Carter's mustard
(Warea carteri)

5-Year Review:
Summary and Evaluation

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

5-YEAR REVIEW
Carter's mustard (*Warea carteri*)

I. GENERAL INFORMATION

A. Methodology used to complete the review: In conducting this 5-year review, we relied on the best available information pertaining to historical and contemporary distributions, life histories, genetics, habitats, and threats of this species. This review includes information from the previous 5-year review (Service 2008) that is still applicable to the species, with updated or new information incorporated, as appropriate. We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period in 2019 (84 FR 14669). We received one public comment during the open comment period. We evaluated and incorporated comments as appropriate in this review. We also used a variety of information resources, including monitoring reports, surveys, and other scientific and management information, augmented by conversations and comments from biologists familiar with the species. Specific sources included the final rule listing this plant under the Endangered Species Act of 1973, as amended (ESA) (52 FR 2227), the Recovery plan (Service 1999) and its amendment (Service 2019), the last 5-year review (Service 2008), peer reviewed scientific publications, and unpublished field observations by Federal, State, and other experienced biologists. The review was contracted to an Archbold Biological Station (ABS) plant ecologist and finalized by the lead recovery biologists for Carter's mustard in the Florida Ecological Services Field Office (FESFO), Vero Beach. Literature and documents used for this 5-year review are on file at the FESFO. All recommendations resulting from this review are a result of thoroughly reviewing the best available information on Carter's mustard. The Service did not seek additional peer review for this updated 5-year review.

B. Reviewers

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C. Background

1. **FR Notice citation announcing initiation of this review:** April 11, 2019, 84 FR 14669.

2. **Listing history:**
   Original Listing
   Federal Register notice: 52 FR 2227
   Date listed: January 21, 1987
   Entity listed: Species
   Classification: Endangered

3. **Associated rulemakings:** There are no associated rulemakings for this species.

4. **Review History:** Each year, the U.S. Fish and Wildlife Service (Service) reviews and updates listed species information to benefit the required Recovery Report to Congress. Through 2013, we performed a yearly recovery data call. The last 5-year status review conducted in 2008 showed this species as stable with no change recommended to the species' status due to the probability of continued populations losses at unprotected sites and the lack of adequate fire management at some existing protected sites.

   Recovery Plan Amendment: September 24, 2019 (84 FR 38291). Amendments to revise the recovery criteria for Carter's mustard.
   Previous 5-year reviews: 1991 (56 FR 56882) and 2008 (84 FR 14669).

5. **Species' Recovery Priority Number at start of review:** 2. A recovery priority number of "2" represents a high degree of threat and high recovery potential.

6. **Recovery Plan or Outline:**
   Name of plan: South Florida Multi-Species Recovery Plan (MSRP) (Service 1999)
   Date issued: May 18, 1999
   Date of amendment to the 1999 MSRP Carter's mustard recovery criteria: September 24, 2019 (Service 2019)
   Dates of previous revisions: January 29, 1990 (Recovery Plan for Eleven Florida Scrub Species) and June 20, 1996 (Recovery Plan for Nineteen Central Florida Scrub and High Pineland Plants).

II. REVIEW ANALYSIS

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

1. Is the species under review listed as a DPS? No. The ESA defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife. Because the species under review is a plant and the DPS policy is not applicable, the application of the DPS policy to the species listing is not addressed further in this review.

B. Recovery Criteria

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

2. **Adequacy of recovery criteria.**

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

    b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? Yes.

3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. **For threats related to recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5 listing factors are not relevant to this species, please note that here.**

The recovery criteria as presented in the 2019 amendment to the recovery plan is broken down into three parts ([1-3] in bold below) for clarity purposes (Service 2019). These criteria address factors A) the present or threatened destruction, modification, or curtailment of its habitat or range; D) inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors affecting its survival. Factors B (overutilization for commercial, recreational, scientific, or educational purposes) and C (disease or predation) are not relevant to this species.

Carter's mustard may be delisted when:

[1] at least 40 populations exhibit a stable or increasing trend, evidenced by natural recruitment and multiple age classes;

There are currently 29 Element Occurrence Records (EORs) of Carter's mustard in the Florida Natural Areas Inventory (FNAI) database and insufficient data to evaluate trends in the known populations. Stable or increasing trends must be observed over several decades, given that Carter's mustard population trends often are cyclic or dynamically changing year-to-year. Demographic data used to analyze population dynamics in Carter's mustard have been collected from three sites, ABS, the Lake Wales Ridge State Forest (LWRSF) Arbuckle Tract, and The Nature Conservancy (TNC) Tiger Creek Preserve (Quintana-Ascencio et al. 2008). Although these data could be used to evaluate population viability in these populations, this has not yet been done. Level 2 demographic data (where densities of plants are tracked over time) are also being collected at the LWRSF Arbuckle and Walk in the Water Tracts (H. Rosner-Katz, LWRSF, pers. comm. 2019) and at Tiger Creek Preserve by TNC (B. Pace-Aldana, TNC, pers. comm. 2020). No work has been done on other

populations. No level 3 monitoring (where individual plants are tracked) is currently occurring (Menges and Gordon 1996). Menges et al. (2019) recommended a combination of Level 2 (tracking counts or densities) and Level 3 monitoring (following individual seeds and plants; Menges and Gordon 1996) but not translocation or captive breeding. Recent declines of Carter's mustard (Pace-Aldana, pers. comm. 2020) emphasize the need for further monitoring.

[2] populations (as defined by criterion 1) in yellow sand scrub or scrubby flatwoods habitats are distributed across the known range of the species;

This species occurs in both sandhill and scrubby flatwoods habitats, but populations are not well distributed across the known range. Protected areas occur across the southern Lake Wales Ridge (LWR) but are sparse in the northern LWR. Schultz et al. (1999) did not detect Carter's mustard at Ferndale Ridge, the northern extent of the species on the LWR. Populations in Miami-Dade and Brevard Counties have been extirpated.

and [3] populations are protected and managed via conservation mechanisms to a degree that enough suitable habitat is present for the species to remain viable for the foreseeable future.

Fire return intervals of 2 to15 years are recommended for Carter's mustard (Menges et al. 2019), and many properties are behind schedule in applying fire. Although prescribed burning is key to the viability of Carter's mustard populations, some populations have not responded well to prescribed burn regimes (see Section C1a below). More detailed and nuanced information is needed to link this species' demography and fire regimes. However, site-specific information and associated analysis of past and planned fire regimes are not readily available. The focus of fire management at these sites should be to maintain scrubby flatwoods and sandhill vegetation, both which require prescribed fire, but at different intervals (Menges 2007). However, there is no consistent monitoring effort to evaluate whether these vegetation types or Carter's mustard are benefiting from the current management regimes.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate), or demographic trends:

Population Sizes and Trends - Carter's mustard populations fluctuate widely from year to year (Menges and Gordon 1996). For burned populations especially, these fluctuations are biennial (peaking every two years) and dampen over time

(Quintana-Ascencio et al. 2008). Fires usually initiate cycles, with the largest population sizes occurring the year following fire. These population cycles are caused by a demographic delay in seed germination (Quintana-Ascencio et al. 2008). Seeds produced in the fall of one year generally enter the persistent soil seed bank, with the first (and largest) pulse of germination in the second winter following seed production. Because fires remove a cohort of plants, a single cycling post-fire cohort will create the damped two-year cycle (Quintana-Ascencio et al. 2008). Along roadsides and in other areas with recurrent disturbances, such cycling may not be evident. Because of these cycles, single-time estimates of population sizes and simple trend analyses cannot provide sufficient information to assess the future dynamics of Carter's mustard populations.

Currently, there are a total of 29 EORs of Carter's mustard in the Florida Natural Areas Inventory (FNAI) database, down from 49 noted in the prior 5-year review. However, this change is not necessarily due to a decline but changes in EOR criteria which combined nearby EORs (FNAI 2020). FNAI records are mainly in the LWR counties of Polk (14 EORs), Highlands (12 EORs), and Lake (1 EOR). Single EORs are in Brevard and Glades counties. The last known observation for the northernmost EOR in Lake County was 1987. The Brevard County EOR was found in 1987 but was first noted as extirpated in 2003. The historical Glades County occurrence was last seen in 1935 (based on herbarium specimens) in what is now Fisheating Creek/Lykes Brothers Conservation Easement, Fisheating Creek Wildlife Management Area.

The overall viability of these EORs is quite variable, with only 3 being potentially excellent, 4 being fair, and 15 being intermediate or difficult to classify. Six EORs are historical and one was noted as extirpated (Brevard County). The majority of EORs have not been observed as extant in at least 20 years (10 EORs last observed in 1989 or earlier, 9 EORs during the 1990s, and 10 EORs since 2004). These data must be interpreted carefully, as many Carter's mustard populations fluctuate widely and may not appear as aboveground plants in many years (Quintana-Ascencio et al. 2008, Rosner-Katz, pers. comm. 2019). Managed sites in the FNAI database include LWRSF (six EORs), ABS (four EORs), Tiger Creek Preserve (two EORs), LWRWEA (two EORs), and seven other managed areas with a single EOR. Six EORs are not associated with a managed area and are probably unprotected. EOR sizes range widely from 0.0156 to 12,341 acres (ac) with a median of 2.81 ac. While the number of EORs in managed areas (23 of 29 or 79 percent) with Carter's mustard has improved since the time of listing, at least six EORs occur on unmanaged sites and their status is largely unknown.

Population sizes of FNAI EORs range widely with large fluctuations from year to year (FNAI 2020). Maximum population size estimates are mainly small (7 EORs with less than 10 plants and 9 EORs with 10 to 99 plants) although some observers noted plants in an EOR were "abundant" or "common". The highest population

sizes are found at Tiger Creek Preserve and have exceeded 1,000 plants in some years (Quintana-Ascencio et al. 2008).

Repeated monitoring of Carter's mustard is being conducted at Tiger Creek Preserve by TNC (Pace-Aldana, pers. comm. 2020). This monitoring has occurred since 1988 with some changes in protocol. The number of patches with at least one individual has dropped from a high of 106 in 2005 to 1 in 2017 and 8 in 2019 (Pace-Aldana, pers. comm. 2020). Some variation in the species' occurrence is due to fluctuations with fire. However, the overall decreasing trend has occurred despite continued burning by land managers at Tiger Creek Preserve. Flooding in some years may have decreased population sizes (Pace-Aldana, pers. comm. 2008). Most areas with Carter's mustard observations before 2010 have not had plants observed during annual checks since that time (Pace-Aldana, pers. comm. 2008).

Carter's mustard has not been sampled in any of ABS's Population Dynamics of Endemic Plants plots and was encountered in only one rare species survey (Menges et al. 2019). However, these surveys have not been targeted for the narrow flowering period of this species.

Staff at LWRSF have been collecting count data from known locations of Carter's mustard since 1995 (with a hiatus from 2004-09). A recent report shows 244 GPS points representing over 1,500 individuals (Rosner-Katz, pers. comm. 2019). However, not all points or individuals have plants in any given year at the LWRSF and it is difficult to discern trends because all points are not visited in all years. The overall trend has been a long-term decline, especially in sites not periodically burned (Rosner-Katz, pers. comm. 2019). In 2018, 394 plants were counted (Rosner-Katz, pers. comm. 2019). Occasional flooding was noted as a possible cause of some of the observed declines (Rosner-Katz, pers. comm. 2019).

In addition to the FNAI database, there are historical records of Carter's mustard from Miami-Dade County (collected 8 to 10 times between 1878 and 1942), where the species is now considered extirpated (K. Bradley, Institute for Regional Conservation, pers. comm. 2008). There was also an unconfirmed sighting at the DuPuis Preserve in Palm Beach County (Gann et al. 2002).

Ecology and Life History - Carter's mustard is an annual plant with seeds that can remain dormant in the soil for decades (Menges and Gordon 1996). Most plants live 12 to 15 months from germination to maturity (i.e., flowering/fruiting) (Weekley et al. 2007). Flowering occurs in September and October and appears to yield more flowers per plant in open and recently burned areas (Menges, pers. comm. 2008a). Plants are self-pollinating (Evans et al. 2000). Pollinators include several generalist insect species. Because of its generalist pollinator syndrome and ability to set self-pollinated seeds, reproductive output (fecundity) is not likely to be limited by small population sizes or pollinators. Seeds can germinate in the fall/winter/spring season following production (Weekley et al. 2007). This

demographic delay in germination means that seedlings produced from a large cohort of flowering plants will themselves flower two years later. If a disturbance destroys one cohort, leaving just one remaining cohort, the demographic delay creates the opportunity for two-year population cycles (Quintana-Ascencio et al. 2008), especially following fires (Menges and Gordon 1996). Two-year cycles have been observed independently in some LWRSF populations (Rosner-Katz, pers. comm. 2019).

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

Evans et al. (2000) found that Carter's mustard had low genetic diversity, a relatively large proportion of genetic variation distributed among populations, and clinal variation in range-wide genetics. The large amount of variation distributed among populations suggests that more than a few populations need protection and management to safeguard the species' genetic variation.

c. Taxonomic classification or changes in nomenclature:

No recent changes. The Integrated Taxonomic Information System (ITIS) recognizes *Warea carteri* Small as a valid taxon (ITIS 2021). There are no taxonomic issues with this taxon.

d. Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors), or historic range (e.g., corrections to the historical range, change in distribution of the species' within its historic range):

More so than other plant species, Carter's mustard distributional information may be incomplete, with occupied sites unknown and formerly known sites now lacking the species. Its fluctuating population sizes, inconspicuous nature when not flowering, and annual habit make assessment of its distribution and conservation status more difficult than is the case for perennial herbs or shrubs. Despite challenges in monitoring, an analysis of the status of Florida scrub conservation included Carter's mustard among the 36 rare species of the LWR and classified the species as of high conservation concern based on number of locations, extent of occurrence, and area of occupancy (Turner et al. 2006).

Carter's mustard populations currently occur along the LWR in Highlands, Polk, and Lake counties in Central Florida, but the species was once more widespread. This plant formerly occurred throughout the entire length of the LWR and on the Winter Haven Ridge. Disjunct and now extirpated populations were known from Miami-Dade and Brevard counties; the loss of these former populations represents a sizeable range reduction for Carter's mustard.

An analysis of land conversion on the LWR suggests that about 78 percent of upland habitats were lost by about 1990 (Weekley et al. 2008). By the early part of this century, about 87 percent of upland habitat was gone (Turner et al. 2006). Habitat losses were greatest on yellow sands and in the northern part of the LWR (Weekley et al. 2008). These conversions would have probably eliminated several Carter's mustard populations, especially in sandhill remnants in Lake County. While the exact original spatial extent of Carter's mustard can no longer be determined, the loss of so much sandhill habitat on yellow sands, one of the primary habitats for Carter's mustard, suggests that many populations have become extirpated. Continued conversion of Florida scrub and sandhill to agriculture, housing, and other developments is currently affecting the number, size, and distribution of Carter's mustard populations.

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

Carter's mustard is found almost exclusively in upland areas and is a soil generalist, being found primarily on yellow or gray sands (Menges et al. 2007, Menges et al. 2019). It is found primarily in sandhills and scrubby flatwoods (Menges et al. 2019), and often at the ecotone between these two vegetation types. In the northern part of its range, most sites are on sandhills. At Tiger Creek Preserve located in the central part of the species' range, it is found in both high quality, frequently burned sandhill, as well as in overgrown sandhill that could also be termed xeric hammock (Menges, pers. comm. 2008b). Near the south end of its range (e.g., ABS), Carter's mustard is found primarily in scrubby flatwoods, often just downhill from a ridge of yellow sand (Menges, pers. comm. 2008c). FNAI habitat descriptions suggest a range of vegetation can support Carter's mustard, including "scrub" (not further described, 9 EORs), scrubby flatwoods/oak scrub (5 EORs), sandhill or hammock deriving from sandhill (5 EORs), sand pine scrub (2 EORs), oak-hickory scrub (1 EOR), open woodland (1 EOR), and disturbed area (1 EOR).

Healthy scrubby flatwoods and sandhill habitats have a fire return interval ranging from 2 to 15 years (Menges 2007, Menges et al. 2019). Although Carter's mustard has large populations after fire (Rosner-Katz, pers. comm. 2019), it can also recover from a persistent soil seed bank after many years or even decades without fire (Menges et al. 2019). However, fire suppression could well lead to decay of seed bank populations and poor response to subsequent fires, eventually resulting in small population sizes (Quintana-Ascencio et al. 2008, Rosner-Katz, pers. comm. 2019). Although preferring post-fire or disturbed sites, Carter's mustard is not a gap specialist. Plants often grow among dense shrubs in scrubby flatwoods or shrubby sandhill sites.

Like many LWR endemic plants, Carter's mustard also grows in disturbed areas such as sandy roadsides and trails (Menges et al. 2019, Rosner-Katz, pers. comm. 2019). Population dynamics in these roadsides often do not show a pronounced

two-year cycle found in burned habitats, presumably because recurrent disturbances allow release of multiple annual cohorts of plants from the seed bank without killing all plants of one cohort.

2. Five-Factor Analysis

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

Carter's mustard was once more widespread. Populations that previously occurred in Miami-Dade and Brevard Counties are now considered extirpated. The species is currently restricted to areas along the LWR in Highlands, Polk, and Lake Counties, where habitat destruction from development continues to occur and development pressure remains high. Sandhill and scrubby flatwood habitats continue to be developed for agriculture, housing, and other uses. Aerial extent of post-Columbian xeric upland habitat loss on the LWR is estimated to exceed 85 percent (Turner et al. 2006, Weekley et al. 2008). Increasing pressure from population growth is likely to result in further loss of these habitats in the future. If trends continue, Carr and Zwick (2016) estimate 34 percent of land will be developed by 2070, up from 19 percent in 2010. At the same time, conservation lands will increase less than 1 percent (from 9,269,000 ac in 2010 to 9,525,000 ac by 2070). Overall, loss of habitat to development, primarily on private lands, will likely continue in Central Florida, eliminating populations and reducing the area of suitable habitat for Carter's mustard. Therefore, habitat on protected lands are critical for the recovery of these scrub plants.

Even on protected lands, Carter's mustard may be threatened by habitat modifications due to inadequate fire management. This species has distinct flushes of recruitment following many fires (Quintana-Ascencio et al. 2008, Rosner-Katz, pers. comm. 2019). Its persistent seed bank in the soil may allow it to recover aboveground populations after many years without fire, although the temporal decay in the soil seed bank has not been quantified. The effect of mechanical surrogates or pre-treatments for fire, which are widely used by land managers on the LWR, is not known for Carter's mustard.

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

Overutilization for commercial, recreational, scientific, or educational purposes was not identified as a potential threat in the original listing package. Since listing, no evidence of overutilization has been found.

c. Disease or predation:

Disease and predation were not identified as potential threats in the original listing package. Low seedling survival rates (Weekley et al. 2007) may be partially caused by disease and predation by insects. In greenhouse culture, Carter's mustard was quite susceptible to fungal rotting and insect predation (Bissett 1987). At this time, however, there is no evidence that herbivory or disease is a threat to Carter's mustard.

d. Inadequacy of existing regulatory mechanisms:

Carter's mustard is listed as endangered by the State of Florida on the Regulated Plant Index (Florida Department of Agriculture and Consumer Services [FDACS] Rule 5B-40). This law regulates the taking, transport, and sale of listed plants. It does not prohibit private property owners from destroying populations of listed plants on their property nor require landowners to manage habitats to maintain populations.

Existing federal (ESA) and state regulations (FDACS Rule 5B-40) prohibit the removal or destruction of listed plant species on public lands. However, they afford no protection to listed plants on private lands. The ESA only protects populations from disturbances on Federal lands or when a Federal nexus is involved. In addition, state regulations are less stringent than Federal regulations toward land management practices that may adversely affect populations of listed plants. In conclusion, there are no existing regulatory measures that reduce or remove the threat of loss of populations or removal/destruction of plants on private property and existing regulatory mechanisms are inadequate to protect this species.

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

Isolated Populations Within a Limited Geographic Range

Any factors that cause individual populations to disappear are of great concern because Carter's mustard is currently found only in a small geographic area on the LWR, and then again only in a subset of upland soils (being generally absent from xeric white sands; Menges et al. 2007). The species' limited geographic range in combination with the loss of habitat has resulted in a highly fragmented landscape where the remaining scrub areas that provide habitat have become more and more isolated from each other, thereby making resiliency, redundancy, and representation more challenging to achieve. Given the limited geographic range of the species, a single catastrophic event could greatly reduce redundancy. In addition, the fragmented landscape may prevent 'rescue' or 'repopulation' from surrounding nearby populations.

Climate Change

There is currently no evidence of negative impacts to Carter's mustard from climate change factors, but this could change in the future. Florida is vulnerable to changes in rainfall and temperatures expected due to climate change. While the strong influence of ocean currents make projecting regional climate in Florida difficult (Kirtman et al. 2017), estimates project that Florida's average annual temperatures will increase approximately 1.5 to 5.5°F (0.8 to 3.1°C) by 2050 and from 2 to 11.5°F (1.1 to 6.4°C) by 2100 depending on the greenhouse gas emission rates and the region in Florida (Runkle et al. 2017). In addition, it is predicted that for Central Florida summer rainfall (wet season) will decrease up to 5 percent by 2050 (Runkle et al. 2017). Higher temperatures and changes in precipitation patterns could alter relative humidity levels and evapotranspiration rates, leading to the potential for more frequent and intense droughts and wildfire events. Scrub and sandhill species, in general, can tolerate drought conditions, but it is unclear how this anticipated future threat will fully affect species like Carter's mustard or the ability to implement prescribed fire.

In addition to changes in precipitation and temperatures patterns, there are also anticipated changes to the severity of tropical storms and hurricanes. Sweet et al. (2017) predicted a 20 percent increase in both rainfall rates and wind speeds near the center of storms due, in part, to higher sea surface temperatures.

Sea-level rise is another anticipated consequence of climate change in Florida. The Central Florida ridges will be spared from the direct impacts of sea level rise that are anticipated for coastal and low elevation areas. However, as sea level rises in coastal regions, development is likely to move inland, further increasing the threat of development in the higher elevation areas, such as the Central Florida ridges (Volk et al. 2017).

Other

Carter's mustard responds well to fire, but its response to other habitat manipulations such as roller chopping and mowing, is not known at this time. Damage to habitat and plants by off-road vehicles (ORVs) and pedestrian trampling could be important at some sites. Carter's mustard stems are fragile and easily broken by such disturbances. However, germination from soil seed banks may be increased by a certain level of physical disturbance. Seedling survival rates are low (3.5-12 percent annually among years and lower for late season recruits than early season recruits) (Weekley et al. 2007) and may be partially caused by unknown disease and predation by insects (Bissett 2008). Flooding at some sites has been considered a contributing factor to population declines (Pace-Aldana, pers. comm. 2008, Rosner-Katz, pers. comm. 2019).

D. Synthesis –

In summary, minor progress has been made in meeting the recovery criteria for Carter's mustard, and much more work is needed to fully achieve recovery. While the number of EORs in managed areas (23 of 29 or 79 percent) with Carter's mustard has improved since the time of listing, at least six EORs occur on unmanaged sites and their status is largely unknown. In addition, there has been documented extirpation of populations in Miami-Dade and Brevard counties. Further loss of unprotected Carter's mustard populations is likely as development continues on the LWR. There are also likely to be other LWR populations on private sites with undocumented patches of Carter's mustard. Some of these may remain extant for years, but some are likely to be destroyed by land development. Lack of fire remains a threat. Fire management on protected sites may not be adequate to support viable populations. While it is difficult to detect long-term declines in the wide-cycling populations of Carter's mustard, in the absence of fire, populations will decline. Managed areas on the LWR vary widely in their successful application of fire, although in general, more frequent fire management is necessary across LWR conservation sites. Secondary threats that could affect Carter's mustard include damage from ORV traffic. Because of its narrow range and restriction to certain soil types, loss of individual populations will threaten the survival of the species as a whole.

Although much has been learned about the biology of Carter's mustard, field constraints and volatile population dynamics make this a difficult species for which to quantify conservation criteria or management strategies. Demographic data have been collected from three populations and integrated into an analysis of population cycling (Quintana-Ascencio et al. 2008). However, no analysis predicting probability of persistence for individual populations has been done. In addition, no higher level (metapopulation) level analysis has been attempted. Such an analysis would be required to predict the probability of persistence of the species as a whole.

The limited geographic range and isolated populations due to habitat loss and fragmentation present additional risk for Carter's mustard. Anticipated climate change factors such as alteration to temperature and precipitation patterns and sea-level rise will only exacerbate these threats. Due to the probability of continued populations losses at unprotected sites and the lack of adequate fire management at some existing protected sites, Carter's mustard continues to meet the definition of endangered under the ESA.

III. RESULTS

A. Recommended Classification:

__X__ **No change is needed**

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Better land management is needed so that protected populations remain extant. Periodic burning is recommended to ensure that aboveground populations are replenished before

seed banks decline. Adaptive management can be used based on data collected on Carter's mustard responses to various fire regimes.

- Data on management activities (e.g., fire, mechanical treatments) should be gathered in management units where level 2 monitoring is being done. These can serve to link information specific to those units, including population size and trends, with detailed demographic models that are keyed to management (e.g., prescribed fire).
- Detailed demographic data from three sites (Quintana-Ascencio et al. 2008) could be used as the basis of a population viability analysis that addresses questions such as how Carter's mustard responds to different fire regimes and what is the prognosis for populations of different sizes. They could also be used to make specific predictions for populations where there were estimates of population sizes.
- For some or all managed sites, collection of additional data on population sizes (level 2 monitoring). These data are being collected at two sites (LWRSF and TNC Tiger Creek Preserve. For Carter's mustard, level 2 monitoring will have to be concentrated in September and October, when plants are visible and more easily counted.
- More data on the response of Carter's mustard to management activities such as roller chopping, mowing, gyro-tracking, logging, and chain-saw felling.
- If significant unprotected populations of Carter's mustard are discovered, these populations should be protected by land purchase or management agreements.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Carter's mustard (*Warea carteri*)

Current Classification: Endangered.

Recommendation resulting from the 5-Year Review:

___ Downlist to Threatened
___ Uplist to Endangered
___ Delist
_X_ No change needed

Review Conducted By: Emily Bauer, Florida Ecological Services Field Office, Vero Beach.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve ROXANNA HINZMAN Digitally signed by ROXANNA HINZMAN Date: 2021.04.08 16:16:57 -04'00' Date _____

* Since 2014, Southeast Region Field Supervisors have been delegated authority to approve 5-year reviews that do not recommend a status change.