

Interim Core Map Documentation for the Antioch Dunes Evening-Primrose

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Interim Core Map Developer: U.S. Environmental Protection Agency (EPA), Office of Pesticide Programs

Species Summary

The Antioch Dunes evening-primrose (*Oenothera deltoides howellii*, Entity ID 784) is an endangered terrestrial plant (dicot). It is a short-lived perennial plant and is subspecies of the birdcage evening primrose (*Oenothera deltoides*). The Antioch Dunes evening-primrose is self-incompatible and is pollinated by insects as the seeds do not possess specialized morphology to aid in dispersal. Consequently, most seedlings are found near adult plants. However, it is currently unknown which species of insects are the primary pollinators. The U.S. Fish and Wildlife Service (FWS) has designated a critical habitat for the species, which can successfully become established, grown and reproduced on a variety of soil substrates including sand dunes, but also clay soil. Historically, the Antioch Dunes evening-primrose is found only within the Antioch Dunes ecosystem and nearby sandy locations near the confluence of the Sacramento and San Joaquin rivers. Since 2021, the species is only known to occur in three sites that fall within the species range – two within the Antioch Dunes National Wildlife Refuge and the other at the Oakley's Silvery Legless Lizard Preserve (Jones et al., 2021).¹ Two separate sites with known extant populations but fall outside the species range occur at the Brannan Island State Recreation Area and the Browns Island (Jones et al., 2021). Additional information on the species is provided in **Appendix 1**.

Description of Core Map

The core map for the Antioch Dunes evening-primrose is based on biological information. The outer extent of this core map is defined by an amalgamation of other boundaries where the species is known to live. Specifically, the Antioch Dunes National Wildlife Reserve (ADNWR), Brannan Island State Recreation Area, Browns Island, and the Oakley's Silvery Legless Lizard Preserve.² ADNWR differs from FWS' designated critical habitat in that the ADNWR boundary omits from the critical habitat area the portion of property that is owned by PG&E. Specifically, the ADNWR boundary is split into two sites: the Stamm (western half) and Sardis (eastern half) units. Both ADNWR sites are the only areas mentioned in the FWS 5-year review as having extant populations. However, a 2021 USGS study – Jones et al. (2021) – that was cited in the FWS' 5-year review (2020) indicated three additional sites which contained extant populations, two of which lies outside the species range.

¹ Jones, S. F., Kennedy, A., Freeman, C. M., & Thorne, K. M. (2021). Intensity of grass invasion negatively correlated with population density and age structure of an endangered dune plant across its range. *Biological Invasions*. <https://doi.org/10.1007/s10530-021-02516-5>

² Oakley's Silvery Legless Lizard Preserve is not a site with strong documentation. However, some older texts referenced this as the East Bay Regional Park District Legless Lizard Preserve because it used to be under the management of the East Bay Regional Park District prior to 2007. Since 2007, it is under the management of the City of Oakley (https://nature.berkeley.edu/classes/es196/projects/2019final/GallegosM_2019.pdf).

Figure 1 depicts the resulting interim core map for the Antioch Dunes evening-primrose. The size of this core map is approximately 1,100 acres. Landcover categories within the core map area are included in **Table 1**. Landcover is predominantly emergent herbaceous wetlands and grassland/herbaceous.

The core map developed for the Antioch Dunes evening-primrose is considered interim. This core map will be used to develop pesticide use limitation areas (PULAs) that include the Antioch Dunes evening-primrose. 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 species expert feedback from FWS. This interim core map has an “average” (3) best professional judgment classification to describe major uncertainties/limitations. The map is based on sites with known extant populations mentioned in FWS documents and a study by Jones et al. (2019).

This core map does not replace or revise any range or designated critical habitat developed by FWS for this species.

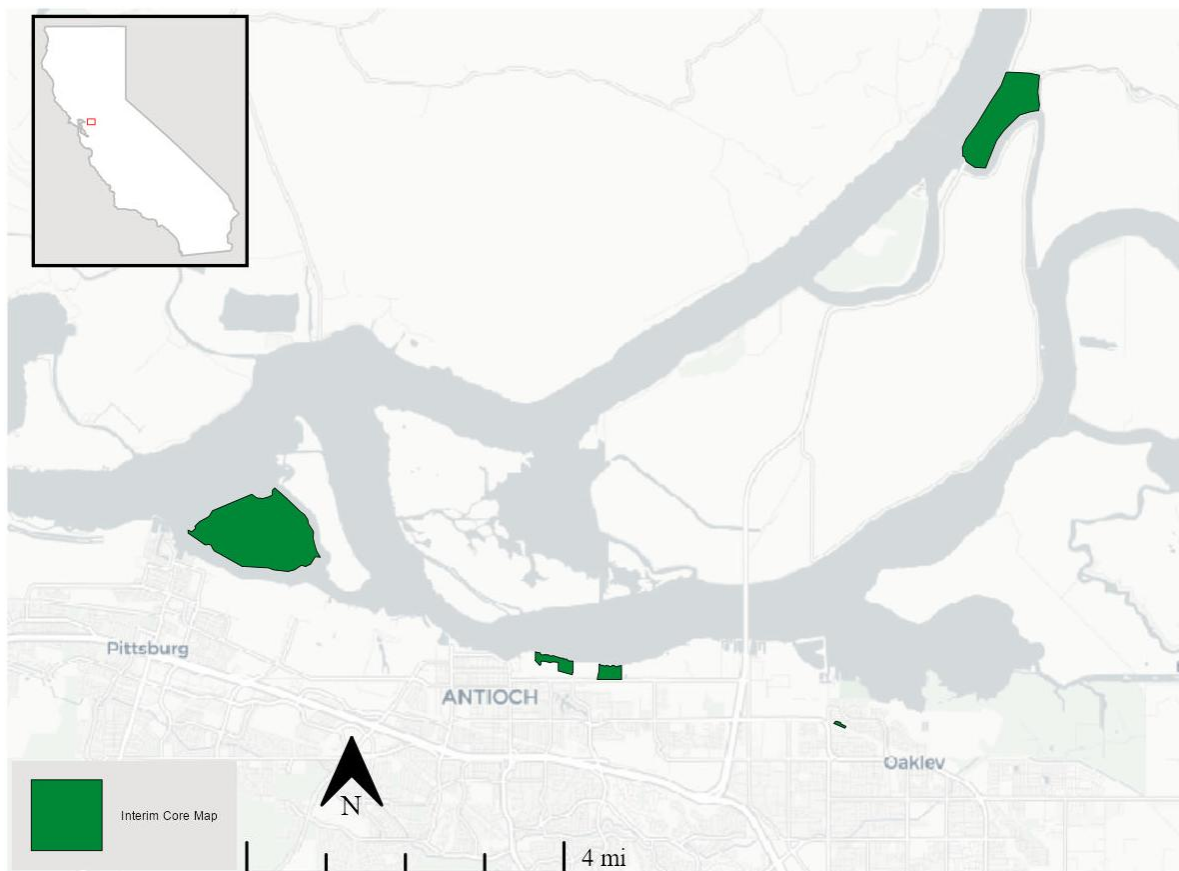


Figure 1. Interim core map for the Antioch Dunes evening-primrose.

Table 1. Percentage of Interim Core Map Represented by NLCD³ 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	5
Agriculture	Cultivated Crops (82)	5	5
Mosquito adulticide, residential	Open space, developed (21)	5	12
Mosquito adulticide, residential	Developed, Low intensity (22)	5	12
Mosquito adulticide, residential	Developed, Medium intensity (23)	2	12
Mosquito adulticide, residential	Developed, High intensity (24)	0	12
Invasive species control	Woody Wetlands (90)	1	82
Invasive species control	Emergent Herbaceous Wetlands (95)	59	82
Invasive species control	Open water (11)	8	82
Invasive species control	Grassland/herbaceous (71)	14	82
Invasive species control	Scrub/shrub (52)	0	82
Invasive species control	Barren land (rock/sand/clay; 31)	0	82
Total Acres	Interim Core Map Acres	~ 1,103	

Evaluation of Known Location Information

There are four datasets with known location information:

- Descriptions of locations provided by FWS
- Occurrence locations in iNaturalist
- Occurrence locations in NatureServe
- Occurrence locations in the Global Biodiversity Information Facility (GBIF)
 - All from iNaturalist; nothing unique

EPA evaluated these four sets of data before selecting the type of and developing the core map. Only iNaturalist, FWS, and Jones et al. (2021) contained information on known locations (**Figures A1-1 through A1-3 in Appendix 1**). Only occurrence data from iNaturalist was used because GBIF did not contain unique observations, and NatureServe only had regional geospatial data but no precise locations. Occurrence data from iNaturalist is obscured for conservation reasons which means that despite there being occurrences far outside of the five sites with known extant populations, it is still consistent with the interim core map. Overall, none of the sources for location information would

³ Dewitz, J., 2023, National Land Cover Database (NLCD) 2021 Products: U.S. Geological Survey data release, <https://doi.org/10.5066/P9JZ7AO3>

support expanding the core map outside of the five sites with extant populations. **Appendix 1** includes more information on the available known location information.

Approach Used to Create Core Map

The core map was developed using the “Process EPA Uses to Develop Core Maps for Draft Pesticide Use Limitation Areas for Species Listed by the U.S. Fish & Wildlife Service (FWS) and their Designated Critical Habitats”⁴ (referred to as “the process”). EPA developed the core map using the 4 steps described in the process document:

1. Compile available information for a species
2. Identify core map type
3. Develop the core map for the species
4. Document the core map

For step 1, EPA compiled available information for the Antioch Dunes evening-primrose from FWS, as well as observation information available from various publicly available sources (including iNaturalist, NatureServe, and GBIF). The information compiled for the Antioch Dunes evening-primrose is included in **Appendix 1**. Influential information that impacted the development of the core map included:

- Occurrences and known locations of the Antioch Dunes evening-primrose are in five sites (ADNWR – Stamm unit, ADNWR – Sardis unit, Brannan Island State Recreation Area, Browns Island, and Oakley’s Silvery Legless Lizard Preserve)
- Designated critical habitat
- Species range

For step 2, EPA used the compiled information to identify the core map type including species range and known location information. The extant populations are located around ADNWR – three of which are within the species’ range while the other two, which represent sites of introduction, lie outside of the range. Therefore, EPA based the core map on the sites with known extant populations. The entire range of the species was not used as the core map because the range contains areas where the species does not occur and omits areas where the species does occur.

For step 3, EPA used the best available data sources to generate the core map. Data sources are discussed in the process document. For this core map, EPA used the boundaries of the 5 sites with known extant populations. The two ADNWR extant site boundaries are taken from the core map for the Lange’s metalmark butterfly. The boundary for the Brannan Island State Recreation Area was manually drawn to fit the park boundary.⁵ The boundary for Browns Island is manually drawn to encompass the entire island. The Oakley’s Silvery Legless Lizard Preserve lacks any strong documentation and so the Agency manually drew the boundary to encompass the open space that is consistent with **Figure A1-3**. **Appendix 2** provides more details on the GIS analysis and data used to generate the core map.

⁴ Dated 2024, available online at: <https://www.epa.gov/endangered-species/process-epa-uses-develop-core-maps-pesticide-use-limitation-areas>

⁵ Source for park boundary: <https://visitcadelta.com/what-to-do/parks/brannan-island-state-recreation-area/>

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

EPA considered using only the ADNWR sites (Stamm and Sardis units) as the core map. However, upon further inspection of FWS documentation, a recent population survey study was done by Jones et al. (2019) which revealed additional sites with extant populations. Thus, the Agency pivoted towards a biological information based core map type.

Appendix 1. Information Compiled for the Antioch Dunes evening-primrose During Step 1

1. Recent FWS documents/links and other data sources

- Five Year Review (2020) (https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/3062.pdf)
- Five Year Review (2008) (https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/1251.pdf)
- Recovery Plan (2019) (https://ecos.fws.gov/docs/recovery_plan/RP%20Amendment_AntiochDunes.pdf)
- Enlist biological opinion (2021) (<https://reports.ecosphere.fws.gov/FWSPublicReports/Reports/Index?reportname=BiologicalOpinionReport>)
- Contra Costa Wallflower and Antioch Dunes Evening-Primrose: Determination of Critical Habitat (1978) (<https://www.govinfo.gov/content/pkg/FR-1978-08-31/pdf/FR-1978-08-31.pdf#page=1>)
- NatureServe (https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.143664/Oenothera_deltoides_ssp_howellii)

2. Background information

- **Status:** Federally listed as endangered in 1978
- **Resiliency, redundancy, and representation** (the 3Rs)
 - “The resiliency of Antioch Dunes evening-primrose is considered to be the ability of this subspecies to continue to maintain viable populations when exposed to environmental and demographic stochasticity, such as associated with typical variation in climate and weather conditions at Antioch Dunes, and in the reproductive and survival rates of the plants in the various populations. Redundancy is considered to be the ability of Antioch Dunes evening-primrose to withstand catastrophic events that have the potential to cause the extinction of one or more populations of plants, but that would not be expected to cause the extinction of the subspecies, so long as there are multiple populations distributed in geographic space with suitable distance among populations. Representation is considered to be the ability of Antioch Dunes evening-primrose to adapt to changes in environmental conditions that might plausibly occur at Antioch Dunes and nearby locations. The Service assumed that genetic diversity and/or diversity among populations that are physiologically or behaviorally adapted to a variety of environmental conditions would improve the viability of the subspecies.” – 5-year Review (2020)
 - “*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).” – Recovery Plan (2019)

- **Habitat**

- Inland dunes; this species will not mature where adult plants have previously grown unless fresh sand is deposited – Nature Serve
- Natural stands of the Antioch Dunes evening-primrose are found only on the riverine dune habitat located on and immediately adjacent to the Antioch Dunes NWR – FWS 5-year Review (2008)
- “It [Antioch Dunes evening-primrose] is regarded as a psammophyte, occurring in nearly pure and shifting sand...” – Recovery Plan (2019)
- “Some specialists have concluded that this species can successfully become established, grown, and reproduce on a variety of soil substrates, including sand dunes, but also clay soil.” – FWS 5-year Review (2020)
- “Many evening-primrose species generally prefer to grow in nearly pure sand and can be regarded as psammophytes (sand-loving plants). Roof (1969) determined that, under cultivation, the Antioch Dunes evening-primrose seedlings will only re-establish within areas with depositions of new sand and this, he speculated, was due to the depletion of scarce nutrients in sandy areas previously occupied by earlier generations of the Antioch Dunes evening-primrose (USFWS 1984). However, Bruce Pavlik’s (1979) research with Eureka Dunes (Inyo County) evening-primrose species revealed that germination of psammophytes depends on the optimal coincidence of three factors: burial depth, moisture, and critical temperature regime (Pavlik 1979). This idea is supported by observations that disturbances to areas of the Antioch Dunes NWR, like disking, tend to produce numerous evening-primrose seedlings without sand refreshment (FWS 1984). Greene (1995) found that the Antioch Dunes evening primrose does not readily propagate when surrounded by non-native weedy plants and determined that removing weeds around the primrose plants enhanced germination. A study by Jones & Stokes Associates in 2000 compared soil taken from areas at the Antioch Dunes NWR supporting healthy populations of Antioch Dunes evening-primrose and Contra Costa wallflower to soil taken from areas where these plants were not supported. The study found that soil conditions supporting the rare plants did not differ from non-supporting soils in nitrogen content, as expected, but differed in the percentage of organic matter present (FWS 2002). Apparently, non-native plants cannot survive and cannot compete with endemics in the nutrient poor and highly permeable sandy soil in which endemic plants thrive (FWS 2002).” – FWS 5-year Review (2008)
- “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).” – Recovery Plan (2019)

- **Pollinator/reproduction**
 - Flowering occurs from March to September. White flowers open early evening and close in the morning.
 - “Blooming may occur in the first year, but it blooms more profusely in the second or later year.” – Recovery Plan (2019)
 - “[Antioch Dunes evening-primrose] is self-incompatible, requiring cross-pollination for viable seed.” – Recovery Plan (2019)
 - “...a lack of soil disturbance inhibited seed germination.” – Recovery Plan (2019)
 - “Antioch Dunes evening primrose is... pollinated by insects....[but]...it remains unclear which species pollinate primrose at Antioch Dunes, and how the diversity and abundance of various potential pollinators may be influencing the population dynamics of Antioch Dunes evening-primrose.” – FWS 5-year Review (2020)
 - “The seeds do not possess specialized morphology to aid in dispersal, and so tend to disperse a short distance by wind and air movements.” – FWS 5-year Review (2020)

- **Taxonomy**
 - Terrestrial Plant
 - Part of the Onagraceae family
 - A subspecies of *Oenothera deltoides*

- **Relevant Pesticide Use Sites**
 - No information specific to pesticides. However, pesticides for mosquito control are listed as one of five critical threats to the species’ critical habitat, the ADNWR. (5-year Review, 2020)

- **Recovery Criteria/Objectives (2006 recovery plan)**
 - “...the Recovery Plan does not identify recovery criteria. In place of criteria, a prime objective was determined: ‘to prevent the further loss of the... Antioch Dunes evening-primrose; to protect introduced populations and their habitats; and to determine the number of populations which are necessary to reclassify... to threatened and to delist.’” – Recovery Plan (2019)

- **Recovery Actions (from Table 5 of 2019 Recovery Plan)**
 1. Protect Antioch Dunes ecosystem and essential habitat for LMB, CCW, ADEP
 2. Restore Antioch Dunes ecosystem, and increase numbers and improve habitat for LMB, CCW, ADEP
 3. Initiate information and education program

3. Description of Species Range

- Figure A1-1 depicts the FWS range. The range was last updated on 11/01/2021. Total acreage of range is around 4,352 acres.

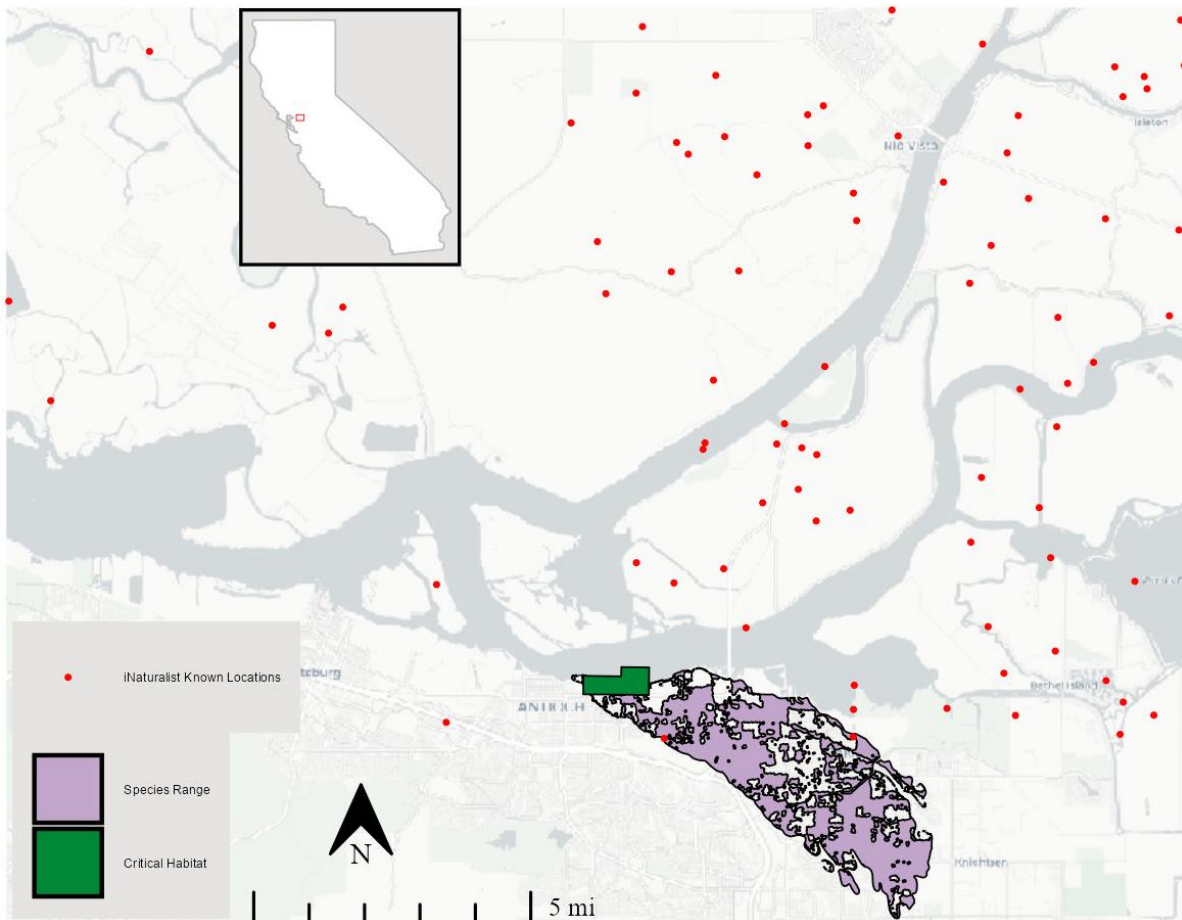


Figure A1-1. FWS range for the Antioch Dunes evening-primrose. The total acreage of the range is around 4,352 acres.

4. Critical Habitat

- FWS has designated a critical habitat for this species (<https://ecos.fws.gov/ecp/species/5970>).

5. Known Locations

- Known Locations Described in FWS Recovery Documents
 - Currently found in only three floodplains in Tennessee (Spring Creek, Barton’s Creek, and Cedar Creek) (Five Year Review 2024)
 - Figure A1-2 depicts the currently known locations from FWS.



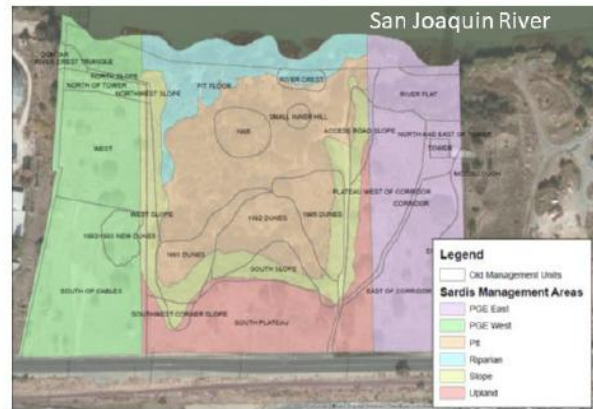
Map A - California



Map B - Antioch Dunes NWR



Map C - Stamm Unit



Map D - Sardis Unit

Figure A1-2. Map of Two Sites with Extant Populations within ADNWR (5-year Review, 2020).

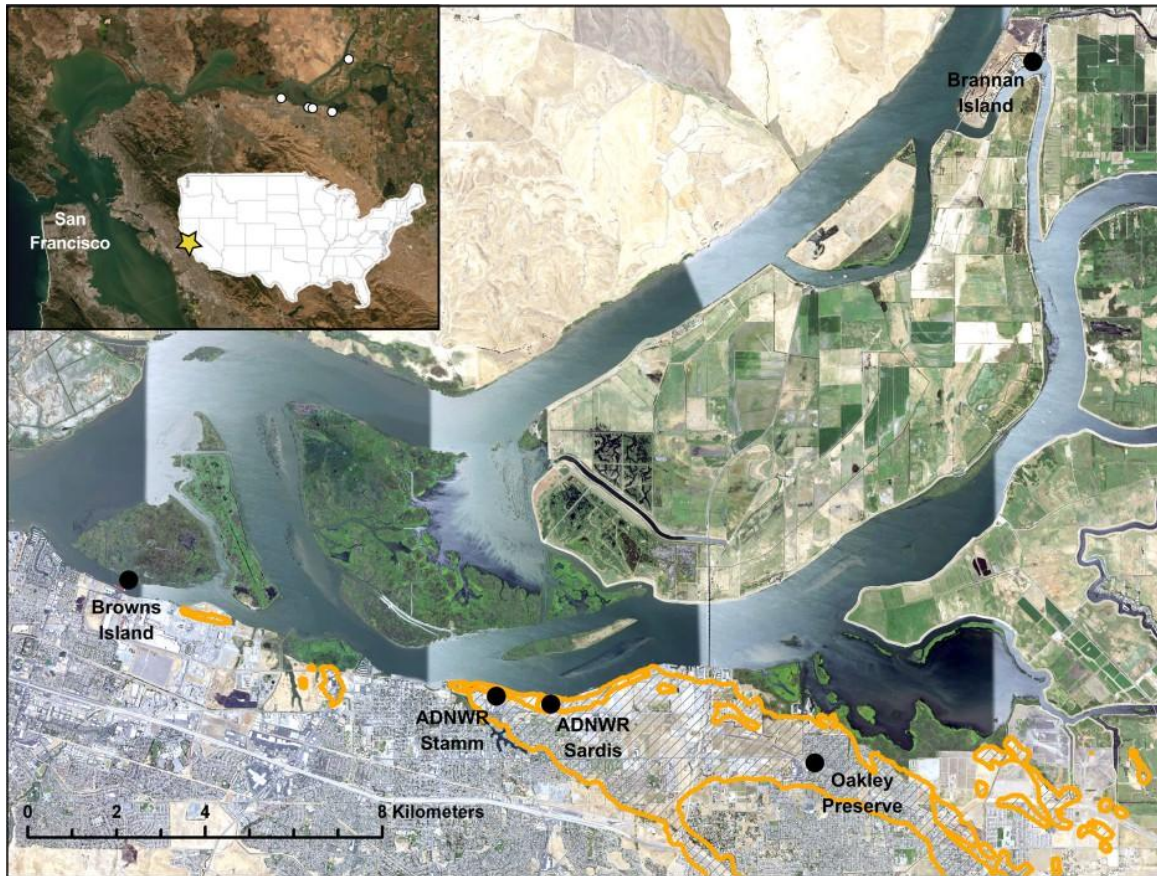


Figure A1-3. Survey Sites with Extant Populations (Jones et al., 2021).

- **Occurrences Included in Public Databases**

EPA queried iNaturalist, GBIF, and NatureServe.

Occurrences in NatureServe were also consistent with other occurrence data (linked [here](#)). Collectively, the occurrence data are consistent with the sites with extant populations used to create the core map.

iNaturalist (available [here](#)) had 84 research grade observations for this species since 2010, many of which appear to fall outside of the sites with extant populations; however, the positional accuracy of the points do not allow EPA to determine if these occurrences were in or out of the five sites with extant populations.

GBIF (available [here](#)) did not contain any occurrence data that was unique from iNaturalist.

Collectively, the occurrence data are consistent with the five sites with extant populations.

Appendix 2. GIS Data Review and Method to Develop Core Map (Step 3)

This core map was created based on biological information, including occupied location and species critical habitat. EPA did not rely on any existing PULA drafts as a starting point for developing this core map.

Dataset References and Software

- NLCD Tree Canopy Cover 2019⁶
 - 30 m raster dataset that contains percent tree canopy estimates, as a continuous variable, for each pixel across all land covers and types for the conterminous US
- Software used: R
- FWS Species Range – last updated on 11/01/2021

2. Datasets Used in Core Map Development

All datasets used in core map development are described in EPA's process document.

3. Core Map Development

- EPA started with the two sites with known extant populations that were mentioned in the FWS' 5-year Review (2020): ADNWR – Stamm Unit and ADNWR – Sardis Unit.
- EPA then appended to that, three additional sites with known extant populations which were mentioned in Jones et al. (2021) which include:
 - a) Brannan Island State Recreation Area
 - i) Boundary: <https://visitcadelta.com/what-to-do/parks/brannan-island-state-recreation-area/>
 - b) Browns Island
 - i) Boundary is self-evident
 - c) Oakley's Silvery Legless Lizard Preserve
 - i) Previously known as the East Bay Regional Park District Legless Lizard Preserve
 - ii) This site lacks strong documentation. However, it used to be under the management of the East Bay Regional Park District prior to 2007. Since 2007, it is under the management of the City of Oakley (https://nature.berkeley.edu/classes/es196/projects/2019final/GallegosM_2019.pdf).
 - iii) Boundary was drawn to encapsulate open space found in the approximate location according to **Figure A1-3**.

⁶ Housman, I.W.; Schleeweis, K.; Heyer, J.P.; Ruefenacht, B.; Bender, S.; Megown, K.; Goetz, W.; Bogle, S. 2023. National Land Cover Database Tree Canopy Cover Methods v2021.4. GTAC-10268-RPT1. Salt Lake City, UT: U.S. Department of Agriculture, Forest Service, Geospatial Technology and Applications Center. 26 p