Key Largo Woodrat
(Neotoma floridana smalli)

5-Year Review:
Summary and Evaluation – 2018 update

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

5-YEAR REVIEW
Key Largo Woodrat / *Neotoma floridana smalli*

This review honors
Dr. Timothy L. King
a kind, generous, and enthusiastic partner
who worked passionately and tirelessly for the conservation
of the Key Largo woodrat and many other imperiled species.

I. GENERAL INFORMATION

A. Methodology used to complete the review:

This update to the 2008 Key Largo Woodrat (KLWR) Five-year Review is based on new information gathered, compiled, and published since the last five-year review. The public notice for this review was published on August 30, 2016, with a 60-day public comment period (81 FR 59650). No comments were received from the public. Comments and suggestions regarding the review were received from peer reviews from outside the Service (see Summary of Peer Review section). We evaluated and incorporated comments as appropriate in this review. No part of the review was contracted to an outside party.

New information, updating the previous review, is provided in italics. *Some portions of the previous review may now be outdated, no longer correct, or obsolete. While the older information remains in this version, the added text, in italics, clarifies the most recent published or known information related to the KLWR's status and recovery.*

Photo credits from cover page (clockwise): C. DeGayner, USFWS, USFWS, M. Cove, C. DeGayner.

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 the lead recovery biologist with the South Florida Ecological Services Office. Literature and documents used for this review are on file at the South Florida Ecological Services Office. All recommendations resulting from this review are a result of thoroughly reviewing the best available information on the Key Largo woodrat (KLWR). The public notice for this review was published on April 26, 2007, with a 60 day public comment period. No comments were received from the public. Comments and suggestions regarding the review were received from peer reviews from outside the Service (see Summary of peer review section). We incorporated comments as appropriate in this review. No part of the review was contracted to an outside party.

B. Reviewers

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Lead Field Office: South Florida Ecological Services Office, Sandra Sneckenberger, (772) 562-3909

C. Background

1. Federal Register Notice citation announcing initiation of this review:
2008: 72 FR 20866 (April 26, 2007)
2017: 81 FR 59650 (August 30, 2016)

2. Species status: Declining (Recovery Data Call 2007). Subspecies status is precarious, and continues to be affected by multiple threats, such as population fragmentation, small population size, and predation (i.e., free-roaming domestic cats, Burmese pythons).

Recent surveys (2012 to present) appeared to indicate an increasing and currently stable population trend prior to Hurricane Irma (Cove et al. 2017a). However, according to a preliminary post-Hurricane Irma assessment (2017/2018), there is evidence of a significant population reduction (Cove 2018). Further assessment is needed to determine if the population has declined or is stable.

3. Recovery achieved: 1 (0-25% recovery objectives achieved).

Progress remains consistent with 0-25% recovery objectives achieved. Over 50% of the recovery tasks outlined in the recovery plan have been completed or are in progress.

4. Listing history
Original Listing
FR notice: 49 FR 34504
Date listed: August 31, 1984
Entity listed: Subspecies
Classification: Endangered

5. Associated rulemakings: None.

6. Review: The Service conducted a five-year review for the woodrat in 1991 (56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The notice stated that Service was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice indicated that if significant data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. No change in the woodrat's listing classification was found to be warranted.
5-year review: 1991, 2008, *and 2017.*
Recovery Plan: 1999

Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress, with the most recent annual evaluation for KLWR completed in 2017. Through 2013, we did a recovery data call that included status recommendations such as "Declining" for this mammal. We continue to show a

species status recommendation as part of our 5-year reviews. In our 2008 5-year review, the species' status was considered declining, and we found that no change to the KLWR's listing classification as endangered was warranted.

7. Species' Recovery Priority Number at start of review (48 FR 43098): 3C. The KLWR is assigned a recovery priority of 3C because the degree of threat to its persistence is high, it is a subspecies with high level of taxonomic distinctiveness, and its potential for recovery is great if threats can be eliminated or minimized. Recovery of the KLWR is in conflict with economic activities. *No change is needed to the RPN in 2018.*

8. Recovery Plan
Name of plan: South Florida Multi-species Recovery Plan (MSRP)
Date issued: May 18, 1999

II. REVIEW ANALYSIS

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? No. The recovery plan (Service 1999) criteria to reclassify the KLWR from endangered to threatened provide constructive qualitative goals, but contain elements that are neither objective nor measurable, or now obsolete. Revision of the recovery plan and recovery criteria is recommended.

The recovery plan (1999) does not include criteria for delisting. Revision of the recovery plan to include delisting criteria is recommended.

2. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. For threats-related recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5 listing factors are not relevant to this species, please note that here.

The criteria included in the approved recovery plan (Service 1999) to reclassify the KLWR from endangered to threatened are:

1) further loss, fragmentation, or degradation of suitable, occupied habitat must be prevented;
2) native and nonnative nuisance species must be reduced by 80 percent;

3) all suitable, occupied habitat on priority acquisition lists on Key Largo must be protected either through land acquisition or cooperative agreements;
4) tropical hardwood hammocks that form the habitat of the Key Largo woodrat must be managed on protected lands to eliminate trash and control exotics; and
5) stable (rate of increase equal or greater than 0.0 as a 3-year running average for 6 years) populations of the Key Largo woodrat must be distributed throughout north Key Largo and three additional, stable, populations established elsewhere within the historic range.

These criteria have not been met. Habitat degradation and loss has continued and threats from nonnative invasive species have increased. A working group has been developed to address new issues and persistent threats.

While population monitoring has indicated a population increase since the last review, the threat of nonnative predators has also increased (specifics in sections C.1.a. and C.2.c.). Several projects restoring hardwood hammock have been initiated and currently are underway, but further habitat loss and degradation has occurred (some due to Hurricane Irma; section C.2.e.). No additional populations have been established. Therefore, we have not met the criteria to reclassify KLWR.

C. Updated Information and Current Species Status

1. Biology and Habitat

Information regarding KLWR biology and habitat can be found within the recovery plan (Service 1999) and the Key Largo Woodrat Captive Propagation Plan (Service 2003). A summary, with the addition of updated information, is provided below.

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: While population trends are difficult to interpret from the various study designs and estimation techniques (Barbour and Humphrey 1982; Humphrey 1988; McCleery 2003; Potts et al. 2007), surveys in the last 20 to 25 years suggest a declining population, currently at very low densities (Florida Fish and Wildlife Conservation Commission [FWC] 2005; McCleery et al. 2006b; Winchester 2007). There is no appropriate estimate of population size to more precisely assess the severity of the decline. Population modeling yielded a high risk of extinction for KLWR within the next 10 years (McCleery et al. 2005; McCleery et al. 2006b).

The distribution of KLWRs within the hammocks of North Key Largo appears to have changed over time. Goodyear (1985), Frank et al. (1997), and McCleery (2003) all conducted trapping along transects or grids that were widely distributed throughout hammock vegetation on North Key Largo.

Goodyear (1985) reported that KLWRs were present on 30 of the 45 transects where she trapped (66 percent). Frank et al. (1997) reported KLWR presence on 14 of the 41 transects where they trapped (32 percent). McCleery (2003) trapped at 60 randomly-placed plots on North Key Largo, and found KLWRs on 10 (17 percent). Winchester (2007) captured KLWRs on 7 of 40 randomly placed grids (18 percent). These data suggest a consistent reduction in the distribution of KLWRs on North Key Largo. Recently however, Greene (2007) trapped KLWRs at 17 of 34 random grids (50 percent). At present, it is unclear whether the most recent field data indicate a true increase in abundance or a change in detection probabilities.

The largest decline appears to have occurred between 1986 and 1995, when no KLWR monitoring was conducted. The population appears to have continued this decline since 1995. Comparisons of population size estimated by Humphrey (1988) and more recent population estimates suggest that the population may have declined by 97 percent or more since 1986 (Service 2003). This magnitude of decline has not been recorded in other woodrat species without substantial changes in habitat characteristics that result in inhospitable conditions or outbreak of a lethal disease. There is no evidence that either of these events have occurred on Key Largo.

The combination of a measured decline in population density and trapping success, the apparent absence of nests which are a normal part of the biology of most woodrats, and the documented reduction in distribution within contiguous habitat on Key Largo support the conclusion that the population has declined. The extremely small number of remaining KLWRs suggests that the current status of the KLWR is precarious. The subspecies may have declined to the point where extinction is likely (Frank et al. 1997), and even if limiting factors are ameliorated, it will be many generations before the population size rebounds.

Recent analyses of trapping data in the periods 1995 to 1996, 2000 to 2001, 2005, and 2007 suggest that the KLWR population had a positive growth rate (λ=1.070) in all but the 2005 study period (McCleery et al. 2013). Abundance estimates from 2008 to 2011 suggest a steep decline from 2008 (estimate of 693 individuals) to 2010 (estimate of 78 individuals), but an increase in 2011 (estimate of 256 individuals; Potts et al. 2012).

From 2013 to 2015, KLWR distribution was assessed by sampling supplemental nests throughout KLWR habitat. The probability of nests being occupied increased annually from 23% in 2013 to 30% in 2014 and 37% in 2015 (Cove et al. 2017a).

While observations of stick nests steadily increased from 2007 to 2012 (Greene 2017), beginning in 2015, there appeared to be a notable increase in natural stick nests, large stick nests, and stick-stacking on most supplemental

nest structures within Crocodile Lake National Wildlife Refuge (CLNWR) and Dagny Johnson Key Largo Hammock Botanical State Park (DJSP) (DeGayner 2016). This perceived increase in stick nest building behavior is related to an increasing use of these nests (e.g., increased abundance)(Cove 2018).

In 2017, trapping surveys yielded a success rate of 4.14 KLWR per 100 trapnights (Cove 2017), with KLWR present on 21 of 32 grids (66 percent). This far exceeds rates documented less than 10 years ago (1.5 KLWR per 100 trapnights; 0.87 KLWR per 100 trapnights; Potts 2008a, 2011, respectively), and signifies an increase in trap success to rates not documented since the 1980s (Goodyear 1985). Preliminary data from a post-Hurricane Irma population assessment have indicated a significant decline (see C.1.e.; Cove 2018).

Because of the continuing decline in population size, and lack of detailed knowledge of the specific mechanism(s) responsible for the decline, 6 pairs of KLWRs were brought into captivity starting in 2002, following the Service's "Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act" (65 FR 56916). There are currently two facilities (Disney Animal Kingdom and Tampa's Lowry Park Zoo) involved in the captive propagation program. The breeding program has been successful, though the facilities are approaching capacity and analyses to avoid inbreeding support few acceptable matings. Research to develop protocols for releasing captive individuals is underway (see **II.C.1.d.**).

From 2002 to 2004, 15 KLWR were brought into captivity. Despite some challenges early in the program with excessive weight gain, apparent lack of interest in mating, and aggression that led to injuries and fatalities, a protocol was developed to successfully care for and breed these relatively asocial mammals (Alligood et al. 2011). A total of 76 KLWR were born in captivity, yielding a total of 91 animals cared for by the two facilities over the course of the program.

In 2010 and 2011, there were three releases of a total of 40 captive-born KLWR back into their habitat in Key Largo. Every individual was radio-tagged and released into man-made "nest structures" enclosed in wire cages. Following an acclimation period, the outer cages were removed. For the pilot release, 13 radio-collared KLWRs were released at CLNWR. Seven of these individuals were found killed by predators within one day to three weeks following their release, and another three were predated within 60 days of their release. All but one predation event (consumed by rattlesnake) displayed characteristics or evidence of feral cat predation. Three KLWR survived beyond 60 days and one individual survived to nine months. Two females gave birth to pups – although both females were subsequently preyed upon before the pups could care for themselves.

Despite increased predator management efforts, a second release of 12 individuals in 2011 yielded similar results with three individuals remaining alive at the end of the 60-day monitoring period. Evidence suggested feral cats were the dominant predator of the released KLWR, and nearly 40 feral cats were removed from the release site since the start of the 2010 releases. The third release occurred on Palo Alto Key (Gore 2012); this location was selected with hopes of lower predation pressure. The 15 KLWR released gained weight and moved among nest sites, but no signs of reproduction (i.e., captured females pregnant or lactating) were observed. Ten individuals were predated within weeks after release, and all but one KLWR succumbed to predation within five months post-release. Native birds of prey were suspected as the predators, possibly great horned owls (Bubo virginianus) or migrating hawks. These results suggested that survival rates of captive-reared woodrats released into the wild remain low even if domestic cats are absent. Preconditioning KLWR prior to release and removing non-native predators may increase survival rates of released individuals. Research focused on releases of captive-bred Allegheny woodrats (N. magister) has recommended anti-predator conditioning and environmental enrichment prior to release to prepare these animals and increase their post-release survival (Blythe et al. 2015).

The captive colony and subsequent releases yielded a tremendous amount of information regarding the KLWR's life history, social system, behavior, as well as their proper captive care. However, largely due to the new information gleaned from the captive colony and these release efforts, the captive breeding program was at a crossroads. The captive propagation program was originally started with the hope of augmenting the wild population. It had limited uses in augmenting the wild population due to inbreeding and taming issues while in captivity, and predation issues upon release. The size and scope of the colony and its management (i.e., capacity, genetics, pre-release conditioning) would have needed to be greatly expanded to potentially be effective for augmentation. Consequently, captive breeding efforts ended in 2011. In lieu of captive breeding, the Service focused resources on efforts to assess the status of each KLWR subpopulation, identify suitable habitat throughout Key Largo, support predator management efforts, enhance the quality of habitat within the species' current range, work towards connecting subpopulations, and determine what would be required to make a captive breeding program effective.

A model was developed to evaluate wild, captive, and released populations of KLWR (McCleery et al. 2014). Based on demographic data gleaned from recent research, this model was designed to determine the potential effectiveness of the captive breeding program; or more specifically, if impacts associated with collecting additional wild KLWR for the captive colony would be offset by the benefits to the wild population (i.e., related to success of the

captive colony and releases of captive-bred KLWR back to the wild). Since recruitment was higher in the wild population and few captive-bred released individuals survived to reproduce, none of the captive breeding and release scenarios that were evaluated positively contributed to the recovery of the KLWR (McCleery et al. 2014).

Regarding demographic characteristics, KLWRs breed year-round with an apparent peak in reproductive activity in the summer (Hersh 1981; Sasso and Gaines 2002). Females typically have two litters a year with one to four young, with litters of two offspring the most common (Brown 1978). Young wean at about 65 days (Savage 2007) and are sexually mature at 5 months. Both male and female densities increase gradually in summer to early fall. Gender ratio estimates approximate 1.2 males to each female (Hersh 1981), however, KLWRs may be capable of assessing resource conditions and responding with various brood reduction / gender bias strategies. The life span of a KLWR is believed to be similar to the eastern woodrat – averaging less than one year, but up to 3 years; though capture of KLWRs at least two years old is not uncommon (Potts 2008b).

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding): Detailed information concerning present levels of genetic diversity and variation in KLWR is presented here. A suite of nine polymorphic microsatellite DNA markers primers have been developed and surveyed for KLWR. An initial survey of structure in the wild population described the genetic variation as fitting a pattern of isolation by distance (King 2008).

The small population size, dramatic decreasing trend, and the lack of detailed knowledge of the specific mechanism(s) responsible for the decline, prompted the implementation of a captive propagation program. The success of the captive propagation program relies, in part, on implementing a biologically sound genetic management program to determine the level of genetic diversity among the wild population and to ensure that this diversity is conserved within the captive populations. Initially, 6 pairs of KLWR were brought into captivity starting in 2002, following the Service's "Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act" (65 FR 56916). Two facilities (Disney Animal Kingdom and Tampa's Lowry Park Zoo) are currently involved in the captive propagation program. The captive populations at Lowry Park Zoo (N=16; seven individuals constitute one family) and Disney Animal Kingdom (N=14; seven of one family) are small in size and represent 75 percent and 59 percent of the genetic diversity observed in the wild, respectively (King 2008). Recommendations for pairings of individuals based on genetic relatedness and kinship are made regularly as new captive-bred individuals are incorporated into the breeding program. This genetically-driven breeding program, which is designed to maximize the genetic diversity, has been successful, though the facilities are

approaching capacity and analyses to avoid the pitfalls of inbreeding depression support few acceptable matings.

See above summary of captive breeding efforts and their cessation. By 2010, the captive colony was at the F4 generation and had diverged from the wild population (King 2010). The two captive colonies were also diverged from each other.

A more extensive survey of microsatellite DNA variation has resulted in unique multilocus genotypes for 133 wild captured individuals. The data did not support the hypothesis that KLWR exists as a single, panmictic (randomly mating) population. Instead, a spatially explicit model incorporating geographic coordinates of collection site and genotypic data identified a series of genetic discontinuities (i.e., barriers to gene flow) across the subspecies' 16 kilometer range resulting in five subpopulations (King 2008).

With five small, disjunct populations, the threat of losing irreplaceable genetic diversity is a concern. As a result of these findings, the USFWS and its cooperators are reevaluating the priorities of the captive breeding program and have altered the recovery strategy so as to augment gene flow among these smaller fragmented populations. Research to develop protocols for repatriating selectively-bred individuals is underway.

Further research identified seven subpopulations, with subpopulations at each end of the range having lower allelic diversity (King 2009). Results also indicated little genetic exchange between four subpopulations, and breaks in population substructure corresponded to natural or man-made habitat fragmentation (King and Young 2009). (Incidentally, all captive founders were from subpopulations 1 and 2 [King 2010], further evidence and likely a cause of captive colony not reflecting the diversity of the wild population.)

Deployment of a continuous "honey-comb" grid of 642 nest structures has recently been completed within the KLWR's habitat on public lands. This grid provides consistent (approximately 6-acre, 10 times the size of a KLWR's home range) sampling units for assessment of the KLWR's population status, as well as connectivity between previously disconnected subpopulations. Upcoming genetic work will evaluate the efficacy of the nests in reconnecting the subpopulations (Cove 2017).

c. Taxonomic classification or changes in nomenclature: KLWRs are the southernmost subspecies of the eastern woodrat (*Neotoma floridana*) (Sherman 1955; Schwartz and Odum 1957). There have been no changes in the accepted taxonomy, which is considered valid (Integrated Taxonomic Information System 2008).

Phylogeographic analysis using mitochondrial (mtDNA)(Neighbor-Joining tree) and mtDNA haplotype network analysis both demonstrated that KLWR are well differentiated from other woodrats, including the eastern woodrat (N. f. floridana; the closest geographically)(King 2009). There have been no changes in the accepted taxonomy, which is considered valid (Integrated Taxonomic Information System 2017).

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): Historically, the KLWR occurred throughout the length of Key Largo south nearly to Tavernier (i.e., Rock Harbor; Schwartz 1952). Their distribution is now patchy, congruous with the loss and fragmentation of hardwood hammock vegetation (McCleery 2003; FWC 2005). The present range of the KLWR includes the northern one-third of Key Largo where large tracts of contiguous tropical hardwood hammock occur, representing about one-half of their original distribution (Barbour and Humphrey 1982; Humphrey 1992).

Residential and commercial development is considered the cause of extirpation of KLWR south of the intersection of U.S. 1 and C.R. 905 (Brown 1978; Hersh 1981). Approximately 880 hectares (ha) of suitable KLWR habitat remains (Humphrey 1988; Service 1999; McCleery 2003; Service 2003; FWC 2005), and individuals are found almost exclusively within public lands (Crocodile Lake National Wildlife Refuge and Dagny Johnson Key Largo Hammock Botanical State Park) (FWC 2005). A few private tracts adjacent to public lands contain suitable habitat and are vulnerable to urbanization.

Until Hurricane Irma, there had been no recent, significant changes in the known distribution of the KLWR since the previous review. (Further assessment is needed to determine if/how the distribution of the KLWR has changed since the storm.) While the proportion of the area occupied has fluctuated, this subspecies remains distributed throughout the tropical hardwood hammock habitat on public lands in the northern third of Key Largo (Potts 2011; Cove 2016). Recent surveys and ongoing monitoring efforts suggest a spatial trend of KLWR persisting at higher densities within the central core of the CLNWR and DJSP, and lower densities at the northern and southern extremities (Cove et al. 2017a). Without implementation of recovery actions on public lands, such as invasive species control, this trend is expected to continue and increase in severity. For instance, the northern extent of the KLWR's currently known range is threatened by a large feral cat colony, and development and free roaming and feral cats encroach at the southern extent.

No KLWR have been captured during limited survey efforts on lands adjacent to known occupied areas (Greene 2011); however, KLWR may be persisting at low densities. Feral cat colonies are prevalent in these areas within Key Largo which may reduce KLWR densities and nest building activities, thereby reducing detectability.

An initially successful translocation project was initiated on Lignumvitae Key (outside the historic range) in 1971 (Brown and Williams 1971; Barbour and Humphrey 1982). Stick nests were observed in the 1980s, but the population was considered extirpated from the key by 1990 (Duquesnel 1994). In 2008, KLWRs from the captive colonies will be released within Crocodile Lake National Wildlife Refuge and the Dagny Johnson Key Largo Hammock Botanical State Park. The focus of this effort will be the development of protocols for conducting, monitoring, and evaluating the reintroduction of the KLWR.

Lignumvitae Key was trapped extensively in 2007 and no rodents were observed or captured (Greene 2017). Please also see discussions in earlier sections regarding releases of captive-bred KLWR.

e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem): Much of the original tropical hardwood hammock on Key Largo was cleared in the past for development or agriculture, and the southern portion of Key Largo is nearly completely developed. These unnatural, patchy incidences of disturbance have resulted in a mosaic of various patch ages that together represent habitat of inferior quality to KLWRs. The only remaining large contiguous tract of tropical hardwood hammock vegetation occurs on the northern half of Key Largo. Approximately 880 ha of the remaining 1,011 ha of tropical hardwood hammock are protected within the boundaries of Crocodile Lake National Wildlife Refuge and Dagny Johnson Key Largo Hammock Botanical State Park (Service 2003). Much of the remaining (unprotected) 131 ha consists of private lands cleared several decades ago and abandoned. Successful regrowth of the hammock, and consequently the suitability of the habitat to KLWRs, varies among these sites.

Crocodile Lake National Wildlife Refuge and Dagny Johnson Key Largo Hammock Botanical State Park were acquired in 1980 and 1982, respectively. Since initial acquisition, both sites have been managed to maintain and restore the native tropical hardwood hammock vegetation on which the KLWR depends, and have continued acquisition of remaining hammock habitat on north Key Largo. Many tracts on these sites were cleared for development or agriculture earlier this century, but hammock vegetation has returned to many of these previously cleared sites. The remaining forest is now composed of a variety of successional stages of tropical hardwood hammock vegetation, reflecting the time since and extent of disturbance.

Theories regarding the habitat preference of KLWR appear to conflict. Once believed to reach highest densities in mature hardwood hammocks (Service 1973; Brown 1978; Hersh 1981; Barbour and Humphrey 1982), KLWRs are now known to use a variety of successional habitat conditions (Goodyear 1985), possibly preferring young hardwood hammock (McCleery 2003). As these habitat types differ mainly in species composition, their physiognomies (i.e., life form, architecture of canopy layers) being comparable, the conflicting assessments of preferred habitat may be a result of differing uses of habitat nomenclature. Furthermore, hammock age classes are confounded with disturbance and the presence of artificial structures, making habitat preference associations with trapping data problematic (Winchester 2007).

Crucial components of KLWR habitat include materials for building stick nests and ample cover (Rainey 1956). More recently, however, KLWRs have been found to occupy areas without obvious stick nests, instead using rock crevices, solution holes, abandoned cars, refuse, or rock piles for the basis of their nests (Goodyear 1985; Service 1999). Over 150 supplemental nest structures (constructed of rock, wood, and recycled materials) have been placed within Crocodile Lake National Wildlife Refuge, with approximately 33 percent of these in use (Potts 2008a).

Several projects geared to restore tropical hardwood hammock have occurred within KLWR habitat. Projects have included the restoration (filling in of) the Carysfort Marina (22 acres), the Keystone (quarry) pit (2 acres), the removal of debris piles at the former Nike Missile Site, and the removal of old buildings, roads, and infrastructure at the abandoned Port Bougainville site (32 acres). Not only do these projects reconnect and restore lost habitat, they also have a positive impact on KLWR populations by removing refugia for black rats and pythons, known or potential competitors and predators of KLWR, respectively. Native plants have been planted in these disturbed areas, which speeds the recovery of these areas back into tropical hammock habitat.

Supplemental nests currently number over 1,550, and there is a minimum of one nest in each of the 6-acre monitoring cells throughout the KLWR's range on public lands (see section C.1.b.).

Hurricane Irma made landfall on Cudjoe Key, less than 90 miles from the KLWR's range, as a Category 4 in September 2017. This large and powerful storm impacted the tropical hardwood hammock through its storm surge and by de-leafing and knocking down trees. The downed trees and copious amounts of sticks felled will provide cover for KLWR and easy access to building materials for their stick nests. Consequently, KLWR could be less vulnerable to predators. The full impacts due to storm surge are not known at this time, but we are continuing to examine the large impacts of this storm on

this low-lying community. Limited post-hurricane survey efforts have indicated a population decline (6 of 10 grids occupied pre-storm were occupied post-storm; Cove 2018).

2. Five-Factor Analysis

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

Habitat loss, fragmentation, degradation. Historically, areas where KLWRs were extirpated would be recolonized as population densities increased and dispersal occurred from adjacent populated areas. As agriculture and urbanization has fragmented the landscape, KLWRs can no longer recolonize these areas as they did in the past. The KLWR requires a minimum habitat size for daily activities; barriers caused by habitat loss and fragmentation compromise their ability to disperse, obtain food and nest site resources, locate a mate, and carry out natural life history behaviors. The ease with which resources can be attained directly affects survival rates, fecundity, juvenile recruitment, and ultimately, population growth rate.

Isolation of small populations also reduces or precludes gene flow between populations and can result in the loss of genetic diversity. Demographic factors such as predation, diseases, and competition are intensified in small, isolated populations which may be rapidly extirpated by these pressures. Especially when coupled with events such as tropical storms, reduced food availability, and/or reduced reproductive success, isolated populations may experience severe declines or extirpation (Caughley and Gunn 1996).

The scope and severity of this threat are high. This threat also increases the severity of all other threats addressed subsequently.

The addition of supplemental nest structures throughout public lands in northern Key Largo is likely to improve connectivity within this area; however, increased fragmentation and reduced connectivity on private lands adjacent to public lands, and throughout greater Key Largo continue to limit KLWR movements and use of habitat patches. Connectivity could be improved southward by deploying supplemental nests after significant outreach and predator removal efforts. A long-term predator management strategy would also need to be developed and implemented (with community support).

Availability of nest sites. Like eastern woodrats, KLWRs may be more limited by the availability of nest sites than by food (Service 1999). The destruction of hammock trees or the energy cost and predation risk involved with construction may be affecting the woodrats' ability to build its large stick nests. While an estimated 20 percent of KLWR nests occur in fallen logs or

root systems, free-standing stick nests appear to be absent from north Key Largo (McCleery 2006a, Winchester 2007).

The scope and severity of this threat are not known. As artificial substrate (rock and debris piles) may be selected over natural nest material because it provides more protection from predators, this threat is coupled with the threat of increased predation pressure (II.C.2.c. Disease and predation).

There is no evidence suggesting that nest site availability is currently a limiting factor. Many natural nests are currently observed and several hundred supplemental nests have been added to the landscape. It is not known if supplemental nests provide benefits similar to natural nests (i.e, yield equal or higher survival or fecundity rates). However, we suspect that supplemental nests provide greater protection from predators, require less maintenance, and last longer than natural nests.

Invasive exotic plants (IEP). Significant resources have been applied to IEP control in the Keys. The Service carries out an IEP control program throughout Crocodile Lake National Wildlife Refuge. Dagny Johnson Key Largo Hammock Botanical State Park is a member of the Florida Keys Regional Working Group that has developed a control plan for IEP on public lands including the state park. The Nature Conservancy and the Florida Keys Invasive Exotics Task Force also conduct complementary programs on other public and private lands. IEP currently do not appear to be a significant threat to KLWR habitat, and the severity of this threat is low.

b. Overutilization for commercial, recreational, scientific, or educational purposes: Not known as a threat. Although scientific research does involve trapping and taking genetic samples (i.e., removal of tail tips to obtain a blood sample), only two KLWRs are known to have died as a result of scientific research (Humphrey 1988; Potts 2008a).

c. Disease or predation:
Disease. Raccoon roundworm (*Baylisascaris procyonis*), while a concern for other woodrat subspecies, has not been reported in south Florida (Forrester 1992). Surveillance for the raccoon roundworm was initiated on Key Largo in 2002, and there is no evidence that this parasite is present within the range of the KLWR (McCleery et al. 2005). As this roundworm is a common parasite of raccoons throughout much of North America and usually results in death in woodrat species (Logiudice 2001), the severity of this threat is high, while the scope remains low.

While no evidence of raccoon roundworm was found in Key Largo, surveillance for this parasite should not be considered obsolete. Even low levels of this parasite on the landscape can impact woodrat populations (Smyser et al. 2013).

The New Guinea flatworm (Platydemus manokwari) is a large predatory flatworm. This species is highly invasive, named one of the "World's 100 Worst Invaders", and primarily affects populations of land snails (Justine et al. 2014). In 2017, several specimens have been collected within KLWR habitat at DJSP incidentally during a herpetological coverboard survey. This species is a vector for the rat lungworm, which can impact rodent populations and cause meningitis in humans (Dalton et al. 2017). No testing for this parasite in KLWR has been conducted and no surveillance for this threat is underway at this time.

Toxoplasma gondii is a protozoan that causes toxoplasmosis. Cats are the only definitive host known for T. gondii, and the parasite is spread to other warm-blooded animals through the cats' feces (or coming into contact with water, food, or soil contaminated by cat feces) (CDC 2017). Consequently, this disease is a concern for all mammals in the Keys due to the presence of feral cat feeding colonies and high density of outdoor cats (Chalkowski 2017). This parasite is well documented as a public health concern and often lethal in rats and mice. Furthermore, Toxoplasma infection has been shown to make rats and mice bolder and even attracted to cat urine (Vyas et al. 2007), which could indirectly strengthen free-roaming cat impacts on woodrats. The threat of disease to such a limited population is high, and investigations regarding the occurrence and potential impact of these possible vectors are underway.

Predation. KLWRs have a number of natural predators: raptors, corn snakes (*Elaphe guttata*), diamondback rattlesnakes (*Crotalus adamanteus*), Florida black racers (*Coluber constrictor priapus*), Keys rat snakes (*Elaphe obsolete deckerti*), owls, and raccoons (*Procyon lotor*). Nonnative predators include free-roaming domestic cats (*Felis catus*), fire ants (*Solenopsis invicta*), and Burmese pythons (*Python molurus bivittatus*).

One of the largest feral cat colonies is operated adjacent to the Dagny Johnson Key Largo Hammocks State Botanical Site, yet there have not been comprehensive or continuous free-roaming cat control efforts in place within the range of the KLWR. Limited cat control has been undertaken in the past on Crocodile Lake National Wildlife Refuge and Dagny Johnson Key Largo Hammocks State Botanical Site. However, it was usually instituted on a small scale, and only targeted a few individual cats. To aid recovery efforts of both KLWR and Key Largo cotton mice, the Service funded a successful larger-scale control effort that was conducted in the winter of 2004 (USDA 2004). Raccoons, while a natural predator, are attracted to areas with feral cat colonies due to regular feedings. This factor, in addition to the general attraction of raccoons to garbage, has likely led to elevated densities of raccoons in North Key Largo (USDA 2004).

Recent research has found that 22 percent of feral cats sampled in Key Largo had a diet primarily consisting of wild prey (over 50 percent wild prey; Cove et al. 2017b). Considering the wildlife community in Key Largo, and cameras documenting cats with rodents in their mouths, these cats are likely preying upon endangered small mammals, including KLWR. Predator management efforts continue, but are concentrated on the CLNWR half of the KLWR's range, which limits overall effectiveness. Sharing efforts and responsibility for this issue among landowners and agencies would greatly advance enforcement efforts and outreach messaging.

Seven non-native Burmese pythons have been captured in Key Largo since April 2007, and predation of KLWRs by Burmese pythons was documented in 2007 (Snow 2008). An eradication program for this non-native predator is in place, but largely relies on reports from the public. Intra-agency partnerships have developed to assess ecological risks, encourage responsible pet ownership, organize exotic pet amnesty days and media campaigns, and form a rapid response team. To specifically protect the KLWR, the Service has funded a USGS project that includes a multi-faceted effort to detect and control Burmese pythons on Key Largo using visual surveys and several types of experimental traps to capture pythons.

Over 25 Burmese pythons have now been captured in Key Largo since 2007 (EDDMapS 2017; USGS, unpublished data). Three 18-inch hatchling Burmese pythons were found and removed from northern Key Largo, near DJSP, in 2016. This was the first sighting of pythons of this age and size in Key Largo, and presents evidence of a breeding population of pythons in Key Largo. Four adult pythons were captured from the remains of the Nike missile base in 2017. The three, 8-foot pythons and one, 16-foot python were found within missile bunkers. An additional adult python was captured during a debris removal/ habitat restoration project at the Nike site in 2016.

Since Hurricane Irma, land managers have anecdotally seen an increase in both feral cat and python observations. Cats may have been abandoned by owners evacuating the Keys, or upon their return. The storm may also have served as a dispersal event for the Burmese pythons, aiding their travel from the Everglades region. With relatively mild habitat impacts from the storm, a possible population increase of both of these known KLWR predators may pose significant indirect effects of the storm on the wildlife in Key Largo.

Predation of KLWRs where recruitment is sufficient and suitable habitat is available is not a concern. Conversely, increased predation pressure on isolated populations from natural and non-native predators can have a substantial impact. The drastic decline of Allegheny woodrats (*N. magister*) in Pennsylvania was attributed primarily to predation by great horned owls (*Bubo virginianus*) and exposure to raccoon roundworms (Balcom and Yahner 1996). In addition, due to their moderate size and mostly terrestrial mode of

life, KLWRs may be particularly vulnerable to predation. In light of the increased level of native predators (USDA 2004), the addition of non-native predators, and the direct relation of this threat to mortality, the severity and scope of this threat are high.

The threat of both disease and predation (by non-native, invasive species) is increasing. The needs to survey for, manage, and understand the population-level effects of potential disease agents and predators are significant.

d. Inadequacy of existing regulatory mechanisms: Information regarding past significant regulatory activities involving KLWR can be found within the recovery plan (Service 1999). A summary, with the addition of updated information, is provided below.

FEMA flood insurance consultation. 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 (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 the KLWR, 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 threatened and endangered species. 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 Rate of Growth Ordinance (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 was not

likely to jeopardize the continued existence of the KLWR. 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.

State and county regulations. The KLWR is listed by the FWC 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 FWC wildlife management areas and wildlife environmental areas according to Florida Administrative Code 68A-15.004. Florida Park Service regulations prohibit take of specimens and destruction of vegetation (i.e., habitat) on park property without a permit.

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 KLWR. 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 KLWR habitat.

Monroe County's Comprehensive Land Use Plan (March 2007) states that development within hammock "shall be reviewed to ensure the functional integrity of the entire hammock" and development proposals within this habitat type "shall identify the extent to which the area is habitat for threatened or endangered species" and adverse impacts to "the functional integrity of the hammock or pineland in which development is to be undertaken, the developer shall provide for mitigation in an amount greater than the area disturbed in the form of replanting disturbed areas with native species or by the acquisition and preservation, including donations, of land containing comparable quality and character of vegetation as the area disturbed."

Pressure to develop remaining residential and commercial land within the range of the KLWR 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., ESA consultation, presumably including continued consultation with FEMA regarding administration of the National Flood Insurance Program). Regulatory mechanisms have reduced the threat of further habitat loss in north Key Largo.

The Monroe County Animal Control Ordinance does not restrict free-roaming cats. This ordinance could be changed, or a Keys-wide ordinance could be added to limit cats to living indoors (or otherwise contained), particularly in sensitive environmental areas.

e. Other natural or manmade factors affecting its continued existence: *Competitors.* The presence of competitors, particularly non-native species, is a significant influence on habitat suitability. Trash dumping occurs throughout the KLWR's range and attracts human commensals. In the past, black rats (*Rattus rattus*) were captured at equal or greater numbers as KLWRs on hammock study sites (Hersh 1981) and thought to be a serious competitor, but subsequent trapping sessions yielded very few captures of black or Norway rats (*Rattus norvegicus*) (Barbour and Humphrey 1982; Goodyear 1985).

In a 2013 camera trap survey of KLWR supplemental nests, black rats were only detected at two of the nest structures, compared to KLWR detected at 65 nests (Cove et al. 2017a). However, more recent live-trapping surveys resulted in the capture of more black rats (n = 108) than woodrats (n = 98) in spring 2017 (Cove 2017). These black rats were evenly distributed throughout the protected habitats with the highest densities at the northern and southern boundaries of the CLNWR and DJBSP. There is growing evidence that black rat populations have increased in recent years, possibly in response to exotic predator management, which should warrant further examination of direct and indirect effects of black rats on KLWR.

Gambian giant pouch rats (*Cricetomys gambianus*), the largest murids, were unintentionally released in Marathon, Florida in 1999. Possible sightings on Key Largo have not been confirmed with trapping (Engeman et al. 2006), but due to their large size, high fecundity, and similar food and nest site requirements, their impact on KLWR would be extensive. An eradication program initiated in Marathon appears to have been successful, though the pouch rats could emigrate by several means (Engeman et al. 2006). Furthermore, the hurricanes of 2005 may have assisted in their dispersal to nearby islands. The severity of this threat is high, while the scope remains moderate.

Over 190 free-ranging Gambian pouch rats have been documented in the Florida Keys, with the majority in Grassy Key, where a captive-breeding colony still exists. Confirmed accounts range from Islamorada to Key West, and the most recent account was in 2017 (EDDMaps 2018; FWC 2018).

Hurricanes. Hurricanes influence vegetational succession in the Florida Keys. Undisturbed hammocks are presumably more resistant to storms than hammocks that have been fragmented or have had surrounding mangrove and

transitional vegetation removed. Damage to habitat from past hurricanes has included windshear, significant canopy loss, uprooting of large trees, understory damage, and significant soil disturbance. Extensive damage represents habitat loss to KLWR, but some disturbance serves to open habitat and allow for greater plant diversity. The severity and scope of this threat are variable and stochastic.

See effects of Hurricane Irma (2017), above under habitat conditions section.

Sea level rise. Sea level rise has been shown to affect conversions of upland communities with low soil and moisture salinities to communities comprised of more salt tolerant plant species and higher soil and groundwater salinities (Ross et al. 1994). This phenomenon may potentially result in the loss of suitable KLWR habitat through inundation or vegetative species composition changes. The general effects of sea level rise within the range of the KLWR will depend upon the rate of rise and landform topography. However, the specific effects across the landscape will be affected by complex interactions between geomorphology, tides, and fluctuations in energy and matter. These effects have yet to be simulated and projected for the range of the KLWR. The imminence of this threat is low, but the severity remains unknown.

The KLWR's distribution appears to be undergoing constriction due to expanding mangrove areas and inland human infrastructure (FWC 2017). This constriction may be pushing ideal habitat inland toward roads which could lead to vehicle-related mortalities. Recent evidence of KLWR using mangrove pods for nesting material, instead of the typical hardwood sticks, may constitute evidence of these habitat changes.

Recent climate change modeling suggests that the tropical hardwood hammock in Key Largo is less vulnerable to sea level rise than other areas in the Florida Keys (FWC 2017). However, at three to four feet of sea level rise, water levels fragment habitat and several habitat bottlenecks materialize; effects further exacerbated by the highway running through the KLWR's range (CR905). This level of sea level rise is forecasted to occur in 43 to 80+ years (2060-2100; NOAA 2017). Additionally, a portion of hammock areas affected by sea level rise will likely transition into mangrove forest, causing further reduction of KLWR habitat (Saha et al. 2011).

D. Synthesis - No change is recommended to the listing classification of the endangered KLWR. The degree of threat to its persistence remains high. It is a subspecies with high level of taxonomic distinctness, and its potential for recovery is considerable if threats can be eliminated or minimized.

Impacts and potential threats to the KLWR and its habitat have increased in the recent past from non-native predators and competitors. With these additional stresses, KLWR habitat is in poor condition and populations are currently fragile. Specifically, about 880 ha of KLWR

habitat is protected on north Key Largo. Trends from trapping data illustrate a population decline for the last 20 to 25 years (FWC 2005; McCleery et al. 2006b; Winchester 2007). A consistent reduction in the distribution of KLWRs on North Key Largo is occurring as well.

Regulatory mechanisms are in place to track impacts to KLWR habitat and aid in minimizing impacts from development on public lands. However, the subspecies' minimum requirements for habitat connectivity, food and nest site resources, and other factors may already be underprovided. Free-roaming cat control programs have occasionally been in place on public lands since 2002, and non-native predators continue to pose a major threat.

Through several years of research and continuous monitoring, researchers have identified a suite of possible causes for the continuous decline in the KLWR population. Remedial measures, including captive propagation, have been developed for the subspecies, but the decline continues and new threats have emerged.

At present, the KLWR is in danger of extinction throughout its entire range. Therefore, no change is recommended to its listing classification as endangered. Despite significant threats that remain, prior to Hurricane Irma, the population appeared to be increasing from recent declines documented in 1996 to 2007, and several recovery actions have been completed or are ongoing. However, population information post-Irma, although limited, suggests that threats from non-native predators have been exacerbated by the storm (i.e., Burmese pythons and free-roaming cats), and the population may have significantly declined or be declining. Both chronic and emerging threats pose more serious concerns to KLWR when their populations are at the lower and more vulnerable intervals within the cycles. Furthermore, as so little remains of their historic range, increased threats can result in significant population-level impacts. Several projects restoring hardwood hammock have been initiated and currently are underway, but further habitat loss and degradation has occurred (including some due to Hurricane Irma). Captive breeding efforts, unless significantly redesigned and expanded, proved to be ineffective in successfully augmenting wild populations. Developing partnerships and continuing focused research and recovery actions will continue to be key to recover the KLWR. Additional assessments of Hurricane Irma impacts are also needed.

III. RESULTS

A. Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X_ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

The top three priorities for future actions are denoted below with an asterisk.

- Old and abandoned roads bisecting hammock habitat should be restored to native vegetation. Research may be warranted to develop restoration techniques effective in this unique environment. *(Partially complete / ongoing)*
- The 1999 Recovery Plan should be revised and updated to reflect the current status and threats to the KLWR, and recovery criteria, objectives, and tasks should be developed or revised. *(Not initiated)*
- Genetic analyses should be conducted to provide further insight into the current KLWR population. Information on the genetic diversity of the population and the genetic makeup of individual KLWRs will provide insight into the current status of the population. *(Partially complete/ongoing)*
- Opportunities to convey the importance of hammock habitat to the public should be sought and pursued. Interpretive signs could be designed and distributed to public land managers on North Key Largo. In addition, an outreach/education program focused on the threats free-roaming cats and exotic pets pose to wildlife should also be developed. *(Partially complete/ongoing)*
- Appropriate parcels for land acquisition should be identified using current knowledge of KLWR movements and habitat use. *(Not initiated)*
- Captive propagation and reintroduction efforts should continue to develop techniques and methods appropriate for KLWRs. *(Partially complete)*
- Further examination of nest sites potentially limiting the KLWR may be warranted. Natural nest materials may be provided in areas occupied by KLWRs to aid in natural nest construction *(Ongoing).* Ex situ research may be appropriate to determine possible causes for nest site selection *(Not initiated).*
- Information concerning the diet of KLWR would aid in habitat restoration, land acquisition, and captive propagation efforts *(Partially complete).* Identifying foraging patterns may allow for better assessment of KLWR's perception and response to predation risk and provide detailed movement information *(Not initiated).* Data from previous research could be reanalyzed to provide insights into habitat use *(Not initiated).* In addition, vegetation surveys measuring several habitat parameters may be important to determine factors influencing habitat use *(Partially complete).*
- Additional information is required concerning potential disease agents and health problems that may afflict KLWRs. Rodents from Key Largo should be screened for a variety of diseases, when considered appropriate. Tentative agreements with the University of Florida - College of Veterinary Medicine, Gainesville, Florida and with the National Wildlife Health Center, Madison, Wisconsin, would allow for such investigations. *(Not initiated)*
- Research focused on determining the relative abundance of KLWR predators, their influence on KLWR behavior, and their effect on survival and recruitment rates is warranted. Predator management strategies and/or more comprehensive predator control should be investigated if appropriate. *(Partially complete/ongoing)*

∗ *Evaluate the basis of KLWR population fluctuations and consider environmental, stochastic, and habitat-associated influences as possible drivers.*

- ∗ *Develop potential adaptation strategies to moderate or delay effects of sea level rise on KLWR. For example, increase connectivity where sea level is likely to cause fragmentation.*
- ∗ *Develop effective, comprehensive means to manage nonnative, invasive species and implement significant efforts aimed to eradicate these species from Key Largo and prevent recolonization.*
- *Continue efforts to restore KLWR habitat, particularly in concert with python removal efforts.*
- *Use monitoring nests (natural or supplemental) or other techniques to assess habitat use or preferences among hammock age classes.*
- *Evaluate KLWR presence outside their currently known range.*
- *Assess the genetic connectivity between previously identified subpopulations.*
- *Work with county, state and federally-owned (and/or managed) lands in Key Largo to eliminate or reduce impacts of feral cat colonies on these lands.*
- *Develop techniques to identify owners/care-givers of individual cats for more effective enforcement of policies (i.e., collars or microchips).*
- *Determine the direct and indirect effects of black rats on KLWR.*
- *Evaluate the short-term and long-term impacts from Hurricane Irma on KLWR and identify remedies.*
- *Determine whether supplemental nests provide greater protection from predators, require less maintenance, and last longer than natural nests.*
- *Initiate disease monitoring for raccoon roundworm and Toxoplasmosis.*

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF THE KEY LARGO WOODRAT *(Neotoma floridana smalli)*

Current Classification _Endangered___
Recommendation resulting from the 5-Year Review

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

Review Conducted By ___Sandra Sneckenberger, South Florida Ecological Services Office___

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 3/31/18

In 2014, Southeast Region Field Supervisors were delegated authority to approve 5-year reviews that do not recommend a status change.

Summary of Peer Review Process for the 5-year Review of the Key Largo Woodrat (*Neotoma floridana smalli*)

A. Peer Review Method:

The document was peer-reviewed internally by Dr. Nikki Lamp, Recovery Program supervisor, of the South Florida Ecological Services Office, and by Jeremy Dixon, Crocodile Lake National Wildlife Refuge Manager. Five outside peer reviewers were chosen based on their qualifications and knowledge of the species. Not all peer reviewers solicited provided a response.

B. Peer Review Charge:

The following guidance was provided to the outside peer reviewers:

1. Review all materials provided by the Service.
2. Identify, review, and provide other relevant data that appears not to have been used by the Service.
3. Do not provide recommendations on the Endangered Species Act classification (e.g., endangered, threatened) of the species.
4. Provide written comments on:
    - Validity of any models, data, or analyses used or relied on in the review.
    - Adequacy of the data (e.g., are the data sufficient to support the biological conclusions reached). If data are inadequate, identify additional data or studies that are needed to adequately justify biological conclusions.
    - Oversights, omissions, and inconsistencies.
    - Reasonableness of judgments made from the scientific evidence.
    - Scientific uncertainties by ensuring that they are clearly identified and characterized, and those potential implications of uncertainties for the technical conclusions drawn are clear.
    - Strengths and limitation of the overall product.
5. All peer reviews and comments will be public documents, and portions may be incorporated verbatim into our final document with appropriate credit given to the author of the review.

C. Summary of Peer Review Comments/Report

Overall, the reviewers found the review to be a complete and thorough review of the best available information regarding the status of the subspecies.

Dr. Daniel Greene, Wildlife Scientist of the Weyerhaeuser Company, provided clarifying language regarding the subspecies' distribution and the KLWR introduction at Lignumvitae Key. Among other helpful comments, he also added finer detail to several points in the status review, including information on restoration projects, pythons, and black rats.

Dr. Timothy Smyser, Biologist at the National Wildlife Research Center, provided insight from his work on a different woodrat species. He asked for clarifying information on KLWR

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population dynamics and trends and captive KLWR releases, and provided many helpful suggestions for additional analyses and further work.

D. Response to Peer Review

All peer reviewer comments were evaluated and incorporated where appropriate.