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# Lower Keys Rabbit

## *Sylvilagus palustris hefneri*

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<b>Federal Status:</b>	<b>Endangered (June 21, 1990)</b>
<b>Critical Habitat:</b>	<b>None Designated</b>
<b>Florida Status:</b>	<b>Endangered</b>
<b>Recovery Plan Status:</b>	<b>Revision (May 18, 1999)</b>
<b>Geographic Coverage:</b>	<b>Rangewide</b>

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**Figure 1. Distribution of the Lower Keys rabbit; this species is endemic only to the Florida Keys.**



The Lower Keys rabbit (commonly known as the Lower Keys marsh rabbit) is endemic to the Lower Florida Keys. The narrow geographic range of this species causes it to be more susceptible to extinction. Habitat destruction and fragmentation associated with residential and commercial construction activities over the past 20 years is responsible for the Lower Keys marsh rabbit's endangered status.

This account represents a revision of the existing recovery plan for the Lower Keys marsh rabbit (FWS 1994).

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### Description

Lower Keys rabbits are small-to-medium sized marsh rabbits, with short, dark brown fur and a greyish-white belly. Their feet are small and their tails are dark brown and inconspicuous. Male and female marsh rabbits do not appear to differ measurably in size or color. Lower Keys marsh rabbits are about 320 to 380 mm in length and weigh between 1,000 and 1,400 g. Their hind feet range from 65 to 80 mm and their ears range from 45 to 62 mm in length (E. Forsy, Eckerd College, personal communication 1996).

This marsh rabbit differs from mainland (*S. p. palustris*) and Upper Keys marsh rabbits (*S. p. paludicola*) in several cranial characteristics (Lazell 1984). The Lower Keys marsh rabbit has a shorter molariform tooth row, higher and more convex frontonasal profile, broader cranium, and elongated dentary symphysis. They are also different in the extent and ornateness of the dorsal skull sculpture. The Lower Keys rabbit is the smallest of the three marsh rabbit subspecies and is distinguished from other marsh rabbits by its dark fur.

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### Taxonomy

A separate species of marsh rabbit (*S. palustris*) in the Lower Florida Keys was first noted by Schwartz (1952) with additional sightings and scat records by Layne (1974).

This species was originally included as a range extension of *S. palustris paludicola* by Hall (1981) based on Layne's findings, although Hall did not examine the specimens. The Lower Keys rabbit (*S. p. hefneri*) was recognized as a distinct subspecies by Lazell (1984) based on an examination of specimens collected from Lower Sugarloaf Key, Monroe County, Florida. *Sylvilagus palustris hefneri* is the most recently described of the three subspecies of marsh rabbit. The new subspecies was named in honor of Hugh M. Hefner in recognition of the financial support received by his corporation. The common name given for this species in the most current FWS list of threatened and endangered wildlife (CFR 17.11) is Lower Keys rabbit. Because it is more commonly called the Lower Keys marsh rabbit in other sources, this common name is also used throughout the account.

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### Distribution

Marsh rabbits are found throughout southeastern North America. *Sylvilagus p. palustris* is found from southeastern Virginia south to the Georgia-Florida border. *Sylvilagus p. paludicola* is found from the Georgia-Florida border south to the Upper Keys. Populations of marsh rabbits probably inhabited the areas of what is known today as the Lower Keys during the Wurm glacial maximum about 40,000-12,000 YBP (Lazell 1984). Since that time, sea level has continued to rise, stranding those species in the Lower Keys approximately 10,000 YBP. The isolation of these species and the unique ecological characteristics of the Keys were responsible for the marsh rabbit's speciation. Today, *Sylvilagus palustris hefneri* is confined to the oolitic and oolitic-coraline composite Lower Keys (Figure 1).

Lower Keys marsh rabbits were first reported from Key West by dePourtales (1877). The Lower Keys marsh rabbit's original range extended from Big Pine Key to Key West (Layne 1974, Hall 1981) encompassing a linear distance of about 48 km. Historically, Lower Keys marsh rabbits probably occurred on all of the Lower Keys that supported suitable habitat but did not occur east of the Seven-mile bridge where it is replaced by *S. p. paludicola*.

In 1995, a comprehensive survey for Lower Keys marsh rabbits located 81 areas, comprising a total of 317 ha, that provided suitable habitat for the Lower Keys marsh rabbit (Forys *et al.* 1996). Lower Keys marsh rabbits have been recorded at 50 of these 81 areas. The majority of these areas of suitable habitat are smaller than 3 ha and the total amount of habitat occupied by the Lower Keys marsh rabbit is about 253 ha (Forys *et al.* 1996). 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.

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### Habitat

In general, other subspecies of *S. palustris* are typically found in saltmarsh areas of slightly higher elevation, such as ridges or islands (Ivey 1959). They also are found along fresh water bordered by hammocks and flatwoods.

**Lower Keys rabbit.**

Original photograph courtesy of  
U.S. Fish and Wildlife Service.



Normally, marsh rabbits are restricted to relatively undisturbed wetlands (Padgett 1989).

The Lower Keys marsh rabbit is habitat specific, depending upon a transition zone of grasses and sedges for feeding, shelter, and nesting. This species primarily occurs in the grassy marshes and prairies of the Lower Keys; which are transitional areas similar in form and species composition to communities interspersed throughout mangrove forests of mainland Florida (Forys and Humphrey 1994). These wetland communities lie in the middle of the salinity gradient in the Lower Keys. Major vegetative species include grasses (*Monanthochloe littoralis*, *Fimbristylis castaneasea*); succulent herbs (*Borrichia frutescens*, *Batis maritima*, *Salicornia virginica*); sedges (*Cyperus* spp.); and sparse tree cover (*Conocarpus erectus* and *Pithecellobium guadalupense*).

Lower Keys marsh rabbits also use marshes at the fresh water end of this salinity gradient. Fresh water marsh areas are dominated by sedges like sawgrass (*Cladium jamiacense*), with succulent herbs like seashore dropseed (*Sporobolus virginicus*) and grasses like cordgrass (*Spartina* spp.). Fresh water marshes are found in depressions in the interior of only a few islands, primarily in the Lower Keys. During the wet season these areas can accumulate standing water.

Marsh rabbits also use coastal beach berm habitat, which is a relatively rare habitat consisting of a vegetated high ridge of storm-deposited sand and shell. Coastal berms are vegetated with over 84 plant species, including bolly (*Guapira discolor*), gumbo limbo (*Bursera simaruba*), poisonwood (*Metopium toxiferum*), seagrape (*Coccoloba uvifera*), and Spanish stopper (*Eugenia foetida*) (Kruer 1992). Coastal berm habitat in the Lower Keys is often disturbed and is found on Money, Ohio, and Porpoise keys, Cook's Island, the north edge of Pye Key, Key Lois, West Content Key and several islands in the Great White Heron NWR, Lower Sugarloaf, Saddlehill, and the

BocaChica/Geiger Key area. Many of these are in private ownership (Kruer 1992). Of these areas, Lower Keys marsh rabbits are known from Long Beach on Big Pine Key and Sugarloaf Beach on the Saddlebunch Keys, but may also occur in other areas.

Freshwater marsh and coastal berm habitats are relatively rare in the Keys. Both fresh and saltwater marshes are limited in the Keys, since mangroves occupy coastal areas and interior fresh water habitat is scarce.

Lower Keys marsh rabbits prefer areas with high amounts of clump grass, ground cover, and *Borrichia frutescens* present, areas closer to other existing marsh rabbit populations, and areas close to large bodies of water (Forys and Humphrey 1994). These marsh rabbits spend most of their time in the mid-marsh (*Borrichia frutescens*) and high-marsh (*Spartina* spp. and *Fimbristylis castanea*), both of which are used for cover and foraging, while most nesting occurs in the high-marsh area (Forys and Humphrey 1994). Lower Keys marsh rabbits occasionally use low shrub marshes and mangrove communities (red mangrove--*Rhizophora mangle*, black mangrove--*Avicennia germinans*, white mangrove--*Laguncularia racemosa*, and buttonwood--*Conocarpus erectus*) for feeding and as a corridor between patches of transitional habitats. In 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 freshwater wetlands, the Lower Keys marsh rabbit may use sawgrass for the same purpose. Not much is known on how marsh rabbits use vegetation in coastal berm areas (Kruer 1992, Forys and Humphrey 1994).

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## Behavior

### Dispersal and Home Range

Adult Lower Keys marsh rabbits of the same sex do not have overlapping home ranges, and may display territorial behavior if another adult enters their home range. The home ranges of these marsh rabbits average 0.32 ha. Adult marsh rabbits have permanent home ranges, while male subadults tend to disperse. 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 usually travel through a variety of habitats between their natal and permanent home ranges, including areas with dense ground cover, mangroves, upland hardwood hammocks, and vegetation between the road shoulder and the water (Forys and Humphrey 1994). Marsh rabbits are good swimmers and will swim when pursued (Ivey 1959, Padgett 1989). Dispersing marsh rabbits suffer high mortalities, particularly when there is a lack of habitat between populations or when there are roads to cross. Dispersing Lower Keys marsh rabbits travel up to two kilometers from their nests, expanding their home ranges with time.

### Population Structure

The Lower Keys marsh rabbit, with its small body size, short life span, high reproductive output, and high habitat specificity, exhibits classic metapopulation community dynamics (Forys 1995). There are 40 subpopulations of rabbits that occur in small disjunct patches of habitat on four keys. Rabbits living in these habitat patches are socially isolated from other patches but interact through dispersal (Forys and Humphrey 1996). Distance among habitats is important because the ability of rabbits to recolonize vacant habitat patches depends upon the presence of habitat corridors. These habitat patches occur in a highly fragmented mosaic of native and disturbed habitat, with few contiguous areas of native habitat greater than 5 ha (Forys 1995). Random population fluctuation is evident in marsh rabbit populations; several populations were so small and contained so few individuals of the same sex that they eventually became extirpated (Forys 1995). The Lower Keys marsh rabbit population is estimated to contain approximately 100 to 300 individuals.

### Reproduction

Both sexes of marsh rabbits (*S. palustris*) begin to sexually mature at about nine months of age. At this time, the majority of the males disperse. Sexually-maturing females do not appear to disperse. 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 5 populations indicates that all females breed and only a portion of the males breed (FWS 1994).

Lower Keys marsh rabbits do not display an apparent seasonal breeding pattern (FWS 1994). However, the highest proportion of females with litters occurs in March and September; the lowest proportion in April and December. The average number of litters produced during the wet and dry seasons do not differ significantly. Other species of marsh rabbits breed year round, but seasonal patterns are more evident (Tomkins 1935, Blair 1936, Holler and Conaway 1979). In South Florida, other marsh rabbit pregnancy rates are usually lower from September through December and higher from February through June (Holler and Conaway 1979). Higher anestrous or infertile periods are also evident from mid-October through mid-March, although anestrous females are present in every month. A large enough proportion of fertile males are able to breed year round. During a breeding season, marsh rabbit males become ready to breed just prior to females, whose breeding may be induced by male behavior. The number of fertile males decreases one month prior to female pregnancy.

Some female marsh rabbits in South Florida may be continuously pregnant and could potentially produce 10-12 litters per year, although this high rate of productivity is rare since some females fail to breed each month (Holler and Conaway 1979). Usually, 75 percent of female marsh rabbits in South Florida are pregnant during the height of the breeding season. Although no estimate is available for Lower Keys marsh rabbits, the average gestation period of marsh rabbits from mainland Florida ranges from 30 to 37 days with an average of 6.92 to 5.68 litters per year, respectively (Holler and Conaway 1979).

The Lower Keys marsh rabbit may be less fecund than other marsh rabbits (FWS 1994). An average of 3.7 litters per year has been reported for Lower Keys marsh rabbits, which is a lower fecundity rate than southern Florida marsh rabbits' 5.7 litters per year (Holler and Conaway 1979). Some marsh rabbits experience

total litter resorption that can affect their reproductive output. The loss of these ovulated ova can be related to maternal physiological changes in response to stressful events like overcrowding (Conaway and Wight 1962). It is not yet known if such stresses cause total litter resorption in Lower Keys marsh rabbits, but with the continual loss of habitat, marsh rabbits may experience similar problems.

A population viability analysis (PVA) conducted for the Lower Keys marsh rabbit predicted that this species will go extinct in the next 20 to 30 years under current conditions (Forys 1995). Although the PVA did not evaluate the effects of any increases in the threats, the FWS 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 was removed (Forys and Humphrey 1996). Persistence was not extended appreciably 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 continued degradation of its habitat and predation by cats are likely to push this subspecies of marsh rabbit towards extinction.

### Foraging

Marsh rabbits and other species of rabbits feed throughout the year on a variety of vegetation. Marsh rabbits do show a preference for particular species, but this is not based on seasonal changes. The climate and vegetation in the Lower Keys are relatively stable coinciding with the marsh rabbits invariant diet (Forys and Humphrey 1994).

Marsh rabbits eat vegetation in proportion to its abundance. The most important food species for the Lower Keys marsh rabbit appears to be *Borrchia frutescens*, which is common in the mid-saltmarsh area. The marsh rabbit spends most of its time feeding in the mid- and high- marsh areas (Forys and Humphrey 1994). Rabbits have been seen foraging on a variety of grass, sedge, shrub and tree species, but have not been seen eating tree leaves or bark. Lower Keys marsh rabbits feed on at least 19 different plant species, representing 14 families (FWS 1994). The most abundant species in the rabbit's diet include *Sporobolus virginicus*, *Salicornia virginica*, *Spartina spartinae*, *Borrchia frutescens*, *Rhizophora mangle* and *Laguncularia racemosa* (Forys and Humphrey 1994). Dietary habits are not affected by sex or season.

Based on their distribution, Lower Keys marsh rabbits appear to need 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 most salt tolerant mammal in the study, could not maintain its body mass on seawater.

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## Relationship to Other Species

Many endemic species, like those in the Lower Keys, have evolved in an environment with reduced levels of competition, predation, and disease, and are thus more susceptible to extinction (Primack 1993). Endemic species are also more vulnerable to extinction due to loss of habitat (Gilpin and Soule 1986) and must balance a dynamic equilibrium between the processes of immigration and extinction in order to survive (MacArthur and Wilson 1963, 1967). This equilibrium is contingent upon the habitat itself, *i.e.*, size and isolation, and upon the ability of the species present to disperse and reproduce. The survival of endemic species and other species in the Lower Keys, including the marsh rabbit, is dependent upon the integrity and health of their habitat.

Many of the endemic species in the Lower Keys depend upon similar or adjacent habitats. The Lower Keys marsh rabbit occupies habitat that overlaps with that of other listed endemic species, such as the endangered Key deer (*Odocoileus virginianus clavium*), Key tree-cactus (*Pilosocereus robinii*), and silver rice rat (*Oryzomys palustris natator*). Marsh rabbits and silver rice rats utilize similar vegetation in salt marshes (*e.g.*, *Sporobolus virginicus*), transitional areas (*e.g.*, *Conocarpus erectus*), and freshwater marshes (*e.g.*, *Cladium jamaicense*). Coastal berm areas on Long Beach and Sugarloaf Beach are used by marsh rabbits, as well as by Key deer who use these same areas for bedding and fawning (Folk *et al.* 1990). Sugarloaf Beach is also used as nesting habitat by threatened Atlantic loggerhead (*Caretta caretta*) and endangered green (*Chelonia mydas mydas*) sea turtles. The state-listed threatened white-crowned pigeon (*Columba leucocephala*) and other bird species also feed along coastal berm areas and within forested marsh areas (Strong and Bancroft 1994).

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## Status and Trends

The Lower Keys marsh rabbit was listed as a federally endangered species on June 21, 1990 (55 FR 25591). The marsh rabbit was listed because of habitat loss and fragmentation, predation by cats, and road mortalities caused by automobiles; critical habitat was not designated. The rabbit was also listed as endangered by the State of Florida in 1989 (F.A.C. 39-27). Although once abundant on many of the Lower Keys including Key West, habitat destruction has limited this marsh rabbit to small populations on a few keys such as Boca Chica, Saddlebunch/Sugarloaf, and Big Pine Key (FWS 1994). Current population estimates range between 100 and 300 rabbits in the Lower Florida Keys. The current status of the Lower Keys marsh rabbit is considered to be declining (FWS 1994). In 1991, there was a high of 300 individuals and by 1993, the population decreased to only 100 individuals (Forys and Humphrey 1994). The marsh rabbit population was higher before 1991. Approximately one-third of the total Lower Keys marsh rabbit habitat is owned by the Department of Defense, one-third is part of the FWS' National Key Deer Refuge and Great White Heron NWR, and the remaining one-third is privately owned.

The Lower Keys marsh rabbit is vulnerable to habitat alteration, contaminants, vehicular traffic, dumping, poaching, domestic animals, feral hogs, fire ants, and exotic vegetation. 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, sheltering, and nesting habitat. All of these threats have disrupted the equilibrium between the Lower Keys marsh rabbit's environment and its survival.

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 immigration rates of the Lower Keys marsh rabbit have to be equal to or greater than the death rates. This subspecies is thought to be less fecund than others, making it more susceptible to demographic and stochastic events (Forys 1995). Direct mortality and disruption of dispersal have reduced reproductive potential. With the lower potential for interchange between subpopulations, the probability of persistence has been decreased substantially.

This 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. Currently, the habitat consists of a mosaic of small native and disturbed habitat patches. In the 2 years between the study (1988-1990) for the Lower Keys marsh rabbit's listing (Howe 1988) and the actual listing, four of the 15 original sites used in the listing were destroyed. Today, the majority of the sites that remain are isolated 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 remain, of these, 39 percent is privately owned and may be vulnerable to urbanization. Only 50 (253 ha) of these 81 patches currently have rabbits present (Forys *et al.* 1996).

The primary cause of the Lower Keys marsh rabbit's decline is habitat loss. In the past 20 years, more than half the area of suitable Lower Keys marsh rabbit habitat has been destroyed for construction of residential housing, commercial facilities, utility lines, roads, or other infrastructure in the Lower Keys. Most of the remaining suitable habitat 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 from one site to another. In larger, urbanized areas where the vegetation has been mowed, dispersing marsh rabbits have no cover from predation. In general, residential and commercial activities in the Keys have affected the Lower Keys marsh rabbit by: increasing the number of residences, increasing habitat alteration (destruction, fragmentation, degradation), increasing species mortality, interfering with reproduction, and decreasing the water quality. These actions have appreciably reduced the likelihood of this species' survival and recovery in the wild.

Because the Lower Keys marsh rabbit 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 and are important for future dispersal and recovery. The potential for recolonization has been decreased or eliminated because of habitat loss or fragmentation at both occupied and unoccupied sites.

Habitat alteration has become the largest effect that prevents this species from returning to its natural state. Continued habitat fragmentation hinders 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; therefore the Lower Keys marsh rabbit may be forced to have smaller territories if habitat is continually fragmented. If urbanization proceeds, habitat will continue to be fragmented and dispersal and migration will be hindered. 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. The destruction and fragmentation of habitat may result in habitat patches that are 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 long term (Forys *et al.* 1996).

Although habitat loss is responsible for the original decline of the Lower Keys marsh rabbit, high mortality from cats may be the greatest current threat to the persistence of the Lower Keys marsh rabbit (Forys 1996). A detailed study of cat diets in the Keys has not been conducted, but rabbits were the largest component of feral cat diets in several studies that have been conducted elsewhere (Jones and Coman 1981, Liberg 1985). Even though the exact extent cannot be determined, the number of cats present in the Lower Keys has increased over the past 20 years with the increase in the residential population. Cats are responsible for both juvenile and adult mortality (Forys 1995). Lower Keys marsh rabbits appear to be equally susceptible to cat predation, regardless of gender or age. Currently, 14 occupied patches have domestic and feral cats present.

As urbanization has increased over the past 20 years, construction of new roads, or the improvement of existing roads, has been necessary to accommodate more vehicles. The construction of roads results in two main threats to the Lower Keys marsh rabbit: interference with dispersal and increased road mortality. Vehicular traffic interferes with dispersal and may prevent essential interchange between subpopulations (Forys *et al.* 1996). Dispersing males are the most vulnerable to road mortality. Dispersal is needed for repopulating sites where rabbits have been extirpated. Since only a portion of the males breed during the year, the loss of these males may lower the likelihood of mating and hence decrease the reproductive potential. The threat of roads and traffic 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.

A significant portion of the remaining population of Lower Keys marsh rabbits is found on Naval Air Station (NAS), Boca Chica. Four Lower Keys

marsh rabbit road kills had been reported on NAS property between 1992 and 1994 (Forys and Humphrey 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 by vehicles during the rabbit's most active period 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 has been killed by an off-road vehicle on NAS property. The amount of road mortality has not been determined for other areas in the Keys, but marsh rabbits may experience the same mortality as on NAS (Forys and Humphrey 1994).

The Lower Keys marsh rabbit may be exposed to pesticides used in marsh habitat. They may also 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 FWS investigated the effects of vertebrate control agents on endangered and threatened species and determined that several chemicals (*e.g.*, Pival) would jeopardize the continued existence of the Lower Keys marsh rabbit (FWS 1993). Chemicals--such as Pival--a rodenticide used to kill rats, are lethal if ingested. The FWS 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 FWS 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 has had a negative impact upon the Lower Keys marsh rabbit that may prevent its recovery.

Other human-related effects 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 invasion of exotic plants and animals to occur. 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 20 years, but to a lesser degree than habitat loss and feral cat predation.

Since the status of the Lower Keys marsh rabbit is declining, urbanization is predicted to have adverse effects that are likely to drive this species to extinction because of its narrow range and distribution, habitat specificity, classic metapopulation community dynamics which rely on dispersal, and low recovery potential. The Lower Keys marsh rabbit is a very sensitive species that is naturally vulnerable to stochastic and deterministic events. Increasing human impacts to natural occurring events only reduces the marsh rabbit's likelihood of survival.

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## Management

To alleviate negative effects on the marsh rabbit at NAS, the FWS consulted with the Navy in 1993 concerning marsh rabbit road mortalities and mowing activities on the base. Several actions have been initiated by the Navy in an attempt to reduce these effects, including the posting of “no mowing” signs in important rabbit habitat, fencing of some rabbit habitat to prevent illegal vehicle traffic, removal of some exotics, and the elimination of the feral cat population on the installation. These cooperative efforts have not only minimized impacts on the rabbit but also provided additional protection. The Lower Keys marsh rabbit and its habitat are also protected on National Key Deer Refuge and Great White Heron NWR. In addition, the two tracts on Sugarloaf Key where the marsh rabbit occurs are in the process of being transferred to National Key Deer Refuge to provide additional protection.

In April 1996, the Recovery Team met to discuss the status of listed species in the Keys and ways to improve that status. Four main recovery objectives were determined as priority actions necessary to prevent the extinction of the Lower Keys marsh rabbit. These include the acquisition of suitable habitat with an upland buffer, control of predation by feral and domestic cats, monitoring of existing populations, and trial reintroduction of rabbits to unoccupied suitable habitat.

Recently, the FWS consulted on how the administration of the National Flood Insurance Program by the Federal Emergency Management Agency (FEMA) affects threatened and endangered species in Monroe County. The Lower Keys marsh rabbit was one of 10 species that was determined to be affected by FEMA's actions. Prior to this consultation, FEMA did not address listed species issues as required by section 7 of the ESA. FEMA's responsibilities to consult arise from 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. Although FEMA is not the only entity involved in this sequence of events, it still has the obligation, as a federal agency, to ensure its actions do not jeopardize the continued existence of a listed species like the Lower Keys marsh rabbit. The FWS concluded that the continued administration of the National Flood Insurance Program by FEMA in the Keys, with its effects on land use planning and zoning and incentives for landowners, was likely to jeopardize the continued existence of the Lower Keys marsh rabbit. As a reasonable and prudent alternative to alleviate jeopardy, FEMA committed to implement procedures to ensure their actions do not jeopardize the marsh rabbit.

Research to better understand the life history parameters of the Lower Keys marsh rabbit conducted over the past few years by the GFC and FWS have been useful in developing more effective conservation measures. In addition, the population viability analysis conducted on the marsh rabbit not only predicted this species will go extinct in the next 20 to 30 years but also resulted in the development of management scenarios to help prevent extinction (Forys 1995).

In conjunction with the GFC, the FWS recently produced Geographic Information System (GIS) maps of suitable Lower Keys marsh rabbit habitat to assist in making better management decisions. Areas in private ownership that are either occupied or unoccupied by rabbits are the most vulnerable to loss. Currently there are 44 suitable habitat patches in private ownership, encompassing

approximately 222 ha. The FWS believes all remaining occupied and unoccupied suitable habitat should be protected in order to ensure the continued existence of the Lower Keys marsh rabbit. In addition, the FWS recommends that a 500 m buffer zone be placed around these areas since adjacent areas are also vulnerable to urbanization. The necessity for a protected buffer is based on the likelihood that human influences will encroach upon and impact the Lower Keys marsh rabbit. The distance of 500 m is based on the use of upland areas by this species and the estimated range of domestic cats. 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's recovery potential is quite low due to the lack of available habitat and increased mortality due to cats and vehicular traffic. This recovery potential is increased if active management actions of populations and habitats are taken (Forys *et al.* 1996). Since urbanization has affected both occupied and unoccupied sites over the past 20 years, not only is survival affected, but the opportunity for natural or managed recovery has been precluded in some areas.

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**Literature Cited**

- Blair, W.F. 1936. The Florida marsh rabbit. *Journal of Mammalogy* 17:197-207.
- Conaway, C.H., and H.M. Wight. 1962. Onset of reproductive season and first pregnancy of the season cottontails. *Journal of Wildlife Management* 26:278-290.
- dePourtales, L.F. 1877. Hints on the origin of the flora and fauna of the Florida Keys. *American Naturalist* 11:137-144.
- Dunson, W.A., and J.D. Lazell. 1982. Urinary concentrating capacity of *Rattus rattus* and other mammals from the Lower Florida Keys. *Comparative Biochemistry and Physiology* 71A:17-21.
- Folk, M.J., W.D. Klimstra, C.R. Kruer and M.L Folk. 1990. Special Report: Key deer accessibility to all of Big Pine. Cooperative Wildlife Research Laboratory, S. Illinois University; Carbondale, Illinois.
- Forys, E.A. 1995. Metapopulations of marsh rabbits: a population viability analysis of the Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*). PhD. Thesis, University of Florida; Gainesville, Florida.
- Forys, E.A. 1996. Multi-Species Recovery Team meeting, April 1996.
- Forys, E.A., P.A. Frank, and R.S. Kautz. 1996. Recovery Actions for the Lower Keys marsh rabbit, silver rice rat, and Stock Island tree snail. Unpublished report to Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.
- Forys, E.A., and S.R. Humphrey. 1994. Biology of the Lower Keys marsh rabbit at Navy lands in the Lower Florida Keys. Semi-annual performance report no. 3 in files of the Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.
- Gilpin, M.E., and M.E. Soule. 1986. Minimum viable populations: the processes of species extinctions. Pages 13-34 in M.E. Soule, ed. *Conservation Biology: The science of scarcity and diversity*. Sinauer Associates Incorporated; Sunderland, Massachusetts.
- Hall, E.R. 1981. *The mammals of North America*. Wiley and Sons; New York, New York.
- Holler, N.R., and C.H. Conaway. 1979. Reproduction of the marsh rabbit (*Sylvilagus palustris*) in South Florida. *Journal of Mammalogy* 60(4):769-777.
- Howe, S.E. 1988. Lower Keys marsh rabbit status survey. Report to the U.S. Fish and Wildlife Service; Jacksonville, Florida.
- Ivey, R.D. 1959. The mammals of Palm Valley, Florida. *Journal of Mammalogy* 40:585-591.
- Jones, E. and B.J. Coman. 1981. Ecology of the feral cat, *Felis catus* (L.), in southeastern Australia. *Australian Wildlife Research* 8:537-547.
- Kruer, C.R. 1992. An assessment of Florida's remaining coastal upland communities: Florida Keys. Prepared for Florida Natural Areas Inventory; Tallahassee, Florida.
- Layne, J.N. 1974. The land mammals of South Florida. *Memoirs of the Miami Geologic Society* 2:386-413.
- Lazell, J.D., Jr. 1984. A new marsh rabbit (*Sylvilagus palustris*) from Florida's Lower Keys. *Journal of Mammalogy* 65(1):26-33.
- Liberg, O. 1985. Food habits and prey impact by feral and house-based domestic cats in a rural area in southern Sweden. *Journal of Mammalogy* 65:424-432.
- MacArthur, R.H., and E.O. Wilson. 1963. An equilibrium theory of insular zoogeography. *Evolution* 17: 373:387.

- MacArthur, R.H., and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press; Princeton, New Jersey.
- Padgett, T.M. 1989. A range extension of the marsh rabbit, *Sylvilagus palustris*, from southeastern Virginia. Virginia Journal of Science 40(3):177.
- Primack, R.B. 1993. Essentials of conservation biology. Sinauer Associates, Incorporated; Sunderland, Massachusetts.
- Schwartz, N.C. 1952. Land mammals of southern Florida and the Upper Florida Keys. Unpublished PhD. Dissertation, University of Michigan; Ann Arbor, Michigan.
- Strong, A.M., and G.T. Bancroft. 1994. Postfledging dispersal of white-crowned pigeons: implications for conservation of deciduous seasonal forests in the Florida Keys. Conservation Biology 8(3):770-779.
- Tomkins, I.R. 1935. The marsh rabbit: an incomplete life history. Journal of Mammalogy 16:201-205.
- U.S. Fish and Wildlife Service [FWS]. 1993. U.S. Fish and Wildlife Service Biological Opinion: Effects of 16 vertebrate control agents on threatened and endangered species. On file at the Vero Beach Field Office; Vero Beach, Florida.
- U.S. Fish and Wildlife Service [FWS]. 1994. Recovery Plan for the Lower Keys marsh rabbit. U.S. Fish and Wildlife Service; Atlanta, Georgia.

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# Recovery for the Lower Keys Rabbit

*Sylvilagus palustris hefneri*

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**Recovery Objective:** RECLASSIFY to threatened

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## Recovery Criteria

Information from recent surveys and a GIS analysis indicates that the Lower Keys marsh rabbit population has experienced local extirpations and is vulnerable to extinction as a result of habitat loss and fragmentation, and other anthropogenic factors. The nature of these disturbances isolates rabbit populations and limits the reproductive potential and survival of the marsh rabbit. Consequently, the objective is to reclassify the Lower Keys marsh rabbit from *endangered* to *threatened* by protecting and managing its habitat in the Lower Keys, reducing mortality from cat predation, and increasing the size of its population. This objective will be achieved when further loss, fragmentation, or degradation of suitable marsh rabbit habitat has been prevented; native and non-native nuisance species have been reduced by 80 percent; all suitable habitat on priority acquisition lists is protected either through land acquisition or cooperative agreements; potential habitat on these protected lands are restored or rehabilitated to provide habitat for the Lower Keys marsh rabbit; and stable populations of the Lower Keys marsh rabbit are distributed on at least five Keys connected to U.S. Highway 1 and three backcountry islands in the Lower Keys. These populations will be considered demographically stable when they exhibit a stable age structure and have a rate of increase ( $r$ ) equal to or greater than 0.0 as a 3-year running average for 6 years.

## Species-level Recovery Actions

- S1. Determine the distribution and status of the Lower Keys marsh rabbit.** Surveys conducted by the GFC in 1995 have provided the majority of information known, but some areas still need surveying. Conduct surveys to determine the distribution and status of marsh rabbits.
- S1.1. Conduct additional surveys to refine marsh rabbit distribution.** Conduct necessary aerial and ground surveys for the presence of marsh rabbits and suitable habitat. Conduct surveys at the northern extent of the range (Big Pine area and the backcountry islands in the Big Pine Complex--e.g., Little Pine Island, Johnson Keys) and the southern extent of the range (Saddlebunch area) to finalize distribution and range map. Conduct surveys along U.S. Highway 1 on Saddlebunch Key.
- S1.2. Conduct presence/absence surveys in areas of unoccupied habitat.** A recent status survey examined potential habitat available and documented the presence or absence of marsh rabbits (Forys et al. 1996 op. cit.). Conduct additional presence-absence surveys in different seasons over a period of 3 years to confirm use or non-use of unoccupied habitat patches.

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- S1.3. Investigate components of both occupied and unoccupied marsh rabbit habitat and determine why rabbits are present or absent.**
- S1.4. Maintain and improve the GIS database for marsh rabbit information.** Compile and maintain marsh rabbit distribution information through the FWS and GFC Geographic Information System (GIS) databases.
- S2. Protect and enhance existing populations.**
- S2.1. Assign a biologist responsibility for implementing recovery actions for the threatened or endangered species of the Lower Keys.** Recovery actions implemented to recover the marsh rabbit will benefit other threatened or endangered species in the Lower Florida Keys, including the Key deer, Keys tree cactus, silver rice rat, and Stock Island tree snail. The number of actions that will be necessary to recover threatened or endangered species in the Middle and Lower Florida Keys will require the attention of a biologist or similarly-trained professional who is dedicated to specifically addressing the recovery needs of these species.
- S2.2. Conduct marsh rabbit reintroductions from natural wild populations.**
- S2.2.1. Develop a standard protocol for conducting, monitoring, and evaluating all reintroduction, translocation, and supplementation efforts of Lower Keys marsh rabbits using the IUCN/SSC Guidelines for Reintroductions.** Develop criteria that determine the type of release to be conducted, evaluate and select release site, identify source and health of release stock, develop and monitor short-and long-term success indicators, and develop a policy on intervention. Ensure release sites are free of threats, especially cats, prior to any release of rabbits.
- S2.2.2. Reintroduce marsh rabbits on Water Key.** FWS manages 20 ha of suitable habitat on Water Key which is within the historic range that once supported rabbits and can currently support about 22-130 individuals. Conduct a direct release of 10 adults to this area from five stable nearby populations. Radio collar and tag adults and monitor three times each week for the first two months, then once a month for the next year. Conduct pellet counts to estimate the number of adults and juveniles.
- S2.2.3. Conduct reintroduction of marsh rabbits to other areas.** Direct release and monitor rabbits on federally owned or managed land on the Torch Keys (e.g., Buccaneer Beach Estate), Little Pine Island, remote backcountry islands, and the Naval Air Station.
- S2.3. Utilize federal regulatory mechanisms for protection.** Conduct section 7 consultations on federal activities. Federal agencies whose actions may affect the rabbit include: COE, FEMA, Federal Housing Administration, and the Rural Electrification Administration. Determine jeopardy thresholds for the marsh rabbit. Estimate and evaluate the type of federal activities over the next 20 years that are likely to cause jeopardy and determine threshold levels for the total population. Coordinate with FWS Law Enforcement to prevent take under section 9. Identify what activities could result in take of marsh rabbits, such as habitat loss, cat predation, mowing, vehicular traffic, and poaching.

- S2.4. Provide information about marsh rabbits to federal, state, county, and city agencies.** Distribute information regarding the presence of marsh rabbits, their protection under the ESA, and ways to minimize impacts. Non-federal agencies that may influence the marsh rabbit include DEP, Department of Community Affairs, GFC, FDACS, Monroe County Mosquito Control, Florida Keys Aqueduct Authority, and Monroe County Government.
- S2.5. Minimize and eliminate disturbance or mortality to the Lower Keys marsh rabbit.**
- S2.5.1. Control or eliminate free-roaming cat populations near rabbit habitat.** Free-roaming cats are abundant in the Lower Keys and are a major threat to juvenile and adult marsh rabbit survival. Establish a program throughout the Lower Keys to control free roaming cats. Establish a program to license domestic cats, implement leash laws, eliminate cat-feeding stations, implement spay and neuter program, increase awareness through educational material, test diseases, and remove nuisance feral cats.
- S2.5.1.1. Continue coordination efforts with NAS, Key West to eliminate free roaming cats from that federal facility.**
- S2.5.1.2. Reduce impacts by free roaming cats. Develop deed restrictions to prohibit free roaming cats in rabbit sensitive areas.** Develop and enforce deed restrictions that minimize the effects of free-roaming cats on Lower Keys marsh rabbits.
- S2.5.2. Control raccoon predation. Raccoon populations are unnaturally high in some areas of the Lower Keys.** Raccoons are capable of killing both adult and juvenile rabbits. Eliminate supplemental food sources-- outdoor cat feeding stations and open dumpsters--to reduce raccoon populations.
- S2.5.3. Minimize marsh rabbit road mortality.** Much of the rabbit habitat left is bisected by roads, making it necessary for animals to cross. Marsh rabbits are most active from dusk until dawn and are more susceptible to road mortality during this time.
- S2.5.3.1. Install chatter strips at known rabbit crossing areas on NAS, Key West and Monroe County roads, where feasible.** Conduct follow-up monitoring to evaluate effectiveness.
- S2.5.3.2. Implement slower speed zones and increase enforcement of existing zones to decrease rabbit roadkills.** A reduction in the nighttime speed limit to 15 mph may decrease the number of road kills both on NAS, Key West and County roads. Conduct follow up monitoring to evaluate the effectiveness.
- S2.5.4. Control poaching.** Marsh rabbits are vulnerable to hunting and poaching. Enforce regulations to prohibit and prevent poaching of marsh rabbits.
- S2.6. Establish captive propagation protocols and plans.** Guidelines and protocol should be established to guide captive propagation efforts, when necessary. Any captive propagation efforts should be conducted in the Lower Keys in as similar to natural conditions as possible, continued only when necessary, and all propagation efforts should be strictly monitored. DOI guidance should be followed.

- S3. Conduct research on the life history and population ecology of the marsh rabbit.** Essential baseline information on the life history of marsh rabbits has been gathered in the last three to 5 years (*e.g.*, Forys and Humphrey 1994, Forys 1995, Forys *et al.* 1996 *op. cit.*). In order to develop reclassification criteria for the marsh rabbit, some additional information is still needed.
- S3.1. Determine if the total population size is large enough to prevent functional extinction and genetic extinction.** The population is estimated to be between 100 and 300 individuals, but is below carrying capacity based on the amount of unoccupied available habitat. Test the predictions of the PVA by obtaining long-term information on population abundance and metapopulation occupancy (Forys 1995 *op. cit.*). Test the PVA's major assumption that population growth is not currently density dependent.
- S3.2. Examine effects on the persistence of the Lower Keys marsh rabbit.** Ascertain what aspect of this species ecology makes it most vulnerable to extinction (*e.g.*, predation, lack of food, inability to find mate). Cats, black rats, raccoons, fire ants, or other animals compete with or prey on the marsh rabbit. Examine how these competitors and predators are affecting each of the subpopulations and their effects on the marsh rabbit's overall persistence.
- S3.3. Determine the effective population size.** Inbreeding does not appear to threaten the marsh rabbit because of its present genetic variation (Forys 1995 *op. cit.*), but because there are single sex populations that have been extirpated, it is important to determine if the population size is effective in preventing inbreeding depression.
- S3.4. Determine the number of subpopulations necessary to maintain a stable or increasing population.** There are 40 subpopulations of rabbits that occur in small disjunct patches of habitat in the Lower Keys. The marsh rabbit appears to exhibit classic metapopulation structure and some movement and exchange between populations is responsible for its persistence (Forys and Humphrey 1994 *op. cit.*). Increases in habitat fragmentation will decrease the rabbit's ability to recolonize different habitat.
- S3.4.1. Identify subpopulations vulnerable to extinction.** Rabbit populations have recently been extirpated from Geiger Key, separating the Boca Chica population from the Sugarloaf/Saddlebunch population. Identify additional subpopulations vulnerable to habitat fragmentation, lost corridors, and reduced dispersal, and focus recovery actions on these sites.
- S3.4.2. Determine the necessary number of subpopulations and level of exchange that will enable the rabbit to persist for 100 years.**
- S3.5. Conduct an experimental marsh rabbit reintroduction and evaluate its effectiveness in increasing the rabbits' persistence.** Determine factors for a stable population structure (*e.g.*, sex ratio, age structure, group size). Investigate these parameters to determine what constitutes a stable population structure. Mortality appears high in each sex and age class (FWS 1994 *op. cit.*), but a healthy age structure and sex ratio is not known.

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- S4. Monitor Lower Keys marsh rabbit populations.**
- S4.1. Conduct long-term monitoring.** Monitor the status of the rabbit using established pellet counting methods (Forys and Humphrey 1994). Monitor presence/absence and degree of abundance yearly until the rabbit is recovered.
- S4.2. Develop methods to monitor demographic parameters.** Monitor sex ratios, age class structure, survivorship, home range size, age of dispersal, and dispersal distance of the rabbit.
- S5. Increase public awareness and instill stewardship.** Develop informational materials and host public workshops to increase awareness about marsh rabbits and instill a sense of stewardship for the protection of this endangered species.
- S5.1. Prepare informational material for the general public.** Distribute materials at visitor information centers and local chambers of commerce.
- S5.2. Develop and implement a free-roaming cat control program.** Conduct workshops to inform residents about the necessity of controlling cat predation on marsh rabbits through licensing programs, leash laws, and spay and neuter programs.
- S5.3. Continue to inform military and civilian personnel at NAS. Inform personnel about the marsh rabbit's presence, its protection under the ESA, and ways to minimize impacts on it.**
- S6. Establish reclassification and delisting criteria.** Develop measurable reclassification criteria based on factors that result in a stable or increasing population, including total population size, number of subpopulations, sex ratio, age structure, habitat condition and availability, and level of threats. Evaluate and monitor the marsh rabbit's status in relation to reclassification criteria.
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### Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat.** Habitat loss is one of the main reasons for the Lower Keys marsh rabbit's decline. Habitat protection and management is paramount to the marsh rabbit's survival. Habitat degradation or loss can decrease the number of rabbits an area can support, contributing to the overall probability of extinction.
- H1.1. Acquire marsh rabbit habitat.** Acquire habitat essential to the rabbit's survival. Develop an acquisition plan based on habitat under greatest threat, while taking into consideration the need for reserve design (*e.g.*, corridors, core areas). About one third of all marsh rabbit habitat is privately owned.
- H1.1.1. Continue Federal acquisition efforts.** Continue to acquire habitat within the National Key Deer Refuge and Great White Heron NWR boundaries.
- H1.1.2. Support State acquisition efforts.** Continue to support the acquisition of state lands by programs such as Florida's Conservation and Recreation Lands (CARL) program.
- H1.1.3. Support and encourage land acquisition by non-governmental agencies.** Habitat not listed for federal, state, or county acquisition may become available for private purchase and management by such organizations as The Nature Conservancy and Florida Keys Land Trust.

- H1.2. Protect and manage marsh rabbit habitat. Most marsh rabbit sites are less than 5 ha in size and are near high concentrations of people.** Protect and manage these areas to prevent negative impacts on the rabbit.
- H1.2.1. Protect marsh rabbits on private lands.** Protect marsh rabbit populations on private land through acquisition, conservation easements or agreements, and education of land owners. Develop agreements or coordinate section 10 permits between the FWS and private land owners to minimize impacts such as feral cats, mowing, and exotics. For example, coordinate with Long Beach Estate Fish Camp to minimize the impact of feral cats and increase exotic control along the nature trail.
- H1.2.2. Protect marsh rabbits on public lands.** Manage public lands for exotics, off-road vehicles, dumping, feral cats and other predators, and vehicular traffic. Identify and minimize other causes of rabbit injury or mortality on public lands.
- H1.2.3. Coordinate with Federal, State and Monroe County agencies and private entities to develop management actions to protect marsh rabbit habitat.** Coordinate with these entities to ensure proposed construction activities that result in land clearing or alteration do not impact the marsh rabbit and its habitat.
- H1.2.4. Protect important corridors.** Several marsh rabbit populations are linked by corridors of low marsh and mangroves. Protect these areas by coordinating with the appropriate permitting offices to avoid any negative impact on the rabbit.
- H1.2.5. Remove invasive exotic vegetation.** Australian pine, Brazilian pepper, and *Colubrina asiatica* thrive in transition zone habitat. Australian pine needles kill undergrowth, destroying the rabbit's food, shelter and nesting sites. Brazilian pepper competes with native trees and grasses as does the viney *Colubrina*. These exotics are most abundant on the NAS and privately owned land. A list of exotic removal priority areas has been given to the Navy (Forys and Humphrey 1994). Continue efforts to remove exotic plants in Lower Keys marsh rabbit habitat.
- H1.2.6. Prevent habitat areas from being mowed.** Grass mowing temporarily destroys shelter, nesting sites, food and may kill young in the nest. Coordinate with NAS, Key West, and private land owners to reduce the impact of mowing on the Lower Keys marsh rabbit.
- H1.2.7. Fence or barricade areas where off-road vehicle (ORV) use and/or dumping is a threat.** Areas along roads are often used by ORVs and as dumps. Dumping and ORV use destroys habitat. Other methods have been attempted to deter ORV use, but fences 0.3 m off the ground appear to be the best method to prevent illegal vehicle use and yet allow rabbit and other species' movements. In areas that are also used by Key deer, alternative methods should be explored.
- H1.2.8. Continue cooperative management at NAS, Key West. NAS has minimized their impacts on the Lower Keys marsh rabbit through management actions.** Continue protection efforts such as controlled mowing, exotic removal, habitat restoration, and cat control.

- H2. Restore and create marsh rabbit habitat.** Several rabbit habitat sites, especially the transition zone, have been scarified by ORV's, covered with refuse, or disturbed by previous land use. Restored, these areas could support more marsh rabbits and decrease the chance of the rabbit's extinction.
- H2.1. Restore natural tidal flow and hydrology by placing culverts or removing fill.** The Big Pine Slough Restoration project will restore tidal flow that will benefit rabbits. Continue hydrological restoration efforts in other areas of marsh rabbit habitat.
- H2.2. Manage mosquito ditches so they do not impact rabbit habitat.** The Coupon Bight Buffer Preserve is proposing to manage mosquito ditches in a way that protects marsh rabbits. Implement this type of mosquito ditch management in other areas of marsh rabbit habitat.
- H2.3. Improve water quality in fresh water sources and create additional fresh water sources.** Restoration efforts on Shepard Tract will remove about 1 m of fill and establish deep water pockets which will benefit the marsh rabbit. Improve water quality in other fresh water areas.
- H2.4. Enhance Lower Keys marsh rabbit habitat.** Remove overstory vegetation in transitional areas in order to promote understory. Rabbit habitat in areas that have been overgrown can be enhanced by encouraging the growth of understory vegetation.
- H2.5. Improve habitat by planting or encouraging native plant species.** Plant native vegetation in areas that have been scarified or degraded.
- H2.6. Create habitat by filling and restoring areas that have been dredged or altered.** Mulch areas or regrade roads to restore and create habitat. Several areas are suitable for this type of restoration, such as habitat on the Torch Keys.
- H3. Conduct research on marsh rabbit habitat and how it affects the rabbit's distribution and abundance.** The decline of the marsh rabbit is attributed to the loss or degradation of its habitat. Understanding the relationships between the rabbit and its habitat will allow for better management of this species.
- H3.1. Investigate how rabbits use different habitat components for survival (e.g., food, shelter, nesting, traveling).**
- H3.1.1. Conduct radiotelemetry on other subpopulations.** Determine how rabbits, on Big Pine Key and other areas, utilize components of their habitat and which components are most limiting.
- H3.1.2. Investigate the effect of habitat change.** Determine how the rabbit's distribution and abundance is affected by increased habitat fragmentation, degradation, and hydrological changes.
- H3.2. Determine an index of habitat fragmentation.** The marsh rabbit inhabits a patchy landscape with very few contiguous habitat patches greater than 5 ha. Marsh rabbits have been able to survive because of the ability to disperse between populations.
- H3.2.1. Investigate movement patterns and the spatial use of habitat to identify important core areas and corridors.**
- H3.2.2. Determine home range and minimum area required.** Determine if home range estimates reflect the norm for the total population. Compare size of home range in fresh water habitat versus salt marsh habitat.

**H3.2.3. Determine if the amount and configuration of habitat is sufficient to support a stable or increasing population of Lower Keys marsh rabbits.**

- H4. Monitor the status of marsh rabbit habitat and examine ecological processes.** Conduct yearly monitoring evaluations of the marsh rabbit's habitat. Overlay habitat quality with GIS mapping of habitat locations, including what patches are being altered or lost each year. Use GIS to update the loss or change of habitat from residential or commercial construction.
- H5. Increase public awareness of Lower Keys marsh rabbit habitat and instill stewardship.** Conduct workshops with the public to inform private land owners on appropriate management practices to preserve marsh rabbit habitat. Encourage private land owners to remove exotics, maintain natural hydrology, refrain from mowing rabbit habitat, and restore disturbed areas. Prepare literature with information regarding the Lower Keys marsh rabbit's habitat and ways to protect it.