Garber's Spurge
Chamaesyce garberi

5-Year Review:
Summary and Evaluation

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

5-YEAR REVIEW
Garber's spurge/*Chamaesyce garberi*

I. GENERAL INFORMATION

I.A. Methodology used to complete the review: This review is based on monitoring reports, surveys, and other scientific and management information, augmented by conversations and comments from biologists familiar with the species. The review was contracted to Keith A. Bradley with The Institute for Regional Conservation (IRC) in Miami, Florida and finalized by the species lead at the South Florida Ecological Services Office. Literature and documents on file at the South Florida Ecological Services Office were used for this review, as well as any information available to IRC. All recommendations resulting from this review are a result of thoroughly reviewing all available information on the Garber's spurge. Comments and suggestions regarding the review were received from South Florida Ecological Services Office supervisors and peer reviews from outside the Service.

I.B. Reviewers
Lead Regional or Headquarters Office: Southeast Regional Office, Kelly Bibb, (404) 679-7132
Lead Field Office: Cindy Schulz, South Florida Ecological Services Office, (772) 562-3909

I.C. Background

I.C.1. FR Notice citation announcing initiation of this review: September 27, 2006. Endangered and threatened wildlife and plants; 5-year review of 37 southeastern species. 71 FR 56545-56547.

I.C.2. Species status: Unknown (2006 Recovery Data Call)

I.C.3. Recovery achieved: 1 (0-25% recovery objectives completed) (2006 Recovery Data Call)

I.C.4. Listing history
Original Listing
FR notice: 50 FR 29345-29349
Date listed: July 18, 1985
Entity listed: Species
Classification: Threatened

I.C.5. Associated rulemakings: N/A

I.C.6. Review History:
5-year review November 6, 1991 (56 FR 56882)
Final Recovery Plan 1999
Recovery Data Call 2000, 2001, 2002, 2003, 2004, 2005, 2006

I.C.7. Species' Recovery Priority Number at start of review: 8

I.C.8. Recovery Plan or Outline
Name of plan: South Florida Multi-Species Recovery Plan (MSRP)
Date issued: May 18, 1999
Dates of previous revisions: October 7, 1988 (original recovery plan)

II. REVIEW ANALYSIS

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

II.A.1. Is the species under review listed as a DPS?

____ ***Yes***
__X__ ***No***

II.A.2. Was the DPS listed prior to 1996?

____ ***Yes***
____ ***No***

II.A.3. Is there relevant new information regarding application of the DPS policy to this DPS (i.e., is there new information since the original (either pre- or post-1996) DPS listing that indicates a need for splitting out, combining or otherwise re-configuring DPSs, or that the listed entity is no longer consistent with the DPS policy)?

____ ***Yes***
____ ***No***

II.A.4. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy?

____ ***Yes***
__X__ ***No***

II.B. Recovery Criteria

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

__X__ ***Yes***
____ ***No***

II.B.2. Adequacy of recovery criteria.

II.B.2.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***
__X_ ***No***

The 1999 recovery plan was written before a comprehensive status survey had been done, and prior to results being received from Herndon's (1998, 2002) demographic, cultivation, and reintroduction studies. A status survey was initiated in 2006 (Green et al. 2006) that has generated range and status data not in the 1999 plan. The recovery criteria, are, however, still relevant, given these newer data.

II.B.2.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)?

__X_ ***Yes***
____ ***No***

II.B.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. For threats-related recovery criteria, please note which of the 5 listing factors[*] are addressed by that criterion. If any of the 5 listing factors are not relevant to this species, please note that here.

1. Enough demographic data are available to determine the appropriate numbers of self sustaining populations required to ensure 95 percent probability of persistence for 100 years.

Very little demographic data are available for Garber's spurge. A previous status survey reported only five occurrences (Austin et al. 1980[*]): Cape Sable, Long Pine Key, Big Pine Key, Bahia Honda Key, and Big Torch Key. Their report included a long list of historical stations, but it does not appear that many of the formerly reported stations were actually inspected to determine if plants were present or absent.

A) Present or threatened destruction, modification or curtailment of its habitat or range;
B) Overutilization for commercial, recreational, scientific, or educational purposes;
C) Disease or predation;
D) Inadequacy of existing regulatory mechanisms;
E) Other natural or manmade factors affecting its continued existence.

[*] In Austin et al. (1980), status surveys were conducted for *C. garberi* and *C. porteriana* var. *keyensis.* This latter taxon is now considered a synonym of *C. garberi*. Therefore, data in the report under *C. porteriana* var. *keyensis* should be referred to *C. garberi.*

Another status survey did not begin until 2006 (Green et al. 2006), and in the interim only a few populations received occasional checks, particularly populations at Deer Hammock in Everglades National Park and at the Deering Estate at Cutler. These have only been surveyed sporadically, usually without full population counts being done. Consequently, no population has been tracked consistently to determine population trends.

Herndon (1998, 2002) conducted the only detailed demographic studies of the species, although they were collected for very short periods of time. His studies were conducted at the Deering Estate and in Everglades National Park near Deer Hammock, both pine rockland sites in Miami-Dade County. The population at the Deering Estate was monitored from December 1996 to March 1999. The population in Everglades National Park was monitored from 1996 to 1998. At the Deering Estate at Cutler the population occurred in a matrix of Miami oolitic limestone and quartz sand. At Deer Hammock the population is restricted to bare oolitic limestone.

Herndon (2002) determined that the population at the Deering Estate was stable during his 27 month study. Results from Everglades National Park were not as clear. Numbers of live plants in study plots dropped by 25% during the study, but a visual increase in population size outside of plots was reported.

In both studies Herndon reported a very high turnover rate, with a high annual death rate coupled with high annual recruitment. In addition, he hypothesized the likelihood of large year-to-year population sizes. Giving extra credence to this hypothesis, Gann (IRC, pers. comm. 2007) reported a large population pulse at Bahia Honda State Park the year following Hurricane Georges which hit the island in 1998. Hundreds of plants appeared within one year of the storm event. In subsequent years the population dwindled to fewer than 20 individuals. Following Hurricane Wilma which hit the Florida Keys in 2005, the population rebounded and currently consists of 700-800 individuals (Green et al. 2006).

Unfortunately, detailed demography for only two populations in pine rockland habitat were studied, and each for short periods. No demographic data are available for any other population. As Herndon (1998) recommends, continual, annual censuses of populations are needed to determine long-term population trends. There is currently not enough demographic data available to determine the appropriate numbers of self sustaining populations required to ensure 95 percent probability of persistence for 100 years.

2. When these populations within the historic range of Garber's spurge are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression.

Most known populations of Garber's spurge are on publicly owned conservation lands and are protected from further habitat loss. On private property, two

particularly significant populations occur in privately owned coastal rock barrens, one on Long Key and another on Crawl Key. Other populations probably exist on private lands but have not been seen due to lack of access and surveys. Several populations occur on public lands that are not considered protected, for example, along the road shoulders on Grassy Key. Because of the species' tendency to grow on disturbed substrates, it is often found in places that are not typically managed for their natural resources.

All populations are threatened to a degree by exotic plant invasion. Populations on Long Pine Key in Everglades National Park are probably the least threatened by exotic plants, because of their isolation and continued management by prescribed fire. Populations in coastal habitats are extremely threatened by invasive plants which constantly colonize via ocean dispersed seeds and can rapidly invade, especially following coastal disturbances such as tropical cyclones.

Fire suppression is a problem at one population in Miami-Dade County at the Deering Estate. The pine rockland area with Garber's spurge has not burned since 1993. Like all pine rockland fragments in Miami-Dade County, it has been impossible to maintain a proper fire cycle at this site. This situation is not likely to change in the near future.

Pine rocklands in the lower Florida Keys, now mostly protected in the National Key Deer Refuge, historically contained populations of Garber's spurge, although this does not seem to be its primary habitat in the keys. It has been collected in pine rockland on Big Pine Key and No Name Key, although no populations are currently known from pine rockland habitat in the Florida Keys. This may be due to the lack of a proper fire regime, compounded with an increase in Key Deer population sizes and subsequent increases in herbivory. Implementation of prescribed fire in the lower Keys, especially in the National Key Deer Refuge, has been a highly contentious issue, with much public opposition. Lack of a proper fire cycle has probably contributed to the dense hardwood and palm understory on islands with pine rockland, and a subsequent reduction in diversity and density of the herb layer, limiting habitat suitability for Garber's spurge.

Sea level rise may soon become a major factor influencing the long-term persistence of populations of Garber's spurge, especially in the Keys and Cape Sable. All of these coastal populations occur at very low elevations, many only meters from the ocean. Sea level rise has been found to be causing a reduction in pine rockland acreage in the lower Keys by Ross et al. (1994), and will have impacts on other types of habitat as well. As described by Wanless et al. (1994), sea level rise will cause drastic impacts to coastal ecosystems in Florida, especially during episodic events like tropical cyclones. Sea level rise will probably degrade much of Garber's spurge's habitat in the Keys and Cape Sable to the extent that it is no longer suitable to maintain populations of the species.

In summary, most populations within the historic range of Garber's spurge are not adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression. This criterion addresses factors A and E.

3. When these sites are managed to maintain the pine rocklands to support Garber's spurge.

Two populations of Garber's spurge are currently known from pine rockland habitat, one in Long Pine Key and the other at the Deering Estate, both sites are in Miami-Dade County. The species has been found in pine rockland in the lower Keys, both on Big Pine Key and No Name Key, but has not been seen in that habitat type in the Keys for many years. Pine rockland habitat in the Keys does not currently seem to be a significant habitat type for the species, although this may be due to heavy predation by Key Deer (see II.C.2.c.), and a lack of regular fires. Instead, populations are found naturally in coastal habitats in the Keys.

Pine rockland on Long Pine Key is well managed. It is burned regularly on a cycle of 1-5 years, mainly in the summer wet season (Cooley 2007b). Exotic plant populations are maintained at a low level by application of prescribed fire. Current management is probably appropriate to maintain populations of Garber's spurge, although without long-term monitoring it is difficult to say this with certainty. It is possible that if fires occur too frequently, then populations of this short-lived species may not have time to recruit and set fruit between fires.

The other pine rockland where Garber's spurge occurs, at the Deering Estate, is not burned regularly. This site is also very susceptible to invasion by exotic plants due to its small size, urban interface, and the lack of regular burning. The last prescribed fire occurred in 1993. Under a proper fire regime this property should have burned two or three times since 1993. With a long interval between fires populations of Garber's spurge will probably decline due at least in part to increasing hardwood and palm densities and accumulations of leaf litter. When fires do occur, they will be much more intense than desired because of increased fuel loads. The impact of intense fires on populations of Garber's spurge is unknown. Pine rockland at the Deering Estate may not be managed to ensure the long-term persistence of the species.

In addition to pine rockland habitat, other habitats should be managed for Garber's spurge where it occurs, including dunes and coastal rock barrens. In Everglades National Park at Cape Sable, major infestations of exotic trees and shrubs have been removed, resulting in an herb and graminoid dominated dune and backdune community – ideal habitat for Garber's spurge which is thriving on Northwest Cape. In the Keys, dunes and backdunes on Bahia Honda Key are also kept free of exotic hardwoods and shrubs.

Management of coastal rock barren habitat is currently insufficient. Two coastal rock barrens where the species occurs are privately owned and not managed. The coastal

rock barren in Long Key State Recreation area has undergone some exotic plant control where the major invader is Brazilian pepper (*Schinus terebinthifolius*). Continued control of this species at that site is needed. In addition, hardwoods are encroaching into all coastal rock barrens in the Keys. This successional process is not understood – control of native hardwoods may be needed to maintain habitat for Garber's spurge in coastal rock barrens.

Several Garber's spurge populations occur in non-natural habitats, especially disturbed roadsides and other places with dry rocky fill. In some cases, these populations are mowed regularly. Regular mowing is probably beneficial in preventing encroachment of shrubs and hardwoods which would shade Garber's spurge (Austin et al. 1980). Mowing too frequently, however, would probably eliminate populations if plants could not grow enough to set fruit between cuttings.

In summary, not all sites are adequately managed to ensure long-term persistence of Garber's spurge. Burning practices must be improved at the Deering Estate and pine rocklands in the lower Keys. Coastal rock barrens need to be managed to remove exotic plants and hardwoods. Places where Garber's spurge occurs on disturbed substrates should be mowed infrequently to allow reproduction, and kept clear of hardwoods. This criterion addresses factor A.

4. When monitoring programs demonstrate that populations of Garber's spurge on these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively reproducing at sufficient rates to maintain the population.

An active status survey (Green et al. 2007b) has shown that populations exist throughout the species' historic range. However, past data are insufficient to determine population trends on sites where the species occurs. Only two small monitoring programs are in existence, one at the Deering Estate at Cutler and one on Long Pine Key in Everglades National Park.

In 2004 Jennifer Possley of Fairchild Tropical Botanic Gardens surveyed the Deering Estate. She estimated a population size of 100-200 plants. This differs from previous estimates of 250-500 (Department of Environmental Resources Management [DERM] 1993) and 600-6,000 (Herndon 2002). The station may be surveyed again in 2007.

In 2005 Hillary Cooley tagged 30 Garber's spurge plants to observe the effects of a planned fire at Deer Hammock, Long Pine Key, Everglades National Park. She then re-sampled the station 4 months after a prescribed burn (Cooley 2007a). She found only 21 of the 30 plants, and 15 of these resprouted after the fire. These plants will be revisited in 2007. The population on Long Pine Key has apparently undergone a dramatic expansion. Historically, the species was known only from the Deer Hammock area in Pine Block A, where it was discovered by George Avery in 1977 (DERM 1993). In 2005 Cooley (2007c) discovered a population to the north in Pine

Block B. Surveys in 2006 revealed that at least 100,000 plants occur in Block B (Green et al. 2007a). Alan Herndon (Tradewinds Tropicals, Inc., pers. comm. 2007) formerly spent a great deal of time conducting a variety of vegetation sampling studies throughout Block B and never saw the species there. This indicates a recent, dramatic population increase on Long Pine Key. Because of the number of plants, geographic size, favorable management activities, and distance from the coast, this is probably the only well-secured population of Garber's spurge in existence.

There is no population of Garber's spurge that is or has been consistently monitored for more than a 2-3 year period. The two populations that were monitored were both in pine rockland habitat in Miami-Dade County. No monitoring has occurred outside of Miami-Dade County or in other habitat types. The first comprehensive status survey that will establish a full list of formerly and currently know sites and population sizes was initiated in 2006 (Green et al. 2006). This status survey should serve as a starting point for further monitoring.

Factor C is not relevant to this species.

II.C. Updated Information and Current Species Status

II.C.1. Biology and Habitat

II.C.1.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: Garber's spurge is currently known from about 17 populations, including two in Miami-Dade County, and one at Cape Sable (on two Capes) and on 14 islands in the Keys in Monroe County (Bahia Honda Key, Big Torch Key, Boca Grande Key, Crawl Key, Key Largo, Cudjoe Key, Fat Deer Key, Grassy Key, Long Key, Long Point Key, Lower Matecumbe Key, Marquesas Keys, Sugarloaf Key, Summerland Key). Some islands contain more than one colony. The species formerly occurred on at least twice as many islands in the Keys, across a wider range of the Miami-Rock Ridge in Miami-Dade County, and formerly ranged more widely on Cape Sable (Green et al. 2006, 2007a, 2007b).

Numbers of individuals in populations vary widely. Some populations have fewer than twenty plants (e.g., Crawl Key rock barren, Cudjoe Key, Key Largo, Lower Matecumbe Key). Two populations are extremely large. On Northwest Cape Sable there may be over 1 million plants (Green et al. 2007b). On Long Pine Key there may be over 100,000 plants (Green et al. 2007a). The total range-wide population size has not yet been determined.

Population trends on sites where the species occurs are not known. The species is very short lived (Herndon 1998, 2002) and can have very wide population fluctuations, making determinations of long-term trends difficult

even with good survey data. The large number of plants at Cape Sable, in particular, may be due to a combination of a fire which occurred there in 2004 and the scouring of the beach during Hurricane Wilma in 2005.

At the Deering Estate, DERM (1993) reported a population size of 250-500 plants based on four days of searches specifically for this species. Herndon (2002) estimated a population size of 600-6,000 plants. In contrast, Possley (2007) guessed that only 100-200 plants were present in 2004. Neither the Herndon nor Possley estimates were based on thorough surveys, so it is impossible to state with certainty any trends based on these data.

Herndon reported mortality and recruitment rates at two sites (1998, 2002). At the Deering Estate, where he reported a stable population, he found annual recruitment rates of 0.20-0.50 plants/initial plant and annual mortality rates of 0.11-0.50 plants/initial plant in a 3 year period.

The population on Long Pine Key has apparently undergone a large expansion. Historically, the species was known only from the Deer Hammock area in Pine Block A, where it was discovered by George Avery in 1977 (DERM 1993). In 2005 Cooley (2007c) discovered a population to the north in Pine Block B. Surveys in 2006 revealed that at least 100,000 plants occur in Block B (Green et al. 2007a). Alan Herndon (pers. comm. 2007) formerly spent a great deal of time conducting a variety of vegetations sampling studies throughout Block B in the 1980s and never saw the species there. This indicates a recent, large population increase on Long Pine Key.

In summary, while Garber's spurge occurs nearly throughout its historic range, there have been population extirpations nearly throughout. It only occurs on at most half of the islands in the Keys where it once occurred, is no longer known from Collier County, and occurs on only one small forest fragment on the northern Miami-Rock Ridge where it formerly ranged much more widely. A notable exception is a large population increase on Long Pine Key. There are insufficient data to report population trends at most sites.

II.C.1.b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding): No genetic studies have been conducted. Herndon (1993) reported morphological variation as "three major groups with different pubescence patterns." It is unknown if this variation has a genetic basis.

II.C.1.c. Taxonomic classification or changes in nomenclature: The currently accepted nomenclature followed here and by Wunderlin and Hansen (2004) is from Herndon (1993). Herndon's treatment differs from that of John Kunkel Small (1903), and Derek Burch (1965, 1966). Daniel Austin (undated) expressed skepticism over Herndon's 1993 treatment, preferring to

follow that by Burch (1965). The U.S. Department of Agriculture, Resources Conservation Service [NRCS] (2007) differs slightly from Herndon (1993).

According to Herndon (1993), *C. garberi* consists of all hairy-capsuled plants in the *C. garberi/C. porteriana* complex – mostly erect plants with cyathia that are solitary in the leaf axils and thick leaves with entire margins. This treatment therefore includes variants that have been described as *C. adicioides* Small, *C. brachypoda* Small, *C. keyensis* Small, and *C. mosieri* Small. Burch (1965, 1966) differed by treating *C. keyensis* as a variety of *C. porteriana, C. porteriana* Small var. *keyensis* (Small) Burch. As noted by Herndon (1993), the characters used by Burch to separate the two taxa are probably related to age of plants and habitat, rather than any genetically based traits.

NRCS (2007) lists the taxon *C.* x *keyensis* Small [*garberi* x *porteriana*]. This may be because Herndon (1989), in a very brief abstract, noted that *C. keyensis* Small may be a rare hybrid between *C. garberi* and *C. porteriana*. Herndon (1993) did not discuss hybridization at all, and in 2007 (pers. comm.) did not remember even proposing a hybrid origin of *C. keyensis,* so this may have been a preliminary hypothesis at the beginning of his studies on the *C. garberi/C. porteriana* group. There is currently no evidence that the two species hybridize.

II.C.1.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 current boundaries of the range of Garber's spurge are similar to the historical range of the species, but there have been some contractions. In Miami-Dade County there has been a contraction due to extensive urbanization. While it formerly occurred from the vicinity of the City of Miami south of the Miami River to the Cutler area, only one population is now known from the Cutler area in what is now the Deering Estate. This is a contraction of about 19 kilometers. It is still known from the other historical location in Miami-Dade County, Long Pine Key.

On the Monroe County mainland, the species was historically known from all three Capes on Cape Sable, representing one large population. In surveys in 2006 it was found on only two Capes, Middle and Northwest Capes (Green et al. 2007a). It is unknown if the population on East Cape was only temporarily eliminated by hurricane damage incurred in 2005.

There is one collection from the vicinity of Cape Romano in Collier County made by Olga Lakela in 1967. This station has not been surveyed again, but there have been no additional reports from this station.

In the Keys Garber's spurge still occurs throughout its entire historical range, from Key Largo to the Marquesas Keys. There have, however, been many

locations where it has been extirpated within its historical range. While formerly found on at least 26 islands, it is no longer known from 12 islands where it once occurred, including Big Pine Key, Boot Key, Fiesta Key, Key West, Lignum Vitae Key, Little Duck Key, No Name Key, Ohio Key, Ramrod Key, Upper Matecumbe, Key West, Summerland Key, and possibly Vaca Key[†]. It is currently known from about 14 other islands.

As discussed in II.C.1.a above, the population of Garber's spurge on Long Pine Key has apparently expanded its geographic range and increased in population size.

Mohr (1901) and Small (1903) both report Garber's spurge from Alabama. Mohr's specimens, collected in 1895 and 1896, are actually *C. prostrata* (Ginzbarg 2007). The reports from Alabama are in error.

II.C.1.e. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem): Development throughout the range of the species has reduced the amount of suitable habitat. Habitat conditions where Garber's spurge currently occurs are typically degraded relative to their historical conditions. This is due to a number of factors, including former site clearing and disturbance, exotic plant invasions, fire suppression, and succession due to sea level rise.

On the Miami-Rock Ridge in Miami-Dade County most pine rockland habitat has been lost. Only 1.8% of its original extent exists outside of Everglades National Park. Where Garber's spurge formerly occurred near the northern end of the Ridge, pine rockland habitat has been almost completely eliminated. The species formerly occurred across an approximately 19 kilometer long stretch of the ridge from the Miami River to Cutler, an area of about 10,500 hectares. There is now only about 50 hectares of pine rockland habitat left in this area, about 0.5% of the historical area. Garber's spurge occurs on only one of the 6 pine rockland fragments in this area, at the Deering Estate. This site suffers from fire suppression.

The site where historical conditions probably most resemble historical conditions is Long Pine Key, where active fire management for more than 50 years has served to maintain a pine rockland ecosystem with a sparse hardwood and palm understory and a diverse, dense herb layer. Few exotic plant species are found in the vicinity of Garber's spurge populations here.

In contrast to Long Pine Key, pine rockland habitat at the Deering Estate has not been burned on a regular basis, and now have a denser hardwood and palm understory than desired, resulting an in sparse herb and grass layer.

[†] Reported in 1906 as Vaca Keys, which could also refer to Boot Key, Fat Deer Key, Long Point Key, or other nearby islands.

Many exotic and weedy plant species are common in the habitat despite ongoing exotic plant control programs by Miami-Dade County.

On Cape Sable, vegetation data collected in plots in 2007 in the Garber's spurge population indicate an extremely disturbed habitat, being dominated by ruderal plant taxa such as Spanish-needles (*Bidens alba* var. *radiata*), common fingergrass (*Eustachys petraea*), and Crow's-foot grass (*Dactyloctenium aegyptium*) (Green et al. 2007b). Cape Sable has a long history of disturbance, starting with construction of two forts in 1838 and the 1850s, and subsequent grazing and farming attempts which occurred until the establishment of Everglades National Park (Tebeau 1968). In 2005, the storm surge during Hurricane Wilma swept over all three Capes, severely scouring the vegetation and depositing large debris lines.

Populations of Garber's spurge in the Keys historically occurred on beach dunes, coastal rock barrens, hammock edges and canopy gaps, and to a lesser extent pine rockland. Ecosystems throughout the Keys have suffered from a wide variety of disturbances since permanent settlement began in 1821. Extensive hammock areas were cleared for agriculture and timber; buttonwood communities were logged for charcoal; fresh water lenses have contracted or degraded due to wells, drainage, and sea level rise; exotic plants have invaded all habitats; pine rocklands have been altered due to fire suppression; and large areas have been destroyed by road building, housing and commercial development. Garber's spurge in part has responded positively to disturbance on some islands, but not enough to mitigate for population reduction due to the above disturbances.

Many populations of Garber's spurge are found in highly disturbed locations, such as the dry rocky roadsides in the Grassy Key area, and the edge of an abandoned marina on Key Largo. Other populations have been found in similar situations. In contrast to populations in naturally undisturbed habitats, these "ruderal" populations are typically very small, and probably do not persist long-term in many cases. This is probably because the disturbed areas may get mowed, bulldozed, sprayed with herbicide, or suffer from other disturbances, so populations do not have the opportunity to persist, and if they do, seldom become large.

Natural habitats where Garber's spurge currently occurs in the Keys are typically altered relative to historical conditions. Coastal rock barrens have all been invaded by exotic plants, especially Brazilian pepper. In addition, these rock barrens may also be undergoing succession to hardwood communities for unknown reasons – successional processes in this ecosystem are not understood and may be related to periodic storm events. Beach dune habitats have been lost due to development, and those that do exist and have Garber's spurge have been invaded by a variety of exotic plants and have constant pressures from trampling due to beachgoers.

II.C.1.f. Other: Herndon (2002) conducted production, germination, cultivation, and reintroduction experiments with Garber's spurge. He found a peak in seed production during the wet months of summer, although there was seed production throughout the year. In seed germination experiments in the field (at the Deering Estate) most germination occurred in the winter and early spring. Most seeds that were sown did not germinate. Of those that did germinate, there was heavy attrition and slow growth. Few seedlings survived more than 2 months. The largest seedling observed in the second year of the study was only 3 centimeters tall.

In Herndon's cultivation experiments, seeds germinated within 2 weeks in a commercial potting mix. Of the seeds that were sown, 25-70% germinated. Cyathia were produced within one month on some plants, and some capsules had matured 6 weeks after sowing. Plants began to decline 13 weeks after sowing. All plants that were grown from the original sowing were dead the year after the start of the experiment (exact months were not reported). Seedlings became common in the original pots, and they were most robust in the summer months. The study was not conducted for a long enough period to determine if Garber's spurge has a persistent seed bank.

Herndon suggested that large numbers of seeds were probably necessary to establish a new population due to the poor recruitment rates in the field experiments and heavy attrition of seedlings under greenhouse conditions.

It can also be extrapolated from Herndon's experiments that new recruits take a minimum of 6 weeks under ideal conditions to produce seed. The time in the field is probably longer. In managing populations that occur on roadsides, mowing should probably occur at intervals of no less than two months to allow juveniles to grow large enough to set seed, although more studies are needed with established populations to verify this.

There are conflicting reports on the direct influence of fire on live plants in the pine rockland ecosystem. Herndon (1998, 2002) reported that plants are killed by fire. Cooley (2007a) found that plants can survive fires. In a study of 30 plants she tagged prior to a prescribed fire, she was able to relocate 21 tags. Of the 21, 15 were attached to live, healthy, plants which probably resprouted after the fire. At the other 6 tags there were no plants, meaning they were probably killed by the fire.

Fairchild Tropical Botanical Garden and the Center for Plant Conservation have begun to establish an *ex-situ* collection of seeds of Garber's spurge from Everglades National Park (Wendelberger and Maschinski 2006). Seeds have been collected from 360 individuals on Long Pine Key and Cape Sable.

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

II.C.2.a. Present or threatened destruction, modification or curtailment of its habitat or range: Development is a concern for this species mainly in the Keys. All populations known from the mainland are in conservation areas. Plants do occur on private properties in the Keys, and there is no legislation that does more than discourage development where Garber's spurge occurs. It is likely that populations exist on private properties that will not be discovered, and that will be developed without knowledge of their existence.

Because most known populations occur in conservation lands, direct habitat modification on public lands is rare. Lack of management on public conservation lands is often a problem. Management activities are apparently successful in Everglades National Park, Bahia Honda State Park, and Key West National Wildlife Refuge. Other sites, however, even on some public conservation lands including the Deering Estate, Long Key State Park, and Lignumvitae Key Botanical State Park, are threatened by fire suppression and/or exotic plants that have been managed insufficiently. Garber's spurge may have become extirpated from pine rocklands in the National Key Deer Refuge on Big Pine Key and No Name Key due in part to fire suppression.

II.C.2.b. Overutilization for commercial, recreational, scientific, or educational purposes: Populations on dunes have the potential to be threatened by trampling from beach goers. Dune access is currently very restricted on sites where Garber's spurge is present, including Bahia Honda State Park and the Key West National Wildlife Refuge. Thus, recreational access to dunes is currently a minor threat where the species occurs. Other forms of overutilization are not a threat.

II.C.2.c. Disease or predation: There have been no documented cases of disease on Garber's spurge. Dooley (1975) reports Garber's spurge as a food plant of Key Deer (*Odocoileus virginianus clavium*), but the extent of its use was not stated. Dooley did report that the genus *Chamaesyce,* as found in samples from 129 Key Deer rumen, was the most frequent taxon of 164 taxa, and 11th in importance value (frequency x volume).

The Key Deer population increased 240% between 1971 and 2001 (Lopez et al. 2004), and this increase has probably had a significant impact on vegetation in the Key Deer's range, including that in pine rocklands (Barrett & Stiling 2006). If Garber's spurge was an important food plant for Key Deer, it may explain the extirpation of the species on No Name Key and from pine rockland on Big Pine Key. Complicating this, however, is the continued lack of regular burning in pine rockland habitat, which may also be implicated for the demise of Garber's spurge in pine rockland habitat in the lower Keys.

II.C.2.d. Inadequacy of existing regulatory mechanisms: Federal and State laws offer little protection to Garber's spurge. The Endangered Species Act (ESA) only protects populations from disturbances when federal lands or a federal nexus is involved, limiting its usefulness on private lands without a federal permit, loan, etc. Many populations are on Federal lands, but almost all are conservation lands. An exception is a population at the Key West Naval Air Station, where the species is protected by the ESA.

Garber's spurge 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. In practice, the law has little effect on protecting rare plants – property owners are not prohibited from destroying populations of listed plants nor are they required to manage habitats to maintain populations.

Monroe County does require mitigation for impacts to rare plant species, including Garber's spurge. If Garber's spurge is found on a property that is to be developed, the property owner would be required to pay a mitigation fee to the County prior to development. This process will only be effective if Monroe County staff can correctly identify the species and distinguish between it and other *Chamaesyce* species, and even then it does not protect the species' habitat.

II.C.2.e. Other natural or manmade factors affecting its continued existence: Sea level rise will become a major factor influencing Garber's spurge in coming decades. With the exception of the population on Long Pine Key, which is about 27 kilometers from the coast at an elevation of about 1.5 meters, all populations are no more than 1 kilometer from the coast, and often only meters from it. Although elevation surveys have not been done at any population location, populations typically occur at elevations that are probably less than 0.5 meters. Recent estimates for sea level rise through the year 2100 range from 28-34 centimeters (Church and White 2006) to 95 centimeters (Wigley and Raper 1992). With estimates averaging 50 centimeters, many populations of Garber's spurge will likely be lost by 2100.

Because some populations are very small, such as those on Crawl Key, Cudjoe Key, Key Largo, and Lower Matecumbe Key, they are subject to extirpation. These populations could become extirpated due to a number of factors, including natural events such as hurricanes and tidal surges, or manmade factors such as mowing or herbicide application.

II.D. Synthesis - The recovery plan for Garber's spurge (Service 1999) contains objective, measurable criteria. While the plan does not contain the most up-to-date data for the species, the recovery criteria are still relevant. Recovery of Garber's spurge will be achieved when populations are protected from habitat loss, degradation, exotic plant invasion, and fire suppression. One recovery criteria that should be modified states that sites must be managed

to maintain pine rocklands to support Garber's spurge. Because pine rockland is not the primary habitat for the species in much of its range, this criterion should be updated to additionally require that dunes, coastal grasslands, and coastal rock barrens be managed to support the species.

Garber's spurge is still found nearly throughout its historical range. It has been extirpated from Collier County and part of Miami-Dade County. Within its historical range many stations where it once occurred have been lost. It probably occurs on less than half of the islands where it once occurred in the Florida Keys. Some populations are very small and are thus threatened with extirpation due to their small sizes. Examples include Cudjoe Key with 1 plant, Lower Matecumbe Key with 10-20 plants, the Crocodile Lake National Wildlife Refuge on Key Largo with 10-20 plants, and Crawl Key with fewer than 10 plants. Two populations are large, with probably over 1 million plants on Cape Sable and over 100,000 plants on Long Pine Key. There have been insufficient studies to determine long-term population trends on any site. At most sites where Garber's spurge does occur, management is insufficient to ensure long-term persistence of the species. All sites are threatened by exotic plant invasions. Populations on private properties and disturbed sites on public properties are threatened with development and other non-natural disturbances.

Sea level rise threatens most populations of Garber's spurge. Only one population is far enough inland and at a high enough elevation to be sufficiently protected over the next 100 years from sea level rise and increased flooding due to tropical cyclone tidal surges. Many populations which occur at elevations of less than 0.5 meters may be lost by the year 2100 if forecasted rates of sea level rise are correct.

Little has been done to implement recovery criteria. Privately owned sites where Garber's spurge occurs should be acquired. Management, especially prescribed fires and exotic plant control, should be implemented or improved on sites where it has been insufficient. Where possible, sites where it has been extirpated should be restored if needed and Garber's spurge should be reintroduced. Much more research is needed to determine long-term population trends at sites where the species occurs. Sites throughout the range of the species and in different habitat types should be monitored regularly in perpetuity to determine population trends. These data will help to determine if implementation of recovery criteria are successful. Because of insufficient acquisition, management, and the threat of sea level rise, Garber's spurge continues to meet the definition of threatened under the ESA.

III. RESULTS

III.A. Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*

_X__ **No change is needed**

III.B. New Recovery Priority Number

III.C. If a reclassification is recommended, indicate the Listing and Reclassification Priority Number (FWS only):

Reclassification (from Threatened to Endangered) Priority Number: ____

Reclassification (from Endangered to Threatened) Priority Number: ____

Delisting (Removal from list regardless of current classification) Priority Number: ___

IV. RECOMMENDATIONS FOR FUTURE ACTIONS -

- Acquire privately-owned properties where the species occurs, including coastal rock barrens on Long Key and Crawl Key.
- Where present on roadsides, maintain an infrequent mowing regime to allow plants sufficient time to flower and disperse seeds. Do not plant turf grasses in or next to roadside populations. Trim hardwoods from edges of population to prevent shading. Communicate these road maintenance guidelines with road maintenance crews.
- Implement a prescribed fire program at the Deering Estate at Cutler with a fire return interval of 3-7 years.
- Ensure that Monroe County regulators can identify Garber's spurge to ensure that developers pay proper mitigation fees when applying for building permits.
- Continue or initiate exotic plant control at all populations.
- Initiate long-term monitoring of presence or population sizes of all populations, or at a minimum, at a subset which includes the geographic range of the species and a variety of habitat types.
- Initiate long-term, detailed demographic studies in a subset of populations which includes the geographic range of the species and a variety of habitat types, including pine rockland, coastal habitats, and disturbed areas.
- Reintroduce populations to stations where formerly present.
- Conduct studies of coastal rock barren habitat to determine successional processes and management needs of the ecosystem.
- Remove hardwoods from disturbed area where Garber's spurge occurs at Crocodile Lake National Wildlife Refuge, and use this population as a source of germplasm for reintroductions into natural habitats in the Key Largo area.
- Conduct genetic studies to clarify relationships with *C. porteriana*, determine if patterns of morphological variation reported by Herndon (1993) are genetically based, and determine if inbreeding depression is occurring within any populations.
- Develop population viability and risk assessments for all populations, based on monitoring and demographic studies.
- Conduct seed bank studies to determine longevity of seed bank and viability under different conditions.

- Study relationship of fire to population demography of Garber's spurge in pine rockland and beach dune habitats.
- Conduct elevation surveys on all sites with Garber's spurge to determine potential impacts of sea level rise.
- Searched recently burned pine rocklands in the lower Florida Keys for Garber's spurge
- Study impacts of hurricanes on Garber's spurge populations in coastal habitats

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Garber's spurge (*Chamaesyce garberi*)

Current Classification _____Threatened_____
Recommendation resulting from the 5-Year Review

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

Appropriate Listing/Reclassification Priority Number, if applicable ___

Review Conducted By ____Keith A. Bradley, The Institute for Regional Conservation

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____Date_____

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.

Lead Regional Director, Fish and Wildlife Service

Approve_____Date_____

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

Cooperating Regional Director, Fish and Wildlife Service

_____Concur _____ Do Not Concur

Signature_____Date_____

APPENDIX A: Summary of peer review for the 5-year review of Garber's Spurge (*Chamaesyce garberi*)

A. Peer Review Method: The Service conducted an influential level of peer review. Recommendations for peer reviewers were solicited from list agencies/organizations. Additionally, five? official peer reviewers and three? unofficial peer reviewers were selected by the Service. Eight? peer reviewers were asked to participate in this review. Individual responses were requested and received from each of the peer reviewers.

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments/Report: Peer review comments were minor. They included requests for clarifications on data, additional recommendations for future actions, editorial issues, and a small amount of new ecological data.

Suggestions for future actions were to study impacts of hurricanes in coastal hammocks on the demography of Garber's spurge, study the impacts of fire in dune ecosystems on the species, communicate road maintenance guidelines to road management crews, and search burned areas on Big Pine Key for Garber's spurge. One reviewer stressed the need, already in the recommendations, that all populations should be monitored for presence or population size, and that detailed demographic monitoring is needed for some populations (recommending specifically burned areas and mowed populations). This reviewer also commented that some recommendations may not be of primary importance, citing genetic work as an example.

Two reviewers made comments that included new ecological data or requested clarifications of data. One reviewer noted that a fire burned northwest Cape Sable in 2004, information that was not available when the 5-year review was written. This fire may help explain the large population size of Garber's spurge at that location. Another reviewer requested clarifications of some data that was reported from Herndon (1998, 2002), including clarifying Herndon's use of recruitment rate, mortality rate, and very high turnover. This reviewer also noted that Herndon's studies were collected for an insufficient amount of time to be useful, and requested a couple of other small clarifications in cited data.

Several reviewers noted that since Garber's spurge had become extirpated from pine rockland habitat on Big Pine Key and No Name Key, that past-land management activities may be responsible. One reviewer stressed that the large population increase in Key Deer over the past several decades may be to blame. This reviewer also cited a thesis that was not seen when preparing the review, indicating that Garber's spurge is a food plant of the Key Deer. Two reviewers suggested that a lack of a proper fire regime in the National Key Deer Refuge may also be a factor in the extirpation of Garber's spurge in lower Keys pine rocklands.

D. Response to Peer Review: The service was in agreement with all comments and concerns received from peer reviewers. Nearly all comments were incorporated into the 5-year review form as appropriate. Some spite-specific recommendations were not included, particularly in reference to restoration and reintroduction sites within the National Key Deer Refuge, since this level of specificity was not included in the plan for other sites. An additional recommendation

was made that an ex-situ seed collection be maintained at Fairchild Tropical Botanic Garden because of the threat of sea-level rise. This may be premature since the species currently exists in many populations that are likely to persist for some time before sea level rise starts to push them towards extirpation.