Interim Core Map Documentation for the Lange's Metalmark Butterfly (LMB)

Date posted on EPA's Geoplatform: July 2025
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Documentation supplemented by the U.S. Environmental Protection Agency's (EPA) Office of Pesticide Programs

Species Summary

The Lange's metalmark butterfly (*Apodemia mormo langei*; Entity ID #421) is an endangered terrestrial invertebrate (species group: insect). The U.S. Fish and Wildlife Service (FWS) has not designated a critical habitat for this species; however, FWS does provide geodata for the species range. It is a univoltine subspecies, producing one brood a year. Adults emerge (eclose) in early August and may be observed until mid- or late September, with egg laying throughout this adult flight period. All life stages of this species are closely tied to *Eriogonum nudum var. psychicola*, also known as Antioch Dunes buckwheat. Currently, the Lange's metalmark butterfly can only be found within the Antioch Dunes National Wildlife Refuge. The Antioch Dune buckwheat serves as the primary nectar source for adult LMBs, sites for oviposition, and as the larval foodplant. Antioch Dunes buckwheat is a perennial forb that requires sandy, well-drained soils and some form of disturbance, preferably by natural processes such as wind or erosion, to shift the sand for seedling establishment. Flowering of Antioch Dunes buckwheat begins in July or August, depending on the climate, and just prior to the emergence of Lange's metalmarks. Additional information is provided in **Appendix 1**.

Description of Core Map

The core map for the Lange's metalmark butterfly is based on biological information – specifically, the one location of known occurrence identified by FWS to be the Antioch Dunes National Wildlife Refuge (ADNWR). The boundary of the ADNWR encompasses two units spanning a total of 67 acres; the western 41-acre Stamm Unit (owned by FWS) and the eastern 26-acre Sardi Unit (14 acres owned by FWS and 12 acres owned by Pacific Gas & Electric). There is no designated critical habitat. **Figure 1** depicts the interim core map for the Lange's metalmark butterfly. The core map boundary is identical to the Antioch Dunes National Wildlife Refuge.

The core map developed for the Lange's metalmark butterfly is considered interim and will be used to develop pesticide use limitation areas (PULAs) that include the LMB. This core map incorporates information developed by FWS and made available to the public; however, the core map has not been formally reviewed by FWS. This interim core map may be revised in the future to incorporate expert

[1] CBD sent EPA the draft core map for this species before EPA released its mapping process document and example documentation. EPA supplemented the documentation and supporting analysis for consistency with EPA's most recent documentation examples made available after CBD developed this core map.

feedback from FWS. This interim core map has a “limited” (2) best professional classification because it consists of the only location identified by FWS that contains an extant population without additions or subtractions. There is confidence in the core map because the species’ occurrence location is highly refined, represents areas important for this species’ conservation, and contains all known populations of this species. This core map does not replace or revise any range or designated critical habitat developed by FWS for this species.

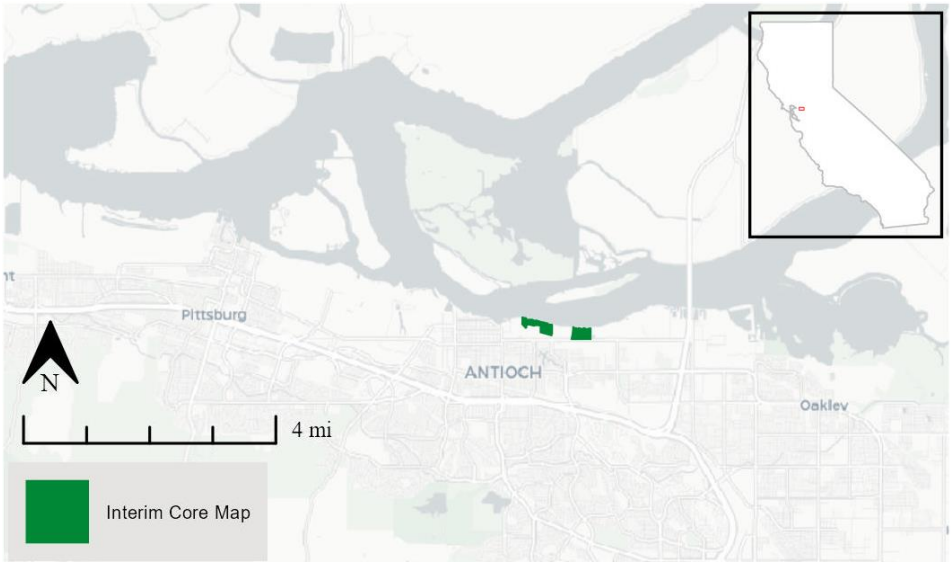

Figure 1. Interim core map for the Lange’s metalmark butterfly. The total acreage of the interim core map is approximately 70 acres.

Table 1. Percentage of Interim Core Map Represented by NLCD[2] Land Covers and Associated Example Pesticide Use Sites/Types.

Example pesticide use sites/types	NLCD Landcover (Value)	% of core map represented by landcover	% of core map represented by example pesticide use
Forestry	Deciduous Forest (41)	0	0
Forestry	Evergreen Forest (42)	0	0
Forestry	Mixed Forest (43)	0	0
Agriculture	Pasture/Hay (81)	0	0
Agriculture	Cultivated Crops (82)	0	0
Mosquito adulticide, residential	Open space, developed (21)	50	92
Mosquito adulticide, residential	Developed, Low intensity (22)	26	92
Mosquito adulticide, residential	Developed, Medium intensity (23)	14	92
Mosquito adulticide, residential	Developed, High intensity (24)	2	92
Invasive species control	Woody Wetlands (90)	0	~8
Invasive species control	Emergent Herbaceous Wetlands (95)	<1	~8
Invasive species control	Open water (11)	5	~8
Invasive species control	Grassland/herbaceous (71)	2	~8
Invasive species control	Scrub/shrub (52)	0	~8
Invasive species control	Barren land (rock/sand/clay; 31)	0	~8
Total Acres	**Interim Core Map Acres**	**~70**	

Evaluation of Known Location Information

There are four datasets with known location information for this species:

- Descriptions of locations provided by FWS;
- Occurrence locations included in iNaturalist;

[2] Dewitz, J., 2023, National Land Cover Database (NLCD) 2021 Products: U.S. Geological Survey data release, https://doi.org/10.5066/P9JZ7AO3

- Occurrence locations included in the Global Biodiversity Information Facility (GBIF); and
- Occurrence locations included in NatureServe.

EPA evaluated these sets of data to inform or support the core map. FWS provided the most refined descriptions of the occurrence information and confirmed that all known locations of extant populations are located within the ADNWR. iNaturalist had 50 research grade observations since 2010. After considering that all have their exact coordinates obscured, these are consistent with the species range and location of known populations. GBIF's occurrence data does not capture this specific subspecies and only goes as taxonomically granular as *Apodemia mormo*. NatureServe included three documented areas, all of which were consistent with the location of the species' known population. **Appendix 1** includes more information on the available known location information.

Approach Used to Create Core Map

CBD first compiled available information for the Lange's metalmark butterfly from FWS documents. EPA added to this by including occurrence information from iNaturalist, GBIF and NatureServe. The information compiled for the Lange's metalmark butterfly is included in **Appendix 1**.

CBD used the compiled information to identify the core map type as "known locations plus 1,000 ft buffer". EPA compared known location data, the species range, and location of known populations and found that these are all consistent with one another. Based on FWS documentation and occurrence data, EPA selected the boundary for the ADNWR (provided by CBD) to use as the species core map; in other words, EPA took CBD's core map and removed the 1,000 ft buffer. EPA would include buffers when developing pesticide use limitation areas (PULAs) to account for pesticide movement from adjacent areas into the core map area.

Discussion of Approaches and Data that were Considered but not Included in Core Map

Alternative approaches and data not documented here were not explored in the development of this interim core map.

Appendix 1. Information Compiled for the Lange's Metalmark Butterfly

1. **Recent FWS Documents**
   - LMB's 5-year Review (2020)
   - LMB's 5-year Review (2008)
   - Species Recovery Plan (2019)
   - Initiation of 5-Year Status Reviews for 59 Pacific Southwest Species (2024)
   - 28 Draft Recovery Plan Revisions for 53 Species in the Southeast, Mountain-Prairie, and Pacific Southwest Regions of the United States; Notice of Availability (2019)
   - Proposed Critical Habitat (1977)

2. **Background information on Species**
   - **Status:** Federally listed as endangered in 1976.
   - **Taxonomy**. Lange's metalmark butterfly is a member of the Riodinidae family is a subspecies of the Apodemia mormo. The species Apodemia mormo (commonly referred to as "Mormon metalmark") occurs in scattered, often isolated, populations throughout western North America and is found in a variety of habitat types, from canyons and valleys to sandy dunes.
   - **Resiliency** – Low (inferred)
     "In addressing resiliency, we sought to establish an individual population minimum viable population size (MVP). We attempted a population viability analysis (per Schulta and Hammond 2003) and found the underlying Lange's metalmark data insufficient to derive any confidence in an estimated MVP size. We then searched the literature to identify possible surrogates, looking for con-generics or even butterflies from the same or different families with similar ecology. […] In evaluating their biology/ecology/life history, combined with the underlying MVP model for overall suitability, our qualitative assessment relied on evaluation of what we considered to be logical individual and combined criteria for each species and the respective MVP model." (Recovery Plan 2019, 22). "We therefore conclude that our recovery criteria minimum population size of a 15-year moving median of 2,600 individuals is a reasonable estimate of an MVP for the Lange's metalmark until, and if, further research, and improved monitoring, defines some other figure with greater statistical certainty." (Recovery Plan 2019, 25). "For the period from 1986-2019, the abundance estimate has ranged as high as 7,488 individuals in 1997, to below 100 in all but one year since 2009…" (Recovery Plan 2019, 9).
   - **Redundancy** - Low
     "It is expected that a single butterfly population can experience significant growth where there is suitable larval habitat (Thomas et al 2011). Research is required to better understand what can be considered suitable, and even optimal, habitat. It should be noted that Riodinidae, the family of butterflies to which Lange's metalmark belongs, are generally sedentary so there is no expectation of natural recolonization or significant gene flow between populations unless they are within close proximity (New 1993, ITIS 2019). Considering this, we do not treat Lange's metalmark populations as metapopulations and suitable habitat must be managed so that butterflies will persist within a representative unit as a single population. With sufficient abundance and stable population trend, we find three and five such units should provide sufficient population redundancy to denote reduced risk

of extinction and recovery, respectively." (Recovery Plan 2019, 25). "Lange's metalmark exhibits extremely limited ecological representation and population redundancy—only remaining in one subsection of the Sardis Unit at ADNWR. The subspecies has not been observed at the Stamm Unit since 2010, and the overall ADNWR population has continued to decline from a peak count of 46 in 2009 to a peak count of four in 2019." (5 Year Review 2020, 14).

- **Representation** - Low
  "As there is no reliable record of the Lange's metalmark's historical distribution, we are suggesting that three and five units containing individual MVPs to enhance range wide persistence via population redundancy will also convey a side benefit of increasing representation. It is not possible at this time to characterize specific attributes of newly restored habitat required to broaden ecological representation, so these features of the units are areal estimates (i.e., acreage) for the present criteria. Considering the importance of the larval foodplant, naked-stem buckwheat, it is imperative that all representative units be managed as dune habitat. This should consist of natural successional and disturbance processes which promote the growth and recruitment of naked-stem buckwheat as well as other nectar sources.

  Due to the Lange's metalmark's close relationship with the naked-stem buckwheat, and possibly other plant species, and the use of PVA results as an alternative recovery criterion threshold, we selected the 15-year moving median interval to evaluate population size for the same reasons it was selected for the Antioch Dunes listed plants (refer to the Oenothera deltoides subsp. howellii and Erysimum capitatum var. angustatum, Population Metrics, Size and Number of Individual Populations, Population Monitoring Time Interval section below for explanation). Also, as the response of the larval foodplant and the Lange's metalmark to climate change is not yet known, it is not addressed here, but will be discussed more in the upcoming five-year review." (Recovery Plan 2019, 26).

- **Habitat Description**
  "The Lange's metalmark butterfly (Apodemia mormo langei) (hereafter referred to as Lange's metalmark), Oenothera deltoides subsp. howellii, and Erysimum capitatum var. angustatum are endemics of a relatively narrow habitat association known as the "Antioch Dunes" along the shore of the San Joaquin River in Contra Costa County, California. Based on historical information, the geographic area that once comprised the tall, open, sand dunes characterized as the Antioch Dunes, is estimated at between approximately 120 acres (Stanford et al 2011) and approximately 500 acres (Service 1978b); estimates differ relative to interpretations of the degree of topographic relief (e.g., what constitutes "tall dunes") and the distinction of other natural community features from the rest of the interior dune habitat.

  The Antioch Dunes were part of a larger habitat association typified by sandy soils, remnant of eolian (wind-blown) processes, which covered approximately 6,800-8,400 acres (Stanford et al 2011). This interior dune habitat was classified as approximately 5,600 acres of "interior dune – vegetation undefined", which was sparsely vegetated and included the Antioch Dunes, and approximately 2,800 acres "interior dune scrub", which was densely vegetated

(Figure 1). Both habitat types included oaks, scrub oaks, and other vegetation; the density of vegetation is what distinguished the two (Stanford et al 2011).

There is limited information about the historical distribution of the Lange's metalmark butterfly, O.d. subsp. howellii, and E.c. var. angustatum beyond the Antioch Dunes and across the broader, interior dune habitat. Relative to the suitability of soils and overall habitat descriptions, these listed species may have also occurred in the "interior dune – vegetation undefined" habitat and within any relatively open interface of the "interior dune – vegetation undefined" and "interior dune scrub" habitats.

Since the mid- to late-1800s, the Antioch Dunes habitat has been mostly destroyed and degraded by sand mining for various commercial uses, conversion to other land uses, invasion by non-native vegetation, and recreational uses (Service 1984). These habitat alterations have also largely eliminated the wind-blown disturbance regime that helps maintain the openness of the dunes in the remaining small and fragmented habitat units. The remaining Antioch Dunes habitat is found almost completely within the two management units of the ADNWR; the approved ADNWR boundary encompasses 67 acres (the 41-acre Stamm Unit, owned by the Service and the 26-acre Sardis Unit, of which 14 acres are owned by the Service and 12 acres are owned by Pacific Gas and Electric) (Service 2002) (Figure 2). The Lange's metalmark is now considered entirely restricted to the remaining Antioch Dunes habitat at the ADNWR (currently only the Sardis Unit), and O.d. subsp. howellii and E.c. var. angustatum are now considered almost entirely restricted to the remaining Antioch Dunes habitat at the ADNWR." (Recovery Plan 2019, 5).

- **Relevant Life History Information:**
  "The Lange's metalmark is a relatively small butterfly, with a wing expanse from 18-27 millimeters [mm.] (0.06 -0.71-inches [in.]), mostly black and orange colored with white spotting, and primarily identified by orange scaling of the discal spot (Comstock, 1939). It is a univoltine subspecies (producing one brood per year) that lays eggs in small clusters on the larval host plant in late summer. The first larval instar emerges from these eggs following the first rain events of the fall, and the leaves of the larval host plant provide both food and shelter throughout the larval instar phases (Arnold, 1978; Arnold, 1980). Adult butterflies begin emerging from pupation in early August and may be observed until mid- or late-September, with females laying eggs throughout this adult flight period (Service, 1984). Adult butterflies may live on average a week, and though little is known about the duration of the larval stages in the wild, pupation is thought to last 6-18 days (Arnold, 1980).

  All life stages of Lange's metalmark are closely tied to Eriogonum nudum var. psychicola (formerly var. auriculatum), hereafter referred to as Antioch Dunes buckwheat. This host plant, also endemic to the Antioch Dunes, serves as the primary nectar source for adult butterflies, as sites for oviposition, and as the larval foodplant (Arnold, 1978). However, Antioch Dunes buckwheat may not be utilized by the Lange's metalmark until plants are about three years old, when it is able to produce robust flowers (Arnold, 1983). Antioch Dunes buckwheat is a perennial forb that requires sandy, well-drained soils and some form of disturbance, preferably by natural processes such as wind or erosion, to shift the sand for seedling establishment

(Arnold, 1978). Flowering of Antioch Dunes buckwheat begins in July or August, depending on the climate, and just prior to the emergence of Lange's metalmarks.

Currently, Lange's metalmark can only be found within the Antioch Dunes National Wildlife Refuge (ADNWR), the last remnants of the Antioch Dunes following commercial mining and land development. The ADNWR boundary encompasses 67 acres; the 41-acre Stamm Unit, owned by the Service, and the 26-acre Sardis Unit, of which 14 acres are owned by the Service and 12 acres are owned by Pacific Gas and Electric (Service, 2002) (Figure 1). Lange's metalmark is associated with Antioch Dunes, a riverbank dune system that historically reached heights of over 100 feet, but specimens collected from Oakley suggest the subspecies may not have been confined to the Antioch Dunes (Howard and Arnold, 1980; Stanford et al., 2011)." (5-year Review 2020).

- **Ecology**
  "All life stages of Lange's metalmark are closely tied to Eriogonum nudum var. psychicola (Antioch Dunes naked-stem buckwheat, hereafter referred to as naked-stem buckwheat), as the primary nectar source for adults, for oviposition sites, and as the larval foodplant. However, naked-stem buckwheat may not be utilized by the Lange's metalmark until it is about three years old, when the plant is able to produce robust flowers (Arnold 1983). Naked-stem buckwheat is a perennial forb that requires sandy, well-drained soils and some form of disturbance, preferably by natural processes such as wind or erosion, to shift the sand for seedling establishment (Arnold 1978). Flowering of naked-stem buckwheat begins in July or August, depending on the climate, and just prior to the emergence of Lange's metalmarks." (Recovery Plan 2019, 7).

- **Relevant Pesticide Use Sites**
  The Lange's metalmark is addressed as a pollinator for this discussion of the potential threat posed by possible insecticide drift from mosquito abatement spraying on neighboring properties (Richmond et al 2015). The Mosquito Abatement District allows for spraying of insecticides to reduce the incidence of West Nile Virus at a wetland adjacent to the Stamm Unit of the ADNWR. The spray could drift on to the refuge and affect pollinators, such as the Lange's metalmark and those that pollinate O.d. subsp. howellii or E.c. var. angustatum. While ADNWR staff have worked with county mosquito control staff to minimize effects from this potential threat, the magnitude of this stressor requires further investigation. (Recovery Plan 2019, 17).

- **Threats**
  "A brief review of the five factors and underlying threats and stressors to the Lange's metalmark, Oenothera deltoides subsp. howellii, and Erysimum capitatum var. angustatum follows. This review synthesizes information from the Recovery Plan, 2008 Five-Year Review, the Lange's Metalmark Butterfly Threat Assessment and Ranking of Potential Management Alternatives (Richmond et al 2015), additional references (as cited), and the 2018 development of recovery criteria. Refer to the documents listed above for more detailed discussion of threats and stressors. A more detailed treatment of current threats and stressors will be discussed in the next five-year review for each species.

A. <u>Present or threatened destruction, modification, or curtailment of its habitat or range</u>

1. Habitat destruction from sand mining, industrial and urban/suburban development, and/or conversion to agriculture
    - Habitat for the Lange's metalmark, *O.d.* subsp. *howellii, E.c.* var. *angustatum*, and pollinators, and area available for habitat restoration is threatened by destruction and conversion to other uses. This threat is largely ameliorated on the ADNWR and other properties with protection/management agreements in place, but not on properties without such agreements.
2. Habitat degradation due to loss of natural disturbance regime
    - The reduction in sand deposition in Antioch Dunes habitat as a result of water management/use (dams, levees, etc.) in the Sacramento/San Joaquin River Delta system and reduced effectiveness of wind-driven dispersal of sand and disturbance of dunes has and continues to reduce overall size and connectedness of the dune natural community.
3. Habitat degradation due to non-native and native invasive vegetation
    - Invasive vegetation colonizes open sand habitat, reducing available suitable Lange's metalmark, *O.d.* subsp. *howellii, E.c.* var. *angustatum*, and pollinator, habitat. Invasive plants out-compete native species, including Lange's metalmark host and food plants, and *O.d.* subsp. *howellii* and *E.c.* var. *angustatum*, for sunlight, space, nutrients, and moisture. They also stabilize the sand/soil, eliminating the natural disturbance regime and may cause soils to become more eutrophic (Thomson 2005a, Thomson 2005b, Chin 2012, McNally 2014). The 2008 Five-Year Review notes that the proliferation of non-native invasive plants has been increasing rapidly since 1998 (Service 2008) and these conditions continue (Chin 2012, McNally 2014, Service 2018a, Service 2018b, Service 2018c, Service 2018d).
    - The use of herbicides to control non-native and native invasive vegetation may also present potential threat to the Lange's metalmark host and food plants, *O.d.* subsp. *howellii*, and *E.c.* var. *angustatum* occurring in the same vicinity. Applying herbicides selected for the target species and using appropriate rates and technique should minimize effects to non-target Lange's metalmark host and food plants, *O.d.* subsp. *howellii*, and *E.c.* var. *angustatum*. These practices have been instituted at the ADNWR, so this threat is considered largely ameliorated there (Service 2008), but it may pose a risk to current and future occurrences of these listed species elsewhere. Additionally, some herbicides may pose threat directly to the Lange's metalmark. In a study of Behr's metalmark, a close relative of the Lange's metalmark butterfly, the herbicides triclopyr, sethoxydim, and imazapyr were found to reduce the number of adults that emerged from pupation by 24-36% after exposure to typical field application rates (Stark et al 2012 in Richmond et al 2015).
4. Habitat degradation due to gypsum dust deposition from neighboring plant (facility)
    - The 2008 Five-Year Review reported that gypsum dust building up on plants may reduce exposure to sunlight and decrease photosynthesis. It may also alter soil chemistry due to introduction of calcium and sulphates, which may affect the growth of the Lange's metalmark host and food plants, *O.d.* subsp. *howellii*

and *E.c.* var. *angustatum* and promote colonization by invasive species. Deposition is noted as affecting mostly the Sardis Unit. The ADNWR staff have met with Georgia-Pacific (G-P) about concerns over the dust and G-P increased efforts to reduce airborne gypsum (beyond the standards for air pollution control) by keeping it wetted down when possible during production activities. At the time of the 2008 Five-Year Review, staff noted a reduction in dust from G-P efforts. The review noted that there was no evidence that gypsum dust was adversely affecting any of the three species (Service 2008). However, it also cited a study that demonstrated that dusts may adversely increase transpiration through the cuticle of insect larvae and cause desiccation and abrasion of the cuticle (Wigglesworth 1945 in Service 2008), which may affect the Lange's metalmark and pollinators of *O.d.* subsp. *howellii* or *E.c.* var. *angustatum*.

- The ADNWR staff reported an increase in gypsum dust deposition at the ADNWR in 2017-2018 (Susan Euing pers. comm. December 12, 2018). In 2018, staff noted that gypsum was being deposited on the refuge at concentrations that coats plants, leading to cancellation of surveys for the Lange's metalmark in some parts of the refuge (Susan Euing pers. comm. August 17, 2018). In 2019, after several weeks into the Lange's metalmark survey season, ADNWR staff confirmed that no surveys had been canceled due to concerns about gypsum dust deposition (Louis Terrazas pers. comm. September 10, 2019). The magnitude of this potential stressor requires further investigation and Service partnership with G-P is ongoing.

5. Habitat degradation due to rogue hiking/trails
    - This activity may cause direct injury or mortality to the Lange's metalmark, to its host and food plants, and to *O.d.* subsp. *howellii* and *E.c.* var. *angustatum* from trampling while also increasing potential for accidental introduction of wildfire from hikers. These threats and stressors were significantly reduced when the ADNWR was fenced in 1986 and the 2008 Five-Year Review (Service 2008) no longer considered recreational and pedestrian traffic to be a significant threat. However, ADNWR staff note that incidence of trespassing and human encampments at the ADNWR has increased in the past several years (Susan Euing pers. comm. December 12, 2018).

B. <u>Overutilization for commercial, recreational, scientific, or educational purposes</u>
These activities represent a threat to the Antioch Dunes species from direct mortality of any individual(s) collected and a reduction in annual recruitment by killing or injuring reproductive individuals.

C. <u>Disease or predation</u>
Arnold (1980 in Service 2008) found that larvae of the Lange's metalmark were parasitized by tachinid flies (family Tachinidae, order Diptera) and by parasitic wasps (families Braconidae and Encyrtidae, order Hymenoptera). The magnitude of this stressor requires further investigation.

Evidence exists of O.d. subsp. howellii infestation by beetles (possibly family Chrysomelidae), which feed on petals, pollen, and seed pods. Also, in the early 1980s up

to 50% of O.d. subsp. howellii was infested with small mirid bugs (family Miridae of the insect order Hemiptera) that prey upon O.d. subsp. howellii, and these insect predators remained an identified threat in 2008 (Service 2008). The magnitude of this stressor requires further investigation.

Three moth taxa are known to prey upon E.c. var. angustatum; a fairy moth (Chalceopla simpliciealla), an egg-eating moth (Calcus spp.), and the diamond back moth (Plutella xylostella) (Service 2008). Pavlik et al (1988b) determined that pre-dispersal predation of seeds significantly impacted reproduction during studies conducted in 1987 and 1988. The magnitude of this stressor requires further investigation.

D. Inadequacy of existing regulatory mechanisms

The 2008 Five-Year Review (Service 2008) reviewed Federal, State, and local regulatory protections and noted no specific inadequacies.

E. Other natural or manmade factors affecting its continued existence

1. Wildfire
    - Because the Lange's metalmark remains above ground, it is susceptible to injury or mortality from wildfire. Due to its currently limited distribution and small population size, a single wildfire could be catastrophic to the species. Wildfire may also cause direct mortality of the Lange's metalmark's host and food plants.
    - Wildfire may cause direct mortality of O.d. subsp. howellii and E.c. var. angustatum plants during vulnerable life stages. These stages include the period from germination during the beginning of the wet season in December through the deposition of seeds in mid-summer. However, historical evidence indicates that the native plants may recover rather quickly from a wildfire (Service 2008). Any mortality would also result in reduced annual recruitment by killing or injuring reproductive individuals. The threat extends to pollinators and other pollinator plant species.
2. Fuelbreak discing
    - Fuelbreak discing may cause direct injury or mortality to the Lange's metalmark, its host and food plants, and to O.d. subsp. howellii, and E.c. var. angustatum. However, it also creates open, disturbed, sand/soil that may be suitable for colonization by O.d. subsp. howellii and E.c. var. angustatum, as well as invasive vegetation. The net impact of this activity to listed plant resilience is unquantified.
3. Loss of pollinators
    - The Lange's metalmark is addressed as a pollinator for this discussion of the potential threat posed by possible insecticide drift from mosquito abatement spraying on neighboring properties (Richmond et al 2015). The Mosquito Abatement District allows for spraying of insecticides to reduce the incidence of West Nile Virus at a wetland adjacent to the Stamm Unit of the ADNWR. The spray could drift on to the refuge and affect pollinators, such as the Lange's metalmark and those that pollinate O.d. subsp. howellii or E.c. var. angustatum. While ADNWR staff have worked with county mosquito control staff to

minimize effects from this potential threat, the magnitude of this stressor requires further investigation.

- As of the 2008 Five-Year Review, there was no evidence that lack or loss of pollinators has negatively impacted O.d. subsp. howellii or E.c. var. angustatum (Service 2008), but both species require cross-pollination, so an adequate pollinator population is necessary. Bees are suspected pollinators for both species and hawkmoths may also be pollinators for the primrose; however, actual pollinator taxa are unknown. This potential threat requires investigation.

4. Low population numbers
    - Extinctions and declines of Lepidoptera species have been widely observed nationwide with building evidence that the cause generally entails both environmental and genetic factors (New 2014). Considering its current size, the Lange's metalmark population is highly vulnerable to demographic and genetic stochasticity. The Lange's metalmark is considered a protandrous subspecies (i.e., males emerge before females), which at low populations may cause complete reproductive asynchrony and can lead to the Allee Effect (Calabrese and Fagan 2004, Calabrese et al 2008, Larsen et al 2013).
    - Although there have been efforts to augment the Lange's metalmark population through head-starting, it is unknown whether genetic variability has been reduced by the release of offspring from just a few individuals into a declining population. A concern is that annual releases may lead to increased inbreeding, as very small numbers of source animals (with no control for possible sibling mating of the collected foundresses) may contribute large components of the actively breeding population after release of captive reared adults/larva. If there has been reduction in genetic representation and inbreeding suppression, extinction risk may have increased with negative effects on egg hatching rates, larval survival, and adult longevity (Nieminen et al 2001, Saccheri et al 1998). If we are to recover the subspecies, the population should be augmented in such a way that both preserves and enhances the genetic variability that remains in the population.
    - Oenothera deltoides subsp. howellii and E.c. var. angustatum are threatened by few and small populations that are limited to a small and localized distribution, which increases the risk of extirpation and extinction due to: (1) Reduced resiliency (the ability of a species to withstand stochastic disturbance; resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations); (2) Low redundancy (spreading risk among multiple populations or a large area to minimize the potential loss of the species from catastrophic events); and (3) Low representation (the breadth of genetic and environmental diversity within and among populations that influences the ability of a species to adapt to changing environmental conditions over time).

5. Climate change
    - An emerging threat for the Lange's metalmark (as for many other butterfly species) is climate change. Distribution trends have been generally documented in many different taxa; but specifically, there is evidence of butterflies declining

in the southern portions of their range as well as expanding their range northward, and it has been noted that the rate of host plant senescence may be increasing, causing asynchrony with butterfly hosts (Parmesan 2007, Forister et al 2010). Specific to the Mediterranean climate regime of California, greater frequency of extremely wet and dry events are projected (Swain et al 2018). Weather extremes and long-term shifts in climate at Antioch could further exacerbate current threats to the Lange's metalmark.

- Oenothera deltoides subsp. howellii and E.c. var. angustatum are threatened by multiple environmental effects anticipated with climate change, which may result in loss of habitat, altered temperature and moisture regimes causing direct mortality and/or impaired reproduction, and altered temperature and moisture regimes causing indirect mortality and/or impaired reproduction via phenological mismatches with pollinators and between pollinators and their host and/or other nectar plants (Richmond et al 2015)." (Recovery Plan 2019, iv)

- **Reclassification Criteria**
  A. Downlisting Recovery Criteria - The Lange's metalmark can be considered for downlisting when:
     1. At least three populations are established at separate, managed locations.
     2. All sites have implemented adaptive management plans to provide dune habitat that provides a disturbance regime that supports naked-stem buckwheat (with some degree of natural recruitment) and a diversity of nectar plants to provide adult food source throughout the flight period. Vegetation monitoring has been conducted over a 15-year period.
     3. As determined by direct monitoring, each population must have a 15-year moving median of 2,600 individuals and minimum effective population size of 50 with a stable or increasing growth rate (lambda).

  B. Delisting Recovery Criteria - The Lange's metalmark can be considered for delisting when:
     1. At least five populations are established at separate, managed locations.
     2. All sites have implemented adaptive management plans to provide dune habitat that provides a natural disturbance regime that supports self-sustaining naked-stem buckwheat (all plants are naturally recruiting) and a diversity of nectar plants to provide adult food source throughout the flight period. Monitoring has been conducted over a 15-year period.
     3.
        a) As determined by direct monitoring, each population must have a 15-year moving median of 2,600 individuals and minimum effective population size of 500 with a stable or increasing growth rate (lambda); OR
        b) population viability analysis determines that the Lange's metalmark, range-wide, has a 95% probability of persistence over a 100-year period.

  C. Recovery Actions

1. Protect Antioch Dunes ecosystem and essential habitat for the Lange's metalmark butterfly , CCW, ADEP
2. Restore Antioch Dunes ecosystem, and increase numbers and improve habitat for the Lange's metalmark butterfly , CCW, ADEP
3. Initiate information and education program

3. Description of Species Range

"[…] the historic range may have included an area of dunes as far east as Oakley (5 miles east of the refuge) (Arnold 1980; FWS 2007b)." (5-year Review 2008, 8)

"The distribution and range of all three Antioch Dunes species have changed little since listing. The Lange's metalmark butterfly, as described earlier, has shifted its population dense areas within the Antioch Dunes NWR corresponding to the availability of host plants that are not encumbered by invasive plant overgrowth (Arnold 1986). Distributions and abundances of host plants for the Lange's metalmark butterfly should increase annually with implementation of the refuge's restoration effort (FWS 2007a)." (5-Year Review 2008, 15)

Figure A1-2 depicts the FWS range map of the Lange's metalmark butterfly. This range was last updated November 2, 2021, and has an area of approximately 4,288 acres.

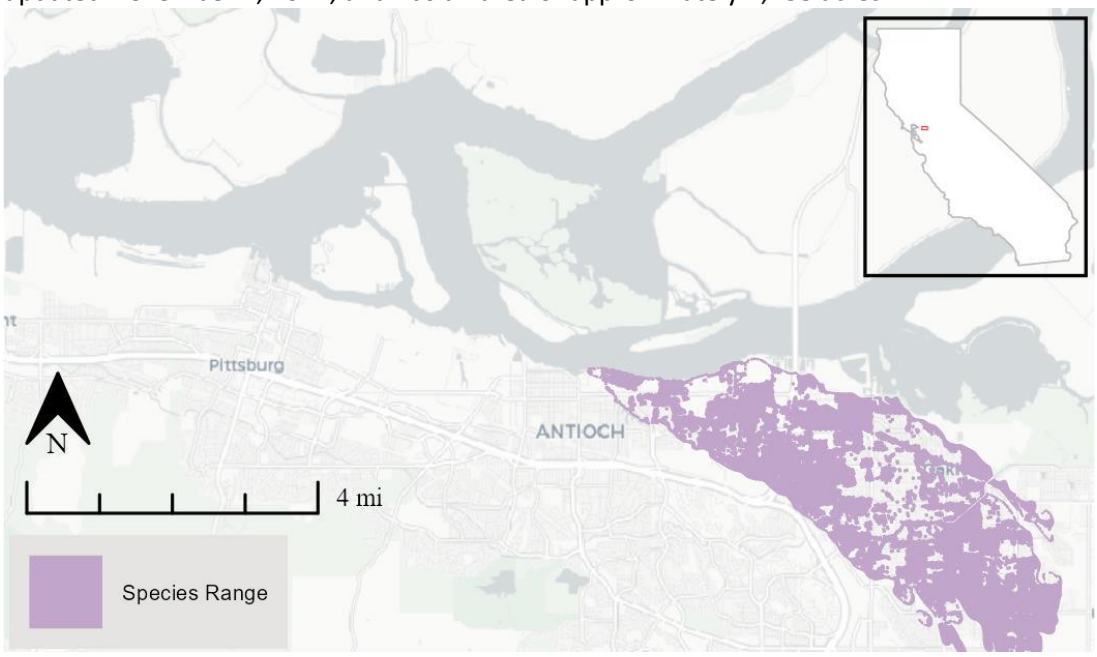

Figure A1-2. Map of the Lange's metalmark butterfly range.

4. Critical Habitat

There is no designated critical habitat for this species.

5. Known Locations

- Occurrences Described in FWS Documents
  - The only location with known population is the ADNWR.

- **Occurrences Described in iNaturalist:**
    - https://www.inaturalist.org/observations?d1=2010-01-01&d2=2025-03-06&quality_grade=research&taxon_id=84172
    - iNaturalist includes 50 research grade observations since 2010 that, taking into consideration that they are all positionally obscured, are consistent with the location of known population (ADNWR)

- **Occurrences Described in GBIF:**
    - Does not have *Apodemia mormo langei* as a species in the database and instead, only goes as taxonomically granular as *Apodemia mormo*
    - https://www.gbif.org/occurrence/search?basis_of_record=OBSERVATION&basis_of_record=HUMAN_OBSERVATION&basis_of_record=OCCURRENCE&country=US&dataset_key=cf3bdc30-370c-48d3-8fff-b587a39d72d6&dataset_key=2e6298fb-d9d7-4915-b69d-890b5aaf91df&dataset_key=cca13f2c-0d2c-4c2f-93b9-4446c0cc1629&dataset_key=8a863029-f435-446a-821e-275f4f641165&taxon_key=1933999&year=2010,2025
    - Search is not very refined because GBIF does not have the correct scientific name
    - After downloading and cleaning, filtered using column 'verbatimScientificName' with value '*Apodemia Mormo*' and using column 'stateProvince' with value 'California'.

- **Occurrences Described in NatureServe:**
    - https://explorer.natureserve.org/pro/Map?taxonUniqueId=ELEMENT_GLOBAL.2.108037
    - NatureServe has several documented locations that are all adjacent to the ADNWR and consistent with the core map given the data resolution.