Key deer
(Odocoileus virginianus clavium)

5-Year Review:
Summary and Evaluation

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

5-Year Review
Key deer (*Odocoileus virginianus clavium*)

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 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. A *Federal Register* notice announcing the review and requesting information was published on June 21, 2005 (70 FR 35689). All recommendations resulting from this review are a result of thoroughly reviewing the best available information on the Key deer. Comments and suggestions regarding the review were received from peer reviews from outside the U.S. Fish and Wildlife Service (Service) (see Appendix A). No part of the review was contracted to an outside party. Comments received were evaluated and incorporated as appropriate.

B. Reviewers
Lead Region: Southeast Region, Kelly Bibb, (404) 679-7132
Lead Field Office: South Florida Ecological Services Office, Phillip Hughes, (305) 872-2753 and Dana Hartley (772) 562-3909.

C. Background

1. FR Notice citation announcing initiation of this review: June 21, 2005 (70 FR 35689)

2. Species status: Stable, 2009 Recovery Data Call. The status is stable based on a lack of significant change in annual trend indices and threats. The abundance index for the last year is below that for the previous year, although not significantly. Because it constitutes a single data point and the difference from the previous year is not substantial, the lower index value over the last year does not confirm a decline, and is consistent with annual (single-year) variation. Given that threat factors have continued at the same level and no decline is evident, the status over the past year is stable.

3. Recovery achieved: 4 (76-100 percent recovery objectives achieved)

4. Listing history
Original Listing
FR notice: 32 FR 4001
Date listed: March 11, 1967
Entity listed: Subspecies
Classification: Endangered

5. Associated rulemakings: Not applicable

6. Review History:

May 21, 1979 (44 FR29566) Review of species listed prior to 1975
July 22, 1985 (50 FR 29901) 5-year review for species listed before 1976 and in 1979 and 1980
November 6, 1991 (50 FR 56882) 5-year review of listed species
Final Recovery Plan: 1999
Recovery Data Call: 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, and 2009

No changes were recommended to the status of the Key deer in the 5-year reviews.

7. Species' Recovery Priority Number at start of review (48 FR 43098): 6c. This designation indicates that the subspecies is subject to a high degree of threat, has a low recovery potential, and its protection may conflict with development or some other economic interest.

8. Recovery Plan
Name of plan: South Florida Multi-Species Recovery Plan (MSRP)
Date issued: May 18, 1999
Dates of previous revisions:
First revision approved June 19, 1985
Original plan approved June 10, 1980;

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? The South Florida MSRP (Service 1999) is the final, approved recovery plan for the Key deer. Six criteria are presented for reclassifying the Key deer from Endangered to Threatened, but only one of these, criterion six, is objective and measurable.

2. Adequacy of recovery criteria.

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

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider

regarding existing or new threats)? Yes, however there is new information on the continuation and increase in rate of sea-level rise which is predicted to result in the permanent loss of 59,000 to 154,000 acres (ac) (23,877 to 62,322 hectares [ha]) in the Keys within the next century (Rahmstrof 2007, The Nature Conservancy [TNC] 2009).

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

The MSRP identifies six criteria for the reclassification of Key deer from endangered to threatened.

1. Further loss, fragmentation, or degradation of suitable, occupied habitat in the Lower Keys has been prevented;

   This criterion has not been met. Habitat destruction due to 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 1980s).

   Geography and hydrology strongly influence urban development patterns as well as the distribution and abundance of Key deer. The historical range of the Key deer in the lower Keys includes a linear array of the mainline keys (a sequence of larger islands which are connected by U.S. 1), and many of the smaller, adjacent keys (outer keys), which have freshwater, at least seasonally (Barbour and Allen 1922, Dickson 1955, Hardin et al. 1984). Eleven subpopulations of Key deer are divided into three geographic categories: (1) two core subpopulations on mainline keys, (2) four non–core subpopulations on the mainline keys, and (3) five non–core subpopulations on the outer keys. The mainline keys, which include 88 percent of the land area, support most of the habitat as well as most of the deer (Lopez 2001, Harveson et al. 2007). However, the mainline keys also contain the majority of the human population, development, and anthropogenic threats to deer.

   Although increased availability of edge habitat due to development and urbanization may provide some benefits to deer (Walters 2001), habitat fragmentation as a result of fencing may also hinder movement and access to potential habitats (Folk et al. 1991, Folk 1992), and in certain areas such effects may be exacerbated due to the presence of roads (Folk et al. 1990, Lopez 2001). Habitat degradation, particularly around residential settings, is a continuing threat due to invasive exotic plants (IEP) and changes in deer behavior and habitat use (Folk and Klimstra 1991b, Lopez et al. 2003a, Klimstra et al. 1974, Folk 1992, Lopez et al. 2004b). Habitat alteration associated with excessive browsing by locally overabundant deer is a growing concern within the core (Barrett et al. 2006).

Freshwater resources, naturally limited in the Keys, have been eliminated or degraded due to development. Additionally, roads, subdivisions, and other developments have disrupted the natural ebb and flow of sloughs and other surface and ground water systems (Folk 1992). The distribution and persistence of freshwater strongly influences the distribution of Key deer (Folk 1992, Folk et al. 1991). The occurrence of perennial water holes is important to each subpopulation because they provide freshwater during the dry season, allowing for year-round residency. Loss of water holes has a widespread, long-term, detrimental impact to deer, particularly outside the core.

Overall, habitat loss, degradation, and fragmentation, including loss and degradation of freshwater sources due to development, remain a threat to the species.

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

   This criterion appears to have been met. Although the magnitude of this threat to deer is low, it is expected to be ongoing. IEPs such as Australian pine (*Casuarina equisetifolia)*, Brazilian pepper (*Schinus terebinthifolius*), and leatherleaf fern (*Colubrina asiatica*) occur on islands throughout the range of the deer. These non-native species can out-compete native vegetation in large areas, reducing the availability of deer forage and degrading deer habitat.

   The Service conducts an IEP control program on National Key Deer Refuge (NKDR) and on State and County lands managed by NKDR staff. The Florida Keys Invasive Exotics Task Force (Task Force), a broad coalition of at least 22 municipal, County, State, and Federal agencies, as well as electrical utility providers, environmental organizations, and other partners (Meyers-Rice and Tu 2001) and TNC conduct complementary programs on other public and private lands. As of 2001, NKDR staff estimated that IEPs had been reduced by 80 percent on public conservation lands (Frank 2001). The Service, TNC, and Task Force have attained further control in subsequent years throughout the deer's range.

3. All suitable, occupied habitat on priority acquisition lists for the Lower Keys is protected either through land acquisition or cooperative agreements;

   Substantial progress has been made towards meeting this criterion. Although roughly 71 percent of potential deer habitat has been acquired for conservation purposes, a sizeable portion (29 percent) remains at risk to development (Service 2006b). A growing concern is the reduced purchasing power of acquisition funds available for the State's Florida Forever Program and the amounts available for allocation in the Keys (TNC 2006). Development pressures, inflation, and rising costs of land may outpace this and other ongoing conservation efforts. Monroe County, Florida Department of Transportation (FDOT), and Florida Department of Community Affairs (FDCA) developed a Habitat Conservation Plan (HCP) for Big Pine Key (BPK) and No Name Key (NNK) (Monroe County et al. 2006). The plan limits developments that may occur within the core between 1994 and 2023, and defines compensations for impacts that will result. The HCP specifies that habitat loss will be compensated at a three to one ratio. The HCP is anticipated to result in the acquisition of approximately 504 ac (204 ha) over 20 years, increasing the area of conservation lands within the core from 69 percent to approximately 77 percent. Rangewide, the portion would increase from 71 percent to approximately 72 percent. Habitat conservation efforts should continue to focus on maintaining the quantity, quality, and spatial extent of habitat and work towards increasing the amount of protected habitat. Further loss of habitat within the core will continue to threaten the potential for recovery of the Key deer.

4. Key deer habitat is managed, restored, or rehabilitated on protected lands;

   Much of the deer's range is in public ownership but continued commitments and expanded efforts from agencies and stakeholders are needed to effectively implement conservation actions on these public lands. Habitat maintenance and restoration on conservation lands are critical components for long-term viability of Key deer. However, the ability to manage ecosystem processes effectively may be partially limited by available resources (e.g., funding, staffing) and other constraints (e.g., land ownership patterns, knowledge of best management practices).

5. Stable populations of Key deer are distributed throughout its historic range;

   The current range of the Key deer extends from the Johnson Keys to Sugarloaf Key. Areas on the periphery of the historical range, which include the Cities of Marathon and Key West, are heavily urbanized and no longer support deer.

   Freshwater availability appears to be the primary determinant of Key deer distribution (Jacobson 1974, Klimstra et al. 1974, Silvy 1975, Folk et al. 1991, Folk 1992). In the lower Keys, only some of the larger keys contain freshwater aquifers. In these areas, freshwater occurs in lenses that float on top of denser, saline ground water in the aquifer. The source of the freshwater is rainwater and recharge is largely restricted to the wet season (summer months). Recharge results from rainwater that pools in basins within uplands (particularly in pine rockland) and then drains into the aquifer through solution holes and sink holes. Only about 20 percent of rainwater serves as recharge for freshwater lenses, most washes out to sea (U.S. Army Corps of Engineers and South Florida Water Management District 2006). Where lenses do not occur, all freshwater other than from anthropogenic sources is ephemeral and dependent upon the temporary capture of rainwater in local basins. Many of the smaller keys, and major portions of larger keys, only hold rainwater for periods of several days (Klimstra et al. 1974, Klimstra 1985). Freshwater resources have been eliminated or degraded due to development. Additionally, roads, subdivisions, and other developments have disrupted the natural ebb and flow of sloughs and other surface and ground water systems (Folk 1992). The construction of canals and mosquito ditches have led to salt-water intrusion in some areas. Sea-level rise as well as the potential of catastrophic storm surges also increases the risk of salt-water intrusion into freshwater sources. Impacts to freshwater resources are continuing to affect suitable habitat and therefore distribution and range of Key deer.

6. Two additional stable populations have been established along the periphery of the historic range of the Key deer. These populations will be considered demographically stable when they exhibit a stable age structure and have a rate of increase equal to or greater than 0.0 as a 7-year running average for 14 years.

   Key deer have been translocated to Sugarloaf and Cudjoe Keys to establish viable subpopulations there. These efforts appear to have been successful, but results have not been observed for sufficient time to draw conclusions regarding long-term viability.

   From May 2003 to late 2005, 39 deer were moved from BPK and NNK to Cudjoe and Sugarloaf Keys to augment these subpopulations. Only two of the translocated deer left the island to which they were moved within 1 year of release. More than 30 deer were established as of 2005 (Watts 2006). Post-release monitoring was conducted through May 2006. Survival of translocated deer was similar (females) or higher (males) than for deer residing in the core. Of 13 marked females subsequently detected with cameras and visual observations, approximately 62 percent had fawns or showed signs of lactation. At least 11 weaned fawns and one unmarked yearling were observed (Parker 2006, Parker et al. 2008). While investigating deer in subpopulations outside the core, researchers in 2008 observed ongoing reproduction and apparent population growth beyond that of previous years (L. Soliz, Texas A&M University (TAMU), personal communication 2008).

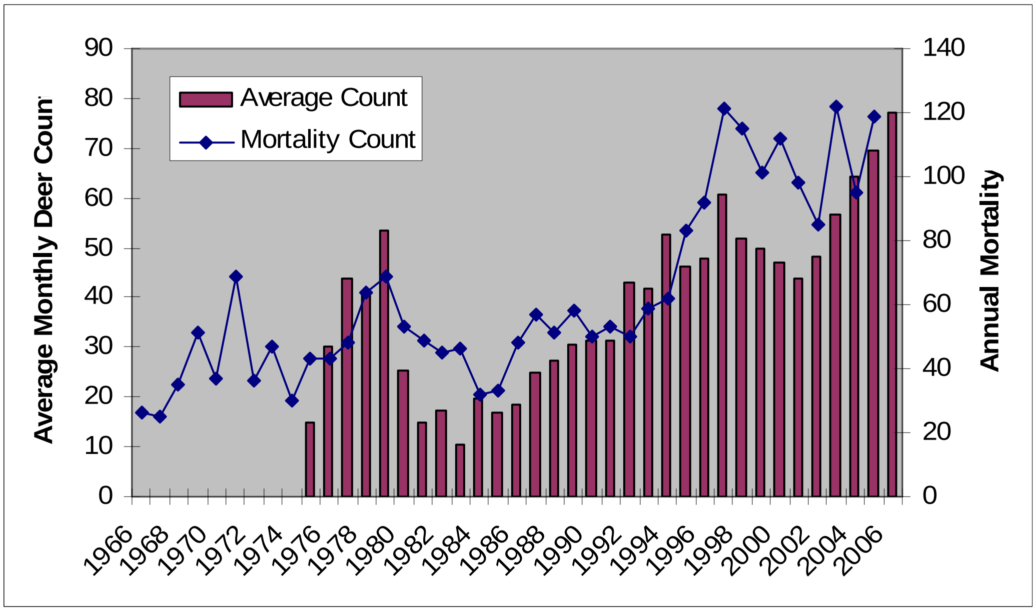
C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends, demographic features, or demographic trends: Harveson et al. (2007) provided estimates of deer abundance from 2000 to 2001 for each of the 11 island complexes which together constitute the entire current range of the Key deer. The 11 island complexes (each containing one or more keys) are equivalent to the 11 Key deer subpopulations which function as a metapopulation. The 11 subpopulations of Key deer are divided into three geographic categories: (1) core subpopulations on mainline keys (n = 2), (2) non–core subpopulations on mainline keys (n = 4), and (3) non–core subpopulations on outer keys (n = 5). For the 11 complexes, abundance estimates were: BPK 406, Torches / Ramrod 94, Sugarloaf 6, Cudjoe 6, Knockemdown / Summerland 8, NNK 78, Little Pine 16, Howe 16, Annette 6, Big Johnson 0, and Newfound Harbor 10 (total = 646). Estimates for subpopulations other than BPK and NNK are considered preliminary and confidence intervals were not provided. By 2001, deer may have occupied all available habitat on BPK, NNK, and Newfound Harbor (Nettles et al. 2002, Lopez et al. 2004a, Harveson et al. 2007). In other subpopulations, deer numbers were estimated to remain well below the carrying capacity of the habitat available to them (Harveson et al. 2007).

The BPK and NNK subpopulations together constitute the core of the Key deer metapopulation. Demographic data have only been estimated for the metapopulation core. Key deer numbers on BPK and NNK in 2000 revealed a 240 percent increase since 1971, a population growth rate of about 5 percent annually (Lopez 2001, Lopez et al. 2004a, Harveson et al. 2007). Deer abundance is concentrated in the core. BPK and NNK combined contain close to three-quarters of the entire metapopulation (BPK alone contains nearly two-thirds) (Lopez 2001, Lopez et al. 2004). The Service and collaborators continue to acquire annual mortality (1966 to 2006) and population (1975 to 2006) trend data for the core (Figure 1; Service 2006a). These data indicate that population growth has been sustained despite increasing annual mortality (Lopez et al. 2004a). Annual mortality on BPK predominantly from deer-vehicle collisions (DVCs), increased in close correlation with population growth from 1976 to 2001 (Lopez et al. 2004a).

Figure 1. Annual average of monthly road counts from the Service survey route on BPK and NNK. Total annual count of all known mortalities is also shown.



As illustrated in Figure 1, annual mortality continues to increase and DVCs continue to be the primary source of mortality. DVCs accounted for approximately 50 percent of all known mortality from 1968 to 1972 and from 1998 to 2000 (Lopez et al. 2003c). However, there were increased mortalities due to entanglement (predominantly in fences; from 0.0 percent in the earlier period to 7.9 percent in the later period) and diseases (from 0.0 to 5.3 percent, respectively). In contrast, the proportion of mortalities attributed to drowning decreased between sample periods (from 9.6 to 2.6 percent, respectively).

Lopez et al. (2003c) estimated mean lifespan of deer on BPK to be 6.5 years in females and 2.9 years in males (maxima 19 and 12 years, respectively) based on data from 1966 to 2000 (35 females, 43 males). Peterson et al. (2003) modeled fetal sex ratios in Key deer. They concluded that 1.45 males to 1.00 female was likely the most accurate of several estimated and hypothetical fetal sex ratios reported in the Key deer literature. However, survival of yearling and adult males is significantly lower than that of females. Accordingly, in yearlings and adults, the sex ratio is female-skewed, with about two females to one male observed on road count surveys (Lopez 2001, Lopez et al. 2003c).

Lopez (2001) proposed that the population response of Key deer to urban development may be characterized like a bell-shaped curve. Deer responded positively to a level of increased development. Beyond certain limits, however, irreparable population decline and habitat loss may result from further development (Lopez 2001, Lopez et al. 2004a, Harveson et al. 2007).

Harveson et al. (2004) illustrated that, as among different subpopulations, trends have also diverged between different portions of the BPK subpopulation. Habitat in the northern and southern portions of BPK differs in quantity and quality (Harveson et al. 2004). Survival was higher in the northern portion of BPK which is less urbanized (less fragmentation, roads, and IEPs). Mortality due to DVCs is higher in the southern portion of BPK. Northern BPK was a source for the deer population as of 2000, while southern BPK was a sink. Similarly, Lopez et al. (2003c) found that annual survival was highest on NNK, intermediate on northern BPK, and lowest on southern BPK. Among the areas, mortality increased in that respective order, as did risks associated with urban landscape factors (highway length, road length, fenced area, and developed land) (Lopez et al. 2003a). These findings are consistent with Lopez's (2001) model of Key deer abundance as a function of urban development.

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding): Peterson et al. (2005) proposed that increasing Key deer-human interaction is leading toward artificial selection. They found that deer density and group size was significantly higher in the vicinity of houses where deer were illegally fed and watered than in randomly selected areas. They hypothesized that "anthropogenic forces are beginning to control selective pressures for Key deer." Specifically, increased tolerance to intra-specific aggregation as well as human contact leads to deer circumventing natural selective pressures associated with attaining natural foods and fresh water. Availability of fresh water was likely the primary selective pressure prior to human settlement in the Keys and watering has altered the importance of historical selection pressures.

Human-habituated deer are increasing and exhibit high survival and reproductive rates in the absence of natural selection pressures. Accordingly, increasing survivorship and numbers of habituated deer may have genetic impacts. Peterson et al. (2005) asserted that a disproportionate amount of fawn recruitment occurs in illegal feeding and watering areas because the sex ratio is strongly female-biased in those areas. These deer have small home ranges and high site fidelity which likely contributes to increased survival because such deer are relatively unlikely to wander and collide with vehicles. Many such urban deer are isolated (in residential areas) from U.S. 1 where most mortality occurs.

Increased human populations and development did not result directly in the demographic and behavioral shifts described above. Outside of illegal feeding and watering areas, group size observed by Peterson et al. (2005) from 1998 to 2002 was not significantly larger than group size from1968 to1973, when human populations and development were lower. Instead, the authors suggest that the shifts are driven by increased habituation to the human environment in areas where feeding and watering occurs. Increased habituation of the overall population was thus associated with increased numbers of people that persistently feed, water, and interact with deer. The authors propose that these relatively few households (where illegal feeding and watering occur) exert a dramatic influence on the deer population, which is driving habituation.

c. Taxonomic classification or changes in nomenclature: Not applicable.

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): The range of the Key deer in 2006 was estimated to encompass 24,676 ac (9,986 ha). Similarly, Lopez (2001) estimated it to be 24,305 ac (9,836 ha) in 2000. The metapopulation core, containing three-fourths of the deer, encompasses approximately 7,166 of those ac (2,900 ha) (Hobgood 2006). BPK is the largest key within the range, and contains the most high quality habitat (upland) and fresh water (Lopez 2001, Harveson et al. 2007). The current range of the Key deer extends from the Johnson Keys to Sugarloaf Key. Areas on the periphery of the historical range, which included the Cities of Marathon and Key West, are heavily urbanized and no longer support deer.

Harveson et al. (2006), focusing on dispersal rates, simulated growth of each deer subpopulation projected for 20 years. Emigrants were assumed to first augment subpopulations on islands nearest to the core and sequentially advance in a stepping stone fashion to more distant islands as population growth and further emigration gradually progressed. According to their model, the more distant keys would still have unoccupied suitable habitat for more than 20 years, even though population growth was assumed to continue in and near the core. Due to the distance from BPK and low rates of dispersal, they estimated that the Cudjoe, Sugarloaf, and Knockemdown / Summerland subpopulations would be slow to increase.

The Service conducted a 3-year translocation program starting in May 2003, to establish viable populations on Cudjoe and Sugarloaf Keys. These keys are on the western periphery of the range, farthest from the core (i.e., farthest from the source subpopulation), and most likely last to receive immigrants from the core or from keys in between. Within the 3-year period (2003 to 2005), 39 deer were moved from the core. As of May 2006, 35 deer were established and reproduction had occurred on both keys.

The Annette, Howe, Big Johnson, Little Pine, and Newfound Harbor subpopulations are on smaller keys detached from the mainline keys (sequence of large keys, which are connected by U.S. 1) and their roads. Unlike any of the mainline keys, the Annette, Howe, Big Johnson, and Little Pine are entirely in public ownership by the Service's NKDR. However, these island areas are relatively small and hold neither a large portion of the deer metapopulation nor a large amount of habitat (Lopez 2001, Harveson et al. 2007). Nonetheless, these subpopulations account for a geographically significant portion of the Key deer's range.

e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem): Although Key deer use all available cover to some degree, they tend to select upland cover types and avoid lowland cover types (Silvy 1975, Lopez 2001, Lopez et al. 2004b). Silvy (1975) found deer use of pine rockland and hardwood hammock to be greater than expected based on availability, expected use of developed land, and limited use of mangrove and buttonwood areas in their home ranges. The species-rich pine rockland and hammock habitat types provide Key deer with food, water, and cover (Klimstra et al. 1974, Silvy 1975, Klimstra and Dooley 1990, Folk 1992, Carlson et al. 1993). Many (30 to 50 percent) of the most important forage plant species are found only in pine rockland and hammock (Klimstra and Dooley 1990, Folk 1992). While these cover types comprise only about 22 percent of the range, approximately 58 percent of freshwater sources (e.g., waterholes, marshes, pine wetlands) occur within them (Lopez 2001). Approximately 85 percent of fawning occurs in hammock and pine rockland (Hardin 1974), which provide important cover for resting and bedding (Silvy 1975, Folk 1992).

The metapopulation core is characterized by having relatively large portions of land area in high quality habitat (uplands with fresh water sources nearby; 42 percent in 2000) (Lopez 2001) or developed (14.2 percent in 2005) (Hobgood 2006). In contrast, outside of the metapopulation core, only about five percent of the deer's range is developed (Hobgood 2006). However, keys outside the core contain relatively little high quality (upland) habitat (19 percent) or fresh water resources (Lopez 2001).

f. Other: On BPK and NNK, Lopez et al. (2005) found that home range size of adult deer was approximately two times larger in the period from 1968 to1972 than during 1998 to 2002. Peterson (2003) analyzed home range size and survival in Key deer fawns through the age of six months (a fawn's range is a subset of the mother's range). Fawn ranges (95 percent probability area) also declined, from 334 ac (135 ha) from 1968 to 1972 to 74 ac (30 ha) from1998 to 2002. However, survival increased from 0.47 to 0.96. The area of developed land increased about 24 percent and the human population increased nearly 10-fold, yet Key deer numbers increased approximately 240 percent during this period. Peterson (2003) concluded that the positive relationship between survival and development was not sustainable because once an (unknown) development threshold was reached; further reduction in range size would preclude deer from accessing enough resources for sustenance.

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

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

Fragmentation—Connectivity of the southern end of BPK with the rest of the island has been threatened due to the U.S. 1 corridor. Any division of BPK would result in a reduction in the subpopulation size. In 2003, the FDOT constructed deer-proof fencing along a 1.6 mile (2.6 kilometer) segment of the highway, with underpasses to allow for safe passage under U.S. 1. Braden (2005) found that DVCs had been reduced 83 to 93 percent inside the fenced area. He also found that deer movements were not restricted by the U.S. 1 improvements. However, considering the entire length of the U.S. 1 corridor on BPK (including the unfenced portion), overall DVCs did not change.

Folk (1992) described threats resulting from fencing, including habitat fragmentation, habitat loss, and risk of entanglement. Lopez (2001) found that 30 percent of the developed areas (230 ac [93 ha]) on BPK and NNK had been completely fenced and unavailable for use as habitat for deer. This equates to more than three percent of the area within the core. Increased fencing results in further fragmentation of habitat and alteration of deer ranges and movement and in certain areas such effects may be exacerbated due to the presence of roads (Folk et al. 1990, Lopez 2001).

Development—Habitat destruction due to development continues to occur, though at low rates (as in the preceding decade, but in contrast to the 1970s and 1980s). Human population size estimates offer a rough index of development. The U.S. Census Bureau (2006a, 2006b) estimated that the size of the human population in Monroe County actually decreased annually between 2000 (79,589) and 2005 (76,329), a change of -4.1 percent. During the same period, the cost of housing in Monroe County increased substantially. Tourism and seasonal occupancy have not declined. However, within the range of the Key deer, this population segment appears to have largely relied upon existing commercial and rental homes in recent years.

The State's Florida Forever program continues to acquire parcels for conservation within the range of the Key deer annually. Through 2005, 1,726 ac (698 ha) out of 2,830 ac (1,145 ha) targeted for acquisition within the Coupon Bight / Key deer project, and 5,175 ac (2,094 ha) out of 11,854 ac (4,797 ha) within the Florida Keys Ecosystem project had been acquired (Florida Department of Environmental Protection 2006). The NKDR manages those lands that are acquired on BPK and NNK and assists in the management of State parcels on adjacent keys within the species' range. The NKDR also continues its acquisition program, though on a smaller scale than the State program. The Service's South Florida Ecological Services Office conducted an analysis of the Key deer's range in 2006 and estimated it to encompass 24,676 ac (9,986 ha). The total portion of habitat in government ownership totaled approximately 17,590 ac (7,118 ha) or 71 percent (Hobgood 2006).

Altered fire regimes in pine rockland—Slash pine (*Pinus elliotii*) communities, locally referred to as pine rockland, are fire-dependant systems that support a variety of rare endemic and native plants (including Federal candidate species), and are considered highly imperiled in Florida (S1) and globally (G1) (Florida Natural Areas Inventory 1990). Pine rocklands are associated with large amounts of fresh water; the highest concentration of fresh water resources and pine rockland are found within the core (Lopez 2001). Specific risks to Key deer associated with altered fire regimes (the lack of frequent fires) in recent decades has not been quantified or fully explored. However, Carlson et al. (1993) reported that fire in pine rockland benefited Key deer (and endemic herbs) by retarding succession, and improved nutritive quality of browse over a short term and quantity of browse over a relatively longer period. Carlson et al. (1993) viewed fire suppression in pine rockland as a threat to Key deer, just as Snyder et al. (1990) viewed fire suppression as a threat to numerous taxa and the system itself, since the floristic composition and structure generally commences toward that of a hardwood hammock after prolonged lack of fire. The implications for deer of extensive conversion of pine rockland to hardwood hammock has not been predicted. Difficulties in conducting prescribed fire have increased with increased human populations and development (Carlson et al. 1993).

The implications of fire restoration for sustainability of the pine rockland in a time of Key deer overabundance has not been fully explored. Depending on the spatio-temporal dynamics of fire, post-fire effects potentially may interact with browsing by Key deer in ways that exacerbate overbrowsing (and potentially overabundance), fail to restore pine rockland components, or both. Additionally, recent hurricane related storm surges have stressed slash pines and other flora within pine rockland, and the stressed pines may be susceptible to mortality from fire, even when fires are executed according to prescription.

b. Overutilization for commercial, recreational, scientific, or educational purposes: Peterson et al. (2003) assessed effects of Key deer captures associated with TAMU / Service studies from 1998to 2000. Capturing and radio-collaring may result in unintentional take (Peterson 2003). However, of 282 deer captured, none perished due to capture activities and no serious injuries resulted.

c. Disease or predation: *Diseases and Parasites*—The incidence of disease in Key deer increased 5.3 percent over the 30-year period from the late 1970s to the late 1990s (Lopez 2001, Nettles et al. 2002). Nettles et al. (2002) concluded that the increase is associated with high deer abundance that exceeds carrying capacity. Currently, one parasite and one disease are present in the deer population that are considered to be population limiting (i.e., slowing the rate of population growth) and another disease represents a potential threat to the population (Nettles et al. 2002).

Large stomach worms (*Haemonchus contortus*, round worms) are a parasite that primarily affects young (< 1 year old) deer (Nettles et al. 2002). Deer that survive develop a partial immunity and will carry moderate numbers of the large stomach worms to pass along to future generations. When the presence of stomach worms is high in the herd, they may be population limiting. When deer become overpopulated or congregate in small areas, such as common feeding areas, the worms can spread and entire age classes can be affected.

Brain abscesses are a disease resulting from bacteria introduced beneath the skin of Key deer, typically in males greater than 3 years of age (Nettles et al. 2002). Although brain abscesses are not likely to cause mortality, the infection can increase the chance of death. For example, brain abscesses can decrease coordination, increasing the likelihood of afflicted deer being hit by a vehicle or drowning in canals. Deer infected with the disease cannot be treated. Brain abscesses appear to be relatively more prevalent in Key deer than in white-tailed deer in general (Nettles et al. 2002).

Additionally, the presence of paratuberculosis or Johne's disease has been documented in Key deer (Nettles et al. 2002, Quist et al. 2002). It was first detected in a Key deer in November 1996. The causative agent of this disease is a bacterium (*Mycobacterium avium paratuberculosis*). The presence of this disease in Key deer was initially considered to be unlikely because the infection is rare in white-tailed deer generally. The origin of the infection in Key deer is enigmatic because no commercial livestock operations occur within the species' range. There are some horses on BPK and other islands. However, the source of the infection in Key deer remains unknown (Corn et al. 2006). Paratuberculosis results in chronic enteritis, lymphadenitis, and emaciation.

Current status and trends for paratuberculosis were reported in Corn et al. (2006) and monitoring of the disease indicated that it had remained localized within the BPK and Newfound Harbor subpopulations (on BPK south of U.S. 1, and Munson and Little Palm Keys, respectively). Previous observations of the disease were limited to these areas (Quist et al. 2002). Although, evidence of paratuberculosis was not found north of U.S. 1 (Corn et al. 2006) the disease was detected in deer along U.S. 1. Moreover, spillover to other mammal species was detected, although cross-species transmission rate was not conclusively determined due to small sample sizes. Based on serologic assays, 2 out of 99 sampled deer were infected. Observations of deer swimming among islands of the Newfound Harbor complex underscored the possibility of disease spread.

The epidemiology has not been studied in free-ranging white-tailed deer and the level of threat to Key deer is unknown. However, the threat is potentially significant; depending in part on how infectious the disease is among Key deer and sympatric animals and how widespread environmental contamination may become (Quist et al. 2002).

Researchers recommended the elimination of illegal feeding, public education about the situation, and further surveillance, particularly of paratuberculosis (Quist et al. 2002, Corn et al. 2006). Feeding of deer by humans encourages local concentrations of deer, increasing the likelihood that stomach worms may spread. Such feeding likely increases the danger of further transmission of the infectious agents (Quist et al. 2002, Corn et al. 2006). Disease is the only source of mortality for which the death rate has increased over the last decade (1997 to 2006) and is more than twice that for any of the three preceding decades (1967 to 1996) (Service 2006a).

Predation—Natural predation on Key deer appears to be rare (Folk 1992) and natural predators are not significant sources of mortality. The American alligator (*Alligator mississippiensis*) has variously been relegated to be an occasional predator (Folk 1992) or scavenger (Hardin et al. 1984) of Key deer. American crocodiles (*Crocodylus acutus*) inhabit mangrove and other estuarine communities and are occasionally observed within the range of the Key deer. Deer may be susceptible to crocodilians when attaining fresh water, foraging among mangroves, or passing through areas inhabited by these predators. Sharks may occasionally prey upon deer swimming across channels and other marine environments when traveling among keys (Folk 1992). Predation by alligators, crocodiles, and sharks is not considered to be a significant threat to the Key deer.

With increased urbanization of the lower Keys, domestic dog numbers and dog-deer interactions have increased. Lopez et al. (2003a) reported that approximately 10 percent of Key deer mortality is due to free-roaming dogs. Harassment by dogs is a recurrent issue in residential areas. Individual cases generally subside due to restraint by owners or intervention by law enforcement personnel. However, direct killing by dogs occasionally occurs and deer entanglement in fences while trying to escape from dogs may result in mortality.

Disease, parasites, and predation have not been documented to be major mortality factors for deer. However, the density of deer on BPK and NNK coupled with increased interaction with humans may increase the risk of infectious disease and parasite transmission. Predation and harassment by free-roaming dogs is expected to continue. Consequently, infectious diseases, parasites, and predation remain a threat to the Key deer.

d. Inadequacy of existing regulatory mechanisms: 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. 1 as it relates to hurricane evacuation time. The County developed a Rate of Growth Ordinance (ROGO) that, as of March 2006, incorporated a land tier system that specifically designates areas of native habitat for listed species including Key deer. The process made it more costly to destroy Key deer habitat, and now discourages development in unfragmented habitat, steers available permit allocations to disturbed areas that are poor habitat for deer, and implements a land acquisition program for areas with native vegetation, including deer habitat. Under the current ROGO, remaining hardwood hammock parcels of significant size are now protected or targeted for protection and development in other native habitat is discouraged.

On June 9, 2006, the Service issued a section 10(a)(1)(B) Incidental Take Permit for Key deer throughout BPK and NNK (expiring June 30, 2023). The recipients (Monroe County, FDOT, and FDCA) developed a habitat conservation plan (HCP) to address habitat loss and vehicle mortality associated with development on BPK and NNK (Monroe County et al. 2006). The HCP allows for the loss of up to 168 ac of potential Key deer habitat (about 2.4 percent of the core) between 2004 and 2023, including no more than seven ac of native habitat. Compensation will be provided by the acquisition of a minimum of three mitigation units for every one development unit of suitable habitat on BPK and NNK. Human-related mortality (e.g., from DVCs) is expected to increase by 4.2 deer per year.

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 (NFIP) in Monroe County was likely to jeopardize the continued existence of Key deer (Case No. 90-10037-CIV-MOORE). Subsequently the Service (2003) issued a jeopardy Biological Opinion (BO) with reasonable and prudent alternatives that required Monroe County to consult with the Service before issuing building permits in suitable habitat for listed species. As a result, the Service provided technical assistance on pertinent projects (virtually all building applications on private parcels throughout the range of the deer, 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 BO within 9 months. 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 completed a new analysis of the NFIP in Monroe County, and provided the BO to the Court on August 8, 2006. The BO provided a revised strategy for implementing regulatory actions pertaining to the Key deer including clarification of FEMA’s oversight role and a more comprehensive approach for evaluating potential impacts. The latter incorporates a lot-by-lot assessment of potential impacts that takes into account the limitations on development imposed by the County's ROGO system with its new designations of geographical tiers. In the BO, the Service concluded that continued administration of the NFIP in the Keys is likely to result in incidental take, but will not jeopardize the continued existence of the Key deer.

FEMA and the Service filed an appeal on April 1, 2008, with the United States Court of Appeals for the Eleventh Circuit arguing that section 7(a)(2) of the Act did not apply to FEMA's flood insurance program and that FEMA had fully complied with the Court's March 29, 2005, ruling. The United States Court of Appeals for the Eleventh Circuit affirmed the judgment of the District Court on April 1, 2009. Subsequently, the Court ordered the Service to submit a new BO by March 31, 2010. In compliance with the Court's order, the Service submitted a new BO on FEMA's implementation of the NFIP in the Keys and its effects on 18 federally threatened or endangered species. The Service concluded again that continued administration of the NFIP in the Keys is likely to result in incidental take, but will not jeopardize the continued existence of the Key deer.

The revised BO also addresses the Court's March 2005, criticism of the 2003 BO's Reasonable and Prudent Alternative (RPA) to avoid jeopardy for the Key Largo wood rat (*Neotoma floridana smalli*), Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*), Lower Keys rabbit (*Sylvilagus palustris hefneri*) and Keys tree cactus (*Pilosocereus robinii*) for (1) relying on voluntary measures and (2) not protecting against habitat loss and fragmentation or otherwise accounting for the cumulative effects of the permitted projects. It completely reviews post 2003 RPA baseline conditions based on higher quality habitat maps. The Service clearly describes in the 2010 BO steps that will be taken if the RPA is not followed, which include new FEMA enforcement mechanisms that are consistent with its regulations. The revised RPA outlines a review process that allows the Service to evaluate cumulative impacts of permit applications. As of August 2009, the Court had not yet ruled to accept or reject the new BO or to lift the injunction on FEMA's issuance of flood insurance for development on properties on the Service's suitable habitat maps for Monroe County.

Pressure to develop remaining residential and commercial land within the range of the Key deer continues. However, development is subject to regulatory oversight by Monroe County, (e.g., the ROGO), the State (e.g., designated an Area of Critical State Concern), and the Service (e.g., the BPK / NNK HCP, and presumably, continued consultation with FEMA regarding the administration of the National Flood Insurance Program).

e. Other natural or manmade factors affecting its continued existence:
Invasive exotic plants—The Service carries out an exotic plant control program throughout NKDR, as well as on State and county lands on BPK and NNK (which are managed by NKDR). TNC and the Task Force conduct complementary programs on other public and private lands. As of 2001, NKDR estimated that non-native exotic species had been reduced by 80 percent on public conservation lands (Frank 2001). Frank (2001) indicated that the exotics control program was entering maintenance mode by 2001. The Service, TNC, and Task Force attained further control in subsequent years. Currently, the magnitude of this threat to Key deer is low.

Collisions with vehicles—DVCs are the largest single source of mortality for Key deer. However, this factor is a function of population size and not controlling population size. The proportion of deer that succumb to DVCs (at least 50 percent of mortalities) has remained consistent overall since the late 1960s (Lopez 2001, Service 2006a).

Drowning—Drowning is the second largest source of mortality. Hardin (1974) reported that fawns were susceptible to drowning in mosquito control ditches. Lopez (2001) proposed that fewer fawns drowned in mosquito control ditches in recent years. However, that proposition was derived from observations of fawns that were a subset of the deer that he and earlier researchers happened to radio-collar, as opposed to research systematically focused on the question and there were fewer fawns in the sampled population in more recent studies. Nonetheless, Lopez (2001) contends that the risk to fawns has declined and continues to decline because of natural and human-assisted infilling of the ditches with silt and spoil and the available data is consistent with that belief. Loss of fawns to drowning no longer appears to be a significant threat to the Key deer.

The frequency of drowning in radio-collared Key deer was lower from 1998 to 2000 (2.6 percent) compared to 1968 to 1972 (9.6 percent) (Lopez 2001). In contrast, mortality data collected by the Service and collaborators indicated that during the four 10-year periods starting in 1967, 3.3, 2.0, 4.0, and 4.1 percent of all documented deaths (N=2,989) were attributable to drowning (Service 2006a). Overall, the available data indicate that drowning is not a major threat to Key deer, and the frequency of drowning has not increased.

Illegal hunting —Illegal hunting played a role in early population declines but has rarely been documented in recent years (Lopez 2001, Lopez et al. 2003a).

Factors associated with urbanization, including behavioral changes and local overabundance of Key deer—Urbanization patterns have been correlated with changes in deer behavior, distribution, diet, habitat, mortality, and abundance (Folk and Klimstra 1991b; Lopez 2001; Lopez et al. 2003a; Peterson et al. 2004, 2005; Harveson et al. 2004, 2007). Changes in the human population have fostered behavioral changes in Key deer, resulting in habituation to urban settings and local overabundance and a variety of threats associated with these. The increase in human-deer interactions has been correlated with deer becoming more sedentary, losing natural alarm and flight responses, and aggregating in larger groups (Folk and Klimstra 1991b, Lopez et al. 2003a, Peterson et al. 2005). This may lead to an increased chance of disease and parasite transmission (Nettles et al. 2002, Quist et al. 2002), impacts to vegetation (Barrett 2004), and susceptibility to poaching (Lopez et al. 2003a).

Overabundance has been increasingly observed throughout the range of the white-tailed deer, particularly within and along urban interface areas. Similarly, Key deer abundance has increased on the urban interface on BPK and NNK in recent decades, particularly around residential settings (Peterson et al. 2005). The growing portion of deer that are habituated to human interactions and breed on the urban interface results in increased rates of urban-born deer, further exacerbating local overabundance and associated problems.

The trophic dynamics of urban feeding Key deer and its spatially-explicit links to population dynamics and the distribution of herbivory, including the carrying capacity of natural areas throughout the area occupied by affected subpopulations, has not been described. Moreover, neither the quantities and nutrient values of foods derived in urban settings, nor the proportions attributable to lawn and landscape vegetation, illicit feeding, or refuse, have been determined for any component of any subpopulation. Although Folk and Klimstra (1991b) did not investigate the aforementioned subjects, they assessed group size and other behavioral shifts in urban feeding Key deer and proposed that foods derived from illegal handouts might result in chronic dietary imbalances in certain deer. Alternatively, nutrients provided in the overall diets of urban Key deer may allow such deer to overcome nutrient deficits associated with diets of natural foods (i.e., high Ca, low P; Widowski 1977). Such deficits have been hypothesized to be a factor in the low productivity of Key deer (Widowski 1977, Folk and Klimstra 1991a). Accordingly, if urban derived foods offset such deficiencies, then the altered foraging patterns of deer and the nutritional characteristics of urban foods are likely contributing to the complex suite of factors that has resulted in overabundance within the core. Folk (TNC, personal communication 2006) suggested that increased nutrients in lawn and garden forage due to fertilizers may be a specific factor increasing deer productivity or altering the sex ratio. She noted that this was speculated on in the 1980s. Causal relationships between foraging energetics and population dynamics have yet to be explored.

A growing threat, particularly in the core of the range, is habitat alteration from excessive browsing associated with local overabundance of Key deer. Barrett (2004) compared baseline vegetation data from the 1990s to data collected in 2002 within NKDR. His study revealed pronounced browsing impacts in mangrove, buttonwood, and hammock communities on islands where deer densities have been relatively high (e.g., BPK, NNK, Big Munson Key). Because Key deer are selective browsers, densities of preferred plant species decreased and non-preferred plant species increased on islands with high deer density. On islands with high deer density, many highly preferred species that had been present in the hardwood hammock understory in the 1990s were virtually absent from samples taken in 2002. These results indicated that, within an approximately 12-year period, heavy herbivory by deer in the understory can influence midstory (and possibly canopy) composition. Without intervention, such conditions are expected to result in altered species richness in the canopy trees. Replacement of canopy trees, by potential recruits from the sub-canopy (i.e., seedlings), will be precluded by continued browsing. This would result in long-term alterations to plant composition and structure.

Locally high concentrations of deer may disrupt the natural process of post fire recovery of woody plants, including important forage species, potentially inhibiting the sustainability that prescribed fire is intended to accomplish. Barrett (2004) found that deer herbivory and fire both shape pine rockland plant communities, but overbrowsing has substantial impacts on preferred herbaceous and woody species.

Hurricanes—Catastrophic events in the form of hurricanes and tropical storms pose a threat to Key deer. Of the parameters entered into Lopez's (2001) population viability analysis, predictions of extinction thresholds were most sensitive to maximal population growth rate, followed by high intensity hurricanes. High intensity hurricanes can sweep deer populations entirely from coastal islands. Given the reduction in the deer's historic range, the threat and impact of tropical storms and hurricanes is now greater than when the species' distribution was more widespread. Additionally, hurricanes can alter the landscape and damage flora due to wind and storm surges. Hurricane Georges in 1998 resulted in extensive damages to pine rocklands and caused numerous waterholes to become saline for many months (Lopez 2003b). Similarly, Hurricane Wilma (October 2005) resulted in a storm surge 5 to 8 feet (1.5 to 2.4 meters) above mean sea-level that displaced fresh water with seawater throughout BPK, killed the slash pine throughout more than 15 percent of the pine rockland, and resulted in an outbreak of bark beetles (Carothers 2006). Unnatural pooling of seawater due to roads and other developments results in hypersalinity, compounding the loss of flora, and such hurricane effects likely interact with sea-level rise (see below). Following Hurricane Wilma, flora other than pines was desiccated throughout the range of the deer and seven months of dry conditions exacerbated this. Another outcome was high fire danger which currently precludes the application of prescribed fire for deer habitat management. To date, specific effects of Hurricane Wilma on Key deer and its habitat have not been identified or quantified.

Sea-level rise—Scientific evidence indicates that climate change is now occurring at an unprecedented rate. Mostly due to thermal expansion and melting land ice, global sea-level rose approximately 7 inches (17centimeters) in the 20th Century, and the current rate of rise is increasing (Intergovernmental Panel on Climate Change [IPCC] 2007). IPCC (2007), Rahmstorf et al. (2007), and TNC (2009) models of sea-level rise predict that 59,000 to 154,000 ac (23,877 to 62,322 ha) of the Florida Keys could be claimed by the sea by the year 2100. On BPK, this would amount to 11 to 96 percent of the islands' pine forest and hardwood hammocks lost (TNC 2009).

> The pine rockland community in the Keys has already undergone a reduction due to sea-level rise (Ross et al. 1994). The distribution, abundance, and availability of limited freshwater wetlands in the lower Keys are essential components of Key deer habitat, profoundly affecting their distribution and ability to persist. The presence of certain waterholes is important to subpopulations of Key deer because they provide fresh water during the dry season. Loss of the waterholes due to sea-level rise could have widespread, long-term, detrimental impacts to the deer, particularly outside of the core.

D. Synthesis - The overall Key deer metapopulation growth rate has remained positive in recent decades. However, this increase was primarily due to annual recruitment of deer in portions of the core (primarily northern BPK and NNK), and the subpopulations in these areas have approached or exceeded carrying capacity. Key deer in other portions of the core (southern BPK) have exhibited annual population declines, and the abundance of non-core subpopulations has remained low.

Habitat destruction due to development continues to occur, though at low rates (as in contrast to the 1970s and 1980s). However, along with development, deer abundance has increased at the urban interface in recent decades, particularly around residential settings. The increased number of deer that are habituated to urban areas has led to local overabundance with its associated problems, including increased disease and parasite transmission, impacts to vegetation, susceptibility to poaching, and erosion of support from local citizens. The incidence of disease in Key deer increased 5.3 percent over the 30-year period from the late 1970s to the late 1990s (Lopez 2001, Nettles et al. 2002). Nettles et al. (2002) concluded that the increase is associated with high deer abundance that exceeds carrying capacity. Habitat alteration associated with excessive browsing by locally overabundant deer is a growing concern within the core. Barrett et al. (2006) found pronounced browsing impacts in mangrove, buttonwood, and hammock communities, on keys where deer densities have been relatively high (BPK, NNK, Big Munson). Because deer are selective browsers, densities of preferred plant species decreased and non-preferred plant species increased on islands with high deer density. Many highly preferred plant species present in the hardwood hammock understory in the 1990s were virtually absent in 2002 (Barrett et al. 2006).

The nine non-core subpopulations are characterized by low deer abundance, supporting only 25 percent of the deer metapopulation. All of the outer keys are relatively small and, with the exception of Little Pine, provide a limited amount of suitable habitat and fresh water. During the last several decades, few deer have persisted on these outer islands. Silvy (1975) estimated that the Little Pine and Johnsons complexes combined could support only about 30 deer, with the majority of those on Little Pine Key. Given the low carrying capacity for deer and the limited availability of fresh water, these islands are not likely capable of sustaining viable populations in the absence of emigration from the core. Key deer have been translocated to Sugarloaf and Cudjoe Keys to establish viable subpopulations there. These efforts appear to be successful, but results have not been observed for sufficient time to draw conclusions regarding long-term viability.

Sea-level rise is the largest climate-driven challenge to refuges and other lands in the sub-tropical ecoregion of southern Florida (Climate Change Science Program [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.” The refuges in that area, including NKDR, are all at particularly high risk (CCSP 2008). The distribution, abundance, and availability of limited freshwater wetlands in the lower Keys are essential components of Key deer habitat, profoundly affecting their ability to survive.

Catastrophic events in the form of hurricanes and tropical storms pose a threat to Key deer. High intensity hurricanes can sweep deer populations entirely from coastal islands. Given the reduction in the deer’s historic range, the threat and impact of tropical storms and hurricanes is greater than when the species’ distribution was more widespread. Additionally, hurricanes can alter the landscape and damage flora due to wind and storm surges. Unnatural pooling of seawater due to roads and other developments results in hypersalinity, affecting fresh water supplies and compounding the loss of flora.

In summary, with the core subpopulation reaching carrying capacity, including local overabundance, there is an increasing threat of a major disease outbreak and a decrease in quality of habitat due to overbrowsing. These threats are exacerbated by the continued loss of habitat from development and the longer-term threat from sea-level rise. Deer abundance in non-core subpopulations is low and limited by the availability of habitat and freshwater that is also threatened by longer-term sea-level rise resulting in submersion of land area and increased salinity. Any portion of the metapopulation is threatened with the potential of a catastrophic hurricane or tidal surge. Therefore, the status of the Key Deer remains endangered.

III. RESULTS

A. Recommended Classification:

X **No change is needed**

IV. RECOMMENDATIONS FOR FUTURE ACTIONS - We are in the process of revising the Key deer recovery plan. There are a variety of data needed in order to better model and assess viability and manage deer. Collaborators have conducted extensive research on population dynamics, home range use, and movement in the core area. For other subpopulations, less rigorous estimates of abundance are available and key demographic and home range characteristics have not been assessed. Additionally, risks associated with disease have not been quantified. Monitoring is needed to assess the outcome of the translocation effort.

Neither forage biomass nor nutritional ecology has been adequately quantified in either natural areas or in developed settings. Linkages between urban foraging energetics, carrying capacity, and metapopulation dynamics should be defined and enumerated. The influence of urban and illegal feeding on Key deer fitness has not been quantified. If habitat management actions (e.g., prescribed fire, reduction in artificial feeding and watering) or carrying capacity need to be explicitly tied to forage distribution, quality, and quantity, forage biomass and nutritional ecology should be studied. Problems associated with the spatio-temporal dynamics of fire in an overbrowsed environment add to the complexity of, and apparently increase the importance of, quantitative research and monitoring of trophic pathways.

Additionally, water resources in the core and outer islands should be quantified, compared to historical data (e.g., Hanson 1980, Folk 1992) where possible to establish baselines and assess changes, and further monitored. These actions would help to facilitate modeling and verifying suspected changes in fresh water resources and threats to those resources. It would be useful to determine any linkages of sea-level rise, changes in deer habitat (e.g., plant community dynamics), and interactions among those with factors associated with deer productivity and other components of population viability. Lack of detailed hydrology and terrain data precludes quantifying the effects of development infrastructure, storm surges, or sea-level rise on water sources and plant communities that sustain the deer. Currently available models (i.e., population viability, dispersal) do not account for effects of the distribution and attributes of freshwater resources on deer.

V. REFERENCES

Barbour, T., and G.M. Allen. 1922. The white-tailed deer of the eastern United States. Journal of Mammalogy 3(2):65-78.

Barrett, M.A., 2004. An analysis of key deer herbivory on forest communities in the lower Florida Keys. Ph.D. Dissertation, University of South Florida, Tampa, Florida.

Barrett, M.A., and P. Stiling. 2006. Effects of Key deer herbivory on forest communities in the Lower Florida Keys. Biological Conservation 129:100-108.

Braden, A. 2005. Evaluation of the effects of a highway improvement project on Key deer. Masters Thesis, Texas A&M University, College Station, Texas.

Carlson, P.C., G.T. Tanner, J.M. Wood, and S.R. Humphrey. 1993. Fire in Key deer habitat improves browse, prevents succession, and preserves endemic herbs. Journal of Wildlife Management 57:914-928.

Carothers, W.A. 2006. Letter to U.S. Fish and Wildlife Service, Vero Beach, Florida, dated June 2, 2006. U.S.D.A Forest Service, Forest Health Protection, Ashville, North Carolina.

Climate Change Science Program. 2008. Climate Models: An Assessment of Strengths and Limitations. Synthesis and Assessment Product 3.1 U.S. Department of Energy, Office of Biological and Environmental Research, Washington, DC.

Corn, J.L., E.J.B. Manning, and K. Pedersen. 2006. Survey for Mycobacterium avium paratuberculosis at the National Key Deer Refuge, Big Pine Key, Florida. Final Report, Challenge Cost-Share Agreement Number 401815G084 between the U.S. Fish and Wildlife Service, Big Pine Key, Florida, and the University of Georgia Research Foundation, Inc.

Dickson, J.D., III. 1955. An ecological study of the Key deer. Florida Game and Fresh Water Fish Commission Technical Bulletin 3, Tallahassee, Florida, USA.

Florida Department of Environmental Protection. 2006. The 2006 Annual Report of the Florida Forever Program. Prepared for the Board of Trustees of the Internal Improvement Trust Fund of the State of Florida. Division of State Lands, Tallahassee, Florida.

Florida Natural Areas Inventory. 1990. Guide to the natural communities of Florida. Florida Department of Natural Resources, Tallahassee, Florida.

Folk, M.L. 1992. Habitat of the Key deer. Ph.D. Dissertation, Southern Illinois University, Carbondale, Illinois. 755pp.

Folk, M.L. 2006. Personal communication. Biologist. E-mail to U.S. Fish and Wildlife Service dated December 14, 2006. The Nature Conservancy, Kissimmee, Florida.

Folk, M.J., and W.D. Klimstra. 1991a. Reproductive performance of female Key deer. Journal of Wildlife Management 55:386-390.

Folk, M.J., and W.D. Klimstra. 1991b. Urbanization and domestication of the Key deer (*Odocoileus virginianus clavium*). Florida Field Naturalist 19:1-9.

Folk, M.J., W.D. Klimstra., C.R. Kruer, and M.L. Folk. 1990. Special Report: Key deer accessibility to all of Big Pine Key. Report to U.S. Fish and Wildlife Service, Big Pine Key, Florida. 41pp.

Folk, M.L., W.D. Klimstra, and C.R. Kruer. 1991. Habitat evaluation: National Key deer range. Final report, Florida Game and Fresh Water Fish Commission. Nongame Program, Tallahassee, Florida. 366pp.

Frank, P. 2001. A review of the 1999 Key deer recovery plan as it relates to the recent initiative to relocate deer to islands on the periphery of the current range of the deer. U.S. Fish and Wildlife Service Memorandum, Big Pine Key, Florida, November 9, 2001.

Hanson, C.E. 1980. Fresh water sources of Big Pine Key, Florida. U.S. Geological Survey Open File Report 80-447.

Hardin, J.W. 1974. Behavior, socio-biology, and reproductive life history of the Florida Key deer, *Odocoileus virginianus clavium*. Ph.D. Dissertation, Southern Illinois University, Carbondale, Illinois.

Hardin, J.W., W.D. Klimstra, and N.J. Silvy. 1984. White-tailed deer population and habitats: Florida Keys. *In* White-tailed deer: ecology and management (L.K. Halls), pp. 381-390. Stackpole Books, Harrisburg, Pennsylvania.

Harveson, P.M., R.R. Lopez, N.J. Silvy, and P.A. Frank. 2004. Source-sink dynamics of Florida Key deer on Big Pine Key, Florida. Journal of Wildlife Management 68:909-915.

Harveson, P.M., W.E. Grant, R.R. Lopez, N.J. Silvy, and P.A. Frank. 2006. The role of dispersal in Florida Key deer metapopulation dynamics. Ecological Modeling 195:393-401.

Harveson P.M., R.R. Lopez, B.A. Collier, and N.J. Silvy. 2007. Impacts of urbanization on Florida Key deer behavior and population dynamics. Biological Conservation 134:321-331.

Hobgood, W. 2006. Email to P. Hughes, U.S. Fish and Wildlife Service, Big Pine Key, Florida, dated April 25, 2006. Transmittal of the table, "Monroe County and Municipalities Species Data". U.S. Fish and Wildlife Service, Vero Beach, Florida.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate change 2007: Synthesis Report. IPCC, Geneva.

Jacobson, B.N. 1974. Effects of drinking water on habitat utilization by Key deer. M.S. Research Paper, Southern Illinois University, Carbondale, Illinois.

Klimstra, W.D. 1985. The Key deer. Florida Naturalist 58:2-5.

Klimstra, W.D., and A. Dooley. 1990. Foods of the Key deer. Florida Scientist 53:264-273.

Klimstra, W.D., J.W. Hardin, N.J. Silvy, B.N. Jacobson, and V.A. Terpening. 1974. Key deer investigations final report: Dec. 1967-Jun. 1973. U.S. Fish and Wildlife Service, Big Pine Key, Florida.

Lopez, R.R. 2001. Population ecology of the Florida Key deer. Ph.D. Dissertation, Texas A&M University, College Station, Texas.

Lopez, R.R. 2006. Comments on draft 5-year review form as unofficial peer reviewer. Email to U.S. Fish and Wildlife Service, Big Pine Key, Florida, dated September 7, 2006. Texas A&M University, College Station, Texas.

Lopez, R.R., N.J. Silvy, P.A. Frank, and B.L. Pierce. 2003a. Effects of supplemental feeding on Key deer behavior in urban areas. Florida Scientist 66:267-272.

Lopez, R.R., N.J. Silvy, R.F. Labisky, and P.A. Frank. 2003b. Hurricane impacts on Key deer in the Florida Keys. Journal of Wildlife Management 67:280–288.

Lopez, R.R., M.E. Viera, N.J. Silvy, P.A. Frank, S.W. Whisenant, and D.A. Jones. 2003c. Survival, mortality, and life expectancy of Florida Key deer. Journal of Wildlife Management 67:34–45.

Lopez, R.R., N.J. Silvy, B.L. Pierce, P.A. Frank, M.T. Wilson, and K.M. Burke. 2004a. Population density of the endangered Florida Key deer. Journal of Wildlife Management 68:570-575.

Lopez, R.R., N.J. Silvy, R.N. Wilkins, P.A. Frank, M.J. Peterson, M.N. Peterson. 2004b. Habitat use patterns of Florida Key deer: implications of urban development. Journal of Wildlife Management 68:900-908.

Lopez, R.R., P.M. Harveson, M.N. Peterson, N.J. Silvy, and P.A. Frank. 2005. From the field: changes in ranges of Florida Key deer – does population density matter? Wildlife Society Bulletin 33:343-348.

Meyers-Rice, B., and M. Tu. 2001. A success story - Florida Keys, southern Florida. The Nature Conservancy, Wildland Invasive Species Program, Davis, California.

Monroe County, Florida Department of Transportation, and Florida Department of Community Affairs. 2006. Habitat Conservation Plan for Florida Key Deer (*Odocoileus virginianus clavium*) and other protected species on Big Pine Key and No Name Key, Monroe County, Florida.

Nettles, V.F., C.F. Quist, R.R. Lopez, T.J. Wilmers, P. Frank, W.Roberts, S. Chitwood, and W.R. Davidson. 2002. Morbidity and mortality factors in Key deer (*Odocoileus virginianus clavium*). Journal of Wildlife Diseases 38(4):685-692.

Parker, I.D. 2006. Effects of translocation and deer-vehicle collision mitigation on Florida Key deer. M.S. Thesis, Texas A&M University, College Station, Texas.

Parker, I.D., D.E. Watts, R.R. Lopez, N.J. Silvy, D.S. Davis, R.A. McCleery, and P.A. Frank. 2008. Evaluation of the efficacy of Florida Key deer translocations. Journal of Wildlife Management 72:1069-1075.

Peterson, M.N. 2003. Management strategies for endangered Florida Key deer. M.S. Thesis, Texas A&M University, College Station, Texas.

Peterson, M.N., R.R. Lopez, P.A. Frank, M.J. Peterson, and N.J. Silvy. 2003. Evaluating capture methods for urban white-tailed deer. Wildlife Society Bulletin 31(4).

Peterson, M.N., R.R. Lopez, P.A. Frank, B.A. Porter B.A., and N. J. Silvy. 2004. Key deer fawn response to urbanization: is sustainable development possible? Wildlife Society Bulletin. 32(2):493-499.

Peterson, M.N., R.R. Lopez, E.J. Laurent, P.A. Frank, N.J. Silvy, and J. Liu. 2005. Wildlife loss through domestication: the case of endangered Key deer. Conservation Biology 19:939-944.

Quist, C.F., V.F. Nettles, S.J.B. Manning, D.G. Hall, J.K. Gaydos, T.J. Wilmers, and R.R. Lopez. 2002. Paratuberculosis in Key deer, (*Odocoileus virginianus clavium*). Journal of Wildlife Diseases 38:729-737.

Rahmstrof, S. 2007. A semi-empirical approach to projecting future sea-level rise. Science 19: DOI; 1126/science. 1135456.

Ross, M.S., J.J. O'Brien, and L.J. Flynn. 1994. Sea-level rise and the reduction of pine forests in the Florida Keys. Ecological Applications 4(1):144-156.

Silvy, N.J. 1975. Population density, movements, and habitat utilization of Key deer, *Odocoileus virginianus clavium*. Ph.D. Dissertation, Southern Illinois University, Carbondale, Illinois.

Snyder, J.R. A. Herndon, and W.B. Robertson, Jr. 1990. South Florida rockland. *In* Ecosystems of Florida (R.L. Myers and J.J. Ewel, eds.), pp. 230-277. University of Central Florida Press, Orlando, Florida.

The Nature Conservancy. 2006. Protecting wild Florida: preserving the best and last wilderness of Florida, Forever. The Nature Conservancy, Florida Chapter, Altamonte Springs.

The Nature Conservancy. 2009. Initial estimates of the ecological and economic consequences of sea level rise on the Florida Keys through the year 2100. The Nature Conservancy, Florida Chapter, Altamonte Springs.

U.S. Army Corps of Engineers and South Florida Water Management District. 2006. Program management plan (final). Florida Keys Water Quality Improvements Program.

U.S. Census Bureau. 2006a. Estimates for Florida Counties [Excel file] [Internet]. U.S. Census Bureau [cited September 25, 2006]. Available from: http://www.census.gov/popest/counties/tables/CO-EST2004-01-12.xls.

U.S. Census Bureau. 2006b. Monroe County Florida [Internet]. FedStats Mapstats website [cited September 25, 2006]. Available from: http://www.fedstats.gov/qf/states/12/12087.html.

U.S. Fish and Wildlife Service. 1999. South Florida multi-species recovery plan. Atlanta, Georgia.

U.S. Fish and Wildlife Service. 2003. Amendment to the June 16, 1997, biological opinion on the effects of the Federal Emergency Management Agency's continued administration of the NFIP in Monroe County, Florida. Atlanta, Georgia.

U.S. Fish and Wildlife Service. 2006a. Key deer mortality master (continuous record of known Key deer mortalities, 1966 to present). Unpublished database. [Accessed October 17, 2006]. National Key Deer Refuge, Big Pine Key, Florida.

U.S. Fish and Wildlife Service. 2006b. Biological opinion on the Federal Emergency Management Agency's National Flood Insurance Program's actions in the Florida Keys. Atlanta, Georgia.

Walters, S. 2001. Landscape patterns and productivity effects on source-sink dynamics of deer populations. Ecological Modeling 143:17-32.

Watts, D.E. 2006. Distribution and abundance of endangered Florida key deer on outer islands. M.S. Thesis, Texas A&M University, College Station, Texas.

Widowski, S.P. 1977. Calcium and phosphorus in selected vegetation from Big Pine Key, Florida. M.S. Res. Pap. Southern Illinois University, Carbondale, Illinois. 83pp.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of
Key deer (*Odocoileus virginianus clavium*)

Current Classification Endangered
Recommendation resulting from the 5-Year Review

_X_ **No change is needed**

Review Conducted By Phillip Hughes

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ____________________ Date 8/19/10

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.

Acting
Lead Regional Director, Fish and Wildlife Service

Approve ____________________ Date 8-23-10

APPENDIX A: Summary of peer review for the 5-year review of Key deer *(Odocoileus virginianus clavium)*

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

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments/Report: Peer review comments provided insights that were beneficial in conducting this review. Although there were a variety of substantive comments, they predominantly addressed the degree to which certain points were emphasized as opposed to points of contention or entirely new subject matter. Comments and concerns covered a variety of topics including: (1) drowning as a threat, (2) urban foraging and energetics as a possible factor in overabundance within the core, (3) increased salinity and reduced availability of freshwater as a threat, (4) illegal feeding as a threat, (5) lack of fire in pine rockland as a threat, and (6) overabundance of Key deer within the core as a threat, and overabundance exacerbating threats from diseases.

D. Response to Peer Review: The Service was in agreement with comments and concerns received from peer reviewers. Comments were incorporated into the 5-year review.

Guidance for Peer Reviewers of Five-Year Status Reviews

U.S. Fish and Wildlife Service, South Florida Ecological Services Office
June 7, 2006

As a peer reviewer, you are asked to adhere to the following guidance to ensure your review complies with 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 (ESA) 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 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 we must use the best available scientific data in determining the species' status. This does not mean we 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 our 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 Cindy Schulz, Endangered Species Supervisor, South Florida Ecological Services Office, at 772-562-3909, extension 305, email: Cindy_Schulz@fws.gov.