

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

Scientific Name:

Chromolaena frustrata

Common Name:

Cape Sable Thoroughwort

Lead region:

Region 4 (Southeast Region)

Information current as of:

04/05/2010

Status/Action

☐ Funding provided for a proposed rule. Assessment not updated.

☐ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

☐ New Candidate

☒ Continuing Candidate

☐ Candidate Removal

☐ Taxon is more abundant or widespread than previously believed or not subject

☐ Taxon not subject to the degree of threats sufficient to warrant issuance of

☐ Range is no longer a U.S. territory

☐ Insufficient information exists on biological vulnerability and threats to s

☐ Taxon mistakenly included in past notice of review

☐ Taxon does not meet the definition of "species"

☐ Taxon believed to be extinct

☐ Conservation efforts have removed or reduced threats

Petition Information

☐ Non-Petitioned

☒ Petitioned - Date petition received: 05/11/2004

90-Day Positive:05/11/2005

12 Month Positive:05/11/2005

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing?
Yes

Explanation of why 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 this 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.

Historical States/Territories/Countries of Occurrence:

- **States/US Territories:** Florida
- **US Counties:** Monroe, FL
- **Countries:**Country information not available

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories:** Florida
- **US Counties:** Miami-Dade, FL, Monroe, FL
- **Countries:**Country information not available

Land Ownership:

Varied, see Table 1. The largest population is on Big Munson Island (approximately 100 acres [40.5 hectares (ha)]), which is owned by The Boy Scouts of America.

Lead Region Contact:

ARD - Ecological Services, Rob Tawes, 4046797142, robert_tawes@fws.gov

Lead Field Office Contact:

South Florida ESFO, Paula Halupa, 772-562-3909, paula_halupa@fws.gov

Biological Information

Species Description:

Bradley and Gann (1999, p. 36) described Cape Sable thoroughwort as an “erect fragrant herb 2-10 dm [decimeters] tall with 1-many stems, hirtellous-puberulent [downy or coarse erect hairs] or short spreading hirsute [more or less erect coarse hairs] throughout; leaves opposite, 3-nerved, 1.5-4 × 0.7-2 cm [centimeters] on a slender petiole 4-10 mm [millimeters] long, lance-ovoid to broadly ovate, toothed or subentire; heads in small clusters ending the numerous branches, forming a diffuse inflorescence; involucre 5.5-7.5 (- 8) mm high; bracts strongly imbricate in several series; flowers ca. 20-25 or more, blue or lavender; achenes (3-) 3.5 – 4.0 mm long. (Adapted from Cronquist 1980).”

Taxonomy:

Bradley and Gann (1999, p. 36) provided a complete history of the taxonomy. “Chapman (1886) was the first to report this species in Florida, calling it *Eupatorium heteroclinium*, reporting it for the ‘Keys of South Florida’.” *E. heteroclinium* had been named by Grisebach in 1864, as a species from Jamaica (Bradley and Gann 1999, p. 36). John Kunkel Small also used this specific epithet, but he moved the species to the genus *Osmia* (Bradley and Gann 1999, p. 36). In 1911, Benjamin Lincoln Robinson recognized the plant from the Keys as an endemic, naming it *Eupatorium frustratum*. Small (1913, 1933 as cited in Bradley and Gann 1999, p. 36) called it *Osmia frustrata*. Ledin (1951 as cited in Bradley and Gann 1999, p. 36) also used *Osmia frustrata*. In 1970, R.M. King and H.E. Robinson placed this species in the genus *Chromolaena* (Bradley and Gann 1999, p. 36). Floras by Long and Lakela (1971 as cited in Bradley and Gann 1999, p. 36) and Cronquist (1980 as cited in Bradley and Gann 1999, p. 36) reverted back to *Eupatorium* (which was traditionally treated as a large genus). Wunderlin (1998 as cited in Bradley and Gann 1999, p. 36) used *Chromolaena frustrata*. In summary, this plant has been consistently recognized as a south Florida endemic since 1911.

The Integrated Taxonomic Information System (ITIS) (2011, p. 1) indicates that the taxonomic standing for *Chromolaena frustrata* (B.L. Robinson) King and H.E. Robinson is accepted. Synonyms include: *Eupatorium frustratum* B.L. Robinson and *Osmia frustrata* (B.L. Robinson) Small (ITIS 2011, p. 1). The online Atlas of Florida Vascular Plants (Wunderlin and Hansen 2008, p. 1) uses the name *C. frustrata*. NatureServe (2010, p. 1) and Florida Natural Areas Inventory (FNAI) (FNAI 2011, p. 4) use the name *E. frustratum*. The Florida Department of Agriculture and Consumer Services (FDACS) also uses the name *E. frustratum*, but acknowledges that Wunderlin uses *Chromolaena frustratum* (Coile and Garland 2003, p. 23). We have carefully reviewed the available taxonomic information to reach the conclusion that the species is a valid taxon.

Habitat/Life History:

Bradley and Gann (1999, p. 37) summarized the habitat as follows, “This herb has been observed most commonly in open sun to partial shade at the edges of rockland hammock and in coastal rock barren. It was historically known from coastal berm along the northern edges of Florida Bay. It is often found under other plant species, buffering it from full exposure to the sun. It has not been observed in disturbed areas. Coastal rock barrens are open communities with no tree canopy and a sparse subcanopy of understory hardwoods. Coastal rock barrens are composed of exposed Key Largo Limestone with a diverse assemblage of herbaceous plant taxa, many of which are halophytes.” The ecology of coastal barrens is poorly understood. Periodic storm events may be responsible for maintaining the community (Bradley and Gann 1999, p. 37).

Cape Sable thoroughwort sometimes occurs along the sparsely vegetated edges of rockland hammocks, which abut coastal swamp forest or buttonwood forests (Bradley and Gann 1999, p. 37). In these instances, plants can be found on exposed bare rock or in a light layer of leaf litter in filtered sunlight (Bradley and Gann 1999, p. 37). The species also occurs in buttonwood hammock and the ecotone between buttonwood hammock and coastal hardwood hammock in the southern Everglades (J. Sadle, Everglades National Park [ENP], pers. comm. 2007). Plants have also been observed on black earth mounds in ENP (J. Sadle, pers. comm. 2008a).

Historical Range/Distribution:

The historical range for Cape Sable thoroughwort was the Florida Keys from Key Largo to Boca Grande Key (19 kilometers [12 miles] west of Key West) and the southern mainland from the Cape Sable or Flamingo area to the Madeira Bay area in what is now ENP (Bradley and Gann 2004, p. 2). Bradley and Gann (1999, p. 36) stated that it historically occurred in Monroe County, both on the mainland and the Keys, in Miami-Dade County along Florida Bay, and just inside Collier County along the Turner River.

Mainland (ENP) — Bradley and Gann (2004, p. 3) provided the following history of the species on the mainland. In 1916, John Kunkel Small observed it in a hammock near the west end of Madeira Bay, along the edge of Florida Bay in what later became ENP. In 1921, Small and others collected specimens farther west, in hammocks between West Lake and Flamingo (collection number 9995, New York Botanical Garden herbarium). Bruce Ledin made collections of the species in 1947, one labeled “Cape Sable” and another labeled “Stream Bank, above Cape Sable.” However, the location of Ledin’s collection is uncertain because botanical collectors have used the term “Cape Sable” to refer to the greater Cape Sable/Flamingo region, not just the Cape itself. Avery (1983 as cited in Bradley and Gann 2004, p. 3) observed plants in low hammocks at two locations, along the west side of the Buttonwood Canal north of Bear Lake Road and south of West Lake. Jimi Sadle (pers. comm. 2010) vouchered ENP plants in both Miami-Dade County [Rowdy Bend Trail (2008)] and Monroe County [east of Snake Bight Trail (2007)].

Keys — Bradley and Gann (2004, p. 4) stated, “*C. frustrata* was historically known from nearly the entire range of the Florida Keys, from Key Largo near the upper end, to Boca Grande Key, west of Key West. It has never been found on the islands north of Key Largo in Biscayne National Park, despite extensive survey work . . . It has also never been found west of Boca Grande in the Marquesas or Dry Tortugas, areas that have also been well explored by botanists.”

Bradley and Gann (2004, pp. 4-7) provided the following history for the Keys:

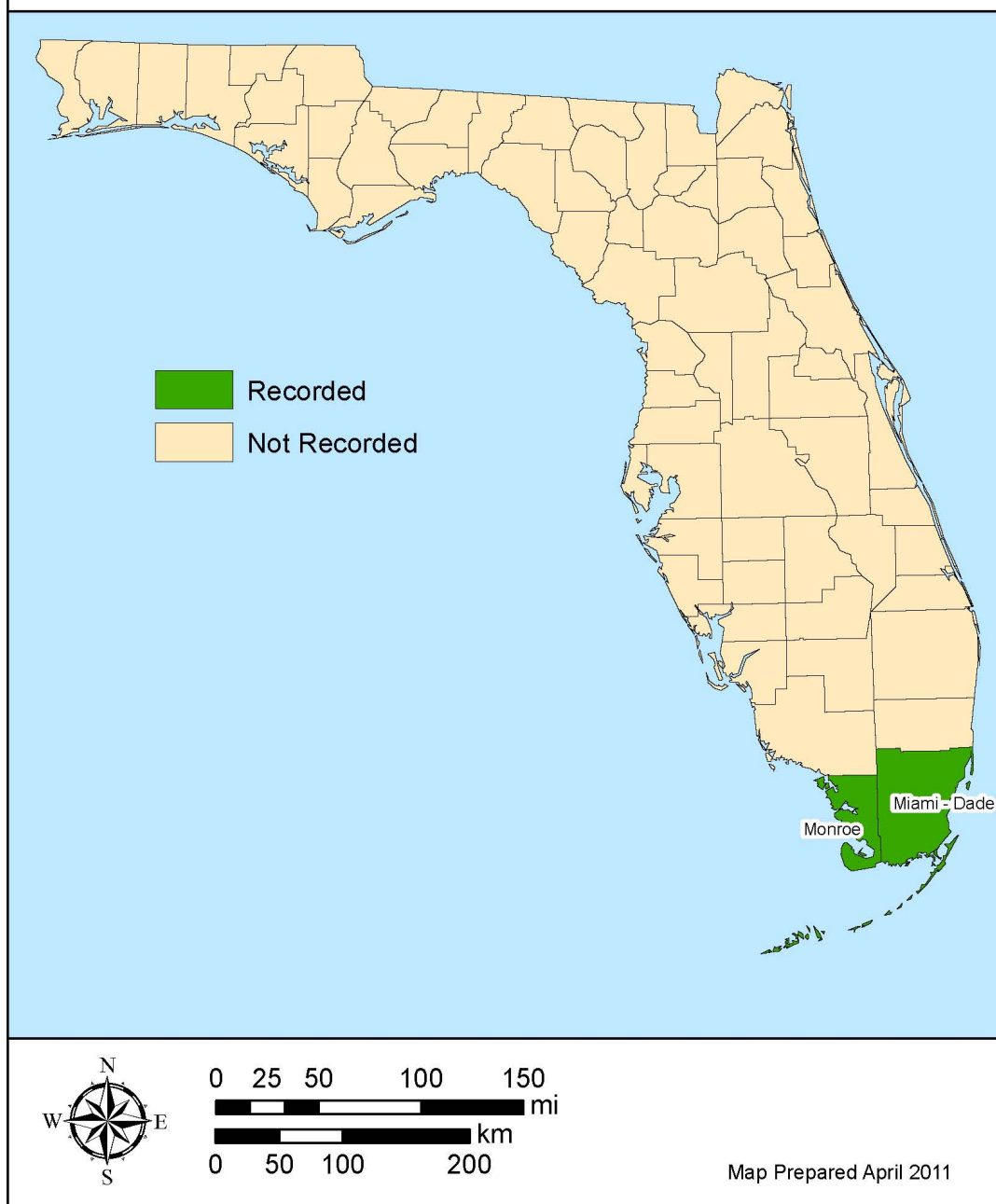
- Big Pine Key — Collected between 1838 and 1853. Another collection, without locality data, was made in 1955. Recent surveys were unsuccessful.
- Boca Grande Key — Collected in 1940, but not seen in 1996. Plants seen in 2003.
- Fiesta Key — Probably collected in 1875 by Alvan W. Chapman. This island is occupied by a campground and is devoid of natural vegetation.
- Key Largo — Northernmost island of occurrence. The species was collected in 1880 (Robinson 1911 as cited in Bradley and Gann 2004, p. 5) and 1930. This large island has undergone extensive disturbance and development, so historic occurrences are likely to have been destroyed.
- Key West — Collected between 1838 and 1853. Only a small fragment of hammock exists at Little Hamaca Park.
- Knights Key — Observed by George N. Avery in 1962. A collection was made in 1979. Residential development occupies the island’s uplands. No suitable habitat remains on the island.
- Lignumvitae Key — Collected in the late nineteenth century. Now part of Lignumvitae Key Botanical State Park, plants still present.
- Long Key — First collected in 1875. Ann Buckley and Ted Hendrickson in 1986 and Keith Bradley in 1995 collected it in a coastal rock barren on the Florida Bay side of Long Key State Park. Plants are still present.
- Lower Matecumbe Key — First collected in 1930. Plants also reported by Janice Duquesnel (Florida Department of Environmental Protection [FDEP], pers. comm. 2005a).
- Upper Matecumbe Key — Collected in 1892. Subsequent collections were made in 1919, 1962, 1968, and by Keith Bradley in 1998. Plants found in 2003.

According to Bradley and Gann (2004, p. 7), numerous reports appear suspect. These include: Roger Hammer 1995 from Greynolds Park, north of Buena Vista in Miami-Dade County; Moldenke 1940 from Buena Vista in Miami-Dade County (collection number 5459) and from “Turner’s River Hammock” in Collier County (collection number 5770); and Small 1933 from hammocks of the Ten Thousand Islands.



U.S. Fish & Wildlife Service

Distribution of Cape Sable Thoroughwort (*Chromolaena frustrata*)



Current Range Distribution:

Bradley and Gann (2004, p. 3) found Cape Sable thoroughwort on five islands in the Keys (Upper Matecumbe Key, Lignumvitae Key, Big Munson Island, Boca Grande, and Long Key) and one small area in ENP. Based upon Bradley and Gann (1999, p. 39; 2004, pp. 3-20), data from The Institute for Regional Conservation (IRC) (K. Bradley, pers. comm. 2007, 2009), and information from ENP (J. Sadle, pers. comm. 2007, 2008a, 2010, 2011a), this plant is extant at the nine sites in Table 1. Information regarding threats at some sites was obtained from Janice Duquesnel (pers. comm. 2005a, 2005b) and Hodges and Bradley (2006, pp. 11, 14, 28).

Table 1. Extant occurrences of Cape Sable thoroughwort.

Site	Owner	County	Population Size	Threats	Post-Hurricane Wilma (populations / habitat)
ENP	National Park Service (NPS)	Miami-Dade	<150	exotic plants	plants initially could not be found after storm, but were later located; habitat altered
ENP, Coastal Prairie Trail	NPS	Monroe	1,500	exotic plants, trail clearing (potential)	6 occurrences found; total population estimated at 1,500 plants; apparent increase
Lignumvitae Key State Botanical Site, Klopp Tract, Lower Matecumbe Key	FDEP	Monroe	10-100 (~81)	exotic plants, trail maintenance, planned development	probable decline in short-term; long-term effect unknown
Long Key Layton Coastal Rock Barren	private	Monroe	100-1,000 (~162)	exotic plants, development	probable decline in short-term; long-term effect unknown / coastal rock barren inundated with salt water
Long Key State Park	FDEP and private land (on acquisition list)	Monroe	100-1,000 (~200+)	exotic plants, development (unacquired parcels only)	probable decline in short-term; long-term effect unknown / rock barren received storm surge
Upper Matecumbe Key	private	Monroe	10-100	exotic plants, development	probable decline in short-term; long-term effect unknown
Big Munson Island	The Boy Scouts of America	Monroe	1000s (several thousand)	herbivory, return of overstory (following Hurricane Georges in 1998), exotic plants, possible development in future (non-imminent)	probable decline in short-term; long-term effect unknown
Boca Grande Key, Key West National Wildlife Refuge	Service	Monroe	25	not assessed	probable decline in short-term; long-term effect unknown
Upper Matecumbe Key, Choate Tract (formerly Teatable Hammock, new addition to Lignumvitae Key Botanical State Park	FDEP	Monroe	18	not assessed (likely exotic plants, maintenance activities, illegal dumping, public use)	probable decline in short-term; long-term effect unknown

ENP — Bradley and Gann (2004, pp. 3-4) searched the Flamingo region but did not visit areas south of West Lake or to Madeira Bay. They observed fewer than 150 plants. Colonies “occurred along the ecotone

between coastal berm and salt marshes dominated by *Conocarpus erectus* and halophytes (e.g., *Sesuvium portulacastrum*, *Batis maritima*, *Salicornia perennis*). At all of the locations where *C. frustrata* was observed, the plants were found in a narrow sub-habitat along the ecotone, in areas of scattered sunlight dominated by *Dicliptera sexangularis* and *Alternanthera flavescens* in the herb layer and by various woody species including *C. erectus*, *Randia aculeata*, *Eugenia foetida*, *Sideroxylon celastrinum*, and *Capparis flexuosa*. *C. frustrata* was found in nearly all of the localities surveyed where this assemblage was found.” (Bradley and Gann 2004, pp. 3-4). “The edges of coastal berms in Everglades National Park have sustained human impacts such as road construction or clearing and exotic pest plant invasions that have probably caused a decline in the number of *C. frustrata* there...” (Bradley and Gann 2004, p. 4). Sadle (pers. comm. 2010) notes that it is highly unlikely that the ENP will build a road through coastal berms now, but that the plant is, ironically, especially abundant along the Coastal Prairie Trail, which is an old cotton road.

The species was not found during a two-year project intended to survey and map rare and exotic plants along Florida Department of Transportation (FDOT) right-of-ways within Miami-Dade and Monroe counties (Gordon et al. 2007, pp. 1, 37).

Population Estimates/Status:

See Table 1. The only large population is on Big Munson Island. Bradley and Gann (2004, p. 7) stated that in the Keys “fewer than 5,000 plants are estimated to exist, with all but about 500 of these present on a single privately owned island.” Two populations in ENP were estimated at 150, but not initially located after Hurricane Wilma (K. Bradley, pers. comm. 2007). Botanists from the IRC, NPS, and Fairchild Tropical Botanic Garden (FTBG) searched following the hurricane, but did not find any signs of either population and noted that the habitat was significantly altered (J. Maschinski, FTBG, pers. comm. 2007). Initially, it appeared that all occurrences of Cape Sable thoroughwort either probably declined or the sites were impacted (e.g., rock barren inundated) due to Hurricane Wilma (K. Bradley, pers. comm. 2007; J. Duquesnel, pers. comm. 2005b). However, it appears that the species is returning to some locations (K. Bradley, pers. comm. 2009).

Jimi Sadle (ENP) and Jesse Hoffman (IRC) conducted surveys for the Cape Sable thoroughwort in various locations between the Coastal Prairie Trail and Monroe Lake in ENP. Six occurrences were recorded with a total population estimate of 1,500 plants (J. Sadle, pers. comm. 2007). The distance between the eastern and westernmost occurrences was 22 kilometers (13.7 miles); plants were found in habitat similar to those described by Bradley (above) as well as in buttonwood forests and the ecotone between aboriginal black earth mounds and salt marsh (J. Sadle, pers. comm. 2007). In addition, three small patches (less than 100 plants total) along the Buttonwood canal in ENP have been relocated; plants are near the location where Bradley had previously found plants and near one of the historical occurrences (J. Sadle, pers. comm. 2008b). A few more locations have been found recently, but the total population estimate and range within ENP remains the same (J. Sadle, pers. comm. 2008a, 2010).

The rounded global status of Cape Sable thoroughwort is considered to be G1, critically imperiled (NatureServe 2010, p. 1). FNAI (2011, p. 4) considers it to be G1, “critically imperiled globally because of extreme rarity (5 or fewer occurrences or less than 1000 individuals) or because of extreme vulnerability to extinction due to some natural or man-made factor.” The FNAI’s element tracking summary data indicated a total of nine element occurrence records in one county, with eight of nine occurrences in management areas (FNAI 2008, p. 4). IRC considers this plant to be critically imperiled (Gann et al. 2002, p. 389). Cape Sable thoroughwort is listed as endangered by the State.

Threats

A. The present or threatened destruction, modification, or curtailment of its habitat or

range:

Most of this species' habitat has been negatively altered or destroyed by human activity. Although this species was found on five Keys in a survey in 2006, sites in Islamorada, Knight's Key, Lower Matecumbe Key, Key Largo, and Key West have been lost due to extensive development (Bradley and Gann 2004, pp. 3-7). Most of the ecosystems on the Keys have been impacted by humans, through widespread clearing of rockland hammocks in the 19th century for farming or building of homes and businesses (Hodges and Bradley 2006, p. 6). Extensive areas of rockland hammock, pine rockland, and other ecosystems have been lost (Hodges and Bradley 2006, p. 6). Bradley and Gann (2004, p. 7) estimated that the Cape Sable thoroughwort has been extirpated from half of the islands where it occurred.

Extant occurrences on private land remain threatened by development (Table 1) (Bradley and Gann 1999, pp. 36, 38-39; Bradley and Gann 2004, pp. 3-20), and habitat destruction is considered a major threat (Gann et al. 2002, p. 387). Any suitable rock barren habitat or rockland hammock on private lands within the species' historic range is threatened by development. Overall, the population in Monroe County is expected to increase from 79,589 people to more than 92,287 (Zwick and Carr 2006, p. 21). All vacant land in the Keys is projected to be developed by 2060, including lands not necessarily accessible by automobile (Zwick and Carr 2006, p. 14).

Prior to Hurricane Wilma, the Cape Sable thoroughwort population was estimated at less than 5,000 plants, with all but 500 present on one privately owned island (Bradley and Gann 2004, p. 7). At this time, we do not believe that this site, owned by the Boy Scouts of America (Big Munson Island), is at risk for development. However, as development pressure and public use needs increase in the Keys, this may change.

In addition, a few occurrences of Cape Sable thoroughwort on public land have been impacted and may continue to be impacted by development with increased public use. In the past, the edges of coastal berms in ENP have been impacted by activities such as road construction or clearing, which have probably caused a decline in the number of plants there (Bradley and Gann 2004, p. 4). Currently, there are no plans to construct roads in suitable habitat in ENP, and all construction and clearing activities within ENP are now reviewed by an interdisciplinary team, including a botanist (J. Sadle, pers. comm. 2007, 2010). However, this is not the case for all public lands. For example, after discovery of Florida indigo (*Indigofera trita* subsp. *scabra* [formerly *Indigofera mucronata* var. *keyensis*]), then a candidate species, at the Klopp Tract, which is part of Lignumvitae Key Botanical State Park (owned by FDEP), a road was constructed through the population for access to new park headquarters and maintenance facilities; additional development is planned (Hodges and Bradley 2006, p. 30). Cape Sable thoroughwort may also be at risk at the Klopp tract because it occurs in the same habitat type.

Climatic changes, including 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, pp. 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, pp. 28-29). Low-lying islands and river deltas will incur the largest impacts (IPCC 2008, pp. 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, pp. 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, pp. 2056-2059), expansion of mangroves into adjacent marshes in the Everglades (Ross et al. 2000, pp. 9, 12-13), and loss of pine rockland in the Keys (Ross et al. 1994, pp. 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. In the Keys, not only are elevation differences between such communities very slight (Ross et al. 1994, p. 146), but the horizontal distances are small as well. 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 Nature Conservancy (TNC) (2010, p. 1) used high-resolution digital elevation models derived from highly accurate Light Detection and Ranging (LIDAR) remote sensing technology to predict future shorelines and distribution of habitat types for Big Pine Key based on sea level rise predictions ranging from the best-case to worst-case scenarios described in current scientific literature. In the Florida Keys, TNC models predicted that sea level rise will first result in the conversion of habitat, and eventually the complete inundation of habitat. In the best-case scenario, a rise of 7 inches (18 cm) would result in the inundation of 1,840 acres (745 ha) (34 percent) of Big Pine Key and the loss of 11 percent of the island’s upland habitat (TNC 2010, p. 1). In the worst-case scenario, a rise of 4.6 feet (140 cm) would result in the inundation of about 5,950 acres (2,409 ha) (96 percent) and the loss of all upland habitat (TNC 2010, p. 1).

Similarly, using a spatially explicit model for the Keys, Ross et al. (2009, p. 473) found that mangrove habitats will expand steadily at the expense of upland and traditional habitats as sea level rises. Most of the upland and transitional habitat in the central portion of Sugarloaf Key is projected to be lost with a 0.2 m-rise in sea level; a 0.5-m rise in sea level can result in a 95 percent loss of upland habitat by 2100 (Ross et al. 2009, p. 473). Furthermore, Ross et al. (2009, pp. 471-478) suggested that interactions between sea-level rise and pulse disturbances (e.g., storm surges or fire) can cause vegetation to change sooner than projected based on sea level alone.

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, pp. 2-3) warned that sea-level is expected to rise at least 3-5 feet (0.9-1.5 meters) within this century. With a 3-4 foot (0.9-1.2 m) rise in 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, pp. 2-3).

All known occurrences of the Cape Sable thoroughwort are in low-lying areas near the coast (Bradley and Gann 1999, p. 38). Jimi Sadle (pers. comm. 2007) believes that sea level rise will ultimately lead to the demise of the species in ENP. Gann et al. (2002, p. 391) identified sea level rise as a major threat to this species. NPS and IRC are collaborating in a funded project to study the impacts of sea level rise on this species in ENP (J. Sadle, pers. comm. 2010). According to Bradley and Gann (2004, p. 4), the impacts of hydrological changes caused by rising sea level, changes in fresh water deliveries, and the construction of the

Buttonwood Canal are unknown. Given the species' narrow range and the small number of individuals that exist, natural and anthropogenic events could extirpate existing populations.

In summary, all known occurrences are at some risk to habitat loss and modification, though we consider losses to residential and urban development to be, in large part, historic. Extant occurrences on private land are threatened by development; some on public land may continue to be impacted by development with increased public use. Habitat loss from development on private lands (at least two sites) is a threat that is both of high magnitude and imminent. All occurrences are in low-lying areas and threatened by rising sea level, though mostly in the future. This threat is of moderate magnitude now, but expected to become severe in the future. Sea-level rise is considered a long-term threat. The threat from changes in freshwater delivery and construction of the Buttonwood Canal is unknown at this time. Overall, the threat of habitat destruction and modification and curtailment of habitat and range is of high magnitude; these threats are considered imminent on private lands, except the property supporting the largest population.

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

None known.

C. Disease or predation:

Bradley and Gann (2004, p. 4) reported that the population on Big Munson Island suffered from severe herbivory, but no insects were observed. We consider this a natural situation and think that plants may be able to periodically withstand this level of impact. Given available information, herbivory does not appear to constitute a threat to the species at this time. We do not have any information on disease.

D. The inadequacy of existing regulatory mechanisms:

FDACS has designated *Chromolaena frustrata* (= *Eupatorium frustratum*) as endangered under Chapter 5B-40, Florida Administrative Code. This listing regulates take without permission of the landowner. It 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 for plants listed by FDACS on private lands. Without local or county ordinances preventing the destruction of the plant, conservation does not occur. Where the species occurs on private land, we consider this threat to be high and imminent. However, for most occurrences, we find this threat to be moderate and non-imminent.

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

Exotic plants are a threat to Cape Sable thoroughwort at nearly all extant occurrences (Table 1) (Bradley and Gann 2004, p. 8; K. Bradley, pers. comm. 2007). *Schinus terebinthifolius* (Brazilian pepper) and *Colubrina asiatica* (latherleaf) are of most significant concern (Bradley and Gann 1999, pp. 37-38; 2004, p. 8). Sadle (pers. comm. 2010) reports that occurrences along Coastal Prairie Trail and habitat within ENP are threatened by latherleaf, Brazilian pepper, and *Thespesia populnea* (portia tree). Brazilian pepper occurs in all habitats where this species occurs and is a serious problem in coastal rock barrens and rockland hammock ecotones (Bradley and Gann 1999, pp. 37-38). Brazilian pepper forms dense thickets of tangled woody stems that completely shade out and displace native vegetation (Langeland and Craddock Burks 1998, p. 54). This can make habitat conditions unsuitable for Cape Sable thoroughwort, which requires open sun to partial shade. Latherleaf is invading large areas of hammocks within ENP along the edge of Florida Bay (Bradley and Gann 1999, p. 37). Latherleaf also forms dense thickets and mats and is of particular concern in coastal hammocks (Langeland and Craddock Burks 1998, p. 122). Bradley and Gann (1999, pp. 37-38) stated that this species

can radically change the structure of hammocks and may be eliminating occurrences of Cape Sable thoroughwort. Without proper control and eradication of these exotics the Cape Sable thoroughwort may become extirpated at some sites.

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, pp. 10-11). In Miami-Dade County, the most frequent naturalized invasive exotic plants recorded were Brazilian-pepper, *Tribulus cistoides* (punctureweed), and *Pennisetum purpureum* (napier grass) (Gordon et al. 2007, p. 11).

In Monroe County, the most frequent invasive exotic plants recorded were Brazilian-pepper, *Leucaena leucocephala* (white leadtree) and punctureweed (Gordon et al. 2007, p. 11). Although exotic plants threaten nearly all remaining occurrences of Cape Sable thoroughwort, paradoxically, removal of exotics can present additional threats. Janice Duquesnel (pers. comm. 2004, 2005a) roped off areas of listed plants at the Klopp Tract of Lignumvitae Key Botanical State Park prior to exotic removal in an area where Cape Sable thoroughwort did not occur. Contractors tasked with removing Brazilian pepper and leadtree used heavy equipment and destroyed numerous individuals of several listed plant species and caused the temporary extirpation of one species (J. Duquesnel, pers. comm. 2004, 2005a). Mechanical removal of exotic or undesirable vegetation with heavy equipment can compact soil and create disturbances that can lead to invasion of fast-growing exotic species. Some mechanical disturbances within ENP such as the construction of Rowdy Bend Trail along the edge of a coastal berm likely impacted Cape Sable thoroughwort, by both clearing habitat and by creating disturbances that later led to exotic plant invasions (Bradley and Gann 2004, p. 4). With limited numbers occurring at most locations, damage to habitat and/or local extirpations can easily occur during exotics control and habitat restoration projects.

Trail maintenance at Lignumvitae Key Botanical State Park is a threat to this species (Gann et al. 2002, p. 391). Cape Sable thoroughwort is now limited to a small area immediately adjacent to an area that is regularly mowed. Gann and Duquesnel were unable to find the species around the site's historic house likely due to regular mowing and "weed-eating" of this area (Gann et al. 2002, p. 391). Similarly, trail clearing activities along the Coastal Prairie Trail could also pose a threat to that population depending on the methods used (J. Sadle, pers. comm. 2010). In 2009, the trail was carefully cleared using hand tools such that no impacts to the plants occurred (J. Sadle, pers. comm. 2010).

Cape Sable thoroughwort is vulnerable to natural events such as hurricanes, which could extirpate existing occurrences or, alternatively, rehabilitate coastal barrens habitat. For example, Bradley and Gann (2004, p. 8) indicated that the population at Big Munson Island may have responded positively to occasional hurricanes or tropical storms (e.g., Hurricane Georges) that thin hammock canopies, providing more light. Similarly, Jimi Sadle (pers. comm. 2007) suggests that the population in ENP may have benefited from hurricanes; some surveys in ENP in 2007 detected more plants than ever previously reported. All communities in which plants were found showed impacts from the 2005 hurricane season, primarily thinning of the canopy and numerous blow downs (J. Sadle, pers. comm. 2007). However, if exotic plants are present at sites when a storm hits, the exotics may respond similarly and become dominant. According to Bradley and Gann (2004, p. 8), this may radically alter the long-term population dynamics for Cape Sable thoroughwort, keeping population sizes small or declining until they eventually disappear.

Storm surges associated with hurricanes result in inundation of habitat with saltwater for varying durations. In 2005, the Keys were impacted by three hurricanes (Katrina, Rita, and Wilma), and vegetation in many areas was top-killed due to salt water inundation (Hodges and Bradley 2006, p. 9). However, there are no definitive data about the long-term effects of storm surges on this species; surges may actually help preserve coastal rock barrens in the long-term (Hodges and Bradley 2006, p. 26). Based upon the best available information, it appears that most occurrences were impacted by Hurricane Wilma and probably declined, at

least in the short-term (K. Bradley, pers. comm. 2007). However, Sadle (pers. comm. 2010) believes that there was an increase in the number of plants following the 2005 storms at least along the Coastal Prairie Trail in ENP. The ability of this species to recover and the effects to the species as a whole over the long-term is not known. The frequency of hurricanes generated in the Atlantic Basin, particularly the frequency of major hurricanes, has increased since 1995. According to the NOAA, Miami-Dade County, the Keys, and western Cuba are the most storm-prone areas in the Caribbean so this threat is expected to continue.

This species appears to be vulnerable to cold temperatures. Some occurrences were burned back by cold snaps in the winter of 2008-2009 (K. Bradley, pers. comm. 2009). Similarly, approximately two weeks of cold temperatures occurred in south Florida in January 2010. Air temperatures dropped to below freezing and reached a low of -2.0° Celsius (28° Fahrenheit) in ENP on January 11, 2010; air temperatures at Royal Palm for the first two weeks of January marked the coldest period recorded over the last ten years (Hallac et al. 2010, p. 1). In general, plants (especially leaves) can be damaged in cold temperatures, particularly when frost / ice forms. Although varying (e.g., none to substantial) amounts of frost damage occurred to different plant species within ENP, the large occurrence of Cape Sable thoroughwort along the Coastal Prairie Trail appeared to have little, if any, damage (Hallac et al. 2010, p. 3). Temperatures in December 2010 were also among the coldest on record within ENP (J. Sadle, pers. comm. 2011b). It is not known to what extent cold temperatures may have affected the species at other locations or what, if any, long-term effect this may have on the population.

For the most part, only small and isolated occurrences of this plant remain in a restricted range. 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. No population viability analyses have been conducted for this plant, but the viability of several small occurrences is questionable.

In summary, the Cape Sable thoroughwort is vulnerable to a wide array of other natural and manmade factors of varying magnitudes. Among these, exotic plants, hurricanes, storm surges, small, isolated occurrences, and restricted range are all of high magnitude and largely imminent, except hurricanes (and related storm surges), which are both historic and imminent. Removal of exotic plants, especially through the use of heavy equipment, is of concern. Depending upon methods used, exotic plant removal and trail maintenance can be threats of moderate magnitude and imminent. Extreme weather events (e.g., extreme cold) are of unknown magnitude.

Conservation Measures Planned or Implemented :

Land purchased for State Parks (FDEP) on Upper Matecumbe Key and Long Key includes populations of this plant in natural habitat. Further acquisition is planned.

Conservation lands with Cape Sable thoroughwort are managed by a variety of entities (Table 1) with various goals and objectives. The Service and the State have supported exotic control programs. Janice Duquesnel (pers. comm. 2005a) indicated that at Long Key State Park Brazilian pepper was removed from the area inhabited by Cape Sable thoroughwort using herbicides and mechanical treatment. Lignumvitae Key Botanical State Park receives exotic plant removal treatments at least quarterly.

The FDOT collaborated on and funded a study of the approximately 1,046 kilometers (650 miles) of FDOT roadway in Miami-Dade and Monroe Counties (District 6) (Gordon et al. 2007, pp. 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, pp. 1, 3).

A study to examine the impacts of sea level rise and salinity on this species in ENP began in 2010 (J. Sadle, pers. comm. 2010, 2011a). This effort will include characterization of habitat (elevation, depth to water table, water table salinity, etc.), study of the plant's ability to tolerate salinity through greenhouse studies, and predictions on the impacts of increased salinity due to sea level rise (J. Sadle, pers. comm. 2010). Information from this study is not yet available (J. Sadle, pers. comm. 2011a).

Summary of Threats :

Based upon available data, there are possibly nine extant occurrences on five islands in the Keys and one small area in ENP. Cape Sable thoroughwort has been extirpated from half of the islands where it occurred (Bradley and Gann 2004, p. 7). Prior to Hurricane Wilma in 2005, the population in the Keys was estimated at roughly 5,000 individuals, with all but 500 occurring on one privately owned island; this island still supports the largest population in the Keys (see Table 1). On the mainland, roughly 1,500 plants or more occur within ENP (J. Sadle, pers. comm. 2007, 2008a, 2010). Cape Sable thoroughwort is threatened by habitat loss and modification, even on public lands, and habitat loss and degradation due to threats from exotic plants at almost all sites (Bradley and Gann 1999, pp. 36-38; 2004, p. 8). Climatic changes, including sea level rise, are major threats that will continue (Gann et al. 2002, p. 391). Low-lying areas will incur the largest impacts (IPCC 2008, pp. 28-29); much of low-lying, coastal south Florida will be underwater or inundated with salt water in the coming century (CCSP 2008, p. 5-31; Ross et al. 2009, p. 473; TNC 2010, pp. 1-36). Since all occurrences are in low-lying areas, all are at-risk from sea-level rise. Potential effects from other changes in fresh water deliveries and the construction of the Buttonwood Canal are unknown. This species is vulnerable to natural disturbances, such as hurricanes, tropical storms, and storm surges. While these factors may also work to maintain coastal rock barren habitat in the long-term, Hurricane Wilma appears to have had severe impacts to this species, at least in the short-term. Occurrences, at most sites, probably declined in the short-term due to inundation of its coastal barren and rockland hammock habitats (K. Bradley, pers. comm. 2007); long-term effects are unknown. Occurrences can be impacted by cold temperatures (K. Bradley, pers. comm. 2009); long-term effects are unknown. Problems (e.g., population loss from hurricanes, potential episodes of poor reproduction, potential inbreeding depression) associated with small population size and isolation are likely major threats; occurrences may not be large enough to be viable. 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.

For species that are being removed from candidate status:

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

Recommended Conservation Measures :

- Acquire the privately owned North Layton Hammock, including area of coastal rock barren and rockland hammock on Long Key (Bradley and Gann 2004, p. 8). Promote conservation easements and landowner agreements, work with private landowners, and enforce regulatory protection at areas that support this species (Service 1999, section 3, p. 191).
- Work with The Boy Scouts of America to manage the rockland hammock on Big Munson Island and limit foot traffic where the plants occur on this island (Bradley and Gann 2004, p. 8).
- Prevent extirpation at Lignumvitae Key Botanical State Park (Gann et al. 2002, p. 392).
- Consider reintroductions to islands where this species has been extirpated (Gann et al. 2002, p. 392, Bradley and Gann 2004, p. 8). Suitable habitat on Big Pine Key was observed in Cactus Hammock within National

Key Deer Refuge and at the north end of Big Pine Key (Bradley and Gann 2004, p. 8). On Key Largo, suitable habitat may exist at John Pennekamp Coral Reef State Park, Dagny Johnson Key Largo Hammocks Botanical State Park, Crocodile Lake National Wildlife Refuge, and Dove Creek Hammocks (Bradley and Gann 2004, p. 8). This species could be introduced to other islands within its historical range between Key Largo and Boca Grande (Bradley and Gann 2004, p. 8).

- Conduct additional surveys on Lower Matecumbe Key and ENP, specifically in suitable habitat between Cape Sable and Madeira Bay, since plants were historically present there (Bradley and Gann 2004, p. 8; J. Sadle, pers. comm. 2007).
- Control exotics through the careful use of manual removal, herbicides, mechanical treatment, or other mechanisms. Avoid heavy equipment, widespread herbicide application, or unsupervised work in areas with this or other imperiled species. Ensure that workers are trained and / or supervised by personnel who can readily identify this and other imperiled species.
- Support exotic species control programs in Monroe County. 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 that are compatible with this species. Minor adjustments to management at some locations may be beneficial to maintaining suitable habitat conditions for this species.
- Resurvey areas impacted by Hurricane Wilma, including Long Key which suffered substantial damage (J. Duquesnel, pers. comm. 2005b).
- Monitor known occurrences on a regular basis (Gann et al. 2002, p. 391).
- Monitor Long Key State Park annually (Bradley and Gann 2004, p. 8). Monitoring would allow detection of changes in population and other vegetation changes in a poorly understood coastal rock barren ecosystem that will help broaden understanding (Bradley and Gann 2004, p. 8).
- Conduct conservation biology and horticulture studies (Gann et al. 2002, p. 392).
- Consider establishing an ex situ collection of germplasm (Gann et al. 2002, p. 392; Ross et al. 2009, p. 477).
- Conduct studies to determine current level of genetic variation remaining in extant occurrences.
- Consider a plan of action to establish a Florida Keys pine rockland core conservation area, in light of anticipated changes due to sea level rise and interactions between sea-level rise and pulse disturbances (e.g., storm surges or fire) (Ross et al. 2009, p. 477).
- Characterize habitats (elevation, depth to water table, water table salinity), examine the plant's ability to tolerate salinity through greenhouse studies, and generate predictions on the impacts of increased salinity due to sea level rise (J. Sadle, pers. comm. 2010).

Priority Table

Magnitude	Immediacy	Taxonmomy	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	Monotype genus	7
		Species	8
		Subspecies/Population	9
	Non-Imminent	Monotype genus	10
		Species	11
		Subspecies/Population	12

Rationale for Change in Listing Priority Number:

Magnitude:

There are possibly nine extant occurrences on five islands in the Keys and one small area in ENP. The Cape Sable thoroughwort has been extirpated from half of the known occurrences in the Keys (Bradley and Gann 2004, p. 7). Prior to Hurricane Wilma in 2005, the population in the Keys was estimated at roughly 5,000 individuals, with all but 500 occurring on one privately owned island (Bradley and Gann 2004, p. 7); this island still supports the greatest number of plants in the Keys. Roughly 1,500 plants occur on the mainland within ENP (J. Sadle, pers. comm. 2007, 2008a, 2010). For the most part, only small and isolated occurrences remain in a restricted range. Habitat loss and degradation due to development are significant threats at a few sites on private land; sites on public land are also at risk to habitat loss and modification. All occurrences are in low-lying areas and at-risk, due to rising sea level. The magnitude of these threats is considered high. Habitat loss and degradation due to exotic plants is a threat at nearly all sites. Removal of exotics and habitat restoration work, depending upon methods, can negatively impact this species and its habitat. The threat of exotics and exotic removal is considered moderate. Incompatible management practices are a problem at one site. Due to its restricted range and few occurrences, Cape Sable thoroughwort is vulnerable to natural disturbances, such as hurricanes, tropical storms, and storm surges; however, this species may also respond positively to hurricanes or other forms of natural disturbance if the disturbance is infrequent and serves to thin the hammock canopy and allow more light to reach the ground (Bradley and Gann 2004, p. 8). Since populations are located in low-lying areas and are very vulnerable to storm surges associated with hurricanes and frequent storms may be detrimental, we consider the magnitude of threat from hurricanes to be high. Plants can be affected by cold temperatures; long-term effects are unknown. Problems (vulnerabilities from environmental, demographic, and genetic threats) associated with small population size and isolation are likely factors. Viability is uncertain; several occurrences may not be large enough to be viable. Overall, the magnitude of threats is high.

Imminence :

At least two occurrences on private land are currently threatened by habitat loss and degradation due to development; the threat from development at these sites is considered imminent. However, habitat loss and modification at most sites (i.e., those on public lands and one private site) is considered non-imminent. Climatic changes, including sea-level rise, are currently occurring. Much of low-lying, coastal south Florida

will be underwater or inundated with salt water in the coming century (CCSP 2008, p. 5-31; Ross et al. 2009, p. 473; TNC 2010, pp. 1-36). Since all occurrences are in low-lying areas, all are at-risk from sea-level rise. Nearly all occurrences are currently threatened by exotic species, removal of exotics, or incompatible management practices. However, some efforts are underway to control exotics on conservation lands. Therefore, threats from exotics are non-imminent. Hurricane Wilma has impacted occurrences in the short-term; long-term effects are unknown. Overall, the threat from hurricanes is considered imminent. Populations are small and isolated. Considering that viable populations of short-lived herbs may be tens of thousands of individuals, and the total population size for this species was thought to be only 5,000 prior to Hurricane Wilma, we believe that threats associated with small population size are likely currently occurring; even the largest occurrence (several thousand individuals) may not be viable. Vulnerabilities from environmental, demographic, and genetic threats associated with small population size and isolation are likely currently occurring. Viability is uncertain. Considering the vulnerability of many of the occurrences to a multitude of frequently occurring threats and the confounding effects of multiple threats acting on any one population with questionable viability, overall threats are imminent.

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

Emergency Listing Review

☐ No Is Emergency Listing Warranted?

No. Population size and overall viability is in question. Occurrences on public lands are insulated from threats such as habitat loss and fragmentation from development. With proper management, some threats to this species can be removed or reduced. There is potential to reintroduce this species to suitable habitat within its range. Climatic changes, including sea-level rise, however, are serious concerns that will be difficult to ameliorate.

Description of Monitoring:

In 2003, the Service funded a project with IRC for a status survey and monitoring of Cape Sable thoroughwort; this project has been completed (Bradley and Gann 2004, pp. 1-20). Monitoring is not being actively or regularly conducted. Jimi Sadle (pers. comm. 2007) is in the process of developing a monitoring program for coastal species in ENP, including Cape Sable thoroughwort. The purpose is to detect changes in rare plant populations due to sea level rise, hurricanes, and other factors. Currently this project is limited due to lack of resources needed for site access (helicopter time), but initial surveys have been carried out in some locations and will continue as resources permit.

Monitoring of plants on State Park properties (FDEP) is conducted every five years. The Service remains in contact with land managers in the Keys.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

Florida

Indicate which State(s) did not provide any information or comment:

none

State Coordination:

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), FDEP, Miami-Dade County, Florida Fish and Wildlife Conservation Commission, FNAI, IRC, Historic Bok Sanctuary, The Nature Conservancy, FTBG, Archbold Biological Station, NatureServe, Miami University, 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. Few comments were received.

The State of Florida does not include plants in their State Wildlife Action Plan.

No new data or comments were received from the State. Information and data previously provided have been incorporated into this assessment.

Literature Cited:

Bradley, K. 2009. Email to Paula Halupa. The Institute for Regional Conservation. Miami, Florida. March 12, 2009.

Bradley, K. 2007. Email to Paula Halupa. The Institute for Regional Conservation. Miami, Florida. March 6, 2007.

Bradley, K.A., and G.D. Gann. 2004. Status survey and monitoring of Cape Sable thoroughwort, *Chromolaena frustrata* (B. L. Rob.) R.M. King and H. Rob. The Institute for Regional Conservation. Final report submitted to the U.S. Fish and Wildlife Service, Vero Beach, Florida.

Bradley, K.A., and G.D. Gann. 1999. Status summaries of 12 rockland plant taxa in southern Florida. The Institute for Regional Conservation. Report submitted to the U.S. Fish and Wildlife Service, Vero Beach, Florida.

Coile, N.C., and M.A. Garland. 2003. Notes on Florida's endangered and threatened plants. Florida Department of Agriculture and Consumer Services; Bureau of Entomology, Nematology, and Plant Pathology—Botany Section. Contribution No. 38, 4th edition.

Duquesnel, J. 2005a. Email to Dave Martin. Florida Department of Environmental Protection. Islamorada, Florida. April 8, 2005.

Duquesnel, J. 2005b. Email to Dave Martin. Florida Department of Environmental Protection. Islamorada, Florida. November 8, 2005.

Duquesnel, J. 2004. Email to Dave Martin. Florida Department of Environmental Protection. Islamorada, Florida. August 2, 2004.

Florida Natural Areas Inventory. 2008. FNAI element tracking summary. Tallahassee, Florida. October 29, 2008.

Florida Natural Areas Inventory. 2011. FNAI element tracking summary. Tallahassee, Florida. April 7, 2011. http://www.fnai.org/PDF/Element_tracking_summary_201103 [Accessed: April 15, 2011].

Gann, G.D., K.A. Bradley, and S.W. Woodmansee. 2002. Rare plants of south Florida: their history, conservation, and restoration. The Institute for Regional Conservation, Miami, Florida.

Gordon, D.R., G.D. Gann, S.E. Green, K.A. Bradley, A.M. Jenkins, and S. Travis. 2007. Mapping of invasive exotic plants and rare native plants on Florida Department of Transportation District 6 right-of-way in

Miami-Dade and Monroe Counties, Florida. Final report to the Florida Department of Transportation District 6 under cooperative agreement 404278-1-32-07. University of Florida, Gainesville, Florida.

Hallac, D., J. Kline, J. Sadle, O. Bass, T. Ziegler, and S. Snow. 2010. Preliminary effects of the January 2010 cold weather on flora and fauna in Everglades National Park. Biological Resources Branch, South Florida Natural Resources Center, Everglades and Dry Tortugas National Parks, Homestead, Florida. February 2, 2010.

Hodges, S.R., and K.A. Bradley. 2006. Distribution and population size of five candidate plant taxa in the Florida Keys: *Argythamnia blodgettii*, *Chamaecrista lineata* var. *keyensis*, *Indigofera mucronata* var. *keyensis*, *Linum arenicola*, and *Sideroxylon reclinatum* subsp. *austrofloridense*. The Institute for Regional Conservation. Final Report Contract Number 401815G011, submitted to U.S. Fish and Wildlife Service, Vero Beach, Florida.

Intergovernmental Panel on Climate Change. 2008. Climate change and water [B.C. Bates, Z.W. Kundzewicz, S. Wu, and J.P. Palutikof, Editors]. Technical Paper of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change Secretariat, Geneva, Switzerland.

Intergovernmental Panel on Climate Change. 2007. Summary for policymakers, In: Climate Change 2007: the Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, Editors]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Integrated Taxonomic Information System. 2011. ITIS standard report page: *Chromolaena frustrata* <http://www.itis.gov/servlet/SingleRpt/SingleRpt> [Accessed April 7, 2011].

Langeland, K.A. and K. Craddock Burks. 1998. Identification and Biology of Non-Native Plants in Florida's Natural Areas. University of Florida. Gainesville, Florida.

Maschinski, J. 2007. Email to Paula Halupa. Fairchild Tropical Botanic Garden. Coral Gables, Florida. May 10, 2007.

Miami-Dade County Climate Change Task Force, Science and Technology Committee. 2008. Statement on sea level in the coming century. January 17, 2008. Miami-Dade County, Florida.

National Oceanographic and Atmospheric Administration. 2008. Sea Levels Online (Mean sea level trend 8724580 Key West, Florida). National Ocean Service, Center for Operational Oceanographic Products and Services. Online [<http://tidesandcurrents.noaa.gov>]. [Accessed October 17, 2008].

NatureServe. 2010. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. <http://www.natureserve.org/explorer> (Accessed: April 8, 2011).

Ross, M.S., J.F. Meeder, J.P. Sah, P.L. Ruiz and G.J. Telesnicki. 2000. The southeast saline Everglades revisited: 50 years of coastal vegetation change. *Journal of Vegetation Science* 11:101–112.

Ross, M.S., J.J. O'Brien, and L. da Silveira Lobo Sternberg. 1994. Sea-level rise and the reduction in pine forests in the Florida Keys. *Ecological Applications* 4:144-156.

Ross, M.S., J.J. O'Brien, R.G. Ford, K. Zhang, and A. Morkill. 2009. Disturbance and the rising tide: the challenge of biodiversity management on low-island ecosystems. *Frontiers in Ecology and the Environment* 7(9): 471–478.

Sadle, J. 2007. Email to Paula Halupa. Everglades National Park. Homestead, Florida. November 29, 2007.

Sadle, J. 2008a. Email to Paula Halupa. Everglades National Park. Homestead, Florida. December 15, 2008.

Sadle, J. 2008b. Email to Paula Halupa. Everglades National Park. Homestead, Florida. February 2, 2008.

Sadle, J. 2010. Email to Paula Halupa. Everglades National Park. Homestead, Florida. January 28, 2010.

Sadle, J. 2011a. Email to Paula Halupa. Everglades National Park. Homestead, Florida. January 31, 2011.

Sadle, J. 2011b. Conversation with Paula Halupa. Everglades National Park. Homestead, Florida. March 17, 2011.

The Nature Conservancy. 2010. Initial estimates of the ecological and economic consequences of sea level rise on the Florida Keys through the Year 2100. The Nature Conservancy, Florida Chapter, Altamonte Springs.

U.S. Climate Change Science Program. 2008. Preliminary review of adaptation options for climate-sensitive ecosystems and resources. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [Julius, S.H., J.M. West (eds.), J.S. Baron, L.A. Joyce, P. Kareiva, B.D. Keller, M.A. Palmer, C.H. Peterson, and J.M. Scott (Authors)]. U.S. Environmental Protection Agency, Washington, DC.

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

Williams, K.L., K.C. Ewel, R.P. Stumpf, F.E. Putz and T.W. Workman. 1999. Sea-level rise and coastal forest retreat on the west coast of Florida. *Ecology* 80:2045–2063.

Wunderlin, R.P., and B.F. Hansen. 2008. Atlas of Florida Vascular Plants (<http://www.plantatlas.usf.edu/>). [S. M. Landry and K. N. Campbell (application development), Florida Center for Community Design and Research.] Institute for Systematic Botany, University of South Florida, Tampa, Florida. (Accessed April 15, 2011)

Zwick, P.D., and M.H. Carr. 2006. Florida 2060. A population distribution scenario for the State of Florida. A research project prepared for 1000 Friends of Florida. Prepared by the Geoplan Center at the University of Florida, Gainesville, Florida.

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:



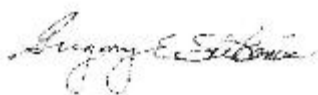
06/22/2011

Date

Concur:

10/07/2011

Date



Did not concur:

Date

Director's Remarks: