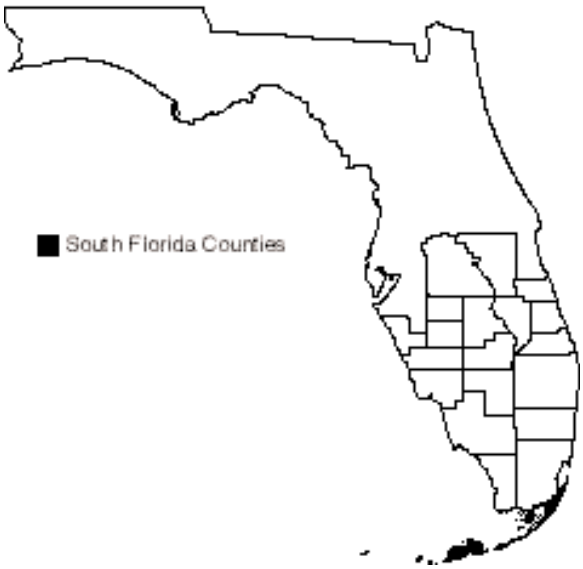
Key Largo Cotton Mouse

Peromyscus gossypinus allapaticola

Federal Status:	**Endangered (August 31, 1984)**
Critical Habitat:	**None Designated**
Florida Status:	**Endangered**
Recovery Plan Status:	**Original (May 18, 1999)**
Geographic Coverage:	**Rangewide**

Figure 1. Distribution of the Key Largo cotton mouse; this species is endemic only to Key Largo in the Florida Keys.



The cotton mouse is one of the most common small mammals in South Florida and throughout the southeastern United States, but the Key Largo cotton mouse is endemic to Key Largo. Once ranging throughout the tropical hardwood hammocks in the Upper Keys south to near Tavernier, the Key Largo cotton mouse is now restricted to the northernmost portion of Key Largo (Barbour and Humphrey 1982). Urbanization of Key Largo has decimated the forests of tropical hardwood hammocks and has reduced the availability of food, shelter, and habitat for the cotton mouse causing it to be in an endangered condition.

This represents the rangewide recovery plan for the Key Largo cotton mouse.

Description

Key Largo cotton mice are larger with a more reddish color than other subspecies of cotton mice from peninsular Florida. Its pelage is red dorsally, with dusky brown sides and white underparts. Its bicolored tail is darker brown on top and whiter underneath. Body length is 170 to 189 mm, tail length is 72 to 87 mm, and hind foot length is 21 to 23 mm.

Taxonomy

The Key Largo cotton mouse was first described as a distinct subspecies by Schwartz (1952a) and is distinguished as a separate subspecies because of its overall larger size (*e.g.*, total length, tail length, skull measurements) and more reddish-colored fur. Its name originates from the Seminole Indian term *allapattah* which stands for the tropical dry deciduous hammocks of South Florida (Humphrey 1992).

Distribution

Cotton mice are found throughout the southeastern U.S, but the Key Largo cotton mouse is an endemic subspecies that formerly occupied hardwood hammock forests on all of Key Largo, Monroe County, Florida (Figure 1). Historically, they were found as far south as Plantation Key, near Tavernier (Layne 1974, Brown 1978a, 1978b), but are currently restricted to hammocks on the northern portion of Key Largo (Humphrey 1992). Attempts to collect the cotton mouse in southern Key Largo have been unsuccessful in recent years and it is now restricted to that portion of the Key north of the U.S. 1-C.R. 905 intersection (Brown 1978a, b; Barbour and Humphrey 1982). This area is commonly referred to as "north Key Largo." The Key Largo cotton mouse was introduced to Lignumvitae Key in 1970 (Brown and Williams 1971), but was apparently unable to successfully establish a population.

Habitat

The Key Largo cotton mouse uses a variety of tropical hardwood habitats including recently burned, early successional, and mature hammock forests, and *Salicornia* coastal strands adjacent to these forests (Humphrey 1992). Hardwood hammocks are highly productive forests with a tall canopy (average 9.8 m) and an open understory (Ross *et al* 1992). Canopy trees include black ironwood (*Krugiodendron ferreum*), gumbo limbo (*Bursera simaruba*) Jamaican dogwood (*Piscidia piscipula*), mahogany (*Swietenia mahagani*), pigeon plum (*Coccoloba diversifolia*), poisonwood (*Metopium toxiferum*), strangler fig (*Ficus aurea*), and wild tamarind (*Lysiloma latisiliquum*). Hammock understory contains torchwood (*Amyris elemifera*), milkbark (*Drypetes diversifolia*), wild coffee (*Psychotria nervosa*), marlberry (*Aroisia escallonioides*), stoppers (*Eugenia* spp.), soldierwood (*Colubrina elliptica*), crabwood (*Gymnanthes lucida*), and velvetseed (*Guettarda scabra*). Ground cover contains cheese shrub (*Morinda royoc*) and snowberry (*Chicocoea alba*). Cotton mice have also been trapped in recently burned areas where bracken fern (*Pteridium aquilinum*) predominates (Goodyear 1985).

Behavior

Much of the information available for the Key Largo cotton mouse is inferred from other cotton mice populations in Florida. The Key Largo cotton mouse builds leaf-lined nests in logs, tree hollows, and rock crevices. The holes occupied by these mice measure 3 to 9 cm in diameter, are often partially covered by leaves or bark and may be located at the bases of trees and near or in woodrat nests (Goodyear 1985). The Key Largo cotton mouse can move at least 2 km in 1 to 2 days. Male cotton mice have larger home ranges than females and home ranges overlap because cotton mice do not defend territories. Other Florida populations of cotton mice are primarily nocturnal and often run and climb on

Key Largo cotton mouse. *Original photograph by Phil Frank.*

tree limbs (Ivey 1949, Humphrey 1992); Key Largo cotton mice probably share these behaviors. Cotton mice use a variety of short musical barking sounds to communicate, which is probably also true for the Key Largo cotton mouse.

Reproduction

The Key Largo cotton mouse breeds throughout the year. Florida populations of cotton mice have high reproduction in the fall and early winter (Bigler and Jenkins 1975, Smith and Vrieze 1979) and reproduction may be affected by agonistic behavior by males or decrease in food supply (Smith 1982, Smith *et al.* 1984). Key Largo cotton mice produce two to three litters a year, with an average of four young in each litter (Brown 1978a). Cotton mice are short-lived, with an average life expectancy of 5 months, although potential longevity is 2 to 3 years. Although seasonal population fluctuations have been documented for cotton mice in South Florida, Smith (1982) found highly variable breeding patterns of cotton mice in the Everglades.

Foraging

Key Largo cotton mice are omnivorous and feed on a wide variety of plant and animal materials (Calhoun 1941, Pournelle 1950, Brown 1978a). Over 70 percent of the tropical hardwood hammock trees and shrubs produce fruits and berries that may provide important food items for the Key Largo cotton mouse.

Relationship to Other Species

The Key Largo cotton mouse is most closely associated with the Key Largo woodrat (*Neotoma floridana smalli*) It is often found in woodrat holes, nests, or

runways (Humphrey 1992). Both of these species are dependent upon the structure, composition, and quality of tropical hardwood hammocks. Several federally listed species occur in the same habitat or adjacent habitat, including the American crocodile (*Crocodylus acutus*), eastern indigo snake (*Drymarchon corais couperi*), and Schaus swallowtail butterfly (*Heraclides aristodemus ponceanus*). In addition, there are at least seven state-protected animals and 20 state-listed plants that also share the same habitat; such as the threatened white-crowned pigeon (*Columba leucocephala*) and Miami black-headed snake (*Tantilla oolitica*) and the endangered lignumvitae tree (*Guaiacum sanctum*), prickly apple (*Harrisia simpsonii*), tamarindillo (*Acacia choriophylla*), powdery catopsis (*Catopsis berteroniana*) and long strap fern (*Campyloneurum phyllitidus*).

Status and Trends

The Key Largo cotton mouse was recognized by the FWS in a notice of review on July 28, 1980 (45 FR 49961). It 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 protection during FWS consultation on a loan from the Rural Electrification Administration to the Florida Keys Electric Cooperative. The loan was to upgrade electrical delivery capability, potentially accelerating residential development on north Key Largo. 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).

Continual growth of the human population and residential and commercial activity in Key Largo has endangered the Key Largo cotton mouse and Key Largo woodrat. Before European settlement, the Upper Keys contained 4,816 ha of deciduous or hardwood hammock forests (Strong and Bancroft 1994). In 1830, the first Federal census counted 517 people in Monroe County, with most of them living in Key West (Simpson 1983). The Monroe County population increased to 5,657 in 1870, with only 60 residing on Key Largo. The Key Largo population increased from 2,866 people in the 1970s to 7,477 in 1980. The first subdivision was built on Key Largo in 1924; by the end of the 1950s, 77 percent of all subdivisions on Key Largo were established (Simpson 1983). The largest subdivision is Ocean Reef and covers more than 1,619 ha. The construction of residential and commercial structures had a dramatic permanent effect on the tropical hardwood forests.

Historically, north Key Largo was cleared primarily for agriculture, but sufficient hardwood hammock remained available to support the characteristic biota. The amount of habitat fluctuated depending on hurricanes, wildfires, historic land use, and subsequent vegetational succession, but the primary upland vegetation was hardwood hammocks. The original range of the cotton mouse included forested uplands of Key Largo south to Plantation. The apparent

extirpation of the cotton mouse from Key Largo south of the U.S. Highway 1-C.R. 905 intersection has been generally attributed to land clearing for residential housing and commercial construction activities (Brown 1978a, 1978b; Hersh 1981). Effects of land conversion in tropical hardwood hammocks have been more extreme in the Upper Keys than in the Lower Keys (Strong and Bancroft 1994). By 1991, 41.2 percent of the deciduous seasonal forest (1,985 ha) had been either cleared or filled to meet human needs. Much of the tropical hardwood hammock vegetation on southern Key Largo has been totally removed or thinned, eliminating habitat for the cotton mouse and the woodrat. Today, Key Largo has the highest concentration of platted lots (4,178), comprising 72 percent of all lots in the Upper Keys. An analysis of this area in 1988 showed that 775 ha of vacant, dry, privately held lands with development potential remains (Monroe County 1989).

Habitat loss and fragmentation has caused the isolation of Key Largo cotton mouse populations. The physical separation caused by these activities makes it increasingly difficult to locate a mate and to disperse. Humphrey (1988) estimated that 851 ha of remaining forest on north Key Largo supported average cotton mice densities of 21.1/ha. Humphrey 1996 (personal communication) feels that numbers have decreased since then, and that the population may have been at high point in 1984. Tropical hardwood hammock fragments up to four ha in size remain on south Key Largo, but may no longer be able to support Key Largo cotton mice. These hammocks may be too small and isolated to support viable cotton mouse populations. Remaining hammocks on south Key Largo are small, isolated, and disturbed. GFC survey results from 1995 indicate a decline in the mouse toward the southern end of its range; also it appears to be extirpated from Lignumvitae Key as none have been present in 1993 or 1997 surveys (Frank *et al.*1997). The mice are vulnerable to invasion by animals associated with humans (dogs, cats, and black rats) which predate or outcompete cotton mice.

Habitat fragmentation, combined with a decreased range, makes the Key Largo cotton mouse more vulnerable to natural catastrophes such as hurricanes or fire; each of these have damaged significant portions of north Key Largo hammocks. Tropical storms and hurricanes pose serious threats to the viability of the remaining cotton mice populations. The small size and low elevation of the Keys uplands make it difficult for cotton mice to find shelter from damaging winds and storm surge. Monroe County has experienced 20 hurricanes between 1900-1990, with 11 of these Category III or greater (NOAA 1995). In 1992, over 240 ha of vegetation in north Key Largo were severely damaged by Hurricane Andrew. Since that time, there is still evidence of habitat destruction, but signs of cotton mouse use have been observed. Other threats, associated with an increase in urbanization, include dumping of trash, possible competition with black rats, and predation by domesticated cats. Dumping of trash increases the size of black rat populations and rodent control agents used for black rats (*Rattus rattus*) kill cotton mice. Black rats may compete against cotton mice and have caused the extinction of two other subspecies of cotton mice (*P. g. restrictus* and *P. g. anastasae*), but the effects on the Key Largo cotton mouse are not known.

Management

In an attempt to establish populations of Key Largo cotton mice in another location, 14 individuals were translocated to Lignumvitae Key State Botanical Site in 1970 (Brown and Williams 1971). Cotton mice are not native to Lignumvitae Key, although the tropical hardwood hammock habitats on this key are similar to those of Key Largo. One individual was trapped in 1977, indicating that reproduction had occurred for several years, but trapping efforts in 1984 and 1990 yielded no cotton mice (Pat Wells, DEP, personal communication 1996), suggesting this species was not able to establish a viable population.

The FWS has issued two major Biological Opinions, pursuant to Section 7 of the ESA, with regard to Federal activities on north Key Largo that have had a considerable impact on the future of the Key Largo cotton mouse. The first opinion (May 1980) addressed Farmers Home Administration's financing of the Florida Keys Aqueduct Authority's pipeline improvements in the Keys. The Biological Opinion concluded that the American crocodile and the Schaus swallowtail butterfly would be jeopardized by increased water supply to north Key Largo that would accelerate the rate of residential, commercial, and recreational construction. The Key Largo cotton mouse and woodrat were not federally listed at that time, but would also be affected in a similar way. To avoid the likelihood of jeopardy, the Farmers Home Administration chose to exclude certain areas from water delivery. Approximately 45 percent of cotton mouse habitat is located in these exclusion zones and should be provided protection from loss of habitat, but the most densely populated cotton mouse habitat occurs outside of the exclusion zones and is subject to loss of habitat.

The second Biological Opinion, issued by the FWS in October, 1983, addressed the Rural Electrification Administration's proposal to provide funding to the Florida Keys Electric Cooperative for the construction of a substation to increase electrical delivery to northern Key Largo. The FWS concluded the proposed action would jeopardize the continued existence of the Key Largo cotton mouse as well as the crocodile, Schaus swallowtail, and the Key Largo woodrat because the increased electrical delivery capacity would facilitate residential construction in the hammocks of north Key Largo. No new electrical hookups have subsequently been made to any of the exclusionary areas described in the Biological Opinion.

There have been discussions among various agencies concerning the conservation of remaining hardwood hammocks on north Key Largo, which would provide 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 ESA, 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. Some

incidental take permits have been issued to subdivisions for the authorized take of Key Largo cotton mice. Subsequent public land acquisition, however, largely precluded the need for an overall habitat conservation plan.

Public land acquisition on north Key Largo has been the most beneficial management action for the Key Largo cotton mouse. Most undeveloped land west of C.R. 905 has been acquired by the FWS as part of the Crocodile Lake NWR, while much of the undeveloped land on the east side of the road has been acquired by the DEP for inclusion in its Key Largo Hammocks State Botanical Site.

The Multi-Species Recovery Team has suggested several priority actions necessary to protect and conserve the Key Largo cotton mouse, including the stabilization of existing cotton mice populations, protection and restoration of habitat, monitoring of existing populations and re-evaluation of its status in 5 years, evaluating and minimizing secondary impacts (cats, black rats, fire ants), and developing reclassification and delisting criteria (FWS 1996). The Key Largo cotton mouse is a state-listed endangered animal and protection is provided to the animal but not its habitat.

Recently, the FWS consulted on how the administration of the National Flood Insurance Program (NFIP) by the Federal Emergency Management Agency (FEMA) affects threatened and endangered species in Monroe County. The Key Largo cotton mouse was one of ten 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 cotton mouse. The FWS concluded that the continued administration of the NFIP by FEMA in the Keys, with its attendant effects on land-use planning and zoning and incentives for landowners, is likely to jeopardize the continued existence of the Key Largo cotton mouse. As a reasonable and prudent alternative to alleviate jeopardy, FEMA committed to implement procedures to ensure their actions do not jeopardize the cotton mouse.

In conjunction with the GFC, the FWS produced geographic information system (GIS) maps of suitable Key Largo cotton mouse habitat to assist in making better management decisions. Areas in private ownership are the most vulnerable to loss. Based on our GIS analyses, 4,877 ha of Key Largo cotton mouse habitat on north Key Largo remain. Of this total, 4,445 hectares (91 percent) are protected and 432 ha are vulnerable to urbanization. Much of this unprotected acreage 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) and other areas throughout north Key Largo. The FWS believes all remaining occupied and

unoccupied suitable habitat should be protected in order to ensure the continued existence of the Key Largo cotton mouse. In addition, the FWS also recommends that a 500-m buffer zone around these areas should be put in place since adjacent areas are vulnerable to urbanization as well. The necessity for a protected buffer is based on the likelihood that human influences encroach upon and impact the cotton mouse. 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 National Audubon Society *et al.* (1990) identified areas of tropical hardwood hammocks throughout Key Largo for proposed acquisition by the State that would preserve the biological diversity of the hammock ecosystem. The FWS believes that protection, conservation, and management of these additional areas is critical to the survival and recovery of the Key Largo cotton mouse.

In the past, very little research focused primarily on the Key Largo cotton mouse and additional information about this species is needed. Density and distribution studies of the Key Largo cotton mouse have been conducted (Humphrey 1988), but the status of the current population is not known. Recently, the GFC, Marathon, and the Florida Cooperative Fish and Wildlife Research Unit, Gainesville, conducted a status survey of the cotton mouse and woodrat on north Key Largo. The study results are expected to provide information on the population density, population fluctuations, survival, reproduction, and movements of these rodents on north Key Largo (Quarterly Progress Report, FWS Research Work Order No. 123).

To increase recovery efforts to protect the Key Largo cotton mouse, the FWS has placed a refuge manager at Crocodile Lakes NWR to coordinate with other agencies and increase the level of law enforcement, restoration of habitat, and protection and monitoring of cotton mice. In addition, a Student Conservation Association intern assists the refuge manager and removes exotic vegetation on the refuge.

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Recovery for the Key Largo Cotton Mouse

Peromyscus gossypinus allapaticola

Recovery Objective: RECLASSIFY to threatened.

Recovery Criteria

Information from recent surveys of the Key Largo cotton mouse and its habitat suggests that the Key Largo cotton mouse has lost more than 50 percent of its habitat to urbanization, that much of the remaining habitat has been fragmented or degraded, and that the nature of the habitat loss provides extremely limited potential for habitat restoration or rehabilitation. Consequently, the objective is to reclassify the Key Largo cotton mouse from endangered to threatened by protecting and managing its habitat on Key Largo, restoring potential habitat, and increasing the size of its population. This objective will be achieved when: further loss, fragmentation, or degradation of suitable, occupied habitat on Key Largo has been prevented; when domestic predators and competitors have been reduced by 80 percent; when all suitable, occupied habitat on priority acquisition lists on Key Largo is protected either through land acquisition or cooperative agreements; when the tropical hardwood hammocks that form the habitat for the Key Largo cotton mouse are managed on protected lands to eliminate trash and control exotics when potential habitat on these protected lands is restored or rehabilitated for the Key Largo cotton mouse; and when stable populations of the Key Largo cotton mouse are distributed throughout north Key Largo and three, additional, stable populations have been established elsewhere within the historic range of the Key Largo cotton mouse. 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 Key Largo cotton mouse.** Key Largo cotton mice formerly occupied hardwood hammock forests on all of Key Largo but are currently restricted to hammocks on the northern portion of Key Largo. Investigate suitable habitat for the presence of cotton mice.

S1.1. **Conduct presence/absence surveys on north Key Largo.** Survey the southern part of north Key Largo along the ecotone of human habitation and hardwood hammock. Evaluate the status of cotton mice here as compared to more contiguous, remote areas.

S1.2. **Survey suitable areas in other parts of Key Largo for the presence of cotton mice.** A few attempts have been made to collect cotton mice in southern Key Largo, but have been unsuccessful. Survey suitable habitat from north Key Largo south to Plantation Key.

S1.3. **Determine the status of cotton mice north of Key Largo.** Survey habitat on Palo Alto, Pumpkin, and Swan Keys, and Little Totten, and Old Rhodes keys in Biscayne NP. These areas contain suitable habitat, but have not been surveyed in detail.

S1.4. **Survey cotton mouse habitat.** Determine habitat characterization and use by cotton mice. Determine why cotton mice are absent in areas with suitable habitat. Assess the condition of occupied habitat and potential habitat. Compare presence of mice in areas of contiguous versus fragmented habitat.

S1.5. **Survey for the presence/absence of black rats simultaneously with cotton mice surveys.** Black rats might compete with cotton mice and may have caused the extinction of two other subspecies of cotton mice. Determine the prevalence of habitat use and overlap between cotton mice and black rats.

S1.6. **Maintain and improve the GIS database for cotton mouse information.** Compile additional survey information into the FWS' existing 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 Upper Florida Keys.** Recovery actions that benefit one of the threatened or endangered species in the Florida Keys (such as actions to recover the Key Largo cotton mouse) will benefit other threatened or endangered species in the same area. At the same time, the number of actions that will be necessary to recover threatened or endangered species in the Upper Florida Keys will require the attention of a biologist or similarly trained professional dedicated to addressing these recovery needs.

S2.2. **Utilize Federal regulatory mechanisms for protection.** Conduct section 7 consultations on Federal activities that may affect the cotton mouse and determine a jeopardy threshold. Coordinate with law enforcement to improve and increase enforcement under section 9 of the ESA, which prohibits take of the cotton mouse. Obtain evidence that shows habitat modification or degradation and secondary impacts (*e.g.*, black rats) have an adverse impact on the cotton mouse's ability to survive or recover and thus constitute take.

S2.3. **Provide cotton mouse information to State, county, and city agencies, including GIS information regarding the presence of cotton mice, their protection under the ESA, and ways to minimize impacts on the mice and their habitat.** Non-federal agencies that may influence the cotton mouse include DEP, DCA, GFC, DACS, Monroe County Mosquito Control, Florida Keys Aqueduct Authority, and Monroe County government.

S2.4. **Conduct cotton mouse reintroductions from natural wild populations.**

S2.4.1. **Develop a standard protocol for conducting, monitoring, and evaluating all reintroduction, translocation, and supplementation efforts of cotton mice using the IUCN/SSC Guidelines for Reintroductions.** Develop criteria that determine the type of release to be conducted; evaluate and select release sites; determine the source and health of release stock; develop short and long-term success indicators; and develop a policy on intervention. Ensure release sites are free of threats prior to any release of cotton mice.

S2.4.2. **Identify potential release sites.** Prioritize relocation sites based on population needs and habitat suitability. Ensure habitat is of sufficient size, is within historic range, contains suitable vegetation, and has long-term protection. Ensure sites have a sufficient carrying capacity to sustain growth of the reintroduced population for a minimum of 25 years.

S2.4.3. **Restore or improve habitat where possible to ensure sites are suitable for augmentation/reintroductions.**

S2.4.4. **Identify suitable release stock.** Identify donor populations and determine size and health of these populations. Determine the effects of translocation on the donor population.

S2.4.5. **Obtain stock for translocation.** Select the number, ages, and sex ratios of cotton mice to be translocated, and the timing of the translocation.

S2.4.6. **Release cotton mice into new sites.** First, augment populations in habitat on north Key Largo that has been restored. Second, reintroduce cotton mice in habitat on the periphery of the range. Third, establish new populations in other suitable areas within the historic range.

S2.4.7. **Monitor introduced populations to determine survival, growth, and reproductive success.**

S25. **Minimize and eliminate disturbance or mortality to the Key Largo cotton mouse.** The level of cotton mouse mortality has not been characterized, although sources of mortality are documented. Implement management actions that reduce mortality.

S2.5.1. **Remove nuisance predators.** Feral dogs and cats, black rats, raccoons, and fire ants can increase cotton mouse mortality. Eliminate food sources and home sites for raccoons and black rats, control free-roaming feral cats and dogs, and destroy fire ant colonies near and in cotton mouse habitat. Enforce deed restrictions of cat control in Ocean Reef Club and other areas.

S2.5.2. **Minimize the effects of pesticides and other biocides.** Mosquito spraying may impact the availability of food species. Rodent control agents used for black rats pose a threat to the cotton mouse. Investigate the effects of these biocides and eliminate any adverse effects on the cotton mouse.

S2.5.3. **Control blatant killing and poisoning**. Cotton mice may be killed by humans in an effort to get rid of nuisance mice and rats. Inform homeowners on the protection of cotton mice and ways to minimize impacts. Develop methods to prevent cotton mouse poisoning.

S2.5.4. **Reduce the effects of road mortality.** Investigate the effects of road mortality on the cotton mouse. Implement appropriate management actions to reduce impacts of road mortality if a need is demonstrated.

S2.5.5. **Minimize the effects of contaminants.** Investigate the effects of contaminants around the old Nike missile site on the refuge, the firing range at Harbor Course, and illegal dumpsites. Remove contaminants that pose an adverse threat to the cotton mouse.

S3. **Conduct research on the biology and life history of the Key Largo cotton mouse**. Conduct studies on the basic biology of the cotton mouse. Investigate reproductive success, productivity, longevity, population size, movements, and dispersal.

S3.1. **Determine if the total population size is large enough to prevent functional extinction and genetic extinction.** Populations fluctuate from year to year. Determine what is the effective population size necessary for survival. Conduct population modeling (*e.g.*, population viability assessment, risk assessment) to predict the persistence of this species.

S3.2. **Determine the number of subpopulations necessary to maintain a stable or increasing population.**

S3.2.1. **Identify subpopulations vulnerable to extinction.** Investigate whether populations on the periphery or near human habitation are more vulnerable to extinction.

S3.2.2. **Determine the necessary number of subpopulations and level of exchange that will enable the cotton mouse to persist for 100 years.**

S3.3. **Determine a stable age structure, sex ratio, and group size for the cotton mouse.**

S3.4. **Examine factors that affect the abundance and distribution of the cotton mouse.** Determine what aspects of this species' ecology makes it most vulnerable to extinction (*e.g.*, predation, lack of food, lack of nesting materials, inability to find a mate).

S4. **Monitor the status of the Key Largo cotton mouse .** Due to the short life span and normal population fluctuation, population declines could go unnoticed unless a continuous monitoring program is established and implemented.

S4.1. **Develop methods to monitor demographic parameters.** Develop methods to monitor sex ratios, age class structure, survivorship, home range size, age of dispersal, and dispersal distance of the cotton mouse.

S4.2. **Conduct long-term monitoring of the status of the cotton mouse.** Monitor presence/absence and degree of abundance semiannually until the cotton mouse is recovered.

S4.3. **Monitor sex ratios, age class structure, and survivorship.**

S5. **Increase public awareness and stewardship.** Develop educational materials and host public workshops to increase awareness about cotton mice and instill a sense of stewardship for the protection of this endangered species.

S5.1. **Prepare educational material for the general public.** Distribute materials at visitor information centers and local chambers of commerce.

S5.2. **Develop and implement a cat, black rat, fire ant, and raccoon control program.** Conduct workshops to educate residents about the necessity to control predation on cotton mice as well as to minimize the effects of black rats and fire ants.

S6. **Establish reclassification criteria**. Develop measurable reclassification criteria based on factors that constitute a stable population, including total population size, number of subpopulations, sex ratio, habitat condition and availability, and level of threats. Evaluate and monitor the cotton mouse's status in relation to reclassification criteria.

Habitat-level Recovery Actions

H1. Prevent degradation of existing habitat. Over 90 per cent of occupied habitat has been purchased. Remaining habitat is restricted to north Key Largo.

H1.1. Acquire all occupied habitat first, then unoccupied. Identify priority areas for acquisition. Acquire all occupied suitable habitat first (Priority 1), then unoccupied (Priority 2). Unoccupied, but suitable habitat is important for future reintroduction activity. Inholding areas are also high priority.

H1.1.1. Continue Federal acquisition efforts. Continue acquisition efforts at Crocodile Lake NWR, which has developed a priority acquisition and restoration list.

H1.1.2. Support State, local, and non-governmental organizations' acquisition efforts. Support effort of entities to acquire cotton mouse habitat including state conservation easements, CARL, Monroe County Land Authority, Florida Community Trust, Florida Keys Land Trust, and The Nature Conservancy. Support the acquisition of lands to be incorporated into the Key Largo Hammocks State Botanical Site.

H1.2. Protect and manage Key Largo cotton mouse habitat.

H1.2.1. Protect cotton mice on private lands. Protect cotton mouse populations on private land through acquisition, conservation easements or agreements, and informing landowners. Develop agreements (*e.g.*, Memorandum of Agreement) between the FWS and private landowners to minimize impacts such as feral cats and exotics.

H1.2.2. Protect cotton mice on public lands. Develop a habitat management plan that outlines priority habitat for acquisition and methods to protect, restore, and minimize impacts on cotton mice and their habitat.

H1.2.3. Coordinate with Federal, State and Monroe County agencies and private entities to develop management actions to protect cotton mouse habitat. Coordinate with these entities to ensure proposed construction activities that result in land clearing or alteration do not impact the cotton mouse and its habitat. Coordinate with the Audubon Society to develop a management plan for Parcel 22. Coordinate with private landowners to protect and manage habitat and minimize impacts to the cotton mouse (*e.g.*, trash, feral cats, *etc.*).

H1.2.4. Avoid clearing or disturbing hammocks. Prevent clearing of hardwood hammocks. Steer construction activities towards already-cleared areas.

H1.2.5. Restrict access to cotton mouse habitat. Restrict access to remote habitat areas to prevent damage caused by campers, homesteaders, trash dumpers, and vehicular traffic.

H1.2.6. Establish and protect 500-m buffers around Priority 1 habitat. The necessity for 500-m protection buffer zones is based on the likelihood that human influences encroach and impact the cotton mouse.

H1.2.7. Prevent fires. Wildfires can quickly destroy large areas of hardwood hammocks. Develop effective fire suppression plans. Prohibit fires and smoking in or near hardwood hammocks.

H1.2.8. Eliminate exotic vegetation. Remove exotic vegetation in cotton mouse habitat and in adjacent upland buffers. Use deed restrictions, covenants, or other means to minimize the likelihood that exotic plants will invade hardwood hammocks. Remove exotic vegetation in refuge boundaries. Support the removal of exotics in other cotton mouse habitat, including Port Bougainvillaea and Ocean Forest Tract (ocean side of Harrison Tract).

H2. Restore both suitable occupied and unoccupied cotton mouse habitat. Several areas are suitable for restoration. Restoration efforts will benefit the hammock habitat, existing cotton mice populations, and future-released populations. Conduct and support restoration activities in cotton mouse habitat.

H2.1. Prepare a hardwood hammock restoration plan for north Key Largo. Several large-scale restoration efforts are underway in South Florida and it will be advantageous to have a plan to link into funding and project implementation opportunities.

H2.2. Restore cotton mouse habitat on refuge property. Restore habitat near the missile site, the borrow pit, gun range, the cockfighting ring, and radio tower.

H2.3. Restore old CR 905 Road to promote cotton mouse habitat.

H2.4. Remove trash and debris. Several old roads into the Crocodile Lake NWR are littered with trash and debris. Remove trash and debris from these and other areas in cotton mouse habitat.

H2.5. Improve hydrology and water quality in cotton mouse habitat. Restore hydrology of Dispatch Slough and other areas in need.

H2.6. Improve habitat by planting or encouraging native plant species. Plant native vegetation in areas that have been scarified or degraded.

H2.7. Create habitat by refilling and recreating areas that have been dredged or altered. This will not include refilling areas that are important to crocodiles.

H3. Conduct research to determine habitat needs for the cotton mouse.

H3.1. Investigate how cotton mice use different habitat components for survival (*e.g.*, for food, shelter, nesting, traveling).

H3.1.1. Investigate stable home range and minimum area requirements. Male cotton mice have larger home ranges than females and home ranges overlap because cotton mice do not defend territories.

H3.1.2. Investigate the effect of habitat change. Determine how the cotton mouse's distribution and abundance is affected by habitat degradation and other human factors.

H3.2. Determine an index of habitat fragmentation.

H3.2.1. Investigate movement patterns and the spatial use of habitat to identify important core areas and corridors.

H3.2.2. Determine if the amount and configuration of habitat is sufficient to support a stable or increasing population of cotton mice.

H4. Monitor the status of cotton mouse habitat and examine ecological processes. Conduct yearly monitoring evaluations of the status of the cotton mouse's habitat. Use GIS capabilities to determine locations and quality of habitat, including what patches are being altered or lost

each year. Monitor the availability of cotton mouse habitat by updating the loss or change of habitat due to residential or commercial construction.

H5. **Increase public awareness of cotton mouse habitat and instill stewardship.** Conduct workshops with the public to inform private landowners about appropriate management practices to preserve cotton mouse habitat. Encourage private landowners to remove exotics, maintain natural waterflow, refrain from destroying mouse habitat, and restore disturbed areas. Prepare literature to provide information regarding the cotton mouse's habitat and ways to protect and conserve it.