Species Status Assessment for La Graciosa thistle (*Cirsium scariosum* var. *loncholepis* [*Cirsium loncholepis*])

Version 1.0

Cover photo. La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) in flower near the mouth of Santa Maria River in the Guadalupe Oil Field, San Luis Obispo County, California, 4 April 2015 (occurrence 6). The yellow flowers in the background are invasive bird's-foot trefoil (*Lotus corniculatus*). Photo courtesy of Jenny Langford, Padre Associates, Inc., Guadalupe, California.

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EXECUTIVE SUMMARY

This report summarizes the results of a species status assessment evaluating the viability of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis* [*Cirsium loncholepis*]) in June 2018 (Table 1). To assess viability, we used the three conservation biology principles of resiliency, representation and redundancy (U. S. Fish and Wildlife Service [USFWS] 2016b, entire; Smith et al. 2018, entire). Specifically, we identified the species' needs, current conditions and status, changes in representation, resiliency and redundancy from historical time to the present, and forecast the likely future status of the species under three plausible future scenarios.

La Graciosa thistle is a biennial or short-lived perennial plant that flowers once and then dies (Lea 2002, p. 67; Teed 2003, p. iv; Baldwin et al. 2012, p. 289), with a probable life span of 2 to 6 years (Lea 2002, p. 68). La Graciosa thistle exists as groups of individuals in wetland habitats in an arid and semi-arid landscape. Potential pollinators include ants, beetles, bees, butterflies and flies (Keil 2001, p. 1; Lea 2002, p. 80). Seed dispersal is by wind (Keil and Turner 1993, p. 236; Lea 2002, p. 7; USFWS 2016a, p. 68) and also likely by water. The species appears to have only a minimally persistent seedbank (Hendrickson 1990b, p. 23; Lea 2002, p. 33; Teed 2003, p. 29; our data in Table 2).

At listing as endangered in 2000 (USFWS 2000, p. 14888), La Graciosa thistle was reported to occur from southern Monterey County southward to the Santa Ynez River, Santa Barbara County (USFWS 2000, p. 14889), and from the Pacific Ocean inland to Orcutt, Santa Barbara County (15.6 km/9.7 mi). The plant was known from 17 occurrences of which eight were likely extirpated. For our purposes, we define an occurrence as a group of La Graciosa thistle plants that is separated by more than 0.4 km/0.25 mi from any other group of La Graciosa thistle plants (California Department of Fish and Game 2011, p. 4). The USFWS (2000, p. 14892) identified the following threats at time of listing: extensive loss of habitat, continuing energy-related activities (maintenance, hazardous waste cleanup) that modify habitat in the Guadalupe Dunes, commercial development in the Guadalupe Dunes, hydrological alterations (including groundwater extraction in and near the Guadalupe Dunes), uncontrolled cattle grazing in the Guadalupe Dunes and along the Santa Maria River, and invasive species.

Currently, 21 extirpated and extant occurrences range coastally from Pismo State Beach (occurrence 14; 35.107367, -120.625009), San Luis Obispo County, southward to the floodplain of the Santa Ynez River near the south entrance of Vandenberg Air Force Base (occurrence 1; 34.662962, -120.556957), Santa Barbara County (32.7 km/20.3 mi distance), and from the Pacific Ocean eastward to a freshwater marsh 1.6 km/1.0 mi northeast of Los Alamos (occurrence 33; 34.748658, -120.259412), Santa Barbara County (31.7 km/19.7 mi distance). The occurrence previously reported in Monterey County has since been determined to be the Alameda County thistle (*Cirsium quercetorum*) (Lea 2002, p. 3). The majority (n = 17) of occurrences are within 6.3 km/3.9 mi of the coast, while four occurrences are at substantially greater distances. Most of the occurrences (n = 16) are in or proximal to two coastal sand dune complexes in San Luis Obispo County: the Callender Dunes just south of Arroyo Grande, and the contiguous Guadalupe Dunes just north of the Santa Maria River.

Of the 21 known occurrences, 16 are likely extirpated, four are currently extant (occurrences 6, 11, 18, 31), and one has unknown status. The four extant occurrences are on lands of various

ownership: one occurrence on private property of Chevron Corporation (18), one occurrence on private properties of Chevron Corporation and another landowner (6), one occurrence on private property with a conservation easement to the Land Conservancy of San Luis Obispo County (11), and one occurrence on Guadalupe-Nipomo Dunes National Wildlife Refuge (31). The primary threat to La Graciosa thistle in 2018 is lack of water, with groundwater decline as the likely major cause. The groundwater decline appears to result by extraction for urban, agricultural, and industrial uses, and it is exacerbated by drought and climate change. Due to its minimally persistent seed bank, any occurrence of the species that has not had flowering plants over several consecutive years is at risk of extirpation.

We evaluated the change in resiliency, representation, and redundancy from historical time to the present, and forecast the likely future status of the species under three plausible future scenarios. Our resiliency analysis determined that three of the four extant occurrences have medium resiliency (score of 2 out of possible 3), suggesting a moderate ability of these occurrences to withstand stochastic and catastrophic events and natural environmental variation. One extant occurrence has low resiliency (score of 1), suggesting little ability for it to withstand stochastic and catastrophic events and natural environmental variation. The results of our representation analysis indicate that the genetic diversity and spatial extent of La Graciosa thistle has declined. The four extant occurrences of La Graciosa thistle are in the Sand Dune Complexes population. Representation across the other three populations appears to have been lost, suggesting the species has lost potential capability of adapting to changes (natural or human caused) in its environment. With only four extant occurrences and 16 likely extirpated occurrences (and one occurrence with unknown status), the redundancy of La Graciosa thistle is severely reduced, decreasing the ability of the species to withstand catastrophic events and to survive in the face of unpredictable and highly consequential events for which adaptation is unlikely.

To forecast the likely future status of La Graciosa thistle, we evaluated three plausible future scenarios projected over 50 years, with each including existing groundwater use and climate change: current conditions with no additional conservation efforts, current conditions with light conservation efforts, and current conditions with major conservation efforts. The results of the future scenario with no additional conservation efforts forecast reduced resiliency, redundancy and representation for La Graciosa thistle over the next 50 years. The future scenario with light conservation efforts forecasts an increase in resiliency, redundancy and representation above levels in 2017/2018, although each would remain low. Only the future scenario with major conservation efforts forecasts sufficient resiliency and redundancy for long-term viability of the species, although representation would remain low. In the latter future scenario we assumed that major conservation efforts would occur at 12 occurrences (one on a National Wildlife Refuge, five on State lands, and six on private properties with likely willing landowners) and comprise the following: monitoring, outplantings, vegetation management, predator management, provisioning of water where necessary, restoration of three dune lakes, and negotiation of water rights. This future scenario would require substantial funding, coordination and collaboration. However, if accomplished, these conservation efforts would provide a major benefit for the species and likely ensure its survival for the next 50 years.

Table of Contents

INTRODUCTION

This report summarizes the results of a species status assessment for the La Graciosa thistle (*Cirsium scariosum* var. *loncholepis* [*Cirsium loncholepis*]; cover photo) in June 2018 (Table 1). *Cirsium loncholepis* was listed as State threatened in 1990 (California Department of Fish and Wildlife 2017b, p. 3) and as federally endangered in 2000 (USFWS 2000, p. 14888). We designated critical habitat in 2004 (USFWS 2004, entire) and revised it in 2009 (USFWS 2009, entire). We completed a 5-year review in 2011 (USFWS 2011, entire). This species status assessment is our 2018 review of the status of the species, compiling the best available information regarding the species' biology and factors that influence the species' viability. Especially important are the records in the California Natural Diversity Database (California Department of Fish and Wildlife 2017a, entire).

This species status assessment assesses the ability of La Graciosa thistle to maintain populations over time. To assess viability, we used the three conservation biology principles of resiliency, representation and redundancy (USFWS 2016b, entire; Smith et al. 2018, entire). These principles are described later in this document. Our approach for assessing viability involved first describing the species' needs, including taxonomy, ecology and historical distribution. We then characterized the current conditions and status, including a detailed account of each occurrence and an analysis of change in resiliency, representation and redundancy from historical time to the present. Finally, we forecast the likely future status of La Graciosa thistle given several plausible future scenarios.

SPECIES NEEDS

Taxonomy

Cirsium loncholepis was described and named by Petrak (1917, p. 375) from a specimen collected "near La Graciosa" by Alice Eastwood in 1906. It is in the aster and sunflower family (Asteraceae; Baldwin et al. 2012, p. 289). The common name La Graciosa thistle is in reference to the collection site of the holotype, which apparently was near Graciosa railway station or La Graciosa village (now south Orcutt; Figure 1) in Santa Barbara County (Wilken 2009, p. 3).

Kelch and Baldwin (2003, p. 142) studied the phylogeny of the genus *Cirsium*, which comprises approximately 80 species in North America. Although many of the species are well differentiated, some are poorly differentiated due to introgression or incipient speciation (Kelch and Baldwin 2003, p. 142). Keil (2006, p. 1) synonymized *C. loncholepis* with *C. scariosum* var. *citrinum*. However, Keil (2010, p. 57) subsequently recognized *C. scariosum* var. *loncholepis* as a new combination and variety. Although Keil (2010, p. 57) observed few, if any, morphological features that distinguish the two taxa, he reported that the coastal populations of *C. scariosum* var. *loncholepis* and montane populations of *C. scariosum* var. *citrinum* were separated by 150 km/93 mi and with no intervening population, but with substantial ecological differences. Baldwin et al. (2012, p. 289) referred to *C. scariosum* as a variable complex of intergrading races, and with some plants not readily assignable to any variety. They stated that *C. scariosum* var. *loncholepis* is probably derived from populations of *Cirsium scariosum* var. *citrinum* near the headwaters of the Cuyama River, which is a tributary of the Santa Maria River. The largest

occurrence of *C. scariosum* var. *loncholepis* is at the mouth of Santa Maria River. *Cirsium scariosum* var. *loncholepis* has the same morphological characteristics and geographic distribution as the previously-recognized *C. loncholepis,* and it is the same listed entity. USFWS (2011, entire) provided additional details.

Life History

La Graciosa thistle is a biennial or short-lived perennial plant that flowers once and then dies (Lea 2002, p. 67; Teed 2003, p. iv; Baldwin et al. 2012, p. 289), with a probable life span of 2 to 6 years (Lea 2002, p. 68). It is an erect or spreading mound-like plant with spines on the leaves and flower heads. The plants have one or more stems that range usually from 10 to 100 cm/4 to 39 in tall but occasionally up to 150 cm/59 in. The lower leaves are 10 to 30 cm/4 to 12 in long with spiny petioles (leaf stalks) and usually deeply lobed with secondary lobes or teeth. The leaves have a wavy edge, with the bases of the middle and upper leaves forming short, spiny wings along the petiole. Flower heads are 2 to 4 cm/0.8 to 1.6 in wide in tight clusters and at the tips of stems. The flowers are 25 to 30 mm/1.0 to 1.2 in long, and nearly white with a purplish tube containing purple anthers (Figure 2). The fruits are achenes (dry fruit containing one seed only; Lea 2002, p. 7), 3 to 4 mm/0.1 to 0.2 in long, and topped with a pappus (umbrella of small hairs) 15 to 25 mm/0.6 to 1.0 in long (Keil and Turner 1993, p. 236) that facilitates wind dispersal (Figure 3). La Graciosa thistle can be confused with the clustered thistle (*Cirsium brevistylum*; Table 3) and cobwebby thistle (*Cirsium occidentale*).

La Graciosa thistle exists as groups of individuals in wetland habitats in an arid and semi-arid landscape. The plants inhabit the margins of wetlands (swales, lakes, ponds, freshwater marshes, streams, rivers, seeps) in southwestern San Luis Obispo County and western Santa Barbara County in central coastal California. The majority of occurrences are associated with wetlands in the backdunes of two coastal sand dune complexes, the Callender Dunes and the Guadalupe Dunes (Figure 1). Many of the wetlands in the sand dune complexes occur where the groundwater table is at or near the surface (Lea 2002, p. 66; California Department of Fish and Game 2005, p. 328), and the water levels rise and fall naturally with rainfall. Low water levels can be exacerbated by drought (Holland et al. 1995, p. 23).

Normal annual rainfall in the geographic range is 33 to 43 cm/13 to 17 in and with an average of 38 cm/15 in (California Department of Water Resources 2004, p. 1), but 24.1 cm/9.5 in was recorded in 2014 (Luhdorff and Scalmanini Consulting Engineers 2015, p. 22). La Graciosa thistle blooms from April to September (Baldwin et al. 2012, p. 289). Potential pollinators include ants, beetles, bees, butterflies and flies (Keil 2001, p. 1; Lea 2002, p. 80). Seed dispersal is by wind (Keil and Turner 1993, p. 236; Lea 2002, p. 7; USFWS 2016a, p. 68) and also likely by water because it is a wetland plant.

Three of the most important studies on the life history of La Graciosa thistle were conducted by Hendrickson (1990b, entire), Lea (2002, entire) and Teed (2003, entire). Each studied population dynamics at the two largest extant occurrences (6 and 18). Hendrickson (1990b, p. 21) counted density of seedlings in occurrence 6 at the mouth of Santa Maria River. During March there were up to 352 individuals per m^2/1.2 yd^2, but during August there were no more than 64 individuals per m^2/1.2 yd^2. Although not observed, Hendrickson (1990b, p. 21) suspected that insect herbivory was the major cause of seedling mortality. The shaded seedlings had substantially

larger leaves that those in sunlight. Hendrickson (1990b, p. 23) wondered if dormant seeds exist in the soil that could buffer population fluctuations. Therefore, she attempted to germinate seedlings of La Graciosa thistle from soil samples of the Santa Maria River bed, but none emerged. She concluded that no dormant seeds were in the soil sample, or else some mechanism prevented any dormant seeds from germinating.

Lea (2002, entire) studied the population dynamics and demography of two occurrences of La Graciosa thistle in the Guadalupe Oil Field (1,145 ha/2,830 ac) in San Luis Obispo County (occurrences 6 and 18), which appear to represent two extremes of habitat conditions. The two groups of studied plants were separated by 2.63 km/1.63 mi. The plants in occurrence 6 were at the river mouth and 0.59 km/0.37 mi from wet beach sand, and the plants in occurrence 18 were inland and 2.81 km/1.75 mi from wet beach sand. Lea (2002, p. 35) reported that plants at occurrence 6 (river mouth, moister conditions) had larger leaves than plants at occurrence 18 (inland, drier conditions). Further, the majority (85%) of plants that flowered were in the larger size classes at each occurrence. At occurrence 6, 85% had the largest leaf >10 cm/3.9 in length, and at occurrence 18, 92% had the largest leaf >7 cm/2.8 in length. All flowering individuals subsequently died, indicating a monocarpic species. At both occurrences the larger flowering plants produced more seeds than the smaller flowering plants (larger plant mean = 473 seeds per plant; smaller plant mean = 168 seeds per plant; Lea 2001 in USFWS 2008, p. 45807). The month of March had the greatest number of germinating seedlings, and seedlings comprised the greatest portion of the population. The germination rate was 13% (occurrence 18), and with minimal contribution from the seed bank (Lea 2002, p. 45). Herbivory of leaves by snails was observed. Lea (2002, p. 71) calculated the population growth rate for both occurrences to be >1, which indicated plant numbers should be increasing if all parameters and ecological conditions remain the same as during the study.

Teed (2003, entire) studied the ecology and population demography of the same two occurrences. The majority of seeds were produced by the largest plants at both occurrences. At occurrence 18, 38% of the flower heads were damaged by insects, whereas at occurrence 6, 19% of the flower heads were damaged by insects. Like Lea (2002, p. 33), Teed (2003, p. 29) reported that all flowering individuals subsequently died. Most seedlings originated from seeds deposited the previous summer rather than from a seed bank. In addition, Teed (2003, p. 58) concluded that La Graciosa thistle is adapted to periodic disturbance. Further, she suspected that the clumped pattern of the species within its habitat is likely due to the seeds being deposited near the parent plant and to the microclimate near the parent plant being especially favorable for survival and growth.

The seed bank of La Graciosa thistle may be similar to that of the wetland jewelweed (*Impatiens capensis*) for which no persistent seed bank exists (Simpson et al. 1985, p. 307). This is supported by the data in our Table 2. Of the 13 occurrences for which zero plants were recorded and then a subsequent census conducted, 11 also had zero plants recorded in the subsequent census. In other words, only two of 13 occurrence were found to be extant after a previous census record of zero plants. This combined with the observations of Hendrickson (1990b, p. 23), Lea (2002, p. 45) and Teed (2003, p. 29) indicate that La Graciosa thistle has only a minimally persistent seed bank.

Individual Needs

La Graciosa thistle inhabits the margins of wetlands (swales, lakes, ponds, freshwater marshes, streams, rivers, seeps). Twenty-two extirpated and extant occurrences are known, and the majority (n = 18) are within 6.3 km/3.9 mi of the coast, while four occurrences are at substantially greater distances inland. The greatest distance is 31.7 km/19.7 mi inland (occurrence 33). Elevations for the coastal occurrences are 43 m/141 ft or less, whereas the inland occurrences are at 107 to 190 m/351 to 623 ft. USFWS (2004, p. 12559) identified the following as the primary constituent elements of critical habitat for La Graciosa thistle: moist, sandy soils associated with dune swales, margins of dune lakes and marshes, seeps, intermittent streams and river margins; native plant communities that support the associated native wetland species, including rush (*Juncus*), tule (*Scirpus*) and willow; and hydrologic processes that support the soil moisture regime favored by La Graciosa thistle, particularly a stable groundwater table near the surface.

La Graciosa thistle requires habitat with water on or near the surface. Twelve occurrences are associated with wetlands in the backdunes of two coastal sand dune complexes where the groundwater table is presumably at or near the surface and water levels rise and fall naturally with rainfall. The largest occurrence is associated with wetlands at the mouth of Santa Maria River. The 21 known occurrences (Tables 1) are in the following drainages, from north to south: Meadow Creek (1 occurrence), Arroyo Grande Creek (3 occurrences), Oso Flaco Creek (5 occurrences), Santa Maria River (8 occurrences), San Antonio Creek (3 occurrences), and Santa Ynez River (1 occurrence).

La Graciosa thistle grows in moist sandy soil with or without an upper organic layer in open areas with sun exposure or shade (Hendrickson 1990b, entire). Hendrickson (1990b, p. 24) observed that most La Graciosa thistle among the sand dunes were on level areas usually on the eastern or northern edges of a swale or lake. The western edges of these wetlands were often bounded by steep slopes of sand. The strong prevailing winds are from the northwest (Hunt 1993, p. 29; USFWS 2016a, p. 28). La Graciosa thistle is frequently associated with willows (*Salix*) (Hendrickson 1990b, p. 24). Potential pollinators include ants, beetles, bees, butterflies and flies (Keil 2001, p. 1; Lea 2002, p. 80).

Kelch (2008, p. 2) portrayed a concept of La Graciosa thistle as a fugitive species. He pointed out that the species is restricted to the transition area from saturated to upland conditions, which is sometimes called upper marsh habitat. La Graciosa thistle shifts its locations over time as local conditions deteriorate to the point that the plants can no longer survive there. The short-lived nature of the plants means the occurrences are dependent on seeds finding new areas that meet the ecological requirements of seedlings in a short timeframe. Such fugitive species are difficult to conserve because the currently occupied habitat may be only a small portion of the area needed for long-term survival.

Genetic Diversity

The number of chromosomes in La Graciosa thistle is $2n$ = 34 (Keil and Turner 1993, p. 236). Villablanca (2012, entire) studied the genetic diversity of La Graciosa thistle at three occurrences (6, 18, 32) in the Guadalupe Oil Field in San Luis Obispo County. Genic diversity (average heterozygosity per locus) was high in each of the three occurrences, inferring one genetic

population with historic connectivity among the occurrences. In addition, the diversity values implied a large breeding population for each occurrence. This suggested that the numbers of individuals in the vegetative state (not flowering; Figures 4, 5, 6) were smaller than the numbers in the seed bank, or that the ancestral population size was substantially larger than the current population size. In light of the reports by Hendrickson (1990b, p. 23), Lea (2002, p. 45), Teed (2003, p. 29) and our own observations regarding a minimally persistent seed bank (see Life History), Villablanca's alternative is inferred: that is, the ancestral population size was substantially larger than the current population size. There was no evidence that the most interior of the three occurrences (32) was more differentiated than the other two occurrences. However, only occurrence 6 (mouth of Santa Maria River) showed significant current gene flow, in which 23% of reproducing individuals were migrants and 70% were local individuals. Occurrences 18 and 32 showed no significant gene flow. The vast majority of all individuals in occurrences 18 and 32 were non-migrants and were therefore likely derived in situ. These two occurrences seemed to be demographically independent of any other occurrence, although there were some genetic connections. Occurrences 18 and 32 were also shown to be inbreeding populations, which we interpret as due to loss of connectivity across the landscape. Inbreeding is a threat because it increases the extinction risk of small populations; in particular, the impact of environmental stress can become significantly greater at higher levels of inbreeding (Bijlsma et al. 2000, p. 511). As of 2015, occurrence 32 was likely extirpated (Table 2).

Historical Range and Distribution

At listing as endangered in 2000 (USFWS 2000, p. 14888), La Graciosa thistle was known from 17 occurrences of which eight were likely extirpated. The reported range was from southern Monterey County southward to the Santa Ynez River, Santa Barbara County (USFWS 2000, p. 14889), and from the Pacific Ocean eastward to Orcutt, Santa Barbara County (15.6 km/9.7 mi). The largest occurrence was at the mouth of Santa Maria River at the edge of the Guadalupe Dunes, which rest on the northern flood plain of Santa Maria River (Cooper 1967, p. 86). Seven occurrences were reported to have fewer than 60 plants each, and numbers for the largest were reported to fluctuate from 6,000 plants to 54,000 plants. The historical distribution of La Graciosa thistle likely included the former extensive wetlands in the mid and lower Santa Maria River Valley. In particular, the former extensive wetlands near Orcutt, Santa Barbara County, have been drained and filled for agriculture and urban use (California Department of Fish and Game 2005, p. 328). Also, extensive wetlands associated with the lower Santa Maria River have been replaced with intensive agriculture (Hunt 1993, p. 39), including the former route of the Santa Maria River to Oso Flaco Lake that existed prior to the 1860's (Cooper 1967, p. 77; Hunt 1993, p. 31). In 2000, all occurrences except one were believed to be on private land (USFWS 2000, p. 14889).

Summary

La Graciosa thistle is a monocarpic species that exists as groups of individuals in wetland habitats in an arid and semi-arid landscape. The seeds are adapted for wind dispersal (Keil and Turner 1993, p. 236; Lea 2002, p. 7; USFWS 2016a, p. 68), and there appears to be only a minimally persistent seed bank. The species needs intact wetland habitats with water on or near the surface across the landscape. Based on Villablanca (2012, entire), the ancestral species

population size of La Graciosa thistle was substantially larger than the current species population size, and historic gene flow among occurrences was likely high.

CURRENT CONDITIONS AND STATUS

Current Range and Distribution

As of the 2011 five-year review (USFWS 2011, p. 7), La Graciosa thistle was known from 19 occurrences of which eight were considered extant, ranging from Pismo Beach, San Luis Obispo County, southward to the Santa Ynez River, Santa Barbara County, and from the Pacific Ocean eastward to Cañada de Las Flores marsh, Santa Barbara County (25.9 km/16.1 mi distance).

In 2018, a total of 21 extirpated and extant occurrences range coastally from Pismo State Beach (occurrence 14; 35.107367, -120.625009), San Luis Obispo County, southward to the floodplain of the Santa Ynez River near the south entrance of Vandenberg Air Force Base (occurrence 1; 34.662962, -120.556957), Santa Barbara County (32.7 km/20.3 mi distance), and inland 31.7 km/19.7 mi from the coast to a freshwater marsh 1.6 km/1.0 mi northeast of Los Alamos (occurrence 33; 34.748658, -120.259412), Santa Barbara County (31.7 km/19.7 mi distance). Of the 21 known occurrences, four are extant, 16 are likely extirpated, and one has unknown status. The details and status of each occurrence are provided in Appendix A, two of which are new (occurrences 33 and 34). In addition, we determine that occurrence 35 should be removed from the California Natural Diversity Database. Recognition of occurrence 35 was based on information in a draft of this species status assessment reviewed by California Department of Fish and Wildlife; occurrence 35 now appears to be based on a technical error or a mis-identification (Kofron 2018a, entire).

Threats to La Graciosa Thistle

In the listing rule, USFWS (2000, p. 14892) identified the following threats to the species: extensive loss of habitat, continuing energy-related activities (maintenance, hazardous waste cleanup) that modify habitat in the Guadalupe Dunes, commercial development in the Guadalupe Dunes, hydrological alterations (including groundwater extraction in and near the Guadalupe Dunes), uncontrolled cattle grazing in the Guadalupe Dunes and along the Santa Maria River, and invasive species. USFWS (2000, p. 14893) further stated that hydrological alteration resulting from groundwater extraction posed the most likely and serious threat.

The primary threat to La Graciosa thistle in 2018 is lack of water, with groundwater decline as the likely major source. The groundwater decline appears to be a result of extraction for urban, agricultural and industrial uses, and it is exacerbated by drought and climate change. Groundwater decline causes habitat loss and degradation for La Graciosa thistle. Past development and agriculture have also caused substantial habitat loss and fragmentation by conversion of land for other uses (Hendrickson 1990b, p. 22). From the 1850's to 1987, 90% of California's coastal wetlands disappeared (Caughman and Ginsberg 1987, p. 24). In the 21st century, the remaining wetlands in central coastal California continue to decrease in quantity and quality (USFWS 2011, p. 11). Due to its minimally persistent seed bank, any occurrence of the species that has not had flowering plants over several consecutive years is at risk of extirpation.

Groundwater Decline

Santa Maria Valley Groundwater Basin

The wetland habitat that supports La Graciosa thistle occurs where the groundwater table is likely at or near the surface. The majority of the occurrences (18 of 21) are in the Santa Maria Valley Groundwater Basin, which extends from Pismo Beach to Point Sal (south of the mouth of Santa Maria River) and inland from the coast to east of the cities of Santa Maria and Orcutt (Luhdorff and Scalmanini Consulting Engineers 2015, Fig. 1.1-1). Recharge of the Santa Maria Valley Groundwater Basin occurs primarily by seepage from the major streams, rainfall percolation and subsurface flow (California Department of Water Resources 2004, p. 2). In general, groundwater levels in the region fluctuate naturally over time but within a relatively small range (Bartolino and Cunningham 2003 p. 1). Conversely from 1918 to 1975, groundwater volume in the Santa Maria Valley Groundwater Basin declined by 33%, including 44% declines in the Guadalupe and Nipomo storage units and a 59% decline in the Santa Maria storage unit (Morro Group 1990, p. A-36). These three groundwater units underlie or are proximal to 15 of the 21 known occurrences of La Graciosa thistle, and they provide most of the water for the intensive agriculture (primarily vegetables and strawberries; Luhdorff and Scalmanini Consulting Engineers 2015, p. 21), residential development, urbanization and industry immediately to the east of these occurrences. Groundwater decline by extraction can lower the groundwater table to such an extent that wetland plants can no longer survive (Bartolino and Cunningham 2003, p. 2; U.S. Geological Survey 2016, p. 2), and we suspect this is likely a primary cause in the decline of La Graciosa thistle (Oyler et al. 1995, p. 46; Figure 7).

From the late 1960's to 2002, the Santa Maria Valley Groundwater Basin has alternately experienced substantial recharge and decline (Luhdorff and Scalmanini Consulting Engineers 2015, p. 8). Most recently since 2002, groundwater levels gradually declined because of land uses along with a lack of water releases from Twitchell Dam upriver, which released no water in 2002, 2003, 2004, 2007, 2009, 2010, 2013, 2014 (Luhdorff and Scalmanini Consulting Engineers 2015, p. 8), 2015 (Anderson 2016, p. 3) and 2016 (Gonzalez 2017, p. 1), and with only limited releases in most intervening years and 2017 along with extended drought (Luhdorff and Scalmanini Consulting Engineers 2015, p. 38; Gonzalez 2018, p. 1). In the vicinity of the Guadalupe Oil Field, the Santa Maria River would usually be dry if not for runoff irrigation wastewater (Mock 2000, p. 7). In 2014, at the southern edge of the Nipomo Mesa, groundwater level was highest in March and by October had declined 7 m/23 ft, and this seems likely linked to seasonal agricultural irrigation (Luhdorff and Scalmanini Consulting Engineers 2015, p. 10). In addition, discussions were underway regarding the sale of water in Twitchell Reservoir to the city of Montecito (San Luis Obispo Coastkeeper and Los Padres Forest Watch 2017, p. 2), which is east of the city of Santa Barbara in southern Santa Barbara County.

The Santa Maria Valley Management Area (Luhdorff and Scalmanini Consulting Engineers 2015, figure 1.1-1) is a subarea of the Santa Maria Valley Groundwater Basin, and it encompasses 12 occurrences of La Graciosa thistle, including three of the four extant occurrences. The groundwater levels in the subarea have fluctuated substantially since the 1920's, with widespread decline between 1945 and the late 1960's, including declines of 6.1 to 12.2 m/20 to 40 ft near the coast and 21.3 m/70 ft near Orcutt. These declines resulted by

progressively increasing urban and agricultural demands, along with drier climatic conditions (Luhdorff and Scalmanini Consulting Engineers 2015, p. 8).

Dune Lakes

The Dune Lakes comprise 10 natural lakes between the city of Arroyo Grande and Oso Flaco Lake, and they contain three occurrences of La Graciosa thistle: occurrence 10 at Mud Lake (likely extirpated), occurrence 11 at Big Twin Lake and Small Twin Lake (extant), and occurrence 16 at Black Lake (likely extirpated). The Dune Lakes are in the backdunes in the northern half of the Callender Dunes. From north to south, the Dune Lakes are Willow Lake, Pipeline Lake, Celery Lake, Hospital Lake, Big Twin Lake, Small Twin Lake, Bolsa Chica Lake, White Lake, Mud Lake and Black Lake (Smith et al. 1976, plate II). These lakes are approximately 1.6 km/1 mi inland and at the western edge of Nipomo Mesa. They are bordered by sand dunes on all sides and are completely land-locked (Smith et al. 1976, p. 13). The Dune Lakes are shallow, and originally they received water only by subsurface seepage, springs and rainfall (Smith et al. 1976, p. 13, 20, 30), along with runoff from Black Lake Canyon (Smith et al. 1976, p. 86).

Cooper (1967, p. 82-86) hypothesized the Dune Lakes originated by rising groundwater filling the wind-blown troughs between the sand dunes. Likewise, Caughman and Ginsberg (1987, p. 239) stated the Dune Lakes formed in the troughs between the sand dunes ~16,000 years ago, and they were fed by groundwater seeping seaward from the Nipomo Mesa. Citing Cooper (1967), Hunt (1993, p. 31) described the Dune Lakes as a surface manifestation of groundwater flowing through gravels of the lower Cienaga Valley (lower Arroyo Grande Creek floodplain; Holland 2013). He identified 10 depressions capable of retaining water in wet years, and with the number of lakes varying depending on the amount of precipitation and groundwater extraction.

The hydrology of the Dune Lakes is complex and unresolved. The California Department of Water Resources (1970, p. 27-28) stated the Dunes Lakes are maintained chiefly by ground water seepage. The chemical quality of their water indicates two sources of supply: unconfined groundwater of excellent quality underlying the Nipomo Mesa, and poor-quality semiperched groundwater of the lower Arroyo Grande Plain. Apparently the unconfined groundwater beneath the Nipomo Mesa intercepts the ground surface in Black Lake Canyon, which forms a shallow slough that feeds Black Lake, Mud Lake and White Lake. However, development along the canyon has lowered the groundwater table so that the lakes now receive seepage from Black Lake Canyon only during extremely wet years (Smith et al. 1976, p. 20). The water levels in the Dune Lakes during the summer months are sometimes maintained by runoff irrigation wastewater (Smith et al. 1976, p. 13) and by some pumped groundwater (Madsen 2017, p. 1), or the lakes may be dry or mostly dry (Whitaker 2017, entire). All of the lakes have completely dried except Black Lake, which is the deepest (Smith et al. 1976, p. 31), and most recently during the 2012 to 2017 drought (Madsen 2017, p. 1). Mud Lake was dry for 5 years (Madsen 2017, p. 1).

The California Department of Water Resources (2002, p. ES6, 54-58, 130) stated the Dune Lakes are perennial surface water bodies connected to perched groundwater situated above the main water table. The perched groundwater occurs where clay lenses intercept the downward percolating water resulting in accumulation above the lenses. The groundwater discharges into

the Dune Lakes as diffuse upward leakage. Similarly, Papadopulos and Associates (2004, p. 11, 23) stated the dune sands under the Nipomo Mesa locally contain layers on which groundwater is perched. Some of the shallow groundwater that percolates downward in the Nipomo Mesa is diverted laterally along these low-permeability layers and discharges into Black Lake Canyon and supports Black Lake, Celery Lake, White Lake and Little Oso Flaco Lake (Papadopulos and Associates 2004, p. 11). Reduction of groundwater discharge to the lakes west of Nipomo Mesa is likely to be a relatively rapid consequence of depleted groundwater beneath the Nipomo Mesa (California Department of Water Resources 2002, p. ES5-ES6).

Cooper (1967, p. 82) first recognized the possibility of subsurface gravity flow of water from Black Lake Canyon to the Dune Lakes, and he reported the use of agricultural wastewater to maintain levels in the lakes during dry periods. Water-surface altitudes of the Dune Lakes in 1952 were 4.5 to 5.5 m/14.8 to 18.0 ft, with the lowest measurement at Mud Lake and with an upward gradient to Black Lake and Black Lake Canyon (Cooper 1967, p. 82-83). Black Lake was previously connected to Black Lake Canyon, which drained into it. The canyon is 8 km/5 mi long, with State Highway 1 and the Southern Pacific Railroad at its lower end. The canyon contains a deep slough with an underbase of peat that is 12 m/40 feet thick. Construction of the highway and railroad has cut off the canyon from Black Lake. Rather than formation by surface runoff, the canyon was likely formed by the sapping of a large spring or springs during the last Ice Age (11,700–110,000 yr ago) when precipitation was probably greater. Historically, water seeped downslope from Black Lake Canyon to the lakes and it was sufficient to supply all of the lakes. Upstream development in the canyon has lowered the groundwater table so that the lakes now receive drainage and runoff only during extremely wet years. The major source of water during the winter and spring came from several springs that fed the lakes, and one spring produced over 100 gallons of water per minute. The construction of a railroad across the canyon and the extraction of groundwater for agriculture and urban development have curtailed the inflow of water to the lakes (Smith et al. 1976, p. 13, 20, 30, 31; Caughman and Ginsberg 1987, p. 239; Morro Group 1990, p. A-11).

Newton (2017) presented an alternative view regarding the hydrology of the Dune Lakes. He stated there are two aquifers under the Nipomo Mesa, one shallow and one deep. The Dune Lakes connect to the shallow aquifer, while water is pumped from the deep aquifer. The two aquifers are not connected, and drying of the Dune Lakes and dune swales is not associated with extraction of groundwater from the deep aquifer to the east. He said the Dune Lakes and dune swales are like vernal pools that fill only by rainfall, with a confining impenetrable layer underneath separating them from the deep aquifer, so their drying is a natural process by drought. However, the concept of shallow and deep aquifers under the Nipomo Mesa separated by an aquiclude (a geologic layer through which water cannot flow, or flows through slowly) is not compatible with observations of wetlands drying at the lower end of Black Lake Canyon. Chipping (1994, p. 72) reported a drop of 2.25 m/7.4 ft in the groundwater table around Black Lake Canyon from 1975 to 1994, despite a rise in the groundwater table at the upper end of the canyon. Chipping (1994, p. 12-13) suspected that the layer between the two aquifers is leaky, with water from the shallow aquifer infiltrating into the deep aquifer as its water is extracted. Chipping (1994, p. 72) concluded "it appears that regional lowering of the water table may be responsible for drying of the wetlands" at the lower end of Black Lake Canyon. Chipping (2017, p. 1-3) subsequently stated that the Dune Lakes contact the groundwater table, which holds up the lakes. The groundwater table under the Nipomo Mesa to the east has dropped by pumping,

which is why the Dune Lakes are dry. Likewise, Garing (2017, p. 1) stated that groundwater under the Nipomo Mesa has been declining since 1965, and he suspects that the Dunes Lakes contact the groundwater table. In his professional opinion, the Dune Lakes are now mostly dry because the groundwater under the Nipomo Mesa is being depleted. In 2015 the groundwater table under the Nipomo Mesa was at its lowest level since at least 1975 (Nipomo Community Services District 2017b, p. 1-1). In 2017 the Nipomo Community Services District (2017a, p. 1) recognized a severe water shortage under the Nipomo Mesa, and with a goal of reducing groundwater pumping by 50%.

Entrance Ponds, Guadalupe Oil Field

The Entrance Ponds (occurrence 32, likely extirpated) in the Guadalupe Oil Field have been monitored annually from 2005 to 2016. The number of La Graciosa thistle plants here declined rapidly from 420 individuals in 2005 to zero individuals in 2015, 2016 and 2017 (Langford 2017b, p. 1-5). Langford (2017b, p. 3) identified the threats here as drought, wetland drying, groundwater decline, and invasive plants (Italian plumeless thistle (*Carduus pycnocephalus*), ripgut brome and foxtail fescue (*Vulpia myuros*)). In addition, Kofron (2017f, p. 1) observed many fallen dead arroyo willows that were altering the habitat, and the fallen dead willows are consistent with a drop in the groundwater table (Holland et al. 1995, p. 40; Chipping 2017, p. 1). Monitoring well 35W-6A1 is 180 m/590 ft southeast of the occurrence at the Entrance Ponds, and both connect to the same aquifer (Langford 2017a, p. 1-2). In October 2016, the elevation of groundwater at the monitoring well was 12.16 m/39.9 ft, whereas in October 2001 it was 16.73 m/54.89 ft (Figure 7). The groundwater table declined 4.57 m/14.99 ft over the 15 years (Langford 2017a, p. 1-2), and the occurrence of La Graciosa thistle at the Entrance Ponds is now likely extirpated.

Drought and Climate Change

A coastal dune swale is a scoured depression between sand dunes where the bottom is at or near the groundwater table. The plant communities at coastal dune swales are usually dominated by phreatophytes (plants with high moisture requirements that have the ability to tap the fringe of the groundwater table), including native marsh baccharis (*Baccharis glutinosa*) and coyote brush (*Baccharis pilularis*), and invasive poison hemlock (*Conium maculatum*). The recent drought has caused a drop in groundwater levels, and just several centimeters/inches can make a substantial difference to the plant community that occurs on site (Holland et al. 1995, p. 41-42; USFWS 2016a, p. 40-41). One of the effects of drought on La Graciosa thistle may be the suppression of seedling recruitment (USFWS 2016a, p. 68) because seedlings have less tolerance for drier conditions than adults (Huber 2005, p. 22).

USFWS (2016, p. 33) stated the following. "Because the wind is capable of eroding sand so deep that groundwater is uncovered, it has produced a scattering of small wetlands and water holes throughout the dunes. The connection of the dune lakes and wetlands with shallow groundwater and agricultural runoff has created important management concerns. For example, during drought years, lakes within the dune areas have gone dry when groundwater supplies were depleted through pumping."

The year 2015 was the warmest since record keeping began in 1880, and most of the warming occurred in the past 35 years with 15 of the 16 warmest years occurring since 2001 (Brown et al. 2016, entire). In particular, California is becoming hotter and drier. The 3-year period from 2012 to 2014 was the hottest and driest in California in the 100-year time frame considered (Mann and Gleick 2015, p. 3858), and it was the most severe drought in California in the past 1,200 years (Griffin and Anchukaitis 2014, p. 2017). Wetland water levels are lowered by drought (USFWS 2016a, p. 40-41). Because La Graciosa thistle is restricted to wetlands, a severe drought can further reduce or eliminate its habitat. Species with small geographic ranges are vulnerable to extinction by climate change (Allan et al. 2005, p. 284). In consideration of the life history traits used by Anacker et al. (2013, p. 197), La Graciosa thistle is highly vulnerable to climate change because of its wetland habitat specialization.

Other Threats

Other identified threats to La Graciosa thistle include the following: reproductive failure, flooding, unstable water level, manipulation of water level, vegetation management (including herbicides, controlled burns, and thistle eradication programs; Keil and Holland 1998, p. 82), invasive species, cattle grazing, cattle trampling, feral pigs, herbivory (rabbits, aphids and other insects, snails, deer, mice), gophers, native willow expansion, bulrushes, habitat alteration by dead fallen willows, road construction and ditch maintenance (Keil and Holland 1998, p. 82), Eurasian flower-head weevils (*Rhinocyllus conicus*) (Keil and Holland 1998, p. 82), off road vehicles, oil production, hunters, water quality issues, genetics of small populations including inbreeding, and loss of connectivity between populations (USFWS 2011, p. 22; Table 4). However, regarding cattle grazing, Hendrickson (1990b, p. 12, 24) and Ingamells (1991, p. 1) considered this activity as potentially benefiting La Graciosa thistle by reducing both invasive and native species in the habitat at occurrences 6 and 19. The threats to La Graciosa thistle in 2018 are listed in Table 5.

Conservation Measures for La Graciosa Thistle

In 2018, conservation measures are being implemented on two properties: the private property of Chevron Corporation, and Oceano Dunes State Vehicular Recreation Area (1,457 ha/3,600 ac). Since 2005, Chevron Corporation has managed occurrences 6, 18 and 32 (Table 6) in the Guadalupe Oil Field under a biological opinion (USFWS 2005, entire) issued under the U.S. Endangered Species Act. Specifically, their actions have included the following:

- annual monitoring of three occurrences of La Graciosa thistle on their property (a fourth occurrence was identified in 2018);
- salvaging and transplanting 1,629 individuals that would have been impacted by remediation and restoration activities, of which 1,136 individuals survived;
- outplanting 2,842 individuals (2,826 grown from seed), of which 1,893 individuals flowered;
- managing invasive plants in the Guadalupe Oil Field; and
- removing feral pigs.

In 2017, occurrences 6 and 18 were extant, whereas occurrence 32 was likely extirpated due to groundwater decline. Occurrence 32 at the Entrance Ponds steadily decreased in numbers from 420 plants in 2005 to 0 plants in 2015, 2016 and 2017. Chevron Corporation will likely conclude

its activities under the biological opinion within 10 years, at which time most legal protection and management of occurrences 6, 18 and 32 will cease. However, Chevron Corporation is seeking a conservation land manager to assume ownership upon completion of their project.

California State Parks is eradicating invasive plant species at occurrences 12 and 20 on Oceano Dunes State Vehicular Recreation Area. Occurrence 12 at Surprise Lake likely became extirpated in 2018 (zero plants in 2018; 65 plants in 2017), and occurrence 20 is also likely extirpated.

Analytical Framework

This analysis assesses the ability of La Graciosa thistle to maintain populations over time (i.e., viability). To assess viability, we used the three conservation biology principles of resiliency, representation and redundancy (USFWS 2016b, entire; Smith et al. 2018, entire).

Resiliency

Resiliency is the ability to sustain populations, or occurrences in the case of La Graciosa thistle, in the face of environmental variation. Environmental variation includes normal year-to-year variation in rainfall and temperatures, as well as unseasonal weather events. To be resilient, a species must have occurrences that are able to sustain themselves through good and bad years. Resiliency is affected also by the degree of connectivity among populations and occurrences.

We evaluated the resiliency of each occurrence of La Graciosa thistle based on the number of individuals at the occurrence and the change in numbers over time (Table 7). We assigned scores ranging from 0 to 3. The highest score of 3 indicated high resiliency, and the lowest score of 0 indicated extirpation. A score of 2 indicated moderate resiliency and 1 indicated low resiliency. We qualitatively define a high resiliency score as the individuals within the occurrence having a high probability of persistence, a moderate resiliency score as the individuals within the occurrence having a medium probability of persistence, and a low resiliency score as the individuals within the occurrence having a low probability of persistence.

In 2018, 16 of the 21 known occurrences of La Graciosa thistle are likely extirpated (occurrences 1, 2, 3, 4, 8, 10, 12, 13, 14, 16, 19, 20, 28, 30, 32 and 34) and, therefore, we assigned a score of 0 for resiliency. At time of Federal listing in 2000, nine of these 21 known occurrences were already likely extirpated. Occurrences 8, 12, 19, 28, 30, 32 and 34 have likely become extirpated since listing in 2000. We do not know the status of occurrence 33; therefore, we assigned "unknown" for resiliency. The resiliency and reported threats for each occurrence are shown in Table 4.

In 2018, four the 21 known occurrences of La Graciosa thistle are extant (occurrences 6, 11, 18 and 31). Occurrence 6 is the largest occurrence, and it is in the Santa Maria River bed and its floodplain near the river mouth. In terms of occupied mapped areas, approximately 22% (26 ha/64 ac) of the occurrence is on the Guadalupe Oil Field of Chevron Corporation, and approximately 78% (91 ha/225 ac) is on adjacent private land that is used for cattle grazing. The most recent census of the portion of occurrence 6 on the Guadalupe Oil Field was in 2017 during which 535 plants were recorded, which included several restored and outplanted areas. This

number is substantially down from the pro-rated high of 23,320 plants that were estimated in 1990. From 2006 to 2017, the numbers of plants ranged from 535 (2017) to 9,751 (2009). Padre Associates (2018, p. 12) attributed the low number of plants in 2017 to flooding and prolonged inundation of the habitat. This occurrence is currently partially protected because Chevron Corporation is conducting its oil field remediation and restoration under a biological opinion issued under the U.S. Endangered Species Act, and it includes coverage for La Graciosa thistle. In addition, cattle grazing is not allowed on the property of Chevron Corporation in the Guadalupe Oil Field. Chevron Corporation's oil field remediation and restoration will likely continue for another 10 years, and upon completion the current legal protection and management for La Graciosa thistle will cease. However, Chevron Corporation is seeking a conservation land manager to assume ownership upon completion of their project. The primary threats to this occurrence on the two properties include reduced water, flooding, uncontrolled cattle grazing, invasive species, and potentially crop agriculture replacing cattle grazing as a land use. This occurrence was assigned a resiliency score of 2, moderate resiliency (large occurrence >500 individuals in last 3 years, decreased number of individuals across years).

Occurrence 11 is in Big Twin Lake and Small Twin Lake on private property south of Arroyo Grande. The Land Conservancy of San Luis Obispo County owns a conservation easement over the two lakes. The most recent census recorded ≥245 plants in 2017. The next highest number was 20 plants in 1988. Therefore, this occurrence was assigned a resiliency score of 2, moderate resiliency (small occurrence ≤500 individuals in last 3 years, increased number of individuals or stable across years). The land manager wishes to conserve La Graciosa thistle on this property.

Occurrence 18 is in swales immediately adjacent to paved roads and oil pads in the Guadalupe Oil Field of Chevron Corporation. The most recent census was in 2017, and 913 plants were recorded, which is lower than the highest number of 23,590 plants recorded in 2014. From 2006 to 2017, the numbers of plants ranged from 240 (2010) to 23,590 (2014), with most of the latter number comprising offspring seedlings of outplanted individuals. This occurrence is currently protected by a biological opinion issued under the U.S. Endangered Species Act, and it is managed by Chevron Corporation. As mentioned above for occurrence 6, Chevron Corporation is seeking a conservation land manager to assume ownership upon completion of their project. This occurrence was assigned a resiliency score of 2, moderate resiliency (large occurrence >500 individuals in last 3 years, decreased number of individuals across years).

Occurrence 31 is in a swale in Guadalupe-Nipomo Dunes National Wildlife Refuge. The most recent census recorded ≥5 plants in 2017, and no vegetative individuals. The highest number of plants recorded here was 300 individuals in 2010, then 172 individuals in 2013, and 10 individuals in 2014. We assigned a resiliency score of 1, low resiliency (small occurrence ≤500 individuals in last 3 years, decreased number of individuals across years). Although this occurrence is protected because it is on a National Wildlife Refuge, it is in decline and near extirpation.

In summary, of the 21 known occurrences of La Graciosa thistle, 16 are likely extirpated, four are extant, and one has unknown status. Three of the four extant occurrences have moderate resiliency, suggesting a moderate ability of these three remaining occurrences to withstand stochastic events and natural environmental variation. One of the four extant occurrences has low resiliency, indicating a reduced ability to withstand stochastic events and natural environmental

variation. Of the four extant occurrences, one is protected on a National Wildlife Refuge, one is protected on private property by a conservation easement, one is currently protected on private property by a biological opinion, and one is on two private properties with current protection on one by a biological opinion.

Representation

Representation is the range of variation within a species, and this variation, called adaptive diversity, is the source of a species' adaptive capabilities. Maintaining adaptive diversity includes both the genetic diversity and ecological diversity of a species. By maintaining these two sources of diversity across a species' range, the responsiveness and adaptability of a species over time is preserved. Genetic diversity is the number and frequency of unique alleles within and among populations. Ecological diversity is the physiological, ecological, and behavioral variation exhibited by a species across its range.

Only one study has examined the genetic diversity of La Graciosa thistle. Villablanca (2012, entire) studied the genetic diversity of La Graciosa thistle at three occurrences (6, 18, 32) in the Guadalupe Oil Field. As described in "Genetic Diversity" above, genic diversity was high in each of the three occurrences, which inferred one genetic population with a single demographic history. Results indicated substantial historic connectivity existed among occurrences and that the ancestral population size was likely substantially larger than the current population size. Results also showed that only occurrence 6 (mouth of Santa Maria River) may have significant current gene flow in which 23% of reproducing individuals were migrants, and 70% were local and derived in situ. Occurrences 18 and 32 showed no significant gene flow and were also inbreeding populations.

USFWS (2011, p. 7) previously recognized 10 populations of La Graciosa thistle, citing the definition of population as "a group of interbreeding individuals" (USFWS 2011, p. 4). However, USFWS (2011, entire) had no data or knowledge as to whether or not the occurrences within their 10 populations were interbreeding. Because information is lacking regarding the genetics of most occurrences in 2018, and 16 of 21 known occurrences are likely extirpated, we tentatively recognize four geographic populations that are based solely on the geographic locations of the 21 occurrences. One main cluster of 16 occurrences is in or proximal to the Callender Dunes and Guadalupe Dunes, and five disjunct occurrences are further to the south and southeast. From south to north, the four geographic populations are the following (Table 4): Vandenberg South – – occurrence 1; Solomon Hills — occurrences 2, 3 and 33; South Orcutt — occurrence 4; and Sand Dune Complexes — occurrences 6, 8, 10, 11, 12, 13, 14, 16, 18, 19, 20, 28, 30, 31, 32 and 34. Vandenberg South is separated from Solomon Hills by 23.4 km/14.6 mi, from South Orcutt by 23.8 km/14.8 mi, and from Sand Dune Complexes by 32.4 km/20.2 mi. Solomon Hills is separated from South Orcutt by 11.4 km/7.1 mi, and from Sand Dune Complexes by 28.4 km/17.7 mi. South Orcutt is separated from Sand Dune Complexes by 17.0 km/10.6 mi.

We recognize that our four geographic populations of La Graciosa thistle may be an artefact of the present-day altered landscape. La Graciosa thistle inhabits wetlands, and many historical wetlands within its geographic range no longer exist. It seems likely that many additional occurrences of La Graciosa thistle previously existed but have been extirpated without discovery.

Further, there may be unrecognized genetic populations within our four geographic populations (Villablanca 2017, p. 1).

Vandenberg South (occurrence 1) is likely extirpated. Solomon Hills' occurrences 2 and 3 are likely extirpated, and the status of occurrence 33 is unknown. South Orcutt (occurrence 4) is likely extirpated. Sand Dune Complexes' occurrences 8, 10, 12, 13, 14, 16, 19, 20, 28, 30, 32 and 34 are likely extirpated; occurrence 31 is extant with low resiliency; occurrences 6 and 18 are extant with moderate resiliency; and occurrence 11 is extant with moderate resiliency. The four extant occurrences are in the Sand Dune Complexes. Hendrickson (1990b, p. 23) observed what she believed to be reproductive failure at three occurrences in the Sand Dune Complexes, and these occurrences are now likely extirpated: Jack Lake (occurrence 8), Surprise Lake (occurrence 12), and Oso Flaco Lake (occurrence 13).

In summary, the results indicate that the genetic diversity and the spatial extent of La Graciosa thistle have declined substantially from historical conditions. Gene flow among the four extant occurrences appears limited, and it was likely much greater historically. The four extant occurrences are in the Sand Dune Complexes population. Representation in the other three populations appears to have been lost, suggesting the species has lost potential capability for adapting to changes (natural or human caused) in its environment.

Redundancy

Species-level redundancy is the ability of a species to withstand catastrophic events. Redundancy protects a species against the unpredictable and highly consequential events for which adaptation is unlikely. In short, it is about spreading the risk. Redundancy is best achieved by having multiple populations or occurrences widely distributed across the species' geographic range, which reduces the likelihood that all populations or occurrences are affected simultaneously by any single event. Given sufficient redundancy, single or multiple catastrophic events are unlikely to cause the extinction of a species. Thus, the greater redundancy a species has, the more viable it will be.

Historically, there were likely many more occurrences of La Graciosa thistle across its geographic range than the 21 known occurrences. Because 16 of the 21 known occurrences are now likely extirpated, redundancy is substantially reduced for the species. Having one of four extant populations in the low resiliency category puts the redundancy of the species further at risk. If any of the four extant occurrences should be lost, the redundancy of La Graciosa thistle would be further lowered, thereby decreasing its chance of survival in the face of catastrophic events (e.g., wildfire, extreme drought, flooding).

In summary, with only four extant occurrences and 16 likely extirpated occurrences (and one occurrence with unknown status), the redundancy of La Graciosa thistle is severely reduced. This reduction decreases the ability of the species to withstand catastrophic events and to survive in the face of unpredictable and highly consequential events for which adaptation is unlikely.

FUTURE SCENARIOS

Future scenario: current conditions for 50 years with no additional conservation efforts

In this future scenario, we presume the current conditions for La Graciosa thistle continue for 50 years, with no additional conservation efforts; that is, the current conditions continue into the future for 50 years, including existing groundwater use and climate change. We anticipate that groundwater will continue to be depleted, and with no additional conservation efforts for La Graciosa thistle. We forecast the likely status for each of the four extant occurrences, assuming that none of the likely extirpated occurrences will return. Since 2005, Chevron Corporation has managed occurrences 6 (in part), 18 and 32 (in part) on their private property in the Guadalupe Oil Field under a biological opinion. Currently, occurrences 6 and 18 are extant and have moderate resiliency. Occurrence 32 became likely extirpated in 2015. Chevron Corporation will likely conclude its activities under the biological opinion within 10 years, at which time the protection and management of occurrences 6, 18 and 32 will cease. We forecast that occurrence 6 (mouth of Santa Maria River) would survive, although with substantially decreased numbers of plants. Occurrence 6 is the largest occurrence with more than 500 plants on Chevron Corporation's property in 2017, and it is mostly in the river bed of the Santa Maria River. We forecast that occurrence 18 would survive, which had moderate resiliency with 913 plants at five locations in 2017. We also forecast that occurrence 11 at Big Twin Lake and Small Twin Lake (private property with conservation easement to Land Conservancy of San Luis Obispo County), which in 2017 had moderate resiliency with $\geq$245 plants (including many robust individuals) at three locations, will persist. Occurrence 31 on Guadalupe-Nipomo Dunes National Wildlife Refuge has low resiliency, and it is in decline and near extirpation. Therefore, we forecast that occurrence 31 will become extirpated under current conditions and with no additional conservation efforts. Under this future scenario, representation, resiliency and redundancy for La Graciosa thistle would remain low with only three extant occurrences (6, 11, 18), while one currently extant occurrence (31) would become extirpated. La Graciosa thistle would lack adaptive capacity in the face of environmental changes, and it would remain highly vulnerable to extinction by stochastic and catastrophic events.

Future scenario: current conditions for 50 years along with light conservation efforts

In this future scenario, we presume the current conditions for La Graciosa thistle continue for 50 years, along with light conservation efforts; that is, the current conditions continue into the future for 50 years, including existing groundwater use and climate change. We anticipate that groundwater will continue to be depleted, and that light conservation efforts for La Graciosa thistle would focus on maintaining the four extant occurrences, and re-establishing four likely extirpated occurrences. The four extant occurrences are the following: occurrence 6 on private properties of Chevron Corporation and another landowner; occurrence 18 on private property of Chevron Corporation; occurrence 11 at Big Twin Lake and Small Twin Lake on private property of Dune Lakes Limited and for which the Land Conservancy of San Luis Obispo County holds a conservation easement; and occurrence 31 on Guadalupe-Nipomo Dunes National Wildlife Refuge. The four likely extirpated occurrences where partners would be most amenable to

conservation efforts include those on State-owned lands and property managed by the Land Conservancy of San Luis Obispo County. The four likely extirpated occurrences that would be re-established are the following: occurrence 12 at Surprise Lake, which was extant in 2017 on Oceano Dunes State Vehicular Recreation Area; occurrence 13 at Oso Flaco Lake, which is still a perennial lake on Oceano Dunes State Vehicular Recreation Area; occurrence 14 on Pismo Beach State Park and for which water would be readily available; and occurrence 16 at Black Lake, which is still a perennial lake on private property of the Land Conservancy of San Luis Obispo County. Under the light conservation scenario we assume the Guadalupe Oil Field is transferred from Chevron Corporation to a conservation land manager with incentive to manage occurrences 6 and 18. The light conservation efforts would comprise monitoring, outplantings, vegetation management, predator management, and provisioning of water. Under this future scenario we anticipate that the four currently extant occurrences (6, 11, 18, 31) would survive and four likely extirpated occurrences (12, 13, 14, 16) would be re-established, which would equal the number of extant occurrences at the time of Federal listing in 2000 (n = 8). We assume the resiliency of all 8 occurrences would increase with implemented management. Representation would remain low because only the Sand Dune Complexes population would include extant occurrences. Redundancy would increase with the increase from 4 to 8 extant occurrences. Although the resiliency and redundancy of La Graciosa thistle would increase above levels in 2018, each would remain low for the species. La Graciosa thistle would still lack adaptive capacity in the face of environmental changes, and it would remain vulnerable to extinction by stochastic and catastrophic events.

Future scenario: current conditions for 50 years along with major conservation efforts

This future scenario would require substantial funding, coordination and collaboration among a diverse group of stakeholders. We presume the current conditions for La Graciosa thistle continue for 50 years, along with major conservation efforts; that is, the current conditions continue into the future for 50 years, including existing groundwater use and climate change. We anticipate that groundwater will continue to be depleted, and that major conservation efforts for La Graciosa thistle will be implemented. The major conservation efforts would include all efforts described in the light conservation scenario (light conservation efforts at occurrences 6, 11, 12, 13, 14, 16, 18, 31), and at each of four additional likely extirpated occurrences (two occurrences on State land, and two occurrences on private properties with likely willing landowners). The four additional likely extirpated occurrences that would be re-established are the following: occurrence 10 at Mud Lake on the private property of Dune Lakes Limited with a willing landowner and for which the Land Conservancy of San Luis Obispo County holds a conservation easement; occurrence 20 at an unnamed wooded swale 749 m/819 yd west of Jack Lake, and at Lettuce Lake, on Oceano Dunes State Vehicular Recreation Area; occurrence 30 at an unnamed swale 914 m/1,000 yd southwest of Oso Flaco Lake on Oceano Dunes State Vehicular Recreation Area; and occurrence 32 at the Entrance Ponds in the Guadalupe Oil Field currently owned by Chevron Corporation and another private landowner. The major conservation efforts at the four additional likely extirpated occurrences would comprise monitoring, outplantings, vegetation management, predator management, provisioning of water where necessary, restoration of Mud Lake (along with restoration of Big Twin Lake and Small Twin Lake), and negotiation of water rights. In this future scenario, resiliency for La Graciosa thistle would increase at 12 occurrences, which would buffer the species from extinction. Resiliency would

presumably increase with increased management at each occurrence, decreasing the risk from stochastic events. As in the light conservation scenario, representation would remain low because only the Sand Dune Complexes population would include extant occurrences. The Vandenberg South and South Orcutt populations are likely extirpated, and we could not gain access to the private properties with the Solomon Hills population. Redundancy, however, would increase from four extant occurrences to 12 extant occurrences, which would substantially reduce the risk of extinction by catastrophic events. Accomplishing this scenario would provide a major benefit for La Graciosa thistle and ensure its survival for the next 50 years.

SUMMARY

La Graciosa thistle was listed as State threatened in 1990 (California Department of Fish and Wildlife 2017b, p. 3) and as federally endangered in 2000 (USFWS 2000, p. 14888). The species is a biennial or short-lived perennial plant that flowers once and then dies. Its life span is probably from 2 to 6 years. It exists as groups of individuals in wetland habitats in an arid and semi-arid landscape. Potential pollinators include ants, beetles, bees, butterflies and flies (Keil 2001, p. 1; Lea 2002, p. 80). Seed dispersal is by wind (Keil and Turner 1993, p. 236; Lea 2002, p. 7) and also likely by water because it is a wetland plant. The species appears to have only a minimally persistent seedbank.

At time of listing as endangered in 2000 (USFWS 2000, p. 14888), La Graciosa thistle was reported to occur from southern Monterey County southward to the Santa Ynez River, Santa Barbara County (USFWS 2000, p. 14889), and from the Pacific Ocean eastward to Orcutt, Santa Barbara County (15.6 km/9.7 mi distance). The plant was known from 17 occurrences of which eight were likely extirpated. The USFWS (2000, p. 14892) identified the following threats: extensive loss of habitat, continuing energy-related activities (maintenance, hazardous waste cleanup) that modify habitat in the Guadalupe Dunes, commercial development in the Guadalupe Dunes, hydrological alterations (including groundwater extraction in and near the Guadalupe Dunes), uncontrolled cattle grazing in the Guadalupe Dunes and along the Santa Maria River, and invasive species. USFWS (2000, p. 14893) further stated that hydrological alteration resulting from groundwater extraction posed the most likely and serious threat.

In 2018, 21 known occurrences of La Graciosa thistle range coastally from Pismo State Beach (occurrence 14, 35.107367, -120.625009), San Luis Obispo County, southward to the floodplain of the Santa Ynez River near the south entrance of Vandenberg Air Force Base (occurrence 1; 34.662962, -120.556957), Santa Barbara County (32.7 km/20.3 mi), and inland 31.7 km/19.7 mi from the coast to a freshwater marsh 1.6 km/1.0 mi northeast of Los Alamos (occurrence 33; 34.748658, -120.259412), Santa Barbara County (31.7 km/19.7 mi distance). This comprises an area of 626 km^2/242 mi^2 in San Luis Obispo and Santa Barbara Counties. La Graciosa thistle inhabits the margins of wetlands (swales, lakes, ponds, freshwater marshes, streams, rivers, seeps). The majority (n = 17) of occurrences are within 6.3 km/3.9 mi of the coast, while five occurrences are at substantially greater distances, the greatest at 31.7 km/19.7 mi inland (occurrence 33). Most of the occurrences (n = 16) are in or proximal to two coastal sand dune complexes in San Luis Obispo County: the Callender Dunes just south of the city of Arroyo Grande, and the contiguous Guadalupe Dunes just north of the Santa Maria River.

Of the 21 known occurrences, 16 are likely extirpated, four are extant (occurrences 6, 11, 18 and 31), and one has unknown status. The four extant occurrences are on lands of various ownership: one occurrence on private property of Chevron Corporation (18), one occurrence on private properties of Chevron Corporation and another landowner (6), one occurrence on private property with a conservation easement to the Land Conservancy of San Luis Obispo County (11), and one occurrence on Guadalupe-Nipomo Dunes National Wildlife Refuge (31). The primary threat to La Graciosa thistle in 2018 is lack of water, with groundwater decline as the likely major source. The groundwater decline appears to result by extraction for urban, agricultural and industrial uses, and it is exacerbated by drought and climate change. Due to its minimally persistent seed bank, any occurrence of the species that has not had flowering plants over several consecutive years is at risk of extirpation.

We evaluated the change in resiliency, representation and redundancy from historical time to the present, and forecast the likely future status of the species under each of three plausible future scenarios. Our resiliency analysis determined that three of the four extant occurrences have moderate resiliency (score of 2 out of possible 3), suggesting a moderate ability of these three remaining occurrences to withstand stochastic events and natural environmental variation. One extant occurrence has low resiliency (score of 1), suggesting little ability for it to withstand stochastic events and natural environmental variation. The results of our representation analysis indicate that the genetic diversity and spatial extent of La Graciosa thistle has likely declined. The four extant occurrences of La Graciosa thistle are in the Sand Dune Complexes population. Representation across the other three geographic populations appears to have been lost, suggesting the species has lost potential capability of adapting to changes (natural or human caused) in its environment. With only four extant (and one with unknown status) of 21 known occurrences, which is down from seven extant of 17 known occurrences at time of Federal listing in 2000, the redundancy of La Graciosa thistle is severely reduced, decreasing the ability of the species to survive unpredictable and highly consequential events for which adaptation is unlikely.

To forecast the likely future status for La Graciosa thistle, we evaluated three plausible future scenarios projected over 50 years, with each including existing groundwater use and climate change: current conditions with no additional conservation efforts, current conditions with light conservation efforts, and current conditions with major conservation efforts. The results of the future scenario with no additional conservation efforts forecast reduced resiliency, redundancy and representation for La Graciosa thistle over the next 50 years, with only three extant occurrences. The future scenario with light conservation efforts forecast a small increase in resiliency, redundancy and representation, with eight extant occurrences all of which would be managed. Only the future scenario with major conservation efforts forecast a substantial increase in resiliency and redundancy, although representation remained low. In this latter future scenario we assumed that major conservation efforts would occur at 12 occurrences (one on a National Wildlife Refuge, five on State lands, and six on private properties with likely willing landowners) and comprise the following: monitoring, outplantings, vegetation management, predator management, provisioning of water where necessary, restoration of Mud Lake (along with restoration of Big Twin Lake and Small Twin Lake), and negotiation of water rights. This future scenario with major conservation efforts would require substantial funding, coordination and collaboration. However, if accomplished, these major conservation efforts would provide a major benefit for La Graciosa thistle and ensure its survival for the next 50 years.

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Appendix A. The 21 known occurrences of La Graciosa thistle.

Occurrence 1. 34.662962, -120.556957 (Wilken et al. 2008, p. 8); 10 m/33 ft elevation; 4.8 km/3.0 mi east of Surf, south of road to Lompoc, Vandenberg Air Force Base, Santa Barbara County. The coordinates that we give are a best estimate. This occurrence is documented by specimens (Clifton F. Smith 5820) collected on 16 July 1958 by Clifton F. Smith of the Santa Barbara Museum of Natural History that are now in multiple herbariums: California Academy of Sciences, California Polytechnic State University, Harvard University, Rancho Santa Ana Botanic Garden, San Diego Natural History Museum, Santa Barbara Botanic Garden, University of California Riverside, and University of Minnesota. Smith (1958) described the location as "scattered in saline soil along edge of willows south of Lompoc-Surf Rd. about three miles airline southeast of Surf. El. 100 ft.?" Despite many searches (Smith 1982, p. 2; McLeod 1986d, p. 1; 1987, Schmalzer et al. 1988, p. 133; Hendrickson 1990b, p. 4; 1994 and 1995, Oyler et al. 1995, p. 46; Keil and Holland 1998, p. 82; Elvin 2007b, p. 7; and 2008, Wilken et al. 2009, p. 7), the plant has not been recorded here since 1958. Hendrickson (1990b, p. 4) saw no plants in 1990 and reported the occurrence as extirpated. She described the location as a willow thicket at the edge of a cultivated field, with thick weeds (mainly invasive blessed milkthistle (*Silybum marianum*)) at the edges. Hendrickson (1990b, p. 9) suggested this occurrence may have been extirpated by a spraying program targeting invasive bull thistle (*Cirsium vulgare*). Hendrickson (1990b, p. 10, map 1) spoke with Smith regarding his collecting location, and then she searched "both sides of the drainage along the base of the hills near Union Ave. almost to the VAFB South Gate." In July 2017, an additional record was added for this occurrence based on a specimen in the California Academy of Sciences (CAS413797; Consortium of California Herbaria 2017a, p. 1) that was collected on 9 August 1949 by E.F. Nickerson. The data are the following: on north side of railroad, Camp Cooke Military Reservation (now Vandenberg Air Force Base), about 3 miles east of Surf, on road to Lompoc, south side of Santa Ynez River, over 10-acre field (34.669904, -120.558230; 9 m/30 ft). We viewed images of the location using Google Earth on 22 February 2017. It is in the south floodplain of the Santa Ynez River on Vandenberg Air Force Base near its south entrance at the junction of West Ocean Avenue and Arguello Boulevard. Much of the area has been cleared and disked for agriculture, along with the construction of buildings and parking areas. However, some natural areas remain along the unnamed tributary of the Santa Ynez River. The Bradbury Dam is on the Santa Ynez River (71 km/44 mi upriver), and it opened in 1958. This dam altered the hydrology downstream (Schmalzer et al. 1988, p. 28) and likely adversely affected habitat of the La Graciosa thistle. This occurrence is 4.8 km/3.0 mi inland from wet beach sand.

Occurrence 2. 34.784740, -120.345300; 34.784709, -120.341174; 176 and 180 m/577 and 591 ft elevation; east branch of Cañada de Las Flores marsh, Solomon Hills, Santa Barbara County. The coordinates that we give are from Elvin (2007a, p. 2) and Hendrickson (1990b, map 3). This occurrence is documented by several specimens collected on 31 August 1973 by Clifton F. Smith of the Santa Barbara Museum of Natural History that are now in herbariums at California Polytechnic State University, Santa Barbara Botanic Garden and University of California Santa Barbara. The labels of the specimens state collection in a freshwater marsh on the east branch of Cañada de Las Flores, in open coast live oak woodland (*Quercus agrifolia*) northwest of Los Alamos. This occurrence is on one private property (272 ha/672 ac) and immediately south of the private property with occurrence 3. Although the former landowner Jeanette Sainz (Thornton 2008, p. 20) showed one site on her map, Hendrickson (1990b, map 3) showed two sites

including one at the "eastern end of the valley," which was identified by on-site discussion with Sainz. This occurrence is 25.6 km/15.9 mi inland from wet beach sand, and it is in the headwaters of San Antonio Creek watershed. We viewed images of the location using Google Earth on 23 June 2017. The marsh is undeveloped, however, most of the land adjacent to the tributary to San Antonio Creek is under crop agriculture. We were not able to obtain permission to visit this occurrence in 2017. This occurrence is likely extirpated. Additional information is provided under occurrence 3.

Occurrence 3. 34.790550, -120.347120; 34.789301, -120.345593; 184 and 186 m/604 and 610 ft elevation; north branch of Cañada de las Flores marsh, Solomon Hills, Santa Barbara County. The coordinates that we give are from Elvin (2007a, p. 1) and Hendrickson (1990b, map 3). This occurrence is documented by two specimens collected on 3 August 1973 by Clifton F. Smith of the Santa Barbara Museum of Natural History that are now in herbariums at Santa Barbara Botanic Garden and University of Minnesota. This occurrence exists as two sites on one private property (135 ha/334 ac), and it is immediately north of the property with occurrence 2. We refer to this occurrence as north branch of Cañada de las Flores marsh. The label of one specimen states collection in a seep on a hillside in Cañada de Las Flores, in open coast live oak woodland northwest of Los Alamos. We viewed images of the location using Google Earth on 1 March 2017, and a paved road divides the two sites. Historical imagery shows that between 2013 and 2014, a grazing fence was installed at one site and disking occurred adjacent to the other site. This occurrence is 25 km/15.5 mi inland from wet beach sand, and it is in the headwaters of San Antonio Creek watershed. We were not able to obtain permission to visit this occurrence in 2017. This occurrence is likely extirpated.

Smith (1976, p. 282; 1998, p. 154) reported the location for occurrences 2 and 3 as Cañada de las Flores marsh near Los Alamos. Hendrickson (1990b, p. 3) saw no plants in 1990, but observed the habitat with the landowner Jeanette Sainz. Hendrickson wrote the following regarding the species and the habitat: around seeps in hillsides above freshwater marsh, the two main sites are on open west-facing slopes near seeps with grassland on the slopes above, and two secondary sites (one near an oak woodland and one near willows at the eastern end of the valley), population has declined in recent years, possibly extirpated. Sainz stated that the numbers fluctuate every year, however, she had never known them to be completely absent. She estimated there were usually ~15 plants at each of the four locations. Later, Sainz (Thornton 2008, p. 14) wrote that generally she never observed more than two or three plants in any location, and typically no more than nine to twelve plants in any year, and the plants were on the edge of the water. Further, she stated that the plant was never in abundance, and it did not appear every year. The only herbarium specimens for the two occurrences were collected in 1973, and photographs documented presence in 1987 (Thornton 2008, p. 17). Elvin (2007a) visited the two occurrences with Sainz in 2007 and saw no plants. He reported that habitat conditions had declined due to grazing intensity, but the essential habitat components still remained (freshwater seeps, native vegetation). Kisner (2009, p. 2) visited the two occurrences with Sainz in 2009 and saw no plants, although habitat remained at three sites.

Occurrence 4. 34.858748, -120.440081; 110 m/361 ft elevation; south Orcutt, Santa Barbara County. This occurrence is based solely on the holotype specimen (CAS165) of La Graciosa thistle collected in June or July 1906 by Alice Eastwood that is in the California Academy of Sciences. The specimen label states "Flora of the Country Adjacent to Santa Maria, California,

near La Graciosa." Smith (1976, p. 282; 1998, p. 154) suggested the location to be near the mouth of San Antonio Creek, but the plant has never been found there. Hendrickson (1990b, p. 8) believed the specimen to be from near the former community of La Graciosa, which was forcibly abandoned and burned in the 1870's. She determined the location of the village to be 600 m/0.4 mi southwest of the junction of East Clark Avenue and State Highway 135 in south Orcutt, which is now mostly freeway and urban development. Similarly, Couch and Fuhring (2010, p. 7) stated that the former community of La Graciosa was near Graciosa Station (Pacific Coast Railway; Rand McNally and Company 1897, p. 1), which was 1.6 km /1 mi south of Orcutt Station (Clark Street in town of Orcutt), and it was probably on the site now occupied by the junction of Highway 1 and State Highway 135. Further, Wilken (2009, entire) of Santa Barbara Botanic Garden studied Eastwood's itinerary and other relevant details. Likewise, he concluded the specimen is probably from near the former Graciosa Station or from near the former village of La Graciosa in what is now Orcutt (specifically, near the junction of East Clark Avenue and State Highway 135). Therefore, we accept that the holotype is from south Orcutt. The town of Orcutt is contiguous with and immediately south of the city of Santa Maria. Searches for the plant in Orcutt in 1986 (McLeod 1986d, p. 2) and 1990 (Hendrickson 1990b, p. 3) were negative. McLeod (1986d, p. 2) observed "there were a couple of likely sites along the Pine Canyon branch of Orcutt creek near Rice Ranch Road but no La Graciosa thistle." South Orcutt is on a terrace of Orcutt Sand (a soil type; Woodring and Bramlette 1950, p. 52), and Pine Canyon is a short canyon on the north slope of Graciosa Ridge (Woodring and Bramlette 1950, p. 5). Henderickson (1990b, p. 9) stated that, although extensive wetlands previously existed in the Orcutt area and could have provided habitat, they have been drained and are now fields or developed. She considered the occurrence to be extirpated. We viewed images of the relevant areas in south Orcutt using Google Earth (dated 5 January 2015) on 30 March 2017, and they are mostly developed. However, small stretches of Pine Canyon and the creek to the west of south Orcutt are undeveloped, although adjacent to development. Kofron (2017d, p. 1) subsequently searched in Pine Canyon in Orcutt Community Park with negative results. We recommend that searches for the species occur in the creek to the west of south Orcutt. This occurrence is not protected, and it is likely extirpated. The location is 15.6 km/9.7 mi inland from wet beach sand.

Occurrence 6. 34.962550, -120.635704; 3 to 12 m/10 to 39 ft elevation; both sides of Santa Maria River and its floodplain and river bed extending from near the river mouth (260 m/853 ft from wet beach sand) to 3.0 km/1.9 mi inland (34.968882, -120.615740), San Luis Obispo and Santa Barbara Counties. The coordinates that we give are the approximate center of the mapped areas (118 ha/292 ac) as shown by Hendrickson (1990b, map 5), McLeod (1984b, p. 1; c, p. 10), and Padre Associates (2017, figure 2). This is the largest occurrence of La Graciosa thistle, which in 1990 was estimated to comprise 106,002 individuals (Hendrickson 1990b, p. 13). The ecosystem is mostly riparian and with moist soil having high organic content in the upper layers and sandy below (Hendrickson 1990b, entire). In 1990, the greatest concentration of plants was nearer the river mouth and associated with native willow thickets, mostly at the south and west margins. Further inland there was less association with willows, and the plants were scattered across the open river bed that had a dense cover of native species: marsh jaumea (*Jaumea carnosa*), saltgrass (*Distichlis spicata*), Pacific silverweed (*Argentina egedii* ssp. *egedii*), and yerba mansa (*Anemopsis californica*). Holland et al. (1995, p. 48) stated that, at the mouth of Santa Maria River, "La Graciosa thistle occurs around the elevated margins of the marshes on the north side of the river and to a lesser extent in the riverbed and as understory in riparian woodland." In terms of occupied mapped areas, 22% of the occurrence is on the Guadalupe Oil

Field of Chevron Corporation, and 78% is on adjacent private land that is used for cattle grazing. The Guadalupe Oil Field is a decommissioned oil field that is undergoing remediation and restoration under a biological opinion. The part of this occurrence in the Guadalupe Oil Field is managed by Chevron Corporation, and it is currently protected by a biological opinion issued under the U.S. Endangered Species Act. Chevron Corporation does not allow cattle grazing on its property in the Guadalupe Oil Field. In addition, Kelly (2013, entire; 2017, p. 2) reported five individuals of La Graciosa thistle along the drainage ditch on the north side of West Main Street before its entrance into Rancho Guadalupe Dunes County Park, Santa Barbara County, 2.4 km/1.5 mi inland from wet beach sand, and there were more individuals nearby in the pasture in the river bed.

Padre Associates (2017, p. 14; 2018, p. A-200) has annually monitored the three occurrences of La Graciosa thistle in the Guadalupe Oil Field since 2005. Most recently in 2017 they recorded 535 individuals in the oil field portion of occurrence 6, which is the lowest number since they began monitoring and includes several restored/replanted areas. The highest number they recorded is 9,751 individuals (2009). Padre Associates (2018, p. ES3) attributed the low number of plants in 2017 to flooding and prolonged inundation of the habitat. This occurrence previously experienced major flooding during 1998 and sustained damage with substantially decreased numbers of plants (Chesnut 1998c, p. 16; Lea 2002, p. 3). There was no evidence of impacts by feral pigs on the Guadalupe Oil Field in 2016, likely because of trapping implemented by Chevron Corporation, and only minor impacts in 2017 (Padre Associates 2017, p. 9; 2018, p. 4-2) . We viewed images of the relevant areas using Google Earth (dated 9 July 2016) on 17 May 2017, and they were mostly undeveloped. The mapped occupied areas are mostly in the river bottomlands. Percolation of flow in the Santa Maria River is controlled in part by releases from Twitchell Dam, which was constructed in 1957. The dam is 48 km/30 mi upriver from the Pacific Ocean, and it is operated to optimize groundwater recharge for the Santa Maria Valley Groundwater Basin. Groundwater flow in the Santa Maria River Valley is generally westward, from inland toward the Pacific Ocean (California Department of Water Resources 2004, p. 3). This occurrence is on two private properties. The primary threats to occurrence 6 include reduced water, flooding, uncontrolled cattle grazing, invasive species, and potentially crop agriculture replacing cattle grazing as a land use.

Potential new locations. 50 m east and perpendicular to south end of road, Santa Maria River mouth (UCSB855597); and south of mouth of Santa Maria River (RSA166700). The former specimen was collected by Ken Hobson and David Pritchett on 23 June 1985, and the latter was collected by E.R. Blakley on 31 May 1962 (Consortium of California Herbaria 2017c, p. 1-3). The details for both locations are vague but appear to be in Rancho Guadalupe Dunes County Park in Santa Barbara County. We recommend searching for La Graciosa thistle near and south of the mouth of the Santa Maria River in Rancho Guadalupe Dunes County Park.

Occurrence 8. La Graciosa thistle (n = 2) was last observed here in 1998 (Chesnut 1998c, p. 16). No plants were observed in 2017 (Kofron 2017a, p. 1; Skinner 2017a, p. 1), and the occurrence is now likely extirpated. Based on information in a draft of this document, California Department of Fish and Wildlife officially combined occurrence 9 into occurrence 8 because the two sites are not separated by >0.4 km/0.25 mi (Lazar 2018a, p. 1). However, because there are two separate wetlands, we present the information separately for each wetland prior to 2018.

Occurrence 8 before 2018. 35.042943, -120.605579; 35.041660, -120.603016; 10 m/33 ft elevation; west and south margins of unnamed wetland, 0.56 km/0.35 mi northwest of Jack Lake,

1.1 km/0.7 mi west of ConocoPhillips Santa Maria Refinery, San Luis Obispo County. The coordinates that we give are based on Chesnut (1998c, map 1). The second location is 250 m east (Hendrickson 1990b, p. 5) of the first location. The occurrence is on private property (43.52 ha/107.5 ac) of Phillips 66 Company but which is managed by California State Parks (Oceano Dunes State Vehicular Recreation Area). McLeod (1980, p. 1; 1986d, p. 2) reported plants here in 1980 (or the 1970's) and 1986. Hendrickson (1990b, p. 14) observed 49 plants (45 vegetative, 1 flowering, 3 seedlings) in 1990. Forty-eight plants were at the west margin of a dune swale (no water) with willows in dry sandy soil. The plants were in a small area between willows and *Rubus*. Many of the plants had been damaged by herbivores, and shading and crowding/competition with other plants were identified as potential threats. One plant was 250 m/820 ft east of this group. Chesnut (1998c, p. 16) saw two plants in 1998. MIG/TRA Environmental Sciences (2016, p. 3-15) reported no plants in 2015, and Skinner (2017a, p. 1) saw no plants in 2017. This occurrence is likely extirpated. We viewed images of the location using Google Earth (dated 13 July 2016) on 29 March 2017, and it is in the backdunes of the Callender Dunes, which cover most of the Nipomo Mesa (Cooper 1967, p. 277). The location is 2.4 km/1.5 mi inland from wet beach sand, and the area appeared to be in a natural state. Although it is not protected, this occurrence is on property that is closed to the public.

Occurrence 9 before 2018. 35.038399, -120.602649; 35.037580, -120.600785; 10 m/33 ft and 13 m/ 43 ft elevation; Jack Lake, 672 m/735 yd west of ConocoPhillips Santa Maria Refinery, San Luis Obispo County. The coordinates that we give are based on Hendrickson (1990b, p. 5) and Chesnut (1998c, map 1). The occurrence is on private property (143.5 ha/354.6 ac) of Phillips 66 Company but which is managed by California State Parks (Oceano Dunes State Vehicular Recreation Area). The swale is in the backdunes between tall, vegetated and non-vegetated sand dunes. Howald (Lazar 2018a, p. 3) observed 30 plants at the edge of the lake in 1979, and Hendrickson (1990b, p. 5) observed plants (40 vegetative, 23 flowering, many seedlings) at two locations: a small area at the northwest edge of the lake (41 plants plus seedlings), and another area with 22 plants scattered among shrubs (*Baccharis*) at the east margin of the lake. Chesnut (1998c, p. 16) saw no plants in 1998, and MIG/TRA Environmental Sciences (2016, p. 3-15) reported no plants in 2015. Staff of the USFWS and Oceano Dunes State Vehicular Recreation Area visited the occurrence on 21 March 2017, and they saw no plants (Kofron 2017a, p. 1). In 2017 the swale was densely forested with arroyo willow (*Salix lasiolepis*), and many had died and collapsed, which is consistent with a drop in the groundwater table (Holland et al. 1995, p. 40; Chipping 2017, p. 1). The swale held no water but the soil was damp. Although biologists searched much of the swale, a large portion was not searched, which presents a possibility the plant was present but not observed. However, the occurrence is likely extirpated. The ecosystem is mostly intact and in a natural state, although the lack of water during March 2017 was a threat (Kofron 2017a, p. 1). We viewed images of the location using Google Earth (dated 13 July 2016) on 28 March 2017, and it is in the backdunes of the Callender Dunes. The location is 2.8 km/1.75 mi inland from wet beach sand. Although it is not protected, this occurrence is on property that is closed to the public.

Occurrence 10. 35.062048, -120.610190; 5 m/16 feet elevation; east margin of Mud Lake, south of Arroyo Grande, San Luis Obispo County (Figure 8). The coordinates that we give are based on Howald (1981a, map), who observed 1-10 plants and first reported this occurrence. The habitat was a freshwater marsh bordering a freshwater dune lake, with native arroyo willow, California bulrush (*Schoenoplectus californicus*) and spreading gooseberry (*Ribes divaricatum*). An herbicide had been sprayed targeting poison oak on parts of the property (491 ha/1,216 ac).

Turner and Pemberton (1983, p. 1) reported >100 plants. McLeod (1986d, p. 2) saw no plants and offered several possible reasons: (1) the boundary where the plants grow changes from year to year; (2) the plants may have been affected by pumping water; (3) the plants may have been affected by spraying for poison oak; and (4) the two previous reports may have been based upon misidentified clustered thistle (*Cirsium brevistylum*), a taxon with somewhat similar appearance (California Department of Fish and Game 2005, p. 328). Kofron (2017c, p. 1) visited the lake in August 2017, with assistance from Connie Rutherford and Mark Skinner. The lake was mostly dry and with its bed covered by a dense layer (30 to 91 cm/1 to 3 ft) of vegetation debris comprised predominantly of stems of dead bulrushes. The property manager (Madsen 2017, p. 1) stated the lake had been dry for 5 years. Kofron (2017c, p. 1) searched the east margin of the lake where the plants were reported to occur and found no La Graciosa thistle. He identified the lack of water and the accumulation of dead vegetation as threats. In discussion with the land manager, Steve Madsen stated that he wishes to restore the lake, including removal of the dead vegetation, and he is agreeable to replanting La Graciosa thistle. The provisioning of water other than runoff irrigation wastewater will be a challenge. The USFWS will endeavor to support restoration of Mud Lake. We viewed images of the location using Google Earth (dated 13 July 2016) on 7 April 2017, and it is in the backdunes of the Callender Dunes. This occurrence is on private property with several houses and other buildings. The landowner manages the terrestrial vegetation for hunting California quail (*Callipepla californica*). The location is 1.9 km/1.2 mi inland from wet beach sand. The property is zoned for four houses, along with grazing and recreational hunting. The Land Conservancy of San Luis Obispo County has a conservation easement over Mud Lake since 2000, and formerly the California Coastal Conservancy and the Nature Conservancy since 1996. Although this occurrence is protected, it is likely extirpated. The landowner also owns the property with occurrence 11.

Occurrence 11. 35.069523, -120.606845; 35.070530, -120.607960; 35.070440, -120.60915; 35.069465, -120.606603; east margin of Big Twin Lake near road; north margin of Big Twin Lake; near road along north shore of Big Twin Lake; northwest margin of Small Twin Lake near road; 4 to 5 m/13 to 16 ft elevation; south of Oceano, San Luis Obispo County (Figure 9). The first three sets of coordinates that we give are from Kofron (2017b, p. 1), who visited the occurrence in August 2017 with assistance from Connie Rutherford and Mark Skinner. At the first set of coordinates they observed ~75 La Graciosa thistle in the dry lake bed in an area 15 x 61 m/50 ft by 200 ft. At the second set of coordinates they observed ~100 plants in the dry lake bed in an area 6 x 61 m/20 x 200 ft. At the third set of coordinates they observed ~70 plants on slightly higher ground in an area 3 x 30 m/10 x 100 ft. The plants included many robust individuals with multiple seed heads and many vegetative individuals. Other plant species in the immediate vicinity included hemlock (Apiaceae) and native marsh baccharis. Kofron (2017b, p. 1) reported Big Twin Lake and Small Twin Lake to be mostly dry and the beds covered with a layer (0.3 to 0.9 m/1 to 3 ft) of predominantly dead California bulrushes. They found no La Graciosa thistle in Small Twin Lake, and they did not search the south or west margins of Big Twin Lake. Kofron (2017b, p. 1) identified the following threats: lack of water, vegetation debris in the lake beds, and invasive species (bull thistle, hemlock, invasive pampas grass (*Cortaderia*)). The fourth set of coordinates is from Kofron (2018b, p. 1), which is where David Chipping (California Polytechnic State University) observed a new location on the northwest side of Small Twin Lake near the road with 41 La Graciosa thistle in a 10 m x 10 m area. Steve Madsen (Property Manager, Dune Lakes Limited.) stated that he drove a tractor though the area two years previous, and also through the area with the first set of coordinates. Clifton F. Smith

collected several specimens at occurrence 11 in 1973: SD124435, RSA321771, UCR111222 and UCSB52716 (Consortium of California Herbaria 2017c, d, p. entire). In addition, Howald (1981a, p. 1) reported 1-10 plants at each of four locations in 1981. McLeod (1984a, p. 1) observed 11-50 plants in moist sand along the northwest margin of Big Twin Lake in 1984. Hendrickson and Parikh (1988, p. 1) observed 20 flowering plants in open shade/no shade in marsh along the south margins of Big Twin Lake and Small Twin lake in 1988. These additional reported locations were near the following coordinates: 35.070784, -120.606630; 35.070250, -120.606651; 35.070013, -120.606337; 35.068825, -120.609804; 35.067876, -120.604711. Cooper (1967, p. 82) and Friedman (1986, p. 2) reported that the landowner regulates the water levels in the lakes. We viewed images of the area using Google Earth (dated 2 April 2015) on 12 April 2017, and it is in the backdunes of the Callender Dunes. Most of the private property (491.96 ha/1,215.66 ac) appears to be in a natural state, with ~10% of the vegetation having been cleared. The property is zoned for agriculture. The location is 1.8 km/1.1 mi inland from wet beach sand. The landowner also owns the property with occurrence 10. The Land Conservancy of San Luis Obispo County has a conservation easement over Big Twin Lake and Small Twin Lake since 2000, and formerly the California Coastal Conservancy and the Nature Conservancy since 1996. Therefore, this occurrence is protected. Seeds from this occurrence could be used to re-establish likely extirpated occurrence 14 at Pismo State Beach.

Possible location. 35.067116, -120.608934; 3 m/10 ft; "White Lake?" of the Dune Lakes, San Luis Obispo County; precise location unknown. This possible location is based on specimens collected 2 August 1958 by C.F. Smith, including SBBG93737, SBBG93738 and RSA518077. The location is "along dead end road about duck ponds at Dune Lake (White Lake?)" (Consortium of California Herbaria 2017c, p. entire). The coordinates that we give are along the north shore of White Lake, which is near (300 m/984 ft distance) the occurrence at Big Twin Lake. This possible location is on private property of Dune Lakes Limited. The lake is under a conservation easement with the Land Conservancy of San Luis Obispo County.

Occurrence 12. 35.012346, -120.607159; 35.012493, -120.607079; 35.012622, -120.607293; 35.012486, -120.607432; 16 to 18 m/52 to 59 ft elevation; Surprise Lake, Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County (Figure 10). The coordinates that we give are based on Chesnut (1998c, map 12). This occurrence was first reported by Howald (1981b, entire) who observed 11-50 plants. McLeod (1987, p. 1) saw 50 plants in 1987. Hendrickson (1990b, p. 6) observed 29 plants in 1990 (14 plants in east group, 15 plants in west group) and reported poor/low reproduction. The plants at the east end of the lake were in open shade under arroyo willows, along with native coyote brush, rosilla (*Helenium puberulum*) and stinging nettle (*Urtica dioica*). The soil was sandy with a thin layer (2 to 3 cm/0.8 to 1.2 in) of organic material. The west group was at the edge of a willow thicket, with *Rubus*, poison oak (*Toxicodendron* spp.) and goldenrod (*Solidago* spp.). Chesnut (1998b, p. 51) saw 54 plants in 1997 and 7 plants in 1998. Elvin (2008, p. 1) observed 10 plants in 2008. MIG/TRA Environmental Sciences (2016, p. 3-16) reported 37 plants in 2013 and 1 plant in 2015. Skinner (2017b, p. 1) recorded 37 plants in 2016 and 65 plants in 2017, all at the west end of the lake. He observed disturbance to the habitat by feral pigs, and also herbivory of the plants (Skinner 2017f, entire). Kofron (2017a, p. 2) visited the lake on 21 March 2017, and it was dry but with a wet substrate of organic debris (leaves, bark, etc.). The La Graciosa thistle occupied 10 x 20 m^2 at the west edge of the lake, in sandy soil with a thin upper layer of vegetation debris. The biggest plants (largest 46 cm diameter) were in the open, and feral pigs had foraged in the area. The lake was densely forested with arroyo willow, and many appeared dead, which is consistent with a drop in the groundwater

table (Holland et al. 1995, p. 40; Chipping 2017, p. 1). He identified lack of water, habitat alteration by the debris of dead fallen trees and feral pigs as threats. Skinner (2018, p.1) recorded zero plants in 2018. We viewed images of the location using Google Earth (dated 9 July 2016) on 3 April 2017, and it is in the vegetated backdunes near the northwest edge of the Guadalupe Dunes. The location is 3.2 km (2.0 mi) inland from wet beach sand. We consider this occurrence protected because it is in a remote part of Oceano Dunes State Vehicular Recreation Area that is now closed to motorized use and where visitation by the general public is unlikely (Glick 2018, p. 1). The occurrence is likely extirpated in 2018.

Occurrence 13. 35.029879, -120.624003; 35.030135, -120.624759; 5 m/16 ft elevation; northwest shore of Oso Flaco Lake, 166 m/182 yd east of the outlet stream, Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County. The coordinates that we give are based on Hendrickson (1990b, p. 6) and Chesnut (1998c, p. 53, map 11). This occurrence was first reported in 1980 (may have been observed in 1970's; McLeod 1980, p. 1), but McLeod (1986b, p. 1) saw no plants ("not found") in 1986. Hendrickson (1990b, p. 6, 15) observed 34 plants in 1990 in two areas: "at the edge of a faint pathway among willows at the tip of the peninsula in open shade," and "about 175 m to the west in grass between some willows." She also observed off-highway vehicle damage to the habitat and poor/low reproduction. Chesnut (1998b, p. 16) saw no plants in 1998, and MIG/TRA Environmental Sciences (2016, p. 3-16) reported no plants in 2015. This occurrence is likely extirpated. Herbarium records include: RSA312493, UC1192200 and UCD130681 collected in 1949; CAS432751, GH427983 collected in 1960; CDA1569, CDA1570, CDA1571, CDA1572 and DS500655 collected in 1962; and OBI61046 collected in 1968 (Consortium of California Herbaria 2017c, d, f, entire). We viewed images of the area using Google Earth (dated 9 April 2013) on 28 April 2017, and it is in the vegetated backdunes at the south edge of the Callender Dunes. The location is 849 m/0.5 mi inland from wet beach sand. We consider this occurrence to be protected because it is in a part of Oceano Dunes State Vehicular Recreation Area that is now closed to motorized use and visitation by the general public is unlikely (Glick 2018, p. 1).

Possible location. 35.034414, -120.630551?; 7 m/23 ft; blowouts in sand dunes toward the ocean on west side of Oso Flaco Lake, Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County; precise location unknown. This possible location is based on two herbarium specimens collected in 1960 by E.R. Blakley: JEPS24720, and SBBG12577. The coordinates that we give are imprecise and based on the limited information for the two specimens (Consortium of California Herbaria 2017c, p. 2; e, p. 1).

Occurrence 14. 35.107367, -120.625009; 7 m/23 ft elevation; Pismo State Beach, northwest Oceano, San Luis Obispo County. This occurrence is based on an observation at Pismo State Beach in 1969 by Holstein (2017, p. 4), and the coordinates that we give are from Holstein (2017, p. 1). He observed a few individuals growing in sand on level ground in small openings in arroyo willow forest in a southeast corner of the park (4.25 km^2/1.64 mi^2), northwest of the junction of Pier Avenue and Norswing Drive. Holstein (2017, p. 2) stated that the openings were dominated by ice plant (*Carpobrotus edulis)*, which was crowding out the La Graciosa thistle. He did not see the plant in 1976 (Hendrickson 1990b, p. 6). McLeod (1986d, p. 2) reported the occurrence as "undoubtedly extirpated." Hendrickson (1990b, p. 6) surveyed the ponds and associated wetlands near Pismo State Beach in 1990 and observed that iceplant was spreading over large areas. She saw no plants and likewise reported the occurrence as extirpated. Holstein (2017, p. 2) visited the park again in 2016, and the basic geography had not substantially

changed. Skinner (2017c, p. 4; d, p. 1) saw no plants in 2017. We viewed images of the location using Google Earth (dated 2 April 2015) on 24 March 2017, and it is adjacent to Meadow Creek in a low terrace 900 m north of Arroyo Grande Creek (Cooper 1967, p. 76). Although the state park is mostly undeveloped, it is surrounded by urban development on three sides. The occurrence is 690 m/755 yd from wet beach sand. In addition, herbarium specimen UC455492 was collected at "Oceano" in 1910 in "low grassy land among sand hills (Consortium of California Herbaria 2017g, p. 1), and it is attributed to this occurrence (California Department of Fish and Wildlife 2017a, p. 15). Although this occurrence is protected, it is likely extirpated. Seeds from occurrence 11 at Big Twin Lake, which is the nearest occurrence to the south, could be used to re-establish this occurrence.

Occurrence 16. 35.057423, -120.603537; 9 m/30 ft elevation; Black Lake, San Luis Obispo County. The coordinates that we give are the center of Black Lake because precise details are lacking. Hoover (1970 [publication date of book], p. 310) reported La Graciosa thistle in "moist hollows among coastal dunes, at least from Black Lake southward" However, no herbarium specimens document this occurrence. Turner and Pemberton (1983, p. 2) reported La Graciosa thistle at Black Lake in 1983, but they subsequently re-identified the collected specimens as clustered thistle (Hendrickson 1990b, p. 16). McLeod (1986c, p. 1) and Hendrickson (1990b, p. 16) saw no La Graciosa thistle in 1986 and 1990, respectively. Hendrickson (1990b, p. 6) observed that much of the lake had dried and its bed was covered with green algae (*Epilobium* spp.) and nettle (*Urtica* spp.), but some potential habitat remained. The California Coastal Conservancy acquired the property (58.3 ha/144 ac) with Black Lake in 1986 and subsequently transferred ownership to The Nature Conservancy, which transferred ownership to the Land Conservancy of San Luis Obispo County in 2000. Whitaker (2017, p. 1) searched around the lake in 2017. She saw no La Graciosa thistle and reported very little habitat and abundant bulrushes. We viewed images of the location using Google Earth (dated 13 July 2016) on 13 April 2017, and it is in the backdunes of the Callender Dunes. The area is mostly undeveloped, but some vegetation clearing has occurred nearby to the southeast. The location is 2.3 km/1.4 mi inland from wet beach sand. Because this occurrence is on property of the Land Conservancy of San Luis Obispo County, we consider it to be protected. However, the occurrence is likely extirpated.

Occurrence 18. 34.977337, -120.620169; 34.975678, -120.617513; 34.976689, -120.615085; 34.977660, -120.615529; 34.981079, -120.615568; 10 to 23 m/33 to 75 ft elevation; vicinity of monitoring wells L11, M-12A, N-12A (restored, outplanted), M-11 and M-2, Guadalupe Oil Field, 720 m/787 yd north of Santa Maria River, 4.3 km/2.7 mi northwest junction of State Highway 1 and State Highway 166 in Guadalupe, San Luis Obispo County. The coordinates that we give are based on Padre Associates (2017, figure 2). The plants are in five swales immediately adjacent to paved roads and oil pads, and in an area comprising 44 ha/109 ac. This occurrence was first identified by Hendrickson (1990b, p. 7), who observed 137 plants (area 20 m x 30 m) in 1990. The plants were in moist sandy soil in a swale among stabilized dunes, with low herbaceous cover (no willows) including native marsh baccharis, Pacific silverweed (*Argentina ededii*) and yerba mansa (*Anemopsis californica*). Lebednik (1995a, b, c, entire) observed 31 plants in 1995 and disturbance by cattle grazing and gophers. Elvin (2006, p. 1) also observed cattle grazing on La Graciosa thistle. Padre Associates (2017, table 3; 2018, p. A-200) has monitored the species in this occurrence since 2006, and most recently in 2017 they recorded 913 individuals. From 2006 to 2017, the numbers of plants ranged from 240 in 2010 to 23,590 in 2014, with most of the latter number comprising offspring seedlings of outplanted individuals.

We viewed images of the area using Google Earth (dated 9 July 2016) on 20 April 2017, and it is in the backdunes of the Guadalupe Dunes. The location is 2.5 km/1.5 mi inland from wet beach sand. This occurrence is managed by Chevron Corporation, and it is currently protected by the U.S. Endangered Species Act because the oil field remediation and restoration activities are occurring under a biological opinion.

Occurrence 19. 34.967390, -120.592720; 17 m/56 ft; immediately north of Santa Maria River in San Luis Obispo County, 2.2 km/1.3 mi northwest junction of State Highway 1 and State Highway 166 in Guadalupe, Santa Barbara County (Figure 11). The coordinates that we give are based on Ingamells (1991, p. 2). This occurrence was first reported by Ingamells (1991, entire), who estimated 100 plants. The plants were growing on irrigated grazing land with recycled water from the wastewater treatment plant of the city of Guadalupe. Associated plants were native balloon sack clover (*Trifolium depauperatum*), invasive white clover (*T. repens)*, bull thistle, blessed milkthistle, and annual grasses. Ingamells (1991, p. 1) reported the species to be thriving, likely due to improved hydrology from wastewater spray and reduced competition with annual grasses by grazing. This occurrence is on private property (158 ha/391 ac), most of which has been irregularly disked and seeded with cattle fodder in recent years (Kofron 2017e, p. 1). The City of Guadalupe holds an easement over the area for discharge of treated water from their wastewater treatment plant. Kofron (2017e, p. 1) visited the property in August 2017, with assistance from Jenny Langford and Melissa Kelly. The property is mostly pasture, and the landowner showed them all locations with water (wooded channel along north boundary, wet pasture on eastern part, lake and ditch along south boundary), but no La Graciosa thistle were seen. Invasive bull thistle was especially dense on the northwest part of the property. Kofron (2017e, p. 1) identified agriculture and invasive species as threats. We viewed images of the location using Google Earth (dated 13 July 2016) on 5 April 2017, and it is in the dry river bed of the Santa Maria River. The property was used for cattle grazing in 2017 (300 head of cattle), and the occurrence is not protected. It is 5.3 km/3.29 mi inland from wet beach sand. This occurrence is likely extirpated.

Occurrence 20. 20A: 35.038460, -120.611143; 10 m/33 ft elevation; in unnamed wooded swale, 749 m/819 yd west of Jack Lake and 1.6 km/1.0 mi west of CononoPhillips Santa Maria Refinery, on Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County. The coordinates that we give are based on Hendrickson (1990a, p. 1; b, p. 14) and Chesnut (1998c, map 13). Hendrickson (1990a, p. 1; b, p. 14) reported a new occurrence with 12 plants in a swale "0.5 mi W of Jack Lake," along with damage to the plants by rabbits. Chesnut (1998b, p. 52) saw no plants at this location in 1998. Heavy rainfall had completely inundated the location, and he surmised that plants may emerge after the area dries. MIG/TRA Environmental Sciences (2016, p. 3-15) reported no plants in 2015. Staff of the USFWS and Oceano Dunes State Vehicular Recreation Area visited the swale in 2017, and they saw no plants (Kofron 2017a, p. 1). The swale is between tall, mostly vegetated and stabilized sand dunes. Further, the swale is densely forested with arroyo willow, and many of these trees were dead and collapsed, which is consistent with a drop in the groundwater table (Holland et al. 1995, p. 40; Chipping 2017, p. 1). The swale held no water but the soil was damp. In brief, the area indicated by Chesnut (1998c, map 13) is now likely altered by the debris of fallen trees. Although biologists searched much of the swale in 2017 (Kofron 2017a, p. 1), a large portion was not searched, which presents the possibility the plant was present but not observed. However, this location is likely extirpated. The ecosystem is mostly intact and in a natural state, with exception of lack of water. Efforts are

currently underway to reduce perennial veldtgrass (*Ehrharta calycina*) in the landscape by spraying with herbicide. Kofron (2017a, p. 1) identified lack of water and habitat alteration by fallen trees as threats. We viewed images of the location using Google Earth (dated 9 April 2013) on 17 March 2017, and it is in the backdunes of the Callender Dunes. The location is 1.99 km/1.24 mi inland from wet beach sand. We consider this location to be protected because it is in a remote part of Oceano Dunes State Vehicular Recreation Area that is closed to motorized use and visitation by the general public is unlikely (Glick 2018, p. 1).

20B: 35.035720, -120.610308; 12 m/39 ft elevation; Lettuce Lake, Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County. The coordinates that we give are at the center of the forested part of the lake, which is 313 m/0.19 mi south of the swale mentioned above. McCoy (1980, p. 48) reported La Graciosa thistle at Lettuce Lake, and he also reported substantial damage to the area by off road vehicles. Chesnut (1998b, map 1) saw no plants in 1998. Skinner (2017e, entire) saw no plants in 2017. The lake was vegetated with arroyo willow (thriving, not dead or fallen), and no surface water was present in October 2017. This location is not validated by a herbarium specimen, and there are no additional reports for the species at Lettuce Lake. The location is 2.1 km/1.3 mi from wet beach sand. We viewed images of the location using Google Earth (dated 9 April 2016) on 2 May 2017, and it is in the backdunes of the Callender Dunes. The lake is 78 m/256 ft from intensive row crop agriculture to the east. We consider this location to be protected because it is in a remote part of Oceano Dunes State Vehicular Recreation Area that is now closed to motorized use and visitation by the general public is unlikely (Glick 2018, p. 1). This location is likely extirpated.

Occurrence 28. 34.957544, -120.582722; 23 m/75 ft elevation; roadside, West Main Street, 800 m/875 yd west of junction with State Highway 1, south Guadalupe, Santa Barbara County (Consortium of California Herbaria 2017c, p. 3) (Figure 12). This occurrence is based solely on one specimen (UCSB47943) that was collected in 1983 (Consortium of California Herbaria 2017c, p. 3). The specimen label states uncommon along roadside on sandy to loamy soil, next to a wet grazed pasture, with non-native perennial rye grass (*Lolium perenne*) and ripgut brome (*Bromus diandrus*). Elvin (2017c, p. 1) saw no plants in 2005 and 2013, and Kofron (2017a, p. 1) saw no plants in 2017. The road is now paved and with a drainage ditch along its south side. On the north side of the road is a dense housing development, and on the south side are disked agricultural fields and a nearby storage area for farm vehicles. In brief, the occurrence is now surrounded by intensive row crop agriculture and urban development, and it is likely extirpated. Kofron (2017a, p. 1) identified agriculture, development, and road and ditch maintenance as threats. We viewed images of the location using Google Earth (dated 13 July 2016) on 27 March 2017, and it is 1.2 km/0.8 mi southwest of the Santa Maria River and in its south floodplain. The location is 6.3 km/3.9 mi inland from wet beach sand.

Occurrence 30. 35.019253, -120.626641; 13 m/43 ft elevation; in unnamed depression, 946 m/1,035 yd southwest of Oso Flaco Lake, Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County. The coordinates that we give are at the lowest point of the depression. This occurrence is based solely on one specimen (UCSB22159) collected in 1967 that is in the herbarium at the University of California Santa Barbara (Consortium of California Herbaria 2017c, p. 3; California Department of Fish and Wildlife 2017a, p. 20). The plant was growing in sandy soil at "1000 yards [914 m] southwest of Oso Flaco Lake." Chesnut (1998c, map 1) did not look for this occurrence because it was not recognized then. We viewed images of the area using Google Earth (dated 9 July 2016) on 10 March 2017. Although the precise location was

not stated, the most likely place seems to be depression at our stated coordinates. The location is 833 m/911 yd inland from wet beach sand, and it is in the backdunes of the Guadalupe Dunes. Although the area appeared to be in a natural state, many vehicle tracks were visible across the depression. A controlled burn was conducted here in 2009, along with weed treatment. Skinner (2017a, p. 1) saw no La Graciosa thistle in 2017. He reported the conditions here were not good, with only a few places where the plant could exist. We consider this occurrence to be protected because it is in a remote part of Oceano Dunes State Vehicular Recreation Area that is now closed to motorized use and visitation by the general public is unlikely (Glick 2018, p. 1). Also, we recommend searching for La Graciosa thistle at the following coordinates, which are nearby places with lower elevations: 35.019649, -120.631349, 7 m/23 ft, at 432 m/473 yd west of the first coordinates; and 35.017277, -120.623793, 6 m/20 ft, at 342 m/374 yd southeast of the first coordinates.

Occurrence 31. 34.99632, -120.60175; 17 m/56 ft elevation (lowest in valley); 3 Pond West, Guadalupe-Nipomo Dunes National Wildlife Refuge, San Luis Obispo County (Figure 13). The coordinates that we give are from Kofron and Rutherford (2017, p. 1), who observed at least five La Graciosa thistle with seed heads near the center of the swale in an area 5 x 10 m/16 x 33 ft in September 2017. Multiple other post-flowering thistle plants were present but not identifiable to species because of decomposition or herbivory by rabbits. They saw no vegetative La Graciosa thistle. The La Graciosa thistle were in an open area in sandy soil with 1 cm/0.4 in of organic soil on top and a thin layer of vegetation debris (Figures 14, 15). Other plants in the immediate vicinity were rushes, coyote brush and hemlock. Willows occupied several parts of the swale, and they appeared dead with some fallen in 2017 (Kofron and Rutherford 2017, p. 1). The swale was dry with exception of a drying waterhole (likely excavated) at its northwest end. Kofron and Rutherford (2017, p. 1-2) saw no La Graciosa thistle in the fenced area at the northwest end where plants previously occurred (34.996673, -120.602917; 17 m/43 ft). This occurrence was first reported by Chesnut (1998b, p. 2) who observed 87 plants in 1997. Later in 2007, Elvin (2010, p. 1) observed ~50 plants, and numerous individuals had been trampled, crushed and broken by cattle that wandered onto the refuge. As of 2010, a boundary fence had been installed and cattle eliminated (Elvin 2010, p. 1). In 2010, 300 individuals were observed; in 2013, 172 individuals were observed; and in 2014, 10 individuals were observed (USFWS 2016a, p. 48). USFWS (2016, p. 48) stated the plants were scattered in 1 ha/2.5 ac of habitat. At least one herbarium specimen (UCR215242; Consortium of California Herbaria 2017c, p. 1) documents this occurrence. Elvin (2017b, entire) collected seeds from this occurrence and dispersed them at Colorado Pond to the south and at Myrtle Pond (35.014158, -120.634629) to the northwest on the refuge in 2014. In 2017, Kofron and Rutherford (2017, p. 1) searched two of the three locations at Colorado Pond where seeds had been scattered (likely excavations; 34.994225, -120.602520; 34.993147, -120.600274) but found no La Graciosa thistle. In 2017, 3 Pond West appeared to be in a natural state, with exception for lack of water. 3 Pond West is in the backdunes of the Guadalupe Dunes, and it is 3.5 km/2.2 mi inland from wet beach sand. Colorado Pond is likewise in the back dunes, and Myrtle Pond is immediately behind the foredunes. Although this occurrence is protected because it is on a national wildlife refuge, it is in decline and near extirpation. Lack of water and herbivory by rabbits are threats (Kofron and Rutherford 2017, p. 1). As an emergency action, we recommend that temporary fencing be placed around any groups of La Graciosa thistle in 2018 to prevent herbivory by mammals. In addition, based upon similar landscape features observed in Google Earth (image dated 27 July 2016), we recommend that searches be conducted in the wetlands in the adjacent valley

immediately to the north, especially near 34.998458, -120.602917 (17 m/43 ft). This location is the lowest in the valley and also on the national wildlife refuge.

Occurrence 32. 34.979440, -120.598600; 22 m/72 ft elevation; Entrance Ponds, 940 m/0.6 mi northwest of the junction of Thornberry Road and entrance gate to the Guadalupe Oil Field, San Luis Obispo County (Figure 16). The coordinates that we give are from Elvin (2006, p. 1), who visited the occurrence and reported the plants were being adversely affected by cattle grazing and trampling (Elvin 2010, p. 2). The wetland comprises two swales, one which is on property of Chevron Corporation (WR1-01) and one on the adjoining private property (WR1-02). A boundary fence extends through the wetland. The plants on the adjacent private property are in a dense willow woodland (Langford 2017b, p. 3). This occurrence was first identified in 2005 and which Padre Associates (2017, table 3; 2018, p. A-200) has monitored annually since 2005. La Graciosa thistle rapidly declined here from 420 plants in 2005 to 0 plants in 2015, 2016 and 2017 (Langford 2017b, p. 1-5; Padre Associates 2018, p. A-200). This occurrence is now likely extirpated. We viewed images of the location using Google Earth (dated 9 July 2016) on 9 May 2017. The wetland is immediately north of the paved road, and the general area appeared to be in a natural state. The wetland is in the backdunes of the Guadalupe Dunes and 4.4 km/2.7 mi inland from wet beach sand. Langford (2017b, p. 2-3) identified the threats as wetland drying, groundwater decline, drought and invasive plants (Italian plumeless thistle, ripgut brome, foxtail fescue (*Vulpia myuros*)). In addition, Kofron (2017f, p. 1) observed many fallen dead arroyo willow trees that were altering the habitat. The fallen dead willows are consistent with a drop in the groundwater table (Holland et al. 1995, p. 40; Chipping 2017, p. 1; Figure 7). The part of this occurrence on property of Chevron Corporation is currently protected by the U.S. Endangered Species Act because the oil field remediation and restoration activities are occurring under a biological opinion. However, the part of the occurrence on the adjacent private property is not protected. This occurrence is not documented by a herbarium specimen.

Occurrence 33 (new). precise location unknown, 34.748658, -120.259412; 190 m/623 ft elevation; marsh on Price Canyon Road, Price Ranch, 1.6 km/1.0 mi northeast of Los Alamos, Solomon Hills, Santa Barbara County. This new occurrence is based on multiple herbarium specimens collected in 1973 and 1975 by C.F. Smith and J. Sainz, including OBI71274, OBI171305, SBBG65980, SBBG65981, SBBG65982, SBBG65983, SBBG80937, SBBG81838 and SBBG96310 (Consortium of California Herbaria 2017c, p. entire). Smith (1976, p. 282) included this occurrence with La Graciosa thistle, however, he stated it might represent an undescribed taxon. We viewed images of the two specimens to which Smith (1976, p. 282) specifically referred, and the herbarium labels (see Keil 2010, entire) state the following: "several in marsh about willows on Price Canyon Road northeast of Los Alamos..." in oak woodland, and "few plants 2-5 ft., scattered about edge of willows...in marsh on Price Canyon Road northeast of Los Alamos." Further, the two specimens bear annotated labels with identification by David J. Keil (2012, entire) of California Polytechnic State University. Dr. Keil determined them to be La Graciosa thistle, although "an unusual form, perhaps derived from hybridization with undetermined second species." The coordinates that we give are imprecise and based on locality data with the aforementioned specimens, along with viewing the landscape in Google Earth. In addition, herbarium specimen RSA355126 is spotted water hemlock (*Cicuta maculata* var. *bolanderi)*, and it was collected also by C.F. Smith on one of the same dates in 1973. It is from a "freshwater marsh about willows...in valley oak (*Quercus lobata*) woodland north-east of Los Alamos, about 1 mile airline" (Consortium of California Herbaria 2017b, p. 1).

We viewed images of the area using Google Earth (dated 5 January 2015) on 10 May 2017, and we identified the property (Price Ranch) by a prominent woodland in a water course in a valley. The property is mostly undeveloped and used for cattle grazing. Many of the adjacent and nearby properties are vineyards. The location is 31.7 km/19.7 mi inland from the wet beach sand, and 8.5 km/5.3 mi southeast of occurrence 2. It is in the headwaters of San Antonio Creek watershed. This occurrence is on private property (219 ha/540 ac), and it is not protected. The current status is unknown. We were not able to obtain permission to visit this occurrence in 2017.

Occurrence 34 (new). 34.973586, -120.608135 (Elvin 2017a, p. 2); 13 m/43 ft. This occurrence is based on Elvin (2006, p. 1) who observed <10 individuals at the edge of Santa Maria River, 3.7 km/2.3 mi inland from wet beach sand on private property of Chevron Corporation in San Luis Obispo County. The location is 720 m/0.45 mi southwest of the nearest colony of occurrence 18. CDA1576 is a herbarium specimen of the California Department of Food and Agriculture. It was collected in 1974 in bottomland of the Santa Maria River, north of West Main Street, and 4.0 km/2.5 miles inland from the coast, Santa Barbara County (Fuller 1975, entire). This particular area has a history of intensive row crop farming, which puts La Graciosa at risk in this location (34.971398, -120.605113; 13 m/43 ft). We attribute this location, although vague and imprecise, to occurrence 34. It is 367 m/0.23 mi southwest of the location reported by Elvin (2017a, p. 2). Langford (2018, p. 1) visited the occurrence in 2018 and saw no La Graciosa thistle. The area was characterized by tall annual grasses and other invasive species (blessed milkthistle, bull thistle, Italian plumeless thistle), a fence and grazing cattle. The part of the occurrence on the property of Chevron Corporation is currently partially protected.

Table 1. Conservation status of the 21 known occurrences of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) in western San Luis Obispo and Santa Barbara Counties, California. SBA Co = Santa Barbara County, SLO Co = San Luis Obispo County.

Occurrence	Location	Landowner	Protected	Status at Federal listing 2000	Status at 5-year review 2011	Status 2017	Last year seen	Last year searched
1	S of Lompoc-Surf Rd 4.8 km/3 airline mi SE of Surf, SBA Co	Vandenberg Air Force Base	no	likely extirpated	likely extirpated	likely extirpated	1958	2008
2	E Branch of Cañada de las Flores, SBA Co	private	no	likely extirpated	likely extirpated	likely extirpated	1989	2009
3	N Branch of Cañada de Las Flores, SBA Co	private	no	likely extirpated	likely extirpated	likely extirpated	1989	2009
4	S Orcutt, SBA Co	unknown	no	likely extirpated	likely extirpated	likely extirpated	1906	2017
6	Santa Maria River bed + floodplain near river mouth, SLO Co + SBA Co	two private (including Chevron Corp)	currently partially	extant	extant, decreased number	extant, decreased number	2017	2017
8	Jack Lake + unnamed wetland 556 m/608 yd N, SLO Co	private (Phillips 66 Company)	no	unknown	unknown	likely extirpated	1998	2017
10	Mud Lake, SLO Co	private with conservation easement to Land Conservancy SLO Co	yes	likely extirpated	likely extirpated	likely extirpated	1983	2017
11	Big Twin Lake + Small Twin lake	private with conservation easement to Land Conservancy SLO Co	yes	extant	extant	extant, increased number	2018	2018
12	Surprise Lake, SLO Co	Oceano Dunes State Vehicular Recreation Area	yes	extant	extant	extant 2017; likely extirpated 2018	2017	2018
13	NW shore of Oso Flaco Lake, SLO Co	Oceano Dunes State Vehicular Recreation Area	yes	likely extirpated	likely extirpated	likely extirpated	1990	2015
14	Pismo State Beach, NW Oceano, SLO CO	Pismo State Beach	yes	likely extirpated	likely extirpated	likely extirpated	1969	2017
16	Black Lake, SLO Co	Land Conservancy SLO Co	yes	likely extirpated	likely extirpated	likely extirpated	1970	2017
18	NW monitoring well M-11, Guadalupe Oil Field, SLO Co	private (Chevron Corp)	currently	extant	extant, decreased number	extant, decreased number	2017	2017
19	immediately N of Santa Maria River, 602 m/658 yd NNW of 8th St (Guadalupe), SLO Co	private	no	unknown	unknown	likely extirpated	1991	2017
20	Lettuce Lake + unnamed wooded swale 749 m/819 yd W of Jack Lake, SLO Co	Oceano Dunes State Vehicular Recreation Area	yes	likely extirpated	likely extirpated	likely extirpated	1990	2017
28	roadside, West Main Street extended, S Guadalupe, SBA Co	private	no	unknown	likely extirpated	likely extirpated	1983	2017
30	946 m/1,035 yd SW of Oso Flaco Lake, SLO Co	Oceano Dunes State Vehicular Recreation Area	yes	unknown	unknown	likely extirpated	1967	2017
31	3 Pond West, SLO Co	Guadalupe-Nipomo Dunes National Wildlife Refuge	yes	extant	extant	in decline, near extirpation	2017	2017
32	Entrance Ponds, Guadalupe Oil Field + adjoining private property, SLO Co	two private (including Chevron Corp)	currently partially	extant	extant, decreased number	likely extirpated	2014	2017
33 (new)	Price Ranch Rd, NE of Los Alamos, SBA Co	private	no	unknown	unknown	unknown	1975	1975
34 (new)	Santa Maria River bed, SLO Co + SBA Co	two private (including Chevron Corp)	currently partially	extant	unknown	likely extirpated	2006	2018

Table 2. Approximate numbers (flowering + vegetative individuals) of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) in the 21 known occurrences in San Luis Obispo and Santa Barbara Counties, California. Column 6C is the portion of occurrence 6 on property of Chevron Corporation, which includes 22% of the mapped area on private properties of two landowners. X = present. Occurrences 33, 34 and 35 are new.

	Occurrence																				
Year	1	2	3	4	6C	8	10	11	12	13	14	16	18	19	20	28	30	31	32	33	34
2018								X[74]	0[72]												0[73]
2017				0[65]	535[13]	0[19, 51]	0[64]	≥245[66]	65[22]		0[50]	0[49]	913[13]	0[63]	0[19, 67]	0[19]	0[51]	≥5[62]	0[13]		
2016					1,510[47]				37[22]				803[48]						0[35]		
2015					2,833[47]	0[40]			1[40]	0[40]			5,374[48]		0[40]				0[35]		
2014					2,880[47]								23,590[48]					10[59]	1[35]		
2013					1,612[47]				37[40]				2,812[48]			0[16]		172[59]	12[35]		
2012					953[47]								649[48]						18[35]		
2011					1,654[47]								247[48]						35[35]		
2010					4,464[47]								240[48]					300[59]	34[35]		
2009		0[5]	0[5]		9,751[47]								280[48]						23[35]		
2008	0[8]				8,362[47]				10[25]				1,005[48]					X[29]	94[35]		
2007	0[4]	0[52]	0[52]		1,339[47]								1,558[48]					50[29]	119[35]		
2006					1,746[47]								2,240[48]						280[35]		<10[70, 71]
2005																0[16]			420[35]		
2002					X[55]								X[55]								
2001					X[42]								X[54]								
2000					X[54]								X[54]								
1998						2[17]			7[24]	0[17]					0[17, 58]						
1997									54[17]									87[30]			
1995	0[9]				X[43]								31[37]								
1994	0[9]												X[36]								
1993																					
1991														100[27]							
1990	0[3]	0[3]	0[3]	0[3]	23,320[61] (106,002[60])	>112[3]			29[3]	34[3]	0[3]	0[3]	137[3]		≥12[3]						
1989		X[3]	X[3]																		
1988								20[31]	25[17]												
1987	0[10]	X[2]	X[2]						50[23]												
1986	0[6]	20[7]	5[7]	0[6]	X[6]	X[6]	0[6]	X[33]	0[7]	0[7]	0[6]	0[6]									

1985		X[2]	X[2]		X[3]																
1984		X[2]	X[2]		X[45]			11-50[32]													
1983		X[2]	X[2]		X[44]		>100[18]					0[3]				X[15]					
1982	0[11]																				
1981					X[46]	X[15]	1-10[28]	4-40[28]	11-50[26]												
1980						X[21]				X[21]					X[38]						
1979						≥30[69]															
1977					X[41]																
1976											0[3]										
1975																				X[15]	
1974					X[56]																
1973		X[2]	X[2]					X[15]												X[15]	
1969											X[12]										
1970												X[34]									
1968						X[15]				X[15]											
1967																	X[15]				
1964						X[57]															
1962					X[15]					X[15]											
1960										X[15]											
1958	X[1]							X[68]													
1949	X[53]									X[15]											
1910											X[20]										
1906				X[14]																	

1. Smith 1958, p. 1.
2. Thornton 2008, p. 14.
3. Hendrickson 1990b, entire.
4. Elvin 2007b, p. 7.
5. Kisner 2009, p. 2.
6. McLeod 1986d, entire.
7. Friedman 1986, p. 3.
8. Wilken et al. 2009, p. 8.
9. Oyler et al. 1995, p. 45.
10. Schmalzer et al. 1988, p. 133.
11. Smith 1982, p. 2.
12. Holstein 2017, p. 4.

13. Padre Associates 2018, p. A-200.
14. Petrak 1917, p. 376.
15. Consortium of California Herbaria 2017c, entire.
16. Elvin 2017c, p. 1.
17. Chesnut 1998c, entire.
18. Turner and Pemberton 1983, p. 1.
19. Kofron 2017a, p. 1.
20. Consortium of California Herbaria 2017g, p. 1.
21. McLeod 1980, p. 1.
22. Skinner 2017b, p. 1.
23. McLeod 1987, p. 1.
24. Chesnut 1998a, p. 1.
25. Elvin 2008, p. 1.
26. Howald 1981b, entire.
27. Ingamells 1991, p. 1.
28. Howald 1981a, p.1.
29. Elvin 2010, p. 1.
30. Chesnut 1998b, p. 2
31. Hendrickson and Parikh 1988, p. 1.
32. McLeod 1984a, p. 1.
33. McLeod 1986a, p. 1.
34. Hoover 1970, p. 310.
35. Langford 2017b, p. 1-5.
36. Lebednik 1994, entire.
37. Lebednik 1995a, b, c, entire.
38. McCoy 1980, p. 48.
39. McLeod 1986b, p. 1.
40. MIG/TRA Environmental Sciences 2016, p. 3-15.
41. Howald 1977, p. 2.
42. Huber 2001, entire.
43. Lebednik 1995d, p. 1.
44. McLeod 1983, entire.
45. McLeod 1984b, p. 1.
46. Vanderwier 1981, entire.
47. Padre Associates 2017, table 3.
48. Padre Associates 2017, table 3 (includes outplantings in restored area for 2011 to 2016).
49. Whitaker 2017, p. 1.
50. Skinner 2017c, p. 4.
51. Skinner 2017a, p. 1.
52. Elvin 2007a, entire.

53. Consortium of California Herbaria 2017a, p. 1.
54. Lea 2002, p. 42.
55. Teed 2003, p. 35.
56. Fuller 1975, entire.
57. Consortium of California Herbaria 2017d, p. 2.
58. Chesnut 1998c, map 1.
59. USFWS 2016a, p. 48.
60. Hendrickson (1990b, p. 13) estimated 106,002 individuals for the entire occurrence 6 (117 ha/289 ac) over properties of two landowners.
61. This is a prorated number (22%) for the 26 ha/64 ac of occurrence 6 on property of Chevron Corporation.
62. Kofron and Rutherford 2017, p. 1.
63. Kofron 2017e, p. 1.
64. Kofron 2017c, p. 1.
65. Kofron 2017d, p.1.
66. Kofron 2017b, p. 1.
67. Skinner 2017e, p. 3.
68. Lazar 2018b, p. 4.
69. Lazar 2018a, p. 3.
70. Elvin 2006, p. 1.
71. Elvin 2017a, p. 2.
72. Skinner 2018, p. 1.
73. Langford 2018, p. 1.
74. Kofron 2018b, p. 1.

Table 3. Thirteen previously recognized occurrences of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) that were removed from the California Natural Diversity Database (Lazar 2017, p. 1; 2018a, p. 1). SBA Co = Santa Barbara County, SLO Co = San Luis Obispo County.

Occurrence	General location	Reason for removal from California Natural Diversity Database
5	Vandenberg Air Force Base, SBA Co	subsequently identified as clustered thistle (*Cirsium brevistylum*)
7	Santa Maria River	included in occurrence 6
9	Jack Lake, SLO Co	combined into occurrence 8
15	Santa Maria River	included in occurrence 6
17	Surprise Lake, SLO Co	mis-mapped, same as occurrence 12
21	Vandenberg Air Force Base, SBA Co	subsequently identified as clustered thistle
22	Vandenberg Air Force Base, SBA Co	subsequently identified as clustered thistle
23	Vandenberg Air Force Base, SBA Co	subsequently identified as clustered thistle
24	Vandenberg Air Force Base, SBA Co	subsequently identified as clustered thistle
25	Vandenberg Air Force Base, SBA Co	subsequently identified as clustered thistle
26	Vandenberg Air Force Base, SBA Co	subsequently identified as clustered thistle
27	Vandenberg Air Force Base, SBA Co	subsequently identified as clustered thistle
29	Laguna Lake Natural Reserve, SLO Co	subsequently identified as Chorro Creek bog thistle (*Cirsium fontinale* var. *obispoense*)

Table 4. Resiliency and representation of the 21 known occurrences of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) in the four geographic populations in San Luis Obispo and Santa Barbara Counties, California. Row 6C is the portion of occurrence 6 only on property of Chevron Corporation, which comprises 22% of the mapped area over properties of two landowners. The numbers of plants include flowering and vegetative individuals. X = species present. Status of occurrence may show first year with zero plants recorded. The following scores are used for resiliency: high = 3, medium = 2, low = 1, and likely extirpated = 0.

Representation	Occurrence	Number of plants recorded during last survey	Highest number of plants recorded	Status of occurrence	Identified threats in previous reports	Resiliency score
Vandenberg South	1	0 / 2008	X / 1958	likely extirpated	lack of water[28], flooding[23], agriculture[2, 10, 36], vegetation management[2], invasive species[28]	0
Solomon Hills	2	0 / 2009	20 / 1986	likely extirpated	drought[2], agriculture[36], cattle grazing[10], cattle overgrazing[7], feral pigs[7]	0
	3	0 / 2009	5 / 1986	likely extirpated	drought[2], agriculture[36], cattle grazing[10], cattle overgrazing[7], feral pigs[7]	0
	33 (new)	X / 1975	X / 1973	unknown	—	unknown
South Orcutt	4	0 / 2017	X / 1906	likely extirpated	agriculture[2], development[2, 36]	0
Sand Dune Complexes	6C 6	535 / 2017	23,320[1] / 1990 106,002[2] / 1990	decreased number, large occurrence 2017	oil production[13, 25], development[36], herbivory[2, 16], cattle grazing[6, 19, 22, 30], cattle trampling[16], flooding[3, 29], feral pigs[29], iceplant[19], gophers[22, 29, 33]	2
	8	0 / 2017	>112 / 1990	likely extirpated	herbivory[2], invasive species[4], off road vehicles[10, 36], lack of water[17], drought[32], reproductive failure[2]	0
	10	0 / 2017	> 100 / 1983	likely extirpated	unstable water level[34], manipulation of water level[26], vegetation management[26], lack of water[38], accumulation of dead bulrushes[38]	0
	11	≥245 / 2017	≥245 / 2017	increased number, small occurrence 2017	manipulation of water level[10, 27], vegetation management[14], lack of water[40], accumulation of dead bulrushes[40], invasive species[40]	2
	12	0 / 2018	65 / 2017	extant 2017; likely extirpated 2018	drought[2], flooding[3], herbivory[2, 9], reproductive failure[2], willow expansion[5], off road vehicles[15], hunters[15], feral pigs[31, 40], lack of water[40], habitat alteration by fallen trees[40]	0
	13	0 / 2015	34 / 1990	likely extirpated	off road vehicles [26, 36], drought[2], reproductive failure[2], willow expansion[4]	0
	14	0 / 2017	X / 1969	likely extirpated	iceplant[2, 12, 36], invasive species[31]	0
	16	0 / 2017	X / 1970	likely extirpated	lack of water[2], unstable water level[34], bulrushes[35]	0
	18	913 / 2017	23,590 / 2014	decreased number, large occurrence 2017	lack of water[6], drought[29, 33], cattle grazing[19, 20, 21, 33], cattle trampling[19, 33], invasive species[19], gophers[21, 29, 33], herbivory[33]	2
	19	0 / 2017	100 / 1991	likely extirpated	agriculture[39], invasive species[39]	0
	20	0 / 2017	≥12 / 1990	likely extirpated	flooding[3], off road vehicles[11, 24], herbivory[11], willow expansion[11], *Rubus*[11], lack of water[17], habitat alteration by fallen trees[17]	0

	28	0 / 2017	X / 1983	likely extirpated	agriculture[17], development[17], road and ditch maintenance[17]	0
	30	0 / 2017	X / 1975	likely extirpated	vegetation management[32]	0
	31	≥5 / 2017	300 / 2010	in decline, near extirpation 2017	cattle trampling[8], feral pigs[8], lack of water[37], herbivory[37], drought[48]	1
	32	0 / 2017	420 / 2005	likely extirpated	cattle grazing[8], cattle trampling[8], lack of water[18], drought[18, 29], invasive species[18], habitat alteration by fallen trees[41]	0
	34 (new)	0 / 2018	<10 / 2006	likely extirpated	invasive species[43], cattle grazing[43]	0

1. This is a prorated number (22%) based on the 26 ha/64 ac of occurrence 6 on property of Chevron Corporation.
2. Hendrickson 1990b, entire.
3. Chesnut 1998b, p. 1.
4. Chesnut 1998c, p. 52.
5. Chesnut 1998a, p. 1.
6. Elvin 2006, p. 1.
7. Elvin 2007a, entire.
8. Elvin 2010, p. 1-2.
9. Skinner 2017f, entire.
10. Friedman 1986, p. 2.
11. Hendrickson 1990a, p. 1.
12. Holstein 2017, p. 2.
13. Howald 1977, p. 2.
14. Howald 1981a, p. 1.
15. Howald 1981b, p. 1.
16. Huber 2003, entire.
17. Kofron 2017a, p. 1.
18. Langford 2017b, p. 2-3.
19. Lea 2002, entire.
20. Lebednik 1994, p. 1.
21. Lebednik 1995b, p. 1.
22. Lebednik 1995d, p.1.
23. Linn 2008, p. 10.
24. McCoy 1980, p. 48-53.
25. McLeod 1984b, p. 1.
26. McLeod 1986d, p. 3.
27. McLeod 1986a, p. 1.
28. Oyler et al. 1995. p. ii, 46.
29. Padre Associates 2017, p. 9-21.
30. Parikh and Hendrickson 1988, p. 1.
31. Skinner 2017c, p. 4.
32. Skinner 2017a, p. 1.

33. Teed 2003, entire.
34. Turner and Pemberton 1983, p. 1-2.
35. Whitaker 2017, p. 1.
36. Morey 1989, p. 5.
37. Kofron and Rutherford 2017, p. 1
38. Kofron 2017c, p.1.
39. Kofron 2017e, p. 1.
40. Kofron 2017b, p. 1.
41. Kofron 2017f, p. 1.
42. USFWS 2016a, p. 48.
43. Langford 2018, p. 1.

Table 5. The threats to La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) in 2018.

	Occurrence																				
Threats in 2018	1	2	3	4	6	8	10	11	12	13	14	16	18	19	20	28	30	31	32	33	34
Groundwater decline	X				X	X	X	X	X			X	X		X		X	X	X		
Agriculture	X	X	X	X										X		X					X
Development	X			X							X					X					
Hydrological alteration				X	X					X						X					X
Uncontrolled grazing			X		X									X							X
Invasive species					X			X	X		X			X					X		
Vegetation management											X						X				
Dead vegetation altering habitat						X	X	X	X						X				X		
Flooding					X									X							X
Habitat disturbance by feral pigs									X												
Herbivory									X									X			
Off road vehicles																	X				
Road and ditch maintenance					X											X					
Drought	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Climate change	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Stochastic events	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 6. Approximate numbers (flowering + vegetative individuals) of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) recorded in the Guadalupe Oil Field, San Luis Obispo County, California, annually from 2006 to 2017 (Padre Associates 2017, table 3; 2018, p. A-200; Langford 2017b). The stated numbers of plants are the total for occurrence 18, occurrence 32 and the portion of occurrence 6 on property of Chevron Corporation (which is 22% of the mapped area over properties of two landowners). The numbers do not include the portion of occurrence 34 on property of Chevron Corporation (< 10 in 2006, 0 in 2018).

Year	Numbers of plants
2017	1,448
2016	2,313
2015	8,207
2014	26,471
2013	4,436
2012	1,620
2011	1,936
2010	4,738
2009	10,054
2008	9,461
2007	3,016
2006	4,266

Table 7. Attributes of occurrences of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) for determination of resiliency scores: 3 = high, 2 = moderate, 1 = low. In addition, a 0 is assigned for likely extirpated.

	Small occurrence ≤500 individuals in last 3 years	Large occurrence >500 individuals in last 3 years
Increased number of individuals or stable across years	2	3
Decreased number of individuals across years	1	2

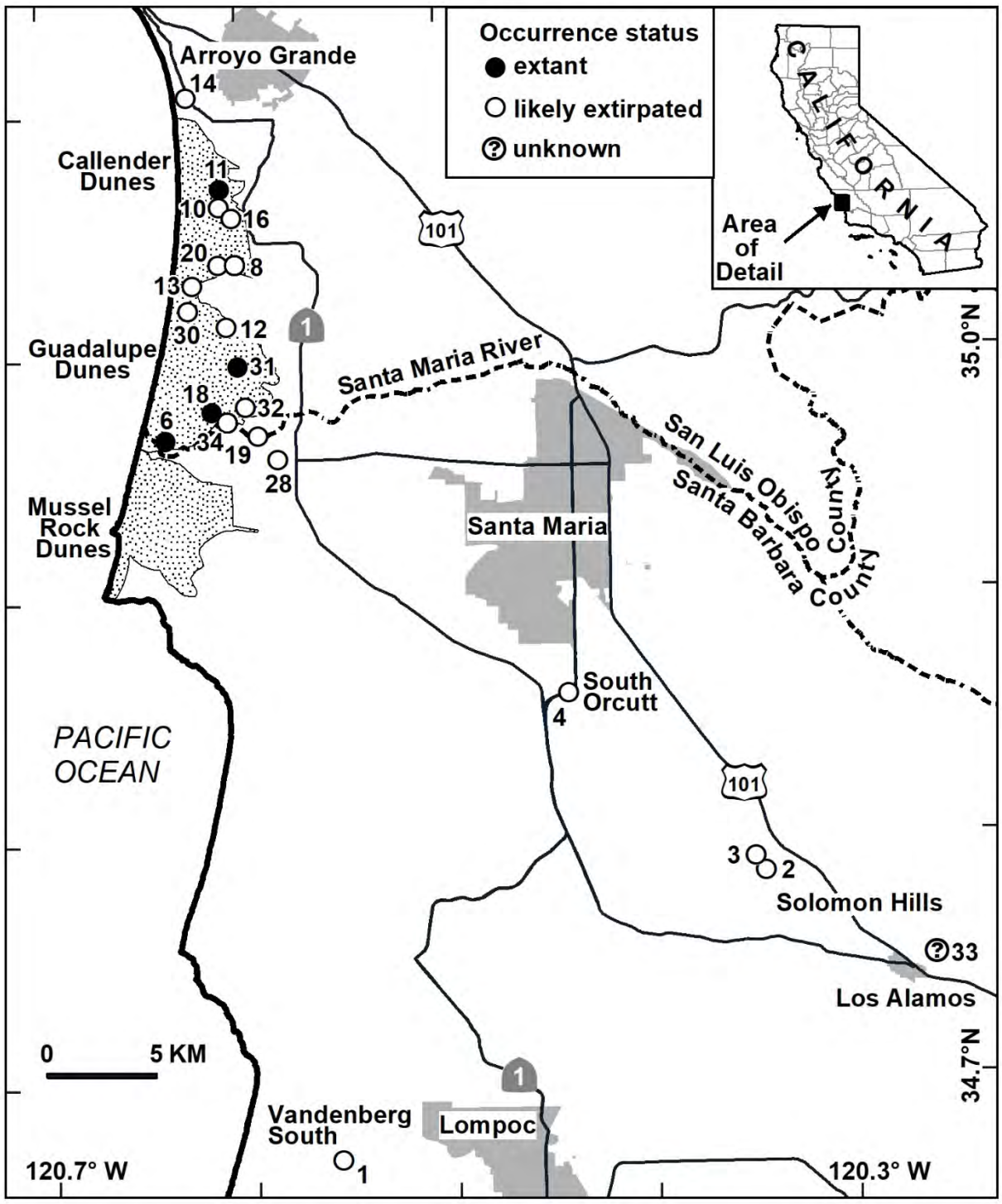

Figure 1. Geographic distribution of the 21 known occurrences of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) in San Luis Obispo and Santa Barbara Counties, California. We tentatively recognize four geographic populations, which from north to south are the following: Sand Dune Complexes (16 occurrences), South Orcutt (1 occurrence), Solomon Hills (3 occurrences), and Vandenberg South (1 occurrence).

Figure 2. An individual of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) with flower near the mouth of Santa Maria River in the Guadalupe Oil Field, San Luis Obispo County, California, 23 May 2013 (occurrence 6). Photo courtesy of Jenny Langford, Padre Associates, Inc., Guadalupe, California.

Figure 3. Seeds of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) from a plant at Big Twin Lake on the private property of Dune Lakes Limited, San Luis Obispo County, California, 30 August 2017 (occurrence 11). Seed dispersal is by wind and also likely by water because it is a wetland plant. Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

Figure 4. A vegetative individual of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) near the mouth of Santa Maria River in the Guadalupe Oil Field, San Luis Obispo County, California, 21 March 2017 (occurrence 6). Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

Figure 5. A young vegetative individual of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) near the mouth of Santa Maria River in the Guadalupe Oil Field, San Luis Obispo County, California, 21 March 2017 (occurrence 6). Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

Figure 6. A group of vegetative individuals of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) near the mouth of Santa Maria River in the Guadalupe Oil Field, San Luis Obispo County, California, 21 March 2017 (occurrence 6). Approximately 100 individuals can be seen in the photograph. Occurrence 6 is the largest occurrence of La Graciosa thistle, with >106,000 plants recorded in 1990. In 2017 the occurrence had a decreased number of plants. Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

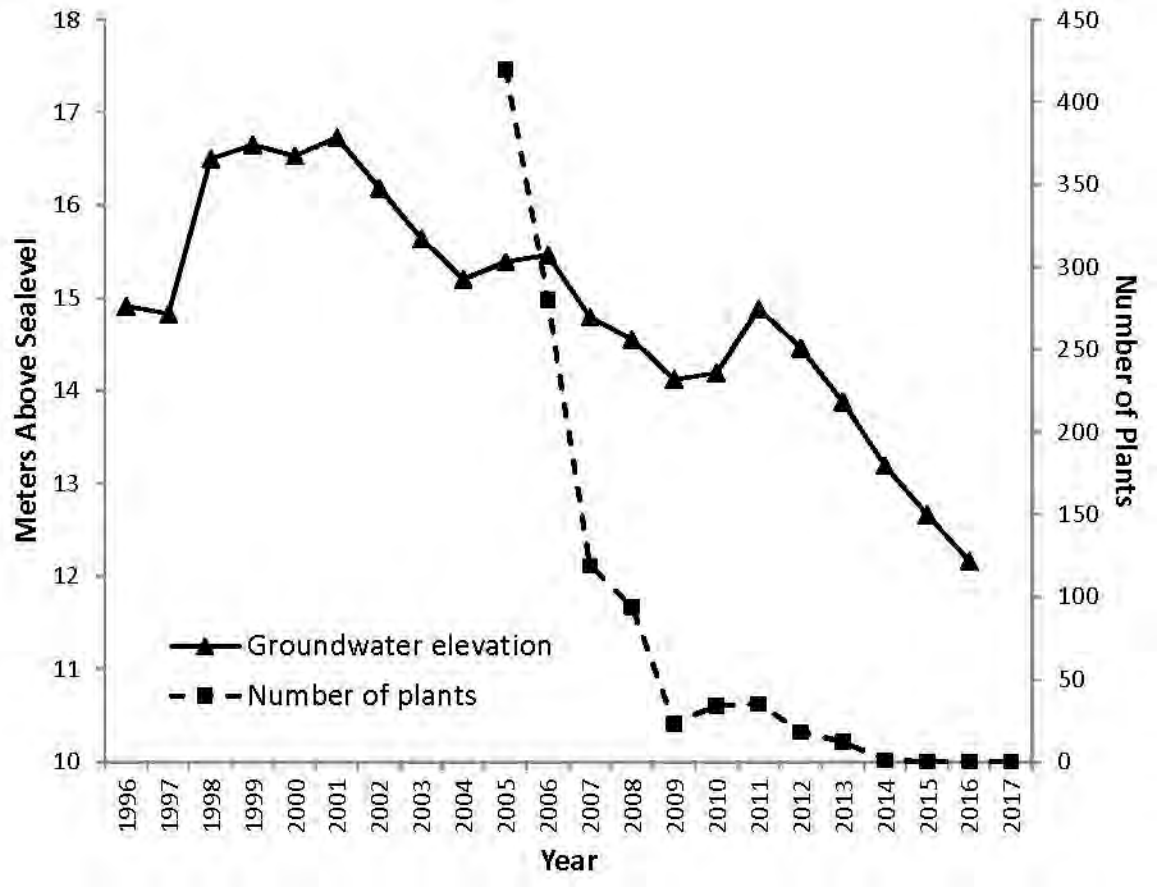

Figure 7. The relationship between the groundwater table and La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) at the Entrance Ponds in the Guadalupe Oil Field, San Luis Obispo County, California (occurrence 32). The elevation (meters above mean sea level) of the groundwater table was measured in October of each year at monitoring well 35W-6A1, which is 180 m/591 ft southeast of occurrence 32. In October 2001 the groundwater elevation was 16.73 m/54.89 ft, whereas in October 2016 the groundwater elevation was 12.16 m/39.9 ft, which is a drop of 4.57 m/14.99 ft. The Entrance Ponds and monitoring well 35W-6A1 connect to the same aquifer. La Graciosa thistle is a wetland plant, and the occurrence is now likely extirpated. The data are from Langford (2017a, b).

Figure 8. Occurrence 10 of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) at east end of Mud Lake on the private property of Dune Lakes Limited, San Luis Obispo County, California, 30 August 2017. The lake was mostly dry, with a drop in the groundwater table as the likely cause. The lake bed is covered by a dense layer (30 cm/1 ft to 91 cm/3 ft) of vegetation debris comprised predominantly of stems of dead California bulrush (*Schoenoplectus californicus*). The occurrence is likely extirpated. The land manager wishes to restore the wetland, including replanting La Graciosa thistle. Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

Figure 9. A group of flowering La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) at the north margin of Big Twin Lake on the private property of Dune Lakes Limited, San Luis Obispo County, California, 30 August 2017 (occurrence 11). In 2017, this occurrence had an increased number of plants. Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

Figure 10. Occurrence 12 of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) at Surprise Lake, Oceano Dunes State Vehicular Recreation Area, San Luis Obispo County, California, 21 March 2017. The lake held no water in March 2017. The lake was densely forested with arroyo willow (*Salix lasiolepis*), and many appeared dead, which is consistent with a drop in the groundwater table. This occurrence was extant in 2017 (65 individuals) and likely extirpated in 2018 (zero individuals). Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

Figure 11. Occurrence 19 of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) on a private ranch in the Santa Maria River bed in San Luis Obispo County, northwest of Guadalupe, Santa Barbara County, California, 29 August 2017. In 1991 the plants were growing on grazing land irrigated with recycled water from the wastewater treatment plant of the city of Guadalupe. In 2017, invasive bull thistle (*Cirsium vulgare*) was abundant, and La Graciosa thistle is likely extirpated. Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

Figure 12. Occurrence 28 of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*), roadside of West Main Street extended in south Guadalupe, Santa Barbara County, California, 21 March 2017. In 1983 the plants were growing along the road and next to a wet grazed pasture. In 2018 the occurrence is likely extirpated. Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

Figure 13. Looking north to occurrence 31 of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) at 3 Pond West, Guadalupe-Nipomo Dunes National Wildlife Refuge, San Luis Obispo County, California, 6 September 2017. The swale is in a long valley between two sand dunes. **X** indicates approximate location of the La Graciosa thistle. The swale was dry with exception of a drying waterhole (likely excavated) at its northwest end. Willows occupied several parts of the swale, and they appeared dead with some fallen in 2017, which is consistent with a drop in the groundwater table. This occurrence is in decline and near extirpation. Photo courtesy of Catherine Darst, U.S. Fish and Wildlife Service, Ventura, California.

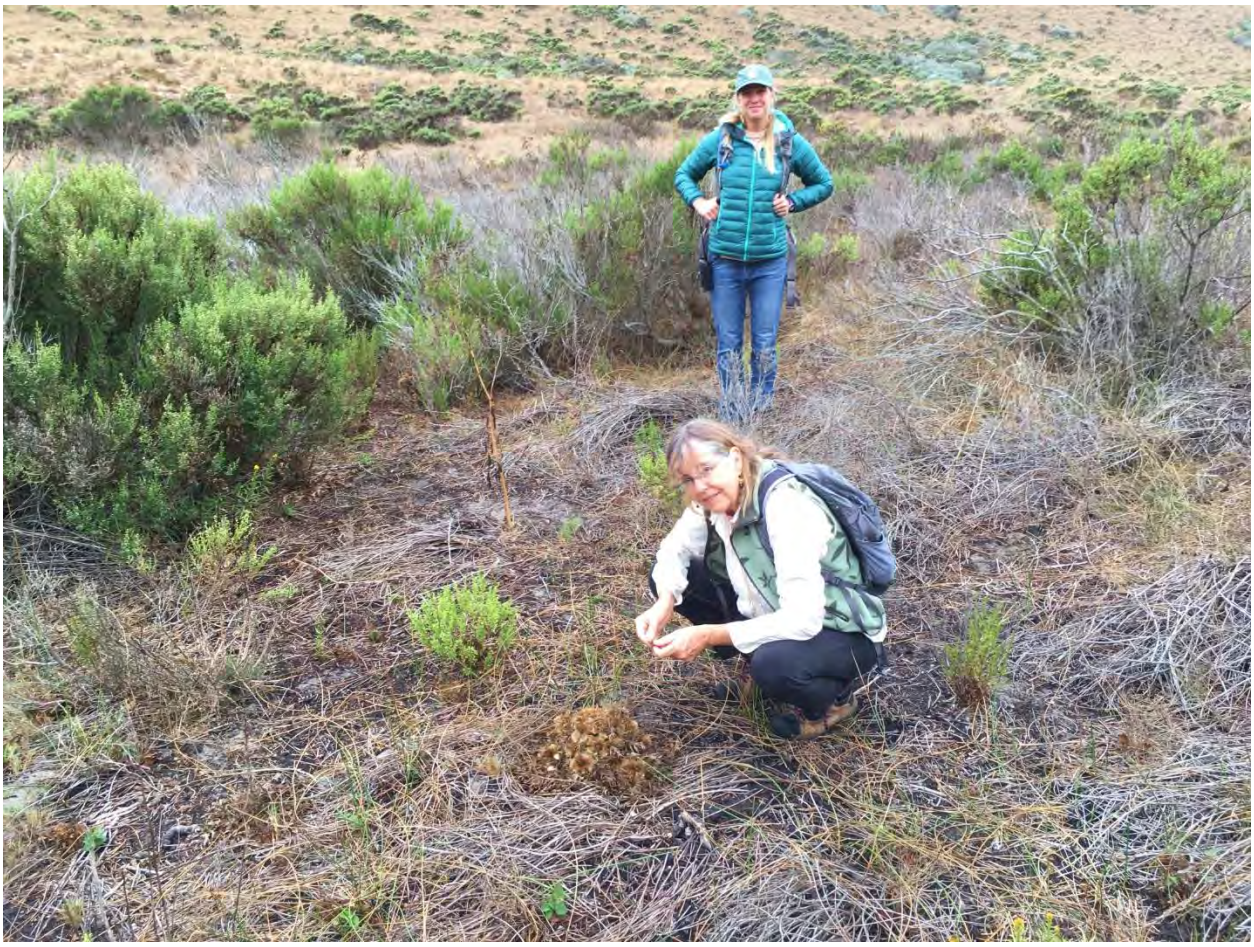

Figure 14. Habitat of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) at occurrence 31, 3 Pond West, Guadalupe-Nipomo Dunes National Wildlife Refuge, San Luis Obispo County, California, 6 September 2017. An individual of La Graciosa thistle (post-flowering and in decomposition) is in the foreground. This occurrence is in decline and near extirpation. Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.

Figure 15. An individual of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*), post-flowering and in decomposition, at occurrence 31, 3 Pond West, Guadalupe-Nipomo Dunes National Wildlife Refuge, San Luis Obispo County, California, 6 September 2017. La Graciosa thistle is a biennial or short-lived perennial plant that flowers once and then dies, with a probable life span of 2 to 6 years. Photo courtesy of Catherine Darst, U.S. Fish and Wildlife Service, Ventura, California.

Figure 16. Occurrence 32 of La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) at the Entrance Ponds, Guadalupe Oil Field, San Luis Obispo County, California, 6 September 2017. The wetland comprises two swales, one on private property of Chevron Corporation and one on the adjacent private property. This occurrence is likely extirpated, having quickly declined in numbers of plants from 420 in 2005 to 0 in 2015, 2016 and 2017. In 2017 the wetland was forested with arroyo willow (*Salix lasiolepis*), and many had died and collapsed. In 2001 the groundwater table was at the surface, and as of 2016 it had declined 4.57 m/14.99 ft. Photo courtesy of Chris Kofron, U.S. Fish and Wildlife Service, Ventura, California.