Biological Opinion on FEMA's Administration of the National Flood Insurance Program in Monroe County, Florida

U.S. Fish and Wildlife Service
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BIOLOGICAL OPINION

ADMINISTRATION OF THE NATIONAL FLOOD INSURANCE PROGRAM IN MONROE COUNTY, FLORIDA, BY THE FEDERAL EMERGENCY MANAGEMENT AGENCY

Federal Agency **Fish and Wildlife Service**

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CONSULTATION HISTORY

On August 25, 1994, the United States District Court for the Southern District of Florida filed a memorandum opinion and final declaratory judgement for *Florida Key Deer v. Stickney* (Case No. 90-10037-CIV-MOORE). The Court directed the Federal Emergency Management Agency (FEMA) to consult with the U.S. Fish and Wildlife Service (Service) to determine whether implementation of the National Flood Insurance Program (NFIP) in Monroe County, Florida, was likely to jeopardize the continued existence of the endangered Florida Key deer.

On July 25 and 26, 1995, the Service and FEMA met to discuss the NFIP, its administration, its implementation, and the Section 7 consultation on the program. During this meeting, the two agencies outlined their roles and responsibilities and duties during the consultation. During this meeting, the Service outlined the Section 7 process as it would apply to the FEMA consultation. In particular, the Service recommended including all threatened and endangered species in the consultation, rather than just the Key deer, to avoid having to re-initiate consultation on the other threatened and endangered species at a later time.

On September 7, 1995, the Service sent a letter to FEMA which summarized the July 1995 meeting and identified which species the NFIP "may affect." This letter initiated formal consultation on the NFIP. In the letter, the Service asked FEMA for an extension of the regulatory consultation time frame due to the complexity of the consultation. The Service also asked FEMA for additional information that would help with the consultation.

On October 5, 1995, the Service spoke with several FEMA representatives to discuss the status of the consultation. The FEMA representatives confirmed that they still needed to provide the information the Service requested in its September 7, 1995, letter. They explained that the delay in delivering the information was caused by the large number of severe weather emergencies along the Gulf Coast States during the fall of 1995.

On January 25, 1996, FEMA sent a letter to the Service explaining the delay in responding to the Service's September 7, 1995, letter. In their letter, FEMA wrote that they understood the consultation to be "the admission of communities into the NFIP as well as the suspension and readmission of such communities, under 44 CFR part 59." FEMA agreed to extend the 135-day consultation period due to the importance of the consultation and agreed to help the Service gather and evaluate information during the consultation.

From April 29 through May 1, 1996, the Service held a meeting to discuss the recovery needs of the threatened and endangered species of the Florida Keys. The meeting was attended by experts on the various threatened and endangered species in the Florida Keys and the managers of public and private lands important to those species. The Service used this meeting to gather the best scientific and

commercial information available on the biology and status of the threatened and endangered species of the Keys, opportunities to recover them, and best management practices to promote their recovery. The meeting's attendees also discussed how FEMA actions would affect listed species.

On May 8, 1996, the Service met with representatives from FEMA and the National Wildlife Federation (NWF) to discuss the status of the Section 7 consultation on the NFIP. The Service explained that the scope of the consultation included 10 of the 17 threatened and endangered species in the Florida Keys, rather than only the Key deer. The Service also presented a schedule for completing the draft Biological Opinion and agreed to provide a draft document to both FEMA and NWF by July 15, 1996. The Service agreed to meet in Washington, D.C., on September 10, 1996, to review the conclusions in the Biological Opinion and to develop any reasonable and prudent alternatives, incidental take statements, and conservation recommendations that might be appropriate.

On July 10, 1996, the Service requested from FEMA and NWF a time extension to provide a draft Biological Opinion. A new date of July 22, 1996, was agreed upon.

On July 22, 1996, the Service provided copies of the draft Biological Opinion to FEMA and NWF.

On August 23, 1996, the Service received written comments from FEMA on the draft Biological Opinion. The most significant concern that FEMA identified was, that draft Opinion did not accurately describe FEMA's administration of the NFIP in Monroe County, Florida. Furthermore, FEMA believes this misrepresentation resulted in overstating their role in the decline of listed species in Monroe County.

On September 10 and 11, 1996, the Service met with representatives of FEMA and the Department of Justice (DOJ) to review FEMA's comments of the draft Biological Opinion and begin discussions on appropriate Reasonable and Prudent Alternatives (RPA). The Service agreed to incorporate the changes recommended by FEMA in their comment letter. FEMA agreed to provide the Service with a description of their administration of the NFIP in Monroe County, for incorporation into the revised draft Biological Opinion.

On September 12, 1996, the Service met with representatives of FEMA, NWF, Department of the Interior (DOI), and DOJ to discuss the status of the Section 7 consultation and receive input from the NWF regarding RPAs.

On October 3, 1996, the Service, FEMA, NWF, DOJ and DOI held a conference call to discuss the status of the Section 7 consultation.

BIOLOGICAL OPINION

This section of the document provides a description of the action, an overview of the action area, a listing of the species that have been included in the Biological Opinion, and a summary of relevant biological and ecological information on the species included in the Biological Opinion. Because of the size of this section, we have provided the following listing of contents to help the reader find specific sections:

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Description of the Action

The action being considered in this Biological Opinion is the administration of the National Flood Insurance Program (NFIP) in Monroe County, Florida, by the Federal Emergency Management Agency (FEMA). FEMA, through the NFIP, controls the risk of flood damage by requiring State and local governments to impose suitable land-use controls in flood plain areas as a condition for eligibility for flood insurance under the NFIP. In return for adopting land-use controls and flood plain management ordinances to minimize the risk of flood damage, FEMA provides Federal flood insurance coverage to private property owners.

Any new construction or improvements to existing structures within Federally designated Special Flood Hazard Areas (SFHAs) cannot be financed with Federal funds or loan guarantees without flood insurance. Direct and indirect Federal funding for private residential or commercial construction, including grants, loans, and mortgages, Federal Housing Authority mortgage insurance, Veteran's Administration mortgages guarantees, and Federal disaster relief all require the purchase of flood insurance. In addition, Federally regulated or insured institutions are prohibited from making, renewing, or increasing loans secured by existing or new structures located in SFHAs of participating communities without flood insurance (FEMA 1991b). Federally regulated or insured institutions may continue to make conventional loans in SFHAs of communities that do not participate in the NFIP.

Consequently, the availability of flood insurance has significant effects on the availability of Federal loans or mortgages from a Federally insured or regulated bank in SFHAs. If flood insurance is not available in an SFHA, the National Flood Insurance Act prohibits Federal agencies (such as the Federal Housing Administration and the Small Business Administration) from making or guaranteeing loans in that SFHA. Federal officers and agencies are prohibited from providing financial assistance for acquisition or construction purposes for use in SFHAs if the community is not participating in the NFIP.

This Biological Opinion is not an evaluation of the effects of the NFIP on threatened and endangered species in SFHAs throughout the United States. Instead, this is a programmatic consultation that is limited to the NFIP as administered in Monroe County, Florida.

As discussed earlier, FEMA, through the NFIP, controls the risk of flood damage by requiring State and local governments to impose suitable land-use controls in flood plain areas as a condition for eligibility for flood insurance under the NFIP. The administration of the NFIP involves several stages of implementation. As administered in the Florida Keys (Keys), the NFIP generally includes the following sequence of actions: (1) First, FEMA imposes several regulatory requirements (see discussion in Overview of the NFIP on page 2.3) in order for Monroe County to be a participating community in the NFIP; (2) then FEMA develops and maintains Flood Insurance Rate Maps, which Monroe County distributes to real estate agents, builders, contractors, etc.; (3) prior to issuing building permits, Monroe County reviews construction plans to ensure compliance with regulatory requirements the county established to participate in the NFIP; for example, Monroe County checks construction plans to ensure they are consistent with base flood elevations; (4) builders, contractors, or landowners then receive all other applicable county, State, and Federal permits prior to actual construction; (5) builders, contractors, or landowners clear their property and construct their homes or other structure; and (6) when the owner of the final structure applies for permanent financing, they are generally required to purchase flood insurance; in the Keys, most of those insurance policies are issued by FEMA.

Action Area of the Consultation

For the purposes of this consultation, the Service considers the action area as the Keys, extending from Key Largo south to Key West in Monroe County, Florida (Fig. 1). The mainland portion of Monroe County is not considered in this Biological Opinion because it is almost entirely contained within Everglades National Park or Big Cypress National Preserve. Consequently, the mainland portion of Monroe County is not likely to be adversely affected by the NFIP and is, therefore, not included in this consultation.

To analyze the effects of the action, we defined the boundaries of the action area more precisely using Geographic Information System (GIS) analyses of spatial information on the following: the distribution of threatened and endangered species in the Keys, vegetative land cover, and areas in the Coastal Barrier Resources System (CBRS). We excluded areas that are included in the CBRS and "otherwise protected areas" from the action area because FEMA does not issue flood insurance in those areas. Public and privately-managed conservation areas are also excluded from the action area because they are also not

likely to be subject to the NFIP. We used GIS analyses to identify those areas in the Keys that (1) support threatened and endangered species or designated critical habitat, (2) have not been cleared for residential, commercial, or other purposes, and (3) could qualify for the NFIP in Monroe County.

Description of action area

The Keys are a 210 km arc of islands extending from Soldier Key to Key West. The Keys are divided into three physiographic zones characterized by their shape, orientation and underlying rock formations: the Upper Keys (Soldier Key southeast to Newfound Harbor Keys), the Lower Keys (East Bahia Honda to Key West), and the distal atolls (Boca Grande Key Group, Marquesas Keys, and Dry Tortugas) (Hoffeister and Multer 1968). The distal atolls are protected islands that are more isolated from the other two groups of Keys and are not considered in this Biological Opinion. For a complete description of the Keys and habitats of the Keys, see Appendix 2. For a list of what habitats the 10 listed species in this Biological Opinion use, see Appendix 3.

The Upper Keys consist of long narrow islands that are situated in a northeast to southwest direction and parallel the reef tract. These elevated, almost continuous islands are composed of Key Largo limestone. The Upper Keys are aligned in such a way that they block almost all direct tidal interaction between Florida Bay and the reef tract, thus creating two different environments (Schomer and Drew 1982). Water flow was further restricted when an overseas railroad was built from 1904 to 1907. Over 27 km of bridges and 32 km of causeways were built where natural water passages previously existed.

The Lower Keys are a triangular group of islands lying at right angles to the Upper Keys in a northwest-southeasterly direction. Their orientation is caused by the directional movement of tidal scour which is a result of the tidal time and height differences between the Gulf of Mexico and the Straits of Florida. Several channels cut between the Lower Keys to connect the Gulf and Florida Bay. These passageways allow for greater water exchange between the two water bodies than the Upper Keys.

Most of the land area in the Keys lies between 0.6 - 1 m (2.0 - 3.0 ft) above high tide. Two locations (located in the Upper Keys) have an elevation of 5 m or more; here topography of the islands change from the typically flat island to elongated with southeast and northwest sides sloping to the Atlantic Ocean and Florida Bay.

Intertidal flats border the islands and give way to shallow water areas that gently slope to deeper water. Florida Bay lies beyond the flats on the northwest side of the Keys. Seaward towards the Straits of Florida, a band of living reefs parallel the coastline.

Overview of the National Flood Insurance Program

The National Flood Insurance Act of 1968, as amended, (42 U.S.C. 4001 et seq.) established the National Flood Insurance Program to protect property owners in flood-prone areas. The Flood Disaster Protection Act of 1973 broadened and modified the NFIP by requiring property owners to purchase flood insurance as a condition of receiving any Federal or Federally-related financial assistance to acquire or improve land or structures that are located in areas identified as having special flood hazards (42 U.S.C. 4002). The National Flood Insurance Act prohibited Federal officers or agencies from approving financial

assistance for acquisition or construction purposes in areas identified as having special flood hazards unless the structure is covered by flood insurance (42 U.S.C. 4012a).

FEMA reduces the cost and damages of flood-related disasters by requiring participating communities to implement effective floodplain management activities and, in specific conditions, requiring the purchase of flood insurance (FEMA 1995). To achieve these purposes, FEMA provides communities with information on areas having special hazards of flooding, mud-slides, and related erosion. This information is generally in the form of maps that identify areas with special flood or erosion hazards, where insurance is required, and premium rates that are based on flood risks. The NFIP relies on community participation to control land uses in these special hazard areas to reduce the risk of property damage from flooding, mud-slides, and flood-related erosion.

Insurance agents have several options for writing flood insurance policies through the NFIP: they can place flood insurance directly through the NFIP, they can place insurance through a program called the "write-your-own program," or they can place insurance through both the NFIP and the write-your-own program. The write-your-own program was established in 1983, as a cooperative undertaking of the insurance industry and the Federal Insurance Program, which administers the NFIP for FEMA. Because the write-your-own program operates within the context of the NFIP, it is subject to its rules and regulations. The write-your-own program allows participating property and casualty insurance companies to write and service Federal flood insurance in their own names. The companies place an expense allowance for the policies they write and process while the Federal government retains responsibility for underwriting their losses. The goals of the program are to increase the policy base, improve services, and involve insurance companies in the NFIP.

Community participation

Before FEMA can issue flood insurance policies in an area, a community must "participate" in the NFIP. For the purposes of the NFIP, a "community" is a State, Indian Tribe, or political subdivision of either a State or a Tribe that has the authority to adopt and enforce floodplain management regulations within its jurisdiction (43 CFR 59.1). Most NFIP criteria are performance standards that govern the construction of new and substantially improved buildings. Communities are specifically allowed and encouraged to adopt floodplain management requirements that are more restrictive than NFIP minimum requirements. Ultimately, however, determinations of whether or not an area can be developed are made by State and local governments through their planning and zoning authorities. To qualify for the NFIP, a community has to establish, adopt, and enforce flood plain management regulations that are applied uniformly to all privately and publicly-owned land within the flood-prone, mud-slide, or flood-related erosion areas in the community. (The complete requirements for community participation in the NFIP are outlined in 43 CFR 60.1 - 60.5).

In 1990, FEMA established the Community Rating System (CRS) as an incentive program that provides flood insurance premium reductions to communities that go beyond the minimum requirements of the NFIP. The CRS was codified by the National Flood Insurance Reform Act of 1994. If communities take additional actions to reduce flood losses, facilitate accurate insurance ratings, and promote awareness of flood insurance, they can reduce their insurance rates through the CRS. Communities choosing not to participate in the CRS are automatically given normal insurance rates.

Through the CRS, communities can receive credit for: (1) Protecting natural flood plain functions, such as providing flood storage, reducing erosion, improving water quality, and providing habitat for diverse species of flora and fauna; (2) advising people about flood hazards, flood insurance, and ways to reduce flood damage;

(3) mapping additional areas; (4) preserving open space; (5) enforcing higher regulatory standards, and managing storm water; (6) addressing repetitive losses, relocating or retrofitting flood-prone structures, and maintaining drainage systems; and (7) implementing flood-preparedness actions, such as flood warning, levee safety, and dam safety.

Flood Insurance Maps

To provide communities with information on SFHA and insurance requirements, FEMA prepares and distributes two types of maps: Flood Insurance Rate Maps (FIRM), and Flood Hazard Boundary Maps (FHBM) (44 CFR Ch.1 Part 64). A FIRM is prepared after a risk study has been completed for participating communities. A FIRM identifies risk premium rate zones and base flood elevations on which actuarial rates are based. An FHBM is the initial map issued for most communities that delineates SFHAs. FEMA's maps recognize 15 zones.

The FIRM maps for Monroe County were originally issued on June 15, 1973. They have been revised seven times with the most recent revision in 1995. The FIRM maps for the Keys currently include AE, AO, VE, and X zones (Table 1).

Table 1. Codes for zones and their definitions used on FEMA maps of Special Flood Hazard Areas (SFHAs)

Code	Definition
AE	SFHAs along coasts subject to inundation by the 100-year flood with water surface elevations determined. Mandatory flood insurance purchase requirements apply.
AO	SFHAs along coasts subject to inundation by the 100-year flood, hazards having shallow water depths and/or unpredictable flow paths between one and three feet. Mandatory flood insurance purchase requirements apply.
VE	SFHAs with water surface elevations determined and with velocity, that is inundated by tidal floods (coastal high hazard area). Mandatory flood insurance purchase requirements apply.
X	Area of moderate flood hazards or area of minimal flood hazards from the principal source of flood in the area. These areas may also receive flooding due to severe rainfall with inadequate drainage systems. Flood insurance is not required, but is available.

Coastal Barriers Resources Act

The Coastal Barriers Resources Act of 1982, as amended (16 U.S.C. 3501 et seq.) (CBRA), established the Coastal Barriers Resources System (CBRS), which is a system of undeveloped coastal barriers along the Atlantic and Gulf of Mexico coasts. Congress established the CBRS units to minimize loss of human life, to eliminate wasteful expenditures of Federal revenues, and to prevent damage to fish, wildlife, and other natural resources. As a result, CBRA prohibits most expenditures of Federal funds that encourage development within the undeveloped, unprotected area in the CBRS, including the sale of Federal flood insurance under the NFIP.

The Coastal Barrier Improvement Act of 1990 (Public Law 101-591) expanded many existing CBRS units and added new ones. The NFIP flood insurance ban affects structures built or substantially improved after November 1, 1990, in CBRS areas added by the Coastal Barrier Improvement Act. The Coastal Barrier Improvement Act also recognized "otherwise protected areas." These areas are lands already protected by public agencies or conservation organizations. Structures built in these areas to support recreation or conservation are eligible for flood insurance.

FEMA identified the units that are in the CBRS on its FIRMs so that insurance agents know where they can sell flood insurance for buildings constructed or substantially improved after the establishment of the CBRS and the designation of "otherwise protected areas."

A study by the National Wildlife Federation found that since 1982, 594 structures have been built in the 186 coastal barrier resource system units in the nation, which amounts to a 40 percent increase. Over half of this construction has occurred in the State of Florida (Jones and Stolzenburg, 1989).

In 1988, the Department of the Interior's Coastal Barrier's Study Group recommended including 19,831 acres of land of the Keys within the CBRS in its report to Congress, with 13,059 of these acres in the Lower Keys. In Monroe County, 8 percent of total land area is in regular CBRS areas, 9 percent is in CBRS areas designated as "otherwise protected areas," and 83 percent is in non-CBRS areas.

Species Included in this Biological Opinion

The Service has determined that the proposed action may adversely affect the following ten species that are provided protection under the Endangered Species Act of 1973:

Common Name	Scientific Name	Listed As
Eastern indigo snake	*Drymarchon corais couperi*	Threatened
Garber's spurge	*Chamaesyce garberi*	Threatened
Key deer	*Odocoileus virginianum clavium*	Endangered
Key Largo cotton mouse	*Peromyscus gossypinus allapaticola*	Endangered
Key Largo woodrat	*Neotoma floridana smalli*	Endangered
Key tree-cactus	*Cereus robinii*	Endangered
Lower Keys marsh rabbit	*Sylvilagus palustris hefneri*	Endangered
Schaus' swallowtail butterfly	*Papilio aristodemus ponceanus*	Endangered
Silver rice rat	*Oryzomys argentatus*	Endangered
Stock Island tree snail	*Orthalicus reses reses*	Threatened

In the action area, critical habitat has been designated only for the silver rice rat and includes Little Pine Key, Water Keys, Big Torch Key, Middle Torch Key, Summerland Key north of U.S. Highway 1, Johnston Key, Raccoon Key, and lower Saddlebunch Keys south of U.S. Highway 1; but not including lands in Township 67S, Range 27E, Section 8, and the northern 1/5 of Section 17. All lands and waters above mean low tide are included in this designation (50 CFR 17.95).

The major constituent elements of this critical habitat that require special management considerations or protection are mangrove swamps containing red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus*

erectus); salt marshes, swales, and adjacent transitional wetlands containing saltwort (*Batis maritima*), perennial glasswort (*Salicornia virginica*), saltgrass (*Distichlis spicata*), sea ox-eye (*Borrichia frutescens*), keygrass (*Monanthochloe littoralis*), and coastal dropseed (*Sporobolus virginicus*); and fresh water marshes containing cattails (*Typha domingensis*), saw-grass (*Cladium jamaicense*), and cordgrass (*Spartina* spp.)

The sections that follow summarize the status of these species across their entire range. Because the Service's biological opinions assess whether a Federal action is likely to jeopardize the continued existence of threatened or endangered species, the Service is required to consider information on the status and trends of those species throughout their range (unless there are separate recovery populations). This section of the Biological Opinion summarizes information on the status and trends of the ten species considered in this Biological Opinion. These summaries provide the biological and ecological information the Service believes is relevant to the analyses we will present in the "Effects of the Action" section of this Biological Opinion. These species represent a wide variety of other flora and fauna that are endemic to the Keys and that use many of the same resources and habitats of species we are including in this Biological Opinion.

Eastern indigo snake *(Drymarchon corais couperi)*

The eastern indigo snake was listed as a threatened species on January 31, 1978 (43 FR 4028). This snake was listed because of dramatic population declines caused by habitat loss, over-collecting for the domestic and international pet trade, and mortalities caused by rattlesnake collectors who gas gopher tortoise burrows to collect snakes (Service 1982a). When the indigo snake was listed, the main cause of its population decline was over-collecting for the pet trade.

Description

The indigo snake ranges from the southeastern United States to northern Argentina (Moler 1992). This species has eight recognized subspecies, two of which occur in the United States: the eastern indigo and the Texas indigo *(D. c. erebennus)* (Conant 1975, Moler 1985a). At one time, the eastern indigo snake occurred in the coastal plain of the southeastern United States, from South Carolina to Florida and west to Louisiana.

Originally described as *Coluber couperi* by Holbrook in 1842, it was reassigned to the genus *Georgia* by Baird and Girard in 1853. In 1860, Cope transferred it to the genus *Spilotes* and described it as a subspecies of *Spilotes corais* in 1862. Cope reassigned the species *corais* to the genus *Compsosoma in* 1900. In 1917, Stejneger and Barbour resurrected the genus name *Drymarchon*, (*Drymarchon corais*, Daudin 1827), including the eastern indigo snake as *Drymarchon corais couperi.* The current taxonomy of this subspecies has been accepted since 1917 (McCrainie 1980).

The eastern indigo snake is the largest non-venomous snake in North America, obtaining lengths of up to 104 inches (Ashton and Ashton, 1981). Its color is uniformly lustrous-black, dorsally and ventrally, except for a red or cream-colored suffusion of the chin, throat, and sometimes the cheeks. Its scales are large and smooth (the central 3-5 scale rows are lightly keeled in adult males) in 17 scale rows at midbody. Its anal plate is undivided. Its antepenultimate supralabial scale does not contact the temporal or postocular scales.

In the Keys, adult eastern indigo snakes seem to have less red on their faces or throats compared to most mainland specimens (Lazell 1989). Several researchers have informally suggested that Lower Keys eastern indigo snakes may differ from mainland snakes in ways other than color.

Distribution and habitat

Historically the eastern indigo snake occurred throughout Florida and in the coastal plain of Georgia. The species has been recorded historically in Alabama and Mississippi. It may have occurred in southern South Carolina, but its occurrence there cannot be confirmed.

Georgia and Florida currently support the remaining, endemic populations of the eastern indigo snake (Lawler 1977). In 1982, only a few populations remained in the Florida panhandle. In these areas, the species is considered rare. Nevertheless, based on museum specimens and field sightings, the eastern indigo snake still occurs throughout Florida, though not commonly seen (Moler 1985a).

In the Keys, eastern indigo snakes have been collected from Big Pine and Middle Torch Keys, and are reliably reported from Big Torch, Little Torch, Summerland, Cudjoe, Sugarloaf, and Boca Chica Keys (Lazell 1989, TNC 1977). P. Moler (GFC, personal communication, 1996) documented eastern indigo snakes on North Key Largo and feels they are probably restricted to Crocodile Lake National Wildlife Refuge and the protected hammock areas on that key. Since thorough surveys have not been conducted in the Keys, the eastern indigo snake may occur on other keys as well.

Over most of its range in Florida, the eastern indigo snake frequents diverse habitats such as pine flatwoods, scrubby flatwoods, flood plain edges, sand ridges, dry glades, tropical hammocks, edges of freshwater marshes, muckland fields, coastal dunes, and xeric sandhill communities. On the central Atlantic coast, eastern indigo snakes can be found in orange groves and near ditches and canals. In south Florida, these snakes are found in pine flatwoods and tropical hammocks or in most undeveloped areas (Kuntz 1977); although they may use open areas more than hammocks. Eastern indigo snakes also use agricultural lands and various types of wetlands, with higher population concentrations occurring in the sandhill and pineland regions of northern and central Florida. In the Keys, indigo snakes utilize similar habitats (Figures 2 and 3).

Smith (1987) radio-tagged hatchling, yearling, and gravid eastern indigo snakes and released them in different habitat types on St. Marks National Wildlife Refuge in Wakulla County, Florida, in 1985 and 1986. Smith monitored the behavior, habitat use, and oviposition sites selected by gravid female snakes. Smith concluded that diverse habitats, including high pineland, pine-palmetto flatwoods, and permanent open ponds, were important for the eastern indigo snake's seasonal activity. Habitat use differed by age, class, and season. Stumps, ground litter, and saw palmetto debris were frequently used as refugia. Adult indigo snakes often used gopher tortoise burrows (*Gopherus polyphemus*) during April and May, while juveniles chose smaller root and rodent holes. The indigo snakes used gopher tortoise burrows as oviposition sites in high pineland areas, while stumps were chosen in flatwoods and pond edge habitats.

Eastern indigo snakes need a mosaic of habitats to complete their annual cycle. Interspersion of tortoise-inhabited sandhills and wetlands improves habitat quality for the indigo snakes (Landers and Speake 1980). Eastern indigo snakes require sheltered "retreats" from winter cold and desiccating conditions. In laboratory experiments, they appear to be especially susceptible to desiccation (Bogert and Cowles,

1947). Wherever the eastern indigo snake occurs in xeric habitats, it is closely associated with the gopher tortoise, the burrows of which shelter the indigo snakes from winter cold and desiccating sandhill environment (Bogert and Cowles, 1947; Speake, *et al.* 1978). This dependence seems especially pronounced in Georgia, Alabama, and the panhandle area of Florida, where eastern indigo snakes are largely restricted to the vicinity of sandhill habitats occupied by gopher tortoises (Diemer and Speake, 1981; Moler 1985b; Mount 1975). In wetter habitats that lack gopher tortoises, eastern indigo snakes may take shelter in hollowed root channels, hollow logs, or the burrows of rodents, armadillo, or crabs (Lawler 1977, Moler 1985b). In south Florida, indigo snakes occur along canal banks, where they use crab holes in lieu of gopher tortoise burrows (Lawler 1977).

Outside of peninsular Florida, eastern indigo snakes are generally restricted to the vicinity of xeric habitats that support populations of gopher tortoises, although they move seasonally into more mesic habitats. Throughout peninsular Florida, the eastern indigo snake may be found in all terrestrial habitats which have not suffered high density urban development. They are especially common in the hydric hammocks of north Florida and in similar habitats throughout peninsular Florida (Moler 1985a).

The average range of the eastern indigo snake is 4.8 hectares during the winter (December-April), 42.9 hectares during late spring/early summer (May-July), and 97.4 hectares during late summer and fall (August- November) (Speake, *et al.* 1978). Adult male eastern indigo snakes have larger home ranges than adult females and juveniles; their ranges may encompass as much as 224 hectares (553 acres) and 158 hectares (390 acres) in the summer (Moler 1986). By contrast, a gravid female may use from 1.4 hectares (3.4 acres) to 42.9 hectares (106 acres) (Smith 1987).

Feeding

The eastern indigo snake is a generalized predator and will eat any vertebrate small enough to be over-powered. The snake's food items include fish, frogs, toads, snakes (venomous as well as nonvenomous), lizards, turtles, turtle eggs, small alligators, birds, and small mammals.

Reproduction

Eastern indigo snakes breed between November and April, with females depositing 4-12 eggs during May or June (Moler 1992). Young hatch in approximately 3 months from late May through August with peak hatching activity occurring between August and September, while yearling activity peaks in April and May (Smith 1987). There is no evidence of parental care although the snakes take 3 to 4 years to reach sexual maturity (Moulis 1976).

Female indigo snakes can store sperm and delay fertilization of eggs; there is a single record of a captive snake laying five eggs (at least one of which was fertile) after being isolated for more than 4 years (Carson 1945). There is no information on how long eastern indigo snakes live in the wild; in captivity, the longest an eastern indigo snake lived was 25 years, 11 months (Shaw 1959).

Threats

As stated earlier, the eastern indigo snake was listed based on a serious population decline caused by habitat loss, over-collecting for the pet trade, and mortality from gassing gopher tortoise burrows to

collect rattlesnakes. At the time of listing, the main factor in the decline of the eastern indigo snake was attributed to exploitation for the pet trade. As a result of effective law enforcement, the pressure from the collectors has declined, but still remains a concern (Moler 1992).

Garber's spurge *(Chamaesyce garberi)*

The Garber's spurge was listed as a threatened species on July 18, 1985 (50 FR 29349). The spurge was listed because of the destruction and degradation of its habitat: pine rocklands, coastal flats, coastal grasslands, beach berms, and beach ridges. The spurge was also listed because of competition from exotic pest plants.

Description

Garber's spurge is a perennial herb belonging to the spurge family (Euphorbiaceae). The Garber's spurge grows either prostrate or erect and has pubescent stems. The leaves are ovate, 4-9 mm long, entire, or obscurely serrate. The cyathia is about 1.5 mm long and is solitary at the nodes; appendages are minute or absent. Capsules are 1.5 mm wide and pubescent with seeds that are smooth or with transverse ridges but not wrinkled.

Distribution and habitat

The Garber's spurge is an endemic of Florida that occurs on less than five locations from Perrine in Dade County, west to Cape Sable, and south to most of the Keys in Monroe County (Small 1913, 1933). The total population of the spurge has been estimated as less than 1,000 individual plants (Muller 1989). While most populations of the Garber's spurge occur in coastal habitats, one population in Dade County is approximately 16 miles inland from Florida Bay.

Garber's spurge grows at low elevations (<3.0 meters) in well- to poorly-drained, calcareous sands or directly on exposed limestone in a variety of open to moderately-shaded vegetative communities. In pine rocklands, Garber's spurge grows in crevices in oolitic limestone. On Cape Sable in Everglades National Park, Garber's spurge has been reported from hammock edges, open grassy prairie, and backdune swales. In the Keys, Garber's spurge grows on semi-exposed limestone shores, open calcareous salt flats, pine rocklands, calcareous sands of beach ridges, and along disturbed roadsides (Figures 2 and 3).

The Garber's spurge occurs in vegetative communities that historically are naturally prone to periodic disturbance. Pine rocklands and coastal grasslands experience frequent wildfires, while coastal habitats are prone to periodic submergence at high tide or during storm surges.

Reproduction

Reproductive ecology in *Chamaesyce* has been poorly studied but it is known to be highly variable (Ehrenfeld 1976, 1979; Webster 1967). The life history of Garber's spurge is a perennial that reproduces sexually by seed. Some spurges are completely reliant on insects for pollination and seed production while others are self-pollinating. Pollinators may include bees, flies, ants, and wasps (Ehrenfeld 1979). Seed capsules of many Euphorbiaceae are explosively dehiscent, ejecting seeds a short distance from the parent plant. The seeds of some species are dispersed by ants (Pemberton 1988).

Threats

The Garber's spurge is threatened by habitat loss, competition from exotic plant species, and fire suppression. While several populations of this species occur on public land, many more may exist on unsurveyed, private tracts which are prone to conversion for residential and commercial construction.

***Key deer** (Odocoileus virginianus clavium)*

By the late 1940s, over-hunting and wanton killing by early Keys visitors and residents had reduced the . Key deer population to the dangerously low level of only an estimated 50-80 individuals, and by the early 1950s only 25 deer remained (Dickson 1955, Service 1980). Immediate efforts to enforce existing hunting bans and to protect the deer from human disturbance allowed the Key deer's numbers to increase slowly. A Federal refuge was established in 1957, and the Key deer was officially listed as Federally endangered on March 11, 1967 (32 FR 4001). The Key deer was listed as an endangered species because of the loss of its habitat to residential and commercial construction and because of high, human-related mortality and human disturbances.

Description

The Key deer is a member of the Cervidae family of the order Artiodactyla, class Mammalia. It was first recognized as a subspecies distinct from the races of *O. v. osceola* and *O. v. virginianus* when it was described by Barbour and Allen (1922). The population has been geographically and reproductively isolated in the Lower Keys since the last glacier melted at least 4,000 years ago.

The Key deer is the smallest subspecies of the North American white-tailed deer. Adult males average 36 kg (80 pounds) and adult females 28 kg (63 pounds). Fawns weigh about 1½ kg (3½ pounds) at birth. Height at the shoulder averages 69 cm (27 inches) for adult bucks and 65 cm (25½ inches) for adult does (Hardin, *et al.* 1984).

The body appears stockier than that of other deer (Klimstra, *et al.* 1978a); the legs are shorter, and the skull is shorter and relatively wider (Klimstra, *et al.* 1991). Pelage varies from deep reddish-brown to grizzled gray, and a distinct black cross or mask is often present between the eyes and across the brow (Klimstra 1992). Antler size and number of points for male Key deer are less than those of other white-tails (Folk and Klimstra, 1991a). Bucks typically grow spikes until their second year, when forked antlers are produced; they attain eight points usually by the fourth year.

Besides their size, Key deer possess a number of characteristics unique from other white-tail deer, including high salt water tolerance (Jacobson 1974), low birth rate, low productivity (Folk and Klimstra, 199lb), more solitary nature, and weak family bonds (Hardin 1974). According to Ellsworth, *et al.* (1994), the Key deer population is the most genetically divergent deer population in the southeastern United States.

Distribution and habitat

The Key deer's historical range probably extended from Duck Key to Key West (Barbour, *et al.* 1992).

The current range includes approximately 26 islands (130 mi^2/330 km^2) from Big Johnson Key to Sugarloaf Key (Folk 1991) (Figure 4). The National Key Deer Refuge (NKDR) and Great White Heron National Wildlife Refuge encompasses much of this territory and is managed for endangered species such as the Key deer. Big Pine Key, the largest of the Lower Keys (2,500 ha/6,000 acres), is the center and hub of the Key deer's range and supports about two-thirds of the entire population (Klimstra, *et al.* 1974).

Average monthly home range size for adult males is about 120 ha (300 acres) and for adult females about 52 ha (30 acres). Yearly ranges for adult males and females average 790 acres and 429 acres, respectively. Males tend to disperse from their natal range as fawns or yearlings. Adult males range over much larger areas during the breeding season (Silvy 1975) and may shift to an entirely new area (Drummond 1989). Territorial behavior is limited to a buck's defense of a receptive doe from other bucks (Klimstra, *et al.* 1974).

Key deer are "creatures of habit," with well defined patterns of activity and habitat use (Klimstra, *et al.* 1974). Established trails, worn deep into the marl soil from years of daily use, are clearly visible in many of the Key deer's movement corridors. Bedding and feeding areas will be used faithfully by individuals, and 'hot spot' road crossings are clearly apparent from roadkill data (Klimstra 1992).

The principal factor influencing distribution and movement of Key deer in the Keys is the location and availability of fresh surface water. Although Key deer have been observed drinking water half as saline (15 ppt) as sea water, Key deer may not be able to survive for long periods without fresh (<5 ppt) water (Folk, *et al.* 1991). The Key deer swim easily between keys and use all islands during the wet season (May to October), but during the dry season (November to April), suitable water is available on only 13 islands (Folk 1991). Big Pine Key and No Name Key provide the most fresh water and support the bulk of the Key deer population. Seasonal availability of special foods (e.g., black mangrove, palm, and dilly fruits) also influences Key deer movements.

Key deer utilize all habitat types within their range, including pine rocklands, hardwood hammocks, buttonwood wetlands, mangrove wetlands, and freshwater wetlands. The habitat types may be used year round or seasonally for feeding, resting, or fawning. Pinelands are very important to Key deer because they contain permanent freshwater sources critical for the long-term survival of the species. Key deer also use residential and commercial areas extensively where they feed on ornamental plants and grasses and where they can seek refuge from biting insects.

Behavior

The social structure of the Key deer is flexible and dynamic, varying throughout the year with the reproductive cycle. Key deer are naturally more solitary than northern white-tails (Klimstra, *et al.* 1978a), though feeding-induced aggregations prevalent on the human-inhabited islands have altered this tendency in recent years (Folk and Klimstra, 1991a). Bucks associate with females only during the breeding season and will tolerate other males when feeding and bedding only during the nonbreeding season. Does may form loose matriarchal groups consisting of an adult female with several generations of her female offspring, but these associations are not stable (Hardin, *et al.* 1976).

The sociobiology of many Key deer on Big Pine Key appears to have changed in recent years as a result

of increasing contact and influence by humans (Folk and Klimstra, 1991a). Increase in group size, reduction in movements, and change in behavior from the early 1970s (Hardin 1974) to the early 1990s (Folk and Klimstra, 1991a) in several subdivisions on Big Pine Key indicate increasing urbanization.

Feeding

Red and black mangroves constitute 24 percent by volume of the diet of the Key deer (Klimstra and Dooley, 1990). However, the Key deer use more than 160 other species to meet nutritional requirements (Klimstra and Dooley, 1990) especially palm fruits (*Thrinax morrisii, Coccothrinax argentata*), blackbead (*Pithecellobium keyense*), grasses, acacia (*Acacia pinetorum*), Indian mulberry (*Morinda royoc*), wild dilly (*Manilkara bahamensis*), and pencil flower (*Stylosanthes hamata*). The widespread availability of ornamental plants in urbanized areas is a powerful food attractant. Key deer readily feed on ornamental plants and may constitute a higher percentage of the deer's diet than once known.

Gross energy values of most Key deer foods are comparable to commercial feeds (Morthland 1972) but may be high in calcium and sodium and low in phosphorus (Widowski 1977). Many of the important food plants occur in pineland and are stimulated by fire, which arrests succession, reduces the canopy, promotes understory growth, decreases invasion by woody species, increases plant palatability, and reduces ground litter. The Key deer's diet varies seasonally with availability of specific plants and changes in nutritional requirements (Carlson, *et al.* 1989; Klimstra and Dooley, 1990).

Reproduction

On average, Key deer produce fewer young than any other free ranging white-tailed deer population in North America (Folk and Klimstra, 1991b). This may be a result of a nutrient deficiency (possibly phosphorus) or an evolved adaptation to a restricted, insular environment. Either way, fecundity (number of fetuses/female) and rate of reproductive activity (percent of females reproducing) are low; and fetal sex ratio (males to females) and mean age of first breeding are high, all resulting in low reproductive performance (Folk and Klimstra, 1991b).

The breeding season begins in September, peaks in October, and declines through December and January (Hardin 1974). Younger animals apparently breed later in the season, if at all (Klimstra, *et al.* 1978b). Male fawns do not breed and female fawns rarely do so. Most yearling males do not breed; however many females will breed as yearlings. Even adults, especially young bucks that are excluded by older, more aggressive males, may fail to breed (Klimstra 1992).

Parturition occurs about 204 days after breeding and peaks in April and May, though spotted fawns have been observed in every month of the year (Hardin 1974). The coincidence of fawning with the rainy season ensures an ample food supply for lactating females. Open hammocks and pinelands are preferred fawning habitats (Silvy 1975). Twinning is infrequent, and triplets have not been documented.

Threats

Key deer were threatened originally by over-hunting. Although hunting has been banned since early 1939, other threats are placing pressures on the status of the Key deer. In recent years, the single-most threat to the Key deer is the loss and alteration of habitat. Human constructional activities have destroyed

essential components of Key deer habitat including vegetation and fresh water resources. Fencing has resulted in a loss of habitat and interference with migration routes. In addition, other human-induced actions adversely affect the Key deer. The number of Key deer killed by automobiles continues to increase as road traffic increases, but higher traffic levels are not the only factor influencing deer which include changes in land use (i.e., fences alter movement patterns and may funnel deer towards on road area) and drought (lack of water can increase deer movement, causing them to come in contact with roads). Illegal feeding of Key deer has resulted in an array of deleterious effects such as ganging behavior as a result of abnormal aggregations. Because Key deer naturally have a low reproductive potential the effects of urbanization and ganging may decrease the likelihood of reproductive success. Key deer are also negatively affected by illegal dumping, contaminants, mining, and free ranging dogs. All of these threats are harming the Key deer's distribution, its habitat, normal behavioral activities, foraging, and reproduction.

Key Largo cotton mouse *(Peromyscus gossypinus allapaticola)*

The Key Largo cotton mouse was recognized by the Service in a notice of review on July 28, 1980 (45 FR 49961). It listed as endangered for 240 days on September 21, 1983, through an emergency listing action (48 FR 43040). The emergency listing was necessary to provide full consideration of the welfare of these species during Service consultation on a loan from the Rural Electrification Administration to the Florida Keys Electric Cooperative. The loan was for construction of a project that would result in accelerated habitat loss. The cotton mouse was proposed as endangered with critical habitat on February 9, 1984 (49 FR 4951) and was listed as an endangered species on August 31, 1984 (49 FR 34504). The proposed critical habitat was withdrawn on February 18, 1986 (51 FR 5746).

Description

The Key Largo cotton mouse is an island subspecies of the cotton mouse *(P. gossypinus),* a widespread species in the southeastern United States. The Key Largo cotton mouse was first described by Schwartz (1952a) as a medium-sized mouse with large ears and protuberant eyes. Its back is reddish- to dusky-brown; its underparts are white. Its body length ranges from 170-189 mm (6.6-7.4 in), tail length ranges from 72-87 mm (2.8-3.4 in), and hind foot length ranges from 21-23 mm (0.82-0.90 in).

Distribution and habitat

The Key Largo cotton mouse formerly occupied all of the hardwood hammock forests of Key Largo (Brown 1978a, 1978b), but is now believed to be restricted to that portion of the Key north of the U.S. 1 - S.R. 905 intersection (Brown 1978 a, b; Barbour and Humphrey, 1982b) (Figure 5). This area is commonly referred to as "north Key Largo." This species also occurred at the south end of the Key, at Plantation Key, near Tavernier (Layne 1974a). Attempts to collect it in southern Key Largo have been unsuccessful in recent years (Barbour and Humphrey, 1982b; Humphrey 1986).

The Key Largo cotton mouse was introduced to Lignumvitae Key in 1970 (Brown and Williams, 1971). Its status on that Key is uncertain, but it has not been successfully captured there since 1977, when one individual was trapped (Jeanne Parks, Florida Department of Natural Resources, personal communication).

Behavior

The Key Largo cotton mouse depends almost entirely on hardwood hammocks. It builds leaf-lined nests in logs, tree hollows, and rock crevices. The holes occupied by these mice measure 3-9 cm (1.2-3.5 in) in diameter and are often partially covered by leaves or bark (Goodyear 1985). Their holes are usually located at the bases of trees, or near or in woodrat nests, although Key Largo cotton mice also use recently-burned areas where bracken fern *(Pteridium aquilinum)* dominate ground layers. The Key Largo cotton mouse can move at least 1 mile in 1 to 2 days. Its home ranges overlap because it does not defend territories.

Feeding

Key Largo cotton mice feed on leaves, buds, seeds, and fruits (Brown 1978a). Elsewhere in its range, however, the cotton mouse is omnivorous and feeds on a variety of plant and animal materials (Calhoun 1941, Pournelle 1950).

Reproduction

The Key Largo cotton mouse breeds throughout the year, producing two to three litters averaging four young (Brown 1978a). The Key Largo cotton mouse is quite short-lived. Its average life expectancy is 30-40 days, although it may live for 2 to 3 years. Male cotton mice have larger home ranges than females.

Threats

The primary threat to the Key Largo cotton mouse is habitat loss and fragmentation caused by increasing urbanization. Traditional development practices in the Keys involve removing all vegetation, then grading and filling the limestone substrate. The apparent extirpation of this species from Key Largo south of the U.S. Highway 1 - S.R. 905 intersection has been generally attributed to land clearing followed by residential and commercial development (Brown 1978a, b; Hersh 1981). Increasing habitat fragmentation, combined with a decreased range, makes the Key Largo cotton mouse more vulnerable to natural catastrophes such as hurricanes or fire (Service 1993c); each of these have damaged significant portions of north Key Largo hammocks. Other threats, associated with an increase in urbanization, include dumping of trash, competition with black rats, and predation by feral cats.

Key Largo woodrat *(Neotoma floridana smalli)*

The Key Largo woodrat was first listed as a threatened species in 1969 under the Endangered Species Conservation Act of 1969; however this only afforded the woodrat protection on Service lands. The Key Largo woodrat was recognized as a candidate for listing in a notice of review on July 28, 1980 (45 FR 49961). The woodrat was listed as endangered for 240 days on September 21, 1983, through an emergency listing action (48 FR 43040). The emergency listing was necessary to provide full consideration of the welfare of this species during a Service consultation with the Rural Electrification Administration. The proposed action was construction of a project that would result in accelerated habitat loss.

The Key Largo woodrat was proposed for listing as an endangered species with critical habitat on February 9, 1984 (49 FR 4951) and was finally listed endangered on August 31, 1984 (49 FR 34504). The proposed critical habitat was withdrawn on February 18, 1986 (51 FR 5746).

Description

The Key Largo woodrat is an island subspecies of the eastern woodrat (*N. floridana*), which occurs widely in the eastern United States. The woodrat was first described by Sherman (1955). The Key Largo woodrat is grey-brown with white underparts, large ears, protuberant eyes, and a hairy tail. The head and body-length of the Key Largo woodrat ranges from 120-230 mm (4.7-9.0 in), their tail-length ranges from 130-190 mm (5.1-7.4 in), and their hind foot-length ranges from 32-39 mm (1.3-1.5 in).

Distribution and habitat

The Key Largo woodrat depends on tropical hardwood hammocks, the climax vegetation of upland areas in the Keys. The woodrat formerly occurred throughout uplands of Key Largo, but is now restricted to tropical hardwood hammocks on north Key Largo, representing about one-half of its original distribution (Brown 1978a, 1978b; Barbour and Humphrey, 1982b) (Figure 5). The woodrat is not necessarily restricted to mature hammocks; it will use a variety of microhabitats within tropical hardwood hammock. Schwartz (1952b) captured woodrats near Rock Harbor in the south portion of Key Largo, however, attempts to collect it there in recent years have been unsuccessful (Barbour and Humphrey, 1982b, Humphrey 1986).

Key Largo woodrat densities on north Key Largo have been variously estimated at 1.2 animals/ha (0.5 animals/a) (Brown 1978b), 2.2/ha (0.9 /a) (Barbour and Humphrey, 1982b), 2.5/ha (1.0/a) (Hersh 1981), and 7.6/ha (3.1/a) (Humphrey 1988). The large differences in the density estimates of Barbour and Humphrey (1982b) and Humphrey (1988) apparently result from differences in sampling techniques. Nevertheless, the method used by Humphrey (1988) is believed to estimate population densities of the Key Largo woodrat more reliably.

A population of Key Largo woodrats was established on Lignumvitae Key (Brown 1971, Barbour and Humphrey, 1982b), but that population may now be extirpated (James Duquesnal, Florida Department of Environmental Protection, personal communication).

Behavior

The Key Largo woodrat, like other members of the genus *Neotoma,* is known for its habit of building large stick nests (Brown 1978b). The woodrats construct their nests out of sticks, twigs, and various other objects that they assemble into mounds that can reach 1.2 m (4 ft) in height and 2-2.5 m (6-7 ft) in diameter. They frequently build their nests against a stump, fallen tree, or boulder and may also use old sheds, abandoned cars, rock piles, and machinery as nest sites. Their nests have several entrances and a single, central nest chamber. Normally, only one adult Key Largo woodrat inhabits a nest and one animal may use several nests. Goodyear (1985) found that Key Largo woodrats occupied some areas on north Key Largo without obvious stick nests, although she noted that the animals had at least a few sticks placed at the entrance to rock crevices they used for their nests.

The home ranges of Key Largo woodrats overlap. Hersh (1978) reported that the mean home ranges of six male and four female Key Largo woodrats were about 2,370 m^2, which is comparable to the home range of other *Neotoma floridana* populations. The dispersal habits of the Key Largo woodrat is probably similar to the eastern woodrat: once a woodrat disperses it stays within its new home range.

Key Largo woodrats appear to depend almost entirely on mature hardwood hammocks (Service 1973; Brown 1978b; Barbour and Humphrey, 1982b; Hersh 1981). The woodrats will use younger hardwood hammocks and disturbed areas adjacent to mature hammocks, but only in lower densities (Goodyear 1985, Humphrey 1988). Key Largo woodrats are active climbers who spend considerable amounts of time in trees (Goodyear 1985). Key Largo woodrats also seem to have definite trails and often use fallen trees to move over the forest floor (Goodyear 1985, Hersh 1978).

Feeding

Key Largo woodrats are nocturnal vegetarians, feeding on a variety of leaves, buds, seeds, and fruits (Brown 1978b).

Reproduction

The Key Largo woodrat is capable of reproducing all year, although there are seasonal peaks: reproductive activity is highest during the summer and lower during the winter (Hersh 1981). Key Largo woodrats have litter sizes ranging from one to four young although the litter normally have two young. Female woodrats can produce two litters a year (Brown 1978b). Both sexes require about 5 months to reach sexual maturity (Hersh 1981). The life expectancy of the Key Largo woodrat is unknown, but is probably similar to other subspecies of *Neotoma floridana* which may live for 3 years, but probably average less than 1 year (Fitch and Rainey, 1956; Goertz 1970).

Threats

The primary threat to the Key Largo woodrat includes habitat loss and fragmentation caused by increasing urbanization. These threats are attributed to the apparent extirpation of this species from Key Largo south of the U.S. 1 - S.R. 905 intersection (Brown 1978a, b; Hersh 1981). Increasing habitat fragmentation, combined with a decreased range, makes the Key Largo woodrat more vulnerable to genetic isolation, and to natural catastrophes such as hurricanes or fire (Service 1993c). Other threats, associated with human encroachment, include predation by feral cats, dumping of trash, and competition with black rats.

Key tree-cactus *(Cereus robinii)*

The Key tree-cactus was Federally listed as endangered on July 19, 1984 (49 FR 29237). The tree cactus was listed because of severe population declines caused by destruction of upland areas in the Keys for commercial and residential development.

Description

Key tree-cactus is a large, tree-like cactus with erect columnar stems, reaching 10 m in height. At

maturity, the plants are either much-branched (in variation *robinii),* or remaining few-branched (in variation *deeringii).* The stems of the tree-cactus are cylindrical, green, succulent, and 5-10 cm thick, with 9-15 prominent ribs. Their areoles bear 15-30 acicular spines that are up to 2 cm long and are thickly pubescent when young. Their flowers are solitary in the upper areoles, nocturnal, and 5-6 cm long. The outer perianth segments of the flowers are green, with tips pointed (in variation *robinii) or* rounded (in variation *deeringii).* The inner perianth segments of the flowers are white. The style is slightly exserted (in variation *robinii)* or included (in variation *deeringii).* The fruit of the Key tree-cactus is globose, depressed and 3.5-4.0 cm in diameter. The coat of this fruit is thin, leathery, bright red and splits open at maturity. The seeds are small, hard, shiny black, and set in a soft, white pulp (Benson 1982; Britton and Rose, 1937; Small 1931).

Distribution and habitat

The Key tree-cactus grow in the coastal hammocks of the Keys (Avery 1982; Benson 1982; Britton and Rose, 1937; Small 1917, 1921) and in the coastal thickets of the Matanzas and Habana provinces of Cuba (Benson 1982; Britton and Rose, 1937). The historical distribution of this species on the Florida Keys–which included populations that are now extinct on Key West, Boca Chica, and Windley Keys–has been substantially diminished by the destruction of populations occurring in the Lower Keys, particularly Key West (Avery 1982; Britton and Rose, 1937; Small 1917, 1921). Key tree-cactus populations presently occur on Upper Matecumbe Key (two populations), Lower Matecumbe Key (one population), Long Key (three populations), and Big Pine Key (two populations) (Adams and Lima 1994) (Figures 6 and 7).

The Key tree-cactus grows in a narrow range of plant associations which include tropical hardwood hammocks and a thorn-scrub association known locally as a "cactus hammock." The major requirements for successful growth of Key tree-cactus are an open canopy and freedom from frequent floods or frequent fires.

Hardwood hammocks inhabited by the species are typically in an early stage of succession following disturbance (Avery [no date]; Small 1917, 1921). Dominant tree species include *Bumelia salicifolia, Bursera simaruba, Coccoloba diversifolia, Ficus aurea, Krugiodendron ferreum, Metopium toxiferum,* and *Piscidia piscipula.* The lower story of the canopy typically contains small trees of the dominant species and plants of *Amyris elemifera, Ateramnus lucidus, Bumelia celastrina, Capparis flexuosa, Eugenia foetida, Guapira discolor, Pithecellobium guadelupense, Randia aculeata,* and *Zanthoxylum fagara* (Austin 1980, Weiner [no date]). These hardwood hammocks are upland communities which are flooded only rarely (during major storms) and are mesic in character (Weiner [no date]).

The thorn-scrub, "cactus hammock" association occurs at relatively low elevations in the Keys and is prone to more frequent flooding. Consequently, the canopy of this vegetative community is lower and more open than hardwood hammocks. *Conocarpus erectus* and *Ximenia americana* are the most typical dominant tree species (Weiner [no date]). *Cereus gracilis, Cereus pentagonus,* and *Opuntia dillenii* are common associates of Key tree-cactus in these habitats. Key tree-cactus is found on high sites within cactus hammocks that are rarely flooded. These sites support the hardwood hammock species listed above, but they are rarely extensive enough to allow typical development of hardwood hammocks (Herndon, personal communication, 1985).

The hardwood hammocks and cactus hammocks in which Key tree-cactus is presently known to grow are all developed on coral rock. Key tree-cactus grows well on well-drained upland sites with little or no soil development. Mineral soil is represented, if at all, by a very thin (<1 cm) layer of rock rubble, calcareous sands, or calcareous marl (Austin 1980; Herndon, personal communication, 1985). A layer of leaf litter 1 to 2 cm thick is typically present (Austin 1980; Herndon, personal communication, 1985). Deeper accumulations of soil may be found in pockets and crevices in the rock. These soils are classified as Histosols (Soil Conservation Service 1975). They are placed in the "catch-all" Rockland groups (Jones 1948). No detailed work has been done on soil types in the Keys due to their small area, agricultural insignificance and lack of well-developed soils. Hammocks on Key West and Boca Chica Key where Key tree-cactus grew in the past, were developed on oolitic limestone. Soil conditions at these sites were not recorded, but were probably similar to those listed above.

Key tree-cactus is found growing in small, isolated patches or clumps. The patches may consist of a single plant, or a group of plants, may cover an area of tens of square meters (Austin 1980, Small 1917). When many plants are found in a clump, most, if not all, of the separate stems likely represent vegetative offshoots of one or a few founders (Herndon, personal communication, 1985). Vegetative reproduction is commonly observed as a result of old stems being knocked to the ground.

Reproduction

Long distance dispersal and establishment of new tree-cactus populations is dependent upon the production of seed. However, reproduction within a single population (a clump) is mostly, if not entirely, vegetative (Herndon, personal communication, 1985). This reproductive strategy (formation of clonal clumps from rooted wind-thrown branches) also accounts, in part, for the clumped distribution of the species (Adams and Lima 1994). Pollination agents are unknown but may include sphingid moths (Adams and Lima 1994). Internal seed dispersal by birds *(Cardinalis cardinalis* for example) is indicated for this species (Austin 1980). The effective dispersers would be those fruit-eating birds which favor openings in the woods (A. Herndon, personal communication, 1996).

The Key tree-cactus can flower year-round, but July, August, and September are peak flowering periods. Mature flowers develop in approximately 12-14 days, and many flowers may occur simultaneously on a single pseudocephalium (Adams and Lima, 1994). Seed dispersal, based on one observation, occurs in August (Austin 1980; Avery [no date]).

Threats

Key tree-cactus has probably always been rare in Florida. The primary cause for this rarity seems to be the rather restrictive habitat requirements of the species. It grows only on lightly-shaded, upland sites. This habitat is not common on the Keys, and, furthermore, is transient in nature. The habitat preferred by Key tree-cactus occurs primarily in disturbed patches of hammock (Avery [no date]; Small 1917, 1921). The location of these patches changes with time as disturbed areas re-grow and new sites are disturbed.

By far, the major threat to the continued existence of this cactus in Florida is habitat loss for the construction of commercial facilities and residential housing on the upland areas in the Keys. This construction activity has been directly responsible for the destruction of several Key tree-cactus populations over the past 7 decades (Austin 1980; Avery [no date]; Britton and Rose, 1937; Small 1921, 1924).

Lower Keys marsh rabbit *(Sylvilagus palustris hefneri)*

The Lower Keys marsh rabbit was listed as an endangered species on June 21, 1990 (55 FR 25591). The Lower Keys marsh rabbit was listed as endangered because of habitat loss and fragmentation, predation by cats, and road mortalities caused by automobiles.

Description

Lower Keys marsh rabbits are small-to-medium sized rabbits, with short, dark brown fur and a grayish-white belly. Their feet are relatively small and their tails are dark brown and inconspicuous. Male and female marsh rabbits do not appear to differ measurably in size or color. The Lower Keys marsh rabbit is the most recently-described of three subspecies of marsh rabbit and was recognized as a distinct subspecies by Lazell (1984). The Lower Keys marsh rabbit differ from mainland (*S. p. palustris*) and Upper Keys marsh rabbits (*S. p. paludicola*) in several cranial characteristics (Lazell 1984). The Lower Keys marsh rabbit is also the smallest of the three subspecies. They can be distinguished from mainland marsh rabbits (*S. p. palustris*) by their fur.

Forys (personal communication, 1996) measured 24 adult Lower Keys marsh rabbits and found that their weight ranged from 1000 to 1400 g, their length ranged from 320 to 380 mm, their hindfeet ranged from 65 to 80 mm, and their ears (skin not dried) ranged in length from 45 to 62 mm.

Distribution and habitat

Lower Keys marsh rabbits were first reported from Key West by dePourtales (1877). The Lower Keys marsh rabbit's historic range (Figure 8) extended from Big Pine Key to Key West (Layne 1974, Hall 1981) encompassing a linear distance of about 30 miles (48 km). Historically, Lower Keys marsh rabbits probably occurred on all of the Lower Keys that supported suitable habitat.

Today, only 81 areas in the Lower Keys provide habitat for this marsh rabbit. Lower Keys marsh rabbits have been recorded at 50 of these 81 areas. Lower Keys marsh rabbits have been found on only a few of the larger Lower Keys (specifically Boca Chica, Saddlebunch, Sugarloaf, and Big Pine Keys) and the small islands near these Keys. There is a large gap in the distribution of Lower Keys marsh rabbits from Cudjoe Key to the Torch Keys. The majority of these areas of suitable habitat are smaller than 3 ha; the total area of suitable habitat is about 317 ha, of which 253 ha is occupied by the Lower Keys marsh rabbit.

Lower Keys marsh rabbits primarily occur in the grassy marshes and prairies of the Lower Keys, transitional areas that are similar in form and species composition to communities interspersed throughout mangrove forests of mainland Florida. These wetland communities lie in the middle of the salinity gradient in the Lower Keys and consist of grasses, sedges, and sparse tree cover that usually consists of buttonwood (Forys and Humphrey, 1992). Lower Keys marsh rabbits also use fresh water marshes dominated by sawgrass (*Cladium jamiacense*), which lie at the fresh water end of this salinity gradient, but this habitat type is relatively rare in the Keys. Lower Keys marsh rabbits occasionally use low shrub marshes and mangrove communities for feeding and as a corridor between patches of transitional habitats.

In these brackish habitats, the two plant species that are most important to the Lower Keys marsh rabbit for cover and nesting are cordgrass (*Spartina spartinae*) and saltmarsh fimbristylis (*Fimbristylis castanea*), both of which are thick, abundant grasses. In fresh water wetlands, the Lower Keys marsh rabbit may use sawgrass for the same purpose.

Based on their distribution, Lower Keys marsh rabbits appear to need only a little fresh water to survive. In a study of several mammals from the Lower Florida Keys, the Lower Keys marsh rabbit was found to have one of the highest capacities to concentrate urine (Dunson and Lazell, 1982). Although further study is warranted, Lower Keys marsh rabbits may be able to survive solely on dew and brackish water. Lower Keys marsh rabbits probably cannot use seawater to meet their need for water; even black rats, the highly salt tolerant mammal, cannot maintain its body mass on seawater.

Behavior

Both sexes of the Lower Keys marsh rabbit begin to sexually mature at about 9 months of age. During this time, the majority of the males disperse. Sexually-maturing females do not appear to disperse. Dispersing marsh rabbits suffer high mortalities, particularly when there is a lack of adequate corridors between populations or when there are roads to cross. Dispersing Lower Keys marsh rabbits travel up to 2 kilometers from their nests.

Adult Lower Keys marsh rabbits of the same sex do not have overlapping home ranges; they may display territorial behavior if another adult enters their home ranges. The home ranges of these marsh rabbits average 0.32 hectares (1.31 acres). Adults of both sexes have similar home range sizes, although the size varies widely among individuals. This individual variability may be due to differences in habitat quality, population density, or the status of an individual in a social hierarchy. Juvenile Lower Keys marsh rabbits appear to use a home range near their nest site.

Lower Keys marsh rabbits appear to be chiefly nocturnal, although they can be active on cloudy days and when they are protected by dense cover.

Reproduction

Similar to other subspecies of marsh rabbits, the Lower Keys marsh rabbit is polygamous and breeds year round. Initial results from a study of 24 rabbits from five populations indicates that all females breed and only a portion of the males breed. Although no estimate is available for Lower Keys marsh rabbit, the average gestation period of marsh rabbits from mainland Florida ranges from 30 and 37 days (Holler and Conaway, 1979).

The Lower Keys marsh rabbit may be less fecund than other marsh rabbits. One study followed 11 adult female Lower Keys marsh rabbits from 2 to 22 months and recorded all nesting behavior (Service 1994). During the study, 31 nesting events were recorded and all females nested and produced a litter at least once. Between 1 - 3 young were observed per nest, with an average of 1.77 per nest.

The female marsh rabbits in this study had no apparent seasonal pattern (Service 1994). However, the

highest proportion of females with litters occurred in March and September, the lowest proportion occurred in April and December. The average number of litters produced during the wet and dry seasons did not differ significantly.

All of the marsh rabbit nests were made in thick grasses and sedges, with 22 of the nests in cordgrass and the other nine in saltmarsh fimbristylis. In general, the marsh rabbit nests consisted of a main chamber with several smaller chambers and exit and entry routes. None of the nests were obviously lined with fur as reported in the northern subspecies. Only two of the females used the same nesting area more than once and none of the females used another rabbit's nest (Service 1994).

Threats

The primary threat to the continued existence of the Lower Keys marsh rabbit is habitat loss. In the past 50 years, more than half the area of the suitable habitat of the Lower Keys marsh rabbit has been destroyed to construct residential housing, commercial facilities, utility lines, roads, or other infrastructure.

Most of the remaining suitable habitat of the Lower Keys marsh rabbit has been degraded by exotic invasive plants, repeated mowing, dumping of trash, and off-road vehicle use. Urbanization has fragmented the sites occupied by the marsh rabbits and has eliminated many of the corridors that allow marsh rabbits to move between fragments. In larger, urbanized areas where the vegetative cover has been mowed, dispersing marsh rabbits have no cover from cats.

Predation from domestic cats (both feral cats and pets) is the greatest source of direct mortality in Lower Keys marsh rabbits. A detailed study of cat diets in the Keys has not been conducted, but rabbits were the largest component of feral cat's diets in several studies that have been conducted elsewhere (Jones and Coman, 1981; Libberg 1985). Lower Keys marsh rabbits appear to be equally susceptible to cat predation, regardless of gender or age.

Adult male Lower Keys marsh rabbits are most frequently killed by cars. This threat has increased in significance because of the magnitude of habitat fragmentation: the size of the remaining habitat fragments forces more adult males to disperse in order to establish territories, putting them at a greater risk of being killed by cars.

Schaus' swallowtail butterfly *(Papilio aristodemus ponceanus)*

The Schaus' swallowtail butterfly was listed as a threatened species on April 28, 1976, because of population declines that had been caused by the destruction of its habitat (tropical hardwood hammocks), mosquito control practices, and over-harvesting by collectors (41 FR 17740). The Schaus' swallowtail butterfly was reclassified to an endangered species on August 31, 1984, because its numbers and range had declined dramatically since its first listing (49 FR 34504).

Description

The Schaus' swallowtail butterfly is a large blackish-brown swallowtail butterfly with contrasting markings that are mostly dull yellow (Klots 1951; Pyle 1981; Opler and Krizek 1984). Their antennae are

black with a yellow knob that has a black tip. Their forewings have a dull yellow median band from the apex to about midpoint of the inner margin, with a short side branch to costa about 1/3 distance from the apex. Their subterminal and terminal lines consist of lunular yellow spots from apex to anal angle. Their hindwings have a yellow median band continuing that of the forewing, and a submarginal row of large yellow lunular spots; the concavities of a deeply scalloped outermargin have yellow edging. Their blackish "tail" is straight-edged (not teardrop-shaped), and is bordered with yellow. The tails have a hollow red spot along the anal margin just above the anal angle, with bluish scaling. A small, inconspicuous red dash is sometimes present basad of the second yellow lunule from the anal angle (between vein M2 and Cu1).

The underside of a Schaus' swallowtail's wings is yellow with black shading mostly in the median and submarginal areas of the forewing, and in the terminal area and tails of the hindwing. A dull brownish red median band extends from costa to inner margin of the hindwing, narrowing before touching these margins. There is extensive bluish scaling along the outer edge of the reddish band of the wing. The wingspan is 2.9 to 4 inches (8.6 to 9.5 cm) (Klots 1951, Pyle 1981, Covell 1985).

The Schaus' swallowtail butterfly is most easily confused with the giant swallowtail (*Papilio cresphontes*) Cramer, which is widespread in eastern North America and also occurs in habitat occupied by the Schaus' swallowtail butterfly. The two butterflies are easily separated by size and color: the giant swallowtail is larger than the Schaus' swallowtail and is more nearly coal-black with brighter yellow lines. The giant swallowtail butterfly has a broader median forewing band that is more broken into spots, and is less separated from the submarginal band toward the apex. The giant swallowtail butterfly's antennae are solid black and its tail is teardrop-shaped, yellow inside bordered with black edging. The reddish markings on the underside of its wings are less brownish and much less extensive than on the Schaus' swallowtail butterfly (Opler 1984).

Distribution and habitat

The present distribution of the Schaus' swallowtail butterfly is limited to undisturbed tropical hardwood hammocks in insular portions of Dade and Monroe Counties, from Elliott Key in Biscayne National Park in the northeast to northern Key Largo to the southwest (Service 1982b, Emmel 1985a) (Figure 2). Individuals have been seen in and adjacent to the Crocodile Lakes National Wildlife Refuge. Captive bred butterflies have been released on six sites in North Key Largo (Figure 9).

There have been two recent possible, but unverified, sightings of Schaus' swallowtail butterflies in the Lower Keys. One Schaus' swallowtail butterfly was seen on Big Pine Key in 1966 (Service 1982b). Another Schaus' swallowtail butterfly was sighted on Lignumvitae Key, a State Park, in 1973 (Covell 1976). The sighting on the latter Key seems possible because the butterfly's foodplant, *Amyris elemifera* (Rutaceae), is present on Lignumvitae Key (Covell 1976). A 1984 survey from Elliott Key to Key West found no Schaus' swallowtail butterflies south of north Key Largo (Emmel 1985a); although a verified sighting occurred on Upper Matecumbe Key in 1986 (Emmel 1986a). In 1985, over 400 Schaus' swallowtail butterflies were seen in Biscayne National Park, and a few were spotted at four sites in northern Key Largo (Emmel 1985b). In 1986, the population of adult Schaus' swallowtail butterflies on Elliott Key was estimated at 750-1000 individuals; in the same year, there were an estimated 50-80 individuals (adults and immatures) on each of Old Rhodes, Totten, and Adams Keys (Emmel 1986a).

The Schaus' swallowtail butterfly was described by Schaus in 1911 from specimens collected in May 1898, in the south Miami area. The last known mainland specimen was collected at Coconut Grove, Dade County, in May 1924 (Service 1982b). One older specimen was reportedly collected at Key West (Service 1982b). A colony flourished from 1935 to 1946 on Lower Matecumbe Key (Service 1982b, Grimshawe 1940), with a single capture recorded there in 1964 (Service 1982b). The Schaus' swallowtail butterfly has been known to occur on northern Key Largo from 1940 to present, although rare since the mid-1970s (Service 1982b). The Schaus' swallowtail butterfly has been known to exist on the larger islands of Biscayne National Park since 1972 (Brown 1973; Covell and Rawson, 1973).

The Schaus' swallowtail butterfly occurs exclusively in mature subtropical dry forest (hardwood hammocks) that are now extensive only in the Upper Keys in Dade and Monroe Counties (Service 1982b). Adults of this species may fly in clearings and along roads and trails, or even out over the ocean for short distances (Rutkowski 1971, Brown 1973), but they typically remain in the hammocks proper (Rutkowski 1971). Nectaring activity usually occurs on blossoms of wild coffee, guava (*Psidium guajava*), or cheese shrub (*Morinda royoc*), along the margins of these hammocks; they rarely feed in areas open to direct sunlight (Service 1982b, Rutkowski 1971).

Other characteristics of Schaus' swallowtail butterfly habitats are that they are relatively high elevation (3 to 4.6 m above sea level), away from tidal waters, and have a mature overstory of trees such as the foodplants gumbo-limbo (*Bursera simaruba*), pigeon plum (*Coccoloba diversifolia*), black ironwood (*Krugiodendron ferreum*), West Indian mahogany (*Swietenia mahagoni*), and wild tamarind (*Lysiloma latisiliquum*) (Covell 1976). These plants grow on a substrate of Key Largo limestone, which characterizes the Upper Keys.

Temperature in Schaus' swallowtail butterfly habitats range from 23°C (74°F) in the Miami area to 25°C (77°F) in the Upper and Lower Keys. Annual rainfall in habitats in the Miami area ranges from 1524-1651 mm, in the Upper Keys it ranges from 1143-1270 mm, and in the southern Keys it ranges from 889-1016 mm.

Dense, mature subtropical hardwood hammock habitat on well-drained substrate with dappled sunlight penetration are essential for the continued survival of both the Schaus' swallowtail butterfly and its primary food plant, torchwood (*Amyris elemifera*) (Emmel 1985a; Service 1982b; Covell 1976; Rutkowski 1971; Brown 1973; Loftus and Kushlan, 1984). The minimum area required is not known. Similarly, the optimum density of primary and secondary foodplants is not known.

Behavior

The Schaus' swallowtail butterfly is territorial to the extent that males have been observed to investigate other males entering their territories within hardwood hammocks (Emmel 1985a). Male butterflies have also been reported as they "patrolled the tree tops at a height of 10 feet or more" during the "hot afternoon" on "bright days," sometimes "descending into open spaces to investigate any other *Ponceanus*" (Rutkowski 1971). Emmel (1985a) also notes that male Schaus' swallowtail butterflies are remarkably adapted to flight within hardwood hammocks and are able to pick their way among branches and around spider webs.

The Schaus' swallowtail butterflies spend much of their time within hammocks, particularly where

sunlight penetrates to give a dappling effect (Emmel 1985a). Courtship has been observed along narrow trails cut through the hammock (Rutkowski 1971; Covell, unpublished). Open areas such as trails or clearings within or near the dense hammock are requisite for courtship activity and nectaring. These open areas may be natural or man-made.

The Schaus' swallowtail butterfly appears to be strictly diurnal. Rutkowski (1971) observed 2 female Schaus' swallowtail butterflies on different days visiting cheese shrub blossoms just before 9 a.m., his earliest observation; another female hovering over cheese shrub at 5 p.m. comprised his last observation during a day (Rutkowski 1971). He found both sexes "within the hammocks, fluttering in diffused light about a foot above the ground at blossoms of Guava ..." during the hottest part of the day (from 1 to 2 p.m.).

While no mass migration of the Schaus' swallowtail butterfly has ever been reported, an individual was followed as it crossed a half-mile expanse of Biscayne Bay between two islands (Brown 1973). In 1986, a Schaus' swallowtail butterfly was seen crossing about 360 meters from Old Rhodes Key to Swan Key (Emmel 1986a). These observations suggest that these butterflies can travel across open water for a considerable distance among the Upper Keys and may be able to travel to and from the mainland.

Adult Schaus' swallowtail butterflies are active primarily in May and June, with most sightings recorded between mid-April and mid-July (Service 1982b). A few August and September records suggest either delayed-emergence during a year, or a facultative second brood (Service 1982b, Brown 1976).

There is only one generation of Schaus' swallowtail butterfly per year and adults are short-lived (Emmel 1985a). There is some evidence from rearing that diapause may extend for at least 2 years (Grimshawe 1940). If this occurs in natural populations, the Schaus' swallowtail butterfly could survive extreme droughts in the season following its larval development by delaying emergence, perhaps until July-September or later (Rutkowski 1971). Some adults are active during July-September as well as during the normal flight period of late April through early July (Brown 1976).

Feeding

Young caterpillars use tender, young leaves of plants such as wild lime and will avoid tougher, older leaves although fifth (final) instar larvae have been observed eating tougher older leaves of torchwood (Service 1982b) and, in a laboratory, prickly-ash (Rutkowski 1971). Adults have been observed taking nectar from blossoms of guava, cheese shrub, and wild coffee (Service 1982b, Rutkowski 1971). Guava seemed to be the nectar source preferred by individuals observed by Rutkowski (1971) and he suggested that the Schaus' swallowtail butterflies will fly some distance from their hammock haunts to find blooming guava flowers. Emmel (1986a) observed frequent nectaring at seven plant species on Elliott Key: cheese shrub, blue porterweed (*Stachylarpheta jamaicensis*), sea grape, dog's tail (*Heliotropium angiospermum*), lantana (*Lantana involucrata*), salt-and-pepper (*Melanthera nivea*), and wild coffee.

Reproduction

The courtship of Schaus' swallowtail butterflies has been partially described in the following observation: "At 10:15 a.m. in a dimly-lit trail through brushy hammock I saw a female and two male *ponceanus* visiting flowers at opposite ends of a Guava tangle. The fresher of the two males eventually

approached this slightly worn female while she was still feeding. He hovered over her. She then settled on the ground with wings flattened and vibrating, raising her abdomen. The male fluttered on the ground behind and then rose over her before flying away" (Rutkowski 1971).

Three courting pairs of Schaus' swallowtail butterflies were observed in 1982 on Elliott Key (Covell, unpubl.) and photographed; details were not recorded. During part of the flight, the males were flying behind the females very low to the ground (1 - 3 m). In the pair photographed, the male was worn and heavily damaged, but the female seemed fresh and whole.

While mating has not been observed in the wild, oviposition in nature has been described. The Schaus' swallowtail butterfly uses torchwood and wild lime to deposit its eggs (Grimshawe 1940; Rutkowski 1971; Brown 1973; Loftus and Kushlan, 1984). These food plants are either at the edge of hammocks along trails impartially sheltered by the canopy or they are in the hammocks proper, at the edge of a clearing or where a fairly large opening in the canopy exists. Females deposit single eggs on the upper surface of the tips of the leaves; however, there is one record of two eggs on a leaf (Service 1982b). Eggs and larvae are not found on plants in open sunlight; however, in contrast, the giant swallowtail, *Heraclides cresphontes,* has been observed ovipositing on wild lime growing in the open (Service 1982b).

Information on survival rate of adults is mostly anecdotal. Earlier projections are that adults live only about 2 weeks, and suffer damage more quickly than similar species that live in more open areas because of hazards of life in the dense brush of the hammock (Emmel 1985a).

No studies on sex ratio have been published, but Covell (1985) has found that males are seen in more abundance than females. Of 245 adult *ponceanus* in collections, 136 were males, 41 females, and 68 had no sex indicated. If these figures were indicative of natural sex ratios, males would outnumber females by more than 4:1. Covell, however, suspects something closer to 2:1, males to females. Female butterflies are typically more secretive than males, and in the case of Schaus' swallowtail butterflies, a skewed distribution might be explained in that conscientious lepidopterists may tend to avoid killing females, heeding the plea to spare females published by Klots (1951) in his popular Field Guide to the butterflies: "None but males should be collected, and then, at most, only one per collector. A similar appeal is found in Kimball's book (1965).

Egg survival rate of 29.7 percent (11 of 37) was cited in one case for a group of eggs collected in the wild. Further mortality of hatching larvae resulted in a survival rate of only 5 percent in the group studied (Emmel 1985b).

Development from egg to adult was described by Grimshawe (1940) and Rutkowski (1971). Eggs take 3-5 days to hatch. Grimshawe also describes pupation:

> "When ready to transform, the larva seeks a place of seclusion, each for itself, and fastens its anal extremity with a button of silk, and throws a heavy girdle around the thorax, supporting the body in an upright, or vertical, position for the long sleep. The encased segments of the body of some of the chrysalides are rusty-brown color; others are gray, etched with moss-green and conforming generally with that of their supporting object. They take on a rigid cast and show no signs of life throughout the entire period of their sleep. Unlike the double and triple-brooded

> related species of neotropical Florida, our butterflies remained in the chrysalis stage either one or two years. As an example, half the caterpillars transforming into the chrysalis stage July 7, 1935, emerged May 8, 1936; the other half remained, hatching May 13, 1937."

Rutkowski (1971) also noted the white osmeteria on the larvae, and drinking of water droplets by fifth-instar caterpillars.

Threats

The primary threats to the survival and recovery of the Schaus' swallowtail butterfly are climatic factors such as hurricanes, freezes, and droughts; habitat loss due to clearing for residential and commercial construction and both man-induced and naturally-occurring fires; and the application of pesticides to control mosquitos.

Silver rice rat (*Oryzomys argentatus*)

The silver rice rat was listed as an endangered species on April 30, 1991 (56 FR 19814). At that time, the silver rice rat was extirpated from one key where it formerly occurred and was believed to be extirpated from two additional keys. The silver rice rat was listed as endangered because its wetland habitat had been destroyed by residential and commercial construction, and by predation, competition, and habitat modification from various introduced mammals. In the final rule listing the silver rice rat as an endangered species, the Service determined that critical habitat designation was not prudent (Service 1991). A reexamination of potential threats to the silver rice rat led the Service to conclude the illicit takings arising from publication of critical habitat may not be so serious as to render designation of critical habitat imprudent. Critical habitat was finally designated on September 30, 1993. It occurs on eight islands in the Lower Keys, and is restricted to a narrow range of wetland habitat types. Some areas have been excluded from critical habitat designation based on comments received on the proposed rule. A complete description of critical habitat for the silver rice rat is given in the Action Area section.

Description

The silver rice rat was originally described as a full species (Spitzer and Lazell, 1978) based on two specimens trapped in a freshwater marsh on Cudjoe Key in 1973. The silver rice rat is distinguished from mainland rice rats based on lighter pelage color, lack of digital bristles on hind foot, and a narrow, delicate skull with elongate nasal bones (Spitzer and Lazell, 1978).

The silver rice rat externally resembles other marsh rice rats in general form, being a medium-sized, semi-aquatic, generalized rat. However, the silver rice rat is distinct because it has no tufts of digital bristles projecting beyond the ends of the median claws in the hind foot, and silver-gray pelage laterally (Spitzer and Lazell, 1978). The body weight of silver rice rats caught in the field range between 60-150 grams; male rice rats are generally heavier than females (Spitzer 1983). External measurements of the holotype specimen for this species (USNM 514995), which is an adult female, are: total body length 251 centimeters, tail 121 centimeters, hind foot 32 centimeters, and ear 17 centimeters (Spitzer and Lazell, 1978).

Distribution and habitat

The silver rice rat is known to occur on 11 islands (Figure 10) in the Lower Keys: Little Pine, Howe, Water, Middle Torch, Big Torch, Summerland, Raccoon, Johnston, Cudjoe, Upper Sugarloaf, and Saddlebunch Keys (Vessey, *et al.* 1976; Goodyear 1984; Wolfe 1987a; Forys, *et al.* 1996). Based on the availability of suitable habitat and proximity to existing populations, the silver rice rat may also occur on several other islands in the Lower Keys including but not limited to Cudjoe, Big Pine, Little Torch, Ramrod, and Boca Chica Keys.

Rice rats were not found on Big Pine and Boca Chica Keys despite the availability of large areas of apparently suitable habitat (Goodyear 1987, Wolfe 1987b). While it is difficult to state with certainty that silver rice rats do not occur on these large islands, it is also unlikely that no individuals would have been captured if a population were present. Because of the semi-aquatic habits of the silver rice rat, the extensive areas it traverses, and fluctuations in small mammal populations, it is reasonable to assume that Boca Chica and Big Pine Keys could be colonized from existing populations on adjacent islands, and that they may support populations of silver rice rats at least periodically. Black rats and raccoons on both Boca Chica and Big Pine Keys could be factors in the absence of silver rice rats from these islands (Goodyear 1983).

Silver rice rats are not found in the Upper Keys presumably because of the lack of suitable habitat (Goodyear 1987). The first two captures of silver rice rats on Cudjoe Key were in a freshwater marsh vegetated mainly with sawgrass and cattails (Spitzer and Lazell 1978). Since those original captures, however, no silver rice rats have been captured in freshwater marshes. Rather, all captures have been in salt marsh habitats (Goodyear 1987). Radiotelemetry and trapping data reveal the use of three topographic zones: low intertidal areas, low salt marsh, and buttonwood transitional salt marsh (Goodyear 1987). Low intertidal and low salt marsh habitats are used by silver rice rats during activity periods, and swales in the low salt marsh are primary foraging sites. Buttonwood transitional salt marsh is at a higher elevation than other salt marsh habitats, and is used for foraging and nesting (Goodyear 1987). The silver rice rat moves through small hammocks and buttonwood transitional zones. A detailed description of the three topographic zones and their use by silver rice rats is provided by Goodyear (1987).

Critical Habitat

Critical habitat for the silver rice rat include areas containing contiguous mangrove swamps, saltmarsh flats, and buttonwood transition vegetation (Service 1993b). These vegetational types, as well as cattail marshes contain the primary constituent elements in critical habitat types.

The original critical habitat proposal included nine keys totaling 10,062 acres on the following islands: Little Pine, Water (north of Big Torch, but not the Water Key west of Little Pine), Big Torch, Middle Torch, Raccoon, Summerland, Cudjoe, Johnston, and Saddlebunch Keys. Approximately 5,003 acres of the proposed critical habitat was within National Wildlife Refuge boundaries. After a scientific and economic analysis, the Service concluded there was no justification for excluding areas from the proposed critical habitat based on economic reasons, although two areas should be excluded from critical habitat designation because they no longer supported significant silver rice rat habitat. These two areas included 1,032 acres, with 460 acres on Summerland Key and 572 acres on Cudjoe Key. Both areas are

located south of U.S. Highway 1, are extensively urbanized and, hence, have little remaining suitable habitat left for the silver rice rat.

Behavior

Silver rice rats are nocturnal and have been reported to range extensively (Spitzer 1983). Spitzer (1983) estimated the home range of a male silver rice rat on Summerland Key to be 22.8 ha (56.2 acres). This animal regularly traveled long distances during a single activity period, and was recorded traveling over 1 km in a single night. This single observation of a male silver rice rat occupying habitat very sparsely populated by other rice rats may not be entirely characteristic of silver rice rats under all ecological conditions, and may be an extreme limit. There is no estimate on the average dispersal distance for silver rice rats; however, their home range size is estimated to be much larger than is known for other rice rats (5-10 times as large).

Feeding

Silver rice rats are generalized omnivores that eat a variety of plant and animal material (Wolfe 1982). The diet of the silver rice rat includes seeds of saltwort, coconut palm (*Cocos nucifera*), and invertebrates including isopods (Spitzer 1983). However, a much greater variety of foods is probably taken.

Reproduction

Silver rice rats construct simple spherical nests located near the ground. Nests are approximately 15 cm in diameter, and constructed primarily of grasses (*Distichilis, Sporobolus*), although the exact materials used in construction may vary (Spitzer 1983). Spitzer (1983) found that a single male silver rice rat on Summerland Key alternately used 16 different nest sites, often quite distant from each other, over a 1-month period.

Reproduction in silver rice rats can occur throughout the year, and is likely influenced by a variety of ecological factors (Wolfe 1982). The reproduction peak occurs after the wet season, from October to November. The gestation period for silver rice rats is 21-28 days, with litter size ranging from 4-6. Spitzer (1983) recorded a pregnant female silver rice rat during winter, and litter sizes of 3-5. We are uncertain how many litters are produced in a year because so few have been caught.

Threats

The main threat to the silver rice rat is degradation and loss of habitat due to urbanization (Barbour and Humphrey, 1982a). Construction activities typically result in the direct loss of habitat as well as secondary effects that extend into surrounding habitats. Related secondary effects include habitat fragmentation and an increase in the densities of black rats and domestic cats. Cats are predators of silver rice rats and there is evidence of interspecific competition between silver rice rats and black rats.

Stock Island tree snail (*Orthalicus reses reses*)

The Stock Island tree snail was listed as threatened by the Service on July 1978 (43 FR 28932) because of population declines, habitat destruction and modification, pesticide use, and over-collecting (Service

1982c). Since its original listing, this threatened snail has probably been eliminated from its historic range on Stock Island by extensive habitat destruction.

Description

The Stock Island tree snail was first described by Say in 1830 based on a snail that was probably collected from Key West. That specimen was lost and the species was later described by Pilsbry around 1946 using a snail from Stock Island. The Stock Island tree snail is a subspecies in the genus *Orthalicus.* Pilsbry wrote that he believed *Orthalicus* (Subfamily Orthalicinae) migrated through tropical America on floating trees that were later blown ashore although he provides no specific evidence of this phenomenon.

Pilsbry (1946) described the Stock Island tree snail as having a shell that "...is rather thin and light, less solid than [other] races of [*Orthalicus*]. White to warm buff, this tint deepening near the lip or behind the later varices; stripes... purplish brown, running with the growth-lines, the stripes and the streaks often interrupted between the bands, and mostly not extending below the lower one; growth-rest varices usually 2 to 4 on the last whorl; three spiral banks, the upper and lower interrupted, are indicated, but weaken with age. Apex white. Aperture showing the varices, bands and streaks vividly inside; columella white, straightened above; parietal callus white, or dilute chestnut in old shells." The characteristics that most distinguish this species from *O. reses nesodryas* are the white apex and white columella and parietal callus. These characteristics are chestnut-brown or darker in *O. reses nesodryas.*

Distribution and habitat

Historically, Stock Island tree snails were found only on Stock Island and Key West. Today, snails are only found in a few hardwood hammocks in the upper Keys (Figure 2). They feed on epiphytic growth on hardwood tree trunks, branches, and leaves. The Stock Island tree snail survives best in hammocks of native trees that support relatively large amounts of lichens and algae. In the Keys, *Orthalicus* is limited to those portions of the islands that are relatively high (minimum elevations of 5-11 feet).

Larger trees support more Stock Island tree snails than smaller trees because they provide the snails with an increased surface area for foraging (Deisler 1987). There is no evidence that Stock Island tree snails prefer certain tree types or species (Deisler 1987). However, Voss (1976) wrote that the tree snails generally prefer trees with smooth bark over trees with rough bark, because the snails would require less energy to crawl over smooth bark. He also believed Stock Island tree snails would prefer smooth bark because it would make it easier for them to form a secure mucous seal when they were estivating, resulting in lower mortalities from dehydration or accidental dislodgement.

Stock Island tree snails are entirely arboreal except when they move to the forest floor for nesting or traveling. Hammocks that contained well-developed soils or leaf litter are probably necessary for nesting activity and dispersal.

No data are available on minimal hammock size needed to support a viable population of tree snails. Suitable habitat would have to include an area large enough to provide for foraging and nesting requirements as well as provide for the microclimate (air temperature and humidity) needed by the Stock Island tree snail.

Behavior

The Stock Island tree snails are active mainly during the wet season. Besides the reproductive activities discussed above, most of the feeding and dispersion takes place during the wet season (May through November). Dry periods (usually December through April) are spent in aestivation in which the Stock Island tree snail forms a tight sealed barrier between the aperture and a tree trunk or branch. Snails may come out of aestivation briefly to feed during dry-season rains or go into aestivation during summer dry spells.

Feeding

Little is known about the feeding habits or food preferences of the Stock Island tree snail. Probable food items include a large variety of fungi, algae, and lichens found on many of the native hammock trees. Mixobacteria and some small mites may serve as a secondary food source. Feeding can occur anytime during the day or night with peak feeding activity occurring from late afternoon through the night to mid-morning and during or immediately after rainfall. Feeding Stock Island tree snails often follow a random twisting path that covers the entire bark surface but will move in a straight line if surface moisture is abundant.

Reproduction

The snails are hermaphroditic, but cross-fertilization appears to be common. They mate and nest in late summer and early fall during the wettest part of the rainy season. They lay approximately 15 eggs per clutch in a cavity that is dug into the soil humus layer, usually at the base of a tree, and take anywhere from 24 to 105 hours to deposit their eggs (Deisler 1987, McNeese 1989). The eggs hatch during the onset of the rains the following spring. Upon hatching the Stock Island tree snails immediately proceed to climb adjacent trees. Most nesting snails appear to be approximately 2 - 3 years old and are estimated to live for up to 6 years, with 2.11 years being the mean age for the Stock Island population at the time of Deisler's study (1987). The Stock Island tree snail's age can be estimated by counting the number of dark "suture-like" lines resulting from pigment deposition during long dry spells (the dry season).

Threats

The greatest threat to the Stock Island tree snail is the loss and modification of its habitat, although natural disasters such as hurricanes and drought can have a significant effect. Because of its limited range, the Stock Island tree snail faces a high risk of extinction from habitat loss or a single, natural disaster.

ENVIRONMENTAL BASELINE

This section of the document summarizes the status of threatened and endangered species in the action area based on an analysis of the effects of previous actions. Because of the size of this section, we have provided the following listing of contents to help the reader find specific sections:

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The "Environmental Baseline" sections of Service Biological Opinions usually summarize the effects of past and present human and natural phenomena on the current status of threatened and endangered species and their habitat in an action area. The "Environmental Baseline" sections of Service Biological Opinions usually establish the base condition for natural resources, human usage, and species usage in an action area which would be used as a point of comparison for evaluating the effects of an action.

In this Biological Opinion, however, the Service is considering an action that requires us to deviate from our normal approach to establishing environmental baselines for an action. Specifically, Monroe County has participated in the NFIP since June 1970, which pre-dates enactment of the Endangered Species Act of 1973. As a result, the action being considered in this Biological Opinion is not a *proposed* action. To the contrary, the NFIP has been in place for almost three decades and is part of the environmental baseline for this Biological Opinion. The effects of this action are reflected in the current status of the species being considered in this Biological Opinion.

Consequently, the Service will treat all effects of the NFIP that occurred from 1970 to 1996 as part of the environmental baseline for this Biological Opinion. In the "Effects of the Action" section of this Biological Opinion, the Service will project the effects of the NFIP on threatened and endangered species if it continued, unchanged, to the year 2020.

Finally, the Service recognizes that the NFIP was not the only program that affected threatened and endangered species in the Florida Keys between 1970 and 1996. The actions of a large number of Federal, State, and local agencies influenced population expansion; habitat loss, conversion, and fragmentation; environmental pollution in ways that adversely affected threatened and endangered species. Some of these actions were interrelated to the effects of the NFIP; for example, a homeowner who purchased flood insurance as a requirement for receiving a mortgage would have also needed a permit from the U.S. Army Corps of Engineers if their house was being constructed in jurisdictional wetlands. In the Environmental Baseline, the Service will (1) provide an overview of these agencies and their authorities, (2) summarize the effects of their actions on threatened and endangered species in the Keys, to the extent information is available, and (3) summarize the status of the species as a result of these actions.

To develop these analyses, the Service relied on published sources, documents provided by FEMA, documents that were generated during the adjudication of *Florida Key Deer v. Stickney,* and documents provided by the State of Florida and Monroe County for information on flood insurance policies, demographic patterns in the Florida Keys, and other social and economic information. The Service relied on published sources, documents provided by FEMA, and documents generated during the adjudication *of Florida Key Deer v. Stickney* for interpretations of the National Flood Insurance Act, the NFIP, and applicable regulations and policy.

The information used in these analyses had limitations. Specific information on flood insurance policies in Monroe County was very limited prior to 1978. The most detailed information on the NFIP and population patterns in Monroe County was available for the late 1980s (that is, the information that was developed for *Florida Key Deer v. Stickney* and collected by the U.S. Census Bureau for the 1990 National Census). Since the 1990 Census, specific information on population trends in Monroe County is limited.

The National Flood Insurance Program in the Florida Keys

As outlined in the Description of the Proposed Action, the action being considered in this Biological Opinion is the implementation of the NFIP in Monroe County, Florida, by FEMA. In June 1970, Monroe County became eligible for flood insurance under the Emergency Program of the NFIP. In June 1973, Monroe County became part of the Regular Program of the NFIP after FEMA compiled flood plain maps and determined that Monroe County's flood plain management regulations were consistent with FEMA's regulatory criteria and the objectives of the National Flood Insurance Act (38 FR 15072). To be enrolled in the NFIP, Monroe County was required to raise the lowest floor of all new buildings above the 100-year flood level (Cross 1989). After Monroe County entered the Regular Program, new construction and substantial improvements of buildings were charged actuarial rates for flood insurance.

FEMA, through the NFIP, controls the risk of flood damage by requiring Monroe County to impose suitable land-use controls in flood plain areas as a condition for the County's eligibility for flood insurance under the NFIP. In return for adopting land-use controls and flood plain management ordinances to minimize the risk of flood damage, FEMA has provided Federal flood insurance coverage to property owners in the Keys. Since Monroe County's enrollment in the NFIP, any new construction or improvements to existing structures in the special flood hazard areas could not be financed with Federal funds or loan guarantees unless the property owner had flood insurance.

As discussed earlier, any new construction or improvements to existing structures within Federally designated SFHAs cannot be financed with Federal funds or loan guarantees without flood insurance. This requirement has had a major role in the acquisition of this insurance, but was not the only factor promoting flood insurance coverage. Although the mortgage requirement has not been totally effective in getting all vulnerable property covered in the NFIP, it has promoted a high degree of coverage, even in non-mortgaged homes. Cross (1989) found that availability of flood insurance has been ineffective in slowing coastal development, especially in the most vulnerable velocity zones, and may, in fact, stimulate growth.

Monroe County's Floodplain Management Ordinance

Florida Keys are one of the most vulnerable areas of the United States to coastal flooding. The Florida Coastal Coordinating Council (1974) concluded that the Keys are turning into one of the greatest man-made natural disasters in history. The first land planning began in Monroe County in 1960, with only a vague flood requirement stating "no building intended for residential purposes shall be moved into or

constructed on land subject to periodic or frequent flooding" (Monroe County 1960). Until the mid-1970s, residential construction had occurred in Monroe County without strong flood zone regulations.

To enroll in the NFIP, Monroe County has passed ordinances that restrict land uses and establish construction standards to minimize the risk of flood damage to new and substantially-improved structures. Ordinance No. 002-1994 amends the language of Monroe County Code Chapters 9.3-315, 9.5-316, and 9.5-317 that deal with floodplain management standards. The most current version of this ordinance was adopted by the Monroe County Board of Commissioners on January 18, 1994.

The purpose of Monroe County's floodplain management provisions (Section 9.5-315) is to promote the public health, safety, and general welfare and to minimize public and private losses due to flood conditions in specific areas; the specific provisions are listed in the ordinance. General provisions (Section 9.5-316) state that no structure or manufactured home hereafter shall be located, extended, converted, or structurally altered without full compliance of the terms of the floodplain standards. These provisions also adopt FEMA's Flood Insurance Study and Wave Height Analysis for Monroe County, Florida, unincorporated areas, or the most current official maps approved by FEMA, and includes rules for interpreting flood hazard issues.

Section 9.5-317 of Monroe County's floodplain management provisions identifies standards for issuing building permits in SFHAs. These standards include requirements for residential construction, nonresidential construction, accessory structures, and manufactured homes, and includes additional provisions for high hazard areas (V-zones) to minimize flood damage. Examples of these standards include: anchoring construction to prevent flotation, collapse, and lateral movement; designing sanitary sewage systems to minimize infiltration of flood waters and contamination from them during flooding; prohibiting man-made alterations to sand dunes, dune ridges, mangrove stands, or wetlands that could increase potential flood damage; locating all new construction landward of the reach of mean high tide; displaying special flood warnings in special flood hazard areas; elevating the lowest floor and any electrical and mechanical equipment to a height at or above the base flood elevation level; ensuring that any enclosures built underneath an elevated building are used for other than human habitation, i.e., exclusively for parking, building access, and limited storage for items such as lawn and garden equipment - the walls of any enclosed area for this purpose must either contain breakaway walls or provide openings to allow the flood waters to enter and reach the level on the outside of the structure.

The status and trend of National Flood Insurance Program in Monroe County

In some cases, the availability of flood insurance has increased the construction of buildings, the demand for properties, and property values in flood zones (Miller 1977, Kusler 1982). Cross (1989) suggested the availability of flood insurance may have contributed to increased construction in coastal flood zones in the Florida Keys. This conclusion was based on such things as the location of new residential construction and the increase in value of real estate since 1973. The availability of flood insurance may have contributed to this increase. New residential construction located within the Lower Florida Keys has increased in the Velocity or V zones, since Monroe County joined the NFIP. Not only did property values in coastal flood zones increase, but over 61 percent of surveyed Realtors and nearly two-thirds of

homeowners believed it was easier to sell property in flood hazard zones with the availability of flood insurance (Cross 1989).

Nearly three quarters of homeowners surveyed, who purchased property in the Lower Florida Keys in the previous 4 years, obtained flood insurance by 1983. After 1979, approximately 68.4 percent of homeowners who did not have mortgages obtained flood insurance (Cross 1989). Those homeowners who chose not to purchase flood insurance believed it was too expensive and could afford losses caused by flood damage. At the same time, homeowners living within areas vulnerable to floods had a slightly greater tendency to purchase flood insurance (Cross 1989).

FEMA began issuing flood insurance policies in 1973. By 1983, there were 37 policies on Big Pine Key. By 1984, the number of policies increased to 552 and by 1989, there were 1,186 policies in effect on Big Pine Key. About half of those policies were for structures built after Monroe County entered the regular program in 1973, while the other half were for structures built prior to 1973 (FEMA 1991). By 1989, there was no source of commercial or residential flood insurance that was generally available in the Keys other than insurance subject to FEMA's rules and regulations (FEMA 1991).

FEMA provided the Service with information on flood insurance policy issuances and claims, effective as of November 30, 1995 (S. Wilson, FEMA, personal communication, 1996). By 1995, FEMA had issued a total of 32,251 flood insurance policies throughout Monroe County. "Write-your-own" companies issued 31,999 of these policies; 25,068 of those policies were issued for residential and commercial units in "unincorporated" Monroe County and 6,029 for residential and commercial units in the cities of Key West, Layton, and Key Colony Beach. FEMA had directly issued 252 policies, with 195 of those for unincorporated Monroe County. Of this total, 24,527 policies had been issued for structures in A-zones and 4,637 policies had been issued for structures in V-zones. Figures 11 and 12 identify the areas of the Keys that are designated as A-zones or V-zones in which flood insurance is required. In X-zones, flood insurance is available, but not required. Also indicated in Figures 11 and 12 are CBRA areas.

Although the number of flood insurance policies had increased in Monroe County, FEMA found enforcement of flood zone ordinances were weak prior to 1983. In 1983 and again in 1987, Monroe County's lack of enforcement jeopardized the County's enrollment in the NFIP. In 1996, FEMA determined that Monroe County was not currently compliant with the minimum standards set forth for participation in the NFIP (FEMA 1996). In the latter case, the two deficiencies were illegally-occupied enclosures below the base flood elevation in residential structures and unpermitted and/or illegal additions to manufactured homes. FEMA directed Monroe County to correct these deficiencies and violations in order to retain their eligibility and participation in the NFIP.

Other Agency Programs and Actions in the Florida Keys

As we mentioned earlier, a large number of Federal, State, and local agencies manage or regulate public and private lands in the Florida Keys or implement programs that have an influence on population expansion, habitat loss and conversion, fragmentation, and environmental pollution in ways that adversely affect threatened and endangered species. Some of these actions are interrelated to the effects

of the NFIP (for example, a property-owner who receives a permit from the U.S. Army Corps of Engineers, the Florida Department of Environmental Protection, or Monroe County and later purchases a flood insurance policy) while other agency actions create independent effects of their own. Over the period of the Environmental Baseline, these agency actions have contributed to the status of the threatened and endangered species that are included in this Biological Opinion. Consequently, the Service will summarize those actions and discuss their interaction with the direct and indirect effects of the NFIP.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (COE) administers a program that regulates the discharge of dredged or fill material into waters of the United States (which include wetlands) under Section 404 of the Clean Water Act. Under the Section 404 program, the COE reviews projects to ensure that authorizing the discharge of fill into waters of the United States is in the public interest. When an individual, agency, or organization wants to place fill into waters of the United States (including wetlands), they apply to the COE for a permit. Although there are some exceptions, the COE generally issues notices that are distributed for public review and comment, then determines if the project is in the public interest before issuing the permit.

Most of the Keys that are within the 100-year flood plain are considered waters of the United States for the purposes of Section 404 of the Clean Water Act. As a result, any activity that required dredging or placement of fill material in waters of the United States (which include wetlands) could be regulated by the COE. The activities regulated by the COE's Section 404 program have had significant effects on threatened and endangered species in the Action Area. Since the early 1980s, the COE has reviewed permit applications to place fill material in the Keys to construct residential housing units, roads, bridges, canals, piers, marinas, and boat docks. The COE has issued hundreds of permits that allowed construction of residential housing, commercial facilities, and roads throughout the Keys; in each instance, however, the COE has consulted with the Service to ensure that their actions were not likely to jeopardize the continued existence of threatened or endangered species, in compliance with the requirements of Section 7 the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.).

U.S. Fish and Wildlife Service

The Service provides technical assistance to other Federal agencies to help them comply with the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) and the Endangered Species Act (16 U.S.C. 1531 et seq.). In the latter capacity, the Service provides comments and recommendations to the COE when it reviews applications for permits to dredge or fill in waters of the United States (which includes wetlands). The Service also consults with all Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of threatened or endangered species, or destroy or adversely modify designated critical habitat. Finally, since 1982, the Service issues permits to "take" threatened or endangered species incidental to activities that are authorized by other laws.

The Service also manages four National Wildlife Refuges in the Action Area: the National Key Deer Refuge (8,009 acres), the Great White Heron National Wildlife Refuge (7,407.53 acres), Key West

National Wildlife Refuge (2,019 acres), and Crocodile Lake National Wildlife Refuge (about 6,800 acres, although acquisition is incomplete).

The National Key Deer Refuge (NKDR) was established in 1957 to protect the Key deer. The pattern of boundaries of the administered lands is unique. The NKDR consists of several hundred individual tracts, some as large as a few hundred acres and as little as 0.2 acres. Most of the NKDR is on Big Pine Key and No Name Key, interspersed with housing developments and public roads. The rest of the Refuge lands are found on Big Torch Key, Middle Torch Key, Cudjoe Key, Upper and Lower Sugarloaf Keys, Knockemdown, Toptree Hammock, Howe, and Annette Keys. The NKDR protects about 15 percent of the remaining habitat for the endangered Lower Keys marsh rabbit.

Crocodile Lake National Wildlife Refuge was established in 1980 to protect critical habitats, including prime feeding and nesting areas, of the American crocodile. The Crocodile Lake National Wildlife Refuge also protects other threatened and endangered species including the endemic Key Largo woodrat, Key Largo cotton mouse, Schaus' swallowtail butterfly, and eastern indigo snake.

For almost 20 years the Service has consulted with the COE on permit applications to place fill material in waters of the United States (which include wetlands). For most of the period between 1978 and 1996, the Service had assessed the effects of residential and commercial construction projects on threatened and endangered species in the Keys through COE permits.

In 1983, the Service consulted with the Federal Housing Administration and the Rural Electrification Administration on a proposal to deliver water and electrical services to the Florida Keys. The Biological Opinion that resulted from that consultation concluded that the project, as proposed, would encourage additional residential and commercial construction and, as a result, was likely to jeopardize the continued existence of the Key Largo woodrat, Key Largo cotton mouse, Schaus' swallowtail butterfly, the American crocodile, and the eastern indigo snake.

Between 1984 and 1993, the Service has issued biological opinions on residential housing, commercial construction, road construction, marinas, boat docks, and canal dredging projects throughout the Keys. In 1984, the Service issued a biological opinion on the final phase of residential housing construction for Port Pine Heights. In 1985, the Service issued a biological opinion on an application for a COE permit to upgrade Card Sound Road between mainland Florida and Key Largo. In 1986, the Service issued a biological opinion on an application for a COE permit to establish a commercial fishing village on No Name Key.

In 1986, the Service issued a permit pursuant to Section 10(a)(1)(B) of the Act that authorized Mr. Howard M. Post to "take" Key Largo woodrats incidental to the construction of residential and commercial facilities. That permit authorized Mr. Post to convert about 1 acre of woodrat habitat on Key Largo in exchange for preserving 1.73 acres of woodrat habitat and restoration of another 2 acres of woodrat habitat in Crocodile Lake National Wildlife Refuge. In 1990, the Service issued a permit pursuant to Section 10(a)(1)(B) of the Act that authorized the Driscoll Properties Company at the Ocean Reef Club to "take" the Key Largo woodrat, Key Largo cotton mouse, and Schaus' swallowtail butterfly incidental to clearing 42 acres of tropical hardwood hammock to construct houses and related facilities

on 86 lots on Key Largo. The Ocean Reef Club now supports approximately 618 single family homes, 700 condominiums, an airport, golf course medical center, several motels, offices and commercial space and over half-million square feet of recreational space. In exchange, for the authority to "take" listed species on the property, the Driscoll Properties Company permanently dedicated 5.94 acres of the property to the conservation of threatened and endangered species.

Florida Department of Environmental Protection

The Florida Department of Environmental Protection (FDEP) provides policy directives to State agencies and regional and local governments. It also supervises regional water management districts, and delegates the authority to carry out programs to these water management districts, other State agencies, and local government agencies. To achieve these goals, the FDEP conducts regulatory programs to control or prohibit air and water pollution and to clean up or restore polluted land and water resources. It also supports research on environmental issues, and provides educational and technical assistance to the public for preventing environmental damage.

Several divisions of the FDEP have natural resource management responsibilities in the Keys: (1) Recreation and Parks; (2) Marine Resources; (3) State Lands, which acquires and manages State properties; (4) Law Enforcement; (5) Beaches and Shores, which has regulatory jurisdiction for construction and excavation activities on sovereign lands seaward of the high-water line in any State tidal waters or within 50 feet of the mean high water line; (6) Water Management, which manages changes in State surface water quality standards, including the quality of freshwater lenses in the Keys, and processes applications for dredge-and-fill permits for projects with more than 10 acres of dredging or filling; (7) Waste Management, which attempts to improve point sources of discharges that affect water quality and underground storage tanks; and (8) Water Facilities. The FDEP administers and manages the Looe Key and Key Largo National Marine Sanctuaries in cooperation with the National Oceanic and Atmospheric Administration (NOAA).

FDEP's programs have been applied variably in the Florida Keys. For example, FDEP's Division of Beaches and Shores has not consistently asserted jurisdiction over construction activities in Monroe County (NOAA 1995).

Department of Community Affairs

The Department of Community Affairs (DCA) is responsible for planning and regulating land use by approving local government comprehensive plans and land development regulations. Planning activities are integrated on the regional, State, and local level. The DCA also administers the Florida Land Management Act, which provides the State-wide framework for comprehensive plans developed by counties.

The DCA administers the Florida Coastal Management Program, which is structured as a network of State agencies that improves the effectiveness and efficiency of implementing existing laws and programs in the coastal zone. The DCA also administers the Areas of Critical State Concern (ACSC) program identifies certain regions of the state for special protection based on perceived threats to

significant natural resources and the need to protect public investments in facilities. The ACSC program ends approximately 250 feet below the mean high-water mark and places limits on upland development and the capital improvements in water quality it requires. ACSCs are critical when there is a need to protect public resources from unregulated or inadequately regulated development.

The governor and cabinet can designate an area by rule, setting the boundaries of an ACSC and the principles to be used for guiding development activities. Once an area is designated, affected local governments have 180 days to submit land development regulations consistent with the principles set forth in the rule. If the local government fails to submit regulations, or if its proposals are insufficient, the State land planning agency may propose development regulations for the governor's and cabinet's approval. Monroe County and the City of Key West were designated as ACSCs by the governor and cabinet in April 1975.

Florida Game and Fresh Water Fish Commission

The Florida Game and Fresh Water Fish Commission (GFC) manages freshwater aquatic life and wild animal life and their habitats to perpetuate a diversity of species and reduce fish and wildlife habitat losses. Under Florida's constitution, the GFC is responsible for protecting freshwater and upland endangered and threatened species. In addition to the specific responsibility to enforce rules with respect to the protection of listed species, GFC law enforcement offices are empowered to enforce State environmental laws.

Department of Agriculture and Consumer Services

Within the Keys, the Department of Agriculture and Consumer Services is primarily responsible for mosquito control, and its Bureau of Entomology and Pest Control administers the state's mosquito control program. Its responsibilities include overseeing all local mosquito control programs, reviewing and approving all county or mosquito control district work plans and work budgets, and administering State funding programs. In addition, the Bureau of Pesticides registers all pesticides, including mosquito control products, for sale and distribution. Using the Bureau's authority, the Department may deny, cancel, or modify the conditions of any pesticide registration.

In Monroe County, the Mosquito Control Authority (see below) has lead responsibility for eradicating adult mosquitoes and for conducting larval mosquito control activities. The objectives are to: (1) Protect human health and safety; (2) promote the state's economic development and facilitate the enjoyment of its natural resources by reducing the number of disease-carrying arthropods; and (3) conduct arthropod control consistent with protecting the environmental and ecological integrity of all State lands and waters.

Florida Keys Aqueduct Authority

Because of the limited drinking water sources in the Keys, almost all potable water is supplied via a pipeline owned and operated by the Florida Keys Aqueduct Authority (FKAA). This public water system

uses well fields and treatment facilities in Dade County for its entire supply. The FKAA is the only public water system in the Keys regulated by the FDEP's Public Water System Supervision program.

In 1980, the Service consulted on a proposal by the FKAA to replace an existing pipeline carrying water through the Keys. Prior to this proposal, the availability of potable water had caused the FKAA to limit the number of new housing and commercial units that could be connected to the public water system (there was a limit of five multi-family dwelling units per year and 20 single- or double-family homes per month). The 1980 Biological Opinion concluded that the proposed pipeline expansion, and the associated increase in housing, was likely to jeopardize the continued existence of the American crocodile, Key deer, Schaus' swallowtail butterfly, and Stock Island tree snail.

Monroe County Government

Monroe County is a nonchartered county, and its authorities and powers emanate from the State legislature; the local government functions in accordance with the Florida constitution. A Board of County Commissioners performs the executive and legislative functions of the county government. The Monroe County government is divided into five divisions: Management Services, Public Safety, Community Services, Growth Management, and Public Works.

Monroe County manages individual resources and regulates land use throughout the Keys through its adapted comprehensive plan, which is predicated upon specific Florida statutes and administrative codes. The County has completed an updated comprehensive plan that is subject to review and amendment by the FDCA (Chapter 163, Part 2 F.S. and Chapter 9J-5 Florida Administrative Codes).

For the entire period included in this Environmental Baseline, the Monroe County Government has undertaken a large number of actions that have affected threatened and endangered species in the Action Area. The Monroe County government issues the building permits that allow residential and commercial construction throughout the Keys and they have designed, planned, and constructed roads and other infrastructure projects. Many of these actions have had significant adverse effects on threatened and endangered species in the Keys. In 1988, the Service concluded that a proposal from the Monroe County Board of Commissioners to upgrade Harbor Lights Road on Big Pine Key was likely to jeopardize the continued existence of the Key deer.

In 1988, Monroe County cleared, graded, and filled a 0.6-mile stretch of the Cross Big Pine Key Arterial Access Road within the Florida Keys Area of Critical State Concern and the National Key Deer Refuge Project Boundary. In 1988, the Florida Department of Community Affairs issued a notice of violation that directed Monroe County to cease work on the Arterial Road project. In 1989, an Administrative Hearing Officer concluded that Monroe County had violated its land use ordinances by constructing the road.

In 1992, Monroe County adopted and implemented a rate of growth ordinance (ROGO) that limits residential growth in the County to 255 dwelling units per year. These units were divided among the Upper, Middle, and Lower Keys as follows: the Upper Keys were allocated 99 residential dwelling units per year; the Middle Keys were allocated 41 dwelling units per year; and the Lower Keys were allocated

115 dwelling units per year. Big Pine Key was allocated at least 20 of the annual allocation for the Lower Keys.

By 1995, an administrative commission concluded that the number of people the Keys can support without severe environmental damage had been exceeded and, as a result, the nearshore waters of the Keys have been degraded, seagrasses surrounding the Keys are declining, and the Key deer are at a greater risk of extinction. By 1996, the Governor of Florida concluded that the Monroe County Year 2010 Comprehensive Plan would result in development impacts that are inconsistent with protection of water quality, upland and marine resources, endangered and threatened species, community character, and public safety.

In 1996, the Monroe County Board of Commissioners proposed to upgrade the level of service provided by roads on Big Pine Key. The Service informed the Board of Commissioners that these actions would increase traffic volumes and speeds and would, therefore, "take" both the endangered Key deer and Lower Keys marsh rabbit.

Monroe County Mosquito Control District

The Monroe County Mosquito Control District (MCMCD) maintains a program of abatement for mosquitoes and other insect pests in the Keys. Its primary mission is to provide effective mosquito control, responsive to the health and safety of the county's residents and visitors, while minimizing adverse environmental impacts. The MCMCD operates from Key West to Key Largo, and serves all municipalities and the unincorporated area of the county.

Changes in the size of the human population in Monroe County

Florida's population growth has been almost exponential since the late 1800s. Just before the turn of the twentieth century, the total population of southernmost Florida was 32,000 people. Nearly 20,000 of those people lived in Key West. By 1960, Florida had almost 5 million residents, by 1970 there were almost 7 million residents, by 1980 there were almost 10 million residents. By 1990, the population of Florida had increased to almost 13 million people. By 2005, the population of Florida is projected to exceed 16 million, making Florida the fourth most populous state in the country. About half of these people are expected to live in the southernmost counties of Florida.

Population growth in southeast Florida (Indian River County south to Monroe County) has increased at a much higher rate than the population of the nation (Stronge 1991). This region experienced the most rapid population growth during the 1950s with an 8 percent annual compound rate. During the 1960s and 1970s, the population continued to grow but at half of the previous rate. The population of Monroe County, excluding Key West, has increased by 67 percent between 1970 and 1980 (Cross 1989). In the 1980s, population growth in the southeast region of Florida was more moderate, but was still more than twice the national rate of growth. The population census data for Monroe County are shown in Table 2.

Table 2. Changes in the human population size in Monroe County (by year)

	1980	1990	1992	2000*	2010*	2020*
Censused population	63,098	78,024	80,968	91,300	102,300	112,300
Functional population		134,600				200,000

* projected population estimate

Between 1980 and 1990 the population of Monroe County increased by 32.8 percent. This increase represents significant differences in this county given the finite amount of land available (Sedway Cooke Associates 1989). Big Pine Key, in particular, now accounts for a larger percentage of the County's population than other areas of unincorporated Monroe County. In 1970, the population of Big Pine Key was less than 800; today it is close to 5,000. Between 1980 and 1988, Big Pine Key experienced a 43 percent increase in population. In 1970, the population of Big Pine Key represented 4.5 percent of Monroe County's total population; by 1980, the population of Big Pine Key represented 6 percent of the County total; by 1988, Big Pine Key represented 7.6 percent of the County's total.

In addition to the resident population, the tourist and seasonal populations must be considered for this area. Almost 20 percent of Florida's annual migration of tourists visit south Florida and the Keys (Phillips and Larson, 1990). The Monroe County Comprehensive Plan found that in 1990 the seasonal residents accounted for an additional 25,040 people and on any given day there are another 29,105 tourists either staying with family or in hotels or rental property. The combination of the peak seasonal and resident populations is called the functional population (NOAA 1995). In 1990 the Key's functional population was estimated as 134,600 (Table 2), with a population density of 1,300 persons per square mile. This combined population is important because of its impact on resources and the government's ability to adequately manage those resources.

The Keys are arriving at a critical point in their history (NOAA 1995). The population has grown steadily and densities have increased while the land available for development has dwindled. In 1975, the Keys were designated as an ACSC because of increasing pressures from population development and growth.

If the projected population figures are extrapolated to reflect the future "functional population," the projected figure for 2020 is nearly 200,000 people (Table 2). Immigration is projected to account for 79.5 percent of the growth in Monroe County for these time periods.

Changes in Land Uses In Monroe County: 1970-1996

In 1992, Monroe County determined how many acres of vacant, developable land were "constrained" by natural resources and the extent to which development could be directed away from these natural areas to areas more suitable for development. This study concluded that Monroe County had 4,975 acres of

natural resource lands remaining. Of this total acreage, 1,137 acres (20 percent) were vegetated but not Coastal High Hazard Areas or the CBRS and another 204 acres (4 percent) were vegetated and in the CBRS but not Coastal High Hazard Areas.

Residential and Commercial Land Use Trends

As part of ROGO, adopted in July 1992, Monroe County expects to allow 255 dwelling units per year to be developed through 2010 (Monroe County 1996) (Table 3). Monroe County also expects to continue to permit 239 square feet of non-residential development for every one dwelling unit permitted. Extrapolating this ratio of 239 square feet per dwelling unit results in a total potential for the County to permit 184,840 more square feet through 2010. Monroe County also proposes policies that will discourage development in CBRS.

An overview of permits issued from 1990 to the present for residential purposes (including mobile homes) shows that more permits were issued in the Upper Keys than the Middle and Lower Keys combined:

Table 3. The number of building permits issued in the Florida Keys by Monroe County, 1990-1996

	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996
Upper Keys	321	236	104	102	115	77
Middle Keys	88	70	53	71	139	60
Lower Keys	208	182	111	42	18	0
Totals	617	488	268	215	272	137

On Key Largo, the northernmost portion of the Key has the highest density of residential and commercial property. One of these properties, the Ocean Reef Club, is an exclusive residential resort facility that consists of approximately 618 single family homes, 700 condominiums, an airport, golf course medical center, several motels, offices and commercial space, and over half-million square feet of lodge/club space.

Public Lands and Land Acquisition

The protected lands in the action area are managed by Federal, State, county, and non-governmental agencies. There are about 65,443 acres of non-submerged land in the Keys (Shermyen 1993). Of this total, five Federal properties encompass 23,235 acres of land. These Federal lands include the NKDR (8,009 acres), the Great White Heron National Wildlife Refuge (7,407.53 acres), Key West National Wildlife Refuge (2,019 acres), and Crocodile Lake National Wildlife Refuge (about 6,800 acres, although the purchase is incomplete). The U.S. Naval Air Station owns 5,700 acres.

The State of Florida owns 5,615 acres of uplands on nine sites. A couple of the larger properties are John Pennekamp Coral Reef State Park (2,436 acres of uplands), and Key Largo Hammocks State Botanical Site (1,700 acres of uplands). The county-owned properties are undefined, but the Monroe County Comprehensive Management Plan states that 20,696 acres are in conservation lands owned by various people.

Changes in Natural Vegetative Communities in Monroe County

In preceding sections, we provided an overview of the NFIP and the programs of other Federal, State, and local agencies in the Florida Keys. Taken together, these actions have had significant effects on the status and trends of threatened and endangered species between 1970 and 1996. It is virtually impossible to assign responsibility to any single agency for changes in the status and trends of threatened and endangered species; however, the combined effect of these actions has been to reduce the area, distribution, and connectivity of the vegetative communities of the islands that form the Keys.

The vegetative communities of the Florida Keys have experienced three periods of human disturbance over the last 300 years. These disturbances have altered the aerial extent, connectivity, and species composition of these areas (Ross 1992; Strong and Bancroft, 1994). The first onset of human encroachment began in the 1700s when Bahamians came to the Keys to harvest timber, particularly mahogany, Lignumvitae, and black ironwood (Tebeau 1971; Strong and Bancroft, 1994). The extent to which these areas were harvested is not known. A second wave of human influence was initiated in the 1900s when the Keys became a popular area for cultivating such crops as pineapple, key limes, and tomatoes. Large areas of land were lost to agriculture during this time (Strong and Bancroft, 1994). The potential for this area to become a farming mecca was subdued with the completion of the Flagler Railroad in 1912. The railroad allowed for less expensive products from Cuba to be transported to the Keys, hence, ending the agricultural boom. The third phase of human disturbance began again in 1924 with the start of modern urbanization and has escalated to the present time (Simpson 1983). Over the years, both upland and wetland plant communities in the Keys have been destroyed and modified to accommodate human needs and interests.

A unique combination of geological history, climate, geography, and environmental forces has made the Keys an important reservoir of landscape, community, and species diversity. The vegetation of the Keys represents a mixture of Caribbean, southern temperate, and local influences. The upland areas of the Keys occur on limestone outcroppings that are called the south Florida rocklands. These rocklands, which form both the Miami Rock Ridge and the Florida Keys, support biotic communities that are a unique combination of a West Indian flora and a southeastern flora and fauna. The relative isolation of these rocklands has also allowed a significant amount of endemism to evolve: 37 endemic herbaceous plants, five endemic trees and shrubs, 10 endemic mammals, 5 endemic reptiles, and such endemic invertebrates as the Stock Island tree snail and the Schaus' swallowtail butterfly all occur in these rocklands.

The south Florida rocklands support two major community types: tropical hardwood hammocks and pine rocklands. Tropical hardwood hammocks are evergreen, broad-leaved forests dominated primarily by trees common to the Bahamas and the Greater Antilles. These hammocks support some of the rarest

plant and animal taxa in the United States, including an abundant, epiphytic flora consisting of ferns, bromeliads, and orchids. In the continental United States, these communities are unique to south Florida and are one of the two most endangered communities in south Florida. Tropical hardwood hammocks, which have been reduced to approximately 6,070 hectares, are largely restricted to the Keys, particularly Key Largo.

Pine rockland communities occur on the Miami rock ridge, the eastern Big Cypress area, and the lower Florida Keys, particularly Big Pine, Little Pine, No Name, Cudjoe, and Sugarloaf Keys. The shrub layer of these communities include more than 90 taxa, most of them tropical plants from the West Indian flora. More than 250 herbaceous species have been recorded from areas in these communities that are not densely covered by shrub species; more than 30 of these taxa are endemic to south Florida.

The area of both the tropical hammock and pine rockland communities have been greatly reduced by expansion of the Miami metropolitan area and land conversion for residential housing in the Keys. Historically, there were more than 150,000 hectares of pine rocklands in the South Florida Ecosystem; approximately 8,500 hectares remain. The NKDR contains most (83 percent) of the remaining pine rocklands in the Keys (Cox, *et al.* 1994). In addition, the remaining pine rockland communities, which are adapted to fire, have undergone extensive alteration because of fire suppression. Without periodic fires, pine rockland communities are prone to invasion by exotic plant species; brazilian pepper (*Schinus terebinthifolius*) and melaleuca *(Melaleuca quinquenervia),* in particular, pose major threats to the native pine rockland communities.

The following summaries represent a more detailed analysis of changes that have occurred to vegetative communities in the Keys between 1970 and 1996. Each of the vegetative communities presented in the following sections provide habitat for one or more of the threatened and endangered species in the Keys. Since most of the threatened and endangered species of the Keys were listed because of habitat destruction and modification, the changes in their habitat will be indicative of their potential population trends.

Upper Keys

Before the arrival of Europeans, the Upper Keys (Ragged Keys to Long Key were studied) contained 4,816 hectares of deciduous or hardwood hammock forests (Strong and Bancroft 1994; Figures 13 to 16). These areas contained a continuous strand of deciduous, seasonal forests encircled by a fringe of mangroves. Since European settlement of the Keys, anthropogenic effects have directly affected the deciduous forests, hardwood hammocks, and mangrove fringes of the Keys. As a result of habitat destruction and modification for residential, commercial, and agricultural uses, most of the hammock forests in the Upper Keys have been lost or fragmented. Since 1924, habitat destruction and modification for residential and commercial uses has had a dramatic, permanent affect on these forests. By 1991, 41.2 percent of the deciduous seasonal forests (1,985 hectares) had been either cleared or filled to meet human needs (Strong and Bancroft, 1994). The pattern of habitat loss and modification in the Keys has resulted in small, fragmented parcels of suitable habitat. Areas that are easily accessible to humans, such as those connected by U.S. Highway 1, have experienced the majority of the adverse affects.

Habitat destruction and modification have affected the northern and southern ends of Key Largo differently. On the northern end of Key Largo, land acquisition by the Service, the State of Florida, and Monroe County has protected extensive areas of hardwood hammocks; the hammocks on the northern-most portion of Key Largo, where Ocean Reef Club and two, small, partially developed subdivisions have been destroyed or modified extensively. By contrast, residential and commercial construction projects have destroyed and fragmented extensive areas of the southern end of Key Largo; the fragmentation has been more severe in seasonal deciduous forests than mangrove forests (Strong and Bancroft, 1994). Residential housing projects have severely deforested the forests on Plantation Key (which has suffered a 70 percent loss of its seasonal forests) and Lower Matecumbe Keys.

Lower Keys

The Lower Keys include Bahia Honda to Key West. We will not provide information on Key West, the vegetative communities on that Key have been cleared with the exception of a few, small fragments that are protected by the City of Key West. The following will address vegetative communities on Big Pine Key and No Name Key. Additional information on other areas in the Lower Keys is provided in more detail in the narrative on the Key deer in this Environmental Baseline (page 3.19).

Big Pine Key contains 10 distinct vegetative communities: pineland, beach-dune hammock, high hammock, low hammock, cactus hammock, buttonwood prairie, buttonwood transitional wetlands, salt marsh, scrub mangrove, and fringe mangrove (Folk, *et al.* 1991). Pineland is the most extensive vegetative community on Big Pine Key and covers about 24 percent of the island. The percent cover of the other vegetative communities on Big Pine Key are: scrub mangrove (15 percent), fringe mangrove (9 percent), low hammock (6 percent), buttonwood transitional wetland (6 percent), salt marsh (4 percent), cactus hammock (1 percent), high hammock (0.9 percent), beach dune hammock (0.6 percent), and buttonwood prairie (0.5 percent). Of these vegetative communities, buttonwood prairie and cactus hammock are found only on Big Pine Key. The remaining 24 percent of Big Pine Key has been cleared for residential housing, commercial areas, highways, roadways, or infrastructure.

Most other vegetative communities on Big Pine Key have also declined in area. Changes in areal coverage of habitat types on Big Pine Key were documented from 1955 to 1989. The area converted for residential and commercial purposes (543 hectares) increased substantially during this period. Decreases were documented in Pineland (348 hectares), all hammock types (145 hectares), buttonwood prairie (12 hectares), buttonwood transition wetland (52 hectares), and salt marsh (119 hectares). Losses in these habitat types can be attributed to development for human needs. Scrub mangrove showed no change in coverage during that period. The only habitat type to show an increase was fringe mangrove (30 hectares). Some of the salt marsh may have been converted to fringe mangrove as ocean levels slowly increased.

No Name Key contains the same habitat types as Big Pine Key with the exception of cactus hammock, beach dune hammock, and buttonwood prairie. Low hammock is the dominant habitat with 27 percent of the island consisting of this habitat type. The absence of wildfires and any prescribed burning accounts for the high percentage of hardwood hammock on No Name Key. Without wildfires, much of the pinelands on this island have developed, through succession, into climax hardwood hammock

communities. Percent cover of the remaining habitat types include fringed mangrove (20 percent), pineland (11 percent), salt marsh (10 percent), scrub mangrove (9 percent), developed (8 percent), and high hammock (4.5 percent). No Name Key is not as diverse in habitats as Big Pine Key; however, the island is relatively undeveloped with the majority of land in public ownership.

Changes in the Status of Threatened and Endangered Species in Monroe County

Between 1973, the year Monroe County first enrolled in the NFIP, and 1996, the population of the Keys increased dramatically. During the same time interval, the acreage of native vegetation that was destroyed or modified to accommodate human needs and interests increased dramatically as well. Vegetative communities that were not destroyed outright, were degraded by exotic plant species brought in with the new human occupants, modified by chemical treatment for mosquito control, and were bisected and fragmented by roads and utility corridors. There are many natural areas that are still in private ownership and thus vulnerable to urbanization impacts (Figures 17a and b). As evidence of the magnitude and effects of the habitat destruction and modification that occurred in the Action Area, most of the threatened and endangered species included in this Biological Opinion were listed during the period of the environmental baseline (Table 4).

Table 4. Threatened and endangered species in the Action Area, when they were listed, and their listing status

Common Name	Year Listed	Listed As
Eastern indigo snake	1978	Threatened
Garber's spurge	1985	Threatened
Key deer	1967	Endangered
Key Largo cotton mouse	1984	Endangered
Key Largo woodrat	1984	Endangered
Key tree-cactus	1984	Endangered
Lower Keys marsh rabbit	1990	Endangered
Schaus' swallowtail butterfly	1976, 1984	Endangered
Silver rice rat	1991	Endangered
Stock Island tree snail	1978	Threatened

The following species accounts summarize how the various threatened and endangered species in the Keys changed between 1970 and 1996.

Eastern indigo snake

The status of the Eastern indigo snake is not well documented in the Keys. According to Lazell (1989), the remote, isolated, and possibly distinct Lower Keys populations have been wholly neglected. The indigo snake is suspected to be in very low numbers in the Keys where it has been observed, and is assumed to be declining mainly because of loss of suitable habitat, as well as other threats (Appendix 4-6).

The eastern indigo snake utilizes a majority of the habitat types available in the Keys, but tends to prefer open, undeveloped areas (Kuntz 1977). Because of its relatively large home range, this snake is especially vulnerable to habitat loss, degradation, and fragmentation (Lawler 1977, Moler 1985b). Lawler (1977) noted that eastern indigo snake habitat has been destroyed by residential and commercial construction, agriculture, and timbering. He stated that the loss of natural habitat is increasing because of these threats; in Florida, indigo snake habitat is being lost at a rate of five percent per year. Low density residential housing is also a potential threat to this species, increasing the likelihood of snakes being killed by property owners and domestic pets. Extensive tracts of wild land are the most important refuge for large numbers of eastern indigo snakes (Diemer and Speake, 1981; Moler 1985b).

In addition to habitat loss, gassing of gopher tortoise burrows to collect rattlesnakes, highway mortalities, and intentional killing, contribute to the snake's status as a threatened species (Diemer and Speake, 1981; Service 1982a). Pesticides that bioaccumulate through the food chain may present a potential hazard to the snake as well (Speake, unpublished data).

Information on the populations of eastern indigo snake in the Keys is wanting. Management tasks identified in the recovery plan for this species elsewhere include: habitat management through controlled burning, testing experimental miniature radio transmitters for tracking of juvenile eastern indigo snakes, maintenance of a captive breeding colony at Auburn University, recapture of formerly released snakes to confirm survival in the wild, presentation of education lectures and field trips, and efforts to obtain landowner cooperation in eastern indigo snake conservation efforts. These projects are either completed or currently ongoing. It is hopeful that results will be used to better understand the status and management needs of the eastern indigo snake in the Keys.

Garber's spurge

The Garber's spurge is an early successional species, found in open, sunny areas throughout the Keys, as well as along road sides. Habitats it occupies are, however, prone to natural disturbance: pine rocklands and coastal grasslands are subject to frequent fire, and coastal habitats are subject to periodic submergence at high tide or during storm surges. The rockland plant communities that support the Garber's spurge have been greatly reduced by land conversion for residential housing in the Keys. The National Key Deer Refuge contains most (83 percent) of the remaining pine rocklands in the Keys (Cox, *et al.* 1994).

Habitat loss and degradation are the primary threats to the Garber's spurge. Indirect effects, such as habitat fragmentation, fire suppression, and exotic plant invasion (Appendix 4-6). Habitat fragmentation

intensifies the effects of natural pulse events such as strong storms and hurricanes. A small, isolated population of Garber's spurge can be eliminated by erosion or deposition of debris during a storm. The pine rockland communities, which are adapted to fire, have undergone extensive alteration because of fire suppression. Without periodic fires, pine rockland communities are prone to invasion by exotic plant species; brazilian pepper (*Schinus terebinthifolius*) and *Melaleuca quinquenervia*, in particular, pose major threats to the native pine rockland communities.

Fire suppression in pineland and grassland areas has eliminated sunny openings that are necessary for the species to survive. In addition, coastal populations of the Garber's spurge also have been threatened by competition and habitat alteration associated with several exotic plant species, including lather leaf (*Colubrina asiatica*), Australian pine (*Casuarina equisetifolia*), and ink berry (*Scaevola sericea*), all of which are common, invasive, exotic species in southern Florida. The coastal grasslands that support populations of Garber's spurge are also fire-dependent ecosystems that must be burned regularly to maintain their suitability for species like the spurge.

Key deer

The Key deer population was estimated at 350-400 animals in the early 1970s (Klimstra, *et al.* 1978b) but declined during the 1980s to 250-300, principally as a result of high mortality and escalated habitat loss due to urbanization (Hardin, *et al.* 1984; Humphrey and Bell, 1986). The population is thought to be currently at 250-300. The Key deer population experiences natural cycles where the population may exceed or drop below the stabilized population estimate as a result of changes in habitat conditions brought about by climatic phenomenon such as drought and wet seasons. Exact population estimates are hard to determine due to the difficulty in surveying techniques. Although the number of individuals in the Key deer population is suspected to have increased over the past few years, the overall status of the Key deer is unstable and declining due to a continuation of threats (Appendix 4-6).

The instability of the Key deer population is due to an increase in human-induced threats. As a result, road mortality continues to increase, as do the negative effects of urbanization and habitat loss. Urbanization has had an extreme effect on reducing the deer's reproductive range. Islands like Cudjoe and Upper Sugarloaf Keys that previously had deers present, are no longer inhabitated by permanent herds, although suitable habitat and fresh water are available. Instead of occupying all available habitat, more deer are overaggregating in a few areas, especially on Big Pine Key where carrying capacity has been exceeded. The higher density of deer in an area can have a negative effect on natural habitat; hence, habitat on several islands like Big Munson and No Name can no longer support the number of deer present. Behaviorial patterns are also affected; for example, normal dispersal patterns have been altered.

Threats to Key Deer from Urbanization

Nearly half of the islands in the range of the Key deer are currently inhabited by people, and eight have large subdivisions and commercial development (Folk 1991). The human population of Big Pine Key in 1990 was estimated at 4,208 permanent residents, a 77 percent increase since 1980; an additional 2,154 seasonal residents spend winters on Big Pine Key (Monroe County Growth Management Division 1992).

Habitat with building structures present have negative influences on Key deer, such as fencing, interference with migration routes, harassment by dogs, death by automobile traffic, dependence upon food and water from humans, behavioral modifications, urbanization or habituation to humans, and concentration of deer. As suggested by Klimstra (1971), because 90-95 percent of the Key deer populations are impacted by land use, the future of this species is dependent upon the outcome of urbanization. Urbanization includes residential and commercial lots, areas disturbed or cleared in preparation for buildings, and right of ways. In some cases, the presence of these structures may discourage deer from using that habitat, but some deer have become habituated to the presence of buildings and may not find it an impediment (Folk, *et al.* 1991). Key deer sometimes use lots with buildings present for feeding, loafing, and insect-escape areas.

Refuge lands originally established to protect the Key deer are know being adversely impacted by large deer aggregations in surrounding subdivisions. Vegetation on Refuge lands adjacent to such areas have been overbrowsed by the large numbers of congregated deer and changes in plant community dynamics have resulted.

Changes in Key Deer habitat

The Key deer are located in small, isolated, and fragmented habitats within very restricted ranges. Even though large parcels of land are in public ownership and are protected, Key deer utilize private property and require additional areas to maintain viable populations needed for long-term survival of the species. Destruction of habitat by human construction activities has increased by over 1,000 percent between 1952-89, with a loss of 500 ha of important habitat. Urbanization has destroyed, fragmented, and degraded habitat located on privately owned property within the Key deer's present range. Land use patterns and disturbance drastically increased from the 1950s to 1990s. Much of the pineland, hammock, buttonwood and saltmarsh was developed between 1955-1989 (Folk, *et al.* 1991). The herbaceous diversity and composition of pinelands changed in these 30 years. As stated in the Key Deer Recovery Plan (1980), the major threat to the survival of the Key deer is the alteration of habitat caused by residential and commercial construction activities. Habitat loss resulting from residential and commercial construction has had the greatest impact of all the man-induced effects.

Loss of habitat, particularly on Big Pine Key, has been the largest threat to the Key deer between 1970-1996. Human construction activities within pinelands has destroyed and degraded habitat that is used by Key deer for feeding, resting, and reproduction. In addition urbanization has eliminated important high shelter needed by Key deer during natural disasters such as hurricanes. Hammocks comprise the majority of uplands on most Keys (Folk, *et al.* 1991). Hammocks serve as critical fawning areas for Key deer and the destruction or degradation of these habitats may have reduced the reproductive potential of the Key deer. Mangrove wetlands, buttonwood wetlands, and salt marshes that provide important food plants and are heavily used by Key deer for feeding have experienced some habitat loss as a result of urbanization. Hardwood hammocks that provide drinking water resources, escape cover, food supply, and shelter have been destroyed by construction activities resulting from urbanization. These areas, for the most part, are now protected under the Clean Water Act and the Harbors and Rivers Act.

Habitat degradation also is a concern. Fire suppression has been responsible for deterioration of important pineland habitat (Folk 1986; Carlson, *et al.* 1989), and the ability of land managers to use prescribed fire has been hampered by increasing urbanization. Fire suppression in the pinelands has adversely affected the Key deer by changing or removing important components of its habitat. Studies by Alexander and Dickson (1972) showed a decrease in the number of woody plants per acre on Big Pine Key from 1951-69 that could be contributed, in part, to the lack of fires on the island. Recently burned areas remove vegetation and provide for an increased amount of high quality browse material (Carlson, *et al.* 1993). However, extremely hot fires can damage pinelands by burning through the soil and duff layer and killing woody vegetation at their roots. Today it is necessary to conduct prescribed burns to help mimic natural conditions, but more information is needed to determine what burn conditions will enhance deer habitat and not harm it. For example, a prescribed burn on Upper Sugarloaf Key resulted in excellent deer habitat, where one conducted on Big Pine Key caused total mortalitiy of almost all pines present. Habitat fragmentation from fencing and urbanization has restricted Key deer movements, creating bottlenecks that have interfered with their ability to reach permanent water and feeding areas and have often forced them to cross roads in areas of heavy traffic. Invasive exotic plant species such as Australian pine, Brazilian pepper, and latherleaf have invaded disturbed areas and out-competed native vegetation, which has reduced Key deer foods and habitat. Feral hogs (*Sus scrofa*) and the habitat destruction they cause has become a major threat to Key deer on Little Pine Key.

Road Kills of Key Deer

Residential and commercial construction that has occurred over the past 20 years has increased the number of vehicles and vehicular traffic in the Keys. This additional traffic has increased the likelihood of Key deer/vehicle collisions. Human-related mortality, primarily road kills, is the greatest known source of Key deer deaths. It is well documented that road mortalities are the major cause of death for the Key deer and can impact the population by removing large numbers of animals. Road mortality contributes 75-80 percent of all known deaths, with an average of about 44 animals per year; half of these occur on U.S. Highway 1 (Drummond 1989). In an internal report on road mortalities from 1986 to 1992, National Key Deer Refuge staff stated that the average mortality on U.S. Highway 1 was 23.9 deer per year. The average between 1980 and 1985 was 20.5 per year. This report indicated that road mortality of Key deer on U.S. Highway 1 has increased in recent years. There were 94 documented deer mortalities in 1995 - 66 were roadkills, the remaining 28 were attributed to other causes. This is the highest number of Key deer road mortalities on record and is more than double the average per year between 1986 and 1992. Road mortalities may be correlated to an increase in deer numbers related to improved habitat conditions caused by above average rainfall over the past few years.

Key deer move more during dry season and breeding season between islands and over islands to find fresh water and females (Folk, *et al.* 1991). During cycles when deer numbers are high, road mortalities may have less of a negative impact on the Big Pine Key deer population because most of the animals removed are dispersing males. However, as habitat continues to be degraded and fragmented, carrying capacity and deer numbers are lowered. Catastrophes, such as hurricanes, may reduce Key deer numbers to the extent that road mortalities could adversely affect the population and could actually drive the deer to extinction.

Of the 51 instances of U.S. Highway 1 road mortalities between 1985 and 1992 where motorist residency was known, 60.8 percent were resident drivers. For mortalities off U.S. Highway 1, 95.5 percent were resident drivers. These data indicate that resident drivers are a major threat to Key deer. Increasing numbers of resident drivers would, undoubtedly, increase the probability of road mortalities of Key deer. Increasing residential and commercial construction would also result in increased numbers of resident drivers.

Time of year is also an issue with Key deer road mortalities. Key deer reproductive biology and tourist influx coincide. The highest number of road mortalities of Key deer occur in May and November, which are times of increased tourists. This temporal phenomenon places greater numbers of moving Key deer, especially bucks, at risk when there are greater numbers of motorists unfamiliar with the area and deer situation.

Since 1994, the Service and FDOT have been cooperating in addressing Key deer mortalities on U.S. Highway 1. The FDOT has just concluded the first portion of an investigation into options to reduce mortalities on U.S. Highway 1. While FDOT only has jurisdiction over issues involving U.S. Highway 1, the information generated by their efforts may be useful in attempting to minimize road mortalities on other county roads.

Fencing and Key Deer

Fencing of private property associated with residential and commercial construction has reduced habitat availability for the Key deer. Native habitat that is fenced is no longer available for use by the Key deer. This loss in habitat has reduced food and water availability, shelter and fawning areas needed by deer to survive and reproduce. Large networks of fencing have fragmented Key deer habitat and restricted movement which has further reduced the availability and value of these areas to Key deer. In some cases, residents have erected fences to keep deer from eating their ornamental plants. Fencing is restricted in many areas under the Monroe County Comprehensive Land Use Plan; however, there is important Key deer habitat that does not receive this protection. As of 1990, almost half (44 percent) of Big Pine habitat was unavailable for deer use because of fences (Folk, *et al.* 1991). Fencing has continued since that time. Currently, a survey by refuge staff is being conducted to assess habitat lost to fencing. An additional concern is the injury or loss of life deer suffer as a result of attempting to jump these fences.

Changes in water quality important to Key Deer

Besides natural limitations on the availability of fresh water, humans have placed pressures on the quality and availability of fresh water sources for Key deer. Fresh water resources have been lost and degraded by direct destruction by residential and commercial facilities built between 1970-1996. The availability of fresh water has been reduced as a result of filling, ditching, draining, pollution (septic tanks), illegal dumping, and pumpage from private wells.

Permanent available fresh water occurs on 13 of the 19 islands Key deer use (Folk, *et al.* 1991) (Table 5). Water is available on a semipermanent basis on Little Torch and Little Johnson, and seasonally on Summerland, Annette, and Big Torch Keys. Sources of water are related to rainfall, permanency of

collecting sites, amount of fresh water trapped in limestone, relationship to fresh water lenses, and effects of human disturbances. Low rainfall periods, such as the one in late 1988 to early 1990, place severe limitations on the availability of fresh water, particularly on small islands (Folk, *et al.* 1991). Significant water resources have been lost due to residential and commercial facilities and filling, pumpage, and drainage have decreased the size of lenses and reduced hydroperiod and increased salinity (Folk, *et al.* 1991).

Impoundments next to U.S. Highway 1 provide fresh water for deer use, but the proximity of these sources has caused deer to be more susceptible to road kills. Impoundments have also affected the salinities of nearby waters. Mosquito ditching has contributed permanent useful water and may be important sites during drought on several Keys (Folk, *et al.* 1991). However, ditching has allowed for intrusion of higher salinity tidal waters which affects the availability of suitable freshwater and changes vegetation (Folk, *et al.* 1991). Excavation of isolated rock pits on Big Pine, No Name, and Summerland Keys have affected water availability by increasing evaporation and salinity and decreasing groundwater flow.

As a result of residential expansion, several wetlands were filled on Big Pine and Sugarloaf Keys. Commercial construction along U.S. Highway 1 and road expansions also resulted in the loss of many wetlands on Big Pine, Ramrod, and Cudjoe Keys (Folk, *et al.* 1991). Two subdivisions, Port Pine Heights on Big Pine and Galleon Bay on No Name, were once wetlands that were destroyed for house construction purposes. The dredging of tidal canals into upland areas has lowered water tables and increased drainage from permanent and seasonal lenses (Wightman 1990).

Table 5. The number of permanent fresh water sources for several Keys inhabited by Key deer 1988-1990 (Folk, *et al.* 1991)

Key	Number of Permanent Water Sites
Big Pine	92
Cudjoe	19
Sugarloaf	17
Big Torch	4
No Name	16
Summerland	1
Ramrod	10
Howe	7
Middle Torch	9
Little Torch	3
Little Pine	25
Knockemdown	4

Key	Number of Permanent Water Sites
Little Knockemdown	6
Big Johnson	2
West Water	2

Illegal feeding of the Key Deer

Illegal feeding of Key deer by the general public has adversely affected this species both directly and indirectly. Public feeding is directly correlated with the increase in the number of residents and tourists that has occurred between 1970-1996. Public feeding may lead to nutritional imbalances, increased chance of disease and parasite transmission, and loss of genetic interchange (inbreeding), all of which can lead to direct loss of Key deer or their reproductive potential. Increased harassment of Key deer by people, automobiles and dogs has stressed the deer, possibly resulting in higher mortality and lower reproduction. Illegal feeding by residents and tourists has resulted in ganging behavior, causing the Key deer to become more sedentary and to lose natural alarm and flight responses (Folk and Klimstra, 1991a).

Loss of genetic viability in the Key Deer

Loss of genetic diversity is another threat to the Key deer because of its island environment and the population bottlenecks it has already experienced (Seal and Lacy, 1990). Ganging behavior, low reproductive potential, the small number of breeders in the population, habitat fragmentation, and scattered distribution make the Key deer especially susceptible to genetic problems. Consequences include loss of heterozygosity, adaptability, and reproductive potential resulting from genetic drift and inbreeding depression (Seal and Lacy, 1990). The small population is also at greater risk from the effects of a natural catastrophe (e.g., hurricane) or disease outbreak.

Other human threats to the Key Deer

Dumping of trash and debris has provided both a source and substrate for the establishment of exotic plants which has colonized and degraded native habitats important to Key deer. A loss in habitat quality has lead to a reduction in carry capacity of the habitat which may be responsible for the reduction in the number of deer utilizing the area. Discarded items such as broken glass and wire pose a direct hazard to Key deer using these areas. Major dumping areas occur on most of the Keys that have undeveloped lands such as Big Pine, No Name, and Cudjoe Keys. While dumping has decreased in recent years due to public education and improved trash pickup programs, it will continue to be a problem as the human population increases in the Keys. Other sources of Key deer mortality include poaching, drowning in ditches and canals, attack by dogs, entanglement in fences, sparring between bucks, and foreign debris in

the digestive tract from feeding from trash containers (T. Wilmers, Service, personal communication, 1996).

Detailed overview of Key Deer habitat

Key deer utilize and rely on a combination of several Keys. The range of the Key deer has been divided into major units to reflect similar habitat units (Klimstra, *et al.* 1974). These units contain habitat characteristics (such as availability of fresh water, food, cover, etc.) and space that are believed to minimally meet the needs of the Key deer and include: Big Pine Complex (Newfound Harbor, No Name, Howe, Cudjoe, Annette, Mayo, and Porpoise Keys); Little Pine (Johnson, East Water and unnamed Keys); Torch (Big, Middle, and Little Torch, West Water, Buccaneer Beach, and Ramrod Keys); Knockemdown (Little Knockemdown, Summerland, Wahoo, Toptree Hammock Keys); and Sugarloaf/Cudjoe. Only the Big Pine complex supports a thriving population of Key deer (Folk, *et al.* 1991). Key deer tend to spend more time on islands with more wetlands. There are fewer deer in the western half of the Key deer range. Population estimates of deer on each key are subjective, due to the lack of accurate surveying methods.

Big Pine Complex

The Big Pine complex contains 11 islands that have 3,680 ha of suitable habitat available to Key deer (Folk, *et al.* 1991). Of the keys in the Big Pine complex, only Big Pine Key, and the Newfound Harbor Keys are subject to residential and commercial construction. The Little Pine complex is in public ownership and is not considered to be affected by FEMA. Both Big Pine and No Name Keys provide permanent sources of fresh water. The largest portion of the Key deer population is found within this complex, with the most occurring on Big Pine. Big Pine and adjacent Howe and No Name Keys support the basic core for the entire Key deer range (Folk, *et al.* 1990). Although space, habitat diversity, and freshwater are low on the Newfound Harbor Keys, these areas still provide seasonal use for Key deer. The islands of this complex are important satellite keys, especially No Name, because they provide seasonal use, and are important for expanding populations (emigrants) as well as transients responding to seasonal drives (Folk, *et al* 1991).

No Name Key

No Name has 491 ha of available habitat for the Key deer, with 10 ha of wetlands. Permanent fresh water on No Name is limited, although about 16 sites are available. The two large quarries are believed to have impacted the availability and salinity of fresh water. Excavation of the southern rock pit began in the early 1980s. Blasting and dredging associated with these pits have fractured the limestone substrate and allowed the intrusion of salt water into the adjacent uplands. No Name supports a resident herd. There is long standing evidence of reproduction on No Name. It is also within swimming distances (0.3 to 0.6 km) to Big Pine Key.

Newfound Harbor Keys (Cooks, Hopkins, Big Munson, and Little Palm Keys)

All of these keys are in private ownership. None of these islands provide year round habitat, but fresh water and food are available. In addition, residents and users continue to illegally feed Key deer. The majority of water available to Key deer on these keys is primarily provided by human sources, e.g., swimming pools.

Big Pine Key

Big Pine Key is the most utilized key by the Key deer and is referred to as the population hub. Big Pine is the reproductive center, with a carrying capacity of up to 65-70 percent of the herd (Folk, *et al* 1991). There are approximately a total of 2,503 ha of habitat available, of which 268 ha are wetlands (Folk, *et al.* 1991). There are two major fresh water lenses that provide the best sources of water available in Key deer range (Hanson 1980; Klimstra, *et al* 1974). There are also several smaller permanent and temporary sources available. Extensive water resource losses have occurred as a result of dredge and fill activities. Approximately only 59 percent of the 407 wetlands with fresh water available were protected in 1991. An average of 47 ha/year, mostly pineland, was cleared on Big Pine Key from 1969-1973 (Klimstra, *et al.* 1980). Big Pine Key has more mosquito ditches than the other keys. Although these ditches sometimes provide sources of fresh water to Key deer, they often are more detrimental. Mosquito ditches interfere with natural water flows, increase road mortality of deer that are attracted to ditches along roads, and increase juvenile mortality from deer drowning in the ditches.

Major Subdivisions on Big Pine Key

To enhance the carrying capacity of Big Pine, it is essential to protect remaining undeveloped habitat. There are numerous subdivisions on Big Pine Key that provide suitable habitat for Key deer. Below there is a description of some of the major subdivisions and the role they play in Key deer biology. Protecting selected segments within these residential areas are important for providing open space and reducing the major problems resulting from human interactions and activities.

Port Pine Heights: Port Pine Heights is located in the northernmost portion of Big Pine Key. This subdivision was the first problem area of urbanization for the Key deer. The subdivision is surrounded by Refuge property. Just north of the subdivision there is a small freshwater wetland area currently under restoration. There is suitable Key deer habitat in Port Pine Heights and adjacent areas. The lots in the Port Pine Heights subdivision are unusual because they are open and Key deer utilize all available lots, especially for insect relief. Key deer also feed on ornamental plants in this subdivision. Although there are canals throughout Port Pine Heights, this is an accessible and important area. Because of its location at the north end of Big Pine Key, Key deer have easy access and exchange from other islands to Big Pine Key. Key deer frequently move to Port Pine Heights from Annette, Howe, and Mayo Keys. Feeding of Key deer by humans remains a problem.

Pine Heights: Pine Heights is south of Port Pine Heights on the western side of Big Pine Key. It

is adjacent to the Refuge and the Refuge owns several lots in this subdivision. There are no water lines to Pine Heights and the number of housing structures is low. Key deer utilize habitat in this subdivision because of its undisturbed natural habitat.

Koehn: Koehn's subdivision is directly to the east of Pine Heights and near Refuge property. Numerous Key deer utilize the habitat in this area. Currently the number of vehicle-caused deaths and injuries is fairly low, although this can change as this subdivision expands.

Palm Villa: Palm Villa is south of Koehn's and is the largest contiguous pinelands tract in private ownership on Big Pine Key. Several fresh water wetlands in Palm Villa provide water sources for Key Deer. There are also some government owned properties within Palm Villa. The number of Key deer road kills has been increasing. Palm Villa has the second highest density of road kills per mile. Because the infrastructure is in place in Palm Villa, the likelihood of expansion is high, which will decrease the availability of habitat and increase the likelihood of car-caused deaths. In addition to road mortality, Key deer are also affected by a ditch adjacent to Palm Villa that acts as a travel barrier.

Sands: Sands subdivision is located just north of U.S. Highway 1. In this subdivision, there is a large 15 acre tract available for Key deer use. Key deer that cross U.S. Highway 1 are likely to seek shelter, food, etc., in Sands. Key deer also use Sands as a corridor to travel from northern areas of Big Pine to southern areas. Young bucks are the most likely to use Sands since, they disperse more than does.

Torch Complex (Big, Middle, Little Torch, West Water, Buccaneer Beach, and Ramrod Keys)

The Torch complex contains six islands encompassing a total of 1,806 ha of which, 640 ha are uplands (563 ha) and wetlands (77 ha) and 1,166 ha are tidal. Populations of deer are estimated between 10-15, which is about 60 percent lower than estimates in the mid-1970s (Klimstra, *et al.* 1974). Most of the keys are fairly close to each other (0.1-0.4 km) and are separated by relatively shallow waters, suggesting swimming is quite likely between islands. Land and road connectors also allow migration between Ramrod and the three Torch Keys. Year round fresh water is found on Big and Middle Torch and Ramrod Keys. Annual reproduction has been documented on at least Big and Middle Torch Keys. Because of its proximity, this complex also plays an important role in providing and absorbing emigrants and transients to and from the Big Pine Complex. The rapid changes in land use over the last two decades has resulted in the destruction of habitat.

Big Torch Key

The considerable size of Big Torch Key (632 ha) offers large areas of contiguous habitat suitable for Key deer use (Folk, *et al.* 1991). Although the habitat is not as diverse (no pineland, but useable hammock, buttonwood, and mangrove areas) as Big Pine Key, it has year round fresh water (32 wetlands), little residential or commercial structures (only two percent as of 1991), and evidence of annual deer use and reproduction. Existing low levels of human encroachment have

not yet overexploited remaining Key deer habitat. There were two documented fawns in 1995. Many of the fresh water resources are located on the north end of the island. A deep canal cut across the key on the southern portion has drained groundwater levels, and may have increased salinity in nearby wetlands (Folk, *et al.* 1991). Some of the wetlands have been affected by residential lots, although all lots do not contain structures. There are high levels of deer activity near the beginning portion of the road, which is the longest stretch of road in Key deer range (next to U.S. 1). Road kills on smaller populations can be tremendous. Many of the deer, especially does, on Big Torch Key are believed to travel to Middle Torch Key and other nearby islands.

Middle Torch Key

Only 2 percent of this key had been developed as of 1991 (Folk, *et al.*). Similar to Big Torch, the habitat does not have high diversity, but does have important unique species such as black torch. There are approximately seven fresh water sources on Middle Torch Key, but mosquito ditching, canals, and other dredge and fill activities continue to threaten these sources. In dry conditions, the availability of fresh water may be more limited. Middle Torch Key has the second highest number of mosquito ditches, next to Big Pine Key. A resident Key deer population exists on Middle Torch Key that has been stable for the past 11 years. Annual reproduction and fawning has been documented over the last several years.

Little Torch Key

The northern portion of Little Torch Key provides the most open available hammock space, while the south has more residential areas. A large tract of hammock in the south region was impacted by a canal system that had been built in the northeast corner during the 1980s. This area was known to support transient deer (Folk, *et al.* 1991). Canals and ditches on this island appeared to block normal tidal flow. Useful fresh water sources do not exist year round on Little Torch Key. Although annual reproduction was documented on Little Torch, this key is important in accommodating movement to and from the Big Pine Complex and other nearby islands. A 100+ acre preserve on the south end of the island, owned by The Nature Conservancy, supports (at a minimum) several transient deer.

Ramrod

Most of the Key deer habitat on Ramrod Key has been destroyed by residential construction. There are no areas in public ownership or protection. Despite the low availability of habitat (e.g., only 20 percent low hammock left), the proximity of Ramrod Key to nearby islands allows for migration through it, either by swimming or traveling along U.S. Highway 1 right-of-way. Fresh water is available from six permanent sites. Ground water levels were influenced by the excavation of several canal systems in hammocks north and south of U.S. Highway 1. Next to Big Pine and Middle Torch Keys, Ramrod had the greatest number of mosquito ditches. At least eight Key deer road deaths were documented between 1968-1973 (Klimstra, *et al.* 1974). At least four deaths have occurred since 1985, with one occurring in 1995. Ramrod has the third

highest occurrences of road deaths and may be a bottleneck area. There are no documented vehicular-caused Key deer deaths south of Ramrod (mile marker 26.4).

The Knockemdown Complex

There are five islands in the Knockemdown Complex. This unit contains approximately 1,208 ha, of which 277 ha are uplands, 23 ha of wetlands, and 751 ha tidal. Knockemdown and Toptree Hammock Keys are primarily in public ownership. There is diverse habitat available to Key deer in this complex, but no annual reproduction has been documented. There may be as few as 2-4 animals in this complex. The large number of free-roaming dogs in this area may dictate the number (or lack) of deer in this complex. The suitability for deer use has been lowered due to the extent of human impacts (Folk, *et al.* 1991). Although this complex is further away from Big Pine Key, is still has the potential to support both resident and migratory populations of Key deer.

Summerland Key

Summerland Key is the sixth largest (475 ha) island in the range of the Key deer. It contains 181 ha of uplands (3 ha of which are wetlands). Of this amount, 37 ha (20 percent) are high quality hammock areas, while 144 ha (80 percent) have been converted to residential and commercial dwellings. Most of Summerland is in private ownership and residential construction activities have impacted most of the suitable Key deer habitat, especially in the southern portion. In the early 1990s, water was found to be available only 8 months of the year on Summerland. The availability of water is suspected to be lower now, if at all. Fresh water sources were affected by the alteration of the upland habitat and canal dredging that occurred in the 1950s-1960s south of U.S. Highway 1. There are no documented Key deer road kills on Summerland between 1985-95, although roadkills occurred prior to this. Summerland most likely provides transitional use. Key deer use bridges to travel from Cudjoe Key, or they can swim to nearby areas.

Little Knockemdown Key

Little Knockemdown Key is a small key that contains 66 ha of uplands, all of which are in private ownership. There is suitable habitat and sufficient availability of fresh water to support Key deer. Free roaming dogs continue to be a problem on Little Knockemdown.

Cudjoe and Sugarloaf Keys Complex

This complex contains two islands that contain over 1,948 ha, of which 524 ha are uplands (with 67 ha wetlands) and 1,424 ha are tidal. About 308 ha are in public ownership, with 65 percent of this located in an isolated segment to the north end of upper Sugarloaf Key. Habitat in this complex is diverse, but construction activities have destroyed high quality habitat, especially on Cudjoe. Key deer can travel to this complex by using other islands as steeping stones, or by traveling on U.S. Highway 1. Fresh water is available year round, but is threatened by continual

human alterations. In the early 1970s, approximately 15-20 deer were reported in this complex (Folk, *et al.* 1991), but today this complex only supports transient deer use. Free roaming dogs also pose threats to Key deer in the Cudjoe/Sugarloaf complex.

Cudjoe Key

Cudjoe contains ample suitable habitat and fresh water resources to support Key deer. Of the 139 ha of low hammock on this island, 41 ha were destroyed by human construction activities. By 1991. The upper portion of Cudjoe Key, north of U.S. 1, contains good habitat. Habitat availability is lower south of U.S. Highway 1 as a result of construction activities, but could support deer. Year round water is available in all major upland areas and in impoundments along U.S. Highway 1. A reduction in the deer population was observed in the early 1970s apparently due to residential development and loss of fresh water (Klimstra, *et al.* 1974). Cudjoe supports transient deer. Cudjoe is proximal to the Knockemdown complex which would allow for deer passing.

Sugarloaf Key

Sugarloaf Key contains 790 ha of habitat, of which 200 ha are in public ownership. At least 82 ha have been destroyed by construction activities. There are at least 15 fresh water holes (13 on refuge property, 11 in pineland, 2 in hammock). Most of the permanent water sites are located in a large area north of U.S. Highway 1 (Folk, *et al.* 1991). Although the north portion in upper Sugarloaf is Federally owned, it may not be large enough to sustain a Key deer herd for long periods of time.

Key Largo cotton mouse

The original range of the cotton mouse probably included all the forested uplands of Key Largo. The amount of habitat undoubtedly fluctuated depending on hurricanes, wildfires, and subsequent vegetational succession, but the primary upland vegetation was usually hardwood hammocks. Much of the hammock vegetation on Key Largo has been totally removed or thinned, eliminating habitat for the cotton mouse. Most of this is attributed to construction activities for commercial and residential development. Traditional practices in the Keys involved removing all vegetation, then grading and filling the limestone substrate. The apparent extirpation of the cotton mouse from Key Largo south of the U.S. Highway 1 - S.R. 905 intersection has been generally attributed to land clearing followed by residential and commercial development (Brown 1978a, b; Hersh 1981). Effects of development in tropical hardwood hammocks have been more extreme in the Upper Keys than in the Lower Keys. Today, Key Largo has the highest concentration of platted lots (4,178), comprising 72 percent of all lots in the Upper Keys.

Hammocks up to 4 hectares (10 acres) in size remain on south Key Largo, but no longer appear to support either species. The reasons for this are not known, but several factors may be responsible. Remaining hammocks on south Key Largo are small, isolated, and disturbed, and contain immature

hammock vegetation. They are more vulnerable to invasion by animals associated with man (dogs, cats, and black rats).

Humphrey (1988) estimated that 851 ha (2100 a) of remaining forest on North Key Largo supported average densities of 15.5 cotton mice per hectare; he extrapolated these densities to estimates of about 18,000 cotton mice on north Key Largo. Humphrey (personal communication, 1996) feels that numbers have decreased since then, and that the population may have been at high point in 1984.

In an attempt to establish populations of cotton mice in another location, 14 individuals were translocated to Lignumvitae Key, a State Botanical Site, in 1970 (Brown and Williams, 1971). Cotton mice are not native to Lignumvitae Key, though the hammock habitats of this Key are similar to those of Key Largo. The fate of the mice released on Lignumvitae Key is unclear. One individual was trapped in 1977, indicating that survival and reproduction had occurred for several years, but trapping efforts in 1984 and 1990 yielded no cotton mice (Jeanne Parks and James Duquesnal, Florida Department of Natural Resources, personal communication).

The survival and recovery of the Key Largo cotton mouse is uncertain due to the number of threats that still exist (Appendix 4-6). Historically, north Key Largo was cleared primarily for agriculture, but sufficient hardwood hammock remained available to support the characteristic biota. Permanent loss of habitat however, is relatively recent. The majority of habitat loss is attributed to residential and commercial construction. Cutting of trees for wood and to collect orchids has also occurred in most of the north Key Largo hammocks (Abhor in Weider 1979). Selective cutting of trees may have minor effects on the Key Largo cotton mouse in that hammock maturity is set back. Although much of northern Key Largo is protected, there are still areas where development could occur. An analysis of this area showed that 1,914.5 acres of vacant, dry, privately held lands with development potential remains (Monroe County 1989).

Hardwood hammock habitat has also been affected by dumping of trash. Trash dumping occurs in areas with road access. Trash includes abandoned cars, junked appliances, building materials, plant debris, and many other items. Such debris does not probably greatly affect Key Largo woodrats and cotton mice, which may find shelter in and around such material, however dumping may encourage invasion of black rats (*Rattus rattus*), and discarded plant material has resulted in the introduction of exotic plants (Service 1993c). Fire risk may also increase with trash dumping; one hammock fire apparently originated in a trash pile (Abhor in Weider 1979).

There have been discussions among various agencies concerning the conservation of remaining hardwood hammock on north Key Largo, which would subsequently afford protection to the endangered Key Largo cotton mouse. In 1984, there was interest on the part of several landowners in developing a Habitat Conservation Plan, pursuant to Section 10(a)(B)(1) of the Endangered Species Act, to allow for residential and commercial development on north Key Largo, while conserving Federally listed species in the area. The planning process was initiated, including representatives of landowners, conservation groups, and State agencies. Density and distribution studies of the Key Largo cotton mouse were conducted (Humphrey 1984, 1988). Subsequent public land acquisition, however, largely precluded the need for an overall habitat conservation plan. Public land acquisition on north Key Largo is perhaps the

most important effort benefitting the Key Largo woodrat and cotton mouse. Most undeveloped land west of S.R. 905 has been acquired by the Service, as part of the Crocodile Lake National Wildlife Refuge. Much of the undeveloped land on the east side of the road has been acquired by the Florida Department of Environmental Protection, as part of its North Key Largo Hammocks project. The prospects for hammock protection and restoration are now much better than when both species were listed as endangered species.

Research on the status of the cotton mouse is also being conducted. Philip Frank of the Florida Game and Fresh Water Fish Commission, Marathon Key, Florida, and Dr. Franklin Percival and Britt Keith of the Florida Cooperative Fish and Wildlife Research Unit, Gainesville, Florida, are currently conducting a status survey of the woodrat and cotton mouse on north Key Largo. The study will end in June 1996 and is expected to provide information on the population density, population fluctuations, survival, reproduction, and movements of these rodents on north Key Largo (Quarterly Progress Report, Service Research Work Order No. 123), and will also consider trapping on Lower Key Largo.

Key Largo woodrat

The Key Largo woodrat historically occurred throughout the forested uplands of Key Largo, but is now restricted to approximately half of its historic range, now occurring only north of the U.S. Highway 1 - S.R. 905 intersection. The decline in the woodrat's range has been generally attributed to land clearing followed by residential and commercial development (Brown 1978a, b; Hersh 1981) (Appendix 4-6). Much of the hammock vegetation on Key Largo has been totally removed or thinned, eliminating essential habitat for the woodrat. Construction practices in the Keys typically involved removing all vegetation, then grading and filling the limestone substrate. Effects of construction activities for commercial and residential development in tropical hardwood hammocks have been more extreme in the Upper Keys than in the Lower Keys. Today, Key Largo has the highest concentration of platted lots (4,178), comprising 72 percent of all lots in the Upper Keys. Although much of northern Key Largo is protected, there are still areas where development could occur. An analysis of this area showed that 1,914.5 acres of vacant, dry, privately held lands with development potential remains (Monroe County 1989).

In addition to land clearing practices, there are other threats to the hardwood hammock habitat resulting from human encroachment that also indirectly affect the woodrat. Cutting of trees for wood and to collect orchids has occurred in most of the north Key Largo hammocks (Abhor in Weider 1979). Trash dumping occurs in areas with road access. Actual debris may not greatly affect Key Largo woodrats, however dumping may encourage invasion by black rats (*Rattus rattus*). Hersh (1981) suggested that the introduced black rat might be a serious competitor for the Key Largo woodrat because black rats equaled or exceeded Key Largo woodrat numbers at her study site. Barbour and Humphrey (1982b), however, collected only one black rat in 1,696 trapnights, while Goodyear (1985) collected only two black rats at 45 trap sites. Competition between the two species is possible, but is not yet known to be a serious factor in the decline of the Key Largo woodrat.

Remaining hardwood hammock habitats are critical for the survival of the Key Largo woodrat. Brown (1978b) estimated that only about 120-160 hectares of hammock suitable for woodrats remained on north

Key Largo. Barbour and Humphrey (1982b) estimated that 475 hectares remained there, supporting an estimated 654 woodrats. Numi Goodyear (personal communication, 1996) repeated some transects of the Barbour-Humphrey study in 1984 and found higher stick nest counts. Goodyear (1985) also trapped woodrats slightly outside the range delineated by Barbour and Humphrey (1982b), documenting the species' presence in the Garden Cove area northeast of the U.S. Highway 1- S.R. 905 intersection. Humphrey (1988) estimated that 851 ha (2100 a) of remaining forest supported average densities of 3.1 woodrats per hectare, and extrapolated these densities to estimates of about 6,500 woodrats on north Key Largo. Humphrey (personal communication, 1996) feels that numbers have decreased since then, and that the population may have been at high point in 1984.

In an attempt to establish Key Largo woodrats in another location, 19 individuals were translocated to Lignumvitae Key in 1970 (Brown and Williams 1971). Although woodrats are not native to Lignumvitae Key, the hammock habitats of this Key are similar to those of Key Largo. The woodrat population on Lignumvitae Key apparently remained at low levels at least until 1977, when Hersh (1978) found only six stick nests. Barbour and Humphrey (1982b), however, estimated that 476 stick nests and 85 woodrats were present on Lignumvitae Key in 1979. Woodrat populations had become dense, with many animals showing scars from intraspecific fighting (Jeanne Parks, Florida Department of Environmental Protection, personal communication, 1996). In the late 1980s, woodrats appeared to decline, and by the spring and early summer of 1990, no woodrats were taken in approximately 400 trap nights. Little or no sign of woodrats could be found, and it appeared that the woodrat population must be at a very low level or even extirpated (James Duquesnal, Florida Department of Environmental Protection, personal communication, 1996).

In 1984, several landowners became interested in developing a Habitat Conservation Plan for the Key Largo woodrat, pursuant to section 10(a)(B)(1) of the Endangered Species Act, to allow for residential and commercial development on north Key Largo, while conserving Federally listed species in the area. The planning process was initiated, including representatives of landowners, conservation groups, and State agencies. Density and distribution studies of the Key Largo woodrat were conducted (Humphrey 1984, 1988). Subsequent public land acquisition largely precluded the need for an overall habitat conservation plan.

The most important effort to conserve the Key Largo woodrat has been public land acquisition on north Key Largo. Most undeveloped land west of S.R. 905 has been acquired by the Service as part of the Crocodile Lake National Wildlife Refuge. Much of the undeveloped land on the east side of the road has been acquired by the Florida Department of Environmental Protection, as part of its North Key Largo Hammocks project. The prospects for hammock protection and restoration are now much better than when the species was listed.

Philip Frank of the Florida Game and Fresh Water Fish Commission and Franklin Percival and Britt Keith of the Florida Cooperative Fish and Wildlife Research Unit are currently conducting a status survey of the woodrat on north Key Largo. The study will end in June 1996 and is expected to provide information on the population density, population fluctuations, survival, reproduction, and movements of this species on north Key Largo (Quarterly Progress Report, Service Research Work Order No. 123). They will also consider trapping in suitable locations on south Key Largo.

Other current research for the woodrat includes studies on territoriality of woodrats (Leslie Hay-Smith, University of Florida, personal communication, 1996); genetics variations (Michael Gaines, University of Miami, personal communication, 1996); and a PhD dissertation on the woodrat (Chris Sasso, University of Miami, personal communication, 1996).

Key tree-cactus

The Key tree-cactus is a unique and rare plant species that occurs only in the Florida Keys within the United States. Populations of the Key tree-cactus have always been uncommon and widely scattered (Small 1917, 1921), but are still vulnerable to a variety of threats. This species inhabits only lightly-shaded upland sites within fragile tropical hardwood hammock habitats. This habitat type is uncommon in the Keys and is transient in nature. As tropical hardwood hammocks mature, or as natural thinning occurs, the suitability for the Key tree-cactus is altered. Populations of this species fluctuate from site to site depending upon the availability of suitable habitat. As a result, the survival and recovery of the Key tree-cactus depends on unoccupied habitat as well as occupied habitat.

Key West once held a large population of this species (Britton and Rose, 1937; Small 1917). The last plants apparently died when the final remnants of the original forest were cleared on the island during the 1920s (Small 1921). Plants on nearby Boca Chica Key (Britton and Rose, 1937) presumably shared the same fate. Populations reported for Windley Key and Lower Matecumbe Key (Small 1917) were presumed to have been destroyed (Avery 1982); the population on Lower Matecumbe Key was recently rediscovered (Adams and Lima, 1994). In recent years, a population of Key tree-cactus on Long Key was destroyed when the hammock where it grew, just east of the town of Layton, was cleared for development.

In the Keys, several populations of Key tree-cactus have been eliminated over the last 70 years by development (Austin 1980; Avery [n.d.]; Small 1921, 1924).

Lower Keys marsh rabbit

The Lower Keys marsh rabbit is endemic to the Lower Keys. Species with narrow geographic ranges are more susceptible to extinction (MacArthur and Wilson, 1967; Rabinowitz 1986). Current population estimates range between 150 and 400 rabbits in the Lower Florida Keys. Urbanization has been a deciding factor in the trend of the Lower Keys marsh rabbit. The Lower Keys marsh rabbit is more susceptible to urbanization because of its geographic range and distribution, habitat specificity, and its population size and community dynamics. Between 1970-1996, urbanization has severely endangered the Lower Keys marsh rabbit.

The Lower Keys marsh rabbit occurs in small, disjunct populations whose survival depends on the emigration and dispersal of individuals. In order to persist, the emigration rates of the Lower Keys marsh rabbit have to be equal or greater than the death rates. This subspecies is thought to be less fecund than others, thus naturally making it more susceptible to demographic and stochastic events (Forys 1995). Since breeding occurs year round, urbanization has affected the Lower Keys marsh rabbit reproductive potential year round. In addition to natural threats, residential and commercial construction in the Keys

have caused direct mortality to the marsh rabbit and disrupted their dispersal. With the potential for interchange between subpopulations lowered, the probability of persistence has been substantially decreased.

The current status of the Lower Keys marsh rabbit is considered to be declining (Service 1996). Habitat alteration over the past 20 years is the main reason for this decline. The Lower Keys marsh rabbit is vulnerable to habitat alteration, contaminants, roads, dumping, poaching, domestic animals, feral hogs, fire ants, and exotic vegetation (Appendix 4-6). These threats have resulted in a decrease in the number of populations, a decline in the individuals in those populations, the isolation of populations, an increase in road mortalities, the increase in feral cat-caused mortality, and the loss of foraging, shelter, and nesting habitat. Some of these effects have been temporary pulse effects such as some contaminants, dumping, poaching, feral hogs, and fire ants, while others have become more serious press effects such as habitat alterations, exotic vegetation, roads, domestic animals, and some contaminants. All of these threats have disrupted the equilibrium between Lower Keys marsh rabbit's environment and its survival.

Habitat alteration

The Lower Keys marsh rabbit is habitat specific, depending upon a transition zone of grasses and sedges for feeding, shelter, and nesting. Without these important habitat elements, the survival of the Lower Keys marsh rabbit is drastically reduced. Due to urbanization between 1970-1996, Lower Keys marsh rabbit habitat has been lost and the remaining habitat is very fragmented. Currently, the habitat consists of a mosaic of small native and disturbed habitat patches. In the two years between the study (1988-1990) for the Lower Keys marsh rabbit's listing (Howe 1988) and the actual listing, 4 of the 15 original sites used in the listing were destroyed. Approximately 23 percent of the total suitable habitat (both occupied and unoccupied by rabbits) is owned by the military, 38 percent is Federally, State, or county owned, and the remaining 39 percent is privately owned. The majority of the sites that remain are isolated from each other by urbanized areas, and population interchange seems unlikely. Few of the contiguous areas remaining are greater than 5 ha (Forys, *et al* 1996). Currently, only 81 patches (317 ha) of Lower Keys marsh rabbit habitat remains, of which, 39 percent is privately owned and therefore may be vulnerable to urbanization. Because of this, 39 percent of the Lower Keys marsh rabbit habitat is vulnerable to destruction or degradation to future residential and commercial construction in the Keys. Only 50 (253 ha) of these 81 patches currently have rabbits present.

Because this species exhibits classic metapopulation dynamics, it relies on the recolonization of vacant habitat patches for survival (Forys, *et al.* 1996). Subpopulations in habitat patches are vulnerable to extinction, but vacant habitat patches have the potential to be recolonized by dispersing rabbits. Those sites that are not occupied are just as vulnerable as occupied sites for they are important for future dispersal and recovery. The potential for recolonization has been decreased or eliminated because the Lower Keys marsh rabbit's habitat has been lost or fragmented. Since urbanization has affected both occupied and unoccupied sites, not only is survival affected, but the opportunity for natural or managed recolonization has been precluded. Habitat alteration has become the largest press effect that prevents this species from returning to its natural state.

Continued fragmentation prevents the probability of successful recolonization due to the isolated nature of the habitat, increased road mortality and cat-caused deaths. Urbanization has isolated subpopulations, and interchange between the majority of the sites is unlikely. Adult territories (of the same sex) do not overlap and may be forced to have smaller territories if habitat is continually fragmented. Future residential and commercial construction in the Keys will continue to fragment marsh rabbit habitat and will interfere with their dispersal and migration.

The minimum habitat size considered suitable to support the Lower Keys marsh rabbit is based on the minimum home range size of 0.3 ha. If destruction and fragmentation of habitat continues, then the habitat may be too small to support subpopulations of the Lower Keys marsh rabbit. For example, five occupied habitat patches located on isolated islands without cat predation were determined not large enough to support viable populations of this species over the long term (Forys 1996).

Roads

As urbanization has increased over the past 20 years, new roads or the improvement of existing roads have been necessary to accommodate the need of more vehicles. The construction of roads has caused two main threats to the Lower Keys marsh rabbit: interference with dispersal and mortality; both of which have become press effects. Vehicular traffic interferes with dispersal and prevents essential interchange between subpopulations (Forys, *et al.* 1996). Dispersing males are the most vulnerable to road mortality. Dispersal is responsible for repopulating sites that were naturally extirpated. Since only a portion of the males breed during the year, the loss of these males can lower the likelihood of mating and hence decrease the reproductive potential.

A significant portion of the remaining population of Lower Keys marsh rabbits is found on Naval Air Station (NAS), Key West. The Service consulted in 1993, with the Navy concerning the ongoing issue of Lower Keys marsh rabbit road mortalities. Four Lower Keys marsh rabbit road kills had been reported on NAS, Key West between 1992, and 1994. This represents only those animals that have been recovered, it is reasonable to assume that others were never recorded (undetected in roadside vegetation or carried off by scavengers). Most Lower Keys marsh rabbits are killed between dusk and dawn. Off-road vehicular activities also affect the Lower Keys marsh rabbit through habitat degradation and direct mortality. At least one animal was killed by an off-road vehicle on NAS, Key West. The amount of road mortality has not been determined for other areas in he Keys, but the Service believes Lower Keys marsh rabbits may experience the same mortality as on the NAS, Key West.

Cat predation

Although, habitat loss is responsible for the original decline of the Lower Keys marsh rabbit, high mortality from cats has also occurred and may be the greatest current threat. Even though the exact extent can not be determined, the Service believes urbanization that has occurred between 1970-1996 has caused an increase in the number of cats present. As discussed in the status of the species and shown in the population viability analysis (Forys 1996), cat predation is one of the greatest threats to the Lower Keys marsh rabbit's persistence. Cats are responsible for both juvenile and adult mortality (Forys 1995). Currently, 14 of 19 occupied patches have domestic and feral cats present and is imposing a press

effect on the Lower Keys marsh rabbit. An increase in this press effect will result in a lower persistence rate of the Lower Keys marsh rabbit.

Contaminants

The Lower Keys marsh rabbit may be exposed to pesticides used on marsh habitat. They also may come in contact with poisons used to control black rats. These contaminants can either be ingested while foraging on plants or drinking water. In a 1993 Biological Opinion, the Service investigated the effects of vertebrate control agents on endangered and threatened species. In that Biological Opinion, the Service determined that several chemicals (e.g., Pival) would jeopardize the continued existence of the Lower Keys marsh rabbit. This conclusion was based on the already endangered status of this species, the lethality of certain chemicals, and the high probability this species would encounter the chemical. Chemicals, such as Pival - a rodenticide used to kill rats, are lethal if ingested. The Service also concluded that if development in the Keys continues to increase, the potential for these animals to come in contact with such chemicals also increases, as does the potential for their extinction. Based on these findings, the Service still believes the continued use of such chemicals will result in the deaths of Lower Keys marsh rabbits. Given that the majority of occupied habitat is adjacent to urbanized areas, and that urbanization continues to expand into their habitat, then it can reasonably be predicted that the use of such chemicals have imposed a press effect upon the Lower Keys marsh rabbit that may prevent its recovery.

Other human effects

Some of the pulse effects caused by humans include contamination, dumping, poaching, feral hogs, and fire ants. Increased nutrients from septic tanks and fertilizers degrade water quality in habitat of the Lower Keys marsh rabbit. Illegal dumping deteriorates habitat and allows the infestation of exotic plants and animals to occur. Poaching has decreased, although it still occurs infrequently. Feral hogs destroy Lower Keys marsh rabbit habitat while foraging, but the extent of impact has not been analyzed. Fire ants have been increasing in marsh habitat and pose a threat to newborns. These human-induced effects have threatened the Lower Keys marsh rabbit over the past 26 years, but to a lesser degree than the above mentioned issues.

Recovery potential

The Lower Keys marsh rabbit's natural recovery potential is quite low due to the lack of available habitat and increased mortality due to cats and roads. This survival potential is increased if active management actions of populations and habitats are taken (Forys 1996). Since residential and commercial construction affected both occupied and unoccupied sites over the past 26 years, not only has the marsh rabbit's survival been affected, but opportunities to recover the marsh rabbit have been precluded.

Schaus' swallowtail butterfly

The majority of the Schaus' swallowtail butterfly population is found on Adams, Elliott, Old Rhodes, Swan, and Totten Keys within Biscayne National Park (BNP). Between 1985 and 1990, the Elliott Key population fluctuated between 600 to 1,000 adults annually, with smaller populations of at least 50 to 100 individuals on each of the other Keys. Hurricane Andrew significantly reduced the BNP's population in 1993 to 58 identified individuals, however, in 1994 the population rebounded naturally to over 600 individuals and is presumed stable (Emmel 1995a).

Within the major Keys of BNP (Elliott, Old Rhodes, Totten, and Adams Keys) and on northern Key Largo, the two food plants of the Schaus' swallowtail butterfly seem adequate to support a healthy population. High numbers of individuals sighted in 1985 (Emmel 1985b) indicate that the Schaus' swallowtail butterfly's population is still capable of periodic peaks. As now managed, BNP also provides adequate cover for both Schaus' swallowtail butterfly adults and food plants (Emmel 1985a, Service 1982b). This cover includes mature and well-drained tropical hardwood hammock with some natural and man-made openings such as narrow trails and clearings where nectaring and courting behavior can take place close to the more enclosed jungle-like forest where adults spend much of their time (Service 1982b).

The Schaus' swallowtail butterfly is restricted to a habitat where its primary foodplant, torchwood, grows abundantly (Service 1982b). This habitat is limited to coastal southeast Florida and the Upper Keys, in mature tropical hardwood hammocks. Prior to human influences, populations of this butterfly were probably subject to naturally occurring population depressions caused by hurricane damage, drought, and rare freezes (Covell 1976). The influence of the Labor Day hurricane of 1935 on the Lower Matecumbe Key population was documented by Grimshawe (1940), though she was incorrect in claiming that the species became extinct (it was found there and on Key Largo in succeeding years) (Henderson 1945). However, Grimshawe's careful searching was negative, and her "before and after" experience demonstrates that this hurricane had a detrimental effect on the biota of the Keys southwest of Key Largo.

Clearing of habitat for urban and agricultural purposes in and around Miami, Homestead, and Lower Matecumbe Key certainly were instrumental in eliminating the Schaus' swallowtail butterfly from its type locality in the extremes of its historic range (Appendix 4-6). Foodplants were probably either eliminated or reduced to small stands incapable of sustaining Schaus' swallowtail butterfly populations (Service 1982b). Similar clearing has occurred within its known north Key Largo habitat, but litigation has slowed development of the area (Covell 1976). Slight alteration of habitat, such as dirt roads and trails through the hammocks, seem to be harmful only in that they permit easy access to collectors, who can catch butterflies when they fly low along these trails. However, small clearings and trail edges seem to promote proliferation of torchwood plants. Natural succession in such places, particularly following hurricanes and fires, could account for population increases in the species and its foodplants (Baggett 1985). Large fires and extensive forest clearing are also detrimental to the species.

Paved roads through Schaus' swallowtail butterfly habitat, particularly S. R. 905 on northern Key Largo, permit road kill of adults, one case of which is documented (Covell 1976). Aerial application of

insecticides to control biting Diptera may affect Schaus' swallowtail butterfly populations on Key Largo, but these effects are not known (Service 1982b, Covell 1976). The pesticides Dibrom, Baytex, and Teknar, used in the Keys for mosquito control, are toxic to the related giant swallowtail in the laboratory (Emmel 1986b).

Collecting of immature stages, as well as adults, may have reduced numbers on Key Largo in the period 1969-1974; but, again the lasting effects cannot be gauged (Covell 1976). Commercial exploitation has existed, but its extent cannot be assessed due to secrecy on the part of dealers.

Little is known about predation by spiders, lizards, birds, or other predators. Damage to wings occurs soon after adult emergence, and beak marks on some individuals indicate frequent bird attacks (Emmel 1985a). Flight behavior among the many obstacles in hammock habitat seems unusually deliberate, in that the butterflies can fly slowly and painstakingly to avoid the many large orb spider webs and branches to a remarkable degree (Emmel 1985a). Emmel also states that butterflies are able to remember flight paths through hammocks and follow them repeatedly. A tendency toward Batesian mimicry, with the Zebra butterfly (*Heliconius charitonius* L., Nymphalidae) as a model has also been observed and discussed (Emmel 1985a, 1986a; Rutkowski 1971). Covell notes that larval predation is surely minimized by oviposition behavior (one egg per leaf and few per foodplant), bird-dropping appearance of the larvae (as in other *Papilio* larvae), secretive behavior of larvae, and bad-smelling scents from the osmeteria when larvae are disturbed (Grimshawe 1940, Rutkowski 1971). Crypsis in the pupa (Grimshawe 1940) as in other swallowtails is also a factor in avoiding predation. Nothing is known about parasites of this species. No information is available regarding diseases of the Schaus' swallowtail butterfly. However, high egg mortality has been observed (Service 1982b, Rutkowski 1971).

The principal future threats to Schaus swallowtail butterfly survival and recovery are the following, in descending order: extreme climatic conditions, especially hurricanes, freezes, and droughts; habitat modification, especially developmental clearing and fires; introduction of pesticides and other hazardous chemicals; and road kills and death by predators, parasites, and collectors.

According to the Service's Recovery Team (1996), recovery actions for the Schaus' swallowtail butterfly should focus on acquiring additional hardwood hammock habitat and protecting those areas and existing hammock from development. Captive propagation and release of this species could facilitate its recovery to those areas. Reclassifying the status of the Schaus' swallowtail butterfly from endangered to threatened would require a total population of 2000 individuals in the seven protected sites where they have been released. One or two additional release sites of suitable hardwood hammock need to be identified in the Middle and Lower Keys.

As part of a recovery action for the Schaus' swallowtail butterfly, 760 pupae were released in 1995 on seven protected sites (T. Emmel, personal communication, 1996). Depredation by birds accounted for an estimated 85-90 percent mortality rate. In 1996, this effort involved the release of 248 female and 155 male adult Schaus' swallowtail butterflies on those same seven sites (Figure 9). All females were mated prior to release. The success of this recovery action is currently being monitored, and an additional release of adults to those same areas has been proposed for 1997, with monitoring continuing through 1998.

Silver rice rat

The silver rice rat occurs on 11 islands in the Lower Keys, and is restricted to a narrow range of wetland habitat types. Populations are widely distributed and occur at extremely low densities. This species appears to be persisting at least on those Keys with available population data, including Raccoon, Saddlebunch, Middle Torch, Big Torch, and Summerland Keys (Vessey, *et al.* 1976; Goodyear 1987, 1993; Wolfe 1987a, 1897b). There has been no follow-up research conducted on Little Pine, Johnston, or Water Keys since the original distribution survey (Goodyear 1984), so the status of those populations is unknown. Silver rice rats apparently no longer occupy the freshwater marsh (type locality) on Cudjoe Key (Barbour and Humphrey, 1982b; Goodyear (1987), but trapping in suitable salt marsh habitat has never been conducted on that particular Key. In a recent study of the population dynamics of the silver rice rat, Forys, *et al.* (1996) confirmed that this species still occurs at extremely low densities (mean = 2.29/ha during 24 trapping periods), in suitable habitat throughout the Lower Keys (Figure 10).

Forys, *et al.* (1996) also found that the silver rice rat occurs at comparable densities in both scrub and fringe mangrove communities. Microhabitat data from that study and from Goodyear (1989) suggest that this species spends most of its time in red and black mangroves. The silver rice rat also requires a large home range. Spitzer (1983) recorded a 22.8 ha home range for a male silver rice rat on Summerland Key. Forys, *et al.* (1996) observed movements of 325m in one day. The need for a large home range may indicate a limited supply of food or freshwater resources for the silver rice rat in the Lower Keys. A low reproductive rate is also an indicator of limiting food resources in wildlife populations. Forys, *et al* (1996) found that juvenile rice rats comprised only 14 percent of the total number of individuals captured in their study. This is significantly less than results from studies of *O. palustris* in Mississippi and Louisiana (Negus, *et al.* 1961; Wolfe 1985). Although survivorship of silver rice rats in the Keys was found to be relatively high, the low proportion of juveniles in this population may indicate a low reproductive rate. In addition, Forys, *et al.* (1996) found that the sex ratio of adults was male biased (66 males:19 females).

The primary threat to the survival and recovery of the silver rice rat is the destruction of wetland habitat where this species occurs (Appendix 4-6). Silver rice rats require expanses of high-quality salt marsh habitat. They are extremely limited in habitat occupancy, occurring in salt marsh and transitional buttonwood habitats. The survival and recovery of the silver rice rat may be adversely affected by construction activities for residential and commercial development, as well as by mangrove trimming. These activities can cause direct mortality of individuals through land clearing and habitat loss. Habitat loss cumulatively creates habitat fragmentation, which may result in isolated patches of habitat too small to support the already unstable populations of silver rice rat. Secondary threats from human encroachment on the viability of the silver rice rat have been difficult to quantify because of the low population densities of this species throughout the Lower Keys.

Domestic cats are abundant throughout the Lower Keys, and forage in the higher elevation salt marsh habitats also used by the silver rice rat. Because rodents are often the most abundant items in a domestic cat's diet (Eberhard 1954; Churcher and Lawton, 1989), the potential for domestic cats to prey upon silver rice rats is high. Given the low densities of silver rice rats throughout the Lower Keys, any increase in cat predation would pose a direct press effect on the species' survival.

Human habitation and solid waste accumulation encourages establishment of black rats. Goodyear (1993) has shown that silver rice rats and black rats exhibit extensive niche overlap, and that islands with high densities of black rats support few silver rice rats. Goodyear's data suggest that black rats may out compete silver rice rats for food and habitat resources; in areas of suitable habitat, the occurrence of black rats may preclude the survival of silver rice rats. Black rats may also prey upon newborn silver rice rats (B. Forys, personal communication, 1995). Pesticides that are used to control black rats also threaten the silver rice rat (Service 1993b).

Exotic fire ants, another secondary effect to human encroachment, may cause direct mortality of silver rice rats. Fire ants have been documented to cause declines in populations of small mammals in Texas (Killion, *et al.* 1990; Killion and Grant, 1993). The ants are attracted to mucous, so newborn silver rice rats would be vulnerable to predation.

In some areas, the natural hydrologic cycles of silver rice rat wetland habitat has been altered by the construction of fill roads, borrow pits, and mosquito ditches. While the effect of these disturbances on silver rice rat ecology is unknown, it is most likely adverse. These alterations may also encourage invasion by exotic vegetation which may reduce the ability of the habitat to support rice rats.

The small, isolated, and widely distributed populations of silver rice rats are also vulnerable to extinction through random demographic fluctuations, loss of genetic variability caused by small population size, and stochastic environmental events (e.g., hurricanes) that may affect the entire population.

Considering the limited range, habitat specificity, and low population density of the silver rice rat, it is unlikely that this animal or its habitat was ever extremely abundant in the Lower Keys, at least in recent times.

Critical Habitat for the Silver Rice Rat

Critical habitat only affects Federal agency actions and does not apply to private, local, or State government activities that are not subject to Federal authorization or funding. Federal agencies affected by the designation of silver rice rat critical habitat include the Service's NKDR, COE, and FEMA (58 FR 46031). Seven of the nine keys in critical habitat are within the NKDR boundaries. Although the NKDR is managed for Key deer, the habitat requirements and biological needs of the species do not conflict. Both the permitting program of the COE and the administration of flood insurance by FEMA are affected by the silver rice rat's critical habitat designation. The COE is required to ensure that issuance of permits, under Section 404 of the Clean water Act, does not likely result in the destruction or adverse modification of critical habitat for the silver rice rat. Permitting actions that may affect the silver rice rat or areas within silver rice rat critical habitat require Section 7 consultation with the Service. These actions include such activities as the filling of transitional wetlands for residential purposes. FEMA provides flood insurance for residential and commercial activities; which in some cases involves structures in silver rice rat critical habitat. A large portion of the construction of platted subdivisions and single family residences has occurred in silver rice rat habitat between 1970-1996. Many of these are located within critical habitat. The construction of these subdivisions resulted in the

loss of silver rice rat habitat. In addition, these construction activities have also increased the number of predators and competitors, such as dogs, cats, raccoons, and black rats.

Stock Island tree snail

The Stock Island tree snail is an arboreal snail inhabiting hardwood hammocks of the Keys. Its historic range includes the islands of Stock Island and Key West. Individuals of the species have since been moved to other hammocks in the Keys and the mainland. The restricted range of this subspecies and extirpation from Key West and much of Stock Island by 1978 led to its being listed as threatened. The population has continued to decline as a result of further habitat loss due to real estate development, pesticide use, over-collecting, and predation by exotic species including fire ants and black rats (Appendix 4-6). The snail has apparently been fully extirpated from its historic range.

The recovery plan for the Stock Island tree snail (Service 1982) reported museum collections as having no Key West specimens beyond 1938. Pilsbry (1946) also believed the snail was extinct from Key West when he wrote his treatise on North American land Mollusca. Others since that time have confirmed a lack of sightings from Key West.

Extant populations of the Stock Island tree snail exist at four locations outside the historical range. All four areas were known to support Stock Island tree snails in the recent past; however, informal surveys conducted by Service and GFC biologists in 1995 showed a decline in populations or no observation of live snails. This would indicate a downward trend in these snail populations. More intensive surveys are required to obtain reliable population trend and status data.

The Stock Island tree snail is declining. Surveys of known populations were conducted in late September and early October 1995 at the peak of the rainy season. The surveys concluded that Stock Island tree snails are now totally absent from Stock Island and Key West. The four populations on Key Largo were all concluded to be existing at some undetermined level, with both live snails and empty shells being found. The surveys also concluded that two of the Key Largo sites, both privately owned, contain fairly healthy populations. The Monkey Jungle population apparently continues to do well. The single known mainland site (Everglades Weather Station) documented by Deisler (1987) and others was surveyed both in 1995 and also previously in 1994. It was concluded that this hammock no longer contains Stock Island tree snails. As previously mentioned, snails are continuously being moved by various individuals. Individuals have recently been distributed to some residents for placement in the Lower Keys and, perhaps on private lands in Key West. Therefore, it is very difficult to track the current distribution.

Because of its limited range, the survivability of Stock Island tree snail is threatened by natural disasters, such as hurricanes and drought. A single natural disaster could extirpate the species completely.

The Stock Island tree snail is subjected to many human-induced threats. However, the greatest threat is loss of habitat. Increased urbanization in the Keys over the last 26 years has led to the destruction, fragmentation and reduction in quality of habitat throughout its historic and present range. Pesticide use near known sites of the Stock Island tree snail has impacted populations by poisoning animals directly or altering reproduction. Dumping or improper disposal of trash and debris has provided both a source and

substrate for the establishment of exotic plants which have colonized and degraded hardwood hammocks used by the Stock Island tree snail. Trash and debris piles have also served as a food source and provided home sites for exotic animals such as black rats that have preyed on the snail. Illegal collecting of Stock Island tree snail has reduced snail populations and contributed to the extirpation of the snail from Stock Island (Service 1982).

There is no active management for the Stock Island tree snail. There have been several cases of Section 9 "take" violations in Key Largo. State Wildlife Officers are currently investigating these incidents, and Service Law Enforcement is also conducting its own investigations.

Integration and Synthesis

The U.S. District Court for the Southern District of Florida concluded that the National Flood Insurance Act constituted a Federal action for the purposes of Section 7 of the Endangered Species Act of 1973, as amended, and required FEMA to consult on whether their action was likely to jeopardize the continued existence of the endangered Key deer. In this section of the Biological Opinion, we provided an overview of the NFIP and summarized how it has affected threatened and endangered species from its beginnings in the Florida Keys (in 1970) to the present (1996). The significance of the NFIP began slowly in the Keys and resulted in only 38 policies by 1983. The number of policies covered by the NFIP increased dramatically in the early 1980s: by 1984, nearly three quarters of homeowners surveyed in the Lower Keys obtained flood insurance. On Big Pine Key, the number of policies increased by more than 14 times between 1983 and 1984 alone (from 37 policies in 1983 to 552 policies in 1984).

By the late 1980s, insurance issued by FEMA or subject to FEMA regulations was the only major source of commercial or residential flood insurance that was generally available in the Keys. For example, by 1989, there were 1,186 policies in effect on Big Pine Key. By 1995, FEMA had issued a total of 32,251 flood insurance policies throughout Monroe County.

Threatened and endangered species in the Keys have been affected by a sequence of events that begins with land use decisions by Monroe County and ends with habitat destruction or modification for residential or commercial construction projects; the NFIP exists within and influences that sequence of events. To participate in the NFIP, Monroe County had to adopt and enforce specific floodplain management regulations that affect land use decisions in the Keys. Once Monroe County became a participating community, the NFIP affects land use decisions in the County by creating a series of incentives, including assuring landowners who build in the County that the Federal government will insure their property against flood damage. However, the NFIP was not the only program in that chain of events; many other Federal, State, and local agencies administered programs that finally determined whether and how a residential or commercial construction project would affect threatened and endangered species in the Keys. The Monroe County government had to issue building permits for these construction projects. The COE had to issue a permit for most of these construction projects and the Service had to issue a biological opinion that allowed the COE to issue a permit that adversely affected threatened or endangered species.

Between 1970 and 1996, many agencies other than FEMA undertook actions that also had significant direct or indirect effects on threatened and endangered species in the Keys. The Florida Keys Aqueduct Authority constructed a water delivery system that increased the availability of potable water in the Keys. The Monroe County government constructed roads and other utilities which increased the level of services provided to the residents of the Keys and made the Keys more attractive for new residents. Many of these projects also required permits from the COE who received biological opinions on the projects from the Service before issuing the permits.

We have not asserted that FEMA or any other agency is singularly responsible for changes in the status and trends of threatened and endangered species between 1970 and 1996. Nevertheless, these actions have had significant cumulative environmental effects on the flora and fauna of the Keys. The status of threatened and endangered species is the best evidence of the environmental effects of these land use changes in the Keys. During the period covered by the Environmental Baseline, nine of the species covered by this Biological Opinion were listed as threatened or endangered because of habitat destruction or modification in the Keys. Between 1976, when it was originally listed as threatened, and 1984, the Schaus' swallowtail butterfly lost so much habitat and so many populations that it was reclassified from threatened to endangered. Between 1988 and 1990, when it was finally listed as endangered, almost one of every three sites that were known to support Lower Keys marsh rabbits was destroyed.

By 1996, the Key tree-cactus has been reduced to two sites in the Keys. By 1996, the Lower Keys marsh rabbit has been reduced to 150 to 400 animals occupying 50 habitat fragments that total about 253 hectares (acres) of the Lower Keys. By 1996, the Stock Island tree snail has been reduced to four populations and has not occurred in its historic range for more than a decade. By 1996, the status of several of the threatened and endangered species in the Keys had declined to the point that extreme measures had to be taken to prevent extinction. To prevent extinction, the Service has had to establish captive populations of the Schaus' swallowtail butterfly and the Stock Island tree snail.

By 1996, the Key deer has been reduced to 250-300 animals and their range has been reduced to Big Pine and No Name Keys, with occasional animals occurring on adjacent Keys. More Key deer are killed by automobiles each year than the herd can produce in a year; no population can survive a death rate that regularly exceeds its birth rate for long. By 1995, an administrative commission concluded that the number of people the Keys can support without severe environmental damage had been exceeded and, as a result, the nearshore waters of the Keys have been degraded, seagrasses surrounding the Keys are declining, and the Key deer are at a greater risk of extinction.

By 1996, the Governor of Florida concluded that water quality in the Keys and Florida Bay had been severely degraded by untreated or improperly treated wastewater and unmanaged stormwater. The Governor also agreed with the conclusions reached by the Administrative Hearing Officer: that the Monroe County comprehensive plan would not protect threatened and endangered species and that the amount of residential and commercial land uses in the Keys has reduced the carrying capacity of the Keys for the Key deer.

EFFECTS OF THE ACTION

In the *Description of the Action* section of this Biological Opinion, the Service provided an overview of FEMA's National Flood Insurance Program in the Keys. After that overview, we summarized information on the biology, ecology, and threats facing threatened and endangered species in the Keys. In the *Environmental Baseline* section of this Biological Opinion, the Service summarized the effects of the NFIP on threatened and endangered species in the Keys. Because the *Environmental Baseline* for this Biological Opinion covers more than 2 decades and includes the actions of other Federal, State, and local programs that affect land uses in the Keys, the Service was not able to separate the effects of the NFIP from the effects of these other actions. As a result the *Environmental Baseline* summarized the actions of other Federal, State, and local agencies and their effects on threatened and endangered species in the Keys from 1970 to 1996.

In this section of our Biological Opinion, the Service will summarize the *probable* direct and indirect effects of the NFIP on threatened and endangered species in the Keys. To evaluate the effects of the NFIP on threatened and endangered species in the Keys, we had to establish the duration of the proposed action. We know FEMA has administered the NFIP in the Keys for about 23 years, as of the date of this consultation. There is nothing in the National Flood Insurance Act or FEMA's implementing regulations that suggests the NFIP will cease in the forseeable future, so we assumed that FEMA will administer the NFIP in the Keys as long as there is a demand for flood insurance and as long as Monroe County participates in the NFIP. We had no information on growth patterns in Monroe County beyond the year 2020, so we evaluated effects based on population trends and land use changes between 1996 and 2020.

As we outlined in previous sections of this Biological Opinion, the Service is assessing the effects of the NFIP on threatened and endangered species in Monroe County, Florida. FEMA, through the NFIP, controls the risk of flood damage by requiring Monroe County to impose suitable land-use controls in flood plain areas as a condition for the County's enrollment in the NFIP. In return for adopting these land-use controls and flood plain management ordinances to minimize the risk of flood damage, FEMA insures property owners against property loss and damage from flooding. The NFIP, as administered by FEMA, is involved in several stages in a sequence of events that begins before a structure is designed and ends with habitat destruction or modification for the construction of residential or commercial structures.

The effects analysis for this Biological Opinion was difficult to conduct because FEMA does not directly permit actions that affect the quantity and quality of habitat for threatened and endangered species in the Keys. Instead, the NFIP affects land use planning and zoning in the Keys and creates incentives or disincentives for landowners in the Keys. We could not quantify the degree to which the incentives provided by the NFIP influenced landowners' decisions on where to purchase property and construct homes. Conversely, we could not quantify the degree to which landowners would chose not to build in the Keys because flood insurance was either not affordable or not readily available. As a result, the

Service had to make several assumptions to analyze the effects of the NFIP on threatened and endangered species in the Keys. First, we assumed that the projected increases in the human population of the Keys were accurate and those people would live in the Keys. Increases in human population in the Keys would then influence direct and indirect effects on listed species. Second, we assumed that all of those people would be exposed to NFIP when purchasing or building a home, when acquiring flood insurance, or when acquiring flood insurance as a condition of receiving a permanent mortgage for their homes. The exposure to the NFIP supports the sequence of events discussed earlier. Third, we assumed that most of these people would make different choices on the location of their home if Federal flood insurance and Federally-insured mortgages were not available in the Keys. Depending on the location of where people chose to build would have an effect on the habitat and species present. Fourth, we assumed that most new construction activity would result in a new or substantially-improved structure. Because of this, the end result would be the destruction or modification of habitat and, in return, impacts on listed species. These assumptions could cause us to overestimate the impact of the NFIP on construction activities in the Keys.

However, we believe our projections are conservative. We estimated the effects of the NFIP based on information on the number of citizens that are projected to move to the Keys and the number of vacant, residential lots available for new housing construction. We could not project the growth of new or existing businesses that require flood insurance or new construction associated with these businesses. Further, we could not verify the accuracy of our residential and commercial information for incorporated areas of the Keys. Therefore, the projected effects of the NFIP does not account for the effects of commercial construction on threatened and endangered species in the Keys.

Assessment Approach

Our assessment of the effects of the NFIP on threatened and endangered species in the Florida Keys is habitat-based. To conduct our assessment we projected changes in habitat area, connectivity, and quality and assumed threatened and endangered species would experience demographic changes (changes in population size, distribution, reproduction, mortality, etc.) rather than assess those demographic changes directly. The relationship between changes in habitat quantity, quality, and connectivity and plant and animal populations has been the subject of extensive scientific research and publication, so we believe our assumption is consistent with the best scientific and commercial information available. What follows is a brief summary of that literature; for more detailed summaries the reader can refer to the work of Fiedler and Jain (1992), Gentry (1986), Gilpin and Soule (1986), MacArthur and Wilson (1967), Nicholson (1954), Odum (1971, 1989), Shafer (1990), and Soule (1986, 1987).

The most basic relationship between habitat and populations is embodied in the concept of *carrying capacity*. The concept of carrying capacity recognizes that a specific area of land or water can support a finite population of a particular species because food or other resources are finite (Odum 1971). By extension, *increasing the carrying capacity* of an area (that is, increasing the amount or quality of resources available to members of a species), increases the number of individuals an area can support over time. By the same reasoning, *decreasing the carrying capacity* of an area (that is, decreasing the amount or quality of resources available to members of a species), decreases the number of individuals an area can support over time. Restoring habitat that had been destroyed or degraded increases the

carrying capacity of an area; conversely, land clearing and land alteration reduce the carrying capacity of an area. In either case there is a corresponding, but non-linear relationship, between changes in the carrying capacity of an area and the number of individuals that area can support. Our concern associated with this particular action is the effect of decreased carrying capacity.

Several mechanisms determine the relationship between reductions in carrying capacity and the response of populations to that reduction. Every organism needs some form of nourishment to become sexually mature and reproduce; some organisms also need shelter and cover to complete their maturation and reproductive processes and to rear their offspring. Reductions in the habitat in which plants and animals find those resources reduce the amount available. At some point, the supply of food or other resources available to plants and animals falls below the demand for those resources; when this occurs, individual plants or animals die and populations decline.

In this Biological Opinion, we try to determine whether implementation of the NFIP in the Florida Keys is likely to reduce the carrying capacity of the Keys for threatened and endangered species. In general, we will make this determination by estimating probable changes in the quantity, distribution, and quality of suitable habitat for threatened and endangered species in the Florida Keys resulting from the construction of residential housing, commercial facilities, or infrastructural improvements. Reductions in carrying capacity from land clearing or degradation are inexorable changes that lead to deterministic extinctions, which occur when individual organisms are denied something essential to their life history (such as space, food, or shelter) or when something lethal is introduced into their habitat (such as domestic animals) (Gilpin and Soule, 1986).

If we determine such a reduction in carrying capacity is likely, based on the principles outlined above, we assume a corresponding reduction in the size and distribution of populations of threatened and endangered species is also likely. At some point, reductions in carrying capacity (and corresponding reductions in the number, size, structure, and composition of plant and animal populations) threaten species with extinction; the species we are addressing in this biological opinion have already crossed this threshold. This Biological Opinion is an assessment of whether implementation of the NFIP in the Florida Keys increases the likelihood of extinction in species that already have a high probability of extinction as a baseline condition.

Methods

To analyze the effects of the proposed action, we compiled what we believe is the best, relevant, scientific, and commercial information available for the Keys using Arc/Info (version 7.0.4; ESRI 1995). Using this information, we constructed data layers in a GIS on (1) the distribution of threatened and endangered species; (2) the distribution of habitat types (that is, vegetative communities); (3) shoreline, primary and secondary roads; (4) FEMA's Flood Insurance Rate Maps; (5) FEMA's Coastal Barrier Resources Maps; and (6) public and private lands that are managed for conservation. We established peer review panels, consisting of species experts, to validate our data on the distribution, abundance, biology, and ecology of the threatened and endangered species included in this Biological Opinion. We had to reconcile some of our data on the Coastal Barrier Resources Maps with FEMA to correct coverage on Big Pine Key and North Key Largo.

Using these data layers, we generated maps for 9 of the 10 species that we included in this Biological Opinion (Figures ##). Those maps represent suitable (that is, occupied and unoccupied habitat) for each of these species. We did not generate a map for the Garber's spurge because our data on its distribution and abundance was limited; consequently the maps for this species represent the best information on the historical distribution of this species and our best estimation of the current distribution of the habitats this species has been associated with. Our mapping effort has a +/- 40 ft data error; that is, every GIS layer is accurate to within 40 ft. For every layer added, this error multiplies. For example, coverage with two layers (vegetative coverage and land management coverage) has an error of 80 feet.

To further analyze the specific effects of the NFIP in the Keys, we narrowed the action area to those areas in which flood insurance is available. We identified those areas by generating maps that isolated areas included in the Coastal Barrier Resources System and "otherwise protected areas;" those areas outside of these two categories are areas in which flood insurance is available. The analysis of effects that follows is based on activities that we believe are likely to occur in the latter area. The amount of habitat for each species that occurs in areas where flood insurance can be issued is listed in the following table. (To generate the percentages in the following table, we identified the amount of habitat that is not within public or private conservation areas. This gave us the total amount of "unprotected" habitat; the percentages represent the amount of habitat in which flood insurance is available as a percentage of the total "unprotected" acreage).

Species	Unprotected habitat affected by NFIP	Percent of Total
Eastern indigo snake	1108 hectares	32
Key deer	2944 hectares	56
Key Largo cotton mouse	22 hectares	5
Key Largo woodrat	22 hectares	5
Key tree-cactus	151 hectares	10
Lower Keys marsh rabbit	243 hectares	56
Silver rice rat	745 hectares	28
Schaus' swallowtail butterfly	570 hectares	50
Stock Island tree snail	443 hectares	50

Since the late 1980s, insurance issued by FEMA or subject to FEMA regulations was the only major source of commercial or residential flood insurance that was generally available in the Keys. Any new construction or substantial improvements to existing structures within Federally-designated SFHAs cannot be financed with Federal funds or loan guarantees without flood insurance. Direct and indirect Federal funding for private residential or commercial construction, including grants, loans, and mortgages, Federal Housing Authority mortgage insurance, Veteran's Administration mortgage

guarantees, and Federal disaster relief all require the purchase of flood insurance. In addition, Federally regulated or insured institutions are prohibited from making, renewing, or increasing loans secured by existing or new structures located in SFHAs without flood insurance (FEMA 1991b).

Projected increases in the size of the human population in Monroe County

Between 1980 and 1990, the population of Monroe County increased by 32.8 percent. Between 1992 and 2020, the population of Monroe County is projected to increase by about 139 percent. These numbers only reflect the increase in the permanent (resident) population of Monroe County; the population is projected to increase by 149 percent (from 1990) if tourists and seasonal residents are included with permanent residents (Table 6).

Table 6: Changes in the human population size in Monroe County (by year)

	1980	1990	1992	2000*	2010*	2020*
Censused population	63,098	78,024	80,968	91,300	102,300	112,300
Functional population		134,600				200,000

* projected population estimate

The more than 31,000 people who are expected to become new, permanent residents of Monroe County between 1992 and 2020 will need homes. Some of these people will acquire Federally insured mortgages to purchase existing residences and hence will acquire FEMA flood insurance, while others will need to comply with FEMA flood requirements prior to building a home or in some cases prior to acquiring a mortgage to build new homes.

Availability of Land for Residential and Commercial Construction in Monroe County

Our analysis of land use in Monroe County is based on information provided by Monroe County and the Monroe County Comprehensive Plans. Currently, there are approximately 21,127 acres of vacant land in Monroe County, comprising approximately 34 percent of the total acreage of the County. These 21,127 acres do not include any of the 14,953 vacant, buildable lots already zoned and platted for residential uses, nor does this acreage include conservation and recreational lands, such as State Parks and Preserves.

Properties available as vacant residential lands include Improved Subdivision (IS), Urban Residential Mobile Home (URM), and Commercial Fishing Village (CFV). These categories allow one dwelling unit per lot. Monroe County uses "lots" to characterize land use instead of acreage. There are a total of 37,128 IS, URM, and CFV lots in Monroe County, of which 21,394 (or 57.6 percent) have already been developed; 14,923 (or 40.2 percent) are vacant and available for structures, and 375 (1.0 percent) are in conservation protection. Of this total, there are 14,923 developable, residential lots and 5,640 developable, non-residential lots remaining in unincorporated Monroe County (Monroe County 1996). Therefore, we estimate about 14,923 lots do not have structures that may be affected by the NFIP.

Although there are 14,923 vacant, developable, residential lots in Monroe County, this number may not reflect the residential construction potential. The construction potential may be lower because Land Development Regulations try to manage the County's growth within its carrying capacity. Monroe County developed a Future Land Use Map that determines future land use patterns and residential and commercial construction based on the critical measure of carrying capacity. Carrying capacity is based on hurricane evacuation clearance times. Future land use predictions may be less than what can actually occur based on carrying capacity. Actual growth patterns are determined through the Permit Allocation System (also known as Rate of Growth Ordinance or ROGO). ROGO is divided into two point systems: residential and non-residential. The residential point system has been implemented since 1992, while the non-residential point system should be fully in place by 1997.

As we will discuss below, this residential construction will not be equally distributed throughout the Keys. In the short term, the rate of growth ordinance implemented by Monroe County would limit the annual rates of growth in the Upper, Middle, and Lower Keys to 99 units, 41 units, and 115 units respectively. After those limits are lifted, half of the construction would probably occur in the Lower Keys, particularly on Big Pine, Big Torch, No Name, and Ramrod Keys. One third of the remaining construction would probably occur on Key Largo. The final percentage would probably occur on Marathon, in the Middle Keys.

The Year 2010 Comprehensive Plan allows 255 dwelling units per year, through 2010. In addition, 239 square feet of non-residential development will be permitted for every one dwelling unit permitted. A total of 610,000 s.f. of non-residential construction could be permitted through 2010 or a total of 61,000 s.f. per year. Already 220,198 s.f. of commercial activity has been permitted, and Monroe county only expects to permit 184,840 more square feet through 2010.

The lots available for new residential and commercial construction are not evenly distributed throughout the Keys (Tables 7, 8). According to Monroe County, the Lower Keys have 45 percent of the vacant lots available in unincorporated Monroe County; about 20 percent of those lots are on Big Pine Key. Thirty-nine percent of the vacant lots are in the Upper Keys; about 28 percent of those lots are on Key Largo. About 16 percent of the lots are in the Middle Keys; about 6 percent of those are on Marathon.

Table 7. Summary of vacant lots, by area, in Monroe County

Area	Vacant Lots		Limits on Dwelling Units*	Narrative
	Number	%		
Upper Keys	5823	39	99	
Key Largo	4178	28		In the upper Keys, Key Largo has 72 percent of all vacant lots
Middle Keys	2345	16	41	
Lower Keys	6755	45	115	

* Since 1992, Monroe County adopted and implemented a rate of growth ordinance that imposed these limits on growth

In the Upper Keys, there are 5,823 vacant lots, with 4,178 lots available in Key Largo. In the Middle Keys, there are an estimated 2,345 vacant lots available for residential or commercial purposes. About 6 percent (933) of these lots occur on Marathon. In the Lower Keys, there are an estimated 6,755 lots available for residential or commercial construction. Of these, 2,919 lots (20 percent) are found on Big Pine Key. Big Pine Key accounts for 43 percent of all vacant lots in the Lower Keys.

Table 8. Percentage of "developable" lots not occupied by structures for various Keys in Monroe County

Key	% lots w/o structures	Key	% lots w/o structures
Big Pine	36	No Name	50
Big Torch	84	Ramrod	28
Cudjoe	21	Sugarloaf	18
Little Torch	18	Summerland	18
Middle Torch	0.00		

An additional 31,000 people are expected to become new, permanent residents of the Keys between 1992 and 2020. Based on the information provided by Monroe County, if only half of these people build new residences, they will occupy all of the lots available for residential construction in the Keys. In other words, *if only half of these people build new residences in the Keys, they will clear all of the habitat on the 14,953 vacant, buildable lots already zoned and platted for residential uses.*

Effects of the National Flood Insurance Program on Listed Species in the Keys

Before purchasing property in the Keys, a potential buyer is made aware of FEMA's flood regulations that set minimum restrictions on those properties within SFHAs. In order to qualify for a Federally insured mortgage or other Federal loan guarantees, land owners in the Keys would have to acquire flood insurance. The Service cannot precisely project how many of these land owners would purchase policies with the NFIP, but we will assume that most land owners who purchase flood insurance will purchase insurance from FEMA or from a write-your-own agency. Given the statements of fact submitted by FEMA (1989b) and the conclusions of *Florida Key Deer v. Stickney,* we believe this assumption accurately reflects the best scientific and commercial information available.

As was true during the Environmental Baseline for this Biological Opinion, the flood insurance policies issued by FEMA would not have direct, adverse affects on threatened and endangered species in the Keys. However, as we wrote in the Environmental Baseline, we believe administration of the NFIP by FEMA, particularly its influence on County land use planning throughout the Keys, is part of a sequence of events that ends with the destruction of the native communities that support threatened and endangered species. As stated in the beginning of this section, the Service is analyzing the effects of FEMA's actions from 1996 to the year 2020.

We realize this projection may not fully integrate the role of Federal, State, and local regulatory agencies in land conversion in the Keys. However, given the *Environmental Baseline* for this Biological Opinion, we believe this approach is consistent with the history of land regulation in the Keys.

Although we cannot predict how homeowners would construct their homes on a particular lot, we will assume they will clear most of the vegetation on property prior to construction. With these assumptions, we would expect residential housing to occur on all of the remaining 14,923 lots in the Keys. In the short term (between now and the turn of the century), Monroe County's rate of growth ordinance limits the pace of residential growth in the Keys to 255 residential units per year. Based on this information, we believe the NFIP could provide incentives for construction on 6,000 and 15,000 vacant lots in the Keys between now and 2020. Each of these new landowners would then apply for building permits, permits from Federal and State regulatory agencies prior to clearing their properties, constructing new houses, and then apply for flood insurance.

The construction of these homes will be preceded by clearing existing vegetation which, as we outlined in the beginning of this chapter, will be a permanent reduction in the carrying capacity of the Florida Keys for plant and animal populations. In addition, these new residential houses and increased numbers of people will have other, indirect effects on threatened and endangered species in the Keys. Construction of these new residential houses will further fragment the already-fragmented habitats of the Keys. The increased numbers of people will increase traffic volumes throughout the Keys and increase the numbers of wildlife killed in collisions with automobiles. The increased numbers of people will increase the demand for new roads and other infrastructure and improvements in existing roads and infrastructure.

This combination of activities has already caused the Service to add all of the species included in this Biological Opinion to the Federal list of threatened and endangered species. The land use planning and zoning ordinances required for Monroe County's participation in the NFIP and the incentives created by the NFIP itself will continue the sequence of events that leads to the destruction of the native communities that provide habitat for these threatened and endangered species. We believe that continuing this sequence of events into the future will further reduce the carrying capacity of the Florida Keys for threatened and endangered species and, consequently, will decrease the likelihood that these species will survive or recover in the wild. In the following section, we discuss the projected effects of the action on the survival and recovery of the threatened and endangered species in the Keys. (In the following section, we will refer to the land use planning and zoning ordinances required for the NFIP and the incentives created by the NFIP as "the proposed action" or "the NFIP, as administered in the Keys.")

Eastern indigo snake

Suitable eastern indigo snake habitat includes all habitat types in the action area except developed lands, mangroves, salt marsh, and deep water areas (Fig 18). Based on our GIS analyses, the proposed action is likely to affect 1,108 hectares of potential eastern indigo snake habitat. This represents 32 percent of the snake's habitat outside of CBRA zones that are vulnerable to construction activity. The activities resulting from the proposed action will result in the destruction of suitable habitat, fragmentation of habitat, the increase in road mortalities, and other human impacts (Appendix 4-6).

Eastern indigo snakes require a mosaic of different habitat throughout their life cycle for such activities as feeding and breeding. The amount of habitat clearing that results during construction activities will remove habitat available for the snake's use. Since indigo snakes have large home ranges (from 5 to 200 hectares), they are susceptible to construction activities that fragment existing habitat types. Although eastern indigo snakes generally eat a wide variety of food items, the loss of habitat may decrease the food base available. Additional growth in the Keys would increase the risk of direct mortality of the eastern indigo snake from property owners and domestic animals. Mortality from vehicular traffic is a pulse effect on this species. An increase in human growth in the Keys would cause a greater probability of direct mortality from automobiles. Secondary exposure to rodenticides used to control black rats may also occur (Service 1993a).

Eastern indigo snake populations in the Keys are peripheral populations that have adapted to the conditions of more isolated and tropical environments. As we discussed previously, the status of this species in the Keys and throughout its entire range is declining due to habitat loss. The proposed action could result in the loss of 1,108 hectares of habitat, fragment existing habitat, interfere with breeding, feeding, and movement and increase snake road mortalities. Considering the low number of individuals and the continual loss of habitat rangewide, additional impacts from FEMA may extirpate this peripheral population from the Keys. Although the Keys population represents only a portion of the total population, the loss of this population would represent a dramatic reduction in the range of a species that is experiencing dramatic declines throughout its range.

Garber's spurge

The Garber's spurge is an early successional species, found in open, sunny areas throughout the Keys, as well as along road sides. The spurge's habitat includes semi-exposed limestone shores, open calcareous salt flats, pine rocklands, calcareous sands of beach ridges, and along disturbed roadsides. Many of these are prone to disturbance: pine rocklands and coastal grasslands are subject to frequent fire, and coastal habitats are subject to periodic submergence at high tide or during storm surges. Habitat loss and degradation are the primary threats to the Garber's spurge. Because the spurge occupies a variety of small, patchy habitats, we were unable to use GIS analyses to calculate the amount of habitat that is likely to be affected by the proposed action.

Although we could not determine the amount of occupied spurge habitat affected by the proposed action, the proposed action would adversely affect this species by providing incentives for habitat loss and the associated loss of individual plants. Residential and commercial construction projects will also have secondary effects, such as habitat fragmentation, fire suppression, and exotic plant invasion. Habitat fragmentation intensifies the effects of natural events like strong storms and hurricanes. A small, isolated population of Garber's spurge can be eliminated by erosion or deposition of debris during a storm. Fire suppression as pulse effects in pineland and grassland areas eliminates sunny openings that are necessary for the species to survive. In addition, all of the above factors increase the threat of exotic plant invasion. Coastal habitats become shaded when exotic species invade, decreasing habitat quality and survival for the Garber's spurge. Although this species is much more stable than once believed, it is critical to protect remaining suitable habitat for its continued survival and recovery. The proposed action may impair the ability for this species to survive and preclude opportunities to recover this species.

Key deer

Prior to European colonization of the Keys in the early 18th century, the Key deer probably was exposed to very few natural competitors or predators. The population dynamics of the Key deer had evolved to withstand natural phenomena such as drought, hurricanes, fire, etc. Behavioral responses (e.g., migration) and physiological adaptations (e.g., low reproductive output) were a result of natural conditions as they existed prior to human influence (Hardin 1974; Klimstra, *et al.* 1974; Silvy 1975; Folk and Klimstra, 1995a). Since the intrusion of man, Key deer have been exposed to influences they had not evolved to overcome, hence their almost extinction between 1940-1950 (Folk, *et al.* 1991), and their continual decline today.

Historically, the maximum population of Key deer was probably between 600-700 individuals occupying about 19,000 acres of habitat in the historical range (Seal, *et al.* 1990). Suitable Key deer habitat is represented as the entire range of the Key deer (Service 1985).

Currently, approximately 5,272 hectares of habitat remain vulnerable to residential and commercial construction. Of that total, 2,944 hectares or 56 percent of the unprotected habitat will be affected by the NFIP. The remaining, suitable habitat of the Key deer can support about 150 deer although the Key deer population is currently estimated between 250-300 individuals. Because of previous and current patterns of urban and commercial expansion in the Florida Keys, there is little opportunity to increase the carrying capacity for the Key deer, so the population will probably decline over time until it approximates 150 animals (Seal, *et al.* 1990, Service 1996).

A population viability assessment (PVA) for the Key deer was completed in 1990 to evaluate the potential risk of extinction in the next 100 years. This analysis provided important information on assessing risk of extinction; impacts of management options on the risk of extinction; and targets for recovery of the Key deer. The PVA predicted that an initial Key deer population of 250, under existing conditions, has a 74 percent probability of going extinct in the next 67 years. For a population size of 150 animals, the probability of extinction increases to 85 percent in the next 62 years (Seal, *et al.* 1990). If habitat continues to be urbanized, the potential for Key deer survival decreases substantially. If loss of habitat ceases, the likelihood of persistence increases (Seal, *et al.* 1990). In addition to loss of habitat, the persistence of the Key deer is affected by natural events such as hurricanes and sea level rise.

Since the current Key deer population probably exceeds the capacity of the habitat to support further, increases in population size, any additional losses of habitat attributed to urbanization will contribute to the decline of the Key deer population and reduce the maximum population size. The NFIP, as administered in the Keys, could result in the total loss or fragmentation of 2,944 hectares of suitable Key deer habitat (Figure 19), which will constitute a further, permanent reduction in the carrying capacity of the Florida Keys for this species. In addition, the proposed action will also increase the number of residents in the Keys which will result in increases in Key deer road mortality, ganging behaviors, negative effects related to urbanization (such as illegal feeding, dogs, decrease in water quality, etc.), and the Key deer's susceptibility to natural catastrophes. Therefore, we believe that continuing the proposed action will appreciably diminish the likelihood of the Key deer's survival and recovery in the wild.

Key Largo cotton mouse

The range of the Key Largo cotton mouse has declined by more than 50 percent because of habitat loss to land clearing for residential and commercial construction (National Audubon Society, *et al.* 1992; Brown 1978a; Hersh 1981; Barbour and Humphrey, 1982b). Most of the remaining habitat is restricted to hammock remnants on the northern portion of this Key (Figure 20). This species requires relatively large areas of mature hammocks that are free from human disturbance (Service 1973; Brown 1978b; Hersh 1981; Barbour and Humphrey, 1982b). Cotton mice will not use habitat proximate to human residences and commercial areas and as a result, the survival and recovery of the Key Largo cotton mouse depends primarily on protection and restoration of all remnant hardwood hammock habitats on Key Largo.

Habitat alteration

Effects of urbanization in tropical hardwood hammocks have been more extreme in the Upper Keys than in the Lower Keys. Today, Key Largo has the highest concentration of platted lots (4,178), comprising 72 percent of all lots in the Upper Keys. Suitable habitat for the cotton mouse includes all of Key Largo north of the U.S. 1 - S.R. 905 intersection (Service 1993c) and tropical hardwood hammocks greater than 5 hectares on the rest of Key Largo. Based on our GIS analyses, only 4,877 hectares of habitat remain for the Key Largo cotton mouse. Of this total, 4,445 hectares (91 percent) are protected and 432 hectares vulnerable to urbanization. Approximately 22 hectares (0.5 percent) of this unprotected habitat is not in the CBRS and could be affected by the proposed action. Most of this unprotected acreage occurs adjacent to the golf course of the Harbor Course residential area on North Key Largo, with a small fragment south of the marina on the western edge of the residential area (west of Gateway Road).

The loss of this 22 hectares of habitat would isolate a population that lives north of the Ocean Reef Colony and would, thereby, eliminate the northern range of this species. In addition, the loss of this habitat would degrade the quality of habitat to the south of the potential development area. In addition to effects on the species' currently occupied habitat on north Key Largo, the majority of habitats in their former ranges on south Key Largo have already been destroyed or fragmented by residential and commercial construction. These areas will be affected by land clearing for residential housing in the Florida Keys and may preclude the opportunities to recover this species. The extent of fragmentation has been more severe in seasonal deciduous forests than mangrove forests (Strong and Bancroft, 1994).

If their habitat is destroyed, the ability of the cotton mouse to forage is diminished. The cotton mouse is omnivorous, feeding on leaves, buds, seeds, and fruits produced from hardwood hammock trees. Further, habitat loss and fragmentation can directly affect the reproductive abilities of the cotton mouse. Physical separation caused by these activities makes it increasingly difficult to locate a mate. The Key Largo cotton mouse is estimated to live an average of 5 months and needs to produce two to three litters of about four young during its short lifespan. Any lack of recruitment of juveniles into the population will result in the decline of the population.

Secondary effects from the proposed action

Additional residential and commercial construction resulting from the NFIP will result in more people,

and thus more domestic animals. Feral cats prey on cotton mice; this increased predation poses a major threat to the survival of this rodent. Dumping of trash encourages invasion by exotic black rats. Rodent control agents used for black rats or Norway rats pose a threat to the cotton mouse (Service 1993a).

Key Largo woodrat

Because the Key Largo woodrat and the cotton mouse occupy similar habitats and were listed for the same reasons, the range of the Key Largo woodrat has declined by the same percentage as the cotton mouse's habitat by more than 50 percent because of habitat loss to land clearing for residential and commercial construction (National Audubon Society, *et al.* 1992; Brown 1978a; Hersh 1981; Barbour and Humphrey, 1982b). Most of the remaining habitat is restricted to hammock remnants on the northern portion of this Key (Fig. 20). A number of the large portions of the remaining habitat are fragmented and surrounded by residential housing. Because this species requires relatively large areas of mature hammocks that are free from human disturbance (Service 1973; Brown 1978b; Hersh 1981; Barbour and Humphrey, 1982b); these woodrats will not use habitat adjacent to human residences and commercial areas. As a result, the survival and recovery of the Key Largo woodrat depends primarily on acquisition and restoration of all remnant hardwood hammock habitats on Key Largo.

Habitat alteration

Effects of urbanization in tropical hardwood hammocks have been more extreme in the Upper Keys than in the Lower Keys. Today, Key Largo has the highest concentration of platted lots (4,178), comprising 72 percent of all lots in the Upper Keys. Suitable habitat for the woodrat includes all of Key Largo north of the U.S. 1 - S.R. 905 intersection (Service 1993c) and tropical hardwood hammocks greater than 5 hectares on the rest of Key Largo. Based on our GIS analyses, only 4,877 hectares of habitat remain for the Key Largo woodrat. Of this total, 4,445 hectares (91 percent) are protected and 432 hectares vulnerable to urbanization. Approximately 22 hectares (0.5 percent) of this unprotected habitat is not in the CBRS and could be affected by the proposed action. Most of this unprotected areage occurs in the golf course of the Harbor Course residential area on North Key Largo, with a small fragment south of the marina on the western edge of the residential area (west of Gateway Road).

The loss of this 22 hectares of habitat would isolate a population that remains north of the Ocean Reef Colony and would, thereby, eliminate the northern range of this species. In addition, the loss of this habitat would degrade the quality of habitat to the south of the potential development area which may preclude future recovery actions (Figure 20). In addition to effects on the species' currently occupied habitat on north Key Largo, the majority of habitats in their former ranges on south Key Largo have already been destroyed or fragmented by residential and commercial construction. The extent of fragmentation has been more severe in seasonal deciduous forests than mangrove forests (Strong and Bancroft, 1994).

Habitat destruction or degradation directly affects the ability of the woodrat to forage. The woodrat is a vegetarian and feeds on leaves, buds, seeds, and fruits produced from hardwood hammock trees. Further, habitat loss and fragmentation can directly affect the woodrat's ability to reproduce. Physical separation caused by these activities makes it increasingly difficult to locate a mate.

Secondary effects from the proposed action

Additional residential and commercial construction resulting from the NFIP will result in more people, and thus more domestic animals. Feral cats prey on cotton mice. Increased predation is a press effect, and poses a major threat to the survival of this rodent. Dumping of trash encourages invasion by exotic black rats. Hersh (1981) suggested that the introduced black rat may be a serious competitor for the Key Largo woodrat, in particular.

Key tree-cactus

The Key tree-cactus is a unique and rare plant species that occurs only in the Florida Keys within the United States. Populations of the Key tree-cactus have always been uncommon and widely scattered (Small 1917, 1921). This species inhabits only lightly-shaded upland sites within fragile tropical hardwood hammock habitats. This habitat type is uncommon in the Keys and is transient in nature. As tropical hardwood hammocks mature, or as natural thinning occurs, the suitability for the Key tree-cactus is altered. Populations of this species fluctuate from site-to-site depending upon the availability of suitable habitat. As a result, it is critical to consider unoccupied habitat as well as occupied habitat for the future conservation of the Key tree-cactus. Potential habitat for the Key tree-cactus includes all hammocks as defined by the Advanced Identification of wetlands study done by Florida Marine Research Institute. Currently there are only two sites that contain self-sustaining popluations. The proposed action is likely to affect 151 acres of Key tree-cactus habitat. Additional construction activities resulting from the proposed action is likely to directly affect the Key tree-cactus in occupied habitats and may affect it in unoccupied habitats as well.

In the Keys, several populations of Key tree-cactus have been eliminated over the last 70 years by development (Austin 1980; Avery [n.d.]; Small 1921, 1924). The survival and recovery of the Key tree-cactus depends on protecting the remaining tropical hardwood hammock areas throughout the Keys. Recovery criteria needed to upgrade this species to threatened include establishing four vigorous self-sustaining populations throughout the Keys. Seven self-sustaining populations would need to be established to delist the species. Presently, two such sites are in existence: one is on Big Pine Key in the cactus hammock, and the other is on Long Key. The National Audubon Society, *et al.* (1992) identified areas of tropical hardwood hammocks throughout the Keys for proposed acquisition by the State that would preserve the biological diversity of the hammock ecosystem. The Service believes that protection, conservation, and management of these areas, as indicated in Figure 21a,b, are critical to the survival and recovery of the Key tree-cactus. The loss of 151 acres because of the proposed action and other accompanying human impacts may impair the ability of this species to survive and preclude the opportunity to recover this species.

Lower Keys marsh rabbit

The criteria we used to analyze the effects of the proposed action on the Lower Keys marsh rabbit are habitat size, habitat quality (vegetation present, exotic infestation, fragmentation), use of habitat (reproduction, feeding), proximity to other rabbit populations, proximity to human influences (cats, roads

etc.). The information presented in the Environmental Baseline outlines the cumulative effects of Federal, State, local, and private actions between 1970-1996 on habitat, reproduction, and likelihood of survival. Based on the information available to us, the Lower Keys marsh rabbit exists on 50 habitat patches within a 48 km (30 mile) area of the Lower Keys. Most of these habitat patches are smaller than 3 ha and the total area of all suitable, occupied habitat is about 253 ha.

A Population Viability Analysis (PVA) predicted that the Lower Keys marsh rabbit will go extinct in the next 20 - 30 years under current existing conditions (Forys 1995). Although the PVA did not evaluate the effects of any increases in the threats, the Service expects that such increases would only accelerate the extinction of the Lower Keys marsh rabbit. When different management scenarios were included in the model, the persistence of the Lower Keys marsh rabbit was extended to 50 years if all predation by cats were removed (Forys and Humphrey, in press). Unless predation by cats was eliminated, none of the other management alternatives improved the persistence of the marsh rabbit. Persistence was not extended as long if all road mortality was removed or reintroductions into vacant patches were conducted. The PVA did not assess whether habitat restoration, introductions into occupied habitats, or a combination of management activities would change persistence rates. Considering the desperate condition of the Lower Keys marsh rabbit, the Service believes any actions that make this condition worse will only push it toward extinction.

Habitat suitability and occupancy was determined by field surveys (Forys, *et al.* 1996). Of the habitat that remains, a large portion of it is located close to human influences. Based on our analyses, 430 ha of suitable habitat are vulnerable to urbanization, of which 243 ha (or 56 percent) could be affected by the proposed action. These areas are indicated on Figure 22. Approximately 56 percent of this habitat is subjected to the proposed action causing an even greater threat to the Lower Keys marsh rabbit.

In addition, a 500 m buffer zone around these sites are also considered to be affected by the proposed action. The necessity for a protected buffer is based on the likelihood that human influences encroach upon and impact the Lower Keys marsh rabbit. The distance of 500 m is based on the utilization of upland areas by this species and the estimated range of domestic cats (Frank, GFC, personal communication, 1996). Upland and wetland buffers are important habitat because they provide connectivity between subpopulations and minimize secondary impacts such as road and cat mortality.

The Lower Keys marsh rabbit is a very sensitive species that is naturally vulnerable to stochastic and deterministic events and continues to exist in an endangered condition. Since the viability of the Lower Keys marsh rabbit is extremely precarious, any further increase in threats, such as urbanization, could easily drive it to extinction. Our concern for the viability of this endangered species is increased because of its narrow range and distribution, habitat specificity, classic metapopulation community dynamics that rely on dispersal, and low recovery potential.

The NFIP, as administered in the Keys, is likely to affect the Lower Keys marsh rabbit by increasing the number of residences in 56 percent of its habitat, increasing habitat alteration (destruction, fragmentation, degradation), increasing species mortality, interfering with reproduction, decreasing the water quality, and precluding recovery. Therefore, we believe the proposed action is likely to appreciably reduce the likelihood of this species' survival and recovery in the wild.

Schaus' swallowtail butterfly

There are a number of existing and potential future threats to the Schaus' swallowtail butterfly survival and recovery. The principle pulse effects include extreme climatic conditions, particularly hurricanes, freezes, and droughts, as well as road kills and death by predators, parasites and collectors. Press effects include habitat modification, fires, and introduction of pesticides and other hazardous chemicals. Although population numbers of the Schaus' swallowtail butterfly fluctuate year to year, between 1924-1981 there has been a general decline in range and numbers. The Schaus' butterfly has been considered rare on north Key Largo since the mid-1970s.

Habitat alteration

Suitable habitat remaining for this species is estimated as 43 percent for Biscayne National Park and 17 percent for north Key Largo. This decline has been attributed primarily to habitat destruction. National Audubon Society, *et al.* (1992) discusses the extent to which tropical hardwood hammocks in the Keys have already been lost to construction activities. North Key Largo contains one of the last remaining protected areas of this habitat. Suitable Schaus' swallowtail butterfly habitat includes all hammocks north of the U.S. 1 and S.R. 905 intersection and all hammocks greater than 5 hectares south of U.S. 1 and S.R. 905. There are 1,143 ha of Schaus' habitat in private ownership that are susceptible to urbanization. Approximately 50 percent of this unprotected habitat is outside of CBRA zones and are affected by the proposed action.

Any additional loss on north Key Largo resulting from the proposed action would adversely affect this species. Human activities would result in loss and fragmentation of habitat, and potential direct mortality of animals. Increasing habitat fragmentation, combined with a decreased range, makes the Schaus' butterfly more susceptible to natural catastrophes such as hurricanes or fire. Conversion of hammock areas to other uses would directly destroy the vegetation upon which the Schaus' swallowtail butterfly depends for feeding and ovipositing of eggs, and thus directly affect the survival of the species.

Secondary effects of the proposed action

The use of commercial pesticides has also attributed to the decline of the Schaus' swallowtail butterfly. Pesticides used for mosquito control would increase with an increase in residential construction. Monroe County currently operates an active mosquito control program. The pesticides Dibrom, Baytex, and Teknar, used in the Keys for mosquito control, are toxic to the related giant swallowtail *(Heraclides cresphontes)* in the laboratory (Emmel 1986b). Mortality of Schaus' swallow-tail butterfly could occur from the use of these chemicals directly, and indirectly, by application to food sources and other components of the habitat. Pesticides can also cause behavioral modification and impaired reproduction. The Service (1993a) states that it is very likely that the extensive use of mosquito control pesticides has greatly reduced butterfly populations. An increase in urbanization also results in an increase in the need for roads. Road mortality of Schaus' butterfly has been documented (Covell 1976) and can be expected to continue into the future.

Effects on recovery

Additional commercial or residential activity in tropical hardwood hammock habitat of the Upper Keys would adversely affect the survival and recovery of the Schaus' swallowtail butterfly. According to the Service Recovery Team (1996), recovery actions for the Schaus' butterfly should focus on acquiring additional hardwood hammock habitat and protecting those areas and existing hammock from destruction. To reconsider reclassification of the Schaus' swallowtail butterfly from endangered to threatened, the Service would require a total population of 2,000 individuals in the seven protected sites where they have been released. In addition, one or two additional release sites of suitable hardwood hammock need to be identified in the Middle and Lower Keys. The National Audubon Society, *et al.* (1992) identified areas of tropical hardwood hammocks throughout the Keys for proposed acquisition by the State that would preserve the biological diversity of the hammock ecosystem. The Service believes that protection, conservation, and management of these areas, as indicated on Figure 23, are critical to the survival and recovery of the Schaus' swallowtail butterfly.

Silver rice rat

The silver rice rat is a rare Lower Keys endemic, existing at extremely low densities where it is known to occur. Forys, *et al.* (1996) confirmed the narrow geographic range and small, local population size for this species. Because of low population densities (an average of 2.3 per ha) the silver rice rat is vulnerable to extinction through random demographic fluctuations and environmental events that may affect the entire population. Suitable rice rat habitat includes habitat as identified in the survey by Florida Game and Fresh Water Fish Commission (Forys, *et al.* 1996) with a 500 m buffer around occupied habitat and habitat on Raccoon and Water Keys (Figure 24). At least 2,643 hectares of suitable rat habitat are in private ownership and could be destroyed by construction activities. Approximately 745 hectares of this total (28 percent) are outside of CBRA zones and are affected by the proposed action.

The loss and degradation of almost one third of the remaining habitat for the silver rice rat would represent a permanent lowering of the carrying capacity for this species. Although we cannot project the population reduction that would accompany such a reduction, we believe such a reduction is reasonably certain. Because of the low densities of silver rice rat populations in the Florida Keys, we believe reducing the amount and quality of its remaining habitat and the size of its remaining populations places the silver rice rat at a greater risk of extinction. Additional human encroachment into silver rice rat habitat would increase the density of domestic cats which are known predators of silver rice rats, and increase the presence of black rats, which are likely competitors with this species. If female silver rice rats are more vulnerable to predation or competition, as a possible explanation for the skewed sex ratio in the population, these threats could ultimately result in the extirpation of the species. Forys, *et al.* (1996) trapped individual rice rats in areas of very sparse residential development and suggested that marshes in proximity to human impacts are still capable of supporting silver rice rats. However, land clearing in or immediately adjacent to silver rice rat habitat could adversely affect the survival and recovery of the species.

Critical habitat

Habitat loss through construction activities, resource limitation, and domestic and non-native predators and competitors are all factors contributing to the low numbers of the silver rice rat in the Lower Keys.

Because of its rarity, population declines could easily occur without notice. Given the unstable nature of the silver rice rat populations in the Lower Keys, and the need for a large amount of contiguous habitat to secure the resources it depends upon, it is critical to protect the 745 hectares of unsecure habitat to ensure its survival and recovery. We believe the proposed action is likely to appreciably diminish the value of this critical habitat for the survival and recovery of the silver rice rat in the wild.

Stock Island tree snail

The Stock Island tree snail has been extirpated from its historic range due to a number of factors including habitat destruction, pesticide use, over collecting, and depredation by fire ants and black rats. Most of the hardwood hammocks that could serve as suitable habitat for the snail on Stock Island and Key West have been destroyed or severely altered by past human activities. Remnants of hammock that remain on these Keys tend to be small in size (less than 0.25 acre) and low quality (few large mature trees), making them unsuitable for the tree snail.

As a result of unauthorized relocations, the tree snail presently occupies five areas outside its historic range. The two sites at Pennekamp State Park and North Key Largo are publicly owned and will not be affected by the proposed action. However, the other three areas located in the south Key Largo Subdivision, Caloosa Cove Camp Ground, and Monkey Jungle are in private ownership and subject to construction activities. One of the lots containing Stock Island tree snail in the south Key Largo Subdivision was recently cleared for a residential development resulting in the death of snails as well as trees containing snails. The owner of this property recently received a permit from Monroe County to clear the remaining habitat for the construction of housing. Monkey Jungle is managed as a tourist attraction, the owner has no plans to destroy or modify any of the hardwood habitat occupied by tree snails. However, ownership and/or management could change at any time or the operation of Monkey Jungle could change, thereby affecting tree snail habitat.

Based on our analyses, approximately 889 hectares of suitable snail habitat are not protected and are vulnerable to urbanization (Figure 25). We believe the proposed action will affect 443 hectares (50 percent) of this habitat. In descending order of magnitude, the greatest threats of the proposed action are the loss or degradation of 443 hectares of habitat, increases in pesticide use, illegal collecting, and predation by black rats and fire ants. The three private areas that harbor populations of tree snails are small isolated tracts of land which makes them highly susceptible to the threats of habitat loss, fragmentation, and reduction in quality. Any loss of habitat or reduction in habitat quality would severely increase mortality of the tree snail and reduce reproductive potential. Housing construction would destroy or remove trees on which the snails feed. Destruction of habitat would affect and reduce reproduction by disrupting hammock soils and leaf litter used as nest areas. Any habitat modification could fragment these areas disrupting movement patterns of snails and destroying the microclimate (air temperature and humidity) important for feeding and reproduction.

Indirect effects associated with the proposed action destroy or remove individual snails from the population and adversely effect behavior and reproduction. The use of pesticides on or near snail habitat can kill snails directly or alter behavior associated with feeding and reproduction. The effects decrease the likelihood of the survival and recovery of the Stock Island tree snail in the wild. Urbanization within

or near snail habitat can promote the establishment of black rats and fire ants that will feed on snails resulting in a reduction in population numbers and reproductive potential. Excessive watering of ornamental plants and lawns can modify snail behavior by bringing snails out of aestivation during the winter months and exposing them to cold temperatures and desiccation. Increased collecting of snails resulting from an influx of residents and tourists promoted by the proposed action will further reduce populations by directly removing these individuals from the wild. Foot traffic associated with collecting can further degrade habitat, reducing reproductive potential of the areas.

The survival of the Stock Island tree snail is tenuous. We believe that reducing remaining, suitable habitat for the tree snail by half would dramatically increase the risk of extinction to this imperilled species in the Keys. The proposed action would also preclude efforts to reintroduce Stock Island tree snails into their historic range, which is essential to the recovery of this species.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the Act.

Actions taken by Monroe County are likely to have the most significant cumulative effects on the threatened and endangered species being considered in this Biological Opinion. The Monroe County government controls land use practices that affect threatened and endangered species within areas subject to the NFIP; the Monroe County government also controls land use practices within areas that are not subject to the NFIP (that is, within units included in the CBRS). As we discussed in the previous section, Monroe County determines actual growth patterns through the Permit Allocation System of their Rate of Growth Ordinance. Monroe County also controls other activities, such as road building and traffic patterns, that have affected threatened and endangered species in the Keys.

Actions under the control of Monroe County have the greatest potential effect on threatened and endangered species in the Keys. The planning and zoning ordinances the County implements establishes land use patterns throughout the Keys. The building permits they issue begin the sequence of events that results in the habitat conversion and destruction that has been discussed earlier in this Biological Opinion. For the cumulative effects analysis, we will focus on the cumulative effects of Monroe County's actions on threatened and endangered species within units of the CBRS, which is the area not influenced by the NFIP. The following table identifies the area of suitable habitat for threatened and endangered species in the Keys that could be affected by Monroe County's actions in the future.

Species	Habitat affected by Monroe County	Percent of Total
Eastern Indigo Snake	1108 hectares	32
Key deer	2238 hectares	44
Key Largo cotton mouse	410 hectares	95
Key Largo wood rat	410 hectares	95
Key tree-cactus	1293 hectares	90
Lower Keys marsh rabbit	187 hectares	56
Silver rice rat	1898 hectares	72
Schaus' swallowtail butterfly	573 hectares	50
Stock Island tree-snail	446 hectares	50

As we discussed in the previous section, there are approximately 21,127 acres of vacant land in Monroe County, comprising approximately 34 percent of the total acreage of the County. These 21,127 acres do not include any of the 14,953 vacant, buildable lots already zoned and platted for residential uses, nor does this acreage include conservation and recreational lands, such as State Parks and Preserves.

Properties available as vacant residential lands include Improved Subdivision (IS), Urban Residential Mobile Home (URM), and Commercial Fishing Village (CFV). These categories allow one dwelling unit per lot. Monroe County uses "lots" to characterize land use instead of acreage. There are a total of 37,128 IS, URM, and CFV lots in Monroe County, of which 21,394 (or 57.6 percent) have already been developed; 14,923 (or 40.2 percent) are vacant and available for structures, and 375 (1.0 percent) are in conservation protection. Of this total, there are 14,923 developable, residential lots and 5,640 developable, non-residential lots remaining in unincorporated Monroe County (Monroe County 1996). Therefore, there are 14,923 lots that do not have structures that may be affected by the administration of the NFIP.

Although there are 14,923 vacant, developable, residential lots in Monroe County, this number may not reflect the residential construction potential. The construction potential may be lower because Land Development Regulations try to manage the County's growth within its carrying capacity. Monroe County developed a Future Land Use Map that determines future land use patterns and residential and commercial construction based on the critical measure of carrying capacity. Carrying capacity is based on hurricane evacuation clearance times. Future land use predictions may be less than what can actually occur based on carrying capacity. Actual growth patterns are determined through the Permit Allocation System (also known as Rate of Growth Ordinance or ROGO). ROGO is divided into two point systems: residential and non-residential. The residential point system has been implemented since 1992, while the non-residential point system should be fully in place by 1997.

As we discussed previously, this residential construction will not be equally distributed throughout the

Keys. In the short term, the rate of growth ordinance implemented by Monroe County would limit the annual rates of growth in the Upper, Middle, and Lower Keys to 99 units, 41 units, and 115 units respectively. After those limits are lifted, half of the construction would probably occur in the Lower Keys, particularly on Big Pine, Big Torch, No Name, and Ramrod Keys. One third of the remaining construction would probably occur on Key Largo. The final percentage would probably occur on Marathon, in the Middle Keys (see Table 8).

The Year 2010 Comprehensive Plan allows 255 dwelling units per year, through 2010. In addition, 239 square feet of non-residential development will be permitted for every one dwelling unit permitted. A total of 610,000 square feet of non-residential construction could be permitted through 2010 or a total of 61,000 square feet per year. Already 220,198 square feet of commercial activity has been permitted, and Monroe county only expects to permit 184,840 more square feet through 2010.

The lots available for new residential and commercial construction are not evenly distributed throughout the Keys (Tables 7 and 8). According to Monroe County, the Lower Keys have 45 percent of the vacant lots available in unincorporated Monroe County; about 20 percent of those lots are on Big Pine Key. Thirty-nine percent of the vacant lots are in the Upper Keys; about 28 percent of those lots are on Key Largo. About 16 percent of the lots are in the Middle Keys; about 6 percent of those are on Marathon.

An additional 31,000 people are expected to become new, permanent residents of the Keys between 1992 and 2020. Based on the information provided by Monroe County, if only half of these people build new residences, they will occupy all of the lots available for residential construction in the Keys. In other words, if only half of these people build new residences in the Keys, they will clear all of the habitat on the 14,953 vacant, buildable lots already zoned and platted for residential uses.

Although we cannot predict how homeowners would construct their homes on a particular lot, we will assume they will clear most of the vegetation on property prior to construction. With these assumptions, we would expect residential housing to occur on all of the remaining 14,923 lots in the Keys. In the short term (between now and the turn of the century), Monroe County's rate of growth ordinance limits the pace of residential growth in the Keys to 255 residential units per year.

Because 72 percent of all of the vacant lots in the upper Keys are on Key Largo and 95 percent of Key Largo is within units of the Coastal Barrier Resources System, land use decisions made by Monroe County could have particularly significant, cumulative effects on the Key Largo cotton mouse and Key Largo woodrat. Specifically, the 410 hectares of habitat for both of the species that is not protected on Key Largo is likely to be cleared for residential purposes in the foreseeable future. These habitats are concentrated along S.R. 905, north of the intersection with U.S. Highway 1 and provide the connective corridor between populations for these species on North and South Key Largo. The loss of these habitats would reduce the area of suitable habitat by 10 percent and is likely to isolate the northernmost populations of both species (in the Ocean Reef Colony area).

Similarly, Monroe County has control over land use decisions with important implications on the endangered Key deer. For several years, the number of Key deer killed or injured by automobiles has threatened the survival and recovery of the Key deer. Recently, the Service has expressed concerns about

the effects of road improvements and new road construction undertaken by Monroe County on Key deer on Big Pine Key. Although the effects of these roads have historically been addressed on a case by case basis, the Service and Monroe County are currently discussing the County's seven-year road construction plan in the hopes of minimizing their effects on Key deer in the future.

CONCLUSION

After reviewing the current status of the 10 threatened and endangered species in the Action Area, the environmental baseline for the Action Area, the effects of the action, and the cumulative effects, it is the Service's biological opinion that continued issuance of flood insurance policies pursuant to the Federal Emergency Management Agency's National Flood Insurance Program is likely to have the following effects on threatened and endangered species in the Florida Keys:

Eastern indigo snake: we believe the continued administration of the National Flood Insurance Program in the Keys is not likely to jeopardize the continued existence of the threatened eastern indigo snake.

Garber's spurge: we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to jeopardize the continued existence of the threatened Garber's spurge.

Key deer: we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to jeopardize the continued existence of the endangered Key deer.

Key Largo cotton mouse: we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to jeopardize the continued existence of the endangered Key Largo cotton mouse.

Key Largo woodrat: we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to jeopardize the continued existence of the endangered Key Largo woodrat.

Key tree-cactus: we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to jeopardize the continued existence of the endangered Key tree-cactus.

Lower Keys marsh rabbit: we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to jeopardize the continued existence of the endangered Lower Keys marsh rabbit.

Schaus' swallowtail butterfly: we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to jeopardize the continued existence of the endangered Schaus' swallowtail butterfly.

Silver rice rat: we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to jeopardize the continued existence of the endangered silver rice rat. Further, we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to destroy and adversely modify designated critical habitat for the silver rice rat.

Stock Island tree snail: we believe the continued administration of the National Flood Insurance Program contributes to the amount of habitat destruction and modification in the Keys and is likely to jeopardize the continued existence of the threatened Stock Island tree snail.

REASONABLE AND PRUDENT ALTERNATIVES

Regulations implementing Section 7 define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) would, the Service believes, avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat.

This biological opinion has identified one reasonable and prudent alternative that, the Service believes, meets the criteria outlined above. The basic premise for this reasonable and prudent alternative is that the NFIP, as administered in the Florida Keys, affects threatened and endangered species through an act of omission, not commission (that is, the NFIP is silent about threatened and endangered species when placing requirements on Monroe County). The second premise is that the NFIP, as administered in the Florida Keys, is not the primary force behind the land use decisions that are jeopardizing the continued existence of threatened and endangered species in the Keys. Based on these premises, in order to be reasonable and prudent, the alternatives should correct the omission and must be commensurate with the significance of the NFIP's affect on threatened and endangered species.

We prepared this reasonable and prudent alternative with an awareness of the larger context of actions that will affect threatened and endangered species in the Florida Keys. As we outlined in the Cumulative Effects section, several other State and local actions will affect the condition of threatened and endangered species in the Florida Keys during the period being considered in this Biological Opinion. Specifically, the carrying capacity study currently being prepared by the U.S. Army Corps of Engineers for the Florida Department of Community Affairs is intended to address growth management issues in the Florida Keys. Thus, we view the following reasonable and prudent alternative as an interim solution. Over the long term, the Florida Keys carrying capacity study is intended to be the precursor of a more comprehensive effort to conserve threatened and endangered species and their habitats in the Florida Keys (either through land acquisition, regulation, or land use planning) on the part of the State of Florida. Over the next 3 - 4 years, we believe this effort will result in permanent, county-wide solutions (such as county-wide Habitat Conservation Planning) that conserve the threatened and endangered species in the Florida Keys.

Finally, this reasonable and prudent alternative is not intended to immediately reverse the rate at which threatened and endangered species decline in the Florida Keys. Our jeopardy determinations were generally based on habitat loss and conversion over a 5- to 20-year period, although the continued existence of some species (like the Lower Keys marsh rabbit) would be jeopardized by the proposed action in less than 5 years. The reasonable and prudent alternative is intended to prevent further declines of the nine species that we concluded were likely to be jeopardized by the proposed action while longer-term protection can effect the recovery of those species.

Reasonable and Prudent Alternative:

FEMA currently requires participating communities to comply with applicable Federal environmental laws. FEMA should modify their guidance on implementation of 43 CFR 60.1-60.5 to establish specific requirements for compliance with the Endangered Species Act of 1973, as amended (16 U.S.C. 1351 et seq.). That guidance should establish the following process:

a. Monroe County, with the cooperation of FEMA and the U.S. Fish and Wildlife Service, will develop maps showing the distribution of threatened and endangered species and their habitats in the Florida Keys within 180 days from the date FEMA submits the biological opinion to the Southern District Court of Florida. These maps will identify areas with (i) suitable, occupied habitat; (ii) suitable habitat for which occupancy is uncertain; and (iii) unsuitable habitat.

b. In areas mapped as containing unsuitable habitat, Monroe County, after making appropriate documentation in the administrative records, can issue building permits without further concerns for threatened or endangered species (or their critical habitats).

c. In areas mapped as containing suitable, occupied habitat or suitable habitat for which occupancy is uncertain, issuance of building permits will require further consultation with the U.S. Fish and Wildlife Service. These consultations would have one of two outcomes:

   1. The Service believes the building permit would not adversely affect threatened or endangered species or designated critical habitat and would provide Monroe County with a letter to that effect. Monroe County would place that letter in the file for that permit for future review by FEMA during their community assistance visits.

   2. The Service believes the building permit may adversely affect threatened or endangered species or designated critical habitat. In this event Monroe County would work with the landowner and the Service to ensure compliance with the Act (that is, to make certain the landowner receives applicable Section 10 permits or, if other Federal permits are required, to make certain the proposal has a completed Section 7 consultation). Either the Section 10(a)(1)(B) permit or the completed Section 7 consultation would be retained in the administrative record for the building permit for future review by FEMA during their community assistance visits.

d. FEMA will consult with the Service every 6 months to evaluate the extent of Act compliance for proposed construction or other development in Monroe County. In addition, during community assistance visits to Monroe County, FEMA will evaluate the administrative records maintained by Monroe County on the permits the County issued for all proposed construction or other development in the County to ensure compliance with this requirement. FEMA shall use information provided by the Service or other Federal, State, or local agencies to achieve this purpose. FEMA should treat any violation of the spirit and letter of this reasonable and prudent alternative as a substantive deficiency pursuant to 44 CFR 60.3, 60.4, and 60.5. Within 60 days of determining non-compliance with the spirit and letter of this reasonable and prudent alternative, FEMA should notify Monroe County that FEMA has initiated the procedures outlined in 44 CFR 59.24, which allows FEMA to place participating communities on probation or suspend them from the National Flood Insurance Program. Unless Monroe County corrects the deficiencies identified in FEMA's notification letter, FEMA should complete the probation or suspension procedures according to the schedules identified in 44 CFR 59.24.

This biological opinion has found that the continued administration of the National Flood Insurance Program, and its contribution to the amount of habitat destruction and modification in the Keys, is likely to jeopardize the continued existence of the threatened Garber's spurge, endangered Key deer, endangered Key Largo cotton mouse, endangered Key Largo woodrat, endangered Key tree-cactus, endangered Lower Keys marsh rabbit, endangered Schaus' swallowtail butterfly, endangered silver rice rat, and designated critical habitat for the silver rice rat. Consequently, the Federal Emergency Management Agency is required to notify the Service of its final decision on implementation of the reasonable and prudent alternatives identified in this biological opinion.

INCIDENTAL TAKE STATEMENT

Sections 4(d) and 9 of the Act prohibit taking (harass, harm, pursue, hunt, shoot, kill, trap, capture or collect, or attempt to engage in any such conduct) of listed species of fish or wildlife without a special exemption. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patters which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is any take of listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or an applicant. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered a prohibited taking provided that such taking complies with the terms and conditions of this incidental take statement.

The Service anticipates incidental take of endangered Key deer, endangered Key Largo cotton mouse, endangered Key Largo woodrat, endangered Lower Keys marsh rabbit, endangered Schaus' swallowtail butterfly, endangered silver rice rat, and designated critical habitat for the silver rice rat as a result of the proposed action. The Service anticipates incidental take of these species will be identified and addressed through the process established in the reasonable and prudent alternative outlined previously. Therefore, the Service is not providing separate authority to incidentally take any of these species in this incidental take statement.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to use their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information that can be used to further the purposes of the Act.

1. FEMA should modify the Community Rating System associated with the National Flood Insurance Program to benefit communities that have implemented community-wide, multispecies conservation planning pursuant to section 10(a)(1)(B) of the Act. Specifically, FEMA already provides credit in the Community Rating System for protection of areas that provide natural and beneficial functions, such as wetlands, riparian areas, sensitive areas and habitat for rare or endangered species. FEMA should implement this Conservation Recommendation by providing the maximum credit for completion of a comprehensive, county-wide Habitat Conservation Plan, with the assistance of the Service. If this plan is completed prior to the revision of Monroe County's Rate of Growth Ordinance, additional credits under the CRS should be assigned to Monroe County.

In order to keep the Service informed of action that minimize or avoid adverse effects to listed species or that benefit listed species or their critical habitats, FEMA should notify the Service's South Florida Ecosystem Office of any conservation recommendations they implement.

REINITIATION - CLOSING STATEMENT

This concludes formal consultation on the Federal Emergency Management Agency's administration of the National Flood Insurance Program in the Florida Keys. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion; (4) a new species is listed or critical habitat designated that may be affected by the action; (5) a completed county-wide habitat conservation plan is not received by the Service within 4 years of the issuance of this biological opinion; or (6) Monroe County is in non-compliance with this biological opinion and FEMA fails to initiate enforcement actions as described in the reasonable and prudent alternative, part d. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation of consultation.

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Figure 1. Action Area for the FEMA Consultation

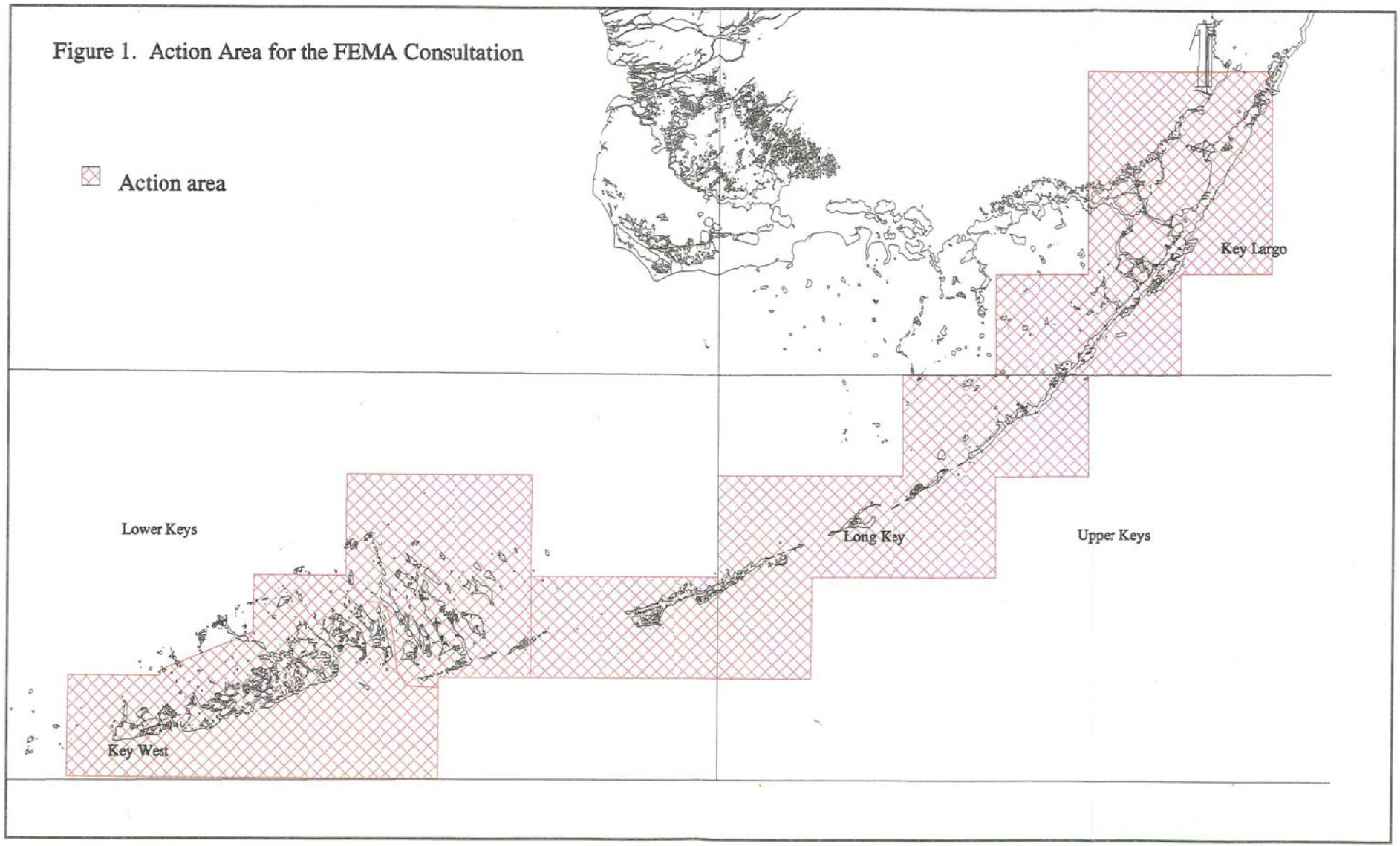
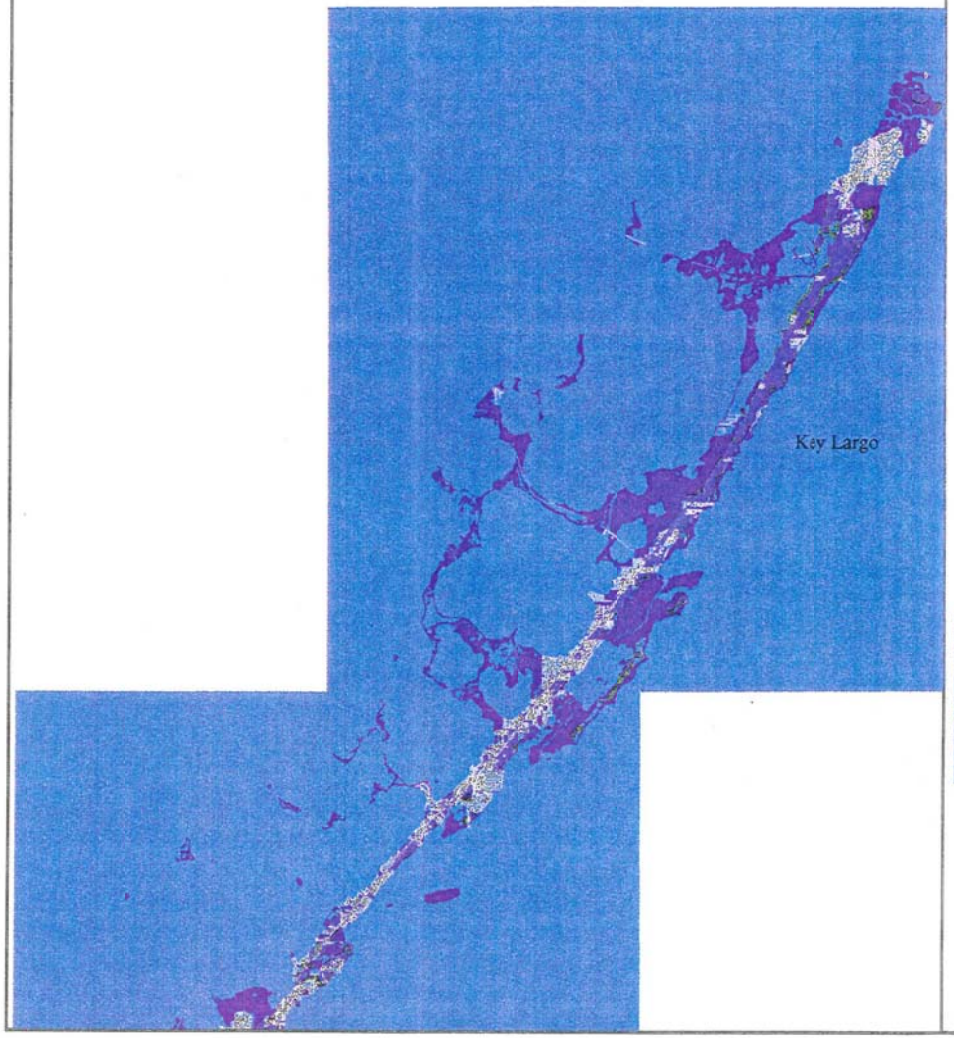


Figure 2. Habitat types of the Upper Florida Keys



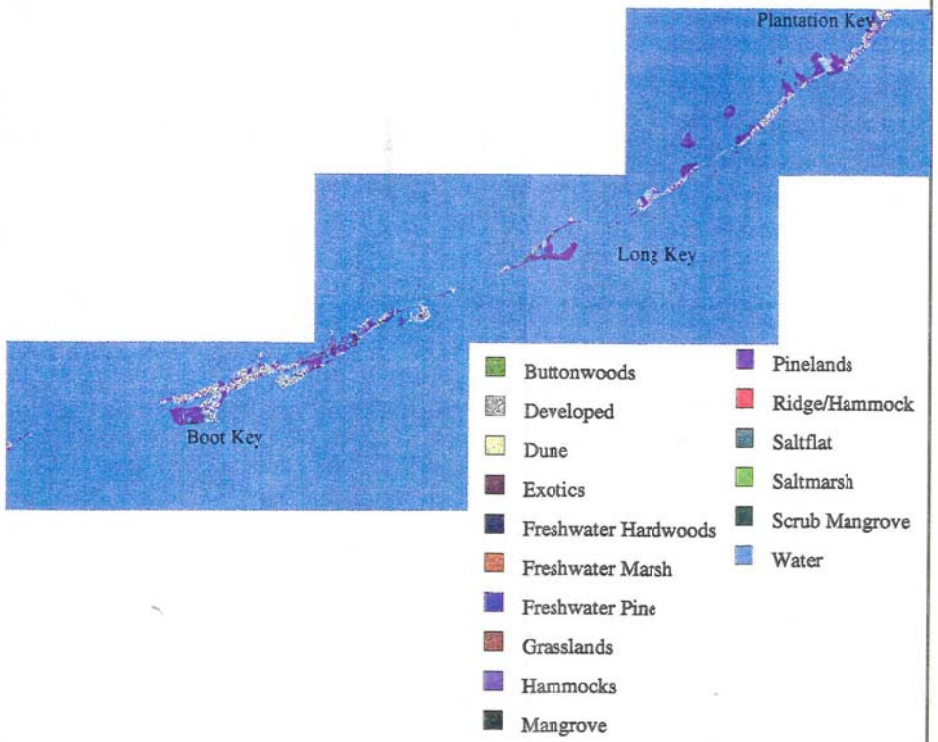


Figure 3. Habitat type of the Lower Florida Keys.

Data Source: Florida Department of Environmental Protection

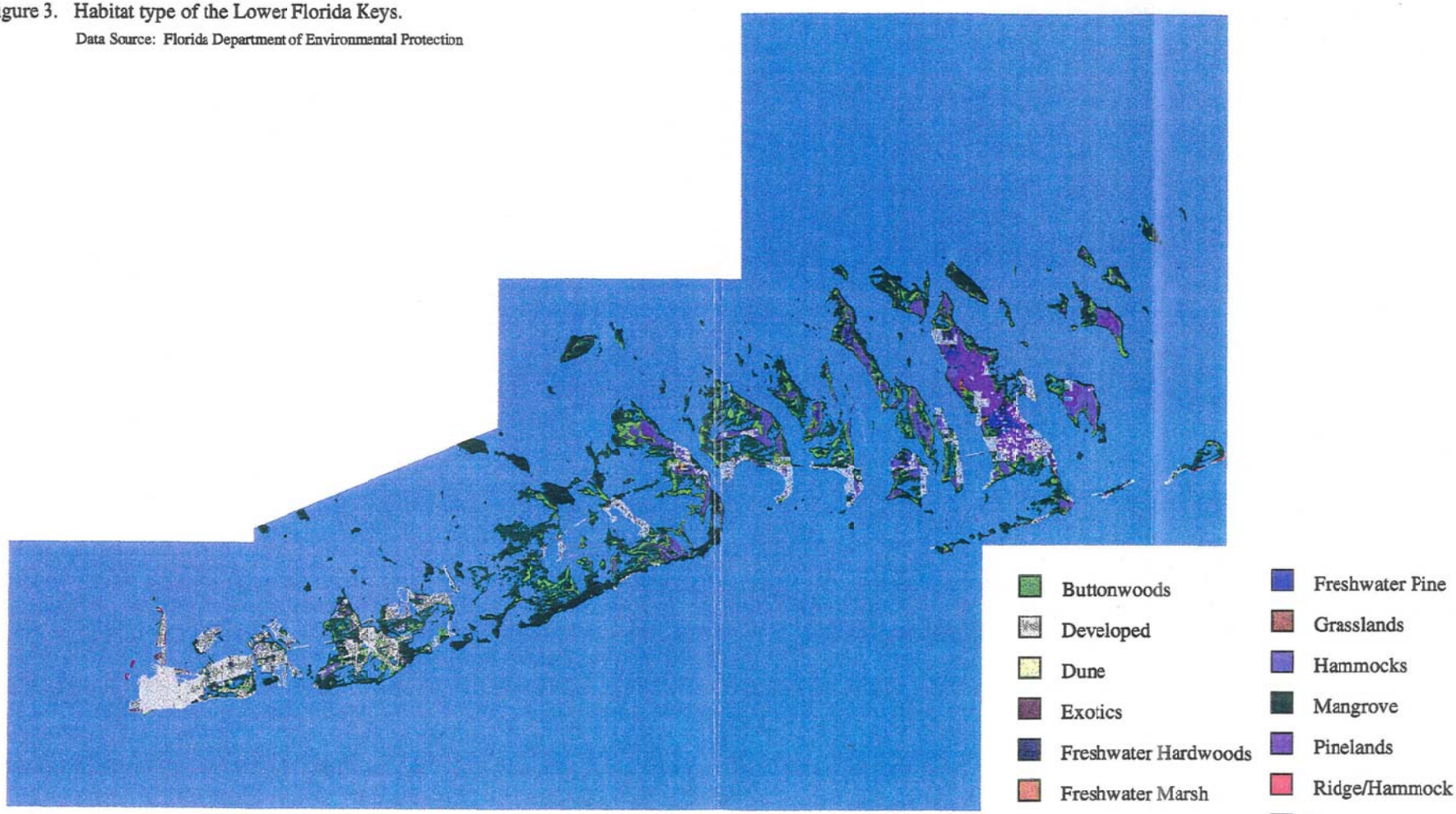
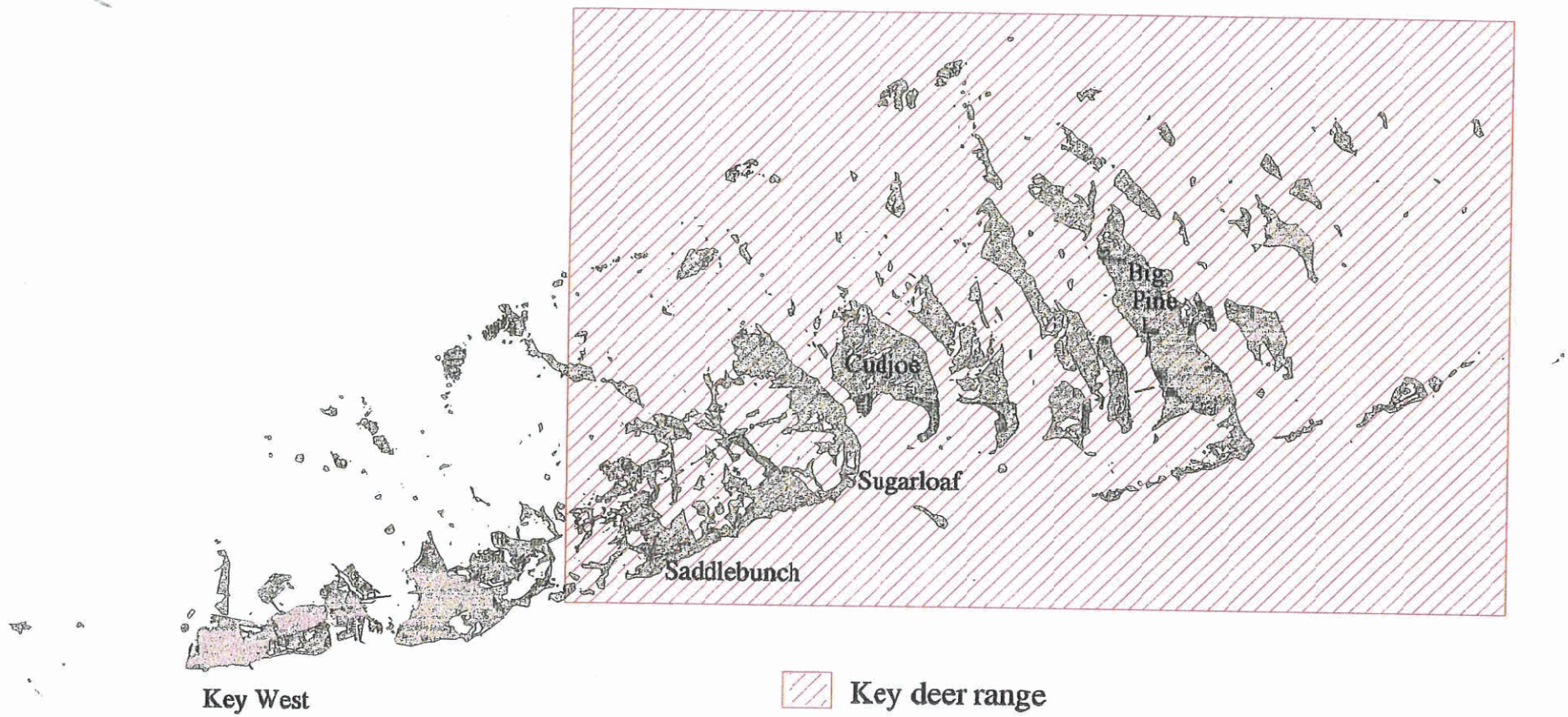


Figure 4 Key deer range in the Lower Florida Keys



USFWS, South Florida Ecosystem Office

Figure 5. Range of the Key Largo Woodrat and the Key Largo Cotton mouse in North Key Largo.

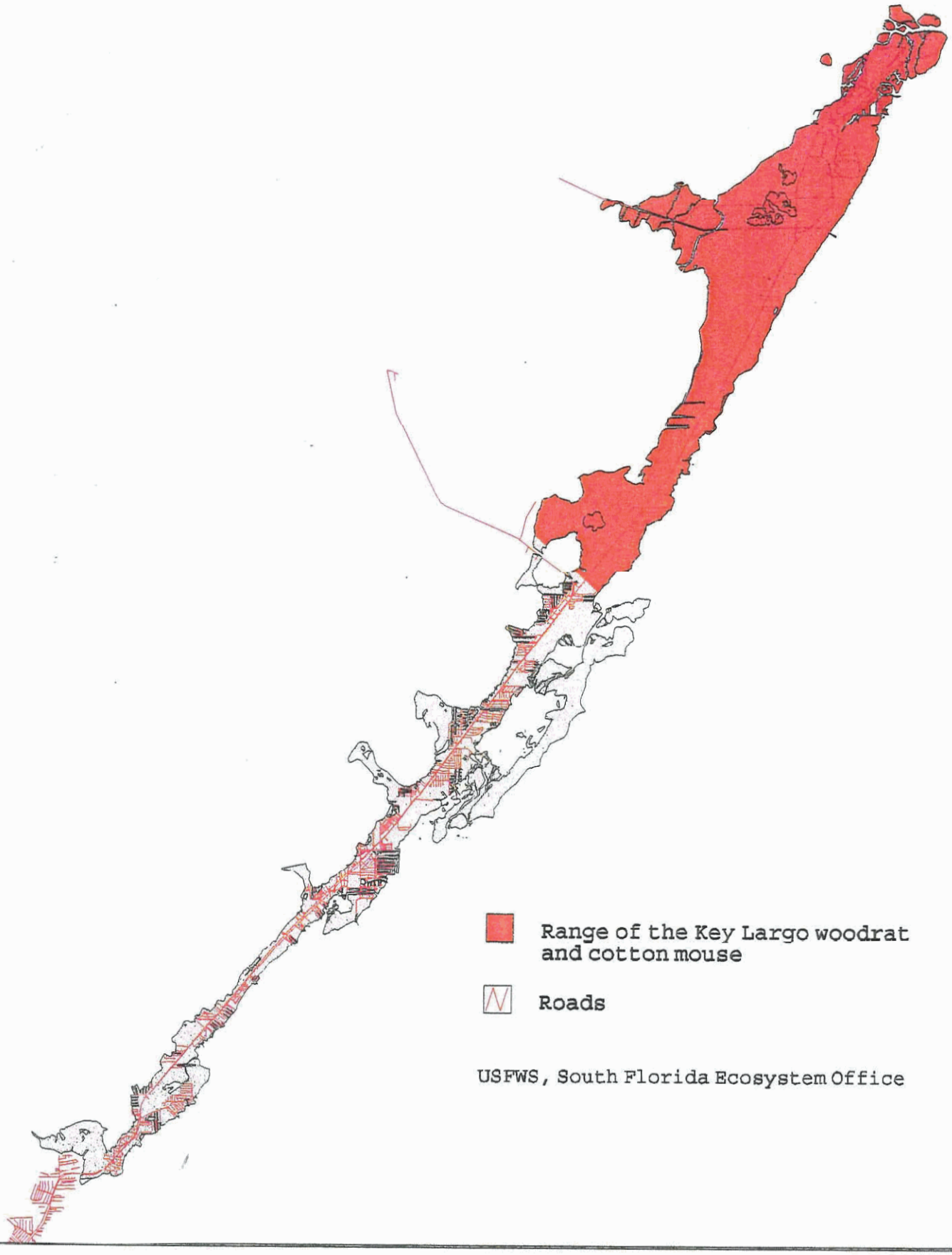


Figure 6. Key Tree-cactus habitat in the Upper Florida Keys

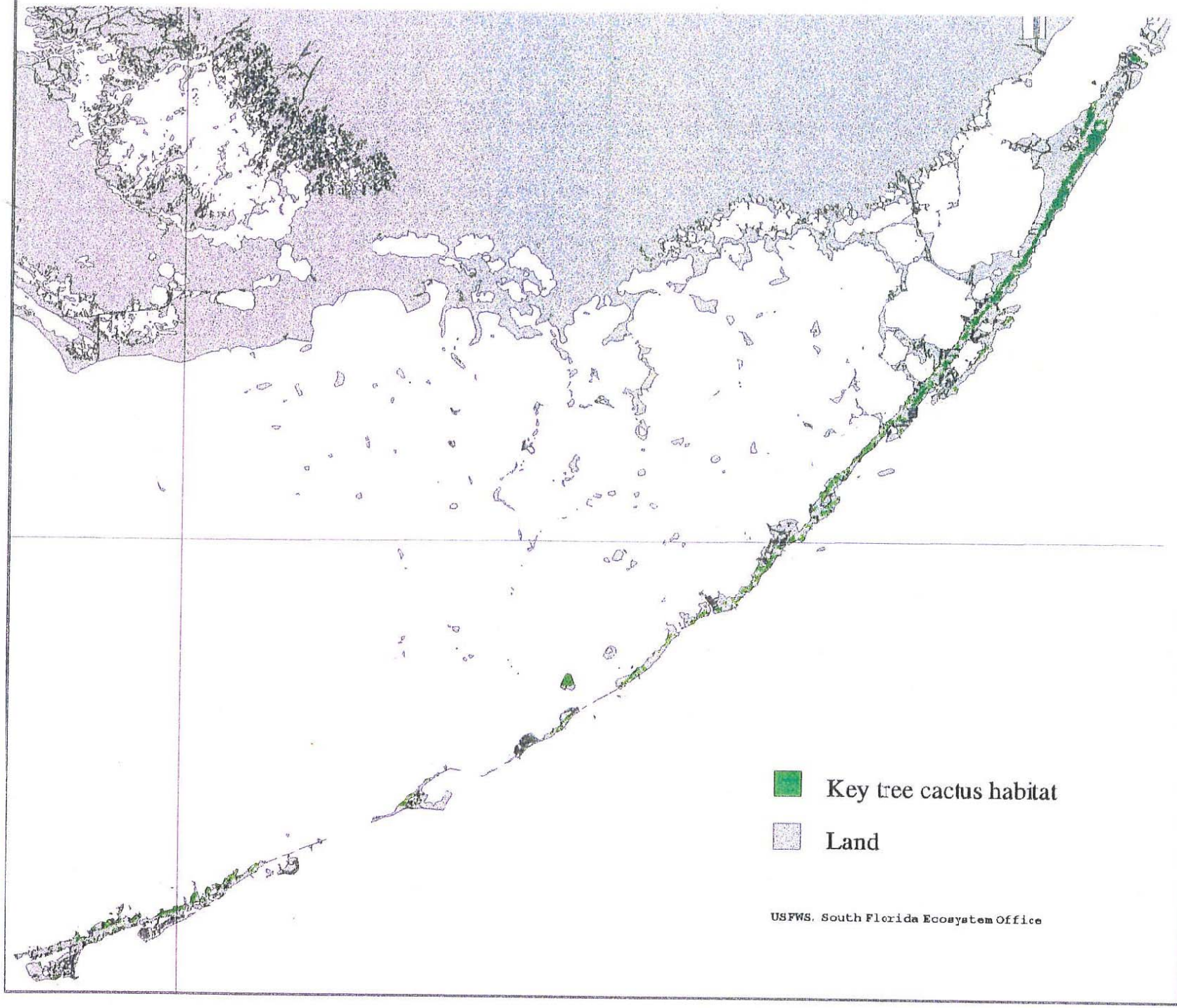


Figure 7. Key Tree-cactus habitat in the Lower Florida Keys

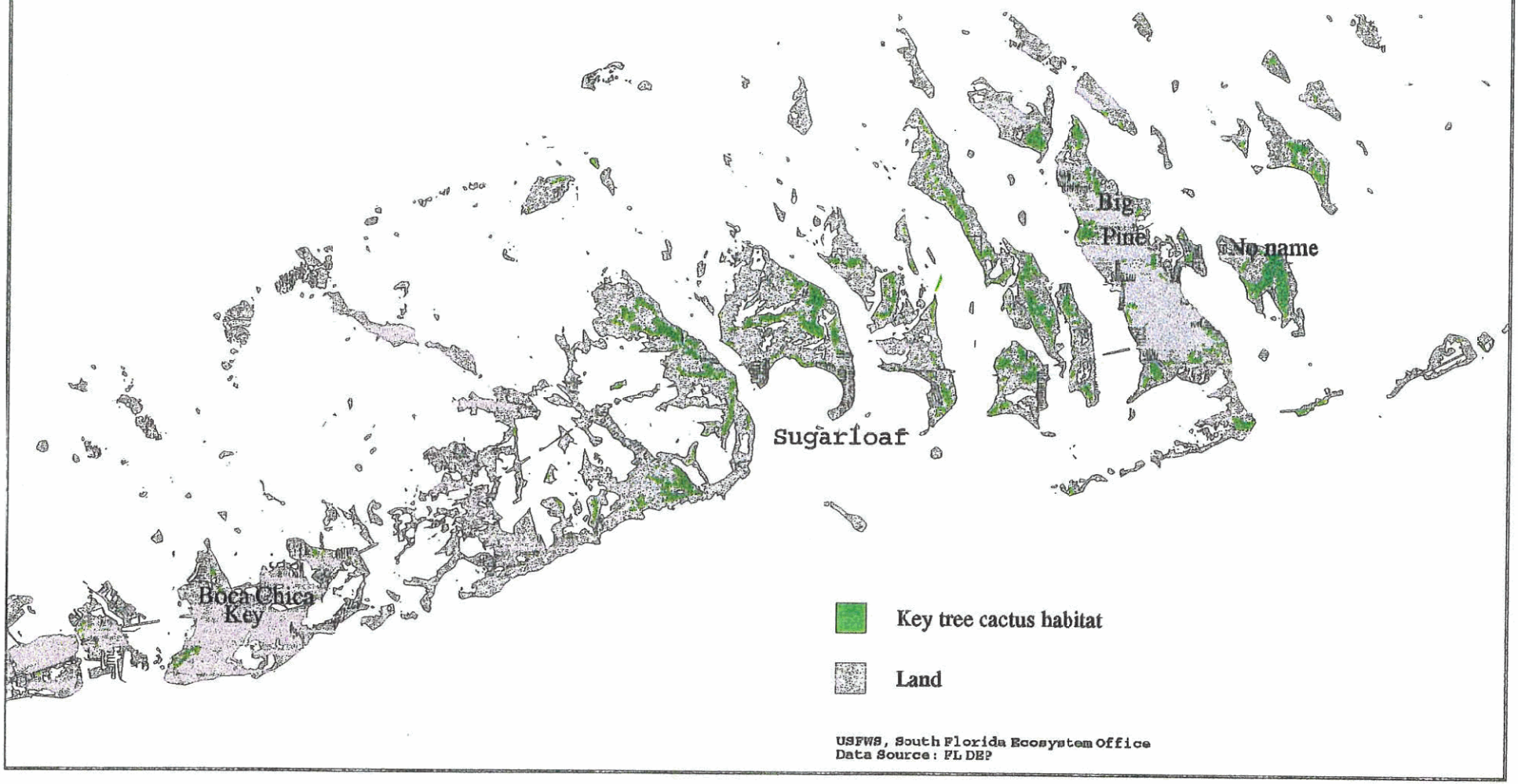


Figure 8. Occupied habitat for the Lower Keys marsh rabbit (*S.p. hefneri*) for the Lower Florida Keys

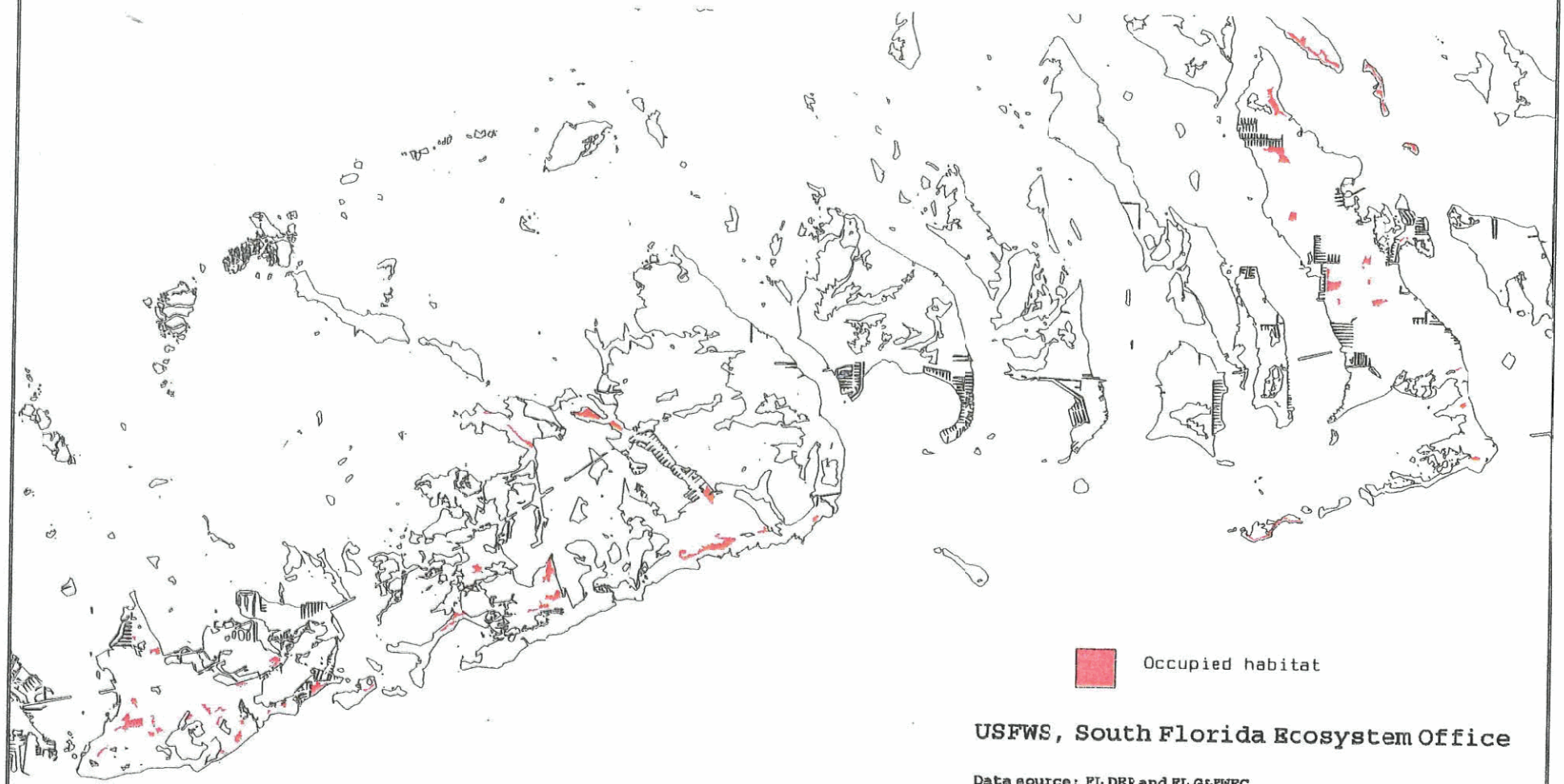


Figure 9. Release sites for the Schaus Swallowtail Butterfly.

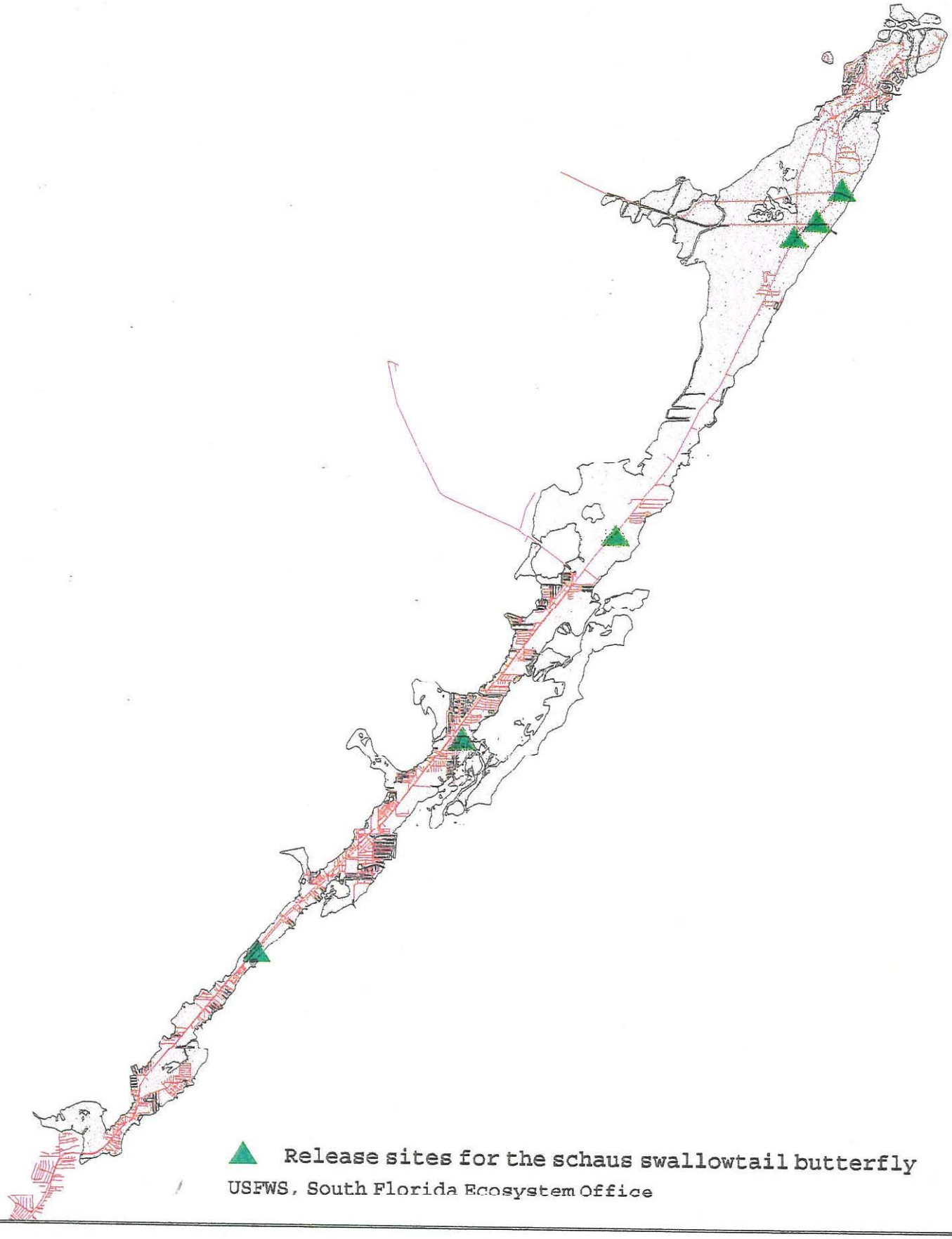
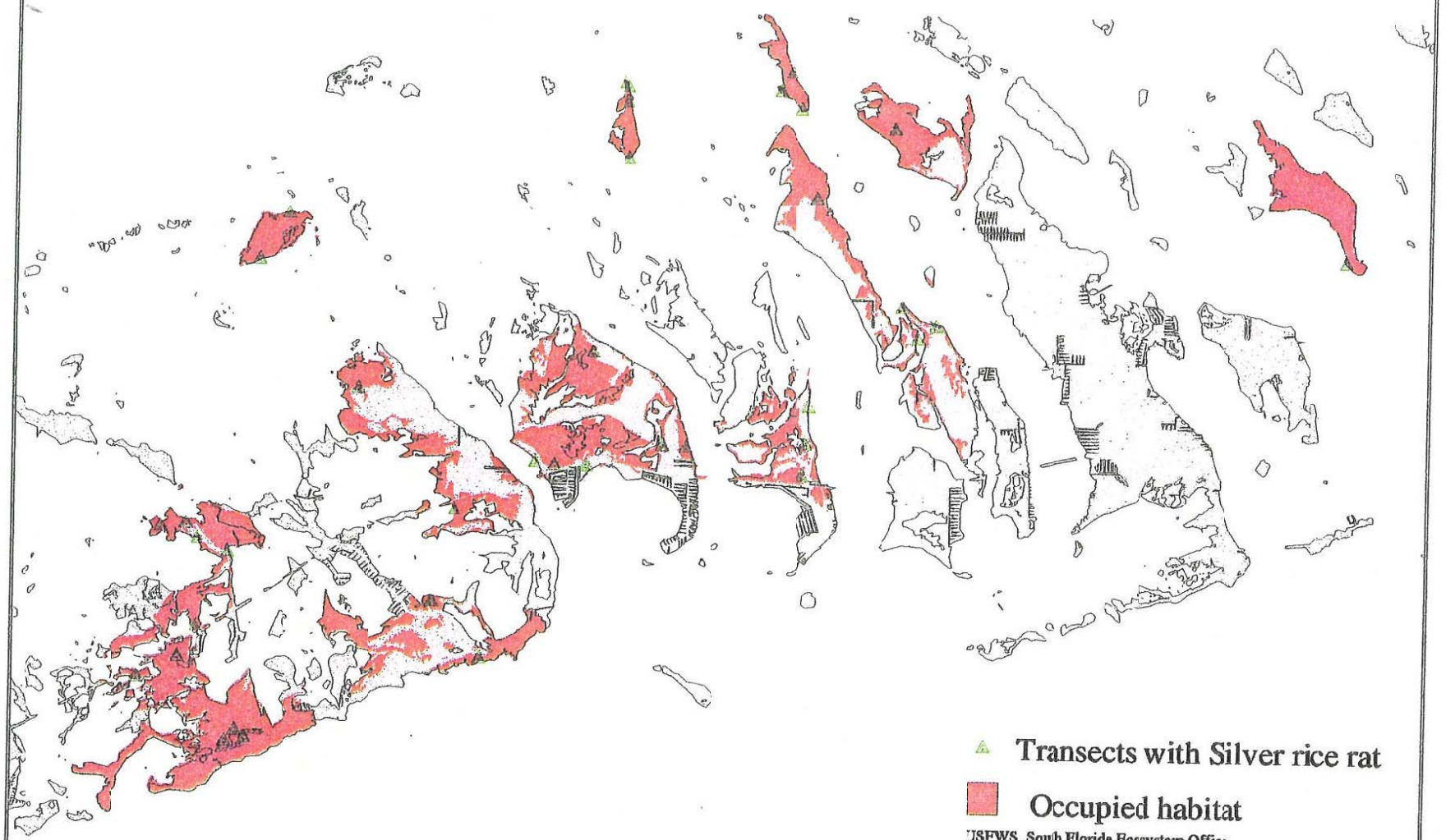


Figure 10. Silver rice rat, occupied habitat and transect sitings in the Lower Florida Keys.



USFWS, South Florida Ecosystem Office

Data Source: FLDEP & FLG&FWFC

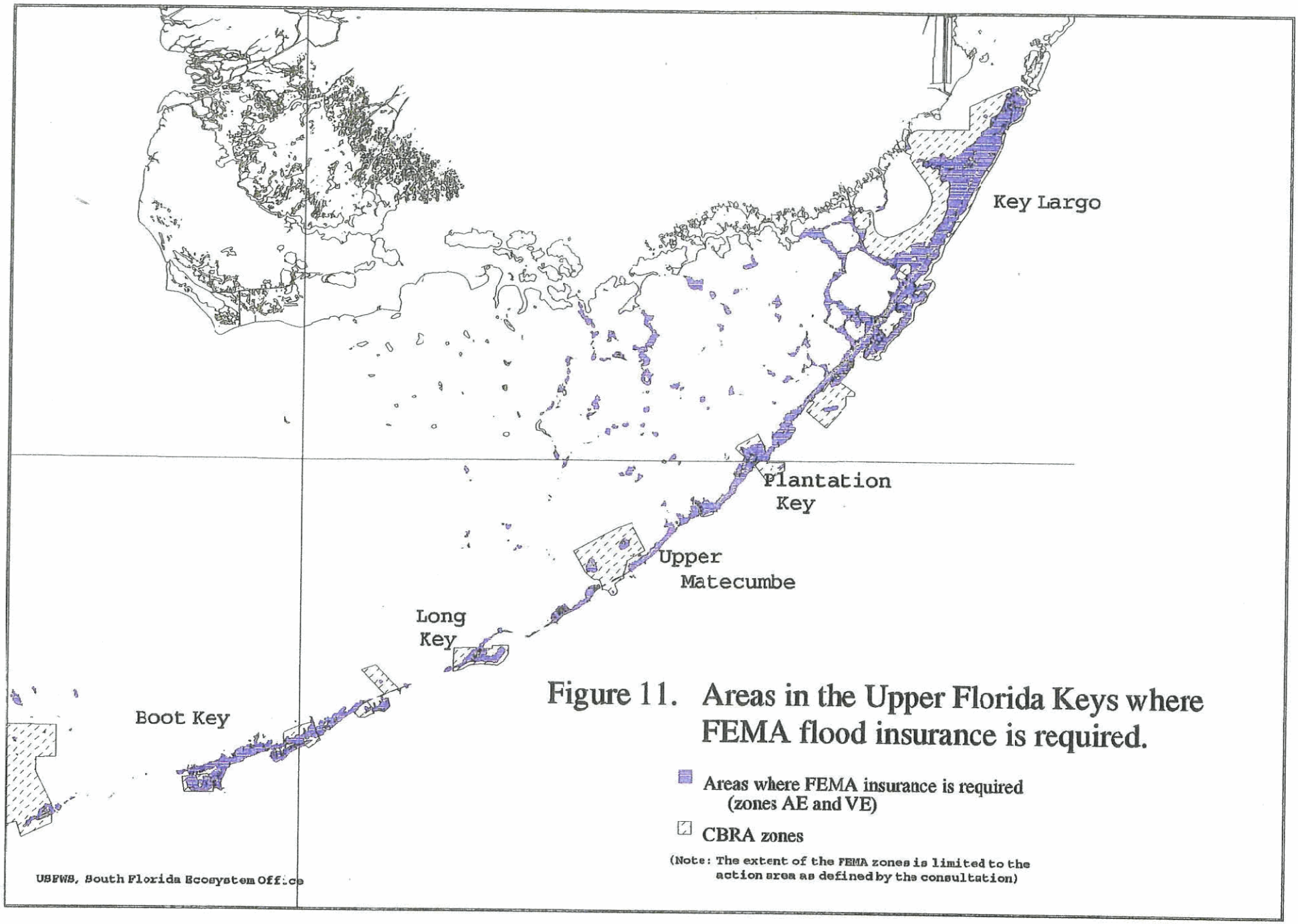
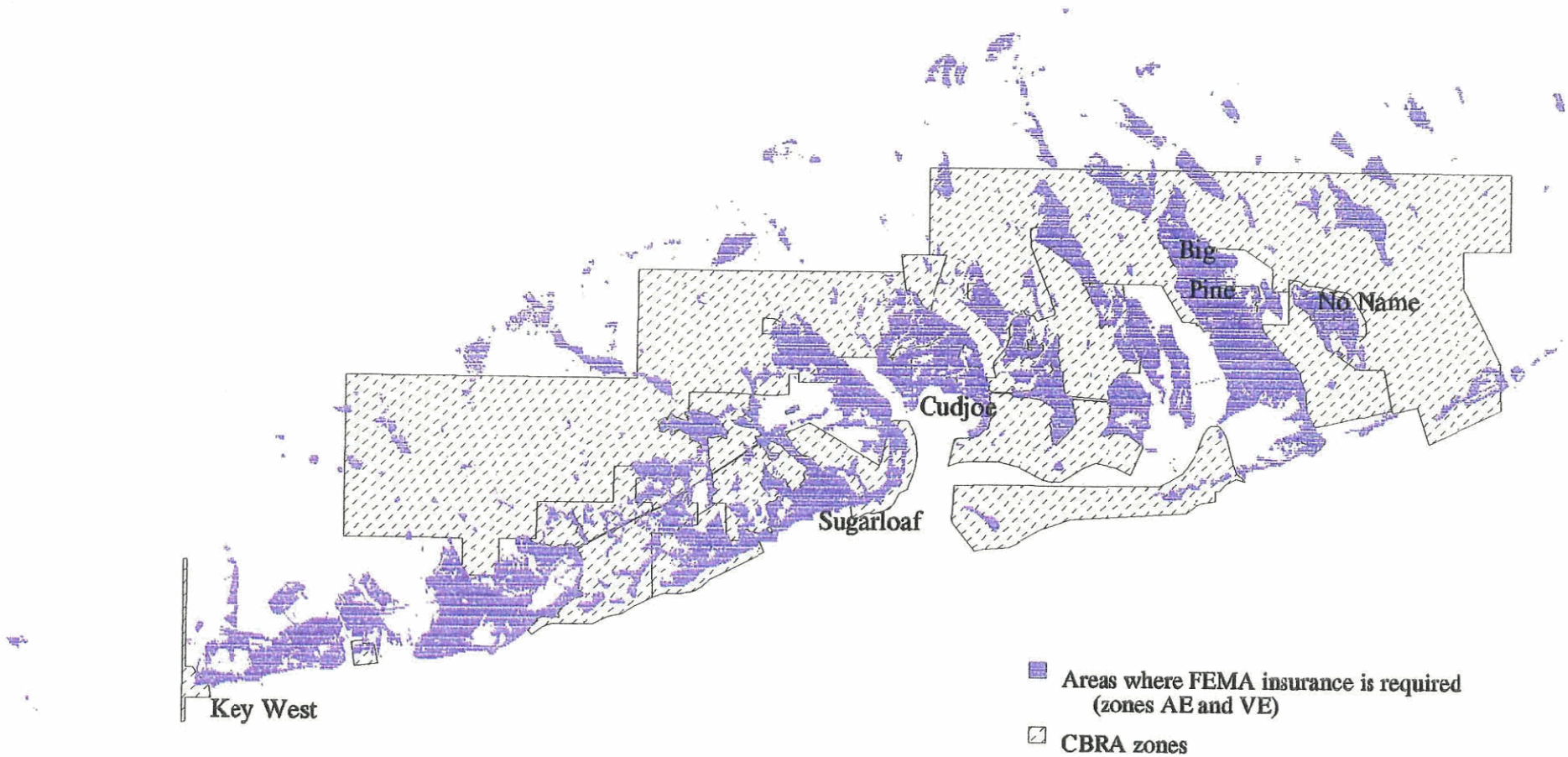


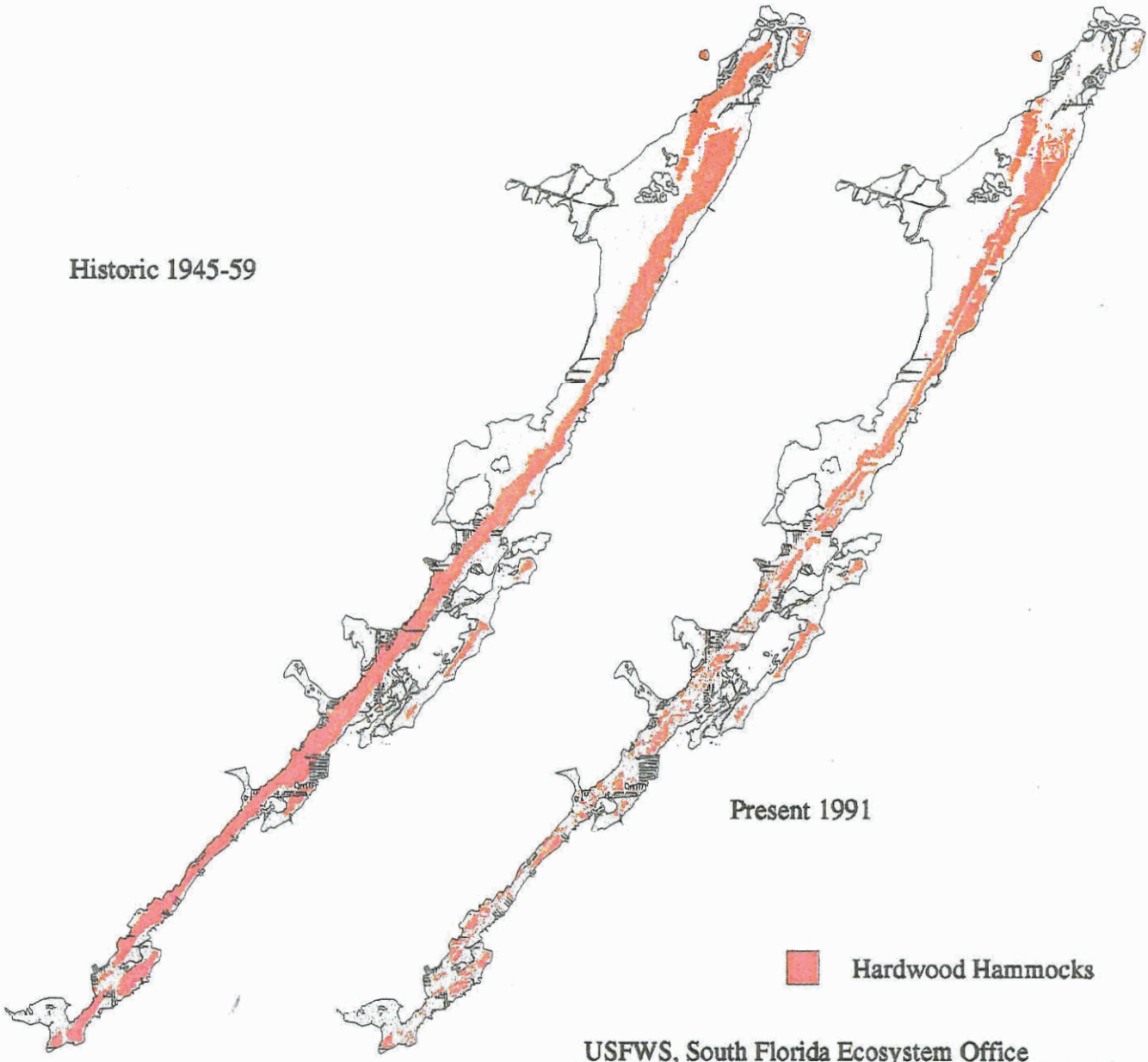
Figure 11. Areas in the Upper Florida Keys where FEMA flood insurance is required.

Figure 12. Areas in the Lower Florida Keys where FEMA flood insurance is required.



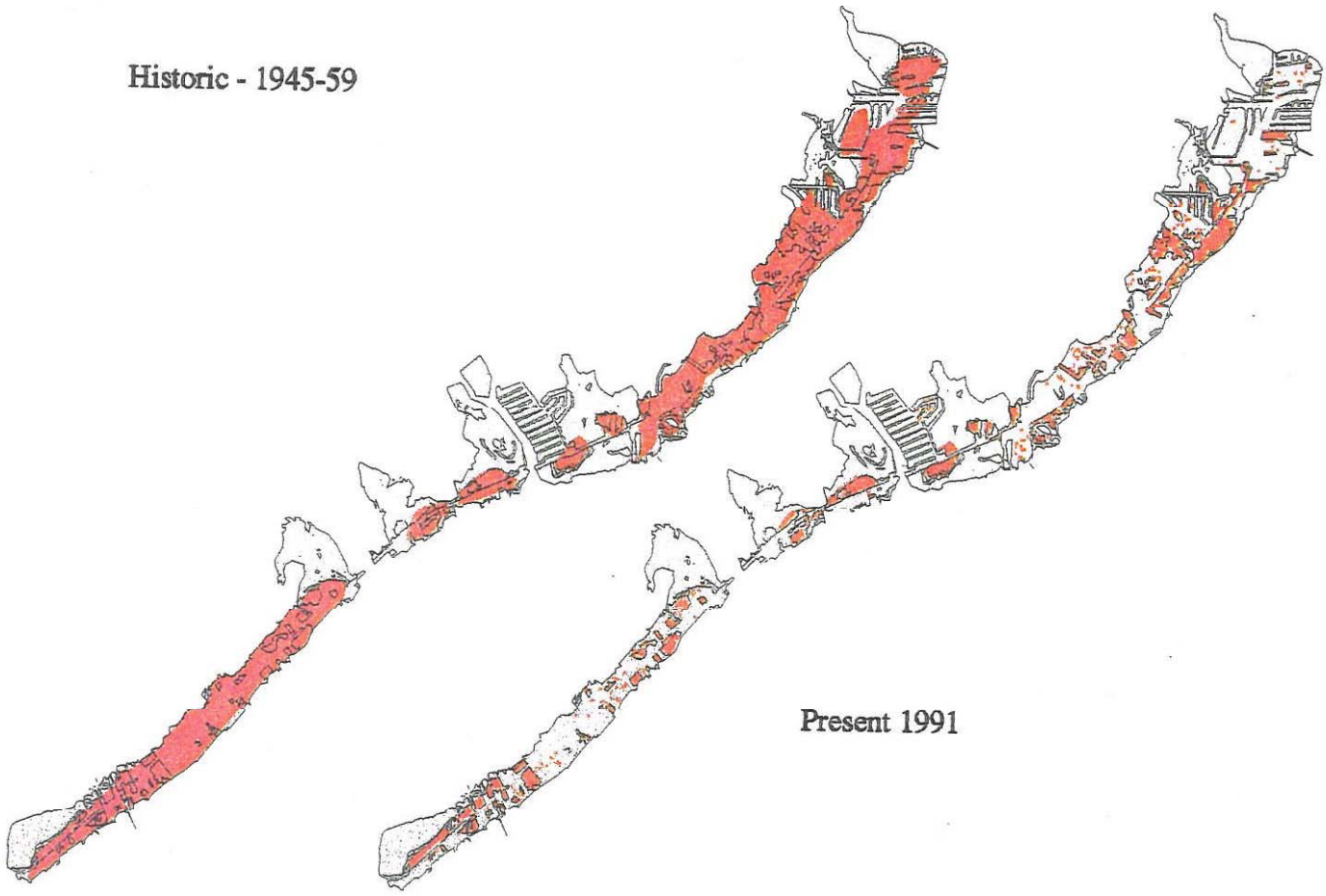
USFWS, South Florida Ecosystem Office
Data Source: FL DEP and Dewberry & Davis

Figure 13. Historic and Present hardwood hammocks on Key Largo.



USFWS, South Florida Ecosystem Office
Data Source: FL DEP and Strong & Bancroft 1994

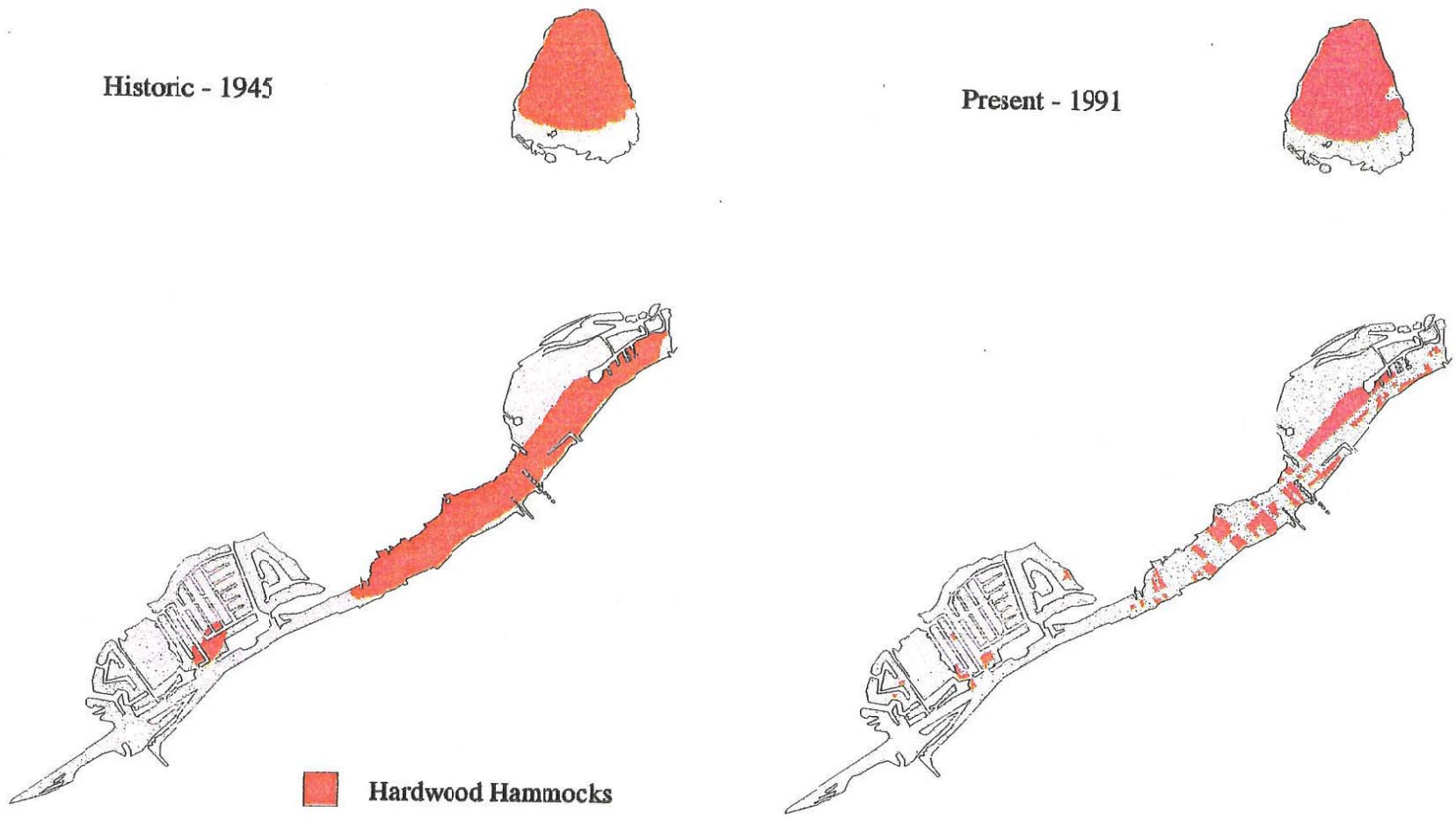
Figure 14. Historic and Present Hardwood Hammocks in the Upper Matecumbe Key area, Florida.



Hardwood Hammocks

USFWS, South Florida Ecosystem Office
Data Source: FL DEP and Strong & Bancroft

Figure 15. Historic and Present Hardwood Hammocks on Lower Matecumbe and Lignumvitae Keys, Florida.



USFWS, South Florida Ecosystem Office
Data Source: FL DEP and Strong and Bancroft 1994

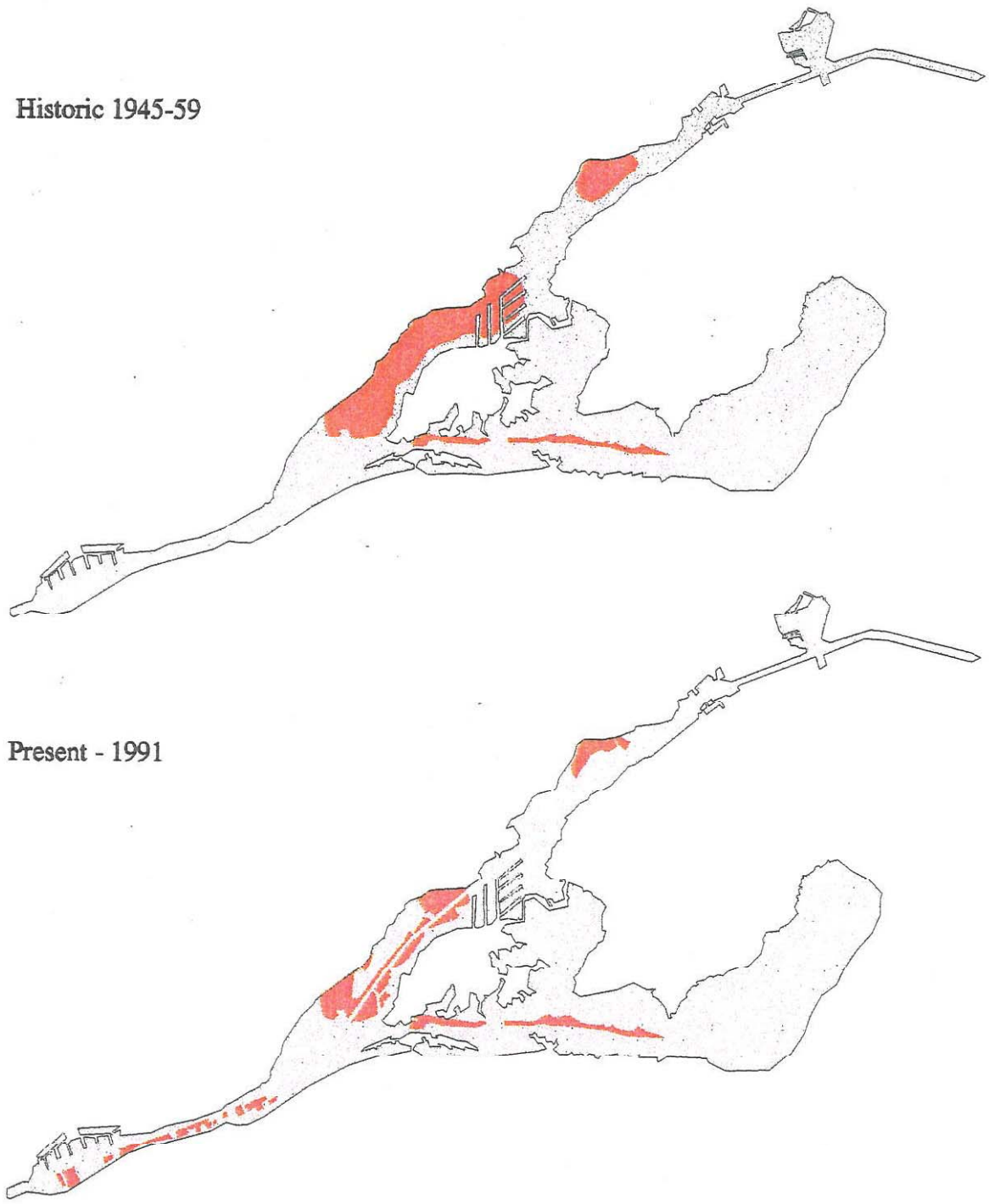


Figure 16. Historic and Present Hardwood Hammocks in Long Key

Hardwood Hammocks

USFWS, South Florida Ecosystem Office

Data Source: FL DEP and Strong & Bancroft 1994

Figure 17a. Unprotected natural areas in the Upper Florida Keys.

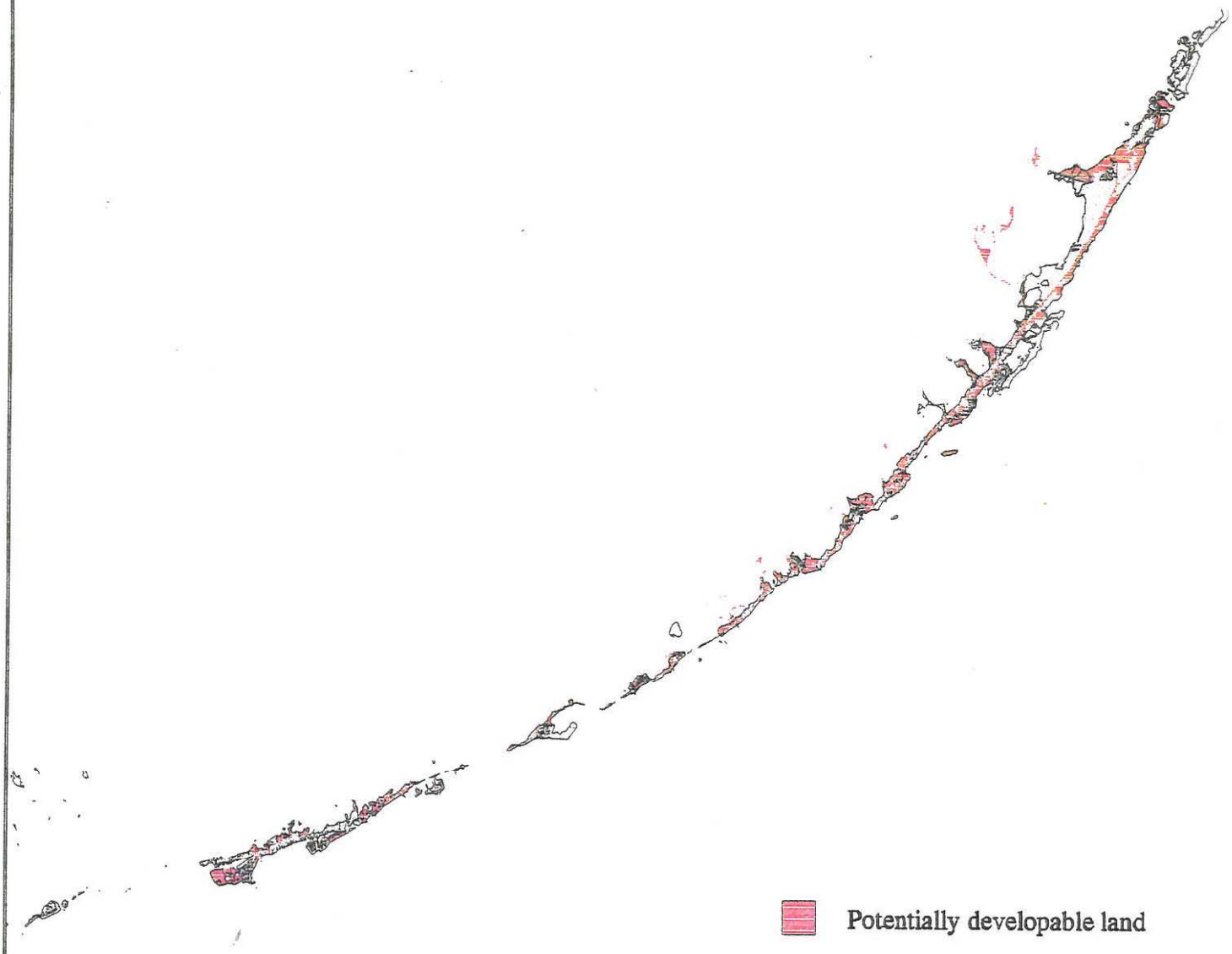
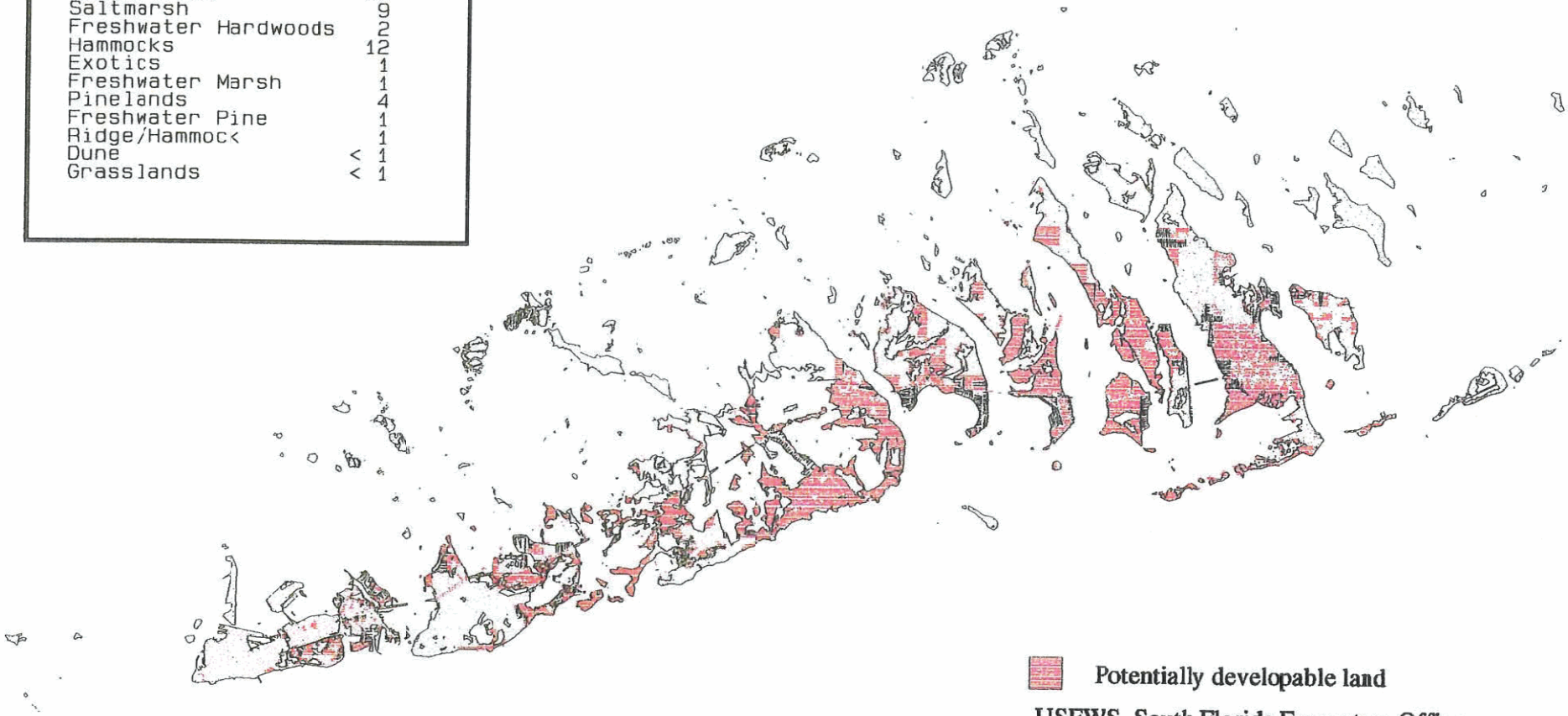


Figure 17b. Unprotected natural* land in the Lower Florida Keys.

Habitat type	Percent
Fringe Mangrove	29
Scrub Mangrove	30
Buttonwoods	10
Saltmarsh	9
Freshwater Hardwoods	2
Hammocks	12
Exotics	1
Freshwater Marsh	1
Pinelands	4
Freshwater Pine	1
Ridge/Hammoc<	1
Dune	< 1
Grasslands	< 1



Potentially developable land

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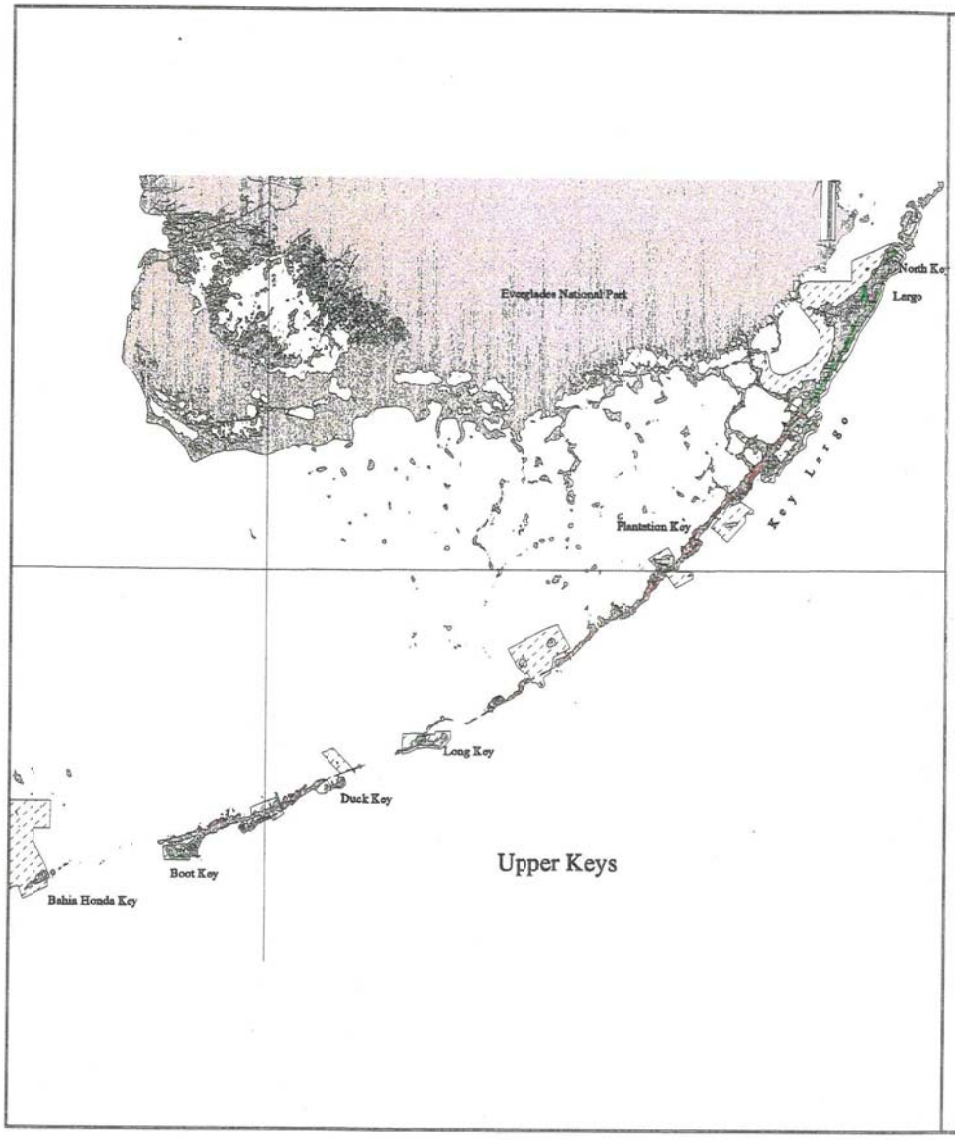
"natural" is defined as undeveloped lands according to the ADID classificiation



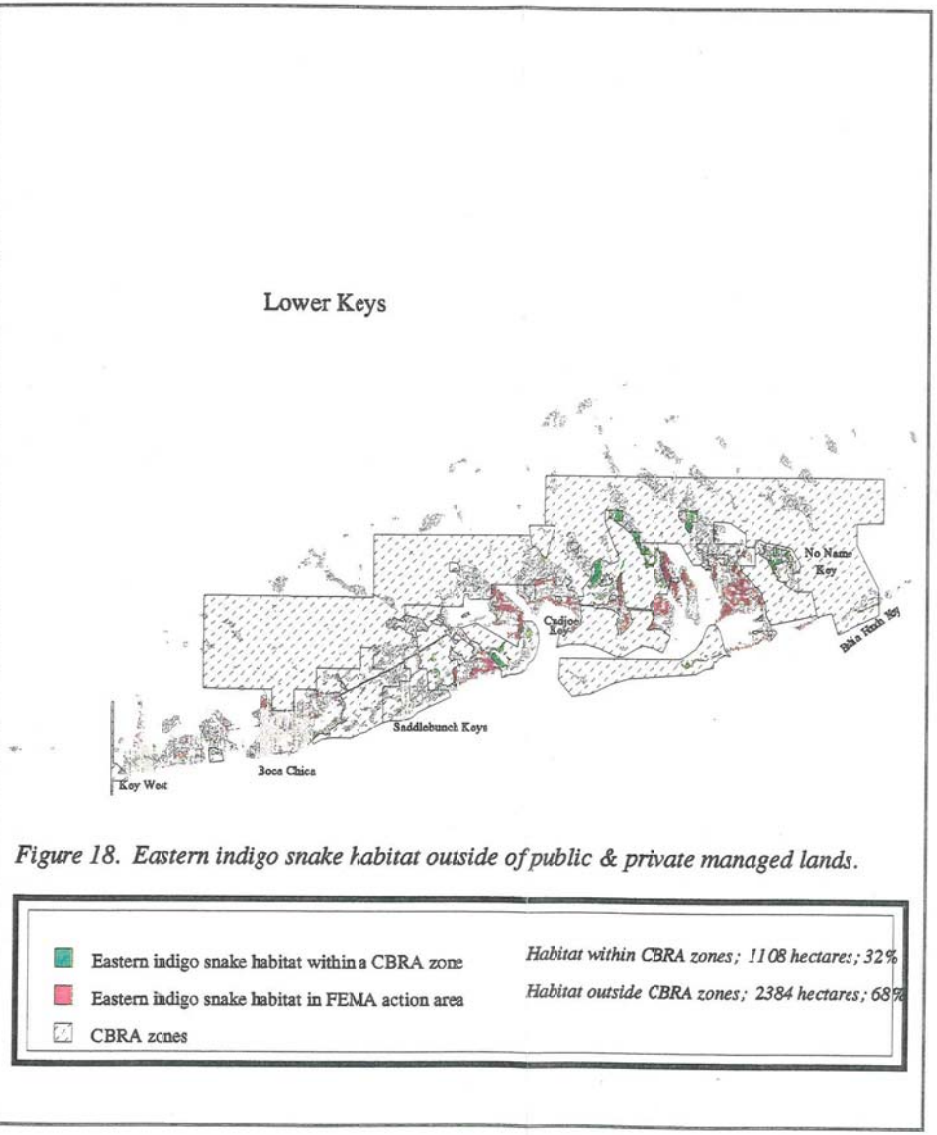


Figure 18. Eastern indigo snake habitat outside of public & private managed lands.

Eastern indigo snake habitat within a CBRA zone	*Habitat within CBRA zones; 1108 hectares; 32%*
Eastern indigo snake habitat in FEMA action area	*Habitat outside CBRA zones; 2384 hectares; 68%*
CBRA zones	

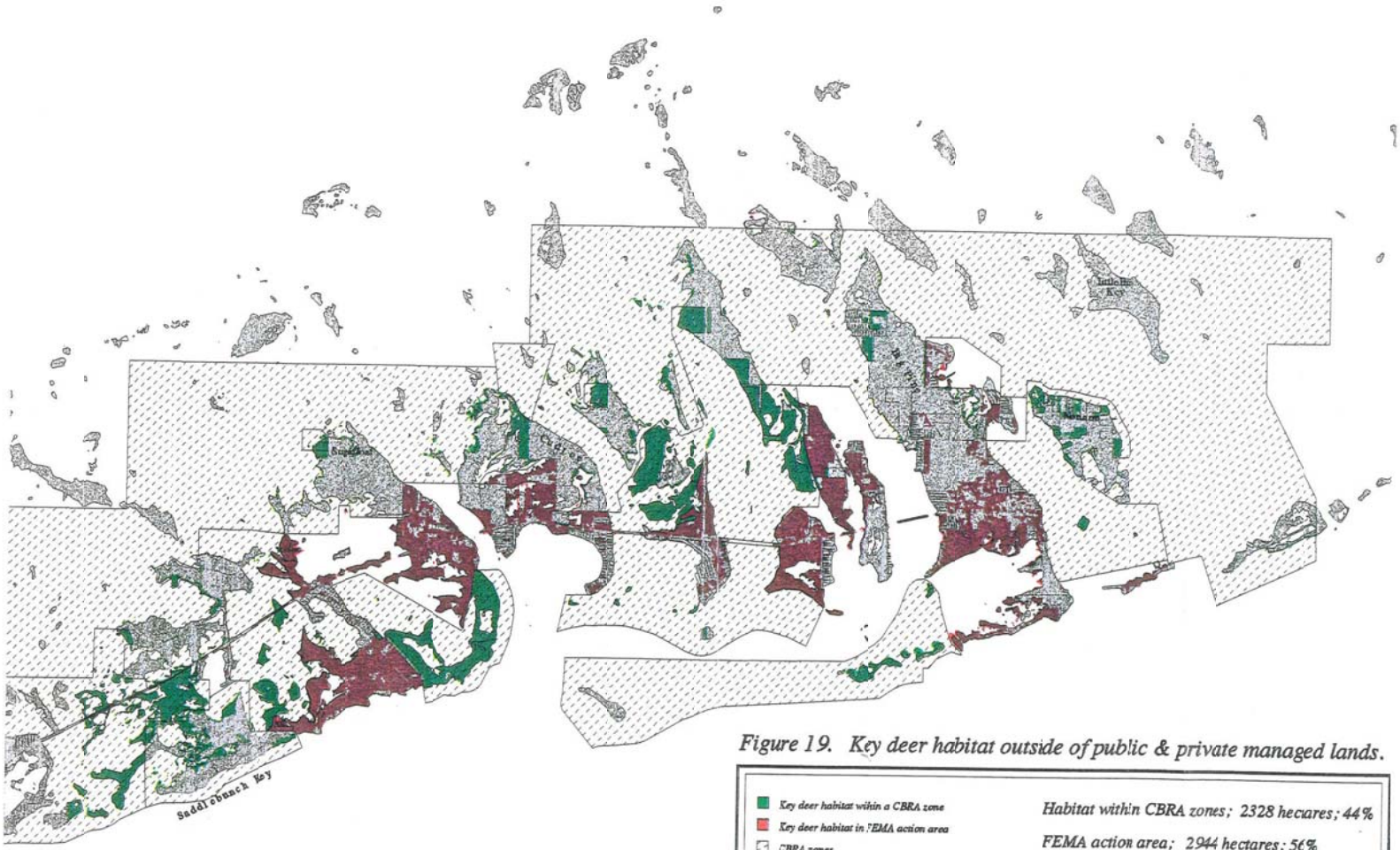


Figure 19. Key deer habitat outside of public & private managed lands.

Habitat within CBRA zones; 2328 hectares; 44%

FEMA action area; 2944 hectares; 56%

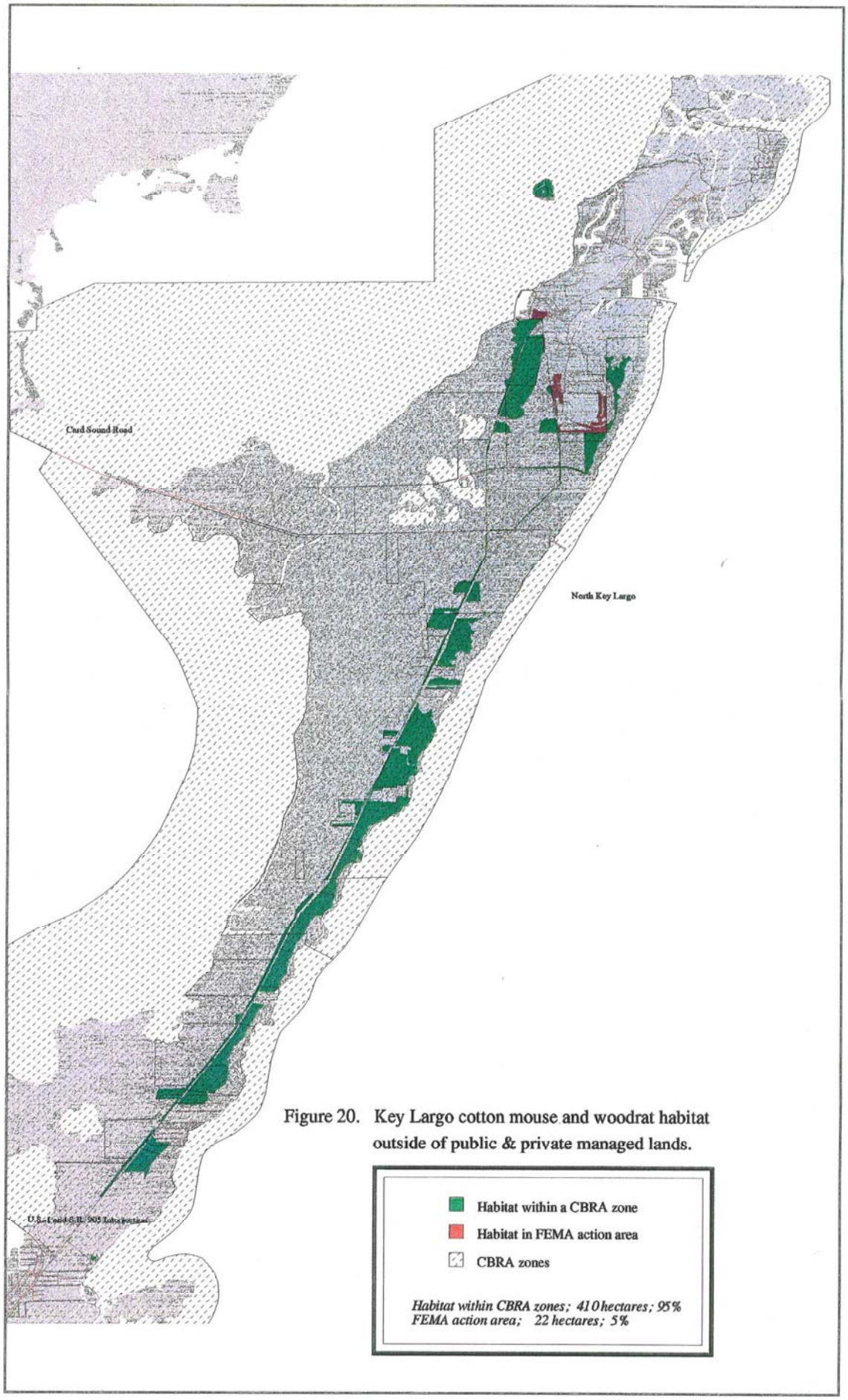
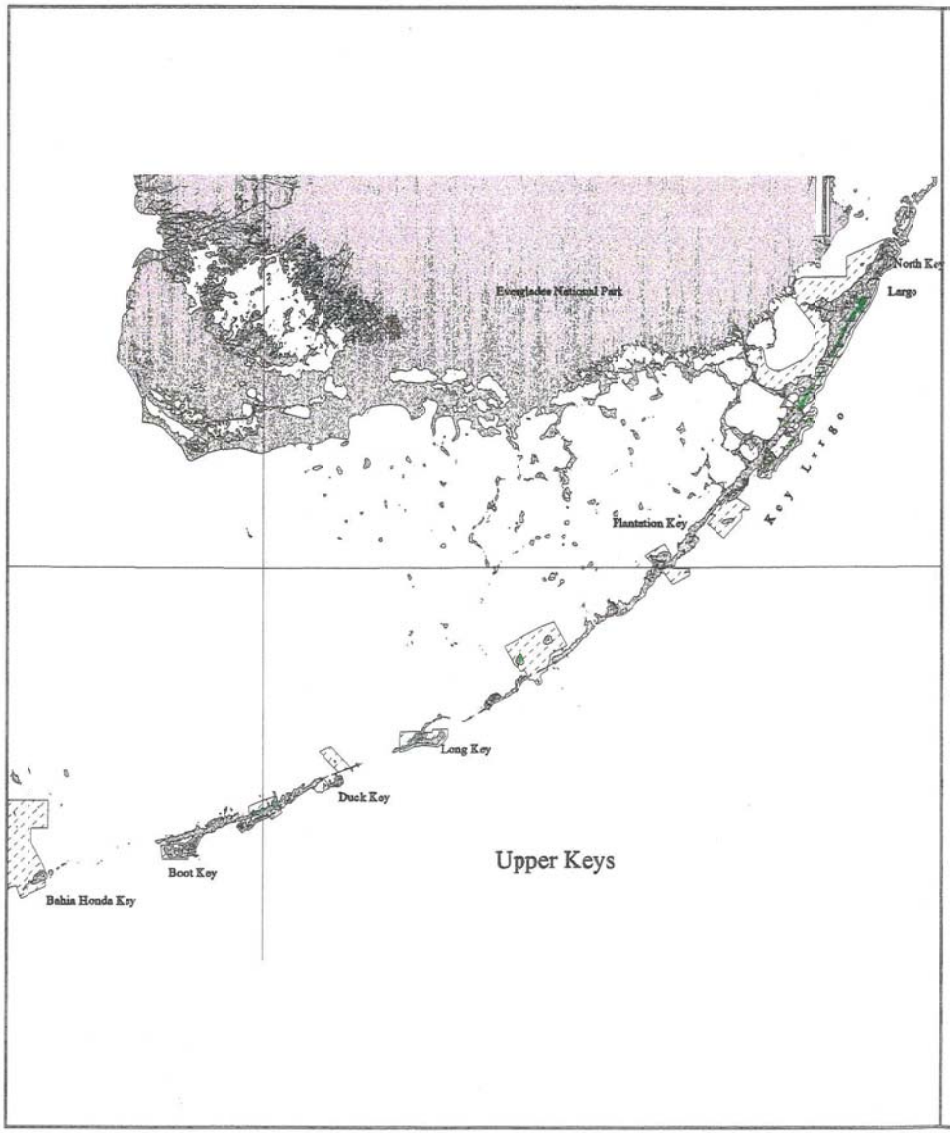


Figure 20. Key Largo cotton mouse and woodrat habitat outside of public & private managed lands.



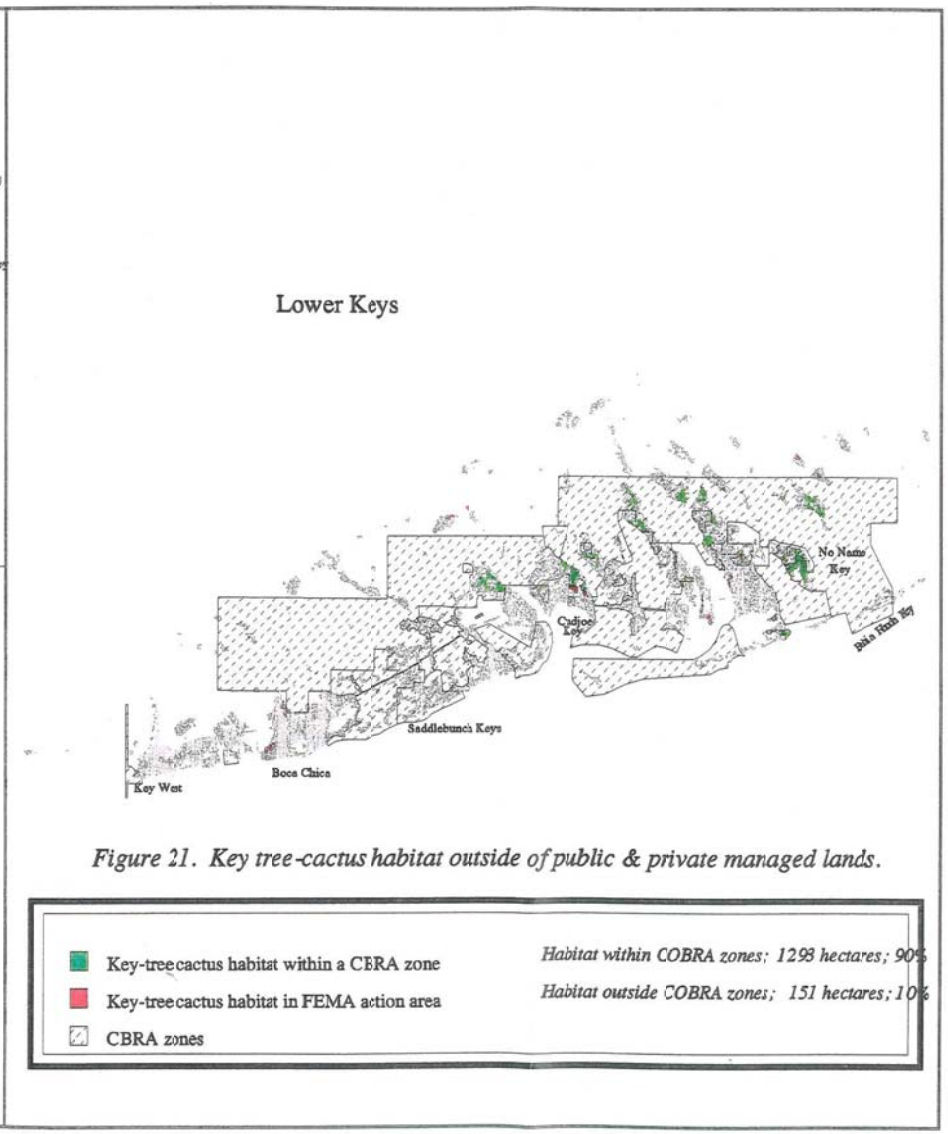


Figure 21. Key tree-cactus habitat outside of public & private managed lands.

- Key-tree cactus habitat within a CBRA zone
- Key-tree cactus habitat in FEMA action area
- CBRA zones

Habitat within COBRA zones; 1298 hectares; 90%

Habitat outside COBRA zones; 151 hectares; 10%

Figure 22. Lower Keys marsh rabbit habitat outside of public & private managed lands.

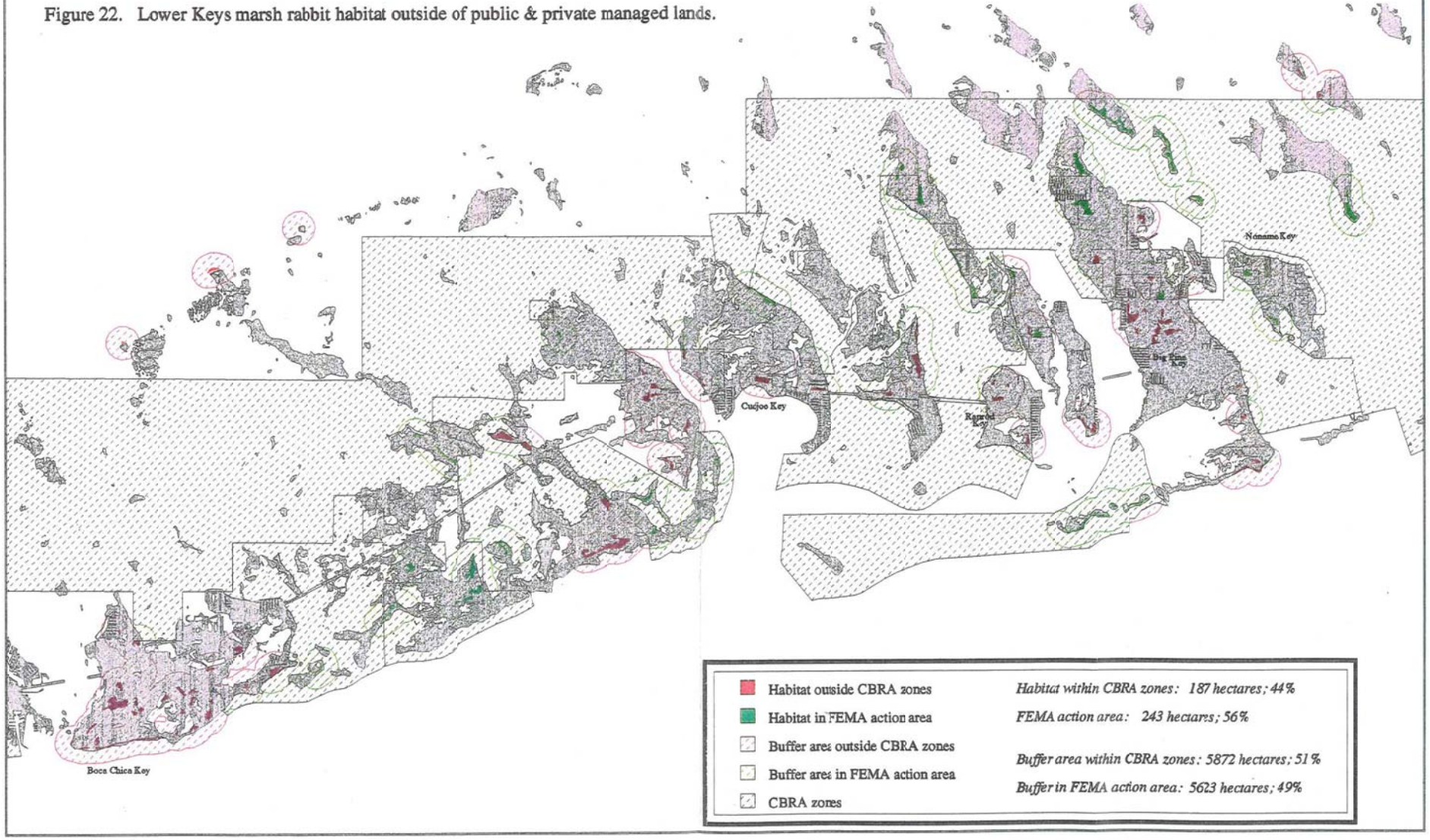


Figure 23. Schaus swallowtail butterfly habitat outside public & private managed lands.

Habitat within a CBRA zone	*Habitat within CBRA zones; 573 hectares; 50%*
Habitat in FEMA action area	*FEMA action area; 570hectares; 50%*
CBRA zones	

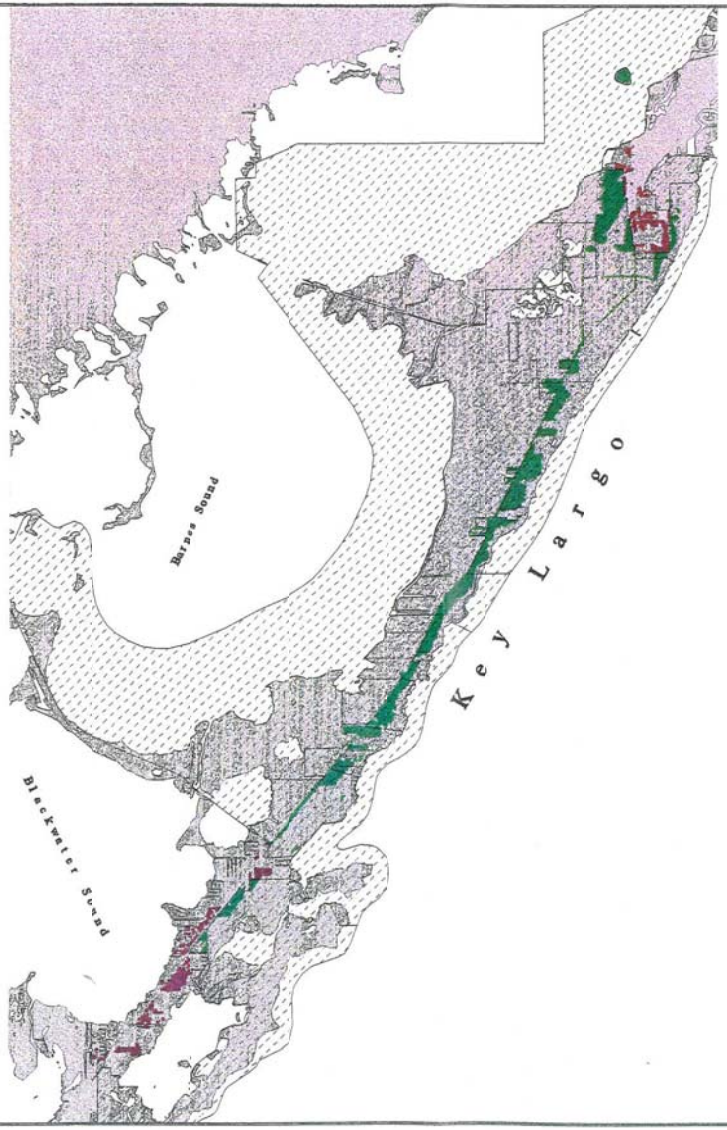


Figure 24. Silver rice rat habitat outside of public & private managed lands.

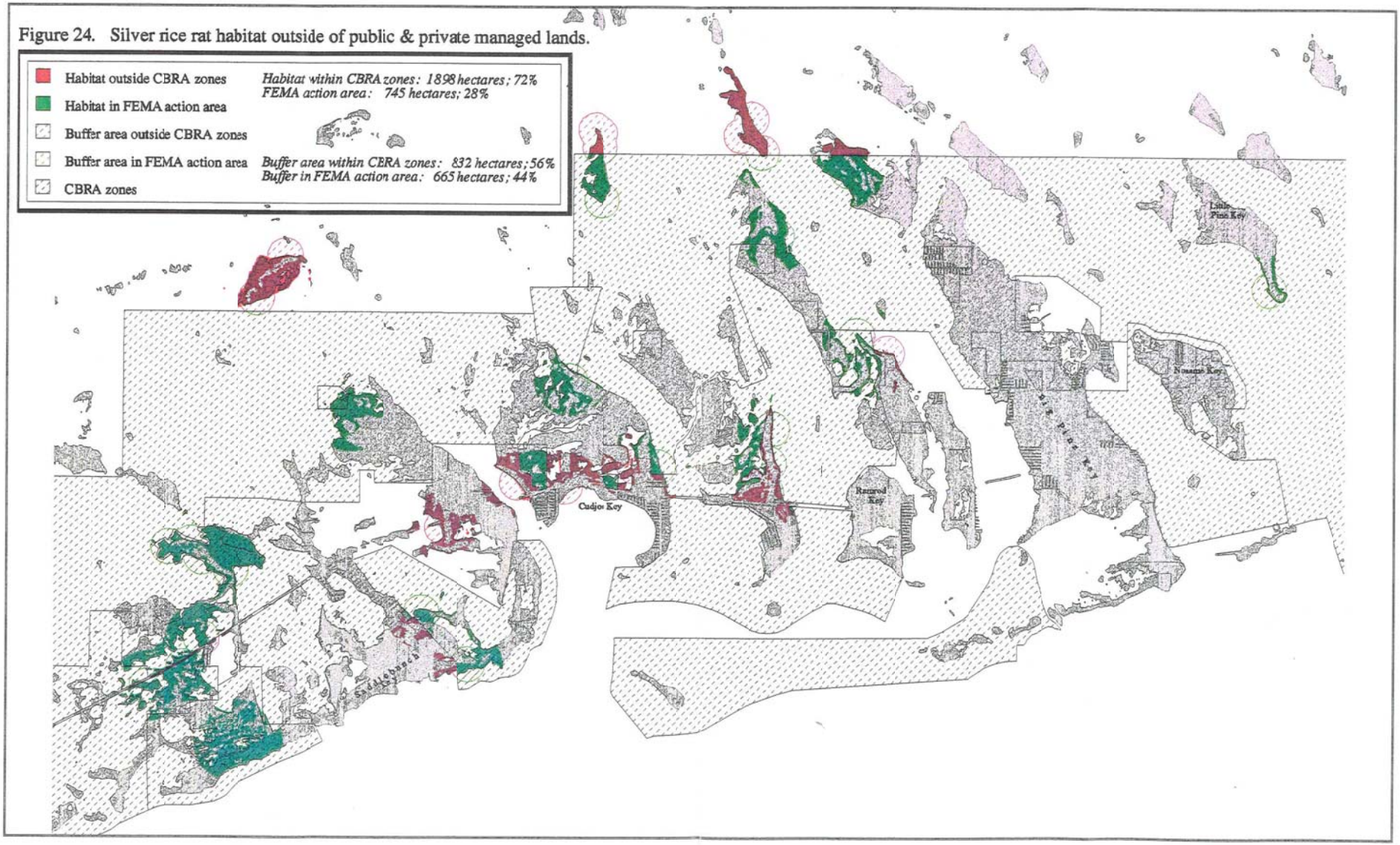
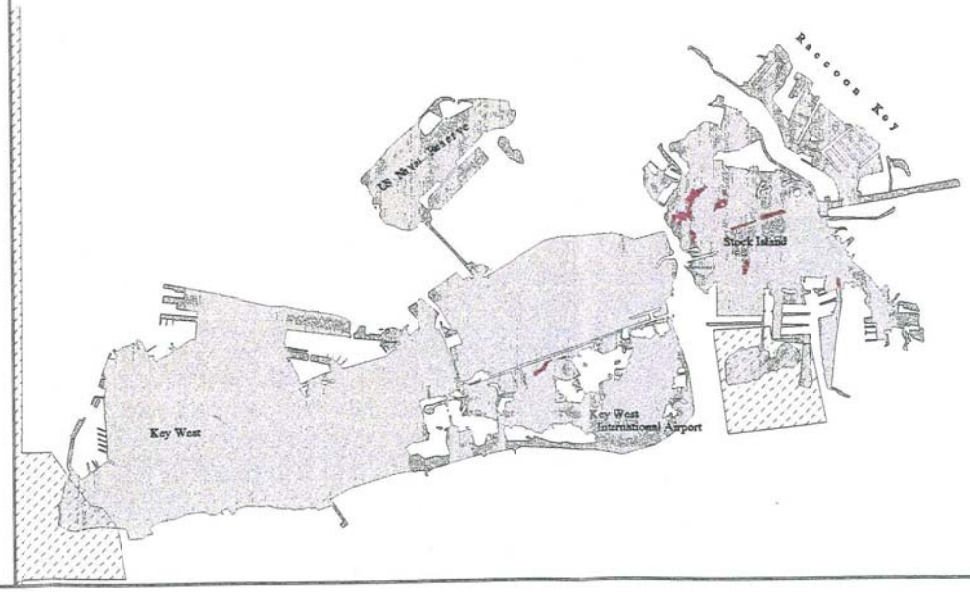


Figure 25. Stock Island tree snail habitat outside of public & private managed lands.

Habitat within a CBRA zone	*Habitat within CBRA zones; 446 hectares; 50%*
Habitat in FEMA action area	*FEMA action area; 443 hectares; 50%*
CBRA zones