesting together; their chicks form mixed creches in nesting areas, providing a "day care" system which enables adults to feed longer and reduces the risk of depredation on all chicks. The Sandwich Tern has a long-term pair-bond allowing egg-laying to be synchronized thereby reducing predation rates on eggs and young (Clapp et al. 1983). Most wintering occurs in Mexico, Central and South America.

The highest numbers on KSC occur during late summer and late fall (Cruickshank 1980, Breininger unpublished data); nesting on KSC could occur (Cruickshank 1980). Management of spoil islands for Least Terns and Royal Terns will also benefit this species. The number of Sandwich Terns using KSC was a small percent of the population in the eastern U.S. (Clapp et al. 1983).

#### Mole Snake (Lampropeltis calligaster rhombomaculata)

The Mole Snake reaches an adult length of 76-101 cm. This kingsnake is brown dorsally with 45-55 reddish blotches down the back (Means 1978). It is generally very similar in appearance to the more common Corn Snake except that all scales on the Mole Snake are smooth and the anal plate is undivided (Means 1978). The range of the Mole Snake is mainly in the Southeast from Maryland to central Florida and west to Mississippi (Means 1978). West of the Mississippi, there is a different subspecies called the Prairie Kingsnake (L. c. calligaster).

The Mole Snake is secretive, fossorial, and tends to be nocturnal. Little is

known about its behavior or habitat requirements. In Florida, the Mole Snake has been identified in 8 counties: Bay, Calhoun, Liberty, Gulf, Walton, Madison, Brevard and Okeechobee (Means 1992). The Mole Snake's range may be continuous throughout Florida from Pensacola to the northern edge of Lake Okeechobee (Means 1992). The native habitat preference for the Mole Snake is largely unknown. Most collections have been made from fallow lands and road crossings. Specimens have been found in pine forests, recently burned pine flatwoods and slash pine stands in early growth stages following logging site preparations (Means 1992). The Brevard county specimen was collected by S. Maness and B. Grout from MINWR on 8 May 1980 (Layne et al. 1986, B. Grout pers comm). The snake was found dead on State Road 402 near Oak Hammock Trail (Layne et al. 1986). Meristic (scale) counts on the Merritt Island Mole Snake determined that it was probably from a natural population (Layne et al. 1986). This specimen is important in that it represents one of the few individuals found in an undeveloped or thinly-settled area with extensive natural habitat (Layne et al. 1986). Some herpetologists believe that at least some specimens reported in Florida are releases by pet owners. The Mole Snake is vulnerable to local extinction and population decline due to its rarity, low density, susceptibility to ground predators and its propensity for persecution (Noss and Labisky, in press). KSC may be a very important location for this snake as it is the only Brevard County reference. A possible search using herpetofauna arrays may be of value in determining the size and habitat preferences of any existing populations of the Mole Snake on KSC. NASA construction operations and fire management plans may affect the occupancy of Mole Snakes. Construction on KSC tends to take place in pinelands due to the expense of building in wetlands or critical scrub habitat. If Mole Snakes tend to occupy pinelands as is suggested from captures, there may be a need to consider the Mole Snake more closely in KSC construction impacts. If Mole Snakes do exploit fallow or disturbed areas, searches for the species during site preparation or after burning could confirm

the species' current existence on KSC and provide habitat preference information.

#### Glossy Ibis (*Plegadis falcinellus*)

The Glossy Ibis is a relative newcomer to the western hemisphere and did not breed in North America until the 1880s. Since the 1950s, they have greatly increased their breeding range throughout Florida, although they were still rare in Brevard County in the 1960s (Trost 1968). Their breeding range is expanding northward and Glossy Ibises now occur along the coast from northern South America to Louisiana and Maine. Although Glossy Ibis populations have increased, they are still susceptible to the primary ecological problem encountered by other waders, namely the loss of wetlands. Girard (1976) reported that the Glossy Ibis was declining across central Florida in the early 1970s. Glossy Ibises probe the substrate with their decurved bills, searching for aquatic invertebrates, insects, and small vertebrates. Glossy Ibises feed on dry land or in shallow water.

Glossy Ibises are abundant breeders in KSC colonies (Table 9) which account for > 10% of the state population which has increased between 1978 and 1986 (Runde 1991). In 1984-85, Glossy Ibises were the second most abundant bird in impoundment surveys in the Pad 39 areas on KSC (Breininger and Smith 1990). However, they are not the second most abundant wading bird in all areas of KSC (Smith and Breininger unpublished data). In 1975, egg loss for the Glossy Ibis on KSC was 59%, which was the highest of all wading birds (Girard 1976). Nestling mortality within the first two weeks was 42%. On KSC, they are common in the mosquito control impoundments and along roadside ditches and canals. As with the White Ibis, there may be cause for concern regarding the bioaccumulation of pesticides and heavy metals in areas where they feed. Impoundments north of 39B and south of SR 402 were used by large numbers of Glossy Ibis in 1984-1985

(Breininger and Smith 1990). This impoundment may be of special importance to Glossy Ibis populations on KSC during some years or for brief periods during most years. The area that received high use is north of the heavy deposition area for shuttle launches so that little impact from operations is anticipated. Water management is likely the most significant influence on KSC Glossy Ibis populations.

#### Florida Prairie Warbler (Dendroica discolor paludicola)

The Florida Prairie Warbler occupies mangrove vegetation along the Gulf and Atlantic coasts of Florida (Stevenson 1978a). The critical habitat for this species is mangroves and this dependence has led to its decline due to the extensive loss of mangrove habitat in Florida. Further impacts may occur due to the expansion of cowbird populations. KSC is just within the northern part of the range of the Florida Prairie Warbler. The northern subspecies (D. d. paludicola) is common here in shrubby habitats during migration (Cruickshank 1980) and is not dependent on mangroves. Most observations during winter or migration in shrubby habitats, excluding mangroves, are probably the northern subspecies. Time spent by most northern migrants is often brief so that few have been sighted during avian studies in scrub and slash pine (Breininger and Schmalzer 1990, Breininger and Smith 1992). No Prairie Warblers were reported in surveys conducted from 1976-1979 except for Christmas Bird Counts (Ehrhart 1979). A few northern migrants may winter on KSC. The Florida Prairie Warbler nests on KSC in low numbers in mangroves and on many spoil islands dominated by shrubby vegetation (Breininger and Smith pers. obs.). The number of Florida Prairie Warblers that nest on KSC may be influenced by the condition of mangroves as a result of hard freezes. Given the dependence of the Florida subspecies on mangroves, one might expect population instability in the vicinity of KSC due to natural variation in mangroves. Historical records indicate the

Florida Prairie Warbler was present prior to impoundment (see Howell 1932). Surveys of the nesting population on KSC are needed. Prairie Warblers abundantly use mangroves surrounding shuttle launch pads during migration (Breininger unpublished data). If the Florida Prairie Warbler is significantly affected by human actions on KSC, mosquito control practices probably have the most influence.

#### Osprey (Pandion haliaetus)

The Osprey has a worldwide distribution (Brown and Amadon 1968). The subspecies P. h. carolinensis occurs throughout much of North America and winters in South America (Henny and Van Velzen 1972). Ospreys in north Florida nest in spring and summer and presumably migrate southward by mid-winter (Ogden 1978c). Ospreys in south Florida nest during winter and spring and either remain there in summer or disperse northward after nesting (Ogden 1978b). Ospreys are indicators of environmental quality (Henny 1983). In Florida, they are considered marginally threatened but the species has been seriously threatened or endangered in other parts of its range (Ogden 1978c). Pesticides have been a factor in their precarious existence elsewhere, but this has not been demonstrated in Florida. In some areas with former chemical contamination problems, reproductive success has been increasing concurrently with the decline in use of DDT and other persistent chemicals (Henny 1977). Sampling throughout Florida has not been sufficient to rule out pesticide contamination in some areas (Ogden 1978c). The decline in Florida has been primarily due to habitat destruction (i.e., nesting habitat), habitat degradation (i.e., pollution), and human disturbance.

Ospreys feed almost completely on fish captured using their talons while diving into the water. Speckled trout (Cynoscion nebulosus) and mullet (Mugil spp.) are common food items (Szaro 1978). Ospreys build large bulky nests and commonly

reuse nests. Lone pairs occur at scattered sites; but small to large colonies have occurred with nests as close as 30 m where food has been abundant (Ogden 1978c). Incubation lasts about 38 days (Stinson et al. 1976, Levenson 1979). Fledging occurs at 44 to 59 days of age and young are dependent on their parents for at least six weeks after fledging (Scotts and Henny 1975, Stinson 1977). Average clutch size is almost 3 eggs (Reeses 1977). Ospreys first breed at three years of age (Henny and Wight 1969) and have lived for at least 25 years (Spitzer 1980). Mortality of first year birds is much higher than that of adults, which have relatively low mortality rates (Henny and Wight 1969, Spitzer 1980). Mortality has been attributed to impact injuries, emaciation, gunshots, respiratory infections, electrocution, diseases and various other causes (Wiemeyer et al. 1980).

Ospreys in Florida have a wide tolerance for nesting substrates (Edwards and Collopy 1988). Historically, Ospreys used snags or live trees for nest sites but they now often use a variety of man-made structures (Henny 1986). They nest on objects that cause problems in the use of the intended structure. Nesting platforms can be built as mitigative measures. They should be sturdy, located away from human disturbance, tall enough and strategically located to allow an unobstructed view of the nest surroundings, and a high perch should be nearby (Henny 1986). Nests in properly constructed platforms can have higher productivity than natural nest structures, as occurred on Sannibel Island where there was an average of 1.5 young produced per active nest (Westall 1983). The FGFWFC regulates nest removal using a permit process where replacement of comparable or better quality nesting support structures is generally required. Guidelines for replacement structures and reporting requirements have been developed by the FGFWFC.

The estimated population of Ospreys for the contiguous U.S. is about 8,000 pairs; there are 1,000-2,000 pairs in Florida (Henny 1983). The south Florida population appears to be decreasing due to lowered food availability (Kushlan and

Bass 1983). Ospreys on KSC nest in winter and spring (Schroeder and Clark 1980). They are common on KSC throughout the year, but a decline begins in October as some birds presumably migrate southward (Ehrhart 1980). Osprey numbers fluctuate due to migration of northern birds as they pass through the area (Henny and Van Velzen 1972, Ehrhart 1980). The following summarizes the number of active Osprey nests observed by MINWR personnel (Annual narratives).

<u>Year</u>	<u>Number of Nests</u>	<u>Successful Nests</u>	<u>Young Produced</u>
1980	10		
1981	9		
1982-85	No surveys		
1986	23	16	24
1987	No surveys		
1988	24	20	35
1989	27	24	44
1990	25	22	42

Pine stands used by Ospreys for nesting are rarely used for facility development on KSC. The highest densities of nests occur along Banana River and north of Haulover Canal where there is little development. Ospreys nest on many NASA structures which become inconvenient for not only the operation but for the pair nesting on the structure when nest removal becomes necessary. No information is available to suggest that there are insufficient nest sites in most areas. At least one Osprey has been killed by lightning on man-made structures on KSC; Ospreys nesting on these structures may be at risk (Leenhouts 1987b).



## White Ibis (Eudocimus albus)

The White Ibis ranges along the U.S. coast and throughout the coastal plain from South Carolina to Texas to South America. White Ibises probe for invertebrates and small vertebrates on dry land or in shallow water less than 10 cm deep. Nesting success depends on suitable feeding habitat. White Ibises typically use woody vegetation for nesting but will nest in marsh vegetation. Nesting areas must be free from excessive predation and disturbance and are usually near feeding habitat (Hingtgen et al. 1985). Although they were very popular with plume hunters in the late 1800s, the White Ibis recovered quickly to become one of Florida's most abundant wading birds. However, in the 1960s, a population decline began that is continuing today (Kale and Amer 1990). The Florida population during 1986-1989 was only 1/3 of the size it was during 1976-1978 (Runde 1991). The destruction of suitable nesting sites and loss of feeding habitat have contributed to declines in the White Ibis populations. Another threat is caused by environmental contamination in their feeding sites. Pesticides and heavy metal accumulation could have drastic effects on the White Ibis as they had on Ibis populations in other parts of the U.S. (Kushlan 1978). Samples of White Ibis tissues from south Florida have contained high levels of mercury (Kushlan 1978).

The White Ibis is the most abundant wading bird on KSC (Table 9, Smith and Breininger unpublished data) although yearly fluctuations in numbers are evident. Large numbers of White Ibis nesting in KSC colonies in 1990 resulted in the KSC population to be nearly 15% of the Florida population although the KSC population is < 10% of the state population during most years (Runde 1991). The Pad 39 area is a prime feeding site for the White Ibis (Breininger and Smith 1990), but the area impacted by launches is small relative to the total habitat available (Smith and Breininger unpublished data). They frequently feed in ditches and along roadsides in

mowed grass. Bioaccumulation in operational areas of KSC that are used as feeding areas by White Ibises may be a concern. There is little development within White Ibis habitat on KSC. Although a small portion of hardwood swamp and swale marsh habitat is developed, these are of little importance to White Ibis populations (Breininger 1990, Breininger 1992). Water management is the most significant influence on KSC populations.

#### Black-necked Stilt (Himantopus mexicanus)

The Black-necked Stilt is a long-legged shorebird that inhabits the shallows of fresh and saltwater wetlands. They range from the western and southeastern U.S. to Peru and winter mainly south of the U.S. Stilts can be found in a variety of wetland habitats but rely upon undisturbed mud/sand flats near water for feeding, nesting, and loafing. They feed on aquatic invertebrates and insects and nest on a fairly open, water-bound mound above the high tide line. An interesting behavior of Stilts is "belly-soaking" in which an individual will carry water via the belly feathers as a means of cooling itself or its eggs and chicks during incubation. It has been reported that over 100 trips a day to the water may be made by an incubating bird (Erlich et al. 1988). Three or four eggs/clutch are typically laid and incubation takes approximately 24 days. The chicks are precocial and leave the nest within 24 hours after hatching (Sordahl 1982). They are capable swimmers at an early age. Predator avoidance strategies of young chicks include hiding and diving underwater. Stilts are loosely colonial and can often be found feeding in large groups. An overall decrease in suitable habitat has occurred throughout Florida.

Most of the U.S. breeding population is west of Florida. Merritt Island was reported as a major breeding area in Florida for Stilts by Howell (1932) and Sprunt (1954). Scattered nesting has been reported along the east coast north of Florida

(Bent 1927) so that some migrants may pass through KSC. Most wintering is south of the U.S.; the most concentrated wintering populations in the U.S. are along the southern coast of Texas, and southern and central California (Root 1988).

Development and modification of wetlands, increased human disturbance, and proliferation of predators such as the Raccoon and domestic pets have had adverse effects on Black-necked Stilt populations in most of Brevard County (Cruickshank 1980).

Black-necked Stilts are present on KSC during spring, summer, and fall, but rarely in winter (Cruickshank 1980). Adults frequently feed in the shallow water of open water impoundments and estuarine waters. They nest in the shallow (<15 cm) water impoundments that are abundant in the area or on mudflats in dry impoundments (J. Lesman unpub. data). Hatching success on KSC is low, primarily due to predation (J. Lesman unpub. data). Black-necked Stilts were abundant in the impoundments surrounding Pad 39B especially from April through August (Breininger and Smith 1990). They were sighted using these areas from March through September. A significant number of individuals nest within the Pad 39B area including within the area that receives heavy launch deposition (J. Lesman and R. Smith unpublished data). No studies have been conducted to quantify effects. Opportunity exists for strategic management of impoundments to benefit this species. Black-necked Stilts are considered to be locally vulnerable to management (Stuckey et al. 1990). A decreasing population trend exists for Black-necked Stilts along Blackpoint Wildlife Drive between 1987-1989 based on MINWR data reported by Clark Engineers and Scientists, Inc. (unpublished draft Environmental Resources Document). Information is needed on population size, distribution, and important habitat components for Black-necked Stilts on KSC. Flooding is an important consideration in impoundments that are used by Stilts for nesting particularly if the BCMCD floods

much of the areas near Pads 39A and 39B. Islands in the estuary that are important for Stilts should have restricted human access.

#### Barn Owl (Tyto alba)

The Barn Owl occurs throughout much of the world. It is an uncommon and inconspicuous resident in Brevard County. Nesting observations often are within abandoned buildings (Cruickshank 1980). Cavities in trees, cliffs, or steep slopes are natural nest sites (Bent 1938). Nesting primarily occurs during winter (Cruickshank 1980) and clutch size is typically 5-7 eggs. They are usually solitary nesters but sometimes nest in loose assemblages (Smith et al. 1974). Northern populations are believed to migrate. Barn Owls tend to be more numerous coastally in south Florida during winter than summer (Hamel et al. 1982). They prefer marshes, ruderal grass, coastal grasslands, and other open habitats for feeding. Dense trees or shrubs are used for roosting. Typical food items throughout the world include small mammals, but other prey types are used depending on locality (Jaksic 1981). Food items of a Barn Owl using a central Florida wetland were mostly small mammals, but also included insects, a few birds, and an Opossum (Chicardi 1990). The four most abundant small mammals were Cotton Rats, Southeastern Short-tailed Shrews (Blarina carolinensis), Round-tailed Muskrats, and Marsh Rice Rats (Oryzomys palustris). Common birds included the Savannah Sparrow and Eastern Meadowlark. Orthopterans were common insect prey. Red-winged Blackbirds (Agelaius phoeniceus), Starlings, and grackles have been described elsewhere as abundant food items (Fritzell and Thorne 1984).

No population estimate is available, but it is reasonable to assume the population size is low. A Barn Owl was observed in Happy Hammock in the winter of 1985/1986 on a few occasions (Breininger pers. obs.). One was observed during the

1991 Christmas bird count. Numerous hangars or other abandoned buildings on CCAFS are used by nesting Barn Owls (M. Mercadante, pers. comm.). Certainly there is suitable habitat and prey populations on KSC. Given their diet, they may play a role in faunal integrity along with other large raptors. The use of abandoned building suggests that old structures may replace old growth trees eliminated by past timbering.

#### Pileated Woodpecker (Dryocopus pileatus)

The Pileated Woodpecker is distributed throughout the southeast U.S. and breeds throughout Florida (Kale and Maehr 1990). It is Florida's largest woodpecker and feeds on ants, insect larvae, and palmetto berries. Pileated Woodpeckers choose foraging habitats having high densities of logs and snags, dense canopies, and tall shrub cover (Bull and Meslow 1977). Most studies regarding breeding habitat have been conducted outside Florida where habitat requirements may differ (Gutzwiller and Anderson 1987). Pileated Woodpeckers form a permanent pair bond and will use the same general area from year to year if not disturbed. They nest from February to June (Cruickshank 1980). Pileated Woodpeckers generally require large, tall trees for nesting because their nest cavity is large and typically located high in snags (Bull 1981). Cavities are also excavated in the dead wood of living trees for both nesting and roosting (Hoyt 1957). Winter homeranges are estimated to be 70 ha in Georgia. Summer homeranges are estimated to be 43-52 ha in Louisiana (Tanner 1942), 130 ha in northeastern Oregon (Bull and Meslow 1977), and 408-549 ha in western Oregon (Mannan 1984). Thus, considerable habitat is needed to support the species. The species does occupy some urban woodlots elsewhere (Ehrlich et al. 1988). The Pileated Woodpecker is a keystone species because old nest cavities provide nesting habitat for other birds and mammals (i.e., Screech-Owls [Otus asio] and bats). Except for some hawks, the species has few predators (Hoyt 1957).

Cruickshank (1980) reported that the Pileated Woodpecker was common in Brevard County until 1960 when it showed a marked decline due to the loss of old pine stands. On KSC, the Pileated Woodpecker occupies many large forests that are comprised of hammocks and swamp vegetation. Pine flatwoods, cabbage palm savannas, and Australian pine stands are occasionally used for foraging and nesting. Pileated Woodpeckers nest in rather open, small stands of trees or telephone poles on KSC. Population size on KSC is uncertain. The species occurs in both broad-leaved forests (Breininger 1990) and pine flatwoods (Breininger unpublished data) at low densities. The problem of needing extraordinary sample sizes to perform surveys for this species is discussed by Verner (1984). A better approach to determine population size would be to use homerange or territory size and the acreage of suitable habitat. Although the species occurs in slash pine, it is not widespread probably due to a lack of old growth associated with historic logging. If no extensive logging occurs and fires do not destroy most slash pine trees and snags, conditions could improve on KSC. No estimates are available to determine what percent of the pine flatwoods are suitable. Many broad-leaved forests appear to have insufficient structure to represent suitable habitat. There are some forests that have few Pileated Woodpeckers, especially red-bay, live and laurel oak forests and young red maple and willow swamps (Breininger 1990). Forested habitats is increasing on KSC due to landscape fragmentation and the disruption of natural fire and hydrological patterns (Schmalzer and Hinkle 1985). Maintenance of old trees suitable for nesting is important for Pileated Woodpeckers and other species that require large trees and snags. Surveys would be useful to better define habitat requirements and population status.

#### Snowy Egret (*Egretta thula*)

The Snowy Egret ranges along the coast from Maine to Texas to northern South

America and occurs inland between New Mexico, Colorado, and California. Plumes of the Snowy Egret were among the most popular fashion ornaments for ladies' hats at the turn of the century. As a result, Snowy Egrets were killed by the thousands and were extremely rare by 1900. After plume hunting was declared illegal, Snowy Egrets began to recover and reached peak population numbers in the 1930s. Since that time, they have been declining steadily, presumably due to the loss of wetlands needed for feeding and nesting (Ogden 1978d). The Florida population during 1986-1989 was 1/4 of the size it was during 1976-1978 (Runde et al. 1991). The Snowy Egret actively stalks small fish, aquatic invertebrates, and insects in shallow water. They feed in many types of freshwater and coastal wetlands including mosquito control impoundments, marshes, swamps, ponds, ditches, and stream banks. Because of their keen eyesight, Snowy Egrets can locate places where prey are abundant. This ability causes other waders to prefer foraging near them, and Snowy Egrets often occur in large mixed-species aggregations (Caudwell 1981). Snowy Egrets nest in mixed heron colonies in small trees.

Snowy Egrets are one of the most common wading birds on KSC, particularly in impoundments and nest in mangroves on spoil islands (Smith and Breininger unpublished data; Table 9). Large numbers of Snowy Egrets nesting in KSC colonies in 1990 resulted in the KSC population to be nearly 18% of the Florida population although the KSC population is < 10% of the state population during most years (Runde et al. 1991). Habitat alteration associated with the discharge from the VAB sewage treatment plant has probably resulted in a loss of habitat for a few Snowy Egrets. The loss of a small percent of the available habitat could occur as a result of habitat degradation associated with shuttle launches. Ditch maintenance activities and stormwater runoff practices have some effects since a small portion of the population is associated with these habitats (Smith and Breininger unpublished data). The largest influence on Snowy Egret populations is associated with water

management practices. Open water impoundments receive high use and provide for most of the preferred feeding habitat on KSC (Breininger and Smith 1990; Smith and Breininger unpublished data).

#### Tricolored Heron (*Egretta tricolor*)

This medium-sized heron ranges along the coastal U.S. from Massachusetts to Baja, California, to northern South America. Because of its dark coloration, the Tricolored Heron was not as highly prized by plume hunters in the late 1800s as the white Egrets. It was considered to be the most abundant heron in the U.S. in the 1930s (Howell 1932), but the population was reduced by loss of wetland feeding habitat in the mid-1900s (Ogden 1978e 1978). Tricolored Herons are still one of the more common herons in Florida, but there is a general downward population trend in the state (Kale and Maehr 1990). The Florida population during 1986-1989 was 1/2 of the size it was during 1976-1978 (Runde et al. 1991).

Tricolored Herons use a variety of feeding methods including stalking and foot-stirring in shallow fresh or brackish water. They eat small fish, but occasionally take amphibians and aquatic invertebrates. Tricolored Herons nest in colonies with other waders, usually over water in mangroves on KSC (Table 9). Large numbers of Tricolored Herons nesting in KSC colonies in 1990 resulted in the KSC population to be 10% of the Florida population although the KSC population is < 10% of the state population during most years (Runde et al. 1991). Nesting occurs on the Bluebill Creek Colony, but shuttle operations appear to have little influence on reproductive success (Smith pers. obs.). Numbers nesting on KSC are probably dependent on conditions in other parts of the breeding range, particularly south Florida (Ogden 1978e). The protected wetlands on KSC provide important feeding and nesting habitat for these birds. This species feeds primarily in open water impoundments and



occasionally in ditches (Smith and Breininger unpublished data). Some regularly occur in the impoundments near shuttle pads (Breininger and Smith 1990), but this area is only a very small percent of open water habitat available. Water level management probably has the greatest influence on Tricolored Herons on KSC.

#### Short-billed Dowitcher (Limnodromus griseus)

The Short-billed Dowitcher breeds in Alaska and northern Canada. Its wintering range includes California and several southern states (Root 1988a); Florida is a peak wintering area in the U.S. (Root 1988a). The species also winters abundantly in the Caribbean, Central and South America (Bent 1927). Counts during migration suggest that their populations are undergoing significant declines (Howe et al. 1989). They are most abundant in Florida during migration (July-November and March-June) (Robertson and Woolfenden in preparation). Dowitchers occur in flooded mudflats and short-grass marshes, probing for aquatic and marine invertebrates in the sand or soft mud.

In Brevard County, they are most common east of the Indian River (Cruickshank 1980) and have been counted on every MINWR Christmas Bird Count for the last 20 years (Stuckey et al. 1990). The number of Short-billed Dowitchers sighted during the 1990 Christmas Bird Count comprised nearly 7% of all seen in Florida during 1991 Christmas Bird Counts. The highest numbers are seen from August through October during fall migration (Cruickshank 1980). A few nonbreeding individuals remain here year-round (Cruickshank 1980). It was assumed that KSC supports at least 10% of Florida's population during migration. Dowitchers and the following sandpipers feed in impoundments and are influenced by water management practices. A small amount of habitat is located in the nearfield zone north of Pad 39B.

### Western Sandpiper (Calidris mauri)

The Western Sandpiper nests mainly in Alaska, migrates through much of Canada, and winters along coastlines in the southern half of the U.S. south to Peru in South America. A large number of male Western Sandpipers winter in the U.S. and a large proportion of females winter further south (Page et al. 1972). They occupy beaches, tidal flats, and short-grass marshes. They eat insects and marine invertebrates. Western Sandpipers are abundant in Florida from July through May, and a few nonbreeders remain year-round (Cruickshank 1980, Kale and Maehr 1990). Since 1970, they have been reported on every MINWR Christmas Bird Count (Stuckey et al. 1990). Approximately 400 Western Sandpipers were sighted during the 1991 Christmas Bird Count comprising nearly 2% of the total seen in Florida; this was the 5th largest sighting in Florida in 1991. More than a thousand are sometimes observed in December on KSC (Breinigner pers. obs.). Cruickshank (1980) reports a winter maximum of more than 2,000 for one year.

### Marbled Godwit (Limosa fedoa)

The Marbled Godwit breeds in three separate locations in North America. The largest area is in the northern Great Plains region (Gibson and Kessel 1989) and two smaller locations include the Alaska Peninsula and James Bay along the Hudson Bay. The breeding range is declining as breeding habitat is converted to agriculture (Erich et al. 1988). The largest winter range center includes the California coastline. Lower concentrations occur along the southeastern coastline north of Florida (Root 1988), although much of the southeastern coastline, including Florida, is used. The importance of KSC can not be properly identified without knowing the winter distribution of separate breeding populations, since conservation goal are to maintain each of the three breeding populations. While wintering in Florida, it feeds on

mollusks, snails, crustaceans, worms and leeches. The Godwit feeds mainly by feel and often forages at night. It prefers mudflats adjacent to wet savannahs or meadows (Johnsgard 1981).

The Marbled Godwit was once an abundant winter resident in Florida but is now less common (Bent 1927, Howell 1932, Kale and Maehr 1990). Cruickshank (1980) cites references that the Marbled Godwit was abundant until the middle of the 19th century. There was a virtual extirpation with no Brevard records in the 20th century until 1950 when small flocks appeared on Merritt Island and at Port Canaveral. By 1960, it was a regular but local visitor to mudflats around Cape Canaveral, MINWR, and Sebastian Inlet. The number of Marbled Godwits sighted during the 1991 Christmas Bird Count comprised nearly 6% of all seen in Florida during 1991 Christmas Bird Counts. KSC had the 2nd largest sighting in Florida with a total of 22 Marbled Godwits. Several individuals were routinely sighted along Black Point Wildlife Drive (Breininger pers. obs.). They occasionally use open water impoundments in the pad 39A and 39B vicinity (Breininger and Smith 1990).

#### Red-shouldered Hawk (Buteo lineatus)

The Red-shouldered Hawk is common in Florida and much of the eastern U.S. There is a permanent resident population throughout the Florida mainland and Keys. (Kale and Maehr 1990). This hawk feeds on insects, crayfish, frogs, snakes, small mammals, and occasionally birds. It feeds primarily in wetlands (Hamel et al. 1982). Red-shouldered Hawks prefer large trees for nesting (Bushman and Therres 1988). Nest sites are often associated with swamps and other bottomland forests. Nests are often used for several years. These species occupy large feeding territories (Schoener 1968) and occupy higher trophic levels. The Red-shouldered Hawk may tolerate human disturbance if large, mature trees are maintained (Erlich et al. 1988).

Alternatively, fragmentation of habitat may impact the species (Bushman and Therres 1988). Large tracts of forest may be required because of competition with the more aggressive Red-tailed Hawk that may use forest fragments (Craighead and Craighead 1956, Hamel et al. 1982).

There are two forms of the Red-shouldered Hawk in Florida: the dark-plumaged northern form which is the one common throughout the U.S, and a paler, light-plumaged southern form found in south Florida (Kale and Maehr 1990). In Florida, Red-shouldered Hawks are primarily associated with moist hardwood forests and mixed pine/broadleaf woodlands. The Red-shouldered Hawk is moderately vulnerable to local extinction, and population decline is fairly probable in Florida (Noss and Labisky in press). Vulnerability is due to its requirements for large areas, low fecundity and its preference for forest interior (edge-avoiding) habitats (Noss and Labisky in press). They are also known to accumulate organochlorine pesticides and PCBs, but habitat loss is still the major threat to the population (Ehrlich et al. 1988).

On KSC, Red-shouldered Hawks are present throughout the year and breed from January through May. The population increases during fall and winter due to migrants from the north. Several large forests occur on KSC and it is important that these large tracts remain intact. Most studies regarding their breeding habitat requirements have been conducted outside Florida where habitat requirements may differ (Gutzwiller and Anderson 1987). There is no information on the breeding population size for this species on KSC. Presumably a population is located within Turnbull Hammock.

Red-shouldered Hawks are primarily associated with hammocks and hardwood swamps on KSC, especially for nesting (Cruickshank 1980, Breininger 1990). They often use adjacent marshes and ruderal areas for foraging. Since 1988, several pairs of the southern form Red-shouldered Hawks have been routinely seen on KSC (Smith and Breininger pers. obs.). No data are available to determine whether this form is

expanding north. Winter bird counts done by MINWR (Annual Narratives) report the following records for Red-shouldered Hawks:

<u>Year</u>	<u>#/Hour</u>	<u># of individuals</u>
1984	0.1	3
1985	No Information	
1986	0.9	3
1987	0.1	24
1988	0.6	25
1989	0.5	23

The importance of KSC to contribute to the regional population of Red-shouldered Hawks is moderately high given there are several large, mature hammocks suitable for nesting on KSC and the surroundings of KSC are becoming increasingly urbanized. KSC is potentially important to regional populations because hammocks throughout much of the area are vulnerable to development and fragmentation. The disruption of fire regimes is resulting in increasing forestation on KSC and elsewhere potentially increasing the amount of suitable habitat. Red-shouldered Hawks tolerate some human disturbance provided that suitable nesting habitat is maintained (Ehrlich et al. 1988). A study of the nesting population on KSC is needed to document suitable forest types that sustain the population. Large forests are readily identified from the KSC vegetation map. GIS files of large forests could be used to plan a survey to study the influence of forest size, shape, and composition on the presence/absence of nesting Red-shouldered Hawks.

#### Cooper's Hawk (Accipiter cooperii)

The Cooper's Hawk is a medium-sized raptor that feeds primarily on small birds

(Johnsgard 1990). This accipiter is similar to the Sharp-shinned Hawk, and it is often difficult to distinguish the two apart. The Cooper's Hawk winters throughout Florida, but the southernmost breeding record is Archbold Biological Station (Layne 1986). The breeding range may be extending southward (Snyder 1978b, Layne 1986). Several nests have been found south of KSC on Merritt Island by a cooperator with the Breeding Bird Atlas project (Wes Biggs pers. comm.). Some literature suggests the species will not nest in small fragments (Hamel et al. 1982) but some suggests it prefers patches, groves, or edges (Johnsgard 1990). The Cooper's Hawk may prefer forest edges and woodlands in winter (Adkisson 1990). This species successfully inhabits some suburban habitats in North America and uses a wide variety of habitat types for hunting (e.g., Murphy et al. 1988). Distances between nest have been recorded to range from 1.6 to 5.5 km (Asay 1987).

The Cooper's Hawk was Blue Listed from 1972-81, became a Species of Special Concern in 1982 and appeared on the Blue List again in 1986. The Blue List is published by the National Audubon Society and serves as an early warning system for species that are experiencing noncyclic population declines but are not yet federally listed. The main threat to this hawk in the past has been the use of pesticides and the accumulation of PCB's. DDT, and its metabolite DDE, appear to be the only contaminants that might threaten eastern populations of Cooper's Hawks (Pattee et al. 1985). Habitat loss influenced the hawk's decline and is the major threat to Coopers' Hawk today (Reynolds et al. 1982). This hawk is very vulnerable to local extinction, and a population decline is highly probable across much of Florida due to low local population density, large area requirements, low fecundity and possible preference for forest interiors.

This hawk was not previously believed to be present on KSC during the breeding season due to a lack of observations and past descriptions of habitat requirements (Ehrhart 1979). Cooper's Hawks may not have been sighted during the

breeding season because of the notorious stealth characteristic of this species. A few individuals were sighted during two years of intensive avian surveys between 1984-1986 (Breininger 1990, Breininger and Schmalzer 1990, Breininger unpublished data). One individual was sighted in July 1987 (Breininger pers. obs.). The species was seen and heard giving nest defense calls (Bent 1937) almost on a daily basis in the late winter and spring of 1988 in a forest and the adjacent scrub near Happy Creek (Breininger and Smith pers. obs.). Individuals were often seen during 1989 at Happy Creek and Tel 4. Nest defense calls and very agitated behavior were observed in a forest in May, although no nest was found. Within minutes after these calls were heard, four Florida Scrub Jays arrived performing mobbing calls. The Cooper's Hawk immediately became quiet and disappeared. An immature Cooper's Hawk was sighted in scrub observing a family of Scrub Jays at Happy Creek during June 1989. An immature Cooper's hawk was found dead on the road near Titan Pad 40 during July 1990 (Breininger pers. obs.). During 1990 and 1991, the authors frequently saw Cooper's Hawks throughout much of the year at all major scrub and pine flatwoods study sites. The Cooper's Hawk may recently have become more abundant. Initial sightings of this bird often result from certain alarm calls made by Florida Scrub Jays. The authors have not yet located a nest.

Virtually any forest that is large enough could be used for nesting on KSC (Bent 1937, Layne 1986) providing it has tall trees (B. Toland pers. comm.). Observations by the authors indicate that this hawk uses many habitats for hunting including scrub and pine flatwoods. The Cooper's Hawk on KSC is not restricted to woodlands and frequently hunts in ruderal areas and low scrub (< 1.5 m). On KSC, Cooper's Hawks are most frequently seen during migration in the fall and also through winter and into spring where there is usually another peak that may be associated with migration.

Records from MINWR raptor counts between September and December show the following:

1978:	<0.1/ten hours of observation
1984:	0.8/ten hours
1985:	0.0/ten hours
1986:	0.6/ten hours
1987:	2.0/ten hours
1988:	2.1/ten hours
1989:	8.0/ten hours

In contrast to the predicted decline for much of Florida due to habitat loss, numbers appear to be increasing on KSC as is suspected for much of the southeastern U.S. (Atkisson 1990). There may be nearly 20,000 Cooper's Hawks in the U.S. and Canada (Johnsgard 1990).

#### Northern Harrier (Circus cyaneus)

The Northern Harrier breeds from Alaska through Canada and the U.S. to Mexico, but not in the southeastern U.S (Bildstein and Collopy 1988). There were several historical breeding records in Florida but none since 1908 (Howell 1932). They winter from southern Canada to South America. Florida is not one of the peak wintering areas (Root 1988) although the Northern Harrier is common (Bohall et al. 1984). Harriers have an unusual curved facial ruff that helps them detect their prey by sound. Food includes small mammals, small birds, amphibians, reptiles and crustaceans (Brown and Amadon 1968, Weller et al. 1955, Collopy and Bildstein 1987). Populations of Northern Harriers were declining in the U.S., but this decline may have slowed and the species may no longer be in trouble (Bildstein and Collopy



1990). They were placed on the American Birds Blue List in 1972. As with most animals dependent on wetlands, loss of habitat is the biggest threat to the Harrier (Bildstein and Collopy 1988). Pesticides may have impacted populations, because 20% of Northern Harrier eggs tested in 1970 showed signs of egg shell thinning (Erllich et al. 1988). Northern Harriers in Florida frequent open habitats dominated by herbaceous cover (Bohall et al. 1984). They often roost communally during winter (Bildstein and Collopy 1990). The abundant prey populations and favorable climatic conditions are attractive to overwintering raptors. Since many migrants spend 7-8 months on wintering grounds, the loss of wintering habitat may have serious impacts on overwintering birds (Keast 1980).

Northern Harriers are a common winter resident on KSC from October through March (Cruickshank 1980). Raptor surveys have been conducted during the migration period from September to November for several years by personnel from MINWR. They report the following numbers of Northern Harriers per hour of observation:

1978 - 0.4	1986 - 0.7
1980 - 1.0	1987 - 0.6
1984 - 0.8	1988 - 0.7
1985 - 2.1	1989 - 0.6

On KSC, Northern Harriers frequent marshes, low recently burned scrub and some ruderal habitats. As long as these habitats remain abundant and uncontaminated, KSC is likely to provide an abundance of suitable habitat for a small portion of the North American population of Northern Harriers. Little loss of KSC wetlands is anticipated, although water and fire management practices have potential for significant effects.

### Wilson's Plover (Charadrius wilsonia)

This species nests along the coastlines from New Jersey south along the Gulf of Mexico and along the coast of Baja. Various islands in the Caribbean are also inhabited. Wintering areas include South Florida, Texas, Louisiana, and South America (Root 1988). The northern limit of the wintering range is near central Florida (Howell 1932). Wilson's Plover inhabits beaches, tidal flats, and sandy islands (Bent 1928). They eat crabs, sand worms, and insects, and are loosely colonial with other shorebird species. They ordinarily lay three eggs with an incubation period of 24-25 days (Bent 1928). Young are able to leave the nest after hatching. They are believed to be site tenacious (Berstrom 1988). This strategy can spell disaster for local populations if the habitat suddenly changes (Bildstein et al. 1991). Surprisingly, no agency currently lists Wilson's Plover as a species of concern in Florida. Populations are expected to decline, particularly with the rising sea level (Bildstein et al. 1991). Few nested on Indian River spoil islands during surveys in the 1970s (Schreiber and Schreiber 1978), and none were sighted in the survey during the 1990s (DNR 1990). Only 261 were sighted in Florida during the 1991 Christmas Bird Survey. Records in American Birds for wintering or migration have generally been less than 200 individuals for the last 10 years. The number of nesting pairs during this period was much less than 100. Ted Below (pers. comm.) is aware of nearly 20 pairs that consistently nest on the west coast. Bill Roberston (pers. comm.) suspects that large numbers nest in the Florida Bay, but there are no numbers to confirm this.

Historical accounts of nesting on KSC are provided by Bent (1928). This plover nested on exposed sandy patches along the Indian River, near "water holes" in salt marshes, in open growths of Salicornia, and on sand dunes. Marsh structure has since been altered by impoundment. Wilson's Plovers were locally common until the 1960s when they began to disappear as their habitat was altered (Cruickshank 1980).

They have been seen during three of 19 MINWR Christmas Bird Counts between 1970 and 1989 (Stuckey et al. 1990). During the 1985 nesting season, a pair of Wilson's Plovers successfully raised young to fledging in an impoundment near LC 39B (Breininger pers. obs.). This area is likely to be subjected to increased flooding for mosquito control. In 1989, two pairs were observed with young chicks on the KSC security beach (D. Cooley pers. comm.). KSC provides suitable nesting habitat which may be more locally significant as unprotected areas are developed. A survey of all possible habitat is needed on KSC.

#### Black-bellied Plover (Pluvialis squatarola)

The Black-bellied Plover breeds in the Arctic tundra and migrates to Florida for the winter. Much of the southeastern coastline represents a significant wintering area for this species (Root 1988). While in Florida, the Black-bellied Plover feeds on small crabs, fish, and small marine invertebrates. They are common in wet meadows, ocean beaches, and mudflats (Cruickshank 1980). Black-bellied Plovers are common in open water impoundments, but are not present in large aggregations (Breininger and Smith 1990). The number of Black-bellied Plovers sighted on KSC during the 1991 Christmas Bird Count comprised nearly 5% of all seen in Florida during 1991 Christmas Bird Counts. Larger numbers are present during spring and fall migration (Cruickshank 1980). This species can be influenced most by water management practices and human disturbances, particularly on beaches with public access.

#### Barred Owl (Strix varia)

The Barred Owl ranges from the Carolinas through Texas and is common in Florida (Kale and Maehr 1990). The owl feeds mainly on small mammals and water-living amphibians and often maintains a feeding perch near the nest. Barred Owls

often prefer areas associated with water, but this may occur due to a need for large trees with cavities, which are often associated with hydric areas, and not because Barred Owls are attracted to water itself (Devereux and Mosher 1984). Most studies regarding breeding habitat for this species have been conducted outside Florida where habitat requirements may differ (Gutzwiller and Anderson 1987). There has been little study conducted to quantify habitat requirements in Florida and the availability of these features in Florida forests. Barred Owls may be territorial; they tend to have minimal homerange overlap except for breeding pairs (Nicholls and Fuller 1987). Barred Owls occupy large feeding territories (Schoener 1968), occur in low densities, and occupy higher trophic levels. Elsewhere they need 400-500 ha of forest per breeding pair (Bosakowski et al. 1987, Nicholls and Fuller 1987). The Barred Owl may require large tracts of unbroken forest (Hamel et al. 1982, Bosakowski 1987) especially because of competition with the larger and more aggressive Great Horned Owl (Craighead and Craighead 1956) which occasionally preys on Barred Owls (Kale and Maehr 1990). The Barred Owl is not as tolerant of human disturbance as some other raptors (such as the Great Horned Owl, Red-shouldered Hawk, and Red-tailed Hawk) and is more often heard than seen. Because of the lack of knowledge and low visibility of this species, it is difficult to determine the population size or stability. This species in Florida is moderately vulnerable to local extinctions, and a population decline is fairly probable in much of Florida (Noss and Labisky in press). Vulnerability is due to its requirements for large amounts of habitat, low fecundity, and preference for forest interiors.

The Barred Owl is a permanent resident on KSC but its abundance is unknown. They nest in hammocks and swamps on KSC (Cruickshank 1980, Breininger 1990). Several large forests occur on KSC; it is important that these large tracts remain intact. Turnbull hammock may have a significant population of the Barred Owl. KSC and Turnbull are probably important for the maintenance of local populations. Forests of

various sizes, shapes, and composition should be investigated for the presence/absence of nesting Barred Owls to determine population size and distribution.

#### Round-tailed Muskrat (Neofiber alleni)

The Round-tailed Muskrat is a smaller version of the Northern Muskrat (Ondatra zibenthicus). It is restricted to most of peninsular Florida and extreme southeastern Georgia. The population status of Round-tailed Muskrats is generally unknown, which is why they are listed as a species of special concern by the FCREPA (Tilmant 1978). The loss of wetlands has probably isolated Round-tailed Muskrats to pockets of appropriate habitat. They inhabit marshes, bogs, and the weedy borders of lakes, eating the roots and leaves of aquatic plants. Nests have also been found in canals and ditches on KSC (Ehrhart pers. comm.). They are able to burrow using fossorial homesites when water levels are low in seasonally flooded habitats (Wassmer and Wolfe 1983). Predators include the American Alligator (Kinsella 1982), Great Blue Herons, Barred Owls, Barn Owls, Great Horned Owls, Northern Harriers, Bald Eagles, and perhaps Great Egrets (Ehrhart 1984). Round-tailed Muskrats build nests of grass with two exits on or near the water; some nests on KSC had an exit and path leading to the grassy shoulders of roads that may have been used as feeding areas (Ehrhart 1976). Abandoned nests are often used by Cotton Rats (Sigmodon hispidus) and Rice Rats (Oryzomys palustris). Round-tailed Muskrats also build feeding platforms that are used by water snakes as sunning sites. This animal is mostly active at night and at dusk (Birkenholz 1963).

The first specimen of the Round-tailed Muskrat was collected from a salt marsh south of KSC in Brevard County in the late 1800s. It is a resident species on KSC and probably breeds here year-round (Ehrhart 1976), producing four or five litters with one

or two young per litter. Trapping conducted in the fall of 1972 yielded 13 captures and five recaptures in approximately 1,000 trap nights (Ehrhart 1976). Round-tailed Muskrats on KSC occur in the salt marshes dominated by Distichlis or Paspalum and in the wide canals along roads (Ehrhart pers. comm.). Densities elsewhere have been reported to be 250 animals/ha (Birkenholz 1963). The authors and former MINWR biologist D. Cooley have not observed them in the abundance that others have observed them in the 1970s (J. Wolfe, J. Stout, L. Ehrhart pers. comm.). They may be very sensitive to water level practices (L. Ehrhart, pers. comm.). Recently, several small colonies have been found by H. Hill (MINWR). A moderate population size was assumed given potential for high densities but limited distribution on KSC.

#### Florida Mouse (Podomys floridanus)

The Florida Mouse is restricted to relatively well drained xeric vegetation types in peninsular Florida. Scrub may be the primary ancestral habitat but sandhill may now be used due to human alterations in the landscape resulting from the increase of oaks in sandhill (Layne 1990). It is the only species of mammal restricted to Florida (Layne 1990). Habitat destruction has been a major threat to this species (Layne 1978b). Common characteristics shared by habitats occupied by the Florida Mouse include an open tree stand, clumps of scrubby oaks and other shrubs, patches of bare ground, and well drained sandy soils (Layne 1978b). The ability of the species to exist in xeric habitat probably depends on behavioral adaptations such as nocturnally and the use of burrows (often Gopher Tortoise burrows) during the day (Fertig and Layne 1963). The Florida Mouse often inhabits the upper 2 m of burrows where it has small vertical tunnels ("chimneys") that are secondary entrances, allowing the burrow to remain occupied even after the tortoise burrow entrance collapses (Jones and Franz 1990). The Florida Mouse has been found in old fields (Blair and Kilby 1936) although

some open sandy areas are unoccupied (Winn and Brown 1970). Although the Florida Mouse is not dependent on Gopher Tortoise burrows in some habitats, it appears to be dependent on their burrows in others (Humphrey et al. 1985). Adaptive advantages of Gopher Tortoise burrow use are protection from predators, more favorable microclimate, and more opportunity to feed during the day without exposure to predators (Layne 1990).

The Florida Mouse prefers an early successional phase after fire but occupies a broad range of conditions (Layne 1990). Long-term study by James Layne at ABS (pers. comm.) showed that the Florida Mouse occupied a broader range of scrub than the Florida Scrub Jay with respect to time since fire. He suggests that the preferred height for Florida Scrub Jays is an indicator of suitable conditions for the Florida Mouse and other members of the small mammal community in scrub. Changes in the abundance of the Florida Mouse due to fire have not been recorded for all habitat types (Arata 1959). The presence of openings may be important. In the Cross Florida Barge Canal Restudy Report (FGFWFC 1976), the frequency with which the Florida Mouse was captured on disturbed sandhills suggested that the species benefited by the presence of openings found in disturbed areas. In scrub, this species was only found in disturbed areas (FGFWFC 1976). The influence of disturbance might vary regionally.

Well drained scrub and slash pine is probably the primary habitat for the Florida Mouse on KSC. Poorly drained scrub and slash pine flatwoods comprise 86% of the total scrub and slash pine flatwoods (Breininger et al. 1991) and these areas occur as a continuum from wet to dry (Schmalzer and Hinkle 1987). Some areas on poorly drained soils have moderate scrub oak cover. Stout (1980) found that the species was present in an oak/palmetto that was on a poorly drained soil type during a portion of one of several years of study. Winn and Brown (1970) noted the Florida Mouse to be absent from palmetto scrub and swamp borders. Thus the habitat may become

increasingly unsuitable along the gradient from dry to wet. Surprisingly, Florida Mice were not found on the dune scrub grid (see Beach Mouse section for study area description) by Stout (1980) or Provancha (unpublished data). Neither were they trapped on the beach grid. Provancha (unpublished data) found no association with Gopher Tortoise burrows in coastal strand on KSC.

Most of the population may be along coastal strand and scrub and on ridges comprising only 15% of the oak/palmetto scrub and slash pine. The scrub creation and restoration program is being performed on well drained soils whereas some of the new facility development occurs on poorly drained soils. Further construction impacts should be minimal unless new projects are implemented that require major new facilities. Sea level rise may represent a long term threat to these populations.

#### Merlin (Falco columbarius)

The Merlin is a small falcon similar in size to the more common Kestrel. The subspecies E. c. columbarius breeds across much of the coniferous belt of North America and winters in much of the southeastern U.S. and in South America (Smallwood and Collopy 1991). Merlins have wintered throughout Florida with the greatest numbers occurring along the coastlines (Smallwood and Collopy 1991). In Florida, between September and April, Merlins may be seen occasionally along beaches, impoundments, marshes, mangroves, prairies, ruderal habitats and scrub (Wiley 1978a). These falcons prey mainly on small birds but also take small mammals and insects (Smallwood and Collopy 1991). They frequently capture small shorebirds such as Dunlin (Calidris alpina). Wintering adults may kill two birds per day (Page and Whitacre 1975). The Merlin population status in North America is poorly understood (Buchanan 1988). Decline in the numbers of migrating or wintering Merlins may have occurred from pesticide contamination (Wiley 1978) although the data may be



insufficient to detect a population decline (Smallwood 1990).

Merlin sightings have been recorded in MINWR Christmas Bird Counts during the past 20 years. Surveys were done from camera pads #9 & #10, Playalinda Beach, Max Hoeck Drive and Mosquito Lagoon during raptor migration. Results from these surveys are as follows:

<u>YEAR</u>	<u>TOTAL #</u>	<u>#/HOURS</u>
1985	1	143
1986	14	438
1987	16	372
1988	15	349
1989	42	677

No Merlins were found wintering on KSC between 1976-1979 (Ehrhart 1979). Cruickshank (1980) reported the Merlin to be a regular winter resident in Brevard County. Some Merlins have consistently been observed using a few locations during several consecutive winters between 1979-1991, suggesting that these birds winter on KSC (Breininger pers. obs.). These locations include several impoundments in the Pad 39A and B areas (1984-1985), scrub in Titan launch complexes (1978-1981), and one mile east of the Happy Creek windtower in scrub (1989-1991). Other locations where they are frequently seen include the CCAFS and VAB industrial areas where they are occasionally observed capturing Rock Doves (Pigeons) and Mourning Doves (Zenaida macroura). Special concerns for KSC are identification of wintering areas and minimizing environmental contamination.

#### American Oystercatcher (Haematopus palliatus)

The American Oystercatcher ranges along the coasts from Cape Cod and Baja,

California south to Argentina, and is a permanent resident in Florida (Kale and Maehr 1990). They do not exhibit the long distance migration patterns characteristic of most shorebird species (Bent 1928). It is a specialized feeder on bivalves, but will also eat crustaceans and worms. Oystercatchers breed from March to July and nest on sandy shores in a shallow depression well above high tide mark. They typically lay two or three eggs (Bent 1928). They are restricted to broad, open coastal beaches, mudflats, and spoil islands near bivalve (oyster) communities.

The American Oystercatcher is listed as a threatened species by the FCREPA (DeGange 1978b). Howell (1932) reported that the species was once common. Rampant development of coastal, sandy beaches has left very little nesting habitat for the Oystercatchers and has forced them from much of their former breeding range. The decline of bivalve "reefs" within the estuaries and egg loss from predators have caused a population decline along the U.S. east coast; Oystercatchers have expanded their range northward in order to locate new suitable habitat and food resources (Erlich et al. 1988).

American Oystercatchers formerly nested along much of both coasts of Florida, but are now very local in distribution (DeGange 1978b). Distribution may be influenced by tenacity of breeding site use (Nol 1985). Oystercatchers can retain stable population sizes despite poor reproductive success for a few years due to relatively high rates of adult survival (Nol 1989). Early reports indicate that nesting occurred in Mosquito Lagoon (Howell 1932). Nesting in Brevard County has been sporadic and they are most common south of Malabar, but are still considered rare (Cruickshank 1980). In 1975, 10-12 pairs were reported nesting on spoil islands in Brevard and Indian River Counties (DeGange 1978b); one nest was reported in 1976; 10-12 pairs were reported in 1978; one pair occurred in 1979. Three individuals were observed on spoil islands in the Banana River in 1980 but no nesting was observed (Schroeder 1980). On KSC during 1981 and 1982, spoil islands in the Banana River

were cleared of vegetation by MINWR personnel to encourage shorebird nesting. One pair was reported nesting on the spoil islands in 1985, but none were reported for 1984 or 1986 (MINWR Annual Narratives). In a recent survey of spoil islands (DNR 1990), one individual was seen near KSC; six were seen in south Brevard; 13 were seen in Indian River County; 10 were seen in St Lucie County; two occurred in Martin County. One individual was seen on a spoil island immediately adjacent to KSC. At least one pair has nested on KSC spoil islands in recent years (J. Hardesty pers. comm.). One Oystercatcher was seen along NASA Causeway several times during January 1991. No Oystercatchers were seen on KSC during the 1991 Christmas Bird Count; the total number sighted for Florida was 1118. Populations of Oystercatchers are relatively low in Florida. The Indian River supports a small population and KSC contributes to this population but KSC is not a population center for the American Oystercatcher.

Clearing shrubs and trees from spoil islands could provide additional nesting habitat unless other conditions are limiting the American Oystercatcher population. An increase in population size if they are regionally site tenacious could be slow. Surveys should be conducted to identify existing and potentially important areas which should then be managed appropriately. Because predation is often a significant cause of reproductive failure, areas where Oystercatchers can feed and watch their nest at the same time are likely to be better habitat (Nol 1989). Spoil islands provide sandy areas for nesting, feeding and loafing with limited access for most mammalian predators and human disturbance. Although KSC has few bivalve reefs, the growth of such reefs should not be inhibited by dredging or other human activities. Areas which have small bivalve colonies or show signs of having had reefs at one time should be protected.

### Dusky Pygmy Rattlesnake (Sistrurus miliarius)

This small rattlesnake ranges from extreme southern South Carolina and southeast Mississippi to the southern tip of Florida (Carr 1940, Stevenson 1976). They occupy a range of habitats including flatwoods, sandhill, mixed pine-hardwood forests, lakes margins, and marshes. Their primary foods are lizards and small snakes, but they will occasionally take mice and insects. Their status in northern peninsular Florida is ranked somewhere between moderately and very vulnerable, with local extinction at least being possible if not probable (Noss and Labisky in press). Threats to this species are ground predators and humans. Little is known about the status of the Dusky Pygmy Rattlesnake on KSC. Three museum specimens have been taken from MINWR, one in 1974 and two in 1977. A live animal was captured in 1981 (Smith pers. obs.). The species was once found to be common in areas north of Pad 39B (R. Franz, Florida State Museum pers. comm.) but has rarely been observed by the authors.

### Great Horned Owl (Bubo virginianus)

The Great Horned Owl is Florida's largest owl with a wingspan of up to 2 m. These top predators feed primarily on rabbits and rodents but eat birds, fish, amphibians and reptiles (Smith et al. 1990). Great Horned Owls have broad habitat requirements and with adequate food and habitat will readily reside in close proximity to humans. The Great Horned Owl population appeared to be increasing in Florida (Smith et al. 1990). It is one of the most common and widespread Owls in the southeast (Smith et al. 1990). Although the Owl is tolerant of many impacts, it may be vulnerable to local extinctions, and a population decline could occur across the northern half of Florida given the urbanization that is occurring (Noss and Labisky in press). They are mainly found in dense pinelands or other forests and woodlands.

They nest in abandoned raptor, corvid or occasionally squirrel nests in broad forks in large trees such as live oaks. They also require day roosts which are usually in dense conifers. Locally, the owls breed and lay eggs from mid-winter to early spring (Cruikshank 1980). Great Horned Owls are present on KSC year round and the population is probably stable since they tolerate minor human impacts. Most large trees and woodlands should remain intact, even around facilities, with minimal disturbance during nesting season. Pesticide use could be detrimental to Great Horned Owls because of their high trophic level. The use of Pigeon poisons on CCAFS is a concern (Smith and Rodier unpublished data).

#### American Alligator (Alligator mississippiensis)

The American Alligator is a member of the family Crocodylidae. There is only one other species of Alligator in the world, Alligator sinensis, which is found in China. The American Alligator once ranged from extreme southeast Virginia to the Florida Keys, west to the Rio Grande in Texas, north up the Mississippi River to southeastern Oklahoma, eastern Arkansas and northwest Mississippi (Fogarty 1978a). Now large populations can be found in Louisiana, Florida and southern Georgia. In Florida, Alligators can be found throughout the state, although the numbers are greater in the peninsula and the panhandle (Ehrhart 1978). The range of the Alligator is limited by cold temperatures and the extent of suitable wetlands. The Alligator uses wetlands along the edges of large lakes, ponds, and in the interiors of swamps and freshwater marshes (Ehrhart 1978).

Alligator populations were greatly reduced by the late 1960s by habitat alteration, indiscriminate killing, and commercial harvesting. Poachers hunting the Alligators for their meat and skins effectively eliminated the animal from much of its original range, namely Texas, Arkansas, and North Carolina. This mass killing led to

the federal listing of the species as endangered in 1967, which protected the animal and allowed it to eventually recover in most of its range. The Alligator is currently listed as threatened due to its similarity of appearance to the endangered American Crocodile. Modern threats include alteration of natural water level patterns and less predictable hydrological functions attributed to water management practices (Kushlan and Jacobsen 1990). The species' reproductive success depends on survival of eggs during a prolonged incubation period where water levels can flood nest sites and asphyxiate embryos (Joanen et al. 1977).

Courtship and breeding begin in spring and last until mid-June. Courtship behavior is denoted by bellowing, a sound that is made by both male and females. The male emits a loud, deep, sonorous roar which is thought to advertise presence and availability to females, as well as identify territory. Females clear an area and then pile vegetation up into a mound approximately 2 m wide and 1/2 to 1 m high. Females lay 20-50 eggs into the central cavity of the mound and then cover it over. The average incubation period is anywhere from 65 to 72 days (Fogarty 1974) during which time the female stays around the nest.

The young Alligators are extremely vocal and emit a "umph" sound that is a signal to the female to open the nest. The young often remain together in the nest area for up to 3 years. During this stage, the young Alligators are susceptible to many predators, such as birds, snakes, Otters, and Raccoons. Their diet consists mainly of insects and invertebrates until they reach approximately 2 m when they are considered to be adults. Examples of their diet include Blue Crabs (Callinectes sapidus), Grass Shrimp (Palaemonetes spp.), Killifish, and Mosquitofish (Gambusia affinis) (Platt et al. 1990). Subadult Alligators consume bugs, crayfish, snails, Round-tailed Muskrats, and Marsh Rabbits (Sylvilagus palustris) (Delany and Abercrombie 1986). As they become adults, their diet results in an increase of larger animals, especially fish and mammals, although they still consume turtles, birds, snakes, and

invertebrates (Fogarty 1978a). Females consume more turtles in northcentral Florida (Delany and Abercrombie 1986). Diet influences both growth rates and reproduction (Chabreck 1972, McNease and Joanen 1981). Studies have shown that Alligators are versatile, opportunistic predators and diet may vary considerably depending on prey associated with the wetlands inhabited.

The female Alligator spends the majority of her time at or near her den and wanders no more than 450 m from it. The male, on the other hand, disperses after copulation is completed to deeper waters, which he prefers until winter when he will remain near the den as well. Homeranges were determined to be between 2.6 and 6.6 ha for 4 females and to be between 183 and 5,083 ha for 14 males in Louisiana (Fogarty 1978a).

Holes constructed by adult Alligators are important components of the habitat for some wetland areas because they provide deeper water used by other animals during dry periods. The hole can extend into an underground tunnel away from a river or the edge of a lake, pond, or ditch. The Alligator uses its mouth and tail to tear the vegetation from the center of the hole and sweep it towards the edges. This edge provides habitat for other wetland species. The plants that occupy this edge serve as nesting areas for many avian species.

Habitat alteration (mainly destruction and drainage of wetlands) and poaching are the major threats to the Alligator. As of 1988 commercial harvesting of Alligators was allowed in various areas of the state, most of which are in south Florida and west of I-95. The purpose of hunting is to maintain the population of the Alligator by harvesting it on a sustained yield basis. On the KSC, the Alligator occurs in many roadside ditches, marshes, and open water bodies. In 1978, the peak population on the refuge was a 5000 animals, now the peak population is 3,500 (MINWR Annual Narratives 1978 and 1989).

### Whimbrel (Numenius phaeopus)

The Whimbrel is a common shorebird primarily during fall and winter along Florida's Gulf and Atlantic coasts (Kale and Maehr, 1990). The species is apparently showing a significant decline (Howe et al. 1989). The Whimbrel feeds on aquatic insects, crustaceans, worms, mollusks and a few seeds and leaves. Breeding takes place in northern Canada and the Arctic and nest are located in the drier portions of wet swales or bogs. The Whimbrel has a long-term pair bond and may not breed until its third year. It winters from South Carolina to southern Chile and southern Brazil. Southern Texas is a peak wintering area in the U.S., although another significant wintering area occurs north of Florida to North Carolina (Root 1988).

On KSC, the Whimbrel may be seen along impoundments, mudflats and other short-grass marsh areas from late July/early August with peaks in September and then again from early April to mid-May. There are usually a few that winter here and do not continue south in September/October. Also, during northward migration, a few stragglers may remain to early June (Cruickshank 1980). None were sighted during the 1990 Christmas Bird Count when 237 were sighted elsewhere in Florida (Sykes 1991). KSC is probably not a population center and the Whimbrel is not abundant in Florida.

### Red-tailed Hawk (Buteo jamaicensis)

The Red-tailed Hawk is one of the most common and well known hawks in Florida and on KSC. This large hawk occupies a wide variety of habitats. Its range covers the entire U.S. and most of Canada and Mexico. A resident of Florida, this hawk is seen in open habitats with high "look-out" spots. In Brevard, nesting occurs in pine flatwoods (Cruickshank 1980, Breininger 1990) in large, mature cabbage palms, live oaks or pines. They feed mainly on rodents and other small to medium-sized



mammals as well as a few birds, reptiles and insects. The Red-tailed Hawk is site tenacious and will use one nest site year after year if not taken over by another species (Hamel et al. 1982). The Red-Tailed Hawk is possibly vulnerable to a population decline but it appears tolerant of most impacts (Noss and Labisky in press). Although this is an abundant and wide-ranging species, there is concern for its nesting habitat requirements. A decrease in trees of sufficient size for nesting could reduce numbers of breeding pairs on KSC. Recent winter raptor surveys show a large increase in Red-tailed Hawk sightings from years 1984 and 1985 which had an average of 0.1 sightings per hour. During 1986 and 1987 there was an average of 0.9 sightings per hour (MINWR Narratives). However, there has been a slight decrease in sightings from 1988 and 1989 with an average of 0.5 sightings per hour (MINWR Narratives). Yearly differences may be due to natural population fluctuations, differences associated with survey methodology (e.g., differences among observers), or a declining trend in the population. Continued surveys on this species will provide useful information. The incorporation of monitoring recommendations in Fuller and Mosher (1987) and Gawlik and Bildstein (1988) would be useful. Declines in the population, especially the local resident breeders, may be an indicator of ecosystem changes, particularly since this species is at the top of the food chain.

#### Little Blue Heron (*Egretta caerulea*)

This small, dark heron feeds in fresh, brackish, or salt water, eating small fish, frogs, lizards, and crustaceans. The Little Blue is a slow, stalking hunter that often feeds alone, but nests in colonies with other species of wading birds. Their breeding range includes the coastal and adjacent states from Massachusetts to Texas south to South America, and they winter in the southeastern U.S. to South America. Immature Little Blue Herons are white and become mottled during their first winter as blue

feathers replace white ones. It is thought that being white allows the young, inexperienced birds to forage in close proximity to Snowy Egrets; because of their keen eyesight, Snowy Egrets are indicators of good foraging habitat (Cauldwell 1983). Adult Little Blue Herons are usually chased and supplanted by Snowy Egrets when feeding.

Population estimates in Florida have been decreasing for the past few decades (Rodgers 1978). The encroachment of Cattle Egrets into the United States may cause problems for Little Blue Herons. There is speculation that the two species compete for similar nesting sites (Kale and Maehr 1990) and disturbance from Cattle Egrets can lead to desertion of the nest by herons (Dusi and Dusi 1968). A greater threat to the Little Blue Heron is the drainage of wetlands they use for feeding sites (Rodgers 1980).

Little Blues occur on KSC year round and nest in small numbers in area colonies from April through June (Cruickshank 1980, Table 9). Colonies are located on natural and man-made spoil islands and mangroves are the preferred nest site. Mosquito control impoundments may have partially replaced feeding habitat lost to human activities elsewhere. Little Blues seem to prefer feeding in impoundments as opposed to the estuary (Leenhouts 1986, Smith and Breininger unpub. data). Impoundments are good habitat for the Little Blue Heron's style of hunting because there are no tidal, current, or wave effects (Rodgers 1982). However, water levels must be shallow in order for the heron to feed efficiently. Water levels are primarily influenced by actions of the BCMCD and USFWS. The edges of canals and ditches are used for feeding along the shallow vegetation/water interface. The use of herbicides in and near the ditches may pose a potential threat to Little Blues and their prey.

## Eastern American Kestrel (Falco sparverius sparverius)

The Kestrel is a common falcon throughout North and South America (Johnsgard 1990). This subspecies breeds across much of North America and winters throughout much of the southeastern U.S. Wintering occurs in particularly dense concentrations, relative to breeding densities, within Florida (Smallwood and Collopy 1991). The estimated wintering population in Florida is about 12,000 birds (Johnsgard 1990). Their diet consists of insects and small vertebrates which they hunt by hovering or pouncing on from a perch, and they will often cache their prey in clumps of grass for later consumption (Erich et al. 1990). Kestrels prefer open habitats with scattered trees, and urban and cultivated areas. They are regularly observed throughout the winter sitting on roadside poles and wires. Sexes show marked differences in habitat occupied on wintering grounds (Smallwood 1987, 1988). A delayed molt in males may delay departure from breeding to wintering grounds. Birds that first arrive often acquire the highest quality territories. These territories allow much of the foraging areas to be visible from choice perch sites; male territories often have more shrubs and trees and less visibility. Individuals may occupy the same areas in successive years (Layne 1982). Banding records suggest that the origin of American Kestrels wintering in Florida is from areas in the eastern U.S. and Canada (Layne 1982).

Loss of habitat and the use of pesticides on their major food source, insects, are the two main threats to this bird (Smallwood and Collopy 1991). Raptor surveys performed during the fall migration period by personnel from MINWR reported the following numbers of American Kestrels per hour of observation: 1984 - 1, 1985 - 0, 1986 - 2.8, 1987 - 4.1, 1988 - 4.1, 1989 - 4.9 (MINWR Annual Narratives). According to nationwide breeding bird surveys from 1965 to 1979, the North American population was in an upward trend and doing well (Robbins et al. 1986). Kestrels occupy mostly open habitats on KSC which are most likely to increase rather than decrease. The

influence of environmental contaminants, primarily the use of pesticides, may be a concern. A few individuals occupy areas in the vicinity of the launch pads, but this area is insignificant relative to the total available.

**Black-wiskered Vireo (Vireo altilogus)**

This species is found along much of the south Florida coastline and in the West Indies (Kale and Maehr 1990). Historical records indicated that only the most southern portion of the Atlantic coast was occupied (Howell 1932). The recent northern edge of its breeding range on the Atlantic Coast is near New Smyrna Beach (Owre 1978a). The Black-wiskered Vireo winters from eastern Columbia, Venezuela, and the Guianas to Amazonia. Mangroves provide the most important habitat, although this species occasionally occupies hammocks and other large hardwoods that border mangroves (Robertson 1955). South of Florida, it is not restricted to mangroves. There has been an increase in sightings of birds in inland Florida and the northern Gulf Coast (Duncan 1974). Their food consists of mostly arthropods gleaned off foliage.

The main threat to this bird is the loss of coastal habitat and destruction of extensive mangrove stands which has occurred along both coasts of Florida. Although mangroves are subject to regulation, areas are still being lost outside. The importance of suitable vegetation adjacent to mangrove vegetation is unknown. Graham (1990) predicted that this species could be extinct by 2001. Many birds that winter in Central and South America and nest in the U.S. are vulnerable to the habitat loss on their wintering grounds (Terborgh 1988). Future potential problems include Cowbird range expansions (see Section 4.1).

Large numbers have not been reported in Brevard County (Cruickshank 1980). The MINWR reports areas of nesting concentration are the south and east end of

Mosquito Lagoon, the north end of Banana River and Dummit Cove (D. Cooley pers. comm.). Black-whiskered Vireos occur in low numbers in mangroves during summer near launch complexes 39A and 39B (Breininger unpublished data). They have been rarely observed in hammocks and swamps (Breininger 1990). Populations of this species may remain variable because KSC is near the edge of their range, and they are dependent on mangroves which are vulnerable to freezes. There is no estimate of the population of the Black-wiskered Vireo on KSC.

#### Red Knot (Calidris canutus)

The Red Knot is a circumpolar shorebird which breeds in the tundra in North America and winters south from the Carolinas to Tierra del Fuego in South America. The Gulf coast of Florida has more Red Knots in winter than Florida's Atlantic coast (Root 1988). Apparently a small population occurs in the vicinity of Cocoa Beach (Root 1988). Less than 1% of the 3,760 Red Knots sighted in Florida during the 1990 Christmas Bird Count were found on KSC (Sykes 1991). Cruickshank (1980) describes the Knot as a fairly common to locally common migrant on mudflats, sandspits, salt meadows and beaches along the coast. It is said to be less common but regular along causeways inland to Merritt Island and the west shore of the Indian River, with no records further west.

#### Common Loon (Gavia immer)

The Common Loon breeds in Alaska, Canada, the northern U.S., Greenland and Iceland. It winters along the coasts from New England through Florida and Texas. Peak wintering areas occur along the South Carolina coast and on the Florida panhandle (Root 1988). The Loon can be seen in Florida in the Gulf of Mexico, Atlantic Ocean, Indian River or other estuarine waters from November through April.

They are a night time migrant and are rarely seen in flight. The Loon feeds mainly on fish which are caught by swimming underwater. Blue listed in 1981-82, the Loon has suffered declines due to loss of habitat and threats to their food source by acid rain (Erlach et al. 1988). Winter population estimates for offshore on much of the southeast continental shelf range from 8700-20,000 individuals (Haney 1990). Wintering Loons use individual feeding territories during the day and gather in "rafts" at night.

Cruickshank (1980) lists the Loon as a common winter visitant on the Atlantic Ocean, Mosquito Lagoon, Port Canaveral and other large bodies of salt or brackish water. They are common in the Indian River and Banana River (Breininger pers. obs.). Every winter, dead, dying or exhausted Loons are seen on the beaches as migration takes its toll on the birds.

#### Black-crowned Night Heron (Nycticorax nycticorax)

This small heron is widely distributed throughout the U.S. and is a permanent Florida resident. As their name implies, they are active during the night, at dawn, and dusk. Black-crowns will eat most anything from invertebrates to small mammals, including nestlings of other heron species. They nest in small trees and shrubs within mixed heron colonies at fresh and brackish water sites.

Black-crowned Night-Herons are common on KSC, although their nocturnal habits make them less obvious than the "day" herons. They nest in several of the area colonies and conservative estimates range from three nests to 30 nests per season (Table 9). As with all of the heron species, protection of the mangroves for nesting is essential (Cruickshank 1980), particularly since much of the KSC mangrove has been stunted by freezes in recent years. Management of impoundment water levels is important for providing feeding habitat for this short-legged wader.

## Loggerhead Shrike (Lanius ludovicianus)

The Loggerhead Shrike ranged from southern Canada to Mexico but is absent from much of its central US range. There are several subspecies in North America. The Migrant Shrike (Lanius ludovicianus migrans) breeds east of the Mississippi and north of the Carolinas and Gulf States. This small, migratory race winters in the southeastern U.S.. Shrike populations in Florida appear larger in winter than in summer and it has long been believed that the migratory race winters in Florida. However, there is no evidence, from banded bird returns, that the migratory race winters in much of Florida and current evidence suggests the apparent increase in winter may be due to seasonal recruits of local populations and some changes in habitat use (Yosef et al. in press). The migratory race is characterized by a longer wing-to-tail ratio, bluish gray rather than dark slaty above, pale slaty rather than white underneath, and smaller bill, with a narrow, sharply bent tip (Bent 1950). This migratory subspecies is being considered for listing by the USFWS. It was once believed, based on circumstantial evidence, that Migrant Shrikes exhibited strong fidelity to the breeding territory from year to year. Much of this evidence was based on unmarked birds and nest reuse; it is now known from banded Shrikes that they will use nests of other Shrikes and other species, and that mate desertion and switching occurs. This is important because low return rates have been established on breeding grounds which either results from high winter mortality or low site fidelity (Haas and Sloane 1989). Even if site fidelity is low, the migrant race has declined.

The Loggerhead Shrike (Lanius ludovicianus ludovicianus) ranges from southern Canada to Mexico and is present all year long over much of its range except in northern areas (Bent 1950). This birds nests in Florida where it is a resident throughout the year. Florida, particularly southcentral Florida, has been considered to be one of three states that represent strongholds of Loggerhead Shrike populations

(Robbins et al. 1986). Nearly all Loggerhead Shrike populations appear to be declining, regardless of race, and the species is already extinct over former parts of its historical range. Current declines in local Shrike populations suggests extinction in southcentral Florida by 2005 (Yosef et al. in press). Listing of the Loggerhead Shrike can be expected as its population becomes threatened with extinction.

Shrikes occupy open country habitats with scattered trees and conspicuous perches. It feeds on rodents, lizards, small birds, grasshoppers, caterpillars and other insects, making it one of the few completely carnivorous passerines. The Loggerhead Shrike has a unique behavior of impaling prey items on thorns and barbed wire as a means of caching food items. Their feeding method is like that of a miniature hawk without talons and they are able to catch small birds in flight by hitting the prey's head with their strong beak.

Shrike declines may relate to loss and alterations of breeding habitat (Brooks and Temple 1988) and pesticide use (Ehrlich et al. 1990, Kale and Maehr 1990). Shrikes accumulate pesticides in high concentrations and a single pesticide exposure can prevent individuals from successful reproduction (Yosef pers. comm.). In at least some areas of the U.S. it appears that the amount of breeding habitat is not limiting populations, since much suitable open country habitat has been unoccupied (Brooks and Temple 1988). Habitat loss in southcentral Florida is likely to be a significant cause for decline due to agricultural development (Yosef et al. in press). Impacts to the prey base can effect Shrike populations. A single fertilizer application can substantially reduce prey populations thereby impacting Shrikes (Yosef unpublished data). Loggerhead Shrikes were Blue Listed in 1972 by the National Audubon Society due to the huge decline in the central U.S. population; a subspecies in California is federally listed as endangered. Shrikes in Florida are moderately vulnerable to local extinction, and population declines are highly probable due to the



dependence on habitats which are prone to human disturbance and development (Noss and Labisky in press).

Shrikes are year-round residents on KSC, breeding from March through June. The breeding population is very low and very local, but Shrikes appear more common in winter (Cruickshank 1980). A pair has established a territory surrounding the Ecological Program building on CCAFS since 1992 (Breininger and Rowe pers. obs.). The 1993 nesting attempt included five nearly fledged young prior to predation (Rowe unpublished data). At least one pair resides near the SLF (Rowe pers. obs.) and also the Playalinda Beach Access Road Crossover area (Breininger pers. obs.). Successful nesting (1990-1992) has been observed on KSC along the edge of slash pine flatwoods and pasture adjacent to Tel 4 Road (Breininger pers. obs.). In winter, Shrikes have been observed in a few low slash pine flatwoods and many ruderal areas (e.g., KSC Industrial Area), including the launch impact zone of Pad 39A. The launch area, however, is only a tiny portion of the available habitat; no dead or injured Shrikes have been observed in post-launch surveys. Shrikes probably vacate this small area when the sound suppression system is initiated 13 seconds prior to ignition of solid rocket boosters. Long-term influence of inhalable particulates from shuttle launches that includes several heavy metals is uncertain (Drese et al. in preparation). Habitat management, pesticide and fertilizer use could effect the Shrike and prey species the most. Historical photography suggest that KSC was once sufficiently open that it should have been good Loggerhead Shrike habitat (Yosef pers. comm.). Now the habitat is too overgrown from insufficient fire. The edges of scrub or pinelands with ruderal areas could represent good habitat but edges do not burn well and most are too tall for Shrikes (Yosef pers. comm.). Carrying capacity can be increased by providing suitable hunting perches in ruderal areas because these often limit Shrike populations. Furthermore proper edge management could enhance populations. This would require keeping the edges of scrub and pinelands relatively clear of trees and

tall shrubs by cutting and proper fire management and restrictions in pesticide and fertilizer use in such areas.

#### Common Ground-dove (Columbina passerina)

The Common Ground-dove occurs from the southern U.S. to Costa Rica and northern South America (Kale and Maehr 1990). It is Florida's smallest dove. They breed during all seasons in Florida and producing up to four clutches of two eggs each per year. Ground-doves inhabit open sandy areas that have scattered grasses and bushes, such as dry woodlands, old fields, pastures, and citrus groves (Cruickshank 1980). They eat weeds, grain seeds, berries, and some insects, picking their food from the ground as they walk along, characteristically bobbing their heads. There is an influx of nonresident birds from October until March (Cruickshank 1980).

The Common Ground-dove was abundant in Brevard County until 1960 when there was a dramatic population decrease (Cruickshank 1980). The 1965-1979 Breeding Bird Surveys showed a highly significant decline in Florida, as well as a significant decline continent-wide (Droege and Sauer 1989). This dove is very vulnerable to local extinction and population decline is highly probable (Noss and Labisky in press). They nest on the ground and are susceptible to ground predators, they depend on a fire-maintained habitat, and are hunted (Noss and Labisky in press). If current population trends continue, the name "Common Ground-dove" may become a misnomer.

Ground nesting birds are uncommon in scrub and slash pine habitats on KSC, even in recently burned areas (Breininger and Schmalzer 1990, Breininger and Smith 1992). Little open sand occurs in undisturbed habitats even soon after a fire (Schmalzer and Hinkle 1987). Mourning Doves and the Northern Bobwhite are common in many areas of disturbed scrub and slash pine, but the Ground-dove is not

(Breininger and Schmalzer 1990, Breininger and Smith unpublished data). Ground Doves are common in some other ruderal habitats such as dike roads and ruderal areas (pers. obs.). Among native and relatively undisturbed habitats, coastal strand appears to represent the habitat most abundantly used by this bird. Raccoons and Feral Hogs may pose a threat to nestlings and eggs.

#### Least Bittern (*Ixobrychus exilis*)

Florida's smallest heron, the Least Bittern ranges from southeastern Canada throughout the eastern U.S. to northern South America. Although they are thought to be locally common (Cruickshank 1980), the cryptic coloration and secretive ways make them difficult to find. They are slow, stalking hunters of frogs, fish, insects, and aquatic invertebrates. They will feed in fresh or brackish marshes where there are reed beds of cattails or low thickets of willows or mangroves. Least Bitterns can have two broods per season of four or five eggs each.

In the Everglades, Least Bitterns prefer pure sawgrass or sawgrass/cattail areas; densities were higher in sparse stands of emergent vegetation than in dense stands (Frederick et al. 1990). They are infrequent in open sloughs, rush (*Eleocharis*) prairies, pickerel weed (*Pontedaria cordata*), arrowhead (*Sagittaria* spp.), and maidencaine (*Panicum hemitomon*). They are associated with edges of dense marsh vegetation (Weller 1961). Kushlan (1973) reported an association with nutrient-rich microhabitats. The Least Bittern also inhabits mangroves in Florida, Mexico, and the Caribbean (Bowman and Bancroft 1989). Water depth is a well documented factor in habitat selection for this species; in nontidal marshes, Least Bittern nests are typically placed over water 0.1-1.0 m deep and are usually within 10 m of open water (Provost 1947, Weller 1961, Swift 1987). On KSC, individuals were seen frequently in several locations dominated by *Spartina alterniflora* in the vicinity of Pads 39A and 39B during

the spring and summer of 1986 (Breininger pers. obs.). They are also often seen in salt marshes along Black Point Wildlife Drive.

The Least Bittern population is widely reported as declining and they have been extirpated from some areas (Kale 1978a). They were placed on the American Birds Blue List (reserved for species that are not officially listed but that are undergoing noncyclic population or range reductions) in 1979. Habitats for feeding and nesting are limiting factors for their survival. Spraying herbicides to kill cattails along ditches may impact this species.

#### Sanderling (Calidris alba)

Sanderlings appear to be undergoing a population decline (Howe et al. 1989). The Sanderling nests within the most northern areas of Canada. In migration, they are common along most of the U.S. coastline down into much of South America. They are common along most of the U.S. coastline in winter and are probably the most abundant maritime wintering shorebird in North America (Root 1988). No single migration route connects breeding and wintering populations (Myers et al. 1990). It is not known if migrating and wintering Sanderlings in Florida have separate breeding populations (Myers et al. 1990). During winter, disputes between neighboring Sanderlings can be seen along most of Brevard's beaches. The beaches within the security zone of KSC and CCAFS allow many Sanderling's to winter with minimal human disturbance.

#### Piping Plover (Chardius melodus)

Unregulated hunting rendered this small shorebird nearly extinct by 1900 (Bent 1929). Populations began recovering following protective legislation, but subsequent to 1945, populations have been on the decline due to impacts within the breeding

range and alteration of wintering habitats (Sidle 1984). Breeding habitat occurs on the upper Atlantic coast, the Great Lakes area, and the Great Plains (Johnsgard 1981). Food typically includes marine worms, beetles, insects, crustaceans, and mollusks (Bent 1929). Most studies have addressed the breeding ecology; few investigations have occurred on wintering grounds (Haig and Oring 1985, Johnson and Baldassarre 1988). Substantial mortality occurs to shorebirds away from their breeding grounds (Baker and Baker 1973). Most of the annual cycle of a Piping Plover is associated with wintering areas (Haig and Oring 1985). Habitat variables that may be important are large inlets (or passes), areas with a high percentage of sandflats or mudflats, broad beaches, and possibly habitat heterogeneity where suitable feeding and roosting habitat are in close juxtaposition (Nicholls and Baldassarre 1990 a, b). Intertidal mudflats may be important feeding habitats. There is difficulty in locating roosting habitat, yet it may be important that this habitat is adjacent to feeding habitat. Piping Plovers often occur mixed with other small shorebirds such as Semipalmated Plovers, perhaps as a strategy to minimize predation (Nicholls and Baldassarre 1990 a, b).

Piping Plovers maintain a high rate of foraging. Daylight hours appear most important since they are visual predators selecting surface prey items (Johnson and Baldassarre 1988) although they have been observed foraging at night (Chapman 1984, Burger 1984). High winds may make their feeding methods difficult. Winter conditions are usually mild on their wintering range, but prey activity may often be low. As a result, they may need to maintain high foraging rates to survive periods of inclement weather (Johnson and Baldassarre 1988). During severe weather, shorebirds can die of starvation within days by depleting their fat reserves (Pienkowski et al. 1984). Mild weather periods on wintering grounds are essential to rebuild fat reserves (Evans and Dugan 1984), yet this is the time when many beaches receive the most use by people.

Low tides are probably the most important time for feeding (Johnson and

Baldwassarre 1988). Piping Plovers feed mostly between the wave impact zone to the high tide drift line on beaches in Texas (Chapman 1984). Site fidelity of Piping Plovers is high and identification and protection of preferred wintering sites from disturbance is warranted (Johnson and Baldwassarre 1988 a, b).

The wintering range includes much of Florida, but KSC is not within a region reported as a peak wintering area (Root 1988). Cruickshank (1980) described the Piping Plover as a fairly common migrant and winter visitant, arriving in late July, early August and departing by mid May. Records suggest that it is chiefly confined to ocean beaches and sandspits, Port Canaveral, and the west shores of the outer ocean strip (Cruickshank 1980). It was not noted in impoundments near the ocean during the UCF surveys in the mid 1970s or during a 1985-1986 survey (Breininger and Smith unpublished). In January 1991, an International Piping Plover Census was conducted in an attempt to more fully document the species status and distribution. January was selected because it was believed that any Piping Plovers sighted during this period would be located on their wintering range; areas that had Piping Plovers at this time would be expected to represent important wintering areas. The entire beach was surveyed on CNS, MINWR, KSC, and CCAFS. No Piping Plovers were sighted. No systematic survey was conducted in other habitat types. Piping Plovers were observed in the highest numbers on the Gulf coast, while numbers on the Atlantic coast were very low (J. Nichols, USFWS, Atlanta, Georgia 1991, memorandum). The results indicate that KSC is not a significant wintering area for this species. Only four Piping Plovers were sighted in Volusia County near Ponce Inlet/New Smyrna Beach, and only one was sighted in Brevard County near Sebastian Inlet. KSC may be used during migration, but there is no data to evaluate whether there are any areas on KSC that are significant for migration.

## King Rail (Rallus elegans)

The King Rail is distributed throughout the eastern U.S., Mexico and southeast Canada. Hybrids between Clapper and King Rails have been reported; a few ornithologists believe King Rails and Clapper Rails are the same species. King Rails feeds on seeds, vegetative matter, Fiddler Crabs, small fish and mollusks. King Rails use a variety of vegetation associations ranging from fresh water, brackish, and coastal salt marshes, to shrub swamps, and upland fields near marshes (Meanley 1969). They nest in marshes within shallow (0-25 cm) water. Drying natural swales may be extremely important for foraging during the brooding period (Eddleman et al. 1988). Like the other rail species, the King Rail is heard more than it is seen. The King Rail nests in thick marsh grasses. The King Rail was Blue Listed in 1976-82 having declined across much of its range. It may deserve a threatened status except in Florida and Louisiana (Eddleman et al. 1988). The main threat to this species has been habitat loss and alteration. Pesticide use and agricultural run off can impact King Rails.

The King Rail is an occasionally observed as a year-round breeding bird on KSC. They may be more common but their secretive habits make them a low-visibility species. They nest in isolated fresh water wetlands located among scrub communities (Breininger 1992) and in cordgrass marshes associated with the St. John River (Leenhouts 1982 a,b). Clapper Rails were abundant in Trost's (1968) study but no mention was made concerning King Rails. Although Clapper Rails are usually believed to be associated with salt water and King Rails with fresh water, one would have expected Trost to identify some King Rails. Some isolated swales may be lost to new facility construction, but this is likely to be a small percent of suitable habitat during any one decade. Swale marshes are maintained by periodic fire so fire management is important for population viability.

### Great Egret (Casmerodius albus)

The Great Egret is a large white wading bird that is a generalist in habitat preference and diet. They have a worldwide distribution; the North American population ranges from Oregon, Minnesota, Ohio, and New York south to Central America. Nonbreeders venture to southern Canada in the summer. Their variable diet consists of terrestrial and aquatic vertebrates and invertebrates. Great Egrets forage in marine, brackish, or fresh water, or on dry land. Feeding habitats include the coastline, tidal creeks, stream banks, ponds, marshes, pastures, mosquito control impoundments, and ditches. Estuarine edge also provides feeding habitat for a significant portion of the population (Smith and Breininger unpublished data). Great Egrets use a variety of trees and shrubs for nest sites; some ground nesting occurs where tree and shrubs are unavailable (Chapman and Howard 1984).

They are a common year-round resident on KSC and nest at several of the area colonies (Breininger and Smith 1990, Smith and Breininger unpublished data; Table 9). Launches and discharge from the VAB sewage treatment plant result in habitat degradation of areas that are small relative to the total habitat on KSC. Ditch maintenance activities and stormwater runoff practices probably influence a small portion of the population. Water management practices have potential to have the most influence on the population.

### Louisiana Waterthrush (Seiurus motacilla)

The Louisiana Waterthrush is a medium-sized warbler found in forests and swamps in the eastern U.S. and in the Mid-west (Hamel et al. 1982). It winters in Central America to northern South America. It feeds on aquatic and terrestrial insects, molluscs, and crustaceans. The Waterthrush is an occasional cowbird host. Part of



the interest in this species by Florida biologists is that the southern edge of its breeding range occurs in northern Florida. Many of the areas suitable in northern Florida are vulnerable to agriculture and other human development (Stevenson 1978b).

The Louisiana Waterthrush occurs on KSC in hammocks, willow and mixed hardwood swamps, and mangroves from July through May but is most common during migration (Cruickshank 1980, Kale and Maehr 1990, Breininger unpublished data). Its relative, the Northern Waterthrush (*S. noveboracensis*) is more common on KSC, especially during fall migration.

#### Bachman's Sparrow (*Aimophila aestivalis*)

The Bachman's Sparrow is a permanent resident throughout Florida north of Lake Okeechobee (Kale and Maehr 1990). Bachman's Sparrow was traditionally associated with mature longleaf pine forests of the southeast where it was associated with grassy openings among pines (Brooks 1938, Haggerty 1986, Jackson 1988, Dunning and Watts 1990). It underwent a range expansion at the turn of the 20th Century north into Illinois and across to Pennsylvania and was found occupying a range of open habitats including abandoned pastures, fields, and clearcuts. Later in the 1930s it disappeared from northern parts of its range (Dunning and Watts 1990). Large populations in the south have also declined (Jackson 1988) so that it is a potentially threatened species that has been on the Blue List each year that it has been compiled (Tate 1986).

Conditions associated with good Red-cockaded Woodpecker habitat are often good for Bachman's Sparrow (Dunning and Watts 1990); populations of both are now only remnants. One of the major threats to these birds is the logging of southeastern pinewoods. Patches of clearcuts are suitable for only short periods of time (Dunning

and Watts 1990). Habitat fragmentation and poor dispersal ability may have led to local extinctions. Other factors include loss of habitat due to development. Bachman's Sparrow is a candidate for federal listing. It is vulnerable to local extinction and population decline is highly probable across much of Florida (Noss and Labisky in press). This is due to low local population size, because it nests on or near the ground, because it is dependent on a fire-maintained habitat, and it is distributed in habitat prone to development or human disturbance.

Bachman's Sparrow was a common and widely distributed resident in Brevard County prior to 1955 but became rare by 1960 (Cruickshank 1980). This Sparrow is now very rare on KSC; a few breeding pairs may nest in dry pine-dominated woodlands (Hamel et al. 1982). One singing male was sighted once in May during upland bird studies (Breininger unpublished data). The more open structure of the KSC landscape before the 1960s may have represented better habitat conditions than occurs today. Many singing male observations have been made on several well-managed ranches, having poorly-drained flatwoods, in southern Brevard County (Breininger pers. obs.).

#### Limpkin (*Aramus guarauna*)

The Limpkin occurs from Mexico to South America, but in the U.S. it is confined almost entirely to peninsular Florida and is essentially nonmigratory. A secretive bird, very little is known about its breeding biology other than Limpkins can breed year-round, and the length of the breeding season depends on food abundance and water level. They inhabit slow-moving fresh water streams and rivers, swamps, and lake margins. Their preferred food is apple snails (Kale and Maehr 1990), but they will also eat other snails, frogs, worms, insects, crustaceans, and mollusks. It is believed that Limpkins are undergoing a long-term population decline (Nesbitt 1978), but lack of life

history information on this bird hampers evaluation of its current status. Limpkins were once hunted for food, but their dependence on wetlands for feeding and nesting appears to be the major threat to their survival.

Limpkins prefer open freshwater near woody vegetation, (Nesbitt 1978, Hamel et al. 1982). They are common in created fresh water wetlands in Orange County (A. Oyler pers. comm., R. Smith pers. obs.). Limpkins will feed in the brackish mosquito impoundments that occur on KSC (Smith pers. obs.) but are not known to breed here. In the 1960s, Limpkins were apparently rare in ungrounded and impounded salt marshes (Trost 1968, Provost undated). More recently, no Limpkins were sighted in a one year study of impoundments and salt marshes near Launch Complexes 39A and 39B (Breininger and Smith 1990), none were sighted in a two year study of freshwater swamps (Breininger 1990), and none were sighted in freshwater marshes south of the VAB Turning Basin (Breininger 1992). Although the species is nonmigratory, some long distance movements do occur during the nonbreeding season, presumably by birds in search of new feeding areas (Nesbitt 1978). Cruickshank (1980) noted the movement of several dozen to MINWR during an extreme drought along the St. John's River in the winter of 1970-1971. Sightings on MINWR Christmas Bird Counts averaged one/year for the past 11 years (Stuckey et al. 1990). Although there is no large population on KSC, habitats may occasionally provide for a few individuals. KSC does not have preferred breeding habitat for this species.

#### Pectoral Sandpiper (Calidris melanotos)

This sandpiper is uncommon throughout its range, which includes most of the U.S. south to Central America. It nests in extreme northern Canada and winters in South America (Root 1988). It inhabits fresh and salt marshes, wet prairies, and agricultural environments. The diet is varied; insects are favored, but spiders, worms,

small vertebrates, and seeds are also eaten. Howell (1932) reported the species as an uncommon migrant in wet short-grass marshes. Sightings of Pectoral Sandpipers in Brevard County are uncommon, but regular during spring and fall migration (Kale and Maehr 1990), with most being reported from August through October (Cruickshank 1980). None have ever been seen during the MINWR Christmas Bird Count (Stuckey et al. 1990).

#### Semipalmated Sandpiper (Calidris pusilla)

This species breeds in much of northern Canada and southern Alaska. During migration, it may range throughout much of the central and eastern U.S. Populations appear to be showing a significant decline (Howe 1989). If any wintering occurs in Florida, it is probably only in south Florida (Phillips 1975). It is very difficult to distinguish this species from the Western Sandpiper due to overlap in bill and some plumage characteristics. Reported sightings in winter are believed to be misidentifications. Most sightings on KSC are transients during migration.

#### Hairy Woodpecker (Picoides villosus)

This woodpecker is common over much of the continental U.S. and is abundant in some areas. It has a broad tolerance for foraging habitats and nest site selection across most of the U.S. (Lawrence 1966, Conner and Adkisson 1977). An individual uses several hectares of habitat, typically using live trees as cavity sites for nesting (Owre 1978). The species is typically rare or uncommon across much of peninsular Florida (Roberston 1955, Rowher and Woolfenden 1969). There is evidence that present day climate is becoming progressively more unfavorable for many northern species, such as the Hairy Woodpecker, that are a receding element in the Florida avifauna (Roberston 1955, Rowher and Woolfenden 1969). The species was reported

by Cruickshank (1980) to be a rare resident in Brevard County confined mostly to pinelands and hardwood swamps. Winter population peaks occur west and north of Florida where most of the population resides. The subspecies P. v. audoboni occurs across much of the southeastern U.S. (Owre 1978b). There are no nesting records for KSC although it has been observed on KSC during all seasons except summer (MINWR Bird List).

#### White-rumped Sandpiper (Calidris fuscicollis)

This generally uncommon sandpiper ranges throughout the eastern halves of North and South America. They nest in extreme northern Canada and winter south of Florida. They are regular, but not abundant in Florida during spring migration (May-June) and fall migration (July-September). White-rumped Sandpipers occur on the coasts and inland. Habitats include mudflats, estuarine shores, tidal marshes, and shallow pools bordered by grass. In Brevard County, they are mostly coastal and are rarely seen west of the Indian River (Cruickshank 1980). In 20 years of MINWR Christmas Bird Counts, they have never been recorded.

#### Red-headed Woodpecker (Melanerpes erythrocephalus)

This species is common to open forests and suburban woodlands but has a patchy distribution in Florida (Kale and Maehr 1990). The species often exists in the same habitat as Red-bellied Woodpeckers and aggression between the species is common; niche differences are most pronounced during the breeding season (Reller 1972). Red-headed Woodpeckers prefer areas with tall trees, high basal area and low stem density, and an open understory (Conner and Atkisson 1977, Venables and Collopy 1989). It flycatches for food acquisition in spring and summer and stores acorns in fall for consumption in winter resulting in seasonal adjustments in habitat

occupancy (Kilham 1958, Moskovits 1978). At Archbold Biological Station, families of Red-headed Woodpeckers break up into individual territories during fall and winter, and occupy open scrubby flatwoods (Moskovits 1978). Aggressive behaviors associated with protection of mast areas are exhibited to other birds such as Florida Scrub Jays. The replacement of open longleaf pine stands with dense turkey oaks, as has occurred in many sandhill communities due to alteration of natural fire regimes, is a significant concern for this species in Florida (Venables and Collopy 1989). Human development is also a significant concern (Noss and Labisky in press).

This bird is rare on KSC and its occurrence in Brevard County is primarily west of U.S. 1 (Cruickshank 1980). The habitat structure in most pinelands on KSC may currently be unsuitable due to a tall, dense shrub layer. Several adults and at least one juvenile resided in the Tel 4 study area during winters from 1990 to 1992 (Breininger pers. obs.). This is the first time they have been seen as residents in the Tel area at least since 1978. The area occupied is adjacent to a pasture on private property having a pine overstory. An individual was seen in a pine stand at Happy Creek for the first time in five years after recent restoration efforts (R. Smith pers. obs.). No Red-headed Woodpeckers were sighted in other pine flatwoods during surveys (Breininger and Smith 1992). KSC is of little or no significance to the species, although the use of the Tel 4 area is interesting. KSC may have supported larger populations when the landscape was more open before the 1960s.

#### Field Sparrow (Spizella pusilla)

The Field Sparrow inhabits pastures, old fields, woodland edges, and other open areas where they feed on weed seeds and insects (Hamel et al. 1982). This sparrow is a winter visitor in most of Florida, but it also nests in the Panhandle. Centers for the wintering population for most of the continental population are north of

Florida (Root 1988). Tall herbaceous plants with scattered shrubs and trees are preferred habitat (Hamel et al. 1982). Threats to the Field Sparrow are urban development and cowbird parasitism. Breeding populations in northern Florida are vulnerable to local extinctions, and a population decline is probable (Noss and Labisky in press). Its vulnerability is due to low local population densities, nesting on or near the ground, dependence on a fire-maintained habitat or vulnerable to alterations of the fire regime, and dependence on habitat which is prone to human development or disturbance.

The sparrows can be seen, although rarely, on KSC from early November through early April (Cruickshank 1980). During some years, singing males are abundant within slash pine flatwoods during spring (Breininger pers obs.). KSC is of minor importance to the species.

#### American Bittern (*Botaurus lentiginosus*)

The secretive nature and cryptic coloration of the American Bittern contribute to the lack of information about this species. They range from Canada to the Gulf states and winter to southern Panama. Nesting is more widespread in the northern half of the continent, but wintering is widespread in the southern states, especially south Florida (Root 1988). American Bitterns live in wet prairies and marshes, camouflaging themselves by standing among the vegetation with their head held vertically. The bulk of their diet is fish, aquatic invertebrates, and small vertebrates. They rarely nest in Brevard County and all records have been from near the St. Johns River, with no nesting reports from KSC (Cruickshank 1980). One was sighted during a one year study surrounding launch complexes (Breininger and Smith 1990). They feed in KSC wetlands and are occasionally observed during the fall and winter when there is an influx of northern birds. The American Bittern was placed on the Audubon Blue List in

1976 and is continuing to decline throughout its range, presumably due to the loss of wetlands habitat (Erich et al. 1988). The KSC contributes to regional populations of northern migrants of this species.

#### Broad-winged Hawk (Buteo platypterus)

This small Buteo breeds from southern Canada and the eastern U.S. to Gainesville, Florida, and winters from south Florida to South America (Mitchell and Millsap 1990). Most of the North American population migrates along the Gulf coast into Central and South America (Johnsgard 1990). Flocks migrate along both coasts during the fall, but few are observed on KSC. Sightings of single birds were recorded on MINWR in 1984, 1988, and 1989 (MINWR Annual Narratives) and 1985 (Breininger pers. obs). The North American population was stable in the 1960s and 1970s (Robbins et al. 1986), but the breeding distribution has decreased in the last few years (Kale and Maehr 1990), presumably due to loss of wetlands. Broad-winged Hawks have a varied diet of small mammals, reptiles, and large insects (Johnsgard 1990). They hunt by spotting prey while sitting on a perch and swooping down on it with wings spread. They inhabit woodlands, especially hardwood swamps and hammocks in the southeast (Hamel et al. 1982). The Broad-winged Hawk is vulnerable to local extinction, and a population decline is probable in northern Florida (Noss and Labisky in press). Rarity is due to low local population densities, wide-ranging (area-dependent) habits, low fecundity, long distance migration, and preference for forest interior habitat. Habitat destruction and human persecution have impacted the species in much of its range. Short timber rotations associated with logging are incompatible unless some older-aged forests remain (Mitchell and Millsap 1990).



### Worm-eating Warbler (Helmitheros vermivorus)

Contrary to what the name implies, the Worm-eating Warbler does not eat worms, but has a diet consisting of insects. It ranges from the Midwest to the Northeast and winters in the Bahamas, Antilles, Mexico, and Panama. It is occasionally a cowbird host and is sensitive to fragmentation of forest breeding habitat. Part of the interest in this species by Florida biologists is that the southern edge of the breeding range of this species occurs in northern Florida (Stevenson 1978c). A few wintering individuals occur near Fort Lauderdale (Root 1988). Typical habitats include deciduous woodlands and hammocks. Individual are occasionally seen in scrub during migration (Breininger pers. obs.). The Worm-eating Warbler occurs only on KSC during spring and fall migrations and is often found during bird kills at the VAB (Taylor and Kershner 1986).

### Brown-headed Nuthatch (Sitta pusilla)

The Brown-Headed Nuthatch is one of the smallest members of the tree-climbing nuthatch family ranging from North Carolina through Texas (Hamel et al. 1982). They inhabit open pine forests and its preferred flatwoods habitat is often home to the Red-cockaded Woodpecker (Kale and Maehr 1990). The Brown-headed Nuthatch feeds mainly on insects and pine seeds and will use a stick or piece of bark as a tool to pry off bits of bark while searching for insects. They are cavity nesters and will excavate their own holes or use abandoned woodpecker holes, fence posts or boxes. Nests are occasionally attended by three birds, the third bird being an unmated male who assists in nest building, maintenance, feeding the female on the nest, and feeding nestlings and fledglings. They maintain year round territories, but defense is limited to the vicinity of the nest cavity.

KSC is on the edge of the range of this species (Hamel et al. 1982). It has not

been sighted in surveys within pine flatwoods on KSC (Breininger unpublished data). Cruickshank (1980) noted it as a declining uncommon resident on the mainland in Brevard County. As is true for many birds that nest over much of the eastern U.S. but drop out southward along the Florida peninsula, the Brown-headed Nuthatch occurs further south down the Florida peninsula interior to the coast (Robertson 1955, Emlen 1978).

#### Hooded Warbler (Wilsonia citrina)

The Hooded Warbler is distributed throughout the eastern and midwestern U.S. from New York to north Florida (Hamel et al. 1982). They winter in the West Indies, and Mexico through Panama. The Hooded Warbler utilizes swamps, moist pine flatwoods and dense undergrowth of mature deciduous forests in the panhandle and northern peninsula south to Ocala (Kale and Maehr 1990). They are most common in the deciduous forests especially mixed hardwood swamps with a dense understory (Hamel et al. 1982). It is entirely insectivorous. Threats to this species include its long-distance migration and the destruction of rainforest wintering habitat, as well as the increased amount of edge which encourages cowbird parasitism on its nesting grounds. Breeding populations of the Hooded Warbler in northern Florida are vulnerable to local extinction, and a population decline is probable (Noss and Labisky in press). A major concern for this species in Florida is the condition of its breeding habitat which does not occur on KSC. On KSC, the Hooded Warbler may be seen occasionally during spring and fall migrations (Cruickshank 1980). This bird has not been abundant during spring migration based on bird kills at the VAB (Taylor and Kershner 1986) and has not been sighted in recent surveys within hammocks and swamps (Breininger 1990). The USFWS (Birds of MINWR) lists the bird as occasional; Cruickshank (1980) lists the species as uncommon.

### Kentucky Warbler (Oporornis formosus)

The Kentucky Warbler is distributed throughout the eastern U.S. to Texas and winters from Mexico to northern South America. It feeds mainly on insects and a few berries. The Kentucky Warbler requires deciduous woodlands with dense, damp undergrowth for breeding (Hamel et al. 1982). It is very sensitive to forest fragmentation and is a frequent Cowbird host. The Kentucky Warbler is one of the most forest-dependent warblers on winter grounds where they defend small territories. The decline of rainforests is also a threat. The species is vulnerable to local extinction, and a population decline is probable in northern Florida due to low local population densities, long-distance migration, nesting on or near the ground, and dependence on forest interior habitat (edge-avoiding) (Noss and Labisky in press). On KSC, the Kentucky Warbler can be seen rarely during spring and fall migrations in swamps and hammocks (Cruickshank 1980).

### Yellow-breasted Chat (Icteria virens)

The Yellow-breasted Chat is found throughout the U.S. except for the extreme North and South. They winter in the south to Panama. It nests in north Florida; some winter in southern Florida (Root 1988, Kale and Maehr 1990). The Chat feeds on berries and insects. The Yellow-breasted Chat occupies dense brush or scrub, especially along wet areas (Hamel et al. 1982). The major threat to the Chat is habitat loss, particularly in the form of increased edge along suitable habitat. It is frequently a cowbird host and increased edge makes the Chat more vulnerable to parasitism by the cowbird. Local extinction is probable and a population decline is highly probable due long-distance migration, dependence on fire-maintained habitat and vulnerability to changes in the fire regime of the habitat (Noss and Labisky in press). Cruickshank (1980) lists it as a possible breeder in Brevard County. The Yellow-breasted Chat is

mostly sighted during migration. During migration, a few individuals were recorded in scrub during studies at the VAB turning basin (Hall et al. 1985, Breininger and Schmalzer 1990). There has been no evidence of nesting south of State Route 402.

#### American Redstart (*Setophaga ruticilla*)

The breeding range of the American Redstart extends from Canada south through the eastern U.S. but is absent from the extreme southeast and southern coastal areas. Their diet consists of insects and occasionally seeds or berries. The American Redstart is a frequent cowbird host but will occasionally destroy cowbird eggs by burying them in the bottom of the nest. Much of the interest in this species by Florida biologists is due to a small nesting population that extends into the Florida panhandle (Stevenson 1978d). The American Redstart is a common spring and fall migrant through Florida in hardwood forests and woodland edges (Cruickshank 1980). Fall migrants arrive between late July and early November, while spring migrants pass through between late March and early June. The bird is frequently sighted in hammocks, swamps, scrub, slash pine, and disturbed habitats on KSC (Breininger unpublished data). It is a species which is commonly found after hitting the VAB during migration (Taylor and Kershner 1986). Redstarts accounted for 7.0% of the VAB kills during 4 years of data collected on fall migrations.

#### Atlantic Ridley (*Lepidochelys kempii*)

The most endangered of the marine turtles, the Atlantic Ridley occurs in the coastal waters of the Gulf of Mexico and occasionally ranges north along the Atlantic coast to New England in the summer months. They are rather small with a shell that is almost circular. Ridleys are primarily carnivorous, eating crabs, mollusks, and fish. The entire population exclusively utilizes a small stretch of the Tamaulipas beach in

the Gulf of Mexico for nesting. When this beach was discovered in 1947, approximately 40,000 females nested; by 1970 that number was reduced to 2,000 (Lund 1978). Once killed for their meat and eggs, Ridley's have been protected since 1970 by the Endangered Species Act. The greatest threat to their continued survival is drowning in shrimp nets (Lund 1978). Although KSC beaches are not used by this species, Atlantic Ridleys apparently frequent the coast; 18 strandings were reported from area beaches between 1980 and 1992 (DNR 1992b).

Atlantic Hawksbill (*Eretmochelys imbricata imbricata*)

This small marine turtle is easily identified by its pointed beak and beautiful heart-shaped shell. It ranges in the warmer parts of the Atlantic, occasionally venturing as far north as New England and south to southern Brazil. They are not well studied and many aspects of their ecology are unknown. Hawksbills feed on marine invertebrates, algae, and mangroves, and they are often associated with coral reefs. Females nest singly on beaches throughout the Caribbean. Hawksbills are endangered throughout their entire range and were federally listed in 1970 . Their shell is the source of "tortoise shell" used for jewelry, which remains popular even though synthetic alternatives exist. They are also hunted for their meat and eggs which are eaten. Young animals are stuffed for curios.

The occurrence of Hawksbills in Florida is relatively rare. Previous to 1978, only two nests had been recorded (Lund 1978b); two more nests were found in 1991 between Patrick Air Force Base and Sebastian Inlet (DNR 1992a). Four carcasses washed up onto area beaches between 1980 and 1992 (DNR 1992b). KSC is probably not important for maintaining populations of Atlantic Hawksbills, although measures in place to protect other species of marine turtles should also benefit any Hawksbills that might wander into our area.

### Roseate Tern (*Sterna dougallii dougallii*)

The Roseate Tern ranges from Nova Scotia to Virginia then from the Florida Keys and Bahamas. Nests are made on the ground in barren or sparsely vegetated sites. They feed, like most terns, by plunge-diving for marine fish. This tern was Blue Listed in 1972 and 1979-86 and is likely to be federally listed as endangered soon (Ehrlich et al. 1988). It is estimated that only 250-300 breeding pairs exist in Florida (Robertson 1978c). Nesting success for this species tends to be poor due to high susceptibility to disturbance and nest predation by mammals and other birds. The Roseate Tern migrates through KSC and may rarely be seen along the shoreline during spring and fall (Cruickshank 1980, Breininger and Smith 1990).

### Atlantic Leatherback (*Dermochelys coriacea*)

Little life history information is available on the Leatherback because they are not often encountered. They primarily frequent the warm open waters of the Atlantic ocean, but range further in the summer. Nesting takes place on several beaches in the Gulf of Mexico, and occasionally on the east coast of Florida. The Leatherback is the largest living turtle and can weigh up to 767 kg (1,600 lbs.). They are the most specialized aquatic turtle with many characteristics that have evolved for life in the open seas. Their shell does not have hard scutes, but consists of a smooth, dark skin. Unlike other turtles, the ribs and vertebrae are not attached to the shell. They eat jellyfish, and the mouth and esophagus are lined with spiny projections that help with swallowing slimy food. Leatherbacks were federally listed in 1970 and they are considered critically endangered. Their eggs are eaten and the oil from their meat is used in cosmetics. KSC may be important as a nesting area. Seventeen nests have been documented from New Smyrna to Sebastian Inlet between 1983 and 1991, including five from CNS, one from CCAFS, and one in 1986 from the KSC secured

beach (DNR 1992a). Thirteen carcasses have been reported on area beaches between 1980 and 1992 (DNR 1992b).

#### Kirtland's Warbler (Dendroica kirtlandii)

This species nests only in a transitory habitat condition within jack pine stands in the northern part of Michigan's lower peninsula (Stevenson 1978e). It winters only in the Bahamas (Terborgh 1989). Habitat loss and degradation on breeding and wintering grounds, combined with cowbird nest parasitism put this species at great risk for extinction. Substantial human intervention is now needed to save the species. A few sightings during migration have been confirmed within Florida (Langridge 1984). KSC is of no known significance for this species.

#### Florida Sandhill Crane (Grus canadensis pratensis)

The Sandhill Crane ranges from northeast Siberia to North America where it is found in Canada, Wisconsin, and Minnesota and winters in south Texas through Mexico (Williams 1978a). The Florida population is estimated to be 5,000-6,000 (Nesbitt 1982). The nonmigratory Florida Sandhill Crane is an inhabitant of marshes and wet prairies throughout the state. The Kissimmee Prairie and Payne's Prairie are both noted for resident Crane populations. Migrants from the Midwest also come to these areas of Florida from late fall through early winter. Breeding takes place from January to June (Bishop 1988). In Florida, winter rains increase breeding success while heavy spring rains decrease success. They often have strong fidelity to their homeranges and restricted movements (Bennett 1989). They prefer open, upland habitat such as pastures that are near permanent emergent wetland habitats (Nesbitt and Williams 1990). Sandhill Cranes were once common residents of Brevard County but are now rare (Cruickshank 1980). A few, including young, have been regularly

observed in Titusville (Reddick and Smith pers. obs.) and south Brevard County (Breininger pers. obs.). They are a common occurrence in the fields and pastures of Melbourne and the St. Johns River. Their occurrence east of the Indian River is rare (Kale 1988) so that the importance of KSC is insignificant.

#### Sooty Tern (*Sterna fuscata*)

The Sooty Tern is almost entirely pelagic except for breeding and nesting. They are water surface feeders rather than divers like most terns, and feed on minnows, flying fish and squid. In winter, the Sooty Tern ranges widely throughout the tropical and subtropical oceans. Breeding takes place mainly south of the U.S. on sandy or coral shores and islands which are sparsely vegetated. There is one large breeding colony on Bush Key in the Dry Tortugas off the Florida Keys. In the U.S., the Sooty Tern has also bred in Louisiana and Texas (Clapp et al. 1983). The main threat to this species is loss of breeding habitat, overgrowth of vegetation, erosion of Bush Key and marine pollution. The Sooty Tern is a transient along the coast of KSC and may be seen occasionally from March through August and during storm systems (Kale and Maehr 1990) when they can be very abundant over nearshore open waters (Breininger pers. obs.).

#### Southeastern Kestrel (*Falco sparverius paulus*)

A smaller version of the American Kestrel (*F. s. sparverius*), the Southeastern Kestrel breeds throughout most of Florida (Smallwood and Collopy 1981). They eat mainly insects and small vertebrates and, like the American Kestrel, prefer open areas with scattered trees as well as urban and cultivated habitats. The Southeastern Kestrel uses cavities in pine trees or snags for nest sites, often taking over holes abandoned by woodpeckers (Kale and Maehr 1990). A minimum diameter of trees at



breast height may be 18-20 cm (Hoffman 1983). Sandhill is the traditional habitat for this subspecies (Bohall-Wood and Collopy 1987). Lizards appear to be an important part of this Kestrel's diet; these are abundant in sandhill (Bohall 1984). In contrast the prey base of many pine flatwoods is different; there are more nocturnal small mammals.

The breeding season is from late August into mid April (Hoffman 1983). The Southeastern Kestrel is vulnerable to local extinction and a population decline is probable across northern Florida (Noss and Labisky in press). Its rarity is due to limited or patchy distribution and vulnerability is based on wide-ranging (area-dependent) habits, low fecundity, dependence on a fire-maintained habitat, and specialization on habitat which is prone to human disturbance. Logging of large pine trees that provide nest sites (Smallwood and Collopy 1991) may explain the decline of this subspecies (Wiley 1978b). The Southeastern Kestrel will use artificial nest boxes (Kale and Maehr 1990).

Cruickshank (1980) reported a few scattered pairs nest in Brevard County. Few or no Southeastern Kestrels nest on KSC, although a few have been seen during the spring and summer when nesting birds should be present. Reasons for their absence are unclear; perhaps past logging eliminated suitable nest sites and the population never recovered. The dense shrub understory that now prevails in most KSC pinelands may also account for their absence since they prefer herbaceous vegetation as foraging habitat (Smallwood 1987, 1990). The lack of sandhill habitat and optimal prey base, may also be a factor for its absence on KSC.

#### Rothschild's Magnificent Frigatebird (*Fregata magnificens rothschildi*)

This large, soaring bird inhabits the oceanic coasts and islands from Baja, California and central Florida to South America. It eats small fish and aquatic

invertebrates which it plucks from the water or robs from other birds while flying. They are colonial nesters on islands with low dense shrubs and lay one egg per year. The only known U.S. colony was established in 1969 in the Marquesas Keys and has had varying success since that time (Robertson 1978d). Frigate Birds occur occasionally at KSC, usually during storms, but more than 80 birds at a time have been reported to roost on islands in the Banana River and Mosquito Lagoon during July - September (Cruickshank 1980).

#### Great White Heron (Ardea herodias occidentalis)

This large wading bird is not considered a distinct species but a color phase of a local population of the Great Blue Heron (A. herodias) (Robertson 1978e). The Great Blue Heron has a nearly continent-wide distribution. The Great White Heron breeds mostly in the Florida Keys and Florida Bay area. This subspecies or a similar subspecies also breeds in Cuba, the Yucatan and elsewhere outside the U.S. (Robertson 1978e). Plume-hunting and past hurricanes may have resulted in population declines. They have no tolerance to nest disturbance but otherwise adapt well to human activity (Robertson 1978e). Regular non-breeding occurrence extends over much of the Atlantic and Gulf coast. They are most often associated with estuarine habitats although some fresh water areas are also used in southern Florida. Individuals are occasionally observed on KSC along NASA Causeway, Black Point Wildlife Drive, and canals at the Visitor's Information Center (Smith, Breininger, and Kehl pers. obs.).

#### Florida Burrowing Owl (Athene cunicularia floridana)

The Burrowing Owl ranges from southwest Canada through the western U.S. to South America, with a disjunct subspecies occurring from central Florida to southern

Argentina. The Florida Burrowing Owl inhabits dry, well-drained prairies and open grasslands, as well as pastures, airfields, golf courses, and parks. They excavate their own burrows or will occasionally use burrows of other animals such as Gopher Tortoises (Bent 1938). Burrowing Owls are nocturnal, but will sometimes forage during the day and can be seen sitting on fence posts or at the mouth of their burrow. They eat primarily insects, but also take rodents, amphibians, and small birds. They are loosely colonial; large groups of several hundred birds were common during the early 1900s (Bent 1938), but now mostly small groups are reported (Owre 1978c). Clutches of 7-9 eggs are typically laid in April and May in burrows (Millsap 1990).

The Florida Burrowing Owl was placed on the Audubon Blue List in 1972 and designated as a Species of Special Concern in 1982 and 1986. Its vulnerability to development in Florida is ranked as moderate, with population decline fairly probable (Noss and Labisky in press). Most of the threats to this owl are caused directly or indirectly by humans. Their natural nesting habitat is being developed rapidly, and they are expanding their range to include areas such as airfields, golf courses, fields on college campuses, and pastures that are prone to disturbance and are often lost to more development. They and their prey are affected by fertilizers and pesticides. The Florida Burrowing Owl responds favorably to management, but perpetuation of the species depends on protecting natural habitat (Owre 1978e). A Burrowing Owl was once reported from KSC in 1976 (MINWR annual narratives). Burrowing Owls might someday colonize KSC, particularly since they have been undergoing a continued breeding range expansion (Courser 1979).

#### American Swallow-tailed Kite (Elanoides forficatus)

This raptor is one of the first neotropical migrants to arrive in Florida in spring; large summer concentrations occur at Lake Okeechobee (Millsap 1987). W.

Robertson of Everglades National Park has estimated the south Florida population to be 250-400 birds. They range throughout the southeastern United States and tropical America, and winter south out of the U.S. (Johnsgard 1990). A significant migration route appears to cross through Florida. Kites eat large insects, small vertebrates, and occasionally fruit. They swoop down upon their prey and consume it in flight. Wet hammocks and swamps are preferred habitat, and the American Swallow-tailed Kite is threatened by drainage of wetlands, deforestation, and hunting. They were once considered for federal listing, but were found to be more abundant or widespread across their range than originally believed. The southeastern U.S. population may include 2,600 individuals (Johnsgard 1990). This raptor was a common sight in Brevard County in the mid-1950s with a small breeding population west of the Indian River (Cruickshank 1980). By the mid-1960s, their numbers had decreased sharply and they became a rare migrant. Breeding in Brevard County is limited to a few birds residing along the St. Johns River valley (Cruickshank 1980) and south Brevard County (Breininger pers. obs.). They are occasionally seen passing through KSC in spring (Breininger, Kehl, and Smith pers. obs.).

#### Swainson's Hawk (Buteo swainsoni)

Swainson's Hawks live on western prairies, in dry woodlands, and in cultivated areas with scattered trees throughout western North America from Alaska to northern Mexico (Johnsgard 1990). In the fall, most of the North American population migrates to the pampas of South America (American Ornithologists Union 1983). A few birds are seen regularly during Christmas Bird Counts in west central U.S. and south Florida (Root 1988). These wintering Florida birds are almost exclusively associated with agricultural fields (Johnsgard 1990). Red-tailed Hawks are often misidentified as Swainson's Hawks (Bent 1937). Until the mid-1930s, flocks of more than 2,000 birds

were common, but their population began to decline and they were placed on the American Birds Blue List in 1972 and upgraded to a Blue List Species of Special Concern in 1986. There may be nearly 400,000 Swainson's Hawks in North America (Johnsgard 1990). Swainson's Hawks are rare visitors to KSC; all reported observations have been in the fall (Cruickshank 1980). KSC is of no consequence for maintenance of Swainson's Hawk populations. Given its infrequent occurrence, it was not considered relevant as a top predator on KSC.

#### Yellow-crowned Night-Heron (Nyctanassa violacea)

This wading bird is less gregarious and more diurnal than the Black-crowned Night-Heron (Kushlan 1976). It nests throughout the eastern U.S. and Canada and from Baja to South America. Florida supports a large wintering population (Root 1988). It occupies typical habitats such as salt marshes, mangroves, hardwood and cypress swamps, and mud flats, but also will live in urban and suburban pine, oak, and Australian pine situations (Meyerriecks 1980). The Yellow-crowned Night-Heron eats crustaceans (especially crabs and crayfish), insects, and fish. They often nest in single-species colonies. Yellow-crowned Night-herons were a common Brevard County resident until drainage of wetlands in the 1950s greatly reduced local populations (Cruickshank 1980). They have been observed on KSC during all seasons of the year, but are not reported to nest here. One individual was seen feeding near an active wading bird colony in 1990, but no nest was sighted (Smith, Breininger, Hall pers. obs.). A juvenile was seen in summer feeding on a fish kill near the VAB (Breininger pers. obs.). The species was much more abundant in areas dominated by mangroves in south Brevard and Indian River County compared to the marshes characteristic of KSC (Trost 1968, Provost undated). As with most wading birds, the loss of wetlands habitat has resulted in significant population declines

(Meyerriecks 1980). Also, the propensity for this species to utilize urban habitats makes them vulnerable to disturbance that negatively influences reproductive success. The protected wetlands of KSC provides feeding habitat for a few Yellow-crowned Night-Herons. It is possible that mangrove islands on KSC could be used for nesting in the future; perhaps nesting has occurred but the event went undetected.

#### Gray Fox (*Urocyon cinereogenteus*)

The species is abundant in many other areas of Florida and not a species of concern on the state level (J. Layne pers. comm.). The Grey Fox is most active at night and during the early morning and late afternoon-evening. They may prefer native habitats over man-altered habitats (Wassmer 1984). Gray Foxes prefer areas with dense cover during the day and more open areas at night (Sunquist 1989). Common foods are small mammals. Reported homerange sizes include 269 ha in south-central Florida (Wassmer 1984) and 550 ha in north-central Florida (Sunquist 1989). Gray Foxes are susceptible to canine parvovirus which may be a significant source of canid mortality in Florida (Wassmer 1984). Distemper was the main cause of adult mortality in Alabama where large populations of Raccoons may be a pool for the disease (Nicholson and Hill 1984). Rabies is another common cause of mortality of Gray Foxes and Raccoons are also pool for this disease (Carey 1982). Epizootic diseases may deplete Fox populations in the eastern U.S. (Carey 1982). Gray Foxes are surprisingly sparse on KSC (Ehrhart 1976). There are few sightings and a few road kills. Although it is not a species that should receive priority over other declining species, the Gray Fox deserves mention because it is a native and could become extinct at the local scale. Occasional road mortality may occur on KSC. The possibility exists that disease once wiped out most Gray Foxes on KSC and the population has

never recovered due to low population size and insufficient linkages to other populations to facilitate recolonization.

#### Wild Turkey (Meleagris gallopavo)

The Wild Turkey is Florida's largest game bird. They range throughout much of the U.S. where ample forest cover is found. Turkeys have been reintroduced in many parts of their former range in the east and midwest where adequate woodlands remain or have recovered. Although acorns are important food items, Wild Turkeys have a diverse diet (Powell 1965). They feed on insects and a variety of seeds including tupelo fruits, and palmetto fruit (Schroeder 1985). They roost in small groups low in trees and nest in grass or low shrubs. During winter, large flocks congregate into unisexual or mixed groups of up to 50 individuals. They occupy a wide variety of habitat types, especially forested habitats, including pine scrub, hardwood swamps, cypress swamps, mesic hammocks, mixed pine and hardwood forests, pine flatwoods, and sandhills (Powell 1965). They breed from February to June. Young are closely tended for about 4 weeks and are then coalesced into family groups. Low saw palmetto and wiregrass and a few myrtle oaks have also been successfully used for nesting (Williams et al. 1971). The breeding potential of the Wild Turkey is often believed to be low with respect to egg laying but this is based on scant data; in some areas ten eggs will be laid in a year and many Turkeys will renest if the first clutch fails (Williams et al. 1976). Wild hogs may destroy Wild Turkey nests (Powell 1965). Wild Turkey populations in Florida have been subject to severe habitat loss, high hunting pressure and diseases spread by domestic poultry (Powell 1965). Small releases have resulted in great success in reestablishing populations in some areas (Williams et al. 1976). The species is vulnerable to local extinction and a population decline is probable over much of Florida due to its wide-ranging (area-dependent) habits, its

dependence on unpredictable and patchy resources, hunting, and ground nesting habitats (Noss and Labisky in press).

Mainland Brevard County had a large (750-999 animals) Wild Turkey population in 1948; however, the population on KSC was low to nonexistent (Powell 1965). Mainland Brevard County had a much lower (50-99 animals) estimated population by 1961 and no Turkeys were believed to occur on KSC at that time (Powell 1965). By 1960, Cruickshank (1980) reported the Wild Turkey to be rare in Brevard County, found mostly in some wooded areas bordering St. Johns River marshes and he expected the bird to be extirpated. Brevard County was not included in the release of Wild Turkeys that was part of the FGFWFC restoration program (Powell 1965). Wild Turkeys were reported from the western edge of Brevard County during the period of 1973-1977 (Williams 1978b, Williams and Austin 1988). Reasons for the apparent absence of Wild Turkeys from KSC are unclear. Diseases devastated a Wild Turkey population in Volusia County (Powell 1965). Recolonization of an extirpated Wild Turkey population on KSC would have been unlikely due to the isolation. Wild Turkeys were introduced at KSC on a number of occasions by MINWR: 1981 - Six hens and three gobblers released during January and February; there were sightings through August and then no more were seen; 1982 - Seven hens and two gobblers released in February; 1983 - Six hens released; 1984 - One gobbler released. The fate of these individuals is unknown. After releases, there were occasional sightings which dwindled until no more were reported. Low population size alone could account for their disappearance. Predators, poaching, or disease could easily have wiped out a few individuals before they had a chance to reproduce. An individual was recently seen north of Haulover (Schaub and Larson, pers. obs.). During the restocking period, Wild Hogs were abundant which could have decreased chances of successful reintroduction. Based on general habitat needs, it appears there is some suitable habitat on KSC.



## White-tailed Deer (Odocoileus virginianus)

The species is abundant in many other areas of Florida and not a species of concern on the state level. Although White-tailed Deer should not receive priority over other declining species, it deserves mention since it is a native and could be extirpated at the local scale. White-tailed Deer populations were declining in Florida in the late 1930s until the FGFWFC began an active management program (Logan and Egbert 1981). A key to their good health and reproduction is food. Deer have relatively high metabolic requirements and relatively small rumen volume so that they can not digest fibrous growth rapidly enough to subsist on high-fiber forages (Short 1963). Grasses, forbs, and browse are the most common food items in spring and summer (Short 1975). Leaves are often nutritious throughout spring and summer, but twigs are usually only nutritious when they are growing rapidly (Short et al. 1973, Blair et al. 1977). Preferred plants in Florida include grape (Vitis), green briar (Smilax), bluestem (Andropogon), hypericum (Hypericum), and dogwood (Cornus) although a wide variety of plants are used (Harlow 1961, Wolters and Schmidtling 1975, Blair et al. 1977). Mushrooms are also important food items (Short 1975, Blair et al. 1977). In fall, acorns (Quercus) and saw palmetto berries are important food items (Harlow 1961). Deer spend most of their time hidden during the day in dense cover and come out into open areas at or just before sunset (Montgomery 1963). Automobile accidents with deer are common; deer are killed in 92% of the accidents (Allen and McCullough 1976). Numbers killed along roadsides are correlated with the numbers seen along such roadsides (Bellis and Graves 1971). Deer fences and their distribution relative to wooded edges and roads have significant influences on deer distribution along roadsides and mortality rates (Puglisi 1974).

There are reports that the species was abundant on Merritt Island just prior to its purchase by NASA and that it was hunted nearly to local extinction in order not to

"waste" the game just prior to NASA taking control of the land in the 1960s. Unexpectedly, the species has not recovered on KSC even though a large Deer population exists on CCAFS. The CCAFS population was believed to be so abundant that controls were required by security to destroy animals to reduce vehicle collisions. Based on FGFWFC data, one would expect sufficient habitat to support a population of several thousand deer. Deer are occasionally seen on KSC north of Haulover Canal. It is believed that individuals recolonized this area from the connection to the mainland near Oak Hill. It is not known why White-tailed Deer have not recolonized KSC. The relatively isolated landscape on KSC minimizes the opportunity for Deer to recolonize KSC. Other studies have found that Deer do not rapidly recolonize some areas where they have been extirpated due to the Deer social system and dispersal characteristics. Food plants listed above are common on KSC. Given the abundance of Deer on CCAFS, habitat does not serve as a obvious explanation. The role of disease and genetics has not been studied. Isolation of small populations can reduce the genetic information contained within such populations, particularly where there have been historical population bottlenecks. Higher heterozygosity may influence metabolic efficiency resulting in enhanced nutritional condition (Scribner et al. 1989). It is not known whether the abundance of Feral Hogs has influenced the reoccupation of KSC by the White-tailed Deer. Hogs consume acorns and use habitat types that produce acorns more frequently when acorns are available (Antonelli 1979, Poffenberger 1979). Road mortality could also be a factor in reestablishment of a KSC Deer herd. Although the species is not a primary concern for NASA environmental management, a reintroduction program by other agencies would be justifiable since this species is an element of the native fauna and may have had a role in community structure. This large herbivore can have a significant role in community structure (Frelich and Lorimer 1985) and may have been a keystone species within areas of the U.S. (McShea 1991).

**Mottled Duck (Anas fulvigula)**

The Mottled Duck ranges throughout Florida to coastal Texas and is our only resident Duck (Kale and Maehr 1990). It lives and breeds in a variety of fresh and brackish water wetlands, impoundments, and inland grassy areas near water. Nesting traditionally occurred in marshes and occasionally scrub (Howell 1932). Their diet consists of aquatic and terrestrial vegetation, aquatic and terrestrial invertebrates, fish, grains, seeds, and berries. Nesting occurs in the drier parts of marshes or on suitable spoil islands. As with most species of animals that depend on wetlands, the loss of habitat to development and agriculture since the 1950s threatens their numbers. Nesting Mottled Ducks and their young are susceptible to ground predators, and adults will readily desert the nest if disturbed. They are a choice bird of hunters because of their large size. Studies using X-rays to examine Mottled Ducks have estimated that 13.7% of the Florida population is carrying ingested lead (Johnson et al. 1984).

Studies conducted from 1964-1980 showed a significant population decline in Florida (Johnson et al. 1984), but trend analysis of Christmas Bird Count data did not support these findings. December surveys of Mottled Ducks performed on MINWR report the following numbers (MINWR Annual Narratives):

1981	100
1984	179
1985	402
1986	227
1988	102

In 1982, a "small die off" occurred, but necropsies were inconclusive (MINWR Annual Narratives). Aerial surveys performed monthly from April 1987 through March 1990 in

operational areas of KSC report the following monthly averages for numbers observed (Smith and Breininger unpub. data):

Jan.	19	Jul.	110
Feb.	20	Aug.	98
Mar.	20	Sep.	209
Apr.	9	Oct.	93
May	28	Nov.	103
Jun.	58	Dec.	11

The population increases considerably after nesting due to successful reproduction. A steep occurs in winter perhaps partially due to hunting. The species is essentially nonmigratory (Stieglitz and Wilson 1968), although some movement to the St. Johns River may occur seasonally (D. Cooley, per. comm.).

KSC is an important area for the Mottled Duck; catch rates here are high when compared to other Florida locations (Montalbano 1980). Most nests are initiated in March and April on KSC with a mean clutch size of 9-10 eggs (Stieglitz and Wilson 1968). Most successful nesting occurs on spoil islands; reproductive success appears to be almost zero on dikes due to predation by Raccoons and perhaps Armadillos (Stieglitz and Wilson 1968). Spoil islands are used by Mottled Ducks for little else as broods are reared in impoundments. Impoundments and nearby areas in the estuary are used for feeding. Information is needed to improve management of existing spoil islands in the Banana and Indian Rivers to provide nesting habitat.

#### Northern Right Whale (*Eubalaena glacialis*)

The Northern Right Whale is the world's most endangered large whale and the most endangered marine mammal in U.S. coastal waters. These robust baleen

whales are slow swimmers and do not dive particularly deep. They can be seen along the Florida coast during the winter months through early spring as they follow their winter migration routes. The western North Atlantic population ranges from the Gulf of Mexico and Atlantic coast of Florida to the coasts of Newfoundland, Nova Scotia, and Labrador. Right Whales are frequently seen in the surf zone along KSC beaches from January through March (Provancha pers. obs.). Sightings of adult and calf pairs in the nearshore zone of KSC and CCAFS are often reported incorrectly as strandings or beaching events.

Right Whales feed almost exclusively on copepods and euphausiids. Commercial whaling of this species on a broad scale began in the early 19th century (Leatherwood and Reeves 1983). Because the Right Whale is highly approachable and is buoyant when dead, it was the easiest, and therefore the "right" whale for whalers to kill and retrieve. Current causes of mortality include entanglement in commercial fishing gear and collisions with ships. Normal behavior patterns may be negatively affected in critical habitats by boat traffic (Marine Mammal Commission 1991). The latest estimate of the western Atlantic population is only 350 animals, despite protection from commercial whaling since 1937 and federal listing as endangered in 1970.

#### Sei Whale (Balaenoptera borealis)

The distribution of the Sei Whale is worldwide, but details are poorly understood. Their movements are described as unpredictable and irregular. Sightings of Sei Whales are recorded occasionally in Florida during winter; however, it is difficult to distinguish these whales from Bryde's Whales (B. edeni). In the middle and southern portions of their range, which includes Florida, they feed on krill, squid, and fish (Leatherwood and Reeves 1983). No sightings or strandings have been

confirmed for the coastline of KSC or Brevard County. As with most whales, the decline of Sei Whales is a direct result of human exploitation.

#### Finback Whale (Balaenoptera physalus)

These deep diving baleen whales are distributed worldwide. The western North Atlantic population winters from the ice edge to the Greater Antilles and Gulf of Mexico. They are generally found in pods of three to seven individuals in offshore waters to about the 1800 m curve. To date, no sightings or strandings are reported in the Smithsonian Institute's national database for the KSC area.

Finback Whale populations are severely reduced through most of the range. They became the whaling industry's most valuable baleen whale after the depletion of the Blue Whales (B. musculus). The Finback Whale was listed as an endangered species in 1970; however, conservation has been difficult as whaling of this species continues in the eastern North Atlantic (Leatherwood and Reeves 1983).

#### Sperm Whale (Physeter catodon)

The Sperm Whale is a toothed whale recognized by its huge box-shaped head that makes up about 33% of its body. The snout houses the spermaceti organ which contains the once commercially prized oil. The population has been substantially reduced by whaling activities and was listed as endangered in 1970. The predominant food is squid, but a variety of fish and benthic organisms are also consumed (Leatherwood and Reeves 1983).

The Sperm Whale is an incredibly deep diver (up to 2800 m) and is seldom found in less than 180 m of water, generally putting them approximately 30 miles off KSC. Migration patterns are variable and dependent on age and sex, but the Cape Canaveral region is not an area of concentration. However, the Cape may be

important as a landmark because depth contours are believed to be used by migrating whales. Two strandings in this area are recorded in the Smithsonian Institute's national database, one in 1980 due east of KSC in the vicinity of Universal Camera Site 10, and one in 1983 near New Smyrna Beach.

Dusky Seaside Sparrow (*Ammodramus maritimus nigrescens*)

This sparrow was known to occur only in northern Brevard County. It was common on MINWR and in a St. Johns River marsh east of MINWR until the 1960s when less than 100 remained at both locations (Sykes 1980). The bird was declared endangered in 1966. In 1980, a few remaining birds were captured and moved to Discovery Island at Walt Disney World (Delany 1981) in a final attempt to save the bird from extinction (Kale 1983). After the captive breeding program failed, the bird was declared extinct after a final survey was conducted in 1989 to insure no birds remained in the wild. Marshes occupied by Dusky Seaside Sparrows had extensive growths of *Salicornia*, *Juncus*, *Distichlis*, and *Spartina* and were often adjacent to the estuary or creeks (Baynard 1914; Nicholson 1928, 1929; Trost 1968; Sharp 1968, 1969, 1970, 1976; Baker 1973). Original declines in the population were attributed to impoundment and loss of salt marsh vegetation (loss of 91% of the habitat), drainage of the St. Johns Basin for agriculture, road construction, housing, extensive winter fires, insecticides, and "bureaucratic delays" (Trost 1968; Baker 1973; Sykes 1980; Kale 1983 a,b; Woodward 1980). Later effects included fragmentation due to railroad and highway development and perhaps fire management practices (Sykes 1980).

In February 1989, a paper by Avise and Nelson in *Science* showed that mitochondrial DNA of three Atlantic coast races of Seaside Sparrows were nearly identical. The popular press reported these findings as proof that the extinct Dusky was just another Seaside Sparrow, that efforts to protect the species were a waste of

money, and made other efforts to minimize the loss of the bird (Kale 1989). The view that the Dusky was not a unique ecological entity was not upheld by most of the scientific and conservation community (Kale 1989). A population such as the Dusky Seaside Sparrow that exhibits morphological differences from all other populations and has been geographically isolated from those populations should be considered important for maintaining biological diversity. A variety of criteria determine when entities such as the Dusky Seaside Sparrow are unique with regards to maintenance of biological diversity. Regardless, the Endangered Species Act allows designation and conservation of separate populations. Discussions with biologists who have studied the species (e.g., P. Sykes, H. Kale) result in a perception that the Dusky Seaside Sparrow was clearly distinct from other populations. The "Hybrid Policy" once considered by Solicitor's Office of the Department of the Interior (the counsel of USFWS) continued the controversy (O'Brien and Mayr 1991). The opinions of that office were that protection of hybrids would not serve to recover listed species and would likely jeopardize the species' existence. This could have revoked the status of several listed species if strict interpretation of this policy was maintained. However, ecologists argued that natural populations of subspecies interbreed and acquisition of new genes can be beneficial when congenital problems result from inbreeding of a small remnant populations (O'Brien and Mayr 1991).

#### Florida Panther (*Felis concolor coryi*)

The Florida Panther is a subspecies of Cougar adapted to the subtropical environment of Florida. Various characteristics that distinguish it from other subspecies include a kink in the tail, a whorl of hair or "cowlick" in the middle back, relatively dark color, short and stiff hair, longer legs, and smaller feet. The existing population includes individuals with genetic information characteristic of a race that



occurs in Central and South America and are products of captive animals released in the past (O'Brien et al. 1990). Since subspecies can and do interbreed in the wild, protection of the Florida Panther continues since it clearly qualifies as a distinct subspecies (O'Brien and Mayr 1991). The Florida Panther was listed as an endangered species in 1967 after almost two centuries of intense hunting and habitat loss caused its extirpation from most of its range. The Panther's historic range extended from eastern Texas or western Louisiana through the southeastern states to parts of Tennessee and South Carolina (Goldman 1946). The Florida Panther currently occupies a few areas of southern Florida, namely Big Cypress National Preserve, Fakahatchee Strand, and the Everglades National Park. The number of Panthers is estimated to be less than 30 animals (Williams 1978c). This is not necessarily enough for a sustainable population, and the Florida Panther is teetering on the brink of extinction.

Habitat requirements for the Panther are very broad and they have been found in all terrestrial forest types in Florida (Williams 1978c). There appears to be a preference for hammocks and mixed swamps (Belden et al. 1988). Major food sources include White-tailed Deer, Wild Hogs (*Sus scrofa*), Raccoons, and Nine-banded Armadillos (Maehr et al. 1990). Mean homerange size estimates are 435 km<sup>2</sup> for males and 202 km<sup>2</sup> for females (Belden et al. 1988). The loss of habitat associated with the growing human population in Florida is the major limiting factor for Panthers (Belden et al. 1988). As habitats are developed and fragmented, there is less area available to sustain Panther populations, and inbreeding and the loss of genetic diversity result. At the current time, there is not a minimum viable population of Florida Panthers; the estimated number needed in the wild is 300 (Belden, pers. comm.). In order to obtain this goal and prevent the extinction of the Panther, a captive breeding program must successfully produce enough young, reintroduce them into suitable habitat, and properly manage the species and its habitat. There are very few wild

areas left that are of sufficient size to accommodate such a wide-ranging animal, so corridors between habitat patches will be necessary for its survival.

The Florida Panther once occurred on KSC, although it does not occur here now. Many Panther sitings have been reported for this area, but none have been confirmed. Evidence such as a photograph, plaster cast of tracks, a Panther kill, a scat, or a siting by a qualified observer has not occurred. In the early 1980s, MINWR conducted surveys to find Panthers on the refuge. Fields along SR 402, where the majority of supposed Panther sitings had been made, were plowed to expose soft dirt. No signs of Panthers were found during this survey, and Panther reports are generally thought to be Bobcats or Jaguarundis, both of which are known to occur on the refuge (D. Cooley MINWR, pers. comm.). The number of reported sitings in Brevard County as of June 1990 was 181 (Belden and Frankenberger 1990). Of these 181, only 3 were made by qualified observers, and none had any evidence to support the claims. The nearest confirmed siting was in Volusia County at Farnton Wildlife Management Area which extends into the northernmost part of Brevard County. One Panther skeleton was found at this location, as well as two scats, lending evidence that three Panthers had been present in the area. They are believed to have been transients traveling northward by using various patches of habitat as corridors (Belden, pers. comm.). Periodic Florida Panther studies are conducted along peripheral areas of their remaining range (Roof and Maehr 1988). Panther surveys have also been conducted by the FGFWFC along the St. Johns River (Belden and Frankenberger 1990). Dogs were used and the river area was combed, but no Panther signs were discovered. Problems with sitings outside the current range also include releases or escaped captive animals representing other subspecies. KSC is unlikely to ever again be inhabited by a population of Florida Panthers.

## Red-Cockaded Woodpecker (Picoides borealis)

The Red-Cockaded Woodpecker ranged through most of the southeast, from southeastern Virginia, eastern Texas, through Kentucky, Tennessee, South Carolina, Georgia and Florida. In 1970, the Red-cockaded Woodpecker was listed as endangered by the USFWS due to its continuing decline throughout most of its range. The U.S. population has been estimated to be 1,500-3,500 clans or 4,500-10,500 birds (Lennartz 1985). The Red-cockaded Woodpecker lives in clans of 2-9 birds where there is one breeding pair and often several helpers that help rear young. This cooperative breeder differs from the Florida Scrub Jay in that female helpers are rare. Young females typically disperse before the beginning of the next nesting season. Each bird in a clan requires its own roost cavity, and these take a minimum of 10 months to construct; suitable cavities are an essential limiting resource (Copeyon 1990). The clan nests and roosts in its own colony that includes a group of 1-30 cavity trees (Jackson 1977) and is used by only one clan. Most cavity trees are clumped within a 500 m diameter area (Harlow et al. 1983). The clan feeds as a unit and is sedentary (Lennartz and Harlow 1979, Hooper and Lennartz 1983). Clutch size is typically 2-4 eggs with a mean number of fledglings of 1.8 young per nest per year (Lennartz et al. 1983). Average clan size before the nesting season is typically 2-4 birds; average clan size after fledgling is typically 4-6 birds (Lennartz et al. 1983).

The Red-cockaded Woodpecker usually selects large, living pine trees that are infested with the heart rot fungus for the excavation of their nest cavities (Jackson 1977). The trees utilized by these birds are usually from old growth forests and have DBH's (diameter at breast height) in the excess of 50 cm. The species may prefer longleaf pines (Pinus palustris) and the largest populations occur in areas dominated by longleaf pine (Lennartz et al. 1983). Other types of pine stands are suitable or marginal. Suitable age for a cavity tree is >95 years for longleaf pine and

perhaps somewhat younger for some other species such as slash pine (Lennartz 1985, Hooper 1988, Hooper et al. 1988). Most descriptions of preferred habitat are an open pine stands with little understory growth (Hovis and Labisky 1985) or at least no dense stocking of hardwoods in the midstory (Lennartz 1985). Such habitat preferences may be related to avoiding competition with Pileated Woodpeckers and Red-bellied Woodpeckers (Melanerpes carolinus) which enlarge cavities and displace residents (Lennartz 1985). An open midstory and understory of mostly grass requires fire to occur approximately every 3-5 years. Red-cockaded Woodpeckers occur where there is a shrub layer, but it is not completely clear what levels of understory and midstory allow population persistence (Hovis and Labisky 1985). The 3-5 year fire frequency may refer to habitat types that are characteristic of plant communities inhabited by Red-cockaded Woodpeckers and not requirements of Red-cockaded Woodpeckers themselves.

Red-Cockaded Woodpecker declined due to lumbering and urbanization. Forest management practices designed to maximize forest product yield have resulted in a decline in suitable habitat. These practices include clearcutting rather than selective cutting, cutting trees at 20 years of age for pulp and 40-60 years for wood, and the replacement of longleaf pine with faster growing species less desirable to the birds (Jackson 1986). Pine plantations do not have the diversity in bird populations characteristic of natural Florida pinelands (Repenning and Labisky 1985, Hirth et al. 1991). The recent large hurricane that struck South Carolina was a catastrophe for the species because many of the pines of its habitat were blown down (Hooper et al. 1990).

There is considerable variation in homerange estimates perhaps because few studies have addressed how much of the habitat present is suitable for foraging in relation to the total amount needed to support a clan (Lennartz 1985). Studies have suggested homerange sizes in Florida of 70 and 145 ha (Nesbitt et al. 1978). This

species uses mostly old, living pines for foraging (Lignon 1970, Morse 1972, Lennartz 1985). Thus, the amount of habitat needed may relate to the proportion that is old growth and the amount of habitat that does not favor Pileated Woodpeckers and/or Red-bellied Woodpeckers. Much controversy has surrounded the issue of minimum viable population sizes; many recommended MVP's do not provide the probabilities to extinction and time to extinction. The estimates provided should emphasize preservation of large remaining tracts needed to have a high degree of confidence for persistence. This is most important to maintain the species but may mislead some into thinking smaller populations are of less importance. Some recommendations have resulted in tracts being larger than what is available today. Recommended reserve sizes have included 25,450 ha (Reed et al. 1988).

The Red-cockaded Woodpecker was fairly common in Brevard County until 1957 but has since become rare (Cruickshank 1980). Only four small colonies in Volusia County (Kale 1988). At least two families occur along Wickam Road in Melbourne and four in south Brevard (Breininger pers. obs.). These families occasionally produce young (L. Smith pers. comm.; Swain and Breininger pers. obs.). More probably occur, especially in southern Brevard, but few surveys have been conducted. One of the significant colonies nearby is in Ocala; it only has 40 colonies. Little is known concerning the Woodpecker's former status on KSC. This species has been reported as a breeding bird on Merritt Island (Jackson 1971). The last siting on KSC was in 1976 (Dwight Cooley per. comm.). Presumably, a corridor of suitable habitat once extended to the Florida mainland at Oak Hill. Although pines are common along this corridor today, it does not have suitable characteristics to be inhabited by a population (because the area is overgrown) and there is no population known within a 30 km maximum dispersal distance (Lennartz 1985) to provide recruitments. Furthermore, given the cooperative breeding system, quick recoveries from decreases in population size are unlikely (Reed et al. 1988). Logging, before

NASA acquisition, may have nearly eliminated the population on KSC and small population size may have then been responsible for its extirpation. Habitat fragmentation and degradation, which occurred in pinelands connecting KSC to the mainland, would prevent recolonization (Conner and Rudolf 1991). Other factors may also have limited the recovery of a KSC population following logging. Fire suppression was practiced on KSC from the 1960s to 1978 and fires are needed to maintain open pine stands. Slash pine dominates pinelands on KSC and few longleaf pines occur. Longleaf pine was apparently not abundant on KSC in the recent past, although it does occur in Brevard County. Red-bellied Woodpeckers are common residents in pine flatwoods on KSC (Breininger and Smith 1992) and in forests interspersed among this habitat (Breininger 1990). Few large pines occur on KSC due to past logging, and there are not enough large pines present to sustain a viable population of Red-cockaded Woodpeckers.

A small population on KSC might have some useful purpose for conservation in the next century, particularly since the species was a former native. Relocation of this species appears possible, although it is not a favorable mitigation for colony destruction (Jackson et al. 1983). There are at least 3,500 ha of slash pine on KSC that in 50 years may be sufficiently old to support clans of Red-cockaded Woodpeckers. If 50 ha is needed per clan, this suggests KSC could support a maximum of 70 clans, which is far from what is considered a suitable MVP. Although 70 clans may not be a goal in a species recovery plan or a reason to consider KSC as significant for maintaining the species, it may still represent a population with good chances of persisting. Because this species was once a native on KSC and MVPs are only crude estimates, establishing a population on KSC in the next century should not be ruled out. The right to plant and harvest pine was granted to the USFWS for lands not used by the space program and a forestry program was encouraged. Extensive

logging, however, could ruin the possibility for future establishment of a Red-cockaded Woodpecker population.

#### Florida Black Bear (*Ursus americanus floridanus*)

The Black Bear is Florida's largest land mammal, yet it is rarely observed in the wild. They were once widespread throughout Florida, except for some islands, until the 19th century (Williams 1978d). Although the Florida Black Bear is a large carnivore its reputation as a vicious predator is not deserved. Black Bears are omnivorous with a diet that includes berries, nuts, tubers, insects, larvae, small mammals, eggs, honey, and carrion. Bear habitat in Florida has been described as a mixture of flatwoods, swamps, scrub oak ridges, bayheads and hammocks (Harlow 1961). Oak and palmetto mast are important food items for Black Bears (Harlow 1961, Maehr and Brady 1984). A reliable estimate of size of the Florida Black Bear population is not easily attained; statewide there may be fewer than 500 individuals (Brady and Maehr 1985). The two largest remaining populations are in the Osceola and Apalachicola National Forests (Williams 1978). They are being considered for listing at the federal level and were listed as threatened by the State of Florida in 1976. Black Bears are extremely vulnerable to a population decline, and local extinctions are predicted (Noss and Labisky in press). Factors influencing this vulnerability include low local population density, their need for large areas of a patchy habitat type (e.g. 6,000 ha [Harris and Gallagher 1989]), low reproductive rate, and exploitation/persecution by humans. They are wide-ranging and one Bear was known to move 140 km in one month (Maehr et al. 1988). Until recently, hunting of Black Bears is still legal and popular, but they were more prized as trophies than for their meat. Black Bears are reported to kill small livestock and damage apiaries and fruit trees; however, efficient methods to protect property from Black Bears without harming

them are available. Even without hunting, the Florida Black Bear is threatened due to habitat fragmentation and road mortality (Brady and Maehr 1985, Harris and Gallagher 1989). They may restrict their movements to avoid areas with high road density and traffic (Brody and Pelton 1989). Road mortality of Black Bear in Florida has increased dramatically each year (data from Wooding and Brady [1986] presented in Harris and Gallagher [1989]). Thus large patches of uninterrupted habitat are needed and only land with low levels of human habitation are suitable as corridors (Maehr et al. 1988).

East coast scrub lands were centers of abundance for the Black Bear (Howell 1929). The Florida Black Bear inhabited the area which is now KSC, but the last reported sighting was in 1954 near Haulover Canal (Salata 1979). Attempts by the USFWS to reintroduce a couple individual Black Bears onto MINWR have been unsuccessful. In September 1978, a male Bear accused of raiding bee hives was relocated from private land near Apalachicola and released on the refuge. It was radiotracked and stayed within one mile of the release site. After two weeks, the animal lost its collar. During April through July 1979, several sightings and raids on apiaries indicated that the Bear was residing in the Happy Creek area (MINWR Annual Narratives). There has been no further sign of this bear since that time. In November 1981, a young female Bear was found nearly dead near Daytona Beach in Volusia County. After several months of treatment and rehabilitation at the Ocala National Forest, she was released on MINWR where the male Bear had been released three years earlier. This animal was not radiotagged and there were no reported sightings after her release (MINWR Annual Narratives). A Black Bear was sighted north on north Merritt Island in 1992. Numerous problems are associated with reestablishing the Black Bear on KSC. Reestablishment has been resisted by apiary operators. The amount of suitable habitat appears insufficient to establish a viable population without intensive population management.



## Red Wolf (Canis rufus floridanus)

The extinct Florida Red Wolf was one of three subspecies of Red Wolf that occupied the southeastern and southcentral U.S. (Layne 1978d in pinelands, forests, marshes, and swamps. Historical literature describes that large predators (Florida Wolf, Florida Panther, and Florida Black Bear) were once abundant on east coast barrier islands (Motte 1837, Howell 1932, Allen 1971). The taxonomic status of the Red Wolf is disputed by some who regard it as a subspecies of Gray Wolf (C. lupus) or a hybrid between the Gray Wolf and Coyote (C. latrans) (O'Brien and Mayr 1991). Regardless of taxonomic disputes, conservation of this animal is still considered a significant goal (Peek et al. 1991). The Red Wolf was largely eliminated across most of its range by heavy hunting, trapping, poisoning, habitat destruction and alteration.

Red Wolf recovery currently includes a captive breeding program with releases that have already occurred and more that are planned (Peek et al. 1991). As of October 1990, there were only 130 Red Wolves (USFWS Endangered Species Technical Bulletin Volume 15, No. 11). It is believed that stock from remnant populations would adapt to Florida environments and that restocking should be a long-term recovery objective (Layne 1978c, Robson 1992). Currently, KSC is not a large area and currently a prime location for release given the limited number of individuals available. However, releasing the species on KSC in the future should be considered (J. Layne, pers. comm.). Red Wolves occupy a variety of habitats including pinelands, hardwood swamps, and coastal marshes (Robson 1992) making habitat on KSC suitable. Studies involving reintroductions have shown evidence that Red Wolves are effective regulators of Raccoons. Thus, their eventual reestablishment could be justified based on their role in faunal integrity even if they require population supplementation if surplus individuals can be made available from other reserves.

## Florida Scrub Lizard (Sceloporus woodii)

The Scrub Lizard is endemic to Florida and is discontinuously distributed in scattered sand pine and oak scrub from Marion and Putnam Counties to Highland County (Jackson 1973, Ashton and Ashton 1982). Populations occur from Brevard to Dade County on the east coast and Lee to Collier County on the Gulf Coast. They eat mainly insects and are ground foragers, which explains their light color when compared to similar lizard species which forage in plants and are darker in color. The Scrub Lizard is dependent on fire-maintained communities with a preference for younger successional stages of scrub (Campbell and Christman 1982). Although sufficiently large tracts of scrub exist in Florida, many areas are devoid of this species. The populations are scattered and in danger of local extinctions, loss of genetic variability and other "island" effects. Much of the scrub present today was once connected and later fragmented into ridges and other islands by global climatic events and sea level changes (Laessle 1958, Delcourt and Delcourt 1981). The disjunct nature of Florida Scrub Lizard distribution may be due to these historical events and the fact that dispersal is impeded by the lizard's habitat requirement for areas to be largely free of herbaceous vegetation (Jackson 1983). Scrub locations in Florida are highly vulnerable to development and fire suppression (Fogarty 1978c).

Although much scrub occurs on KSC, researchers working on the refuge have never seen a Florida Scrub Lizard during thousands of field hours working in suitable habitat. It is unlikely that the lizard would go unnoticed if it did occur here. Jackson (1973) did not find this lizard on KSC, although he did find it just west of KSC on the mainland. It is common in some adjacent mainland areas (Breininger pers. obs.). Most (perhaps 85%) scrub and pine flatwoods on KSC have a significant herbaceous understory (Schmalzer and Hinkle 1987, Breininger et al. 1988). The combination of

herbaceous understory within most potential habitat and the almost isolated nature of KSC may explain the absence of this lizard.

#### Florida Crowned Snake (Tantilla relictæ neilli)

The Florida Crowned Snake has a distribution primarily north of KSC which may be within the southern boundary of its range along the east coast of Florida (Ashton and Ashton 1981). Tantilla relictæ typically occupies sandhill and scrub habitat and rarely mesic habitats within central Florida (Campbell and Christman 1982, Smith 1982, Ashton and Ashton 1981). The lack of a light collar behind the head distinguishes (Tantilla r. neilli) from other subspecies. This xeric adapted species requires loose sand and is commonly found just below the soil surface (Campbell and Christman 1982). These "sand-swimmers" have a specialized diet primarily of terebrinoid beetle larvae, although they also eat centipedes, snails (Smith 1982), and other insect larvae (e.g., termites). Very little is known about Tantilla relictæ because of its fossorial (burrowing) nature. They prefer younger successional phases of scrub, especially disturbed areas (Campbell and Christman 1982). The Florida Crowned Snake is ranked as moderately vulnerable (Noss and Labisky in press) with a population decline possible. They are fairly tolerant of some impacts, but are susceptible to ground predators and disturbance. This species was not found on KSC by Ehrhart (1976) and has never been captured here in bucket traps used during Gopher Tortoise studies. Specialized surveys are necessary to determine the status of this species on KSC.

#### Coastal Dunes Crowned Snake (Tantilla relictæ pamlica)

Very little is known about this small (12-19 cm) secretive snake that inhabits isolated coastal dunes and scrub areas on the east coast of Florida from Cape

Canaveral to Palm Beach County (Ashton and Ashton 1981). They burrow into the soft sand, eating centipedes and insect larvae that live underground. This subspecies differs from other subspecies in its habitat requirements, a definite light band on its neck, and a more pointed snout. Widespread development of the Florida east coast is the biggest threat to this snake. The expanse of unspoiled dunes protected by KSC and CCAFS may be important for maintaining the Coastal Dunes Crowned Snake, if it occurs here. This species was not found on KSC by Ehrhart (1976), and was not captured in bucket traps during Gopher Tortoise studies conducted in scrub and slash pine interior to the coastal strand. The limited distribution, low abundance, and habitat specificity of this snake indicate that it should be considered as an endangered or threatened species (McCoy and Mushinsky 1990). Specialized surveys are needed to determine the status of this species on KSC.

#### Southeastern Big-eared Bat (Plecotus rafinesquii)

Also known as the Eastern Lump-nosed Bat, this species is medium-sized with very large ears (2.5 cm) and two lumps on the snout. Its color is gray above and white below. This bat ranges over much of the southeast but in Florida, it is mainly found north of Highlands County and is believed to be completely absent from south Florida (Brown 1978a). This Bat is not abundant in any known location in Florida but appears to be sparingly scattered throughout the northern half of the state (Brown 1978a). The Southeastern Big-eared Bat is one of the most secretive and least known Bat species, making population and distribution estimates difficult (Brown 1978a). This Bat uses heavily forested areas. It feeds well after dark, much later than the more commonly seen "twilight" Bats. It is a strict insect-forager and may actually land on plants to catch soft-bodied insects (Brown 1978a). It roosts in dilapidated buildings, shacks, and old cabins located in pine and hardwood forests or in hollow trees, crevices and behind

loose bark. This is one of the few Bats to readily roost in semi-lighted situations and will often hang clearly visible from rafters or roof peaks in dimly-lit cabins (Brown 1978a). Their tolerance to humans ends here, however, because this Bat is easily disturbed and will awaken quickly. When aroused, the Bat flies immediately (most other Bats remain docile for a period of time after waking) making the Southeastern Big-eared bat difficult to capture and easily stressed by human harassment. The Bat is moderately vulnerable to local extinctions, and a population decline is probable due to its rarity, low local population density, low fecundity and persecution due to cultural bias (i.e., people don't like bats). Pesticides are extremely detrimental to Bats and have been a cause of decline in bats (Clark et al. 1982).

The occurrence of the Southeastern Big-eared Bat on KSC is unknown. Central Florida is the approximate southern limit of the species range. The species was not reported during Cross Florida Barge Canal surveys and most or all records of the species in Florida are north of Brevard County (FGFWFC 1976). Surveys done by Ehrhart in 1975 found only two Bats flying around a utility light near Pad 39B. The Bats were not identified. The surveys done by Ehrhart were performed at dusk; therefore, it is unlikely that the two bats seen were Southeastern Big-eared Bats. Because of the lack of surveys specifically for bats, it is not possible to know whether or not the Southeastern Big-eared Bat uses KSC. There seems to be ample habitat and food sources and therefore it is likely that a number of Bat species reside on Merritt Island. Protecting the Southeastern Big-eared Bat on KSC would include allowing old buildings and structures in forested areas to remain standing and decrease the use of pesticides which deplete and poison food sources. A survey is needed to determine the occurrence and seasonal distribution of bats on KSC.

## Indiana Bat (Myotis sodalis)

The Indiana Bat (also known as the Indiana Myotis) is a medium-sized, sepia-colored bat whose range is mainly north of Florida. It is known in Florida by only two records during winter from Mariana, Florida in the Panhandle. It is unknown, but doubtful, if they occur in Florida during other months and very unlikely that they occur at any time of the year on KSC. Being a hibernating species, the Indiana Bat uses caves with specific temperature and humidity characteristics to survive through the winter. The Indiana Bat prefers caves with temperatures ranging from -3.0 to 17.0 degrees Celsius. Most Florida cave temperatures are much higher than this in winter except for the Old Indian Cave in Mariana, Florida where the Indiana Bat has been found. The Indiana Bat is listed as endangered by FCREPA due to its small distribution and vulnerability to human disturbance. The greatest threat is its specific habitat requirements and the ease in which these requirements are modified to an unacceptable level by humans. It is estimated that 87-97% of the total Indiana Bat population occupies only 7 caves during winter throughout the U.S. (Humphrey and Scudder 1978). This makes the entire population extremely vulnerable to disturbance, harassment, vandalism, and cave commercialization. Between 1965 and 1978, 60,000 Indiana Bats were lost in one cave due to excessive disturbances and 80,000 were lost in three caves after new structures were built at their entrances which changed airflow and warmed the caves' temperatures (Humphrey and Scudder 1978). Vandalism is also common, and there are two instances on record in which a few people killed thousands of Indiana Bats in a matter of minutes. Because of these and other factors, the Indiana Bat has suffered a severe decline from approximately 640,000 in 1960 to 460,000 in 1975, which represents a 28% reduction in the population (Humphrey and Scudder 1978). There is no estimate of the population for 1980 to 1990, but it is reasonable to assume, because human disturbance has not

ceased, that the population has not increased and has most likely decreased even more.

**Big Brown Bat (Eptescius fuscus fuscus)**

The population size and status of this species in Florida is undetermined; extermination of roost sites and exposure to pesticides are its greatest threat (Gore 1992). This Bat is widely distributed and regarded as common over much of the U.S. This is one of the larger bats in Florida; it feeds primarily insects captured over mostly open areas. A wide variety of roost sites are used including houses and other buildings. This Bat has never been reported on KSC but it may occur here based on its potential distribution (Gore 1992).

**Northern Yellow Bat (Lasiurus intermedius floridanus)**

The population size and status of this Bat in Florida is undetermined; habitat loss is its greatest current threat since the collapse of the Spanish moss (Tillandsia usneoides) industry (Kern 1992). The subspecies is distributed along the coastal plain of the southeastern U.S. This is one of the larger bats in Florida. The species is strongly associated with the epiphytic bromeliad, Spanish moss and is often found with sandhills and live oak hammocks. They also forage primarily over open areas such as fields and marshes (Jennings 1958). This Bat has never been reported on KSC but it may occur here based on its potential distribution (Kern 1992).

**Brazilian Free-tailed Bat (Tadarida brasiliensis cynocephala)**

The population size and status of this species in Florida is undetermined; colony destruction of roosts and exposure to pesticides and heavy metals are its greatest threat (Belwood 1992). The subspecies is widely distributed over much of the

southeastern U.S. This is one of the smaller bats in Florida; it feeds primarily insects. These Bats occur in large numbers within roost sites which are typically buildings. This Bat has never been reported on KSC but it may occur here based on its potential distribution (Belwood 1992). (Smith 1982, Ashton and Ashton 1981). The lack of a light collar behind the head distinguishes (Tantilla r. neilli) from other subspecies. This xeric adapted species requires loose sand and is commonly found just below the soil surface (Campbell and Christman 1982). These "sand-swimmers" have a specialized diet primarily of terebrinoid beetle larvae, although they also eat centipedes, snails (Smith 1982), and other insect larvae (e.g., termites). Very little is known about Tantilla relicta because of its fossorial (burrowing) nature. They prefer younger successional phases of scrub, especially disturbed areas (Campbell and Christman 1982). The Florida Crowned Snake is ranked as moderately vulnerable (Noss and Labisky in press) with a population decline possible. They are fairly tolerant of some impacts, but are susceptible to ground predators and disturbance. This species was not found on KSC by Ehrhart (1976) and has never been captured here in bucket traps used during Gopher Tortoise studies. Specialized surveys are necessary to determine the status of this species on KSC.



## APPENDIX B. Concerns for Wildlife Species Not Listed as Endangered or Potentially Endangered

Herpetological amphibian and reptile studies have not recently been conducted on KSC, except for studies on a few potentially endangered species such as Indigo Snakes, Gopher Tortoises, Atlantic Green Turtles, Atlantic Loggerhead Turtles, and East Coast Diamondback Terrapins. Some basic surveys were conducted in the 1970s by Seigel (1977, unpublished data) who is planning to reinitiate surveys. Others (e.g., R. Schaub, R. Seigel, R. Smith, and M. J. Barkazill) are initiating further studies. Other than those already listed for KSC as endangered or potentially endangered based on literature reviews, few species appear restricted to one habitat type (Breininger 1985, Breininger, Smith, and Seigel in preparation). This is expected since many amphibians and reptiles are less associated with habitat nomenclature than habitat features (Campbell and Christman 1982). This does not preclude extreme habitat specificity but it recognizes a poor data base for many species. Ephemeral marshes are well recognized as essential breeding ponds for many species (Moler and Franz 1987), yet these comprise several habitat types if dominant vegetation is used for classification. For example, Spartina bakerii is a dominant ephemeral, isolated, and fresh water wetland but it is also a dominant brackish salt marsh connected to permanent waters. Fortunately, the ephemeral marshes are abundant on KSC. Habitat fragmentation, excessive predation by hogs or mesopredators, and road mortality, may be the biggest threat to the herpetofaunal community. No amphibians that occur on KSC are listed as endangered or potentially endangered except for the Gopher Frog (Table 2). Most amphibians that occur on KSC are common except for the Barking Treefrog (Hyla gratiosa), Eastern Narrow-mouthed Toad (Gastrophryne carolinensis), Greater Siren (Siren lacertina), and Lesser Siren (Siren intermedia). Many reptiles were previously described as rare (Ehrhart

1976) or are now rarely (if ever) seen by the authors. These include the Florida Scarlet Snake (Cemophora coccinea), Eastern Hognose Snake (Heterodox platyrhinos), Pine Woods Snake (Rhadinaea flavilata), Striped Crayfish Snake (Regina alleni), Florida Brown Snake (Storeria dekayi), and Florida Pine Snake. Several of these are nocturnal, fossorial, or otherwise require specialized techniques to observe them. Some, such as the Striped Crayfish Snake, would probably be found to be abundant if specialized methods were used to determine their presence (R. Seigel pers. comm.). These rare herpetofauna need further investigation.

A number of birds are not listed as endangered and potentially endangered (Table 2) on KSC but are vulnerable within the southeastern U.S. (Hunter 1990). These species and other habitat considerations specific to migratory birds are discussed below. Waterbirds comprise the largest group of birds that winter or pass through KSC during migration (Cruickshank 1980). The Black Tern (Chlidonias niger) is the only waterbird not listed as endangered or potentially endangered on KSC (Table 2) but is listed as regionally vulnerable (Hunter 1990). This species is occasional offshore and along the coast during migration in late summer. Nearly 29 species of ducks winter on KSC; management for winter waterfowl is a primary wildlife enhancement objective within impoundments. Nearly 53 species of shorebirds use KSC; only about 1/5 of these are listed as endangered or potentially endangered (Table 2). Many shorebirds use northern staging areas such as the Bay of Fundy to build stores of fat needed for nonstop flights across the Atlantic Ocean to Central and South American wintering areas during fall migration (Hicklin 1987). Perhaps most shorebirds have insufficient energy reserves during spring migration and must fly along the Atlantic or Mississippi flyways (McNeil and Burton 1976). Little information is published concerning the significance and habitat use of migrating shorebirds on KSC. Shorebirds (especially Charadrii sandpipers) are candidates for declines due to

loss of suitable breeding habitat, wintering habitat, and habitat for staging along migration routes (Howe et al. 1989, Goss-Custard and Durrell 1991). Dramatic decline of prey abundance, associated with foraging shorebirds in migration areas, suggests that management of the size and accessibility of prey is needed (see reviews in Burger and Olla 1984, Evans et al. 1984).

Thirty-two species of warblers occur on KSC but only a few are breeders and none are abundant breeders. Nearly 18 warblers winter on KSC and 14 pass through during migration (Cruickshank 1980). Only a few warblers are abundant in winter on KSC; the peak wintering areas for most warblers is elsewhere (Root 1990). The Yellow-rumped Warbler is one of the most abundant wintering species using habitats with shrubs or trees (Breininger and Schmalzer 1990, Breininger 1990, Breininger and Smith 1992). Unlike most wintering warblers, which are obligate insectivores, the Yellow-rumped Warbler is successful in Florida because it is linked to winter frugivory, especially wax myrtle berries (Morse 1989). The Common Yellowthroat is an abundant wintering species common in all habitats dominated by shrubs or tall emergent vegetation; a few individuals may nest on KSC (Breininger and Schmalzer 1990, Breininger 1992). The Palm Warbler is an abundant wintering species in many habitats. Pine Warblers (Dendroica pinus) are abundant in winter within pinelands and a few may nest on KSC.

Most of the eastern U.S. is comprised of deciduous forest. However, deciduous forest only occurs in swamps on KSC and is a small amount of the available habitat (Provancha et al. 1987). Species characteristic of the eastern deciduous forest, declining in the southeastern region (Hunter 1990), that migrate through KSC include the Ovenbird (Seiurus aurocapillus), Wood Thrush (Hylocichla mustelina), Cerulean Warbler (D. cerulea), and Kentucky Warbler. Species characteristic of deciduous

shrubby areas that are declining in the southeast (Hunter 1990) include the Northern Prairie Warbler (*D. d. discolor*) and Golden-winged Warbler (*Vermivora chrysoptera*). Other migrating warblers, listed as declining in Florida, include the Louisiana Waterthrush, American Redstart, and Yellow breasted Chat (Table 2). The Northern Prairie Warbler is abundant in many shrubby habitats during migration and is present in low numbers in winter; the American Redstart is very abundant during migration in wooded and forested areas (Breininger unpublished data).

Approximately 15 species of sparrows winter on KSC (Cruickshank 1980). All or most use a variety of habitats with an abundance of herbaceous plants which are abundant in disturbed areas. The Song Sparrow (*M. melodia*), Swamp Sparrow (*Melospiza georgiana*), and Savannah Sparrow (*Passerculus sandwichensis*) are most abundant. Sparrows on KSC listed by Hunter (1990) are the Field sparrow, Grasshopper Sparrow (*Ammodramus savannarum pratensis*) and Henslow's Sparrow (*Ammodramus henslowii*). Henslow's Sparrow is either rare or very secretive on KSC and is associated with grassy habitats including grassy swales in pinelands (Cruickshank 1980). Scrub and pinelands are native habitats used by Swamp Sparrows and Field Sparrows. Salt marshes, particularly those with salt grass, are the native habitat having the greatest abundance of wintering sparrows, especially Savannah Sparrows, Song Sparrows, and Sharp-tailed Sparrows (*A. caudacutus*). The Marsh Wren (*Cistothorus palustris*), Sedge Wren (*Cistothorus platensis*) and occasionally the Short-eared Owl (*Asio flammeus*), which is declining (Hunter 1990), also winter in salt marshes. The Gray Catbird (*Dumettella carolinensis*) is listed as declining by Hunter (1990) and is very abundant during winter in many habitats on KSC. The Sharp-shinned Hawk (*Accipiter striatus velox*) is of regional concern (Hunter 1990) and very abundant during spring and fall migration in many habitats. Miscellaneous birds that winter or migrate through KSC and that are of regional

concern (Hunter 1990) use a variety of shrubby areas, woodlands, or forests; these include the Orchard Oriole (Icterus spurius), Whip-poor-will (Caprimulgus vociferus), Bewick's Wren (Thyromanes bewickii), and Painted Bunting (Passerina ciris).

A few species of regionally declining birds (Hunter 1990) that are not listed as endangered or potentially endangered locally (Table) nest or may nest on KSC. The Common Nighthawk (Chordeilis minor) is abundant during the summer in ruderal areas, old fields, mudflats, disturbed or recently burned scrub and pinelands; this species winters south of KSC. The Yellow-billed Cuckoo (Coccyzus americanus) is a uncommon breeder in forests on KSC (Breininger 1990) that winters south of KSC. Chuck-will's-widow (Caprimulgus carolinensis) is a very abundant breeder in many habitats that mostly winters south of KSC. The Northern Flicker (Colaptes auratus) is a common permanent resident in pinelands, broad-leaved forest, and miscellaneous disturbed habitats (Breininger and Schmalzer 1990, Breininger 1990, Breininger and Smith 1992). The Ruby-throated Hummingbird (Archilochis colubris) may breed and winter on KSC in low numbers in a variety of habitats (Cruickshank 1980).

Most mammal species that are not listed as endangered or potentially endangered use a variety of habitat types (Harrison 1975, Ehrhart 1976, Stout 1980, Breininger 1985, Breininger, Smith, and Seigel in preparation). Bats represent a group of mammals that occur on KSC but little is known concerning their distribution, seasonality, demographics, and habitat use. Bats probably are the taxa most poorly understood on KSC. The status of several bats that may occur on KSC were discussed in Appendix A. Several species have recently been reported on KSC; they include the Seminole Bat (Lasiurus seminolus), the Evening Bat (Nycticeius humeralis) and the Brazilian Free-tailed Bat (Tadarida brasiliensis) (Barkaszi, pers obs.). A large colony of Brazilian Free-tailed Bats and a smaller colony of Evening

Bats occupies at least one bridge on KSC. The Southeastern Big-eared Bat (*Plecotus rafinesquii*) has not yet been reported but is expected to occupy some habitats on KSC (Jennings 1958). The Golden Mouse (*Ochrotomys nuttalli*), common to broad-leaved forests is important for biological diversity because it is more specialized than many other mammals (J. Layne, pers. comm.).

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13. ABSTRACT (Maximum 200 words)  <p>Buffer zones for space operations provide for a wildlife diversity unsurpassed among most federal facilities in the continental U.S. demonstrating the coexistence possible with one of man's greatest technological achievements. This document ranks 119 resident or migratory wildlife species that are endangered or declining. The ranking system herein was based on species' vulnerability to extinction and the relevance of Kennedy Space Center (KSC) for maintaining populations in the U.S. and Florida. One amphibian, 19 reptiles, 80 birds and 19 mammals were considered endangered or declining. KSC is an integral area for regional species diversity being the focus of the Merritt Island/Cape Canaveral/Turnbull Ecosystem which is part of the Indian River Lagoon watershed, an estuary of national significance. Many species that use this system also use the nearby St. Johns River Basin ecosystem. These two ecosystems are biological corridors between temperate Carolinian and tropical/subtropical Caribbean biotic provinces. Threats to biological diversity on KSC were also reviewed. Traditional environmental assessments, resulting from environmental regulation guidelines, focus on environmental contaminants and habitat lost due to construction. However, this review suggested that small population sizes, isolation of populations, ecosystem and habitat fragmentation, road mortality, and other edge effects may represent more critical threats to biological diversity than the traditional topics.</p>
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