Lower Keys marsh rabbit
(Sylvilagus palustris hefneri)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region
South Florida Ecological Services Office
Vero Beach, Florida

5-YEAR REVIEW
Lower Keys marsh rabbit/*Sylvilagus palustris hefneri*

I. GENERAL INFORMATION

A. Methodology used to complete the review: This review is based on monitoring reports, surveys, and other scientific and management information, augmented by conversations and comments from biologists familiar with the species. The review was conducted by a biologist with the South Florida Ecological Services Office. Literature and documents on file at the South Florida Ecological Services Office were used for this review. All recommendations resulting from this review are a result of thoroughly reviewing all available information on the Lower Keys marsh rabbit (LKMR). Comments and suggestions regarding the review were received from peer reviewers from outside the Service (refer to Appendix A). No part of the review was contracted to an outside party. The public notice for this review was published on September 27, 2006, with a 60 day public comment period.

B. Reviewers
Lead Regional Office: Southeast Regional Office, Kelly Bibb, (404) 679-7132
Lead Field Office: South Florida Ecological Services Office, Phillip Hughes, (305) 872-2753

C. Background

1. FR Notice citation announcing initiation of this review: September 27, 2006, 71 FR 56545.

2. Species status: Decreasing (2006 Recovery Data Call). The long-term trend for the LKMR is decreasing, as evidenced by multi-decadal reductions in occupied habitat patches, and new and ongoing threats. Rangewide inventories of patch occupancy during 1988 to 1995 and from 2001 to 2007 reveals that the number of occupied patches has steadily declined.

3. Recovery achieved: 2 (26-50% recovery objectives achieved) (2006 Recovery Data Call)

4. Listing history
Original Listing
FR notice: 55 FR 25588-25591
Date listed: June 21, 1990
Entity listed (*species, subspecies, DPS*): Subspecies
Classification (*threatened or endangered*): Endangered

5. Associated rulemakings: Not applicable

6. Review History:
5-year review November 6, 1991 (56 FR 56882). In this review, different species were simultaneously evaluated with no species-specific, in-depth assessment of the five factors, threats, etc. as they pertained to the different species' recovery. The notices summarily listed these species and stated that no changes in the designation of these species were warranted at that time. In particular, no changes were proposed for the status of the LKMR.
Final Recovery Plan: 1999
Recovery Data Call: 2000, 2001, 2002, 2003, 2004, 2005, 2006

7. Species' Recovery Priority Number at start of review (48 FR 43098): 6C (6 = high degree of threat, low recovery potential; C = there is some degree of conflict between the species recovery and economic development).

8. Recovery Plan or Outline
Name of plan: South Florida Multi-Species Recovery Plan (MSRP)
Date issued: May 18, 1999
Dates of previous plans: Original plan approved January 1, 1994

II. REVIEW ANALYSIS

Population refers to all LKMR throughout the range. Based on genetics, geographical settings, and dispersal distances, the LKMR population appears to consist of multiple, distinct metapopulations (described below). LKMR predominantly occur in distinct habitat patches, groups of which constitute metapopulations. Accordingly, patch and subpopulation are used synonymously in this document. Because LKMR are spatially structured in metapopulations, the loss of LKMR in a patch is referred to as extinction (loss of a population unit, consistent with metapopulation terminology). Extinction may also refer to the species, if so stated. Extirpation is used for extinctions of LKMR over a larger area such as a cluster of patches or a key (island).

A. Application of the 1996 Distinct Population Segment (DPS) policy

1. Is the species under review listed as a DPS? No

2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy? No

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? Yes

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? No

3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.

The MSRP provided the following criteria to meet the objective of reclassification to threatened; delisting criteria were not provided.

1. Further loss, fragmentation, or degradation of suitable marsh rabbit habitat has been prevented.

Threats from direct habitat loss as a result of development have been significantly reduced over the last 20 years (Lopez 2001, Monroe County et al. 2006, Service 2006). The Naval Air Station Key West (NASKW) routinely implements a variety of management practices in order to avoid or minimize habitat degradation (U.S. Navy 2002). Over the last 25 years, the Keys Environmental Restoration Fund (KERF) and collaborators have undertaken a variety of projects that included localized benefits to LKMR habitat (Hobbs et al. 2006). However, this criterion has not been accomplished, because lasting effects of past developments, continued pressure to develop, and natural processes (e.g., hurricanes) remain as threats (that are difficult to quantify). The impacts of old mosquito control drainage ditches on LKMR habitat have not been investigated. The intensity and frequency of salt water incursions due to storm surges and sea level rise have increased (Ross et al. 1994, Lopez 2001, Carothers 2006, Bradley 2006), resulting in degradation of LKMR habitat in portions of the range (Service 2006). The Service (2006) also identified woody vegetation encroachment as a potential threat to LKMR habitat. Little habitat-related monitoring or research has been conducted as a tool to assess such threats, the secondary impacts of old developments such as ditches, or the efficacy of restoration efforts. This criterion addresses factors A and C.

2. Native and non-native nuisance species have been reduced by 80 percent.

This appears to have been attained, or nearly so, for invasive exotic plants (IEP). Although IEP mapping projects have been undertaken, detailed tracking of efforts and results in terms of IEP populations or areas covered appears to be unavailable, thus specific percentages cannot be calculated. Members of the Florida Keys Invasive Exotics Task Force (FKIETF) have conducted IEP control in habitats throughout the range of LKMR. Approximately $3,140,000 has been spent to treat IEP scattered over about 7,300 acres (2,954 hectares [ha]) since 1998 (Hobbs et al. 2006). Lead tree (*Leucaena leucocephala*) invaded habitat in several LKMR patches on NASKW, but the Navy and FKIETF are working to gain control in these areas. Throughout most of the range, IEP do not currently appear to be a significant threat to LKMR habitat. Domestic cats (*Felis catus*) and raccoons (*Procyon lotor*), remain a significant threat to LKMR (LaFever 2006). Control of these predators was initiated on NASKW in 2005 and the National Key Deer Refuge (NKDR) in 2007. This criterion addresses factors A and E.

3. All suitable habitat on priority acquisition lists is protected either through land acquisition or cooperative agreements.

This has not been accomplished, although significant progress has been made. Of all suitable habitat patches (areas with the characteristics necessary to support a resident population, exclusive of transient use areas or corridors) ($N = 228$), more than 45 percent occur on NKDR, State, and County lands that were acquired predominantly for conservation purposes. Another 24 percent occur on NASKW. Fourteen percent are in mixed (government and private) ownership, and 17 percent occur on private parcels. Within the range of the LKMR, most of the remaining private parcels with native habitat, including LKMR habitat, are potentially eligible for fee-simple acquisition, contingent upon availability of funds and willing sellers. This is predominantly due to the Florida Forever Program administered by the Florida Department of Environmental Protection (FDEP). As of 2005, this program had acquired 6,901 acres (2,793 ha) out of 14,684 acres (5,942 ha) targeted. Some of those acquisitions included LKMR habitat, but such details were not specifically tabulated to the present. NKDR, Monroe County, and private conservation organizations administer additional, smaller acquisition programs. Acquisitions by Monroe County include mitigation parcels derived according to Rate of Growth Ordinances (ROGO), and anticipated under the Big Pine Key-No Name Key Habitat Conservation Plan (HCP) (Monroe County et al. 2006). This criterion addresses factor A.

4. Potential habitat on these protected lands are restored or rehabilitated to provide habitat for the Lower Keys marsh rabbit.

This has not been accomplished. IEP are largely absent from LKMR habitat or under active control projects on protected lands. However, threats from hurricanes and (potentially) woody vegetation encroachment due to disturbances (such as fire suppression or altered salinity or other soil characteristics) can impact LKMR habitat rangewide, regardless of land status. Ecological processes and functions that influence LKMR habitat have largely not been researched or monitored. Accordingly, whether the general quality of LKMR habitat has exhibited widespread change is not well documented. Actions carried out specifically to enhance LKMR habitat have been rare. Initial pilot projects included mechanical control of woody vegetation on NKDR (winter 2005-2006) and the application of prescribed fire, with a dual objective to facilitate airfield vegetation management, on NASKW (April 2007). This criterion addresses factor A.

5. 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.

The LKMR was listed because of habitat loss and fragmentation, predation by cats, and road mortalities caused by automobiles (Service 1999). Until the late 1980s, records of LKMR subpopulations were largely generalized at the scale of individual keys or groups of keys. By that time they had been reported to be extirpated from entire keys, including Key West and the Torch Keys (Lazell 1989, de Pourtales 1877). Few data on population demographics have been collected after the mid-1990s. Based on patch occupancy surveys in the 1990s and current decade, LKMR have continued to decline throughout the range (Forys and Humphrey 1999a, Faulhaber 2003, Faulhaber et al. 2007, Service 2007a). Currently LKMR occupy only four Keys connected to U.S. Highway 1. They persisted on several backcountry islands until 2005 (Faulhaber et al. 2007), but as of 2007 were estimated to remain on only two, one of which they had been translocated to in 2002. At the scale of individual patches, overall occupancy rates have declined by up to 27 percent since 2003 (about 24 patches per year). Declines may have accelerated since the late 1980s, but widespread surveys were conducted in few years prior to 2003, so the record is discontinuous prior to 2003. Declines were particularly extensive in the Big Pine Key area after 2005, apparently due to effects of Hurricane Wilma (Service 2007a). Significant current threats appear to include predation, hurricanes (direct and secondary effects), vehicle strikes, and small (and declining) metapopulation sizes and distributions. Increasing inter-patch distances and threats associated with dispersal are likely related through (and magnified due to) positive feedback. This criterion addresses factor E.

6. 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 (Service 1999).

Records of LKMR populations have consistently indicated long-term decline (Lazell 1989, Service 1999, Forys and Humphrey 1999a, Faulhaber 2003, Faulhaber et al. 2007, Service 2007a). Abundance cannot increase when subpopulations go extinct at a much greater rate than they are colonized. Instead, population growth likely declined in a direct correlation with subpopulation extinctions. The specific relationship remains to be quantified.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate), or demographic trends: The Service (1999) estimated the LKMR population totaled 100 to 300 individuals, based on occupied habitat. Forys and Humphrey (1999a) conducted a population viability analysis (PVA) that estimated a 100 percent probability of extinction within 50 years. Subsequent to that work, detailed studies of population demographics have been lacking. However, habitat patch occupancy, based on the presence or absence of fecal pellets, has been estimated in recent years (Service 2007a). These data provide a spatial index of population dynamics (the persistence of subpopulations at the scale of habitat patches). The data, described below, have been generally consistent with Forys and Humphrey's (1999a) predictions regarding the probability of extinction.

Rangewide surveys of habitat occupancy were initiated in 2001. From 2001 to 2003, Faulhaber (2003) identified, delineated, and mapped suitable (potentially occupied) habitat patches throughout the species' range. He identified 228 suitable habitat patches and all but 8 were surveyed for occupancy. Faulhaber (2003) also tabulated data from historical surveys (1988-1995), and determined that, of the 228 patches he delineated, 142 had been investigated in the earlier period. Overall, 71 (50 percent) had been occupied during 1988-1995. Faulhaber's (2003) comprehensive inventory indicated that 102 (45 percent) patches were occupied during 2001-2003. Of the 142 patches that were surveyed in both periods, only 62 were still occupied between 2001 and 2003. This represented a 13 percent decrease or an average decline in patch occupancy of about 1.4 percent annually. Two of the patches no longer provided suitable habitat (Faulhaber 2003). By 2005, only 52 of the 71 patches remained occupied (Faulhaber et al. 2007), indicating a 27 percent decrease since the 1988-1995 period.

Only a portion of the potential or historical range has been known to be occupied since detailed investigations were initiated in 1988. Of the 228 patches with suitable habitat as of 2001-2003, only 152 are encompassed within the current range (i.e., 152 patches occur on currently occupied keys). Overall, 131 of those 152 patches had been occupied one or more years since 1988. During 1988-1995, 2001-2003, 2004, 2005, 2006, and 2007, approximately 73, 70, 66, 61, 44, and 44 percent of surveyed patches within the current range were occupied (Service 2007a). Again, the results indicate a steep decline in patch occupancy. The greatest decline between any two years occurred between 2005 and 2006.

Since 2004, occupancy surveys have been conducted annually between January and April throughout the current range. Using the 2001-2003 period as a baseline, these data yield annual estimates of the net change in patch occupancy, accounting for colonizations, re-colonizations, extinctions, and persistent occupancy. Occupancy rates have continued to decline annually (Service 2007a). Since 2003, occupancy has declined 27 percent, or 7 percent annually. Population abundance likely declined in proportion to patch (subpopulation) extinction. Additionally, as the number of occupied patches has declined, subpopulation isolation increased commensurately.

Patch extinction rates were not constant among different portions of the current range. The current range appears to consist of three separate metapopulations (Forys and Humphrey 1999a), the Boca Chica area (BCHI) (Boca Chica, Geiger, East Rockland and Saddlehill Keys), the Sugarloaf area (SUGAR) (Sugarloaf and Saddlebunch Keys), and the Big Pine area (BPK) (Big Pine, Annette, East Water, Howe, Johnson, Little Pine, Mayo, Newfound Harbor, Porpoise, and No Name Keys). As of 2007, the frequency of patch extinctions had increased in the following order: BCHI, SUGAR, and BPK (19, 32, and 49 percent of all extinctions, respectively). Since 1988, 131 patches were found occupied one or more years, with 46 on BCHI, 32 on SUGAR, and 53 on BPK. By metapopulation, 26, 41, and 51 percent of the once occupied patches on BCHI, SUGAR, and BPK, respectively, were extirpated as of 2007.

In addition to the current range, potential habitat occurs in two other areas. One constitutes a large gap in the middle of the current range of the LKMR. That area (TOR-CUD) includes all the keys (Cudjoe, Ramrod, Summerland, and Torch Keys) between BPK and SUGAR. Faulhaber (2003) confirmed earlier (1988-1995) indications that none of the patches in TOR-CUD were occupied. Some of the keys were historically occupied (Lazell 1989), but details are limited (all patch specific records of occupancy occur in BCHI, SUGAR, and BPK). The remaining area (OUTER) includes several small keys that fall outside of the existing metapopulation areas and TOR-CUD and have never been shown to harbor LKMR, but exhibit suitable habitat (Faulhaber 2003). Table 1 summarizes the status of all 228 patches of suitable habitat up to and including May 4, 2007. Of the 131 patches that have been documented to contain LKMR at one time, extinctions (65) have accumulated to the point where they nearly equal the number of extant patches (66) (Service 2007a). Accordingly, had the history of patch occupancy been documented rangewide (i.e., historical losses in TOR-CUD), the number of extinct patches would well exceed the number of extant patches.

Table 1. The status of all 228 LKMR habitat patches as of May 4, 2007. Values represent counts of habitat patches (and percentage of total number of patches).

METAPOPULATION	NO. OF OCCUPIED PATCHES (PERSISTENT, COLONIZED, OR RE-COLONIZED)		NO. OF EXTINCT PATCHES		NO. OF SUITABLE PATCHES (POTENTIAL HABITAT)		TOTAL NUMBER OF HABITAT PATCHES (% OF TOTAL)	
BCHI	35	(69)	11	(22)	5	(10)	51	(22)
SUGAR	14	(27)	21	(41)	16	(31)	51	(22)
BPK	14	(22)	35	(56)	14	(22)	63	(28)
TOR-CUD	0	(0)	0	(0)	57	(100)	57	(25)
OUTER	0	(0)	0	(0)	6	(100)	6	(3)

METAPOPULATION	NO. OF OCCUPIED PATCHES (PERSISTENT, COLONIZED, OR RE-COLONIZED)		NO. OF EXTINCT PATCHES		NO. OF SUITABLE PATCHES (POTENTIAL HABITAT)		TOTAL NUMBER OF HABITAT PATCHES (% OF TOTAL)	
Total	63	(28)	67	(29)	98	(43)	228	(100)

The simulation results in Forys and Humphrey's (1999a) PVA indicated that "the marsh rabbit metapopulation at Boca Chica had the highest chance of going extinct, the lowest exponential growth rate, and was predicted to become extinct the fastest.... The Big Pine metapopulation was more likely to persist, had a higher exponential growth rate, and was predicted to become extinct the slowest". The SUGAR metapopulation was intermediate. Forys and Humphrey (1999a) suggested that "larger patches, such as those on Big Pine, were more resilient to the effect of cat predation" and catastrophes. Forys and Humphrey's (1999a) investigations also indicated that inbreeding depression and hurricanes may be important influences. When those factors were excluded from the PVA, only BCHI was predicted to go extinct, whereas when they were incorporated, all 3 metapopulations were predicted to have a 100 percent chance of extinction in 50 years. Additional conclusions based on the PVA were that: "While removal of vehicular mortalities eliminated the chance of extinction for the Big Pine metapopulation and removal of feral cat predation eliminated the chance of metapopulation extinction for the Saddlebunch and Big Pine metapopulations, only a removal of all cat (feral and domestic) predation eliminated the chance of extinction for Boca Chica".

After the 1988-1995 period, observed trends in patch occupancy (Figure 1) indicate that patch extinctions accumulated steadily in BCHI. Initially, extinctions appear to have been less frequent in BPK. However, a major decline occurred in BPK after 2005. That decline is temporally correlated with Hurricane Wilma in October 2005. The influence of Wilma may have been mostly due to secondary effects on habitat as opposed to direct mortality. LKMR were observed from roads in at least two areas on Big Pine Key in the winter and spring months of 2005-2006. Yet the survey data indicates the occurrence of a widespread crash in subpopulation persistence. These observations may indicate that LKMR were on the move more than usual, engaged in habitat seeking behavior. Such behavior would likely result in stress to LKMR, and would expose them to increased risks. On BCHI, individual LKMR drowned, but in contrast to BPK the survey data indicate that resilience or resistance was exhibited at the scale of patches. Subpopulations on the southeastern portion of BPK were extirpated earlier, between the 1988-1995 and 2001-2003 survey periods. All six patches documented to contain LKMR in the early period were extinct by 2001-2003. Faulhaber et al. (2007) speculated that this might have resulted from the storm surge associated with Hurricane Georges in 1998. The evidence indicates that Georges did not have widespread impacts on patches throughout BPK (Service 2007a). However, the characteristics of the storm's surge may have resulted in disproportionate impacts in southeastern Big Pine Key. Ultimately, however, BPK declined more precipitously than the two other metapopulations due to the post-Wilma (2005) losses. Patches throughout the range were inundated by the storm surge associated with Wilma. The available data suggest that LKMR in BPK were impacted more severely by Wilma than were the other metapopulations.

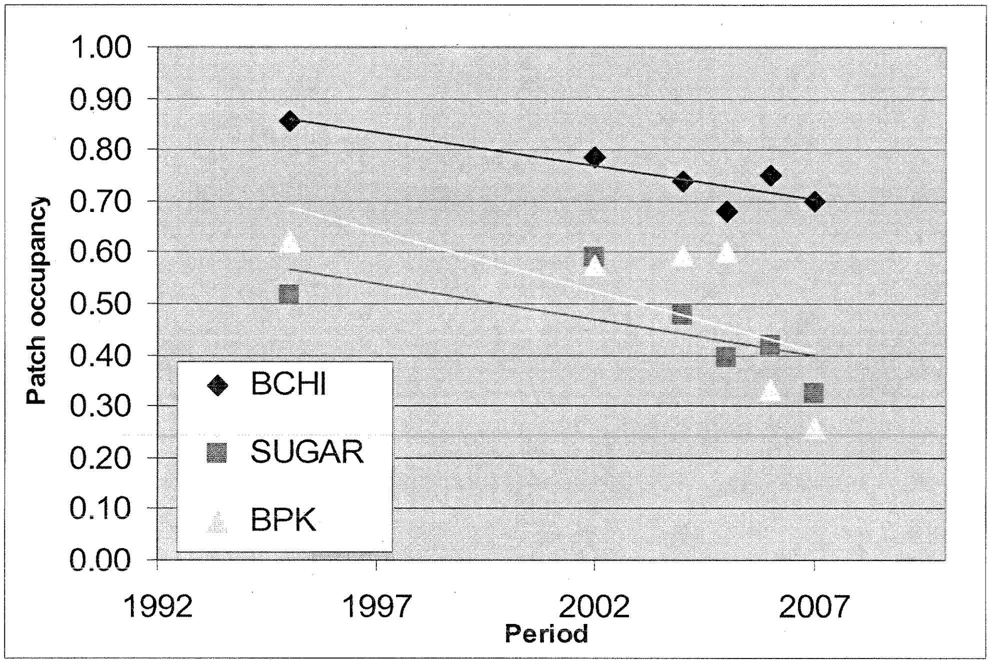

Figure 1. Patch occupancy (proportion of surveyed patches that were occupied) among the BCHI, SUGAR, and BPK metapopulations, according to period (year or group of years). Grouped data include 1988-1995 (1995 on x-axis) and 2001-2003 (2002 on x-axis).

Forys and Humphrey (1999a) pointed out that an assumption of their model was that environmental variation was not correlated among subpopulations. This may be why the actual subsequent trends, in terms of the rank order of declines among the three metapopulations, are no longer consistent with the prediction that the BCHI metapopulation would tend towards extinction most rapidly (Forys and Humphrey 1999a). In addition, the period of observation subsequent to the PVA encompassed two major storm surges, which impacted the BPK metapopulation more intensely than the others.

Although Forys and Humphrey (1996, 1999b) suggested that large patches in BPK may render that metapopulation more persistent than others, they noted the potential significance of close spacing among patches. LKMR have small home ranges, spend most of their lives in one patch, and females in particular exhibit small dispersal distances. Patches near other patches were deemed to be relatively important because they allowed for movement between patches. Based on a discriminate function analysis (DFA) that compared occupied to unoccupied patches, patch isolation (distance of a patch to the nearest patch) explained most of the variation (Forys and Humphrey 1999b). In BCHI, a relatively large number of patches are closely and relatively evenly spaced. This may have contributed to the relatively low rate of extinction observed in BCHI patches as of 2007.

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding): On the extreme ends of the range, eastern (Big Pine Key area) and western (Boca Chica Key area) metapopulations exhibit strong genetic differentiation, and very limited or no genetic exchange (Crouse 2005). Crouse (2005) analyzed patterns of genetic variation within and among island populations of the LKMR, using mitochondrial sequence data (control region; 763 base pairs [bp]). Phylogenetic analyses of the mitochondrial sequences revealed that two main lineages exist, corresponding with eastern and western portions of the range. There was strong genetic separation between LKMR populations in terms of mitochondrial DNA haplotypes (19 bp). Mitochondrial DNA variation was low, as is typical for island populations. Apparently, the strong phylogenetic differentiation within the LKMR is due to dispersal barriers.

c. Taxonomic classification or changes in nomenclature: None. The Integrated Taxonomic Information System (ITIS 2007) was checked while conducting this review.

d. Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors), or historic range (e.g., corrections to the historical range, change in distribution of the species' within its historic range): LKMR may have occurred in Key West historically (de Pourtales 1877). The current range of LKMR appears to be spatially differentiated into three metapopulations (BCHI, SUGAR, and BPK), and at least two clades (a lineage resulting from a dichotomous splitting of an earlier lineage). A fourth major portion of the historical range, TOR-CUD, has no extant subpopulations. It forms a large gap between BPK and SUGAR. Details regarding how this gap came about are lacking. However, that the eastern and western metapopulations are genetically distinguishable indicates that at the rangewide scale, naturally limited dispersal has been in effect for a long time (Crouse 2005). It remains unknown whether TOR-CUD subpopulations contained additional haplotypes, or to what extent they shared affinities with either BPK or SUGAR. On the scale of individual keys, the saltmarsh environments inhabited by LKMR, like other habitats throughout the lower Keys, have been highly fragmented by human developments (Forys and Humphrey 1999b). This results in additional barriers to successful dispersal (Forys and Humphrey 1996, 1999b), and likely contributes to ongoing range retraction and population decline.

In the BPK metapopulation, patches throughout the southeastern portion of Big Pine Key were extirpated between the 1988-1995 and the 2001-2003 survey periods. Faulhaber et al. (2007) suggested that this may have resulted from the storm surge associated with Hurricane Georges in 1998. Subsequently, additional patches throughout the peripheral portion of Big Pine Key were extirpated, with many losses following Hurricane Wilma in 2005. Occupied patches are now loosely clustered within two relatively small areas, one mid-central and the other north-central. Patches on No Name and Porpoise Keys were extirpated by about 2004. Annette and Howe Keys were extirpated after 2005, but one of two patches on Mayo Key remained occupied as of April 2007. LKMR that had been successfully translocated to Water Key were lost after 2005. LKMR had been translocated to three patches on Little Pine Key in 2002. By 2004, they expanded to a fourth patch on Little Pine Key, and then a fifth on adjacent East Water Key. However, the latter was extirpated after Hurricane Wilma. The four patches on Little Pine Key were still occupied as of 2007. In the SUGAR metapopulation (like elsewhere), aggregations of closely neighboring patches generally survived or not in a linked fashion. The loss of certain patch clusters left fewer, more widely spaced aggregations. A few lone patches also persisted, resulting in increased isolation in those instances. Several patches scattered about U.S. Highway 1 in the middle of the Saddlebunch Keys were extirpated. This appears to have resulted in a large gap between remaining, occupied clusters on the bay-side and the Atlantic side of the Saddlebunch and Sugarloaf Keys. In the BCHI metapopulation, patches on Geiger and Saddlehill Keys were extirpated. Patches on Boca Chica Key, the core of BCHI, have largely persisted as of 2007. Overall, of the three metapopulations, extirpations were most widespread in BPK. A fourth area, Water Key, lies adjacent to the TOR-CUD area. LKMR were translocated to that key in 2004. As on Little Pine Key, LKMR showed initial success, including sign of reproduction. However, the patch was extirpated subsequent to Wilma.

Some general patterns in the distribution of patch extirpations have emerged. In the period of observation, patches on narrow peninsulas and narrow islands appear to suffer higher extinction rates. Additionally, in BPK if not elsewhere, it appears that patches closer to the outer perimeter of islands experience a higher extinction rate than more interior patches. LKMR subpopulations, habitat, or both may be more vulnerable to deterioration in outer fringe patches compared to interior patches. This may relate to sea-level influences. However, reduced probabilities of immigration may partly explain the pattern. Patches set on the perimeter of islands may have a low probability of immigration from at least one direction (the direction of the open water), whereas interior patches may receive immigrants from any direction, hypothetically with equal probability. Moreover, a given degree of human-induced fragmentation in the more elongated bands of habitat on the coastal margins may have different impacts (i.e., cause greater isolation) than in more interior areas. Accordingly, island geometry and human impacts may interact at the landscape scale to strongly influence patch dynamics. Mechanisms that underlie the pattern of high extinction rates both in peninsulas and in coastal margins may be related or independent. Additionally, survival of a given patch appears to have a strong dependence on the fate of closely adjacent patches (patch extirpations are spatially and temporally autocorrelated). That effect may play out very rapidly (i.e., the fates of patches within a cluster of patches are often shared within one year's time) or may take multiple years. Accordingly, the degree of autocorrelation is dependent upon the particular stressor, although stressors likely interact in complex ways to yield various outcomes over time and among different clusters of patches. The underlying links between stressors, demographics, patch distribution and attributes, and extinction remain to be fully identified or quantified.

e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem): The 228 patches of suitable habitat covered 2,011 acres (814 hectares [ha]) in 2003 (Faulhaber 2003). Patch size ranged from 0.25 to 126 acres (0.1 to 51.0 ha), with a median patch size of 4.5 acres (1.8 ha). The 102 occupied patches in 2001-2003 totaled 1,292 acres (523 ha). However, habitat availability and selection has not been quantitatively assessed at the landscape scale. Faulhaber's (2003) habitat delineations have not been tested, a few LKMR sightings have occurred outside the perimeters, and additional evidence indicates that areas demarcated as habitat are conservative in many cases (P. Hughes, Service, pers. comm. 2006). Forys and Humphrey (1999b) found that patch size was not a strong predictor of LKMR persistence in a patch, although patch size may interact with important factors. Ninety percent of occupied patches and 88 percent of the total occupied land area were found on Big Pine, Sugarloaf, Saddlebunch, and Boca Chica Keys (Faulhaber 2003). Big Pine and Boca Chica Keys together contained 61 percent of all occupied patches and 68 percent of the total occupied land area.

Within the current range, at least 56 percent of suitable LKMR habitat is in public (Service, U.S. Navy, State, Monroe County, and South Florida Water Management District) ownership (Table 2) (Faulhaber 2003, Service 2007a). The remainder is in private or mixed (private and public) ownership. Almost all of the patches in BCHI are encompassed within NASKW. In contrast, nearly half of the habitat area in SUGAR is in private ownership. In BPK, more than 52 percent is in public land, predominantly on the Service's National Key Deer Refuge (NKDR). On the large, unoccupied keys within the historical range (TOR-CUD), at least 40 percent is in public ownership. Rangewide, more than 45 percent of individual LKMR patches occur on government properties that were predominantly acquired to facilitate the conservation of native diversity. Another 24 percent occur on NASKW. Thirty-one percent are in mixed (government and private) or private ownership.

Table 2. Ownership of suitable LKMR habitat (the area of patches) in acres (ha). Derived from Faulhaber (2003), Appendix B.

	Public[1]	Private	Mixed[2]	Total
BCHI	329 (133)	10 (4)		339 (137)
SUGAR	109 (44)	171 (69)	87 (35)	366 (148)
BPK	492 (199)	52 (21)	400 (162)	944 (382)
TOR-CUD	138 (56)	74 (30)	131 (53)	343 (139)
OUTER	20 (8)			20 (8)
Total	1,087 (440)	306 (124)	618 (250)	2,011 (814)

[1]Includes approximately 25 acres (10 ha) owned by The Nature Conservancy.
[2]Mixed ownership patches that include private and publicly owned land.

Numerous areas throughout the historical range were fragmented by roads, canals, and subdivision development (Forys and Humphrey 1999a). For example, connectivity of the southern end of Big Pine Key with the rest of the island appears to have been entirely precluded by the presence of U.S. Highway 1 and adjacent development (Faulhaber et al. 2007). However, further destruction of LKMR habitat for development was significantly reduced after the late 1980s (Lopez 2001, Monroe County et al. 2006, Service 2006). Accordingly, if widespread habitat change has been a significant factor in the recent declines of LKMR, then the stressors include additional factors other than direct destruction of habitat for human development.

In a DFA that compared variably occupied LKMR sites to consistently occupied sites, Forys and Humphrey (1999b) found that patch attribute variables that pertained to vegetation type and height were important predictors. Although patch isolation (inter-patch distance; a landscape variable), was an important variable in predicting the use of a patch by LKMR, the amount of thick ground cover within a patch was the single most important variable in predicting whether a patch would be consistently occupied. The most important ground cover was a clump grass, cordgrass (*Spartina spartinae*). Forys and Humphrey (1999b) argued that thick ground cover is important for predator avoidance as well as for nesting. Additionally, consistently occupied sites contained fecal pellets from juvenile LKMR significantly more often than did variably occupied patches. They suggested that the anti-predator function of such cover may be the most important factor in population persistence, as in other lagomorphs.

LKMR predominantly inhabit and are largely restricted to the saltmarsh-buttonwood (*Conocarpus jamaicense*) transition zone. However, they also inhabit freshwater wetlands, and historically, coastal beach berm communities (Forys and Humphrey 1996, 1999b). The freshwater wetland habitats predominantly occur within a matrix of pine rockland. Forys and Humphrey (1999b) did not assess the effect of woody vegetation on patch use. However, much of the remaining LKMR habitat has extensive growth of buttonwood, for the most part, but also other woody shrubs and trees. Perry (2006a) evaluated habitat selection of LKMR on NASKW during a dry season (winter). He assessed the predictive ability of habitat variables, including visual obstruction, canopy coverage (percent cover of overstory vegetation), bunchgrass density, horizontal obstruction, bare ground, grass, forbs, and litter, in delineating the core areas of LKMR home range from areas not included in core areas. Of these variables, visual obstruction (high), percent canopy coverage (low), and bunchgrass density (high) best explained the presence of LKMR home range cores. LKMR selected areas with relatively high visual obstruction values, less canopy coverage, and more bunchgrasses. The effect of model parameters also differed by site, indicating that spatial variation was also important in predicting the presence of home range cores. Home range cores were found to have a dense structure of low herbaceous cover, including bunchgrasses. They avoided areas with mature buttonwoods and high canopy cover.

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

a. Present or threatened destruction, modification or curtailment of its habitat or range:

Development—Historically, habitat destruction due to development appeared to be the primary source of endangerment of the LKMR (Forys 1995, Service 1999). In the last 20 years, loss or fragmentation of LKMR habitat to development has been greatly reduced. Extensive land acquisitions, a temporary building moratorium on Big Pine Key, the HCP, and regulations such as the Clean Water Act (62 Stat. 1155, as amended; 33 U.S.C. 1251-1376) and Monroe County's ROGO, have contributed substantially to this outcome (Lopez 2001, Monroe County et al. 2006, Service 2006). However, the effects of past habitat loss continue to stress LKMR populations, predominantly because it eliminated dispersal corridors and reduced the area of contiguous habitat (Forys and Humphrey 1996, 1999a, 1999b). This reduced the opportunity for recolonization of extirpated patches. LKMR metapopulations consist of small, disjunct subpopulations. Connectivity among suitable habitat patches is necessary for LKMR dispersal among patches, and dispersal is a necessary process if metapopulations are to remain self-sustaining. The probability of demographic or genetic rescue by successful dispersal among isolated habitats has declined. Additionally, habitat destruction and fragmentation may have caused some habitat patches to be too small to support persistent LKMR subpopulations. These threats not only impact the viability of local subpopulations, but also reduce the probability of successful dispersal among subpopulations. Due to increased inter-patch distances, the influence of secondary effects of development such as cat predation are likely exacerbated by habitat loss, because a dispersing LKMR must travel over greater distance, resulting in greater exposure. The habitat loss and fragmentation resulted from development of homes, businesses, roads, and canals. Options for habitat improvements must now focus upon remaining natural areas.

The State's Florida Forever program continues to acquire conservation land within the range of LKMR. Targeted areas encompass most of the remaining privately owned LKMR habitat (and other native habitat) throughout BPK, TOR-CUD, and SUGAR. Through 2005, 1,726 acres (698 ha) out of 2,830 acres (1,145 ha) targeted for acquisition within the Coupon Bight-Key Deer Project, and 5,175 acres (2,094 ha) out of 11,854 acres (4,797 ha) within the Florida Keys Ecosystem project had been acquired (FDEP 2006). Some of those acquisitions included LKMR habitat, though species-specific details have not been tabulated. The NKDR manages those lands that are acquired on Big Pine and No Name Keys, and assists in the management of State parcels on adjacent keys within the species' range. The NKDR also continues its acquisition program, though on a smaller scale than the State program.

Ditches, dug in an attempt to facilitate mosquito control, were cut across large portions of the LKMR range. These ditches likely effect hydrological and plant community dynamics in LKMR habitats. The effect of these ditches on saltmarsh transition zones, other habitats, or LKMR has not been studied. A ditch inventory and remediation project was conducted in the lower Keys (completed 2000) (Hobbs et al. 2006). Ditches were plugged at 11 sites on Big Pine Key, which benefited approximately 13.5 acres (5.5 ha), including some LKMR habitat.

Prevalence of hardwood overstories in LKMR patches—Lack of natural disturbance factors in LKMR patches may result in further deterioration of habitat, because floristic changes, including woody encroachment, may result in unfavorable habitat conditions. Transition zone marshes, which generally occur in narrow bands between mangroves and upland (hardwood hammock and pine rockland) communities, are generally dominated by cordgrass and buttonwood. While buttonwood is present in or adjacent to most LKMR habitat, cordgrass and other ground cover is known to be a critical element. Similarly, while buttonwood is a typical element of the saltmarsh transition flora, its level of dominance may be variable, depending on site histories or initial floristics (as opposed to a fixed climax) in some cases. In some LKMR patches it may be joined by other woody species as well. Elsewhere, it dominates the overstory layer as a monoculture, and ranges in density from sparse (buttonwood savannah) to dense (closed canopy woodland). Where buttonwood forms a dense canopy, herbaceous cover is generally sparse. In some areas, advancement of buttonwood or other hardwoods may be a factor in patch extinctions because critical ground cover is lost. Such one-sided advancement may be due to the absence of disturbances such as fire, or some other perturbation to the saltmarsh transition system. If this is the case, it is a threat of high magnitude and growing imminence, due to the importance of the habitat type and the dwindling number of extant subpopulations.

All 228 delineated patches of suitable LKMR habitat cover only 2,011 acres (814 ha) (Faulhaber 2003). However, within the range of the Key deer (*Odocoileus virginianus clavium*), which encompasses only part of LKMR geographical range, Lopez (2001) attributed approximately 4,374 acres (1,770 ha) to transitional zones with buttonwood. It is possible that some of the area that makes up this discrepancy contains not only dispersal habitat, but areas which had been primary habitat for LKMR in the past. The saltmarsh transition zone is typically expressed as a long sinuous belt in the landscape. When LKMR patches are overlain onto saltmarsh transition cover maps, the patches are disjunct and small relative to the overall cover of saltmarsh transition zones, which also form corridors between delineated LKMR patches (P. Hughes, Service, pers. comm. 2006).

The physical and ecological factors that control the distribution and abundance of buttonwood require study. Some areas may have had more herbaceous cover previously or the prevalence of buttonwood may be due to conditions that specifically favor buttonwood encroachment. Prescribed fire may be a practical tool to prevent woody encroachment and promote regeneration of forbs and grasses that are critical resources for LKMR. Habitat expansion appears necessary for the recovery of LKMR. Regardless of whether fire was a major natural (or cultural) driver of ecosystem dynamics in saltmarsh transition zones in the past, fire or mechanical thinning may be necessary in these systems to benefit LKMR.

During the winter of 2005-2006, the Service carried out a pilot project in which small gaps within large stands of dense buttonwood were removed in two areas within a LKMR patch on Big Pine Key. The total area of buttonwood removed was under 1 acre (0.4 ha). The Service is observing the vegetation response while monitoring for LKMR. On April 28, 2007, prescribed burns were conducted within two occupied LKMR patches on NASKW. The total area of the burns was approximately 7.4 acres (3 ha). The purpose of these burns was to enhance ground cover for LKMR while controlling woody vegetation around NASKW runways.

Hurricane storm surges—Hurricanes may alter landscapes and flora due to storm surges and wind, which may impact LKMR habitat. Hurricane Georges in 1998 resulted in extensive damage to pine rocklands and caused numerous waterholes to become saline for many months (Lopez 2001). Similarly, Hurricane Wilma (October 2005) resulted in a storm surge 5 to 8 feet (1.5 to 2.4 meters) above mean sea level that displaced fresh water with seawater throughout Big Pine Key, killed slash pines throughout more than 15 percent of the pine rockland, and resulted in an outbreak of bark beetles (Carothers 2006). Other salt intolerant flora was desiccated throughout the LKMR range as well, and seven months of dry conditions exacerbated this. Seawater pooled in depressions within freshwater marsh habitats inhabited by LKMR on Big Pine Key. Additionally, roads and other developments caused retention of seawater and further hypersalinity, compounding the loss of salt-intolerant flora, including herbaceous cover. For example, populations of endemic forbs of the pine rocklands were significantly reduced throughout pine rocklands on Big Pine Key following Wilma (Bradley 2006), at least in the short term. Mortality following the storm surge resulted in substantial changes in the distribution of the endemic forbs, with surviving plants more concentrated in the higher, central portions of Big Pine Key. The majority of LKMR habitat outside of the saltmarsh transition zone occurs within freshwater marshes associated with these pine rocklands. Surge related disturbance to freshwater habitats may relate to why, as described above, subpopulations on Big Pine Key exhibited the most precipitous decline of any part of LKMR range. It is possible that post-surge effects include reductions in food resources or alterations in habitat structure that render LKMR more vulnerable to predators in some areas. However, the specific effects of recent hurricanes on LKMR habitat have not been quantified. Extant subpopulations on Big Pine Key are now clustered in two small areas in the central portion of the key. Hurricane effects are exacerbated by sea-level rise.

Sea level rise—Sea-level rise has been shown to result in degradation and elimination of pine rockland in the Keys due to increased salinity of water available to plant roots (Ross et al. 1994). Impacts on other communities have not been estimated. On Big Pine Key, freshwater wetlands comprise a significant component of LKMR habitat, and thus profoundly effect the distribution of suitable habitat. Loss of freshwater wetlands could have widespread, long-term, detrimental impacts to LKMR, particularly on Big Pine Key. There has been much speculation that waterholes in the lower Keys are increasingly saline, but little monitoring or data are available to better characterize this threat. LaFever (2006) modeled potential impacts of sea-level rise on three LKMR metapopulation areas. LaFever (2006) concluded that abandonment of human dominated areas (i.e., development and roads), as opposed to protecting them from ongoing sea level rise, may significantly ameliorate habitat impacts because it could allow for upslope migration of habitat. LaFever (2006) estimated that there were 2,896 acres (1,172 ha) of potential LKMR habitat throughout the range, and that most (1,396 acres [565 ha]) were in the middle elevation class. Because of this elevation distribution, the greatest proportional impact would occur under a moderate sea level rise scenario (a rise that encompassed lands in the middle elevation class). Because a high proportion of BCHI was in the lowest elevation class, BCHI was anticipated to be the earliest and most affected of the metapopulations.

Invasive exotic plants—Significant resources have been applied to IEP control in the lower Keys. The Service carries out an IEP control program throughout NKDR, as well as on State and county lands on Big Pine and No Name Keys. The Nature Conservancy and the FKIETF conduct complementary programs on other public and private lands. Consistent records of control efforts and outcomes have not been produced for the different IEP species, and specific risk or cost trajectories have not been projected. However, IEP currently do not appear to be a significant threat to LKMR in BPK or SUGAR. IEP occur within certain LKMR patches in BCHI. However, NASKW has initiated an aggressive program to control IEP within LKMR habitat (Hobbs et al. 2006, Service 2007b). Currently, the magnitude of this threat to the LKMR is low. It is not yet certain whether increased hurricane activity will result in increased threats from IEP, but such an effect has not been apparent.

b. Overutilization for commercial, recreational, scientific, or educational purposes: Capturing and radio-collaring LKMR for research purposes may result in unintentional take. Out of 108 LKMR captures conducted by Faulhaber, one died due to unknown causes during handling. Three additional LKMR were killed by raccoons after being trapped. Faulhaber (2003) developed methods to fortify the traps so that LKMR were no longer vulnerable to raccoons, and this problem has been eliminated in subsequent research involving capture. Hunting is believed to have played a role in early population declines, and Forys (1995) documented one case of poaching. However, poaching has not been documented in recent years. Overall, the magnitude of threats from overutilization is low.

c. Disease or predation: Although direct habitat loss has decreased in recent years as a result of regulations on development, indirect effects from development continue to threaten LKMR. Feral and free-ranging domestic cats are common throughout the range, and pose a serious threat to the LKMR. The PVA conducted by Forys and Humphrey (1999a) suggest that cats are controlling LKMR populations. The number of cats present in the lower Keys has increased with the increase in the human residential population (Forys and Humphrey 1999a). Additionally, raccoon populations may be subsidized by human development and their high numbers further the threat of predation. Using spotlight surveys, Forys (1995) found that approximately 50 percent of the cats in LKMR patches wore collars, and were probably not feral. Forys et al. (1996) reported that feral or domestic cats occurred in 14 of 19 LKMR subpopulations newly located during the course of their investigation. No detailed study of cat diets has been conducted in the Keys. However, LKMR of all ages and genders are susceptible to cat predation (Forys 1995). Of 24 mortalities documented by Forys (1995), predation was the greatest source. Seven kills were attributed to cats, 6 to cats or raccoons, and 2 to raccoons. More than 50 percent of all mortalities were attributed to cats and raccoons.

Predation from domestic cats is the greatest source of direct mortality in LKMR, and may be the greatest current threat to the persistence of LKMR (Forys and Humphrey 1999a). When different management scenarios were included in Forys and Humphrey's (1999a) PVA, the persistence of the LKMR was extended to 50 years if all predation by cats was removed. In the absence of controlling cat predation, persistence was not extended appreciably if all road mortality was removed or reintroductions into vacant patches were conducted. Results from a subsequent PVA conducted by LaFever (2006) on LKMR at NASKW were consistent with Forys and Humphrey's (1999a) findings that cat predation is the greatest threat to LKMR persistence. The impact of cats likely varies with the distribution and density of both cats and LKMR. Additionally, those density factors likely interact with habitat and landscape conditions, which are variable, and this complex of factors produces the actual level of vulnerability to predation for LKMR. No studies of predator behavior and anti-predator responses of LKMR have been conducted.

Predator control was initiated in BCHI by NASKW from November 2005 to January 2006, resulting in the removal of 17 feral cats and 169 raccoons (36 additional raccoons were released). From June to August 2006, 3 feral cats and 66 raccoons were removed (2 raccoons were released) (Perry et al. 2006). In May 2007, a predator trapping program was initiated on Service lands with LKMR habitat.

Natural predators for LKMR include the eastern diamondback rattlesnake (*Crotalus adamanteus*) and possibly the alligator (*Alligator mississippiensis*) (Forys 1995). Of 24 mortalities documented by Forys (1995), 3 were attributed to snakes. Additionally, large numbers of *Buteo* hawks and other raptors pass through the range of LKMR during the spring and fall migrations (Lott 2006). Such species include routine predators of *Sylvilagus* rabbits and likely take some LKMR during migration. One of those raptors, the red-shouldered hawk (*Buteo lineatus*), is a permanent resident within the lower Keys and may prey upon LKMR (Forys 1995). Bald eagles also nest in or near LKMR habitat, and one was reported to take a LKMR at NASKW (Forys 1995). These sources of predation appear to be insignificant relative to cat predation, but may add to cumulative impacts. Predation by snakes and cats has continued to be reported for the last several years (Faulhaber et al. 2007).

d. Inadequacy of existing regulatory mechanisms: LKMR are listed by the Florida Fish and Wildlife Conservation Commission as endangered (Chapter 39-27, Florida Administrative Code). This legislation prohibits take, except under permit, but does not provide any direct habitat protection. Wildlife habitat is protected on Florida Fish and Wildlife Conservation Commission wildlife management areas and wildlife environmental areas according to Florida Administrative Code 68A-15.004.

The State of Florida has compelled the Monroe County Board of Commissioners to strengthen controls on land use since at least 1975 when the Keys were designated an Area of Critical State Concern. A critical regulatory factor is the level of service on U.S. Highway 1 as it relates to hurricane evacuation time. The County developed a ROGO that, as of March 2006, incorporated a land tier system that specifically designates areas of native habitat for listed species, including the LKMR. The process made it more costly to destroy habitat and now discourages development in unfragmented habitat, steers available permit allocations to disturbed areas that are poor habitat for native fauna, and implements a land acquisition program for areas with native vegetation, including LKMR habitat.

On June 9, 2006, the Service issued a section 10(a)(1)(B) Incidental Take Permit (ITP) for Key deer, LKMR, and Eastern indigo snakes on Big Pine and No Name Keys (expiring June 30, 2023). The recipients (Monroe County, FDOT, and Florida Department of Community Affairs) developed a HCP to address habitat loss associated with development in the project area (Monroe County et al. 2006). The HCP allows for the loss of up to 7 acres (2.83 ha) of native habitat. Compensation will be provided by the acquisition of a minimum of three mitigation units for every one development unit of suitable habitat on Big Pine Key and No Name Key. As part of this process, the recipients are required to address the feral cat issue to benefit LKMR in the project area.

On August 25, 1994, the United States District Court for the Southern District of Florida directed the Federal Emergency Management Agency (FEMA) to consult with the Service to determine whether implementation of the National Flood Insurance Program in Monroe County was likely to jeopardize the continued existence of federally listed species including LKMR (Case No. 90-10037-CIV-MOORE). In 2003, the Service issued a jeopardy biological opinion with reasonable and prudent alternatives that required Monroe County to consult with the Service before issuing building permits in suitable habitat for listed species. Thus, in recent years, the Service provided technical assistance on pertinent projects (virtually all building applications on private parcels throughout the range of LKMR, excluding Coastal Barrier Resource Act zones). On September 9, 2005, the Court ordered an injunction against FEMA issuing flood insurance on any new developments in suitable habitat of federally listed species, and required the Service to submit a revised biological opinion within nine months (deadline later extended to August 9, 2006). Because the Court ruled that the 2003 reasonable and prudent alternatives were invalid, Monroe County was no longer required to consult with the Service before issuing building permits in suitable habitat and the Service suspended technical assistance on building permit applications.

The Service finalized its reanalysis of the National Flood Insurance Program in Monroe County, and provided a biological opinion to the Court on August 8, 2006 (Service 2006). The biological opinion provides a revised strategy for implementing regulatory actions pertaining to the LKMR. This strategy includes clarification of FEMA's oversight role and a more comprehensive strategy of evaluating potential impacts. The latter incorporates a lot-by-lot assessment of potential impacts that takes into account the limitations on development imposed by the County's ROGO system with its new designations of geographical tiers. In the biological opinion, the Service concluded that continued administration of the National Flood Insurance

Program in the Keys is likely to jeopardize the continued existence of the LKMR. The Court will determine whether to accept the biological opinion and whether to lift the prohibition on FEMA's issuance of flood insurance in Monroe County.

Pressure to develop remaining residential and commercial land within the range of the LKMR continues. However, development is subject to regulatory oversight by Monroe County, (e.g., the ROGO), the State (e.g., designated an Area of Critical State Concern), and the Service (e.g., the HCP, and presumably, continued consultation with FEMA regarding administration of the National Flood Insurance Program). In addition, the Service conducts section 7 consultation with NASKW on their activities that may affect the LKMR. In order to avoid or minimize habitat degradation, the NASKW routinely implements a variety of management practices identified in a 1994 LKMR Management Plan and the 2000-2010 Integrated Natural Resources Management Plan (Navy 2002). These include cat and IEP control, prohibitions to off-road vehicle use and mowing, and public education about LKMR issues.

e. Other natural or manmade factors affecting its continued existence:
Small and decreasing population size—The ongoing reduction in the number, area, and connectivity of occupied patches leaves remaining patches at greater vulnerability to extinction due to both demographic and environmental stochasticity. Additionally, the LKMR is thought to be less fecund than other subspecies (Forys 1995), making it less resilient to population bottlenecks and relatively more susceptible to demographic fluctuations and stochastic events. Forys and Humphrey (1999b) found that consistently occupied patches were more likely to produce juveniles than were patches that were variably occupied. Additionally, they found that inter-patch distance (patch isolation, which increases with patch extinctions) was the most important variable in a DFA used to explain patch occupancy. This suggests that ongoing extinctions may provide positive feedback such that surviving patches are increasingly susceptible to extinction. In an attempt to partly offset this threat, the Service has initiated a LKMR translocation program (Faulhaber et al. 2006). Additionally, the Service funded the development of a patch occupancy monitoring protocol (Perry 2006b).

Hurricanes—The magnitude of threats from stochastic events such as hurricanes are enhanced due to the characteristics of small, poorly dispersed populations and vice versa. Hurricane Wilma (October 2005) resulted in a storm surge that covered most of the land area in the lower Keys. At the time, seven LKMR were radio-collared on NASKW (BCHI metapopulation). Five of the six were determined to be dead, with all or most deaths attributed to drowning or other storm effects. Sign (tracks and fecal pellets) of surviving LKMR was also detected immediately after the storm (N. Perry, Texas A&M University [TAMU], pers. comm. 2005).

TAMU conducted patch occupancy surveys on NASKW in November to December of 2005, after the passage of Hurricane Wilma. Comparing patches that had been occupied pre- and post-Wilma ($N = 33$), the net loss of occupied patches was 11 (33.3 percent) (Service 2007a). However, surveys in 2006 and 2007 indicated that there had not been a significant impact (Figure 1). This was not the case on BPK, indicating either that the BPK metapopulation was not as resistant or resilient to the storm surge, that the habitat on BPK was impacted to a greater degree than in BCHI, or both. Predator control on BCHI may also have contributed to limiting impacts from the storm surge on that metapopulation.

Vehicle-related mortality—Mortality of LKMR from vehicular strikes has been documented as an important factor impacting the species (Forys and Humphrey 1999a). Roads can interfere with home range movements and dispersal and may prevent essential interchange between subpopulations (Forys and Humphrey 1999a). Dispersing males are the most vulnerable to road mortality. In BCHI, vehicle strikes accounted for approximately 33 percent of all documented mortality between 1992 and 1994. NASKW subsequently imparted stricter controls on off-road driving, and enhanced awareness of the issue in BCHI (Forys 1995, Service 2007b). Road mortality on Big Pine Key is poorly documented, but at least three individuals have been recovered since 1990. We are not aware of documented road mortalities subsequent to Forys (1995). It is reasonable to assume that some strikes go unrecorded. Moreover, it is possible that vehicle-related mortality is rarely observed simply because LKMR numbers are highly depressed. Accordingly, while vehicle strikes have not been documented recently, available data indicates that road mortality has the potential to be a threat of significant magnitude and should be monitored very carefully.

D. Synthesis - All three LKMR metapopulations (BCHI, SUGAR, and BPK) have continued to decline since 1988, as evidenced by patch (subpopulation) extinctions exceeding colonizations on an ongoing basis. The declines are consistent with PVAs that predicted extinction within 50 years. The level of extinction threat has increased steadily in recent decades, and increased annually in recent years. In BCHI, extinctions have accumulated steadily, but gradually relative to the other metapopulations. In SUGAR and especially in BPK, extinctions have accumulated more rapidly. Additionally, extant subpopulations have become more isolated (i.e., mean inter-patch distance has increased), yet less widely distributed (e.g., fringe subpopulations have been lost). Proportionate losses of subpopulations increased after Hurricane Wilma (2005), and possibly after Hurricane Georges (1998), at least on BPK. The BCHI metapopulation appeared to be more resilient to effects of Wilma, but predator control in BCHI subsequent to Wilma may have benefited LKMR. From 2002 to 2004, LKMR were translocated to suitable habitat on Little Pine and Water Keys (BPK metapopulation). Survival was high and reproduction occurred in both cases, and the colonization of Little Pine persisted after Wilma but that of Water Key did not.

Certain threats accounted for in the recovery plan (Service 1999) are now considered to be of lesser magnitude and imminence relative to earlier periods. For example, habitat destruction has been significantly reduced, particularly in wetlands inhabited by LKMR. Additionally, IEP are not a significant threat on NKDR and adjacent public lands, and an eradication effort has been initiated for affected LKMR patches on NASKW. With reduced population size and increasing isolation as subpopulation extinctions progressed, the magnitude and imminence of threats due to catastrophes and genetic, demographic, and environmental stochasticity has likely increased. Additionally, the probability of rescue by successful dispersal among increasingly isolated habitats has declined. The most significant threat, predation, continues unabated in much of the LKMR range. However, predator (cat and raccoon) control was initiated on NASKW (BCHI) in 2005 and on NKDR (BPK) in 2007. In general, hurricane activity, and specifically high intensity hurricanes, has increased. The threat of storm surges has increased as well, and is exacerbated by rising sea level. LKMR habitat is highly fragmented in most areas. Proliferation of hardwood overstories may cause a decline in habitat quality due to reductions in food plants or preferred cover, and may alter the vulnerability of LKMR to predation. Therefore, due to these threats, we find that the LKMR continues to meet the definition of endangered under the ESA.

III. RESULTS

A. Recommended Classification: The recovery criteria for downlisting / delisting have not been met; therefore, no change in classification is warranted.

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
_X_ **No change is needed**

IV. RECOMMENDATIONS FOR FUTURE ACTIONS – Collaborative strategies that focus efforts and increase efficiency by sharing resources and information, such as the case among the Service, NASKW, and other collaborators, should be continued. Research, including patch occupancy modeling that benefits our understanding of how LKMR metapopulations function, should be refined and expanded. The monitoring and modeling efforts should further refine the state of our knowledge such that recovery and section 7 actions can be specifically focused where they will be most useful, and result in more certain outcomes that reduce extinctions and increase colonization of patches. Models should incorporate sea level rise effects, and in order to improve such models, detailed elevation models are required. Accordingly, LIDAR measurements should be acquired and interpreted for the entire range. Monitoring of patch occupancy should be continued throughout the current range. Ongoing assessments of population persistence or viability derived from these data should henceforth incorporate breakdowns by land ownership. Additionally, the practice of applying a standard, more intensive monitoring grid within patches that will be and that have been subject to management actions (or project impacts) should be continued on NASKW and NKDR, and elsewhere to the extent practicable. Efforts should be increasingly directed by a system of monitoring and models. Recovery actions, section 7 consultations, models, and monitoring efforts, which are already integrated to a significant extent, should be formalized into a system of adaptive management.

Controlling of predation has been identified as the most important task if LKMR recovery is to succeed. Cats have been identified as the primary source while raccoons are a significant contributor. Predator control efforts should continue, and methods to further understand the distribution of cats and overabundant raccoons in relation to LKMR should be incorporated into the work. Outreach efforts aimed at educating residents (particularly those living near LKMR patches) about the effects of predation should be expanded, and additional ways to reduce the threat should be explored. Additionally, research on the behavioral and physiological attributes of LKMR that characterize their anti-predator strategies and needs may provide invaluable insight. Translocations within LKMR historic range should be continued and monitored. Translocations serve to reduce the rate of subpopulation extinctions. LKMR habitat and habitat selection should be better defined and quantified at multiple spatial scales. Saltmarsh transition zone ecosystems are poorly understood. This system supports the majority of LKMR. Accordingly, an understanding of how this system functions may be critical to understanding habitat influences on LKMR population dynamics. Buttonwood in this system should continue to be manipulated and monitored in order to explore potential benefits to LKMR. Such manipulations should include fire and mechanical treatments. These needs extend to freshwater marsh systems within pine rocklands in the BPK metapopulation, as well. A related, system wide factor is patch size. The importance of contiguous areas of habitat (e.g., homogeneous herbaceous cover) should be tested for and addressed in the context of adaptive management. Existing data on LKMR genetics indicate that diversity is low, as might be expected, but the available information do not inform us as to whether inbreeding, for example, is a cause for greater concern; and therefore LKMR genetics should be further examined.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Lower Keys marsh rabbit
(Sylvilagus palustris hefneri)

Current Classification Endangered
Recommendation resulting from the 5-Year Review

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
_X_ **No change is needed**

Appropriate Listing/Reclassification Priority Number, if applicable _____

Review Conducted By ___Phillip Hughes____________________

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ____________________ Date 8-23-07

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

for **Lead Regional Director, Fish and Wildlife Service**

Approve ____________________ Date 9/21/07

The Lead Region must ensure that other regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. If a change in classification is recommended, written concurrence from other regions is required.

Cooperating Regional Director, Fish and Wildlife Service

_____Concur _____ Do Not Concur

Signature________________________________Date_______

APPENDIX A: Summary of peer review for the 5-year review of Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*)

A. Peer Review Method: The Service conducted an influential level of peer review. Recommendations for peer reviewers were solicited from the Florida Fish and Wildlife Conservation Commission, Monroe County (no response received), and The Nature Conservancy. Additionally, two peer reviewers were selected by the Service. Individual responses were requested from six peer reviewers and responses were received from three reviewers.

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments/Report: Reviews largely conveyed affirmation that the status review was informative and accurate. Some specific concerns given in the status review were reiterated as mutual concerns by reviewers. One reviewer specifically affirmed the importance of incorporating potential effects of sea level rise in modeling efforts, and added that recently acquired LIDAR data (providing detailed renderings of topography) could be a powerful tool applicable to such efforts. Outreach efforts aimed at educating residents (particularly those living near rabbit patches) about the effects of cat predation were recommended. A reviewer stated that it was not clear what percentage of public lands suitable for marsh rabbits are owned by the State of Florida, and asked whether the State was participating in any marsh rabbit population monitoring, habitat management, funding, or feral cat control on properties they own. A reviewer noted that the status of rabbits on private lands was not provided.

D. Response to Peer Review: In each case wherein a recommendation or question was provided by a reviewer, we agreed with the recommendation or found that the question had merit and importance. Regarding sea level rise modeling, we added a synopsis of a recent document that touched on that subject, explicitly stated the importance of sea level rise modeling, and recommended incorporating LIDAR as a tool to facilitate such efforts (the Service is a contributor to a project which is attaining such LIDAR data). Substantial, increasing public outreach and education about cat predation has been undertaken by NKDR, particularly during and since the period in which the peer review was conducted. Nonetheless, other stakeholders and authorities have failed to engage in a like fashion. Accordingly, we incorporated the recommendation that education and outreach about cats should be expanded. Land ownership for each marsh rabbit patch can be found in Appendix B of Faulhaber (2003), which was provided to each reviewer and is otherwise available on the internet. On Table 2 of the review, which summarized land ownership, we added a notation that references the source. We attempted to summarize or otherwise address all rabbit related conservation work (including population monitoring, habitat management, funding, and feral cat control) that was conducted within the period that is germane to the review. We did not invariably indicate either inaction or participation as a function of land owner or organization. Most of the rabbit habitat that is on public land is owned by the Service (NKDR) and the Navy (NASKW). Much of the State-owned lands with rabbit habitat are managed by NKDR. On remaining State lands, it is our understanding that the State did not carry out specific management actions for marsh rabbits. However, as described in the review, State agencies collaborate in exotic plant control efforts in general. Additionally, State personnel routinely share information with Service personnel and others involved with active projects involving rabbit research and management. To the present, all of the available reports about the status of rabbit populations are based on geographical aggregations of patches (i.e., metapopulations), thus no breakdowns of population viability by ownership were available for the review. The review does address threats, including the adequacy of regulatory mechanisms, which differ according to ownership. Overall, in recent years, geographical location appears to be a more significant factor in whether a patch remains occupied than does ownership of a particular patch in most cases. However, that generality can change, particularly if regulatory mechanisms change. This is part of the reason that acquisition from willing private sellers receives emphasis in the review. We inserted a recommendation that patch occupancy monitoring and reporting henceforth includes a breakdown by land ownership.