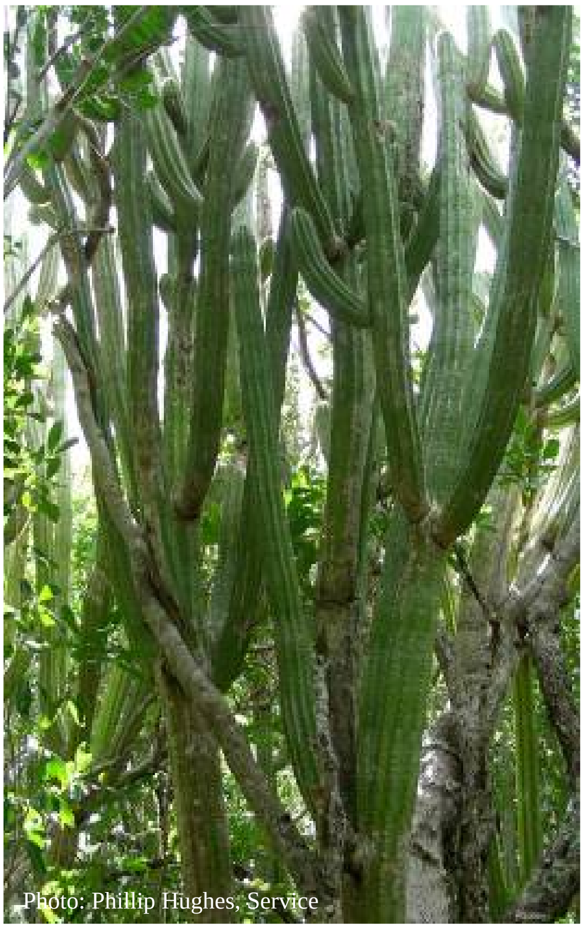
Key tree-cactus
(Pilosocereus robinii)

5-Year Review:
Summary and Evaluation



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

5-YEAR REVIEW
Key tree-cactus / *Pilosocereus robinii*

I. GENERAL INFORMATION

A. Methodology used to complete the review: This review is based on monitoring reports, surveys, and other scientific information, augmented by conversations and comments from biologists familiar with the Key tree-cactus. The review was conducted by the lead recovery biologist for the species in the U.S. Fish and Wildlife Service (Service), 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 scientific information on the Key tree-cactus. Public notice of this review was given in the *Federal Register* on April 9, 2009, with a 60-day public comment period (74 FR 16230). No part of the review was contracted to an outside party. Comments received and suggestions from peer reviewers were evaluated and incorporated as appropriate (see Appendix A).

B. Reviewers
Lead Region: Southeast Region, Kelly Bibb, 404-679-7132

Lead Field Office: South Florida Ecological Services Office, David Bender, 772-562-3909

C. Background

1. FR Notice citation announcing initiation of this review: April 9, 2009. 74 FR 16230

2. Species status:
Uncertain (2009 Recovery Data Call). The status of Key tree-cactus is uncertain based on incomplete information regarding trends in populations and the continuing trend in threats over the past year.

Key tree-cactus has experienced an overall loss of approximately 80 percent of all plants, and 87 percent of all stems from 1994 to 2007. The population at National Key Deer Refuge (NKDR) on Big Pine Key, once the largest, has experienced the most precipitous decline. It has decreased by 91 percent, from 564 plants in 1994 to 53 plants in 2007. Between 2004 and 2009, five populations have continued to decline and two appear stable (Maschinski et al. 2009, corrected numbers from Devon Powell, Fairchild Tropical Botanical Garden [FTBG], pers. comm. 2009; P. Hughes, Service, unpubl. data 2006). Data suggest that recent decline may be related to increased soil salinity at sites where the plants occur (Maschinski et al. 2009). Since 2004, large numbers of plants have exhibited yellowing, followed by stem-rot at the base of the main trunk. The weakened cacti eventually topple over. Seedlings of Key tree-cactus have rarely been documented, and none were observed in the past three years (Maschinski et al. 2009). While six of seven populations are either protected by agreements or located on publicly-owned conservation land, most populations have experienced a precipitous decline over the past 6 years.

3. Recovery achieved:
1 (1 = 0-25 percent of recovery objectives achieved).

4. Listing history
Original Listing
FR notice: 49 FR 29234
Date listed: July 19, 1984
Entity listed: Species
Classification: Endangered

5. Associated rulemakings: None

6. Review History:
Five-year review: November 6, 1991 (56 FR 56882). In the 1991 review, multiple species were simultaneously evaluated with no in-depth assessment of the five listing factors or threats as they pertained to the species' recovery. The notices summarily identified these species and stated that no changes in the designation of the species under review were warranted at that time. In particular, no changes were proposed for the status of Key tree-cactus**.**

Recovery Plan: 1999

Recovery Data Call: 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, and 2009.

7. Species' Recovery Priority Number at start of review (48 FR 43098):
5c (species with a high degree of threat, low recovery potential, and that is in conflict with construction or other development projects).

8. Recovery Plan
Name of plan: South Florida Multi-Species Recovery Plan (MSRP)
Date issued: May 18, 1999
Dates of previous revisions: Key tree-cactus Recovery Plan, September 1986 (original plan).

II. REVIEW ANALYSIS

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

1. Is the species under review listed as a DPS? The Endangered Species Act of 1973 as amended (ESA) defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife. Because the species under review is a plant, the DPS policy is not applicable and not addressed further in this review.

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? No.

Criterion 2, which reads, "When native and non-native nuisance species have been reduced by 80 percent," is ambiguous because it does not define the metric that will be reduced (i.e. canopy cover, basal area, individuals per acre). Furthermore, Key deer (*Odocoileus virginianus clavium*) is the species which has presented itself as the greatest nuisance to Key tree-cactus (Maschinski et al. 2008). Since Key deer are themselves an endangered species, criteria need to be developed to address reduction of deer impacts to Key tree-cactus using fences or other methods.

Criterion 5, which reads "Populations will be considered demographically stable when they exhibit sexual reproduction and have a rate of increase (r) equal to or greater than 0.0 as a 3-year running average for 6 years," needs to be corrected because an r-value of 0.0 indicates population decline. A stable population is represented by an r-value of 1.0.

Criterion 6, which calls for reestablishment of stable populations of Key tree-cactus within its historic range, needs to be reconsidered in the context of sea level rise (SLR). If SLR is indeed causing increased soil-salinity at Key Tree-cactus sites, this undermines the future viability of all populations in the historic range. Likewise, since the plants may take 20 years or more to mature from seed (shorter for clonal recruits), then only four generations (or less) can be expected to persist at these sites, assuming the best possible scenario for climate change predictions. Thus, careful analysis is needed to ensure sensible use of finite conservation resources. Selection of reintroduction sites within the historic range should focus on higher elevation sites that will persist as suitable habitat for the longest period.

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.

The criteria do not address other natural or manmade factors affecting the continued existence of Key tree-cactus, including SLR and storm surges, which may degrade habitat (by increasing soil salinity levels).

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 stated Recovery Objective is to reclassify from endangered to threatened. Delisting criteria have not been developed.

Key tree-cactus may be reclassified from endangered to threatened when:

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

This criterion has not been fully met. Six of seven populations are on protected lands (Maschinski et al. 2009). One populations is located on private land is not protected from habitat destruction (Maschinski et al. 2008). All populations occur in areas affected by storm surges, which degrade habitat through soil salinisation. SLR may have broad-reaching affects on Key tree cactus habitat within the next 100 years (TNC 2008, U.S. Climate Change Science Program [CCSP] 2008). The criterion addresses factor A and E.

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

This criterion is too vague to determine whether it has been met. It lacks specificity as to what taxonomic groups of species are to be controlled, and for what duration. The species which has presented itself as the greatest nuisance to Key tree-cactus is the Key deer (Maschinski et al. 2008), which is also an endangered species. This criterion should be revised as discussed above. This criterion addresses factor E.

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

This criterion has not been met. Six of seven populations are on lands protected through acquisition or agreements (Maschinski et al. 2009). One population that occurs on private land currently has no protection from development and could potentially be destroyed by the landowner at any time without violating any state or Federal laws. The criterion addresses factor A.

4. Potential habitat on protected lands is restored or rehabilitated for the Key tree-cactus.

This criterion has not been met. The Village of Islamorada, Florida Department of Environmental Protection (FDEP), and NKDR all have plans to restore Key tree-cactus habitat through active management. However, the Service is not aware of any effort that is currently ongoing. This criterion addresses factor A.

5. Stable populations of the Key tree-cactus are distributed on secure sites within its historic range (including two on Upper Matecumbe, one on Lower Matecumbe, three

on Long Key and two on Big Pine Key). Populations will be considered demographically stable when they exhibit sexual reproduction and have a rate of increase (r) equal to or greater than 1.0 as a 3-year running average for 6 years.

This criterion has not been met. Data from 2004 through 2009 show that five populations have continued to decline and two appear to be stable (Maschinski et al. 2009). One population on Long Key is not protected from development because it is located on private property and no agreement is in place to secure it from development. This criterion addresses factor A and E.

6. Three additional populations that are stable have been established on Windley Key, Boca Chica Key, and Key West.

This criterion has not been met. No additional populations have been established to date. Reintroductions will be considered upon the completion of additional research, including genetic analyses that are still needed. This criterion addresses factor A.

Conservation Measures

Land Acquisition

FTBG and the Conservation Fund (a national non-profit) recently worked to secure $5.1 million in grant funding to preserve a private parcel of land where a population of Key tree-cactus occurs. In 2008, the Village of Islamorada submitted a grant application to Florida Communities Trust (FCT) with the help of The Conservation Fund and FTBG. In June of 2009, The Village of Islamorada finalized the purchase of the 9-acre Key tree-cactus Preserve, protecting the parcel from future development. Funding for the acquisition came from Florida Forever through the FCT, a statewide competitive grant program for land acquisition. FTBG, as an official partner, provided some funding and agreed to provide assistance with management of the Key tree-cactus (Maschinski et al. 2009).

Reintroductions Plans

Potential reintroduction sites have been examined at Crocodile Lake National Wildlife Refuge and State Parks on Windley Key and Upper Matecumbe. A proposal for the two projects on state land was submitted and approved by the FDEP, Division of Recreation and Parks (FDEP 2008).

Ex situ measures

Ex situ conservation measures that have been implemented for Key tree-cactus include long-term seed storage at National Center for Genetic Resource Preservation (in Fort Collins, Colorado) representing multiple maternal lines. Cuttings have been taken from a large number of plants, and from all populations, and are being grown at FTBG in Miami, Florida and the Desert Botanical Garden in Phoenix, Arizona. So far, 40 maternal lines are represented. The goal of FTBG is to have at least 100 maternal lines for use in outplanting projects. Currently, managers at NKDR and botanists at FTBG have permits to 'salvage' cuttings from downed plants. Regular monitoring of the populations provides the ability to take advantage of these salvage opportunities.

C. Updated Information and Current Species Status

1. Biology and Habitat

The Key tree-cactus is a member of the cactus family (Cactaceae). It is a tree-like columnar cactus growing to 10 m tall. Individuals can be un-branched or many-branched. The tops of the tallest individuals may project above the hammock canopy. The stems of the tree-cactus are cylindrical, green, succulent, and 5 to 10 cm thick, with 9 to 15 prominent ribs. Large, solitary, green flowers open at night. The pollinators of Key tree-cactus are unknown (Service 1999).

The biology and habitat of the Key tree-cactus has been described by Britton and Rose (1920), Small (1917), Austin (1984), Hennessy and Habeck (1994), and Adams and Lima (1994). Information on the habitat and life history of the Key tree-cactus is summarized in the Key tree-cactus Recovery Plan (Service 1986) and revised in the South Florida Multi-Species Recovery Plan (MSRP) (Service 1999). Relevant biology and habitat information is summarized and updated in this review.

The Key tree-cactus is known in the U.S. only from Monroe County, Florida in the Florida Keys. It is a member of the rare and declining tropical hammock community. Populations are extant on Upper and Lower Matecumbe Keys, Long Key, and Big Pine Key (Adams and Lima 1994, Service 1999, Florida Natural Areas Inventory [FNAI] 2009).

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:

<u>Reproductive Biology</u>

Most Key tree-cactus plants occur as clumps with a major stem and several to multiple satellite stems. Adams and Lima (1994) stated that the formation of clonal clumps from rooted wind-thrown branches appears to be the major reproductive strategy in the species. Many branches develop adventitious roots at their origins (Adams and Lima 1994), suggesting adaptation to vegetative reproduction. As with many clonal plants, the connections to prostrate stems or fallen branches from which new clones originate may deteriorate over time, making it difficult to discern vegetative stems from stems produced from seeds. Molecular genetics techniques are required to determine the genetic constitution of clonal clusters with any certainty.

The pollinator of Key tree-cactus remains unknown. Flowers open at night, have a garlic-like odor, and produce sweet nectar. Adams and Lima (1994) stated that these characteristics suggest pollination by nectar-feeding bats. However, no such bats are native to the Florida Keys. Adams and Lima (1994) also speculated that a sphingid moth could be the likely pollinator. However, in their study, they did not observe bats or other pollinators. Wind pollination is not likely because the pollen grains are large and flowers tend to be at least a meter apart (Hennessy and Habeck 1994). Insects have been collected in sticky traps placed around flowers, but most appear to be diurnal fliers that were captured incidentally (Hennessy and Habeck 1994). Experiments have demonstrated that bagged and un-bagged flowers can produce fruits, so large pollinators are apparently not required (Adams and Lima 1994). The evidence suggests that the species is capable of self-fertilization, but further research is required to gain a better understanding of its breeding system and pollination biology.

The amount of canopy cover (and thus amount available light) seems to affect the amount of flowering in Key tree-cactus. Adams and Lima (1994) reported a 'striking correlation' existed between the presence of flower-bearing pseudocephalia (area of the stem that bears flowers) and the degree of canopy cover directly overhead. Of the 44 flower-bearing pseudocephalia measured, 9.1 percent formed under moderately covered to fully covered canopy conditions. The majority (90.9) percent formed under moderately open to fully open canopy conditions (Adams and Lima 1994). If seedling recruitment requires an open canopy, it is possible that the species is adapted to respond to openings in the canopy through increased flowering and seed production, facilitating recruitment in suitable microsites while favorable conditions exist.

Adams (1997) provides one of the only sources of reproductive potential of Key tree-cactus. He found that 22 percent of flower buds opened and eventually set mature fruit. The majority (78 percent) fell before producing viable seeds. He determined that each fruit produces a mean of 536 small, round, black, mature seeds and a mean of 146 small, flat, pale-brown aborted seeds. Seed viability varied significantly between fruits, from 90 percent or more to less than 10 percent. Calculated seed viability was 58 percent (percent germinated under laboratory conditions) (Adams 1997). *In situ* germination rates were much lower (11.75 percent), suggesting a significant degree of damping off or seed predation (Adams and Lima 1994). Maschinski et al. (2009) reported laboratory germination rates of 86.8 percent for untreated seeds, and 94.9 percent after a one-minute acid (1N H_2SO_4) soak, indicating that the species still exhibits high seed viability.

Seed dispersal by birds (such as the northern cardinal, *Cardinalis cardinalis*) is indicated for this species. The effective dispersers would be those fruit-eating birds, which favor openings in the woods. Ants may also disperse seeds (Adams and Lima 1994).

Demographic Features

Little is known of the long-term demography of Key tree-cactus because it is a long-lived species and demographic data are sparse. Adams and Lima (1994) recorded baseline demography for the species from 1991 to 1993. Demographic monitoring was not resumed until 2007.

Key tree-cacti are long-lived plants, but no estimation of their lifespan has been published. The oldest plant reported by Adams and Lima (1994) was estimated at 51 years old. They estimated that this plant first flowered 26 years after germination of the seed that produced it. This estimate agrees with experimental data from Lamb and Lamb (1976) for *Pilosocereus palmeri* and *P. chrysacanthus* indicating that plants began flowering at 20 and 25 years of age, respectively, when grown from seed.

Seedling recruitment has been rare or non-existent for the past decade. Adams and Lima (1994) reported that the NKDR population consisted of 6.9 percent seedlings, defined as relatively new recruits having originated as sexual propagules. Neither Maschinski et al. (2007, 2008, 2009), Service biologists (Steve Klett or Phillip Hughes), or any other observers have reported finding seedlings in the wild since 1994. However, cactus seedlings are extremely small for the first few years and could be exceedingly difficult to detect amongst hammock vegetation. Clonal (vegetative) recruitment has recently been observed at sites in the Upper Keys, but none has been observed in recent years at NKDR (J. Maschinski, FTBG, pers. comm. 2010).

Population Trends and Recent Decline Phenomenon

Monitoring and surveying for the Key tree-cactus has been somewhat limited. The first quantitative survey of all known Key tree-cactus sites was conducted by Adams and Lima (1994) from 1991 to 1993 and serves as the baseline for analyzing population trends. From 1994 to 2001, little monitoring and apparently no research was focused on the species. FTBG and the Institute for Regional Conservation (IRC) conducted limited monitoring on Big Pine Key in 2001. FTBG began regular, annual monitoring of all but one (the private landowner refused permission to survey his property) Key tree-cactus populations in 2007.

In 2004, Service biologists recognized a widespread pattern of decline affecting most populations of Key tree-cactus (Steve Klett, U.S. Fish and Wildlife Service, pers. comm. 2004, P. Hughes, unpubl. data 2006).

Declining cacti show a lack of living tissue (only woody pith) at the base. The typical pattern of decay extends upwards on individual plants, as an advancing edge of necrotic tissue expanding toward the branch tips. As their bases weaken, larger plants eventually fall over. Disease was initially suspected due to the synchrony of symptoms across multiple populations, and the rapid onset of decline. The preeminent alternative hypothesis was that, in the absence of disturbance, succession of hardwood hammock associates was affecting the cacti. The mechanism was speculated to be competition for light (due to increased canopy cover of hardwoods), nutrients, or soil moisture (P. Hughes, unpubl. data 2006; Maschinski et al. 2009). Other speculated causes of the decline included hydrologic stressors, stand age, or herbivory (P. Hughes, unpubl. data 2006; McAuliffe and Rice 2008). Staff at NKDR and FTBG investigated the possibility of disease. Tissue samples sent to two different plant pathology labs on at least two separate occasions failed to reveal anything except secondary pathogens, such as *Phytophthora* (P. Hughes, unpubl. data 2006, Goodman et al. 2008, McAuliffe and Rice 2008). This led to a theory of multiple causation (i.e., a threat[s] added to stress). Stress was hypothesized to be caused either from wounding or from physiological stress, ultimately leading to pathogenic infection. In the Lower Keys, wounding could be caused by herbivory or antler polishing by Key deer. Numerous environmental factors could cause physiological stress.

Some have hypothesized that hurricane storm surges may have precipitated the recent population decline (S. Klett, pers. comm. 2005). Storm surges can temporarily inundate large areas with seawater, which then drains off and, or percolates through the soil, leading to increased soil salinity. Soil salinity beyond a plant’s tolerance causes difficulties with water uptake and cell osmotic potentials, causing stress to the plant and cell mortality. Compromised tissue can then be infected with secondary pathogens which cause further injury, eventually leading to mortality of the plant. Storm surges inundate large areas of the low-lying Florida Keys, and cyclone activity was high in 2004, the year the decline phenomenon was first noticed. In August 2004, Hurricane Charley passed near the Keys, producing an estimated storm surge of up to 2 m. The surge, combined with incoming waves, caused extensive flooding of low-lying coastal areas (National Hurricane Center 2005). Hurricane Wilma struck the Keys in October 2005. After the hurricane had passed, a storm surge of up to 2.4 m developed from the backwash out of the Gulf of Mexico and completely inundated a large portion of the lower Keys (National Hurricane Center 2006). Maschinski et al. (2008) provides a local resident’s account confirming that the area of NKDR where the Key tree-cactus occurs was completely inundated during the storm surge produced by Hurricane Wilma. Storm surge from Hurricane Wilma also inundated populations on Long Key (Maschinski et al. 2008, S. Klett, pers. comm. 2006).

FTBG began work in 2008 to test the hypothesis that increased soil salinity was connected to the decline phenomenon. Maschinski et al. (2009) tested soil samples from multiple Key tree-cactus sites and found a positive correlation between high soil salinity and areas of high cactus mortality. Within the sites with the greatest cactus mortality, the portions of the population occurring in lower elevations had higher soil salinity and higher mortality. This led to the current working hypothesis that increased soil salinity has contributed to the recent decline (Maschinski et al. 2008).

By 2008, data began to suggest that the decline may be starting to level-off. The population decreases noted from 2007 to 2008 were primarily a result of the death of plants that were classified as "dying" in 2007. In 2008 only a few new dying plants were observed, and a few plants that were originally classified as dying in 2007 were actually found to be alive and apparently healthy (Goodman et al. 2008). Data for 2007 through 2009 show that four populations continued to decline in number of stems and that two appear stable (Maschinski et al. 2009). A seventh population, located on Long Key, was last surveyed in 2006, when it consisted of six small plants (S. Klett, pers. comm. 2006).

Continued annual monitoring will be important in determining if the decline is continuing or if the populations are becoming more stable and to determine the relationship between disturbance events and cactus population dynamics. Even if the decline episode appears to be subsiding, it has left most populations with only a fraction of the individuals they had 10 years ago, and this likely has greatly diminished the overall viability of these populations.

Status of Extant Populations

As of July 2009, there were approximately 260 stems spread across seven populations. The species has experienced a decline of approximately 80 percent of all plants and 90 percent of all stems from 1994 to 2009 (based on data from Adams and Lima 1994, S. Klett, pers. comm. 2006, Maschinski et al. 2009). See Table 1 for a summary of population sizes for all extant populations. The names of properties and their locations are omitted in this review to protect sensitive locality information.

Big Pine Key supported two populations in the early 1990s (Adams and Lima 1994). The population at NKDR was historically the largest Key tree-cactus population in both number of plants and areal extent (Adams 1997). This population has experienced the greatest loss, from 564 plants (2200 stems) in 1994 to 56 plants (58 stems) in 2007, a decline of 90 percent (95 percent for stems) (Maschinski et al. 2009). The recent decline has severely affected this population. Many plants have died and there has been no clonal recruitment in recent years (J. Maschinski, pers. comm. 2010). As noted above, a storm surge inundated the hammock during Hurricane Wilma in 2005 (Maschinski et al. 2008). Cactus mortality (and soil salinity) at the site was greater in the lower elevation portion of the hammock (Maschinski et al. 2009) where one would expect storm surge inundation to be of greater depth and have longer residence time. Key deer frequent the hammock and are suspected to wound cactus when they engage in antler-polishing (Maschinski et al. 2008). These two factors are believed to be the primary cause of the steep decline of this population (Maschinski et al. 2009). A second population was also reported from Big Pine Key by Adams and Lima (1994) consisting of a single plant with numerous stems. This population was not found in subsequent surveys, and is probably extirpated.

Upper Matecumbe Key supports two populations (Adams and Lima 1994). One population is located on state land and is thought to represent a single genet (plant originating from seed) with numerous clonal stems (Adams and Lima 1994, Maschinski et al. 2009). The number of stems in this population increased from 14 to 29 between 1994 and 2007, but decreased to 21 as of 2009. The second population is on private land purchased by the Village of Islamorada and designated a nature preserve in 2009 (Maschinski et al. 2009). This population has declined in number of stems by 72 percent - from 10 plants (177 stems) in 1994 to 4 plants (50 stems) in 2009, and has been severely impacted by the recent decline episode (Maschinski et al. 2009).

Lower Matecumbe Key supports a single population of Key tree-cactus (Adams and Lima 1994, Maschinski et al. 2009). It is located on private land, but is protected under a conservation easement. However, a large house was recently built very close to the plants (FNAI 2009). This population has declined in number of stems by 26 percent - from 78 stems in 1994 to 58 in 2008.

Long Key supports three populations of Key tree-cactus (Adams and Lima 1994, Maschinski et al. 2009). Two are protected on state land. One of these declined from 10 plants (60 stems) in 1994 to 1 plant (13 stems) in 2009 (90 percent decline in plants, 78 percent decline in stems) (Maschinski et al. 2009). The second increased in number of stems by 388 percent, from one plant (16 stems) in 1994 to three plants (78 stems) in 2008 (Maschinski et al. 2009). The third population on Long Key is located on private property and is currently threatened by development (Maschinski et al 2008). This population has declined 99 percent from 814 stems in 1994 to 6 stems in 2006 (the number of plants was not reported in 2006) (S. Klett, pers. comm. 2006). The population has not been surveyed since 2006. As of 2009, the status of this population is unknown.

b. Genetics, genetic variation, or trends in genetic variation (*e.g.*, loss of genetic variation, genetic drift, inbreeding):

No genetic studies have been conducted on Key tree-cactus. Genetic analysis should be used to determine the remaining level of genetic diversity within and between populations. This may help clarify whether most of the historical dispersal has been vegetative or if it involved dispersed seeds (Maschinski et al. 2008). No other information is available regarding genetic variation, genetic drift, or inbreeding. Given an 80 percent decline in populations, it is probable that genetic diversity in the species has eroded considerably over the past 15 years.

c. Taxonomic classification or changes in nomenclature:

The taxonomy of Key tree-cactus is reviewed thoroughly in Adams and Lima (1994) and summarized in the MSRP (Service 1999). The taxonomy of *Pilosocereus* in the Keys has been historically confusing and is not yet clearly resolved. Most recently both *P. robinii* and *P. bahamensis* have been grouped into the more widespread species *Pilosocereus polygonus* (Lem.) Byles & G.D.Rowley (Zappi 1994, Anderson 2001). Botanists who are familiar with the Key tree-cactus have not adopted this taxonomy, and *P. polygonus* is not recognized by the Integrated Taxonomic Information System (ITIS) (ITIS 2010a). The Flora of North America (1993) also states that this treatment is not supported by existing data. The ITIS accepts *Pilosocereus robinii* (Lem.) Byles & Rowley as a valid taxon. Two varieties are recognized, *P. robinii* var. *deeringii* (Small) Kartesz & Gandhi and *P. robinii* var. *robinii* (Lem.) Byles & Rowley (ITIS 2010b). The taxonomic position of *Pilosocereus* populations in Cuba is uncertain (Adams and Lima 1994). The Service will defer any decision to adopt the revised taxonomic scheme until the ongoing difficulties with classification in this group of taxa are settled.

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):

A detailed discussion of the historic losses of Key tree-cactus populations is provided in the MSRP (Service 1999). A summary and updated information follows.

The Key tree-cactus has been known since at least the early 1800s and was first reported in Key West by Torrey & Gray (1838). The species occurs only in Monroe County, Florida. The distribution of Key tree-cactus has decreased over the past 200 years as the Florida Keys have been transformed by commercial and residential development (Service 1999). The historical range of Key tree-cactus included the entire expanse of the Florida Keys, from Key West to Key Largo (Adams and Lima 1994), encompassing an area of about

80 miles (128 kilometers [km]) east to west, and 30 miles (48 km) north to south. The current range is approximately 50 percent of that area – 40 miles (114 km) east to west, and 15 miles (24 km) north to south. Records exist for populations on Key West, Boca Chica Key, Big Pine Key, Long Key, Lower Matecumbe Key, Upper Matecumbe Key, Windley Key, and Key Largo (Adams and Lima 1994).

The number of islands now occupied by Key tree-cactus has been reduced by 50 percent. As of 2009, the distribution of this species is restricted to seven populations on four islands of the Florida Keys (Big Pine Key, Long Key, Lower Matecumbe Key, and Upper Matecumbe Key) (Adams and Lima 1994, Service 1999, Maschinski et al. 2009, FNAI 2009). Populations formerly found on Key West, Key Largo, Windley and Boca Chica keys, have been extirpated (Service 1999, FNAI 2009). It is reasonable to speculate that high mortality rates over the past 10 years have resulted in populations that are smaller in overall extent and have lower stem densities than in the past.

Key tree-cactus may occur at an unknown number of sites in coastal thicket habitats in the provinces of Matanzas and Habana, in Cuba. Unconfirmed (and outdated) reports suggest that its distribution in Cuba has been reduced to a single population at Varadero Beach on the Icacos peninsula, north of Matanzas (Adams 1997). As of 2009, the status of Key tree-cactus in Cuba is unknown. The Service should investigate the status of the species in Cuba.

e. Habitat or ecosystem conditions (*e.g.*, amount, distribution, and suitability of the habitat or ecosystem):

A detailed discussion of the habitat of the Key tree-cactus is provided in the MSRP (Service 1999). Important features are summarized below. The Key tree-cactus grows in a narrow range of plant associations, which include tropical hardwood hammocks and a thorn-scrub association known locally as a cactus hammock (Service 1999). Hardwood hammocks are mesic upland communities which are flooded only rarely (during major storms) (Service 1999). The thorn-scrub association occurs at relatively low elevations in the Keys and is prone to more frequent flooding. The Key tree-cactus found in the thorn-scrub association occur on relatively higher sites that are rarely flooded (Service 1999).

As early as 1917, the cactus was scarce and on the verge of extirpation as a result of habitat destruction (Small 1917). Development in the Florida Keys continued throughout the 20th century and habitat destruction lead to the listing of Key tree-cactus as endangered in 1984 under the ESA (Adams and Lima 1994, Service 1999). Since 1984, losses of Key tree-cactus populations and coastal hammock habitat to development have continued (Service 1999).

Data suggest that habitat suitability may be compromised at a number of Key tree-cactus sites due to increased soil salinity (Maschinski et al. 2009). Maschinski et al. (2008) found that cactus mortality was highest in areas of higher soil salinity. Soil salinity exceeding the physiological tolerance of Key tree-cactus may be the cause of the most recent mortality pulse. Higher salinity may have resulted from storm surges, saltwater intrusion, or both. Storm surges during tropical storms and hurricanes inundated areas where Key tree-cactus occurs on Big Pine and Long Keys (Maschinski et al. 2008). The impact of storm surges is exacerbated where ground and surface water systems are chronically impaired due to the influence of roads, subdivisions, and mosquito ditches (Maschinski et al. 2008). Impermeable structures may cause impoundment of seawater following surges and mosquito control ditches may provide more direct and linear route for storm surges to penetrate coastal hammocks. Maschinski et al. (2008) also found that soil salinity increased with depth at some sites, which may be indicative of persistent salinity in the groundwater.

There has been an ongoing, informal debate regarding canopy conditions that are most favorable to the Key tree-cactus. It has been stated that the habitat preferred by Key tree-cactus is primarily in disturbed patches of hammock where the hardwood canopy is less dense, allowing more light for Key tree-cactus (Service 1999). Adams and Lima (1994) observed more profuse flowering in cacti that were moderately shaded versus those with heavy shading. This has led some to postulate that hammock succession may lead to overgrown conditions that are not favorable to Key tree-cactus. Meanwhile, others have maintained that the species does not do well in full sun. However, there is no evidence to support either conclusion. Healthy populations in the Middle Keys grow under dense canopy cover compared with those in the lower keys, where the decline has been most severe. Historical photographs of large, healthy colonies document canopy cover that appears moderately open (30 to 50 percent canopy cover), and healthy plants are observed growing in full sun at some sites (Maschinski et al. 2008). As discussed above, flowering may be more profuse in more open-canopied sites (Adams and Lima 1994).

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

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

Habitat loss in the Florida Keys is detailed in the MSRP. The historic decline of Key tree-cactus was directly linked to the clearing of hardwood hammocks for development (Service 1999). Habitat destruction from development continues to occur and development pressure remains high; however, habitat loss currently occurs at substantially lower rates than in earlier periods (*e.g.*, 1970s to 1990s). Clearing of hammocks for development is currently a threat to one population which remains unprotected on private land. Six of seven Key tree-cactus populations are protected from habitat loss to development. Four are protected on public conservation lands and two are protected by covenant or easement on private property.

Development continues to fragment the remaining habitat, restricting gene flow between populations, and limiting the potential for expansion or shift in the species range in response to environmental changes.

The recent decline of Key tree-cactus populations reported since 2004 appears to be linked to habitat modification due to storm surges and SLR. Maschinski et al. (2009) linked relative soil salinity levels to Key tree-cactus mortality. Ross et al. (1994) documented the conversion of upland vegetation to transitional halophyte (salt tolerant) dominated vegetation in the Florida Keys due to salt-water intrusion. Rockland hardwood and thorn scrub hammocks are at elevation close to sea level and are vulnerable to changes in habitat brought about by SLR. It is likely the effects of salt-water intrusion and storm surges will continue and increasingly have negative impacts on Key tree-cactus and its habitat.

The drainage canal networks at some Key-tree cactus sites may increase inundation during storm surges because they provide a linear uninterrupted path for storm surges to penetrate hammocks. While one might suppose that these also facilitate drainage, Maschinski et al. (2008) reported that canals still contained brackish water for 16 months after a hurricane storm surge event.

b. Overutilization for commercial, recreational, scientific, or educational purposes:

The threat of overutilization for commercial or recreational purposes was identified at the time of original listing in 1984 (49 FR 29234). Key tree-cactus is an attractive species with high horticultural value as landscape ornamentals. Cacti are regarded as one of the groups of plants that are most vulnerable to illegal collection due to their popularity with collectors worldwide (Anderson 2001). Laws prohibit the removal of cacti from State and Federal protected areas, but enforcement is difficult due to insufficient resources and the the remoteness of the plants. There is recent evidence that the illegal trade in rare cacti includes Key tree-cactus. For example, a potted Key tree-cactus was sold across state lines on a well-known auction website in 2006 (Ebay 2006). The buyer subsequently surrendered this plant to Service law enforcement. Key tree-cactus is vulnerable to unlawful exploitation and collection and removal of plants from any of the protected areas for commercial or recreational reasons would be detrimental to the species. All sites with Key tree-cactus should be monitored for possible illegal collection activities.

c. Disease or predation:

There is no data to suggest that disease is the primary cause of the recent declines in Key tree-cactus populations. Tissue samples from several dying cacti were sent for analysis on more than one occasion. Results by Tropical Research & Education Center (TREC) of University of Florida – Institute of Food & Agricultural Sciences (UF-IFAS) (Aaron Palmateer; UF-IFAS, TREC Pathology Lab, Homestead) and Tim Schubert, (Florida Department of Agriculture and Consumer Services [FDACS], Pathology, Gainesville) in January and April 2005, respectively reported no primary pathogens. A second test was conducted by TREC in 2008 and again, no primary pathogens were detected (P. Hughes, unpubl. data 2006, Goodman et al. 2008).

Goodman et al. 2008 reported that a single cactus showed symptoms of basal rot that included 'black goo' leaking from the affected area. These are typical signs of bacterial necrosis in cacti. These bacteria are known to infect other large columnar cacti such as Saguaro (*Carnegiea gigantea*). Since this symptom has only been observed in one individual Key tree-cactus, evidence is insufficient to connect this observation to the range-wide decline phenomenon.

Goodman et al. (2008) observed that the surface of the soil just below the leaf litter at one site was entirely made up of frass from the introduced yellow-banded millipede (*Anadenobolus monilicornis*). While this organism is not known to be damaging to plants, they suggested that the predominance of frass could modify the soil structure or chemistry and possibly have an effect on plants.

The native ant species, *Crematogaster ashmeadi* and *Solenopsis abdita* were observed removing the pulp and seeds from still-attached fruits and carrying them to ground level. In addition, the pulp and seeds of split fruits that had fallen were similarly removed by these two ant species (Adams and Lima 1994). There is no evidence suggesting seed predation by ants is a threat to Key tree-cactus. Ants may actually aid in seed dispersal.

Hennessy and Habeck (1994) reported 'feeding damage' on plants in NKDR. Observed damage included complete girdling of woody trunks, uprooting, and chewing of stems. Maschinski et al. (2008) documented damage to cactus trunks at NKDR in which the fleshy tissue was removed down to the woody core of the plant. Damage occurred within 1.0 m of the ground and often on the exposed side of the plant that are more easily accessible to deer. Key deer are believed to damage Key tree-cactus through herbivory and antler polishing (Maschinski et al. 2008). Damage caused by herbivory or antler polishing by Key deer may weaken plants, making them more vulnerable to other stressors.

d. Inadequacy of existing regulatory mechanisms:

Key tree-cactus is listed as endangered by the State of Florida on the Regulated Plant Index (Florida Department of Agriculture and Consumer Services Rule 5B-40). This law regulates the taking, transport, and sale of listed plants. It does not prohibit private property owners from destroying populations of listed plants on their property nor require landowners to manage habitats to maintain populations. Existing Federal and State regulations prohibit the removal or destruction of listed plant species on public lands. However, such regulations afford no protection to listed plants on private lands. The ESA only protects populations from disturbances on Federal lands or when a 'Federal nexus' is involved for other lands, meaning any action that is authorized (e.g. permitted), funded or carried out by a Federal agency. In addition, State regulations are less stringent than Federal regulations toward land management practices that may adversely affect populations of listed plants on private land.

Monroe County has adopted a point system of evaluation for building permit applications. Building permit applicants are required to replace listed plants and native vegetation removed from the construction site elsewhere on the property. Monroe County requires mitigation for impacts to rare plant species, including Key tree-cactus. If Key tree-cactus is found on a property to be developed, the property owner would be required to pay a mitigation fee to the County prior to development. Clearing is limited to 10 to 30 percent in high quality habitat. A conservation easement may then be placed on the remaining native habitat. These protections are limited, and populations can be still destroyed by private landowners. As such, existing regulatory mechanisms are adequate to protect Key tree-cactus, with exception of the single remaining unprotected population on private land.

e. Other natural or manmade factors affecting its continued existence:

<u>Hurricanes</u>

Hurricanes have the potential to adversely affect tree-cactus populations. High winds can bring surrounding vegetation crashing down on top of individual cacti, injuring or killing them. However, hurricanes also open hammock canopies, allowing light to penetrate, thus providing conditions that may be favorable to cactus regeneration.

Hurricane Georges made landfall on Big Pine Key in October 1998 and caused severe damage to the tree-cactus population on the NKDR. Maschinski et al. (2008) provides accounts by several individuals describing dramatic impacts to the lower Keys hammocks after Hurricane Georges. Many of the larger cacti were directly damaged by high winds or injured by airborne debris.

A range of models suggest that due to global warming, future tropical cyclones (typhoons and hurricanes) will likely become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea-surface temperatures (IPCC 2007). The long-term impacts of hurricanes on tree-cactus are difficult to predict, but because the number of locations where Key tree-cactus occurs has been reduced, the potential threat of hurricanes is significant.

Storm Surges

Hurricanes also cause storm surges, which inundate Key tree-cactus habitat with seawater. Maschinski et al. (2008) provides a local residents account which confirms that the area of NKDR where the cactus occurs was completely inundated during the storm surge produced by Hurricane Wilma in 2005. In a hammock where a Key tree-cactus population has decreased by about 90 percent, a past storm surge is evidenced by 'wrack line' of debris at that site (Maschinski et al. 2008).

Storm surges during tropical storms and hurricanes have inundated areas where Key tree-cactus occurs on Big Pine and Long Keys (Maschinski et al. 2008). Storm surges can modify habitat by increasing soil salinity. Data suggest that high soil salinity may be the cause of the recent decline phenomenon in Key tree-cactus populations (Maschinski et al. 2009). The cause of the high salt levels is suspected to be salts deposited by storm surge events, from saltwater intrusion of groundwater, or both. Storm surges temporarily inundate large areas with seawater, which then drains off and percolates through the soil, leading to increased soil salinity.

Sea Level Rise (SLR)

The projected global average sea level in 2100 will be 0.18 to 0.59 m higher than the average reported from 1980 to 1999 (IPCC 2007). SLR predictions do not take into account the full contribution of melting ice sheets, because existing data are inadequate to quantify these inputs. As a result, the predictions may underestimate SLR (IPCC 2007). SLR is the largest climate-driven challenge to refuges and other lands in the sub-tropical ecoregion of southern Florida (CCSP 2008). According to CCSP (2008), much of low-lying, coastal south Florida "will be underwater or inundated with salt water in the coming century". SLR is expected to exacerbate inundation, storm surge, erosion and other coastal hazards. Small islands, low-lying coastal areas and coastal systems such as mangroves and salt marshes are identified as areas that will be especially affected (IPCC 2007).

TNC (2008) used high-resolution digital elevation models derived from highly accurate Light Detection and Ranging (LIDAR) remote sensing technology to predict future shorelines and distribution of habitat types for Big Pine Key based on SLR predictions ranging from the best-case to worst-case scenarios described in current scientific literature (IPCC 2007, TNC 2008). Readily available lower resolution digital elevation data was used to provide a preliminary assessment of SLR risk for the entire Florida Keys.

In the Florida Keys, the TNC models predicted that SLR will first result in the conversion of habitat, and eventually the complete inundation of habitat. Conversion of low-lying areas of Sugar-loaf Key from pine rockland to transitional halophyte-dominated vegetation has already been documented Ross et al. (1994). Keys vegetation types occupy distinct bands along an elevation gradient that is influenced by frequency of tidal inundation. The tidal zone, dominated by mangroves, is the lowest elevation and is continuously saturated by salt water. At slightly higher elevations, transitional habitats are dominated by salt-tolerant vegetation and at higher elevations grade into drier upland habitats dominated by pine forests and broadleaf hammocks. As sea level rises, shallow water displaces tidal habitat which moves upslope and in turn displaces transitional habitat which moves upslope and displaces upland habitat (TNC 2008).

All scenarios modeled for Big Pine Key by TNC (2008) result in a smaller island as tidal habitat marches inland, upland habitats gradually shift toward more salt tolerant vegetation, and are ultimately inundated. In the ‘best-case’ scenario, a rise of 18 centimeters (cm) results in 34 percent of Big Pine’s upland habitats being inundated by 2100. In the ‘worst-case’ scenario, a rise of +140 cm results in 96 percent of Big Pine’s upland habitats being inundated by 2100, with tidal areas occupying the remaining four percent and all transitional and upland habitats having been totally displaced. The Key tree-cactus site on Big Pine Key is an area of raised elevation and remains as dry land under best-case to moderate-case scenarios. Under the worst-case scenario most of the area where Key tree-cactus currently occurs will be inundated by 2100.

While habitat may be only partially inundated by 2100 in the scenarios modeled by TNC (2008), it is likely that under any scenario, soil salinity will continue to increase, either by pulses as with successive storm surges, or incrementally due to saltwater intrusion. The Service anticipates that these processes will act separately or synergistically to cause ongoing mortality pulses of Key tree-cactus and eventually result in the conversion of their existing coastal hammock to transitional habitats and then tidal areas dominated by mangroves.

D. Synthesis

The Key tree-cactus is restricted to seven populations on only four islands of the Florida Keys (Big Pine Key, Long Key, Lower Matecumbe Key, and Upper Matecumbe Key) (Maschinski et al. 2009, Service 1999, Florida Natural Areas Inventory 2009). Six of seven known populations have some level of protection - one on Federal land, three in state parks, and two on private lands. One population on private land has no protection and could be destroyed at any time by development.

Habitat destruction accounts for the historic loss of Key tree-cactus populations. More recently, a widespread precipitous decline began affecting populations of Key tree-cactus. From 1994 to 2009, Key tree-cactus has experienced an overall loss of approximately 80 percent of all plants, and 90 percent of all stems (Adams and Lima 1994, S. Klett, pers. comm. 2006, Maschinski et al. 2009). The population at NKDR on Big Pine Key, once the largest, has experienced a 94 percent decline. Between 2006 and 2009, five populations have declined, and two appear stable. Viable seed are still produced by wild plants at multiple sites, but seedlings of Key tree-cactus have rarely, if ever, been documented in the wild since 1994. As of July 2009, there were approximately 260 plants spread across the seven populations (Maschinski et al. 2009).

Dying Key tree-cacti turn yellow and then rot from the base upward until plants eventually fall over. Tissue samples sent to two different plant pathology labs failed to reveal anything except secondary pathogens. Maschinski et al. (2008) found that cactus mortality was highest in areas of higher soil salinity, which may have resulted from storm surges, saltwater intrusion, or both. Storm surges temporarily inundate large areas with seawater, which then drains off and percolates through the soil, leading to increased soil salinity. The current working hypothesis is that increased soil salinity coupled with stressors from physical damage most likely caused by mammalian herbivory and antler polishing by Key deer have caused the decline. However, further research is needed to test this hypothesis. By 2008, there was some evidence that the rate of decline may be decreasing. Continued annual monitoring will be important in determining if the decline trend is continuing or if the populations are becoming stable.

SLR threatens to first modify and then eliminate the habitat of Key tree-cactus over the next 100 years (TNC 2008; Ross et al. 2009). Documented habitat changes toward halophyte dominated plant communities suggest that SLR may have already begun to modify habitats in the Florida Keys. Given the IPCC (2007) prediction for SLR over the next century, it is likely the effects of salt-water intrusion will continue and will increasingly have negative impacts on Key tree-cactus and its habitat.

None of the recovery criteria for reclassification have been fully achieved to date. In particular, one of seven remaining occurrences currently has no protection, because it is located on private land. Native and non-native nuisance species have not been reduced by 80 percent, and no potential habitat on protected lands has been restored or rehabilitated for the Key tree-cactus. Populations are not distributed on secure sites across its historic range, greater than half continue to decline, and sexual reproduction has not been observed in decades. Finally, no additional, stable populations have been established through translocation. For these reasons, Key tree-cactus continues to meet the definition of endangered under the ESA.

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

B. New Recovery Priority Number _N/A_

IV. RECOMMENDATIONS FOR FUTURE

- Continue to acquire privately owned parcels when there are willing sellers.
- Experiment with plant enclosures at NKDR to prevent potential damage to the plants by Key deer.
- Continue to monitor mature individuals for flowering/fruiting and collect seed if found.
- Continue and increase monitoring for signs of disease.
- Attempt to increase seed set through hand pollination in selected plants to equalize representation in stock available for reintroduction projects.
- Maintain an aggressive program to salvage representative samples from dying cacti.
- Continue to monitor extant populations to confirm whether the rapidly declining populations have truly stabilized after 2007.
- Initiate genetic assessments to determine the genetic structure of the species at a range of spatial scales (clusters, populations, and species). Include the *P. bahamensis* population on Key Largo, and *Pilosocereus* in Cuba to determine the identity of these populations and relationship to *P. robinii*.
- Expand *ex situ* collections via cuttings from earlier collections and from seeds. Complete studies of soil to further test hypothesis that soil salinity is the main cause of the population decline.
- Conduct a greenhouse experiment to determine the range of salinity tolerance of Key tree-cactus.
- Determine the importance of specific elements and conditions that contribute to increased soil salinity – saltwater intrusion, storm surges, elevation, and drainage patterns.
- Continue to monitor soil salinity at all sites to provide early detection of rising salinity or evidence of declining salinity.
- Expand the scoring and evaluation of potential reintroduction sites.
- Develop an Emergency Response Plan for hurricanes and storm surges.
- Provide the Village of Islamorada ongoing technical support regarding cactus and site management in the newly acquired parcel.
- Reintroduce cactus in multiple, well dispersed sites, including those with raised elevation in the Lower Keys (*e.g.*, NKDR; Key West Tropical Forest and Botanical Garden), and representing a range of percent canopy cover.

Table 1. Summary of extant population of Key tree-cactus (1994 baseline data from Adams and Lima 1994, 2006 data from S. Klett, pers. comm. 2006, 2007-2009 survey data from Maschinski et al. 2009, corrected numbers from D. Powell, pers. comm. 2009). “NS” indicates that the population was not surveyed (for plants, stems, or dying stems) in the years indicated.

Population	**Plants**		**Stems**					**Dying Stems**		
	1994	**2007**	**1994**	**2006**	**2007**	**2008**	**2009**	**2007**	**2008**	**2009**
1	564	53	2200	NS	56	48	33	18	1	5
2	1	4	16	NS	78	78	NS	0	0	NS
3	10	1	60	NS	13	13	13	0	0	0
4	29	NS	814	6	NS	NS	NS	NS	NS	NS
5	8	55	78	NS	62	58	NS	1	2	NS
6	10	4	177	NS	86	NS	50	1	NS	2
7	1	1	14	NS	25	22	21	0	1	0
Total	**623**	**118**	**3359**	**6**	**320**	**219**	**117**	**20**	**4**	**7**

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF KEY TREE-CACTUS (*Pilosocereus robinii*)

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 David Bender, Botanist

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ____________________ Date 4/1/2010

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 8-27-10

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.

Summary of peer review for the 5-year review of the Key tree-cactus (*Pilosocereus robinii*)

A. Peer Review Method: Three peer reviewers were selected by the Service. Individual responses were requested and received from all three peer reviewers.

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments/Report: In general, the reviewers felt the five-year review was comprehensive, well-written, and that assertions were adequately supported by the cited literature.

A reviewer stated that research should be conducted on habitat preference in regard to canopy closure to resolve the debate over the ideal degree of canopy cover for Key tree-cactus populations. They also stated that hand pollination should be attempted to increase seed set and recommended genetic studies to reveal any genetic structure in the populations.

A second reviewer had no comments, but provided a reintroduction proposal that was not on file at SFESO and had not been identified in the Status Review.

A third reviewer provided numerous recommendations for future actions, including genetic studies, increasing *ex situ* holdings, re-introduction to historic sites and assisted migration to novel sites. The reviewer also felt that because the "future of this species in the wild is extremely bleak…an organized and controlled effort should be made to introduce this species widely into the horticulture trade in south Florida."

D. Response to Peer Review:
In response to the reviewer who recommended research on genetic structure of populations and the ideal degree of canopy cover for Key tree-cactus, the Service agrees. Genetic studies were previously identified in the Recommendations for Future Actions section of the Status Review. The Service added canopy closure research to the Recommendations section of the Status Review.

Based on the second reviewers input, the Service added details about specific reintroduction projects that are currently in the planning stage.

The Service agrees with most the future actions recommended by the third reviewer and those were already included in the Recommendations section of the review or in the MSRP. The Service remains cautious regarding the idea of promoting Key tree-cactus in the horticultural trade. The purpose of the ESA is to prevent extinction and promote recovery of species in the wild. Key tree-cactus is already reasonably secure from absolute extinction because the species is well represented in multiple botanical gardens across the United States. Moreover, increased interest in the species would likely increase the risk of illegal collecting of wild specimens. Botanical Gardens are currently working with the Service to increase number and genetic representation of *ex situ* holdings. As to introduction to novel sites (taken as sites outside the species historic range), the Service regards this as an action of last resort. *Ex situ* measures ensure that material will be available to facilitate alternate conservation strategies in the future, if the species becomes extinct in the wild due to habitat loss or modification due to SLR.

Guidance for Peer Reviewers of Five-Year Status Reviews

U.S. Fish and Wildlife Service, South Florida Ecological Services Office

March 27, 2009

As a peer reviewer, you are asked to adhere to the following guidance to ensure your review complies with U.S. Fish and Wildlife Service (Service) policy.

Peer reviewers should:

1. Review all materials provided by the Service.

2. Identify, review, and provide other relevant data apparently not used by the Service.

3. 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 that potential implications of uncertainties for the technical conclusions drawn are clear.
   - Strengths and limitation of the overall product.

5. Keep in mind the requirement that the Service must use the best available scientific data in determining the species' status. This does not mean the Service must have statistically significant data on population trends or data from all known populations.

All peer reviews and comments will be public documents and portions may be incorporated verbatim into the Service's final decision document with appropriate credit given to the author of the review.

Questions regarding this guidance, the peer review process, or other aspects of the Service's recovery planning process should be referred to Dana Hartley, Endangered Species Supervisor, South Florida Ecological Services Office, at 772-562-3909, extension 236, email: Dana_Hartley@fws.gov.