U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Linum carteri* var. *carteri* Small

COMMON NAME: Carter's small-flowered flax

LEAD REGION: 4

INFORMATION CURRENT AS OF: April 2010

STATUS/ACTION:
___ Species assessment - determined species did not meet the definition of endangered or threatened under the Act and, therefore, was not elevated to Candidate status
___ New candidate
_X_ Continuing candidate
___ Non-petitioned
_X_ Petitioned - Date petition received: May 11, 2004
__ 90-day positive - FR date:
__ 12-month warranted but precluded - FR date:
__ Did the petition request a reclassification of a listed species? No
FOR PETITIONED CANDIDATE SPECIES:
a. Is listing warranted (if yes, see summary of threats below)? yes
b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? yes
c. If the answer to a. and b. is "yes", provide an explanation of why the action is precluded. Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for the species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The "Progress on Revising the Lists" section of the current CNOR (*http://endangered.fws.gov/*) provides information on listing actions taken during the last 12 months.

___ Listing priority change
Former LP: ___
New LP: ___

Date when the species first became a Candidate (as currently defined): October 25, 1999

___ Candidate removal: Former LP: ___
___ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
___U – Taxon not subject to the degree of threats sufficient to warrant issuance of a

proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.

___ F – Range is no longer a U.S. territory.

___ I – Insufficient information exists on biological vulnerability and threats to support listing.

___ M – Taxon mistakenly included in past notice of review.

___ N – Taxon does not meet the Act's definition of "species."

___ X – Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Flowering Plants, Linaceae, Flax Family

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Florida, U.S.A.

CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE: Florida, Miami-Dade County, U.S.A.

LAND OWNERSHIP: Varied, see Table 1. There are nine extant occurrences, five on private land (four at-risk, one in conservation), one on public land (non-conservation), and three on conservation land. The largest occurrence is at the U.S. Department of Agriculture (USDA) Subtropical Horticulture Research Station, which is 200 acres (81 hectares [ha]) in size; however, Carter's small-flowered flax is found on only a portion of this area.

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BIOLOGICAL INFORMATION

Species Description: Carter's small-flowered flax is an annual or short-lived perennial herb endemic to Miami-Dade County, where it grows in pine rocklands, particularly in disturbed pine rocklands (Bradley and Gann 1999, p. 70). Bradley and Gann (1999, p. 70) described the species as follows, "Stems erect 23-36 cm [centimeters] tall, commonly branched near the base, puberulent; leaves slender, 18-26 mm [millimeters] long, 0.8-1.2 mm wide, entire, alternate, closely overlapping at the base of the plant, more distant above; stipules with paired dark glands; inflorescence an ascending or spreading cyme; pedicels 4.5-9 mm long in fruit; sepals lanceolate, short-awned, glandular toothed, 3-nerved; petals orange yellow, broadly obovate, 9-17 mm long, quickly deciduous; fruit straw-colored, ovoid, 4.1-4.6 mm long, 3.4-3.7 mm diameter, dehiscing into five two-seeded segments; seeds narrowly ovoid-elliptic, 2.3-2.8 mm long, 1-1.3 mm wide. (Adapted from Rogers 1963 and 1968). In habit and flower the plant closely resembles pitted stripeseed (*Piriqueta caroliniana*) in the Turneraceae."

Taxonomy: "Small (1905) named *Linum carteri* for plants collected by him in Miami-Dade County in 'pinelands between Cocoanut [Coconut] Grove and Cutler' in 1905. Just two years later in 1907 Small put it in a segregate genus, calling it *Cathartolinum carteri*. He followed this treatment again in 1913 and 1933. In a 1963 revision of the genus in eastern North America,

Rogers noted the close relationship of Florida plants to those in the Western United States and renamed the plants as a variety of *L. rigidum*. Small's concept of this taxon included both pubescent and glabrous plants, with or without stipular glands. In a 1968 study of southern Florida plants, Rogers split the taxon into two varieties, calling them *L. carteri* var. *carteri*, and segregating the glabrous plants as *L. carteri* var. *smallii*. He based this division on new genetic data from Mosquin and Hayley (1967) and his own morphological data. *L. carteri* var. *carteri* was treated as endemic to Miami-Dade County, while *L. carteri* var. *smallii* was slightly more widespread in southern Florida. This treatment has been followed by Long and Lakela (1971), Robertson (1971), and Wunderlin (1998)," (Bradley and Gann 1999, p. 70).

The Integrated Taxonomic Information System (ITIS) (2010, p. 1) uses the name *Linum carteri* var. *carteri* and indicates that this species' taxonomic standing is accepted. *Cathartolinum carteri* and *Linum rigidum* var. *carteri* are given as synonyms (ITIS 2010, p. 1). NatureServe (2009, p. 1) uses the name *L. carteri* var. *carteri*. The Florida Department of Agriculture and Consumer Services (FDACS) recognizes the name *L. carteri*, including *L. carteri* var. *carteri* (Coile and Garland 2003, p. 32). In summary, there is consensus that *L. carteri* var. *carteri* is a distinct variety. We have carefully reviewed the available taxonomic information to reach the conclusion that the species is a valid taxon.

Habitat / Life History: Carter's small-flowered flax is found in pine rocklands, particularly those that are scarified or have undergone some sort of soil disturbance (e.g., firebreaks, canal banks, edges of railway beds) (Bradley and Gann 1999, p. 71, 75; FNAI 2007, p. 1-14). None of the known occurrences are from a completely undisturbed pine rockland (Bradley and Gann 1999, p. 71). Bradley and Gann (1999, p. 71) indicated that all documented occurrences are within scarified pine rocklands, in disturbed areas adjacent to or within pine rocklands, or in completely disturbed areas. This species does not tolerate shading or litter accumulation, and therefore may have been excluded from much of its former habitat by fire suppression (Bradley and Gann 1999, p. 71).

The reproductive ecology and biology of this taxon is not well understood, but reproduction is sexual (Bradley and Gann 1999, p. 71). The magnitude and frequency of seed production is unknown; some fruits dehisce in a characteristic 5-parted star pattern, while others never dehisce (Fellows 2002, Appendix D2, p. 1). Preliminary demographic monitoring showed that plant growth is fairly stable from July through October, flowering and fruit production was most abundant in July, and plant survival declined in the fall (Maschinski et al. 2002, p. iv).

Maschinski and Walters (2008, p. 27) studied *in situ* germination and growth-to-maturity of plants growing in the wild at two sites, measuring height, number of branches, number of buds, flowers, and fruit of 32 seedlings. Of the total 32 seedlings tracked, only 6 set fruit (Maschinski and Walters 2008, p. 27). The mean time to set first bud was 197 ± 2.4 days, while mean time to first fruit set was 226 ± 2.3 days (Maschinski and Walters 2008, p. 27). The 226-day growth-to-maturity enables Carter's small-flowered flax to contribute seeds to a next generation in a relatively short period (Maschinski and Walters 2008, p. 28). Once mature, individuals may live one to several years producing multiple fruits (Maschinski and Walters 2008, p. 28). Growth-to maturity may be influenced by season of germination; seeds germinating in the summer may

grow to maturity more rapidly than seedlings that germinate in the fall or winter (Maschinski and Walters 2008, p. 28). Carter's small-flowered flax is capable of flowering throughout the year, but tends to have most abundant flowering and fruiting following rain (Maschinski and Walters 2008, p. 28).

To examine population viability in response to disturbance, long-term demographic studies were initiated in 2003 at a disturbed site, an undisturbed, and later, a site that had both disturbed and undisturbed sections (Maschinski 2006, p. 82; Maschinski and Walters 2007, p. 55). Maschinski (2006, p. 83) reported that Carter's small-flowered flax has typical behavior for an early successional species. Higher densities of plants were found at the mown site where competition with other plants is decreased (Maschinski 2006, p. 83; Maschinski and Walters 2007, p. 56). However, mowing can also eliminate reproduction entirely in very young plants or delay reproductive maturation (Maschinski and Walters 2007, p. 56). Disturbance from mowing was found to result in higher mortality, but greater fruit production (Maschinski 2006, p. 83). Because mowing had been a repeated pressure on one population for more than 50 years, it is possible that mowing is also selecting for plants that can grow and reproduce more rapidly than the disturbed site plants (Maschinski 2006, p. 83). This work confirms, to a degree, the recommendation by Bradley and Gann (1999, p. 71) that "periodic mowing in these areas may partially replace fires, maintaining an open, shrub free understory."

Preliminary models indicated that population viability was greatly affected by reproduction and whether there is a persistent seed bank (Maschinski 2006, p. 83; Maschinski and Walters 2007, p. 56). Fruiting was variable across years and sites, such that there was no clear effect of mowing on fruit production (Maschinski 2006, p. 82; Maschinski and Walters 2007, p. 56). Seedlings and juveniles (non-reproductive) had a higher probability of survival to adult stage at the undisturbed site than at the mown site; however, the mown site had higher reproduction than the undisturbed site (Maschinski 2006, p. 82). Models indicate that transitions from seedling to adult and adult reproduction greatly influence population trajectories (Maschinski and Walters 2007, p. 56). Increasing these vital rates is critical to improving population persistence (Maschinski and Walters 2007, p. 56). Year-to-year variation was found to be extremely high across populations and subject to the unpredictability of weather (Maschinski and Walters 2007, p. 56). Continued monitoring is needed to determine whether disturbance regime has a persistent impact on life history (Maschinski 2006, p. 83).

Historical Range/Distribution: John Kunkel Small and Joel J. Carter first collected this species in 1903 between Coconut Grove and Cutler (Gann et al. 2002, p. 463). Bradley and Gann (1999, p. 70) indicated that it has been found at many widespread locations, from the Coconut Grove area of Miami (latitude 25° 43.8') to southern Miami-Dade County, terminating near SW 280 Street (latitude 25° 30.4'), a range of about 24 miles. Since 1903, Carter's small-flowered flax has been found in pine rocklands from as far north as the Brickell Hammock area to as far south as the Naranja area (Gann et al. 2002, p. 463).

Bradley and Gann (1999, p. 72) believed that several occurrences represented misidentifications - that the plants were either sand flax (*Linum arenicola*) or *L. carteri* var. *smallii*. For example, a previous report of the plant occurring at Homestead Air Reserve Base site is now considered to

be erroneous (K. Bradley, The Institute for Regional Conservation [IRC], pers. comm. 2008). Based upon data from IRC, Carter's small-flowered flax is extirpated from Brickell Hammock (owner unknown) due to development, Charles Deering Estate (owned by Miami-Dade County) for unknown reasons, and the Red Road and 114 Terrace locations (private land) due to development (K. Bradley, pers. comm. 2007). Austin et al. (1980, p. 3) noted that there were four historical sites for this species in a study of southern Florida, including National Key Deer Refuge and Great White Heron National Wildlife Refuge. However, in 1980, Austin et al. (1980, p. 3) found only one site remaining, representing a 75 percent reduction in number of sites, and attributed the reduction to urbanization. Gann et al. (2002, p. 463) indicated that most of the species' habitat has been destroyed.

Current Range/Distribution: Carter's small-flowered flax currently exists at nine sites in Miami-Dade County. Based upon Bradley and Gann (1999, p. 74), Gann et al. (2002, p. 463), data from IRC (K. Bradley, pers. comm. 2007; 2008), and data from Fairchild Tropical Botanic Garden (FTBG) (J. Maschinski, FTBG, pers. comm. 2007), this plant is extant at the sites in Table 1. However, two occurrences on private land may be extirpated because most of the site has been destroyed (**) (K. Bradley, pers. comm. 2007).

Table 1. Extant occurrences of Carter's small-flowered flax.

Site	Owner	Occurrence Size	Threats	Habitat
Cocoplum Development	Private	11-100	development	in scarified pine rockland
Gifford Arboretum Pineland	Private	11-100	development	in scarified pine rockland
Old Dixie Pineland (=Keg South Pineland) **	Private	11-100	development, exotic plants	along edges of FEC railway tracks, adjacent to pine rockland
Owaissa Bauer Addition	Miami-Dade County	11-100	fire suppression, exotic plants	in scarified pine rockland
Ponce and Riviera Pineland **	Private	11-100	development	in scarified pine rockland
R. Hardy Matheson Preserve, North Of Snapper Creek	Miami-Dade County	11-100	mountain biking, fire suppression, exotic plants	in disturbed pine rockland
Rockdale	Miami-Dade County	11-100	poor management	in scarified pine rockland
USDA Subtropical Horticulture Research Station	USDA	100-1,000	development, exotic plants	edge of pine rockland
Montgomery Foundation	Montgomery Botanical Center	80	not available	not available

According to Bradley and Gann (1999, p. 74) and Gann et al. (2002, p. 463), Carter's small-flowered flax is known from three conservation lands owned by Miami-Dade County: Camp Owaissa Bauer, R. Hardy Matheson Preserve, and Rockdale Pineland. Bradley (pers. comm. 2005) reported that one site, a scarified pine rockland lot at Ponce and Riviera in Coral Gables has been destroyed; the lot has been cleared and homes are being constructed on the site. The

occurrence at Old Dixie Pineland is likely extirpated since most of the site has been destroyed for construction of a Busway by Miami-Dade County (K. Bradley, pers. comm. 2005, 2007). In 2006, FTBG discovered a new occurrence on property owned by the Montgomery Botanical Center (J. Maschinski, pers. comm. 2006).

The species was not found during a two-year project intended to survey and map exotic and rare plants along Florida Department of Transportation (FDOT) right-of-ways within Miami-Dade and Monroe counties (Gordon et al. 2007, p. 1, 39).

Population Estimates/Status: The total population size is estimated to be between 250-1,800 individuals (See Table 1). Maschinski et al. (2003 p. v; 2004, p. iv) noted that this short-lived perennial has widely fluctuating numbers of individuals. Development, exotic plants, mountain biking, modification to fire regime, mechanical disturbance, and herbicide use were cited as threats (Bradley and Gann 1999, p. 71-74). Since most of the occurrences were not on conservation lands, Bradley and Gann (1999, p. 71) stated that this taxon is in severe danger of extinction. Bradley and Gann (1999, p. 71) indicated that the conservation lands where this species occurs contained only a few dozen plants combined, one of which was damaged by maintenance crews. Since 1999, data from IRC indicates that two additional occurrences may have been extirpated since most of those sites were destroyed (Old Dixie Pineland [=Keg South Pineland] and Ponce and Riviera Pineland) (K. Bradley, pers. comm. 2007). However, one occurrence at the USDA Subtropical Horticulture Research Station, previously thought to have 11-100 plants, was found to have more plants (i.e., at least 100-1,000 or possibly more) (K. Bradley, pers. comm. 2007), and a new occurrence was discovered (Montgomery Foundation) (J. Maschinski, pers. comm. 2006).

The rounded global status of Carter's small-flowered flax is considered to be T1, critically imperiled (NatureServe 2009, p. 1). NatureServe (2009, p. 1) indicates that this taxon is endemic to one Florida county with its preferred habitat including disturbed edges of pine rocklands, a globally imperiled ecosystem. NatureServe (2009, p. 1) states that viability of all remaining occurrences is uncertain due to their small size and isolated nature. The Florida Natural Areas Inventory [FNAI] (2010a, p. 6; 2010b, p. 12) ranks it as G2T1, species imperiled globally, subspecies critically imperiled globally. IRC considers its status as "critically imperiled" (Gann et al. 2001-2008, p. 1). Carter's small-flowered flax is listed as endangered by the State.

THREATS:

A. The present or threatened destruction, modification, or curtailment of its habitat or range. Residential and commercial development and agriculture have drastically reduced the habitat for Carter's small- flowered flax throughout pine rocklands in south Florida. Pine rockland habitat in Miami-Dade County has been reduced to about 11 percent of its natural extent, from 182,780 acres (74,000 ha) to only 20,106 acres (8,140 ha) in 1996 (Kernan and Bradley 1996, p. 2). Outside of Everglades National Park, only about one percent of the Miami Rock Ridge pinelands have escaped clearing and much of what is left is in small remnant blocks isolated from other natural areas (Herndon 1998, p. 1).

Habitat loss continues to occur in this species' range and most remaining suitable habitat has been negatively altered by human activity. As a result, some opportunities exist to conserve this plant on private land in Miami-Dade County, but there is little opportunity to acquire more conservation lands. Conservation of privately-owned pine rocklands in Miami-Dade County is largely a matter of County government cooperation with private landowners, and the County offers incentives for landowners to maintain their natural forest communities (NFCs).

Of the remaining species' occurrences, four are on conservation lands. Bradley and Gann (1999, p. 71) stated that since most occurrences are not on conservation lands, this taxon is in severe danger of extinction. This species is threatened by on-going urban development (NatureServe 2009, p.1), and habitat destruction is a major threat (Gann et al. 2002, p. 463). One occurrence was lost due to development in 2003 (Maschinski et al. 2004, p. v). Any occurrences and suitable habitat remaining on private land are threatened by habitat loss and degradation, and threats are expected to accelerate with increased development. The human population within Miami-Dade County, which comprises the historic and current range for this species and therefore supports all of the remaining occurrences, is currently greater than 2.4 million people, and the population is expected to grow to more than 4 million by 2060, an annual increase of roughly 30,000 people (Zwick and Carr 2006, p. 20). More than half of the known occurrences remain on private land within this County; however, it is likely that this species will be lost from most of these sites, with increased development pressure.

The most important conservation action for this species is to acquire or protect privately owned sites (Bradley and Gann 1999, p. 71; Gann et al. 2002, p. 463). Given the small number of plants at most sites and the species' restricted range, it is not clear that existing occurrences are large enough to persist. Persistence will likely be largely dependent upon conservation of all remaining occurrences on private lands and the implementation and success of management measures on conservation lands, including prescribed fire and exotic plant control.

Climatic changes and sea level rise are major threats to south Florida, including this species and its habitat. The Intergovernmental Panel on Climate Change (IPCC) reported that the warming of the world's climate system is unequivocal based on documented increases in global average air and ocean temperatures, unprecedented melting of snow and ice, and rising average sea level (IPCC 2007, p. 2; 2008, p. 15). Sea-level rise is the largest climate-driven challenge to low-lying coastal areas and refuges in the sub-tropical ecoregion of southern Florida (U.S. Climate Change Science Program [CCSP] 2008, p. 5-31, 5-32). The long-term record at Key West shows that sea level rose on average 0.088 inches (0.224 cm) annually between 1913 and 2006 (National Oceanographic and Atmospheric Administration [NOAA] 2008, p. 1). This equates to approximately 8.76 inches (22.3 cm) over the last 100 years (NOAA 2008, p. 1).

IPCC (2008, p. 28) emphasized it is very likely that the average rate of sea-level rise during the 21st century will exceed that from 1961 to 2003 (i.e., 0.071 inches [0.18 cm] per year), although it was projected to have substantial geographical variability. Partial loss of the

Greenland and/or Antarctic ice sheets could result in many feet (several meters) of sea-level rise, major changes in coastlines, and inundation of low-lying areas (IPCC 2008, p. 28-29). Low lying islands and river deltas will incur the largest impacts (IPCC 2008, p. 28-29). Because dynamic ice flow processes in ice sheets are poorly understood, timeframes are not known; however, modeling indicates that "more rapid sea-level rise on century timescales cannot be excluded" (IPCC 2008, p. 29). According to CCSP (2008, p. 5-31), much of low-lying, coastal south Florida "will be underwater or inundated with salt water in the coming century."

IPCC (2008, p. 3, 103) concluded that "climate change is likely to increase the occurrence of saltwater intrusion into coastal aquifers as sea level rises" and that "sea-level rise is projected to extend areas of salinisation of groundwater and estuaries, resulting in a decrease of freshwater availability for humans and ecosystems in coastal areas". From the 1930s to 1950s, increased salinity of coastal waters contributed to the decline of cabbage palm forests in southwest Florida (Williams et al. 1999, p. 2056-2059), expansion of mangroves into adjacent marshes in the Everglades (Ross et al. 2000, p. 9, 12-13), and loss of pine rockland in the Keys (Ross et al. 1994, p. 144, 151-155). Hydrology has a strong influence on plant distribution in these and other coastal areas (IPCC 2008, p. 57). Such communities typically grade from salt to brackish to freshwater species. Human developments will also likely be significant factors influencing whether natural communities can move and persist (IPCC 2008, p. 57; CCSP 2008, p. 7-6).

The Science and Technology Committee of the Miami-Dade County Climate Change Task Force (MDCCCTF) (2008, p. 1) recognized that significant sea level rise is a very real threat to the near future for Miami-Dade County. In a January 2008 statement, the MDCCCTF (2008, p. 2-3) warned that sea-level is expected to rise at least 3-5 feet (0.9 – 1.5 m) within this century. With a 3-4 foot (0.9 – 1.2 m) rise sea level (above baseline) in Miami-Dade County: "Spring high tides would be at about + 6 to 7 feet; freshwater resources would be gone; the Everglades would be inundated on the west side of Miami-Dade County; the barrier islands would be largely inundated; storm surges would be devastating; landfill sites would be exposed to erosion contaminating marine and coastal environments. Freshwater and coastal mangrove wetlands will not keep up with or offset sea level rises of two feet per century or greater. With a five foot rise (spring tides at nearly +8 feet), Miami-Dade County will be extremely diminished." (MDCCCTF 2008, p. 2-3).

In summary, all known occurrences are at some risk to habitat loss and modification. Extant occurrences on private land are threatened by development. Most occurrences are in low-lying areas and will likely be affected by rising sea level. The threats are ongoing and, therefore, imminent. The magnitude of the threat level of habitat loss from development is high, since most sites are not protected. The magnitude of the threat level of habitat loss from sea-level rise is currently low, but expected to become severe in the future.

B. <u>Overutilization for commercial, recreational, scientific, or educational purposes</u>. None known. However, FTBG states that Carter's small-flowered flax is a member of the *Linum rigidum* complex, and therefore may contain the α--carotenoids leutin and 5,6-monoepoxide

(Robertson 1971 as cited in Fellows et al. 2001, p. 4 and Fellows et al. 2004, p. 96), both of which are hypothesized to reduce the risk of certain cancers (Fellows et al. 2001, p. 4; Fellows et al. 2004, p. 96). At this time, we have no evidence indicating that Carter's small-flowered flax is being used for this purpose. Therefore, we believe that collection for medicinal purposes is not a threat at this time.

C. Disease or predation. None known.

D. The inadequacy of existing regulatory mechanisms. FDACS has designated *Linum carteri*, which includes variety *carteri* and variety *smallii*, as endangered under Chapter 5B-40, Florida Administrative Code. This listing provides little or no habitat protection beyond the State's Development of Regional Impact process, which serves to disclose impacts from projects, but provides no regulatory protection on private lands. Without local or county ordinances preventing the destruction of the plant, conservation does not occur.

Miami-Dade County enacted the Environmentally Endangered Lands Covenant Program in 1979 (Service 1999, p. 3-177). The Miami-Dade Forest Resources Program has regulatory authority over pine rocklands and tropical hardwood hammocks and is charged with enforcing regulations that provide partial protection on the Miami Rock Ridge (Service 1999, p. 3-177). This includes authority over all Natural Forest Communities (NFCs) in the County, including County- and city-owned parcels (Service 1999, p. 3-177). Despite these conservation mechanisms, the species and habitat is still at risk. The threat is imminent and the magnitude of the threat from this factor is high.

E. Other natural or manmade factors affecting its continued existence. Fire is required to maintain the pine rockland community. Periodic fires may be important to this taxon, and the lack of fires in most forest fragments in Miami-Dade County during the last century may be one of the reasons why this taxon occurs primarily in disturbed areas (Bradley and Gann 1999, p. 71-72). Under natural conditions, lightning fires typically occurred at 3 to 7-year intervals. With fire suppression, hardwoods eventually invade pine rocklands and shade out understory species like Carter's small-flowered flax. Fire suppression has reduced the size of the areas that burn, and habitat fragmentation has prevented fire from moving across the landscape in a natural way. Thus, many pine rocklands are gradually becoming tropical hardwood hammocks.

Natural fires are unlikely to occur or will likely be suppressed in the remaining highly fragmented pine rockland habitat in Miami-Dade County. The use of prescribed fire is recommended for this species (Bradley and Gann 1999, p. 71-72; Chafin 2000, NA; Fellows et al. 2004, p. 95-96). Fellows et al. (2004, p. 95) suggested that fire could be beneficial as it creates openings in the habitat, but that the potential for adults to survive from rootstock is unknown. Bradley and Gann (1999, p. 71) recommended that attempts be made to introduce this taxon into intact pine rocklands that have an open, fire-maintained understory. Fire suppression and modification of fire regime are threats to this species; fire suppression threatens Carter's small-flowered flax at three sites on conservation lands (Table 1) (Bradley and Gann 1999, p. 74; K. Bradley, pers. comm. 2007). In addition, fire suppression and lack

of prescribed fire is also a threat on private lands. Private landowners generally do not have the means or desire to implement prescribed fire on their property, and doing so in a fragmented urban environment is difficult and costly.

Exotic plants are a threat at half of the extant sites, including the largest occurrence (Table 1) (Bradley and Gann 1999, p. 72-74; K. Bradley, pers. comm. 2007). Invasive exotic plants, especially Burmareed (*Neyraudia reynaudiana*) and Brazilian pepper (*Schinus terebinthifolius*), threaten Carter's small-flowered flax. Brazilian pepper is the most widespread and one of the most invasive species. If left uncontrolled in a fire-suppressed pineland, it will form a dense single-species canopy almost completely eliminating native vegetation. Earleaf acacia (*Acacia auriculiformis*), natal grass (*Rhynchelytrum repens*), shrub verbena (*Lantana camara*), and tongue tree (*Albizia lebbeck*) are some of the other exotic species in pine rocklands. More species of exotic plants could become problems in the future. In much of south Florida, Old World climbing fern (*Lygodium microphyllum*) is a serious threat. All of these species affect the characteristics of a fire when it does occur, providing fuel for fires that is much hotter than when the main fuel was native pine needle duff. Therefore, with the presence of invasive exotic species, it is uncertain how fire, even under a managed situation, will affect Carter's small-flowered flax. Bradley and Gann (1999, p. 71-72) indicated that the control of exotic plants is one of the most important conservation actions for this species and a critical part of habitat maintenance.

In a recent study to better understand the location and extent of invasive exotic plants and rare native plants along roadways in Miami-Dade and Monroe Counties, 88 of 121 (73 percent) total target exotic plant species were found in at least one road segment (Gordon et al. 2007, p. 10). Of the 16,412 road segments surveyed, 6,264 (38 percent) contained at least one exotic plant species; some segments contained more than one species of invasive exotic plant (and as many as 15) (Gordon et al. 2007, p. 10-11). In Miami-Dade County, the most frequent naturalized invasive exotic plants recorded were Brazilian-pepper, puncture weed (*Tribulus cistoides*), and napier grass (*Pennisetum purpureum*) (Gordon et al. 2007, p. 11).

Carter's small-flowered flax may be threatened by changes in the frequency or intensity of disturbance factors (Maschinski and Bradley 2003, p. 37; Maschinski and Walters 2007, p. 55; 2008, p. 27). Non-compatible management practices are a threat at most protected sites; several are mowed during the flowering and fruiting season (NatureServe 2009, p. 1-2). In some cases, in the absence of fire, periodic mowing can help maintain open, shrub-free understory and provide benefits (Bradley and Gann 1999, p. 71; Maschinski and Walters 2007, p. 56). However, mowing can also eliminate reproduction entirely in very young plants, delay reproductive maturation, and kill adult plants (Maschinski and Walters 2007, p. 56; 2008, p. 28). As with natural levels of herbivory, mowing disrupts the apical meristem and triggers production of additional lateral branches; plants can produce compensatory branches following mowing and live to reproduce at a later time (Maschinski and Walters 2008, p. 28). The impact of mowing can be modified by timing of mowing event, rainfall prior to and following the event, and numbers of plants that have reached reproductive state prior to mowing (Maschinski and Walters 2008, p. 27). Maschinski and Walters (2008, p. 28) recommended adjusting the timing of mowing to occur at least three weeks after

flowering is observed in a population to allow a higher probability of adults setting fruit prior to the mowing event. With flexibility and proper instructions to land managers and ground crews, mowing practices could be implemented in such a way as to scatter seeds and reduce competition with little effect on population reproductive output for the year (Maschinski and Walters 2008, p. 28).

Mountain biking has been identified as a threat at one site (Bradley and Gann 1999, p. 71, 74; K. Bradley, pers. comm. 2007). Fellows et al. (2004, p. 95) indicated that occurrences on protected lands are on road edges, suggesting that the very open habitat created by large scale disturbance is beneficial. Fellows et al. (2004, p. 95) did not recommend that disturbance in the form of roads cease except in cases where the entire occurrence is smothered by plant waste (from mowing or other maintenance) or land slide (from vehicles, bikes).

Based on the small numbers of individuals within the species' narrow range, catastrophic events such as hurricanes or tropical storms may negatively impact the species by altering the vegetation composition or water levels, or simply by creating masses of urban debris that may be disposed of in remnant pinelands (as happened in 1992 with Hurricane Andrew). According to the National Oceanographic and Atmospheric Administration, Miami-Dade County, the Keys, and western Cuba are the most storm-prone areas in the Caribbean so this threat is expected to continue.

Only small and fragmented occurrences of this plant remain. As a result, threats associated with small population size ensue. These include potential vulnerabilities from environmental (catastrophic hurricanes), demographic (potential episodes of poor reproduction), and genetic (potential inbreeding depression) threats. Viable plant populations for small, short-lived herbs may consist of tens of thousands of plants. Although no population viability analysis has been conducted for this species, indications are that existing occurrences are at best marginal, and none are truly viable. Lack of dispersal between occurrences may also be a threat (Fellows et al. 2004, p. 95).

In summary, Carter's small-flowered flax is vulnerable to a wide array of natural and human factors, including: fire suppression, exotic plants, mountain biking, non-compatible management practices, changes in frequency or intensity of disturbance factors, illegal dumping, hurricanes and extreme weather events, storm surges, small and isolated occurrences, and restricted range. These threats are imminent. The magnitude of these threats is high for all of them except mountain biking, which is low.

CONSERVATION MEASURES PLANNED OR IMPLEMENTED

In 1979, Miami-Dade County enacted the Environmentally Endangered Lands Covenant Program, which reduces taxes for private landowners of pine rocklands and tropical hardwood hammocks who agree to not develop their property and manage it for a period of 10 years (Service 1999, p. 3-177). Miami-Dade County also purchases NFCs, including tropical hammocks and pine rocklands. The Miami-Dade Forest Resources Program has regulatory authority over pine rocklands and tropical hardwood hammocks and is charged with enforcing regulations that provide partial protection on the Miami Rock Ridge (Service 1999, p. 3-177).

This includes authority over all NFCs in the county, including county- and city-owned parcels (Service 1999, p. 3-177). In cooperation with the Service and IRC, Miami-Dade County funded a project to map the existing NFCs and inventory rare and sensitive plants species on these lands. This project has been completed.

Management options for Carter's small-flowered flax at the Miami-Dade County preserves were assessed by FTBG, and a Conservation Action Plan was developed for this species (Fellows et al. 2001, p. 1-6; 2004, p. 93-97). Population viability is likely to be greatly influenced by the presence or absence of a persistent seed bank, so future demographic monitoring studies by FTBG will include a seed bank analysis, as well as efforts to determine whether the disturbance regime has a persistent impact on this plant's life history (Maschinski 2006, p. 83; Maschinski and Walters 2007, p. 56).

In 2002, FTBG initiated a demographic study to answer basic life history questions (Maschinski et al. 2002, p. 13). In 2003, long-term demographic studies were added where the abundance, growth, and phenology of Carter's small-flowered flax are compared between disturbed and undisturbed sites (Maschinski et al. 2003, p. 2).

In 2005, the Service funded IRC through the Private Stewardship Grant Program to facilitate restoration and management of privately owned pine rockland habitats in Miami-Dade County. Restoration efforts include exotic plant control, light debris removal, hardwood management, and reintroduction of pines. Management plans include recommendations for prescribed burning, debris cleanup, and exotic plant control. This project is fully completed.

In 2007, the Service funded IRC to implement conservation activities associated with three candidate plant species: Carter's small-flowered flax, Blodgett's silverbush (*Argythamnia blodgettii*), and Florida brickell-bush (*Brickellia mosieri*) on pine rockland fragments in Miami-Dade County in private ownership. The objective of this project is to restore suitable habitat and reintroduce and establish new occurrences of the plants in pine rocklands. In 2008, the Service funded IRC to conduct reintroductions of one federally listed endangered plant species and four federal candidate plant species on publicly owned pine rockland preserves in Miami-Dade County. The goal is to increase the number of occurrences of listed and candidate plant species to help implement recovery efforts and decrease risk of extinction. Target species included: Carter's small-flowered flax, deltoid spurge (*Chamaesyce deltoidea* spp. *deltoidea*), Florida brickell-bush, sand flax (*Linum arenicola*), and Florida prairie-clover (*Dalea carthagenensis* var. *floridana*). Reintroductions will attempt to establish new occurrences of each species and increase population sizes. Working with a variety of partners, IRC is making progress with prescribed fire, plant cultivation, and reintroduction to select sites (Bradley et al. 2009, p. 1-9). In February 2009, IRC began cultivation of 49 cuttings and 357 seeds using germplasm obtained from three sites (Rockdale, R. Hardy Matheson, the USDA site) (Bradley et al. 2009, p. 2, 4). In February 2009, a total of three plants had been planted on a private landowner's property (Bradley et al. 2009, p. 3). Plants were monitored and watered on a weekly basis and, because of lack of regular rainfall, watering was increased to twice a week for several weeks until the plants became established (Bradley et al. 2009, p. 3). However, success has been limited, most likely due to drought conditions (Bradley et al. 2009, p. 3). As of May 2009, none of the seeds had

germinated (Bradley et al. 2009, p. 2). In July 2009, IRC successfully conducted its first prescribed fire at the George N. Avery Pineland (K. Bradley, pers. comm. 2009).

The Service's Coastal and Partners for Fish and Wildlife programs are also pursuing similar habitat restoration projects, which could help improve the status of the species. In 2009, $400,000 of stimulus funding was allocated to the IRC for habitat restoration in Miami-Dade County through the Coastal program as part of the Pine Rockland Initiative (D. DeVore, Service, pers. comm. 2010). The Partners for Fish and Wildlife program is also supporting similar habitat restoration projects in Miami-Dade County.

The FDOT collaborated on and funded a study of the approximately 650 miles of FDOT roadway in Miami-Dade and Monroe counties (District 6) (Gordon et al. 2007, p. 1, 3). The study was conducted by The University of Florida, in collaboration with IRC and the FNAI to survey and map exotic and rare native plants along FDOT right-of-ways within Miami-Dade and Monroe counties and to create a database that can be updated to reflect future activities and conditions (Gordon et al. 2007, p. 1, 3).

FTBG maintains an *ex situ* collection to safeguard species from extinction, to provide plants for reintroduction or augmentation, and for use in studies of rare species' biology (Wendelberger et al. 2008, p. 1). In 2005, FTBG collected 448 seeds from its *ex situ* collection (Frances et al. 2005, p. 6). In 2006, FTBG collected seeds (unspecified number) from 36 individuals (from the USDA site) (Wendelberger et al. 2006, p. 1). In 2008, FTBG collected 1,550 seeds (from the USDA site) and 486 seeds (from Rockdale) (Wendelberger et al. 2008, p. 1).

In order to maintain an *ex situ* seed collection, FTBG conducted germination trials to test the effects of different storage techniques on seed viability (Walters and Maschinski 2007, p. 53). All trials produced moderate levels of germination. Storage recommendations are to desiccate, freeze, and send to the National Center for Genetic Resources Preservation (NCGRP) in Fort Collins, Colorado (Walters and Maschinski 2007, p. 53). In 2004, FTBG collected 198 seeds from three sites for storage (Frances 2004, p. 15). In 2005, FTBG collected 697 seeds to send to NCGRP (Frances et al. 2005, p. 6).

SUMMARY OF THREATS

There are nine extant occurrences of Carter's small-flowered flax, located in remnants of its former pine rockland habitat in Miami-Dade County (Table 1) (Bradley and Gann 1999, p. 74; K. Bradley, pers. comm. 2007; 2008). Few occurrences are on protected land. Most remaining occurrences are small and isolated. This species is threatened by habitat loss, which is exacerbated by habitat degradation due to fire suppression, the difficulty of applying prescribed fire to pine rocklands, and threats from exotic plants (Bradley and Gann 1999, p. 70-74; Fellows 2004, p. 95-96; FNAI 2007, p. 283; NatureServe 2009, p. 2). Remaining habitats are fragmented. Climatic changes and sea level rise are long-term threats that will continue; these factors are expected to ultimately reduce the extent of available habitat. Non-compatible management practices are a threat to Carter's small-flowered flax at most protected sites; several sites are mowed during the flowering and fruiting season (NatureServe 2009, p. 2). In the absence of fire, periodic mowing can help maintain open, shrub-free understory and provide

benefits (Bradley and Gann 1999, p. 71; Maschinski and Walters 2007, p. 56). However, mowing can also eliminate reproduction entirely in very young plants, delay reproductive maturation, and kill adult plants (Maschinski and Walters 2007, p. 56; 2008, p. 28). With flexibility and proper management, threats from mowing practices can be reduced or negated. The species is vulnerable to natural disturbances, such as hurricanes, tropical storms, and storm surges. Due to the few remaining occurrences within a restricted range and the small and isolated occurrences, this species is vulnerable to environmental (catastrophic hurricanes), demographic (potential episodes of poor reproduction), and genetic (potential inbreeding depression) threats. We find that this species is warranted for listing throughout all its range, and, therefore, find that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

RECOMMENDED CONSERVATION MEASURES

- Acquire privately owned parcels that support this plant (e.g., Cocoplum) or contain suitable habitat (Bradley and Gann 1999, p. 71; Gann et al. 2002, p. 463; Fellows et al. 2004, p. 96; Gann et al. 2006, p. 1). However, management would be required to benefit disturbance-phyllic species (Fellows et al. 2004, p. 96).
- Prevent further destruction or degradation of existing pine rocklands and adjacent areas (Service 1999, p. 3-191). Acquire available fragments, promote conservation easements and landowner agreements, work with private landowners, and enforce regulatory protection of pine rocklands and adjacent areas that support this species (Service 1999, p. 3-191). Work with partners to designate the area with pine rockland fragments at the USDA site as a conservation area and restore disturbed areas to re-connect the fragments (Gann et al. 2006, p. 1).
- Map and monitor known occurrences on a regular basis (Gann et al. 2006, p. 1).
- Re-establish occurrences or introduce it to intact pine rocklands that have an open, fire-maintained understory (Bradley and Gann 1999, p. 71).
- Use prescribed fire. All pine rocklands adjacent to occurrences of this taxon should be burned periodically (Bradley and Gann 1999, p. 72). In areas that have been suppressed for many years, reintroduce fire in a step-wise fashion, and implement a component for monitoring that captures the health of the community and species that occur in association with Carter's small-flowered flax (Bradley and Gann 1999, p. 72).
- Control exotics in pine rockland through the careful use of manual labor, herbicides, and prescribed fire (Bradley and Gann 1999, p. 72).
- Support the exotics control program in Miami-Dade County. Management of pine rocklands that contain exotics is complicated in fragmented areas bordered by urban development (Bradley and Gann 1999, p. 72); control seed sources, use outreach, and encourage the development of strategies and partnerships to maximize effectiveness.
- Work with land managers and agencies to implement management practices compatible with this species. Minor adjustments to mowing practices at some locations may be beneficial to maintaining suitable habitat conditions.
- Discourage the use of herbicide spraying of canal banks and other areas near this species, which could impact some occurrences (FNAI 2007, p. 283, 285).
- Conduct propagation research and consider introduction to conservation lands (Fellows et

al. 2004, p. 96). Once horticulture methods have been developed, it may be possible to introduce this species to some protected sites (Fellows et al. 2004, p. 96).

- Study the habitat requirements for this species to develop more specific management plans (Fellows et al. 2004, p. 96). Such information will be useful in potentially expanding existing occurrences or improving current habitat conditions (Fellows et al. 2004, p. 96).
- Continue and expand demographic studies to determine the impact of mowing on population growth (Fellows et al. 2004, p. 96).
- Provide instructions to land managers and ground crews about the appearance of this plant while in fruit so that mowing practices do not negatively affect occurrences (Maschinski and Walters 2008, p. 28). Adjust the timing of mowing to occur at least three weeks after flowering is observed; this could allow a higher probability of adults setting fruit prior to the mowing event (Maschinski and Walters 2008, p. 28). Adjust the height of mower so that there is a higher probability that mowing will not kill adult plants (Maschinski and Walters 2008, p. 28).
- In the absence of periodic fire, consider raking forest litter to help recruitment in undisturbed areas where leaf litter may accumulate to an extent that will be detrimental to seedling establishment (Maschinski and Walters 2008, p.28).
- Conduct studies to determine current level of genetic variation remaining in extant occurrences and to assist in management efforts.

LISTING PRIORITY

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	**Imminent**	Monotypic genus	1
		Species	2
		Subspecies/population	**3***
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

Rationale for listing priority number:

Magnitude:

There are nine extant occurrences of Carter's small-flowered flax. Only small and isolated occurrences remain in a restricted range. Habitat loss and degradation due to development is a major threat, as most of the remaining occurrences are on private land or non-conservation public land. Climatic changes and sea level rise are long-term threats that will likely reduce the extent of habitat. Nearly all remaining occurrences are threatened by fire suppression, difficulty in applying prescribed fire, exotic species, or incompatible management practices. Carter's small-flowered flax is vulnerable to natural disturbances, such as hurricanes, tropical storms, and storm surges. Due to the small and fragmented nature of the current population, stochastic events, disease or genetic bottlenecks may strongly affect this species. Although no population viability analysis has been conducted for this species, indications are that existing occurrences are at best marginal and none are truly viable. Lack of dispersal between occurrences may also be a threat. Overall, the magnitude of threats is high.

Imminence: Habitat loss and degradation due to development is a current threat at five occurrences on private or non-conservation public land. These threats are considered imminent. Sea level rise is currently occurring and has resulted in the loss of pine rocklands. However, this is considered a long-term threat since we do not have evidence that it is currently affecting any population. Nearly all occurrences are currently threatened by one or more of the following factors: fire suppression, difficulty in applying prescribed fire, exotic species, or incompatible management practices. However, some efforts are underway to use prescribed fire and control exotics on conservation lands owned by Miami-Dade County. Hurricane Andrew impacted this area in the past, and future hurricanes are expected; this threat is considered imminent. Problems associated with small and isolated occurrences are likely currently occurring. All indications are that Carter's small-flowered flax does not currently exist in sufficient numbers to have viable populations, even if all the sites on conservation lands are well managed. Overall, threats are imminent.

Yes Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed?

Is Emergency Listing Warranted? No, however, status should be carefully monitored. Several occurrences are on public lands. With proper management, some threats to this species can be removed or reduced.

DESCRIPTION OF MONITORING

Monitoring for this species is not actively or regularly conducted at most sites. FTBG is monitoring three sites: Montgomery Botanical Center, USDA Subtropical Horticulture Research Station, and R. Hardy Matheson Preserve (J. Maschinski, pers. comm. 2006). To examine population viability in response to disturbance, long-term demography studies were initiated at a disturbed site and at an undisturbed site in 2003 (Maschinski 2006, p. 82). In 2006, a new site was added to the study that contains both disturbed and undisturbed sections (Maschinski and Walters 2007, p. 55). Additional research is needed to determine whether a disturbance regime has a persistent impact on life history (Fellows et al. 2004, p. 95-96).

The Service completed a project with IRC and Miami-Dade County to map public and many

private NFCs for the County's geographic information system. This project provided a list of plant species for each site. The project enables the County to manage information on pinelands and detect changes in their extent.

COORDINATION WITH STATES

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment: The Service requested new information (observations, data, reports) regarding the status of this plant or any new information regarding threats to this species from: FDACS, NPS, Service (National Wildlife Refuges), Florida Department of Environmental Protection, Miami-Dade County, Florida Fish and Wildlife Conservation Commission, FNAI, IRC, Historic Bok Sanctuary, The Nature Conservancy, FTBG, Archbold Biological Station, NatureServe, University of Central Florida, Florida International University, University of Florida, Princeton, members of the Rare Plant Task Force, botanists, and others. In total, the previous assessment was sent to approximately 200 individuals.

The State of Florida does not specifically list plants in its State Wildlife Action Plan.

Indicate which State(s) did not provide any information or comments: None.

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APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: _____ June 15, 2010
for Regional Director, Fish and Wildlife Service Date

Concur: _____ Date: October 22, 2010
ACTING
Director, Fish and Wildlife Service

Do not concur: _____ _____
Director, Fish and Wildlife Service Date

Director's Remarks:

Date of annual review: April 21, 2010
Conducted by: Paula Halupa, South Florida Ecological Services Office