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Status of the Endangered Chorro Creek Bog Thistle *Cirsium fontinale* var. *obispoense* (Asteraceae) in Coastal Central California

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Abstract.—Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* (Asteraceae) is a biennial or short-lived perennial plant up to 2 m tall that occurs only in San Luis Obispo County, west of the outer coast ranges. It was listed as endangered under the California Endangered Species Act in 1993 and the U.S. Endangered Species Act in 1994. Chorro Creek bog thistle is a serpentine endemic, occupying perennial seeps and springs in serpentine soil and rock in western San Luis Obispo County from north of San Simeon Creek to south of the city of San Luis Obispo. At federal listing in 1994 Chorro Creek bog thistle was known from nine occurrences (one of these presumed extirpated) and with an estimate of <3,000 individuals. In 2016 the conservation status of Chorro Creek bog thistle is substantially improved because of an increased number of known occurrences along with an increased number of occurrences that are protected. Only two of nine known occurrences were protected in 1994, whereas 10 of 21 occurrences are protected in 2016. There are many other locations with habitat that have not been searched, in particular on private land. It is highly likely that additional unknown occurrences exist in San Luis Obispo County, and possibly also in Monterey County to the north and Santa Barbara County to the south. In consideration of the available information, we conclude that Chorro Creek bog thistle is still endangered. However, when using the international standards of IUCN, we assign the category data deficient because of the limitations of our data.

The fountain thistle *Cirsium fontinale* is a plant in the aster and sunflower family (Asteraceae) with a known geographic range extending from San Francisco County southward to San Luis Obispo County in western California. Three varieties are recognized (Baldwin et al. 2012): Crystal Springs fountain thistle *C. fontinale* var. *fontinale*, Mount Hamilton fountain thistle *C. fontinale* var. *campylon,* and Chorro Creek bog thistle *C. fontinale* var. *obispoense*. Crystal Springs fountain thistle occurs west of San Francisco Bay in San Mateo and San Francisco Counties. Mount Hamilton fountain thistle occurs south and east of San Francisco Bay in Alameda, Santa Clara and Stanislaus Counties. Chorro Creek bog thistle occurs only in San Luis Obispo County, 176 km south of the nearest occurrence of Mount Hamilton fountain thistle (USFWS 2014). Chorro Creek bog thistle and Crystal Springs fountain thistle were listed as endangered under the U.S. Endangered Species Act in 1994 and 1995 (U.S. Fish and Wildlife Service [USFWS] 1994, 1995), respectively, and also under the California Endangered Species Act in 1993 and 1979 (California Department of Fish and Wildlife [CDFW] 2016b), respectively. Mount Hamilton fountain thistle is not listed.

Chorro Creek bog thistle is a biennial or short-lived perennial plant up to 2 m tall. Its spiny leaves have glandular hairs on the upper and lower surfaces, and its flowers are white, pink or lavender with a drooping posture. Each flower head produces ≈73 seeds (mean), which are up to 4 mm long (Turner and Herr 1996) and with a pappus (set of bristles) that aids dispersal.

Chorro Creek bog thistle is diagnosed from the other two varieties by combination of several morphological characteristics of the stem, leaf, inflorescence, flower and fruit. Baldwin et al. (2012) provide complete descriptions of the three varieties.

At federal listing in 1994, Chorro Creek bog thistle was known from nine occurrences, one of these presumed extirpated, and with an estimate of <3,000 individuals. Identified threats were cattle grazing (trampling, herbivory), proposed development, water diversions, road maintenance, inadequate legal protection, stochastic events (in particular drought), and invasive (non-native) plants (USFWS 1994). Two occurrences were protected. USFWS (2014) reviewed the conservation status of Chorro Creek bog thistle (19 known occurrences) and recommended no change in the legal listing status. Our purpose is to review and enhance the knowledge of Chorro Creek bog thistle, in particular its distribution, ecology, abundance, threats, management and conservation status in 2016.

Materials and Methods

We surveyed and censused many occurrences of the Chorro Creek bog thistle in San Luis Obispo County from 2009 to 2016, and we found five previously unknown occurrences. We counted and estimated (after gaining experience by counting) the number of plants in each colony (a spatial group of separate individuals) and occurrence that we observed. We considered reports of the USFWS and CDFW, data in the California Natural Diversity Database (CDFW 2016a), and personal communications from other biologists who also observed the species. Using all available information, we summarize the knowledge of Chorro Creek bog thistle in 2016. We consider a location with the species as a separate occurrence if it is >0.4 km from the nearest occurrence (California Department of Fish and Game 2011). The stated distances and the stated numbers of plants are approximates. Elevations were determined using tools in Google Earth. Latin and common names of plants follow Baldwin et al. (2012), with exception of *C. fontinale* var. *obispoense* for which we use Chorro Creek bog thistle rather than San Luis Obispo fountain thistle. Areas (ha) of properties are from records of the County of San Luis Obispo and the City of San Luis Obispo. We provide the relevant and available details for each occurrence in Appendix 1. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the USFWS.

Results and Discussion

Chorro Creek bog thistle (Fig. 1) is a serpentine endemic (Safford et al. 2005; Baldwin et al. 2012.), occupying perennial seeps and springs in serpentine soil and rock in western San Luis Obispo County (Fig. 2). Although we conducted no soil tests, each of the 21 known occurrences is on or adjacent to a serpentine deposit according to geologic maps (Wiegers 2009, 2010) and/or geologist David Chipping (USFWS 2014). Serpentine soil and rock are characterized by low calcium to magnesium ratios, and with calcium at significantly lower levels relative to surrounding areas. In addition, serpentine soil and rock frequently contain elevated levels of heavy metals (e.g. iron, nickel, chromium, cobalt), which are toxic to most other plants, and they are often deficient in essential plant nutrients (e.g. nitrogen, potassium, phosphorus; Brady et al. 2005). Because of their ultramafic origin, which in western San Luis Obispo County is associated with tectonics and subduction (Wiegers 2009, 2010), serpentine substrates are often steep outcrops (Brady et al. 2005). Accordingly, we report that Chorro Creek bog thistle occur mostly on slopes (Fig. 3).

Chorro Creek bog thistle typically live 2 or 3 years. The plant forms a rosette of leaves in the first year that can attain up to 0.9 m diameter. Stalk development begins during February

Fig. 1. Flower head of Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* on Camp San Luis Obispo (occurrence 3), San Luis Obispo County, California (12 May 2005). Photo courtesy of David Magney, Ojai, California.

or March of the second year, and it continues to May or early June with some plants attaining >2 m height, although 0.5 to 1.0 m is most common. Flowering generally occurs during May to mid-June, and with some branched stalks bearing >25 flowers. After flowering and setting seed, the stems turn brown, lean to one side and eventually fall. Some living plants may persist into a third year if sufficient energy reserves remain. Under drought conditions, stalk development is less vigorous, and the buds and flower heads develop substantially faster, but fewer actually flower. This is likely an adaptive strategy for quickly producing seeds before the substrate dries. At several occurrences with dense, invasive grasses (e.g. Laguna Lake Natural Reserve), Chorro Creek bog thistle are often unable to spread their leaves into rosettes. Instead, they appear like spiny romaine lettuce, most of which flower and set seed. As the invasive grasses die back in midsummer, the leaves of the plant fall outward and form a carpet around its center, which suppresses future growth of grasses. This results in a substantial amount of seed germination within the circle of old leaves during the following year and with little seed germination beyond the circle (Chipping in USFWS 2014).

In 2016, we report that the 21 known occurrences of Chorro Creek bog thistle comprise a geographic range of 253 km^2, extending from north of San Simeon Creek (35.63087, -121.06535) to south of the city of San Luis Obispo (35.239909, -120.699012; 58 km distance). The 12 occurrences (10-21) identified since listing have expanded the geographic range by 69% (150 km^2), and six of these occurrences are protected while six are not: protected — four occurrences (14, 15, 16, 17) on public lands owned by the City of San Luis Obispo, one

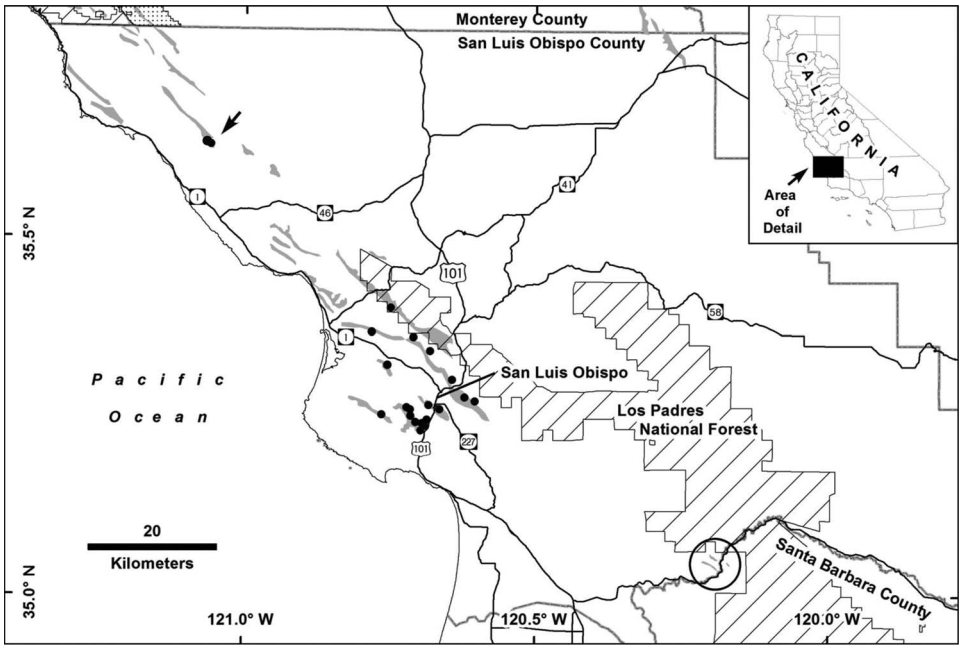

Fig. 2. The known geographic distribution of Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* in western San Luis Obispo County, California. Black dots indicate the 21 known occurrences, and the arrow indicates the two northernmost occurrences near San Simeon Creek. The plant inhabits perennial seeps and springs in serpentine soil and rock (gray shaded areas). We recommend searching for additional occurrences in San Luis Obispo County in the serpentine soil and rock indicated in this map. See also Fig. 4 and 5.

occurrence (13) on private property with a conservation easement to the City of San Luis Obispo, and one occurrence (12) legally protected on private property with an open-space easement to the County of San Luis Obispo; not protected — one occurrence (19) on a property owned by the California Army National Guard, four occurrences (10, 18, 20, 21) on five private properties, and a "lost" occurrence (11; precise location unknown) likely on a private property. Also, it is highly likely that additional unknown colonies and occurrences exist in San Luis Obispo County, and possibly in Monterey County to the north and in Santa Barbara County to the south (Figures 2, 4 and 5), and in particular on private property.

All known occurrences of Chorro Creek bog thistle are west of the outer coast ranges, and at 38 to 380 m elevation. Occurrences 1 and 18 (San Simeon Creek watershed; Table 1) are the northernmost occurrences, and with a distance of 37 km from the nearest occurrence (9, tributary of San Bernardo Creek in Chorro Creek watershed) to the southwest. The other 18 occurrences are clustered in three primary watersheds (Chorro Creek, San Luis Obispo Creek, Los Osos Creek), with a maximum distance of 5.8 km between any two occurrences. Occurrence 2 at Laguna Lake Natural Reserve in the city of San Luis Obispo comprises multiple colonies at 14 seeps. Occurrence 13 near Loma Bonita Drive is 1.6 km to the southeast on the same serpentine outcrop in the city of San Luis Obispo. Occurrences 4, 5, 7, 8, 14, 15, 16 and 21 are associated with a serpentine outcrop in Irish Hills southwest of the city of San Luis Obispo, and occurrence 12 near Serpentine Lane is also in Irish Hills on a separate serpentine outcrop 4.1 km west of these occurrences. Occurrences 10, 11 and 17 occupy a serpentine outcrop

Fig. 3. Occurrence 13 of Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* in the central part of the city of San Luis Obispo (the urban area), San Luis Obispo County, California (16 December 2011). This occurrence comprises a single colony at a seep on private property that is used for cattle grazing. Trampling is not a threat because the plants are on a steep, rocky slope. The landowner granted a conservation easement to the City of San Luis Obispo (the local government).

immediately north and east of the city of San Luis Obispo. Occurrences 3, 6, 9, 19 and 20 are associated with serpentine outcrops in foothills north and west of the city of San Luis Obispo.

Most occurrences (1, 2, 3, 4, 6, 8, 9, 12, 14, 17, 18, 19, 20) of Chorro Creek bog thistle are comprised of multiple colonies. Information on abundance is limited because recent census data are lacking for 11 occurrences (Table 2). Although 10 occurrences were censused during the past 5 y (2012 to 2016), four were last censused in 1993, one in 1987, one in 1997, one in 2001, and one in 2007. Only occurrence 3 on Camp San Luis Obispo was subject to formal and regular monitoring (1994 to 2008). Currently, 14 occurrences are subject to informal and irregular monitoring, and seven occurrences have no monitoring. Six occurrences were reported to comprise >1,000 plants at particular points in time: occurrence 1 (San Simeon Creek), >1,000 plants in 1984 (CDFW 2016a); occurrence 2 (Laguna Lake Natural Reserve), most recently 1,718 plants in 2016 (pers. obs.); occurrence 3 (Camp San Luis Obispo), most recently 1,782 plants in 2014 (Kevin Merk, San Luis Obispo, pers. comm. 2016); occurrence 6 (El Chorro Biological Reserve), most recently 2,200 plants in 1993 (Chipping in USFWS 2014); occurrence 10 (Miossi Creek), >1,000 plants in 1997 (CDFW 2016a); and occurrence 12 (near Serpentine Lane), >4,000 plants in 2001 (CDFW 2016a). The greatest estimates for the 15 other occurrences range from 3 to 800 plants.

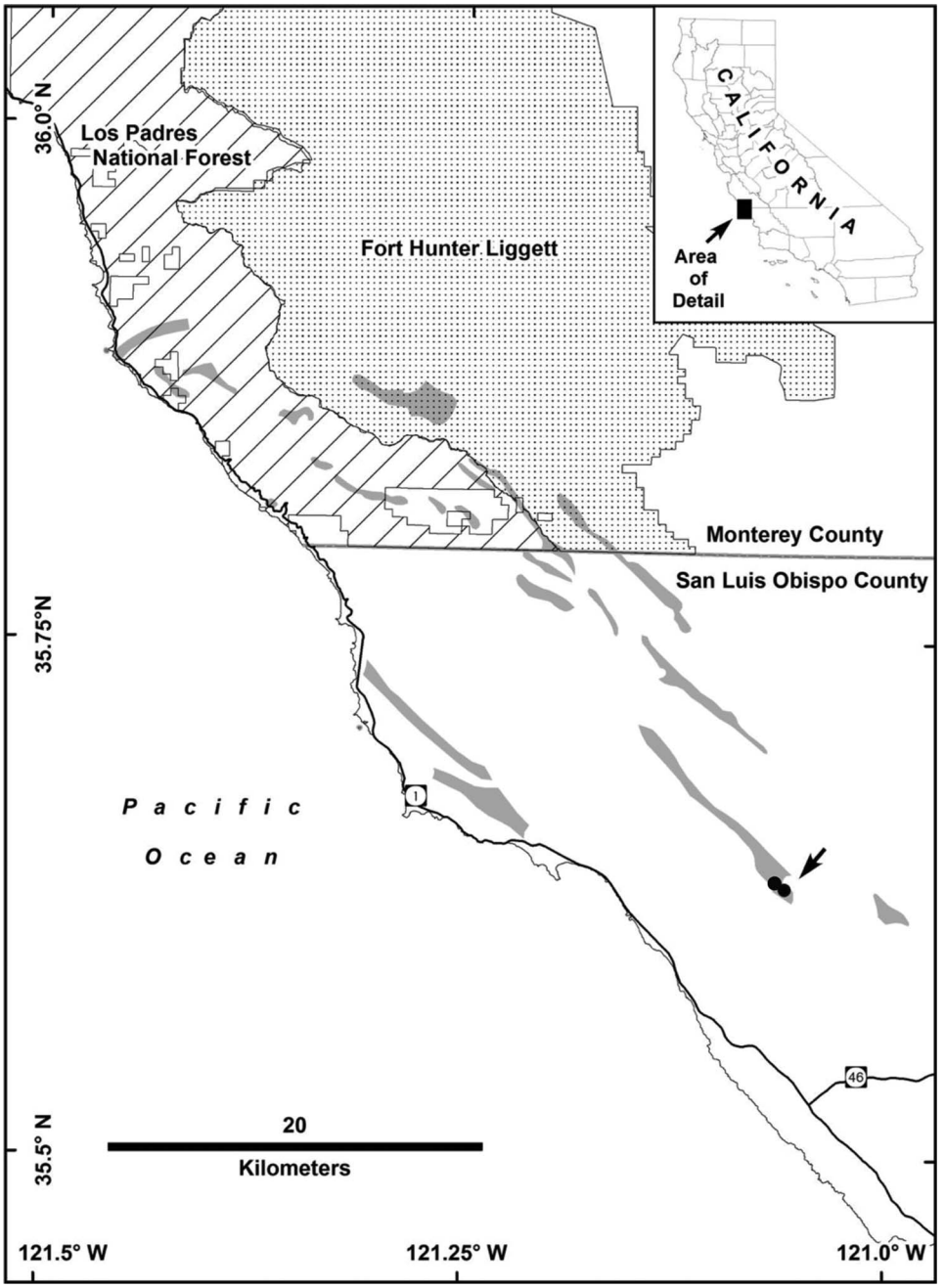

Fig. 4. Serpentine soil and rock (gray shaded areas) in Monterey County, California. Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* inhabits perennial seeps and springs in serpentine soil and rock in western San Luis Obispo County, as currently known. The arrow indicates the two northernmost occurrences near San Simeon Creek. We recommend searching for additional occurrences in Monterey County in potential habitat in the serpentine soil and rock indicated in this map. See also Fig. 2 and 5.

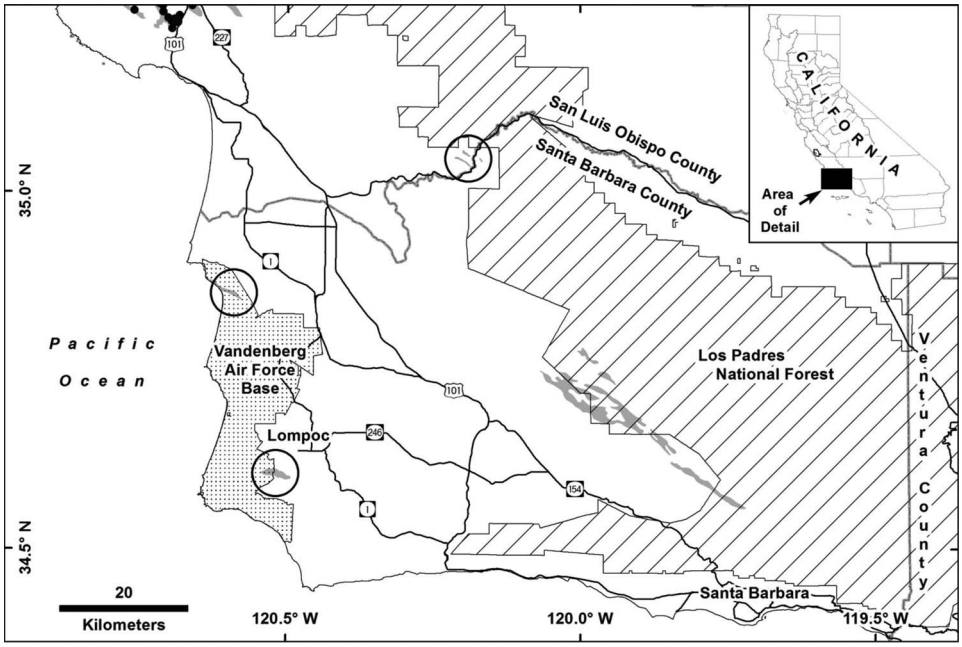

Fig. 5. Serpentine soil and rock (gray shaded areas) in Santa Barbara County, California. Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* inhabits perennial seeps and springs in serpentine soil and rock in western San Luis Obispo County, as currently known. The group of black dots (upper left) indicates the southernmost occurrences in the vicinity of the city of San Luis Obispo. We recommend searching for additional occurrences in Santa Barbara County in potential habitat in the serpentine soil and rock indicated in this map. See also Fig. 2 and 4.

Since 1968 the Eurasian flower-head weevil *Rhinocyllus conicus* has been introduced at multiple locations in North America (Herr 2004) as a biocontrol agent for invasive thistles *Carduus* and *Silybum*, including San Luis Obispo County in 1973 (Goeden et al. 1985) and in particular Camp San Luis Obispo in the early 1980's (California Army National Guard in USFWS 2014). The adult weevils congregate on young thistles in early spring to feed and mate. They lay eggs (mean 192 eggs per female) on developing flower heads into which the subsequent larvae tunnel and feed on. Pupation occurs in the flower head, with adults emerging in midsummer. One generation per year is produced (Zwolfer and Harris 1984). By 2005 the weevil occurred in 26 states and Canada (Dodge 2005), with multiple reports of feeding also on native thistle *Cirsium* (Turner et al. 1987). This weevil was reported feeding on Chorro Creek bog thistle at three occurrences: San Simeon Creek (Herr 2004; Chipping in USFWS 2014;), Laguna Lake Natural Reserve (Herr 2004), and Camp San Luis Obispo (California Army National Guard in USFWS 2014). At San Simeon Creek, 28% of the flower heads were infested throughout the growing season (42% in July 1995), and with 27% (mean) of seeds destroyed in the infested flower heads. Seed loss was 8% of total seed set at the study site (Turner and Herr 1996; Herr 2004; John Herr, U.S. Dept. Agric., Albany, Calif., pers. comm. 2012). Turner and Herr (1996) reported a phenological difference in peak egg laying of the weevil in relation to flower head production of Chorro Creek bog thistle. At Laguna Lake Natural Reserve (Herr 2004), infestation rates were 32% in May (1996) and 5% in July (1995). Magney (USFWS 2014) saw no weevils at Camp San Luis Obispo in September (2005), although the California Army

Table 1. Distribution of Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* in western San Luis Obispo County, California: the primary and secondary watersheds of the 21 known occurrences.

Primary watershed	Secondary watershed	Occurrence
San Simeon Creek		1
	North Fork (some colonies)	18
Chorro Creek		3
		19
	Pennington Creek	6
	San Bernardo Creek	9
	San Luisito Creek	20
San Luis Obispo Creek		13
		21
	Prefumo Creek	2 Laguna Lake
		4
		5
	Froom Creek	7
		8
		14
		15
		16
	Miossi Creek	10
	Reservoir Canyon Creek	11
		17
Los Osos Creek		12

National Guard (USFWS 2014) subsequently observed weevils feeding on Chorro Creek bog thistle in 2012. Lutz (2013) saw no evidence of weevils at Reservoir Canyon Natural Reserve (occurrence 11). In sum, we consider the Eurasian flower-head weevil a threat because it was seasonally destroying a substantial number of seeds at the occurrence where studied.

Regarding cattle grazing in and near the habitat of Chorro Creek bog thistle, herbivory and trampling are the two obvious issues. At Camp San Luis Obispo, cattle grazing caused a substantial decrease in established plants and a substantial increase in juvenile plants (Mardesich and Laughlin in USFW 2014). Along with Chipping (Calif. Polytech. St. Univ., pers. comm. 2012) and Nancy Siepel (Calif. Dept. Transport., San Luis Obispo, pers. comm. 2012) who observed cattle grazing in the vicinity of Chorro Creek bog thistle, we consider the effects of herbivory as minor and not a threat because the spiny plants are generally unpalatable (USFWS 1998). However, trampling can severely damage established plants, especially when water is limited and cattle congregate at the water. In addition, cattle can damage the structure of the riparian area or seep (e.g., damage to streambank by hooves, damage to soil by defecation; Swanson et al. 2015).

The USFWS (2014) identified stochastic events as a threat to Chorro Creek bog thistle. Species with small populations are vulnerable to extinction by stochastic events (Shaffer 1981, Ricklefs 2008). This means that environmental or demographic chance or randomness can cause the population size to fluctuate, and in small populations the fluctuations are more likely to include zero. The 21 occurrences of Chorro Creek bog thistle exist as a metapopulation in a relatively small geographic area (271 km^2), and with only six occurrences reported to contain >1,000 individuals. Therefore, we consider stochastic events an ongoing threat.

Table 2. Approximate numbers of Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* in the 21 known occurrences in western San Luis Obispo County, California.

	Occurrence																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
2016		1718[f]					0[f]	250[f]													
2015													≥200[f]		3[f]	86[f]					
2014			1782[g]																		
2013																	689[e]				
2012							0[f]	800[f]											>100[l]		300[f]
2011		1400[f]			150[f]								500[f]	500[f]		63[f]				>200[m]	
2008			1872[c]																		
2007			762[c]	>200[a]																	
2006		1750[j]	1565[c]																		
2005			1843[h]										300[a]								
2004			1759[h]																		
2003			643[a]																		
2002			3393[a]																		
2001			2792[a]									>4000[a]					270[i]				
2000			4433[a]																		
1999		>2000[a]	4644[a]																		
1998			822[a]																		
1997			1055[a]							>1000[a]											
1996			1782[a]																		
1995			2871[a]																		
1994			1845[a]																		
1993	285[b]	1025[b]	250[c]	557[b]	70[b]	2200[b]		250[b]	500[b]									792[b]			

Table 2. Continued.

	Occurrence																				
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1992	375[b]						10[b]														
1989		100[a]																			
1988	550[a]																				
1987	<150[a]						15[a]	>100[a]			25[k]										
1986	100[d]	1000[d]		150[b]	50[b]	<1000[a]															
1984	>1000[a]			>100[a]																	
1981		1000[a]		30[a]		<1000[a]															

[a] California Department of Fish and Wildlife (2016a).
[b] Chipping (USFWS 2014).
[c] Holland (USFWS 2014).
[d] Friedman (USFWS 2014).
[e] Lutz (2013).
[f] pers. obs.
[g] Merk, pers. comm. 2016.
[h] Magney (USFWS 2014).
[i] Carter (2002).
[j] Elvin (USFWS 2014).
[k] Consortium of California Herbaria (USFWS 2014).
[l] Waldburger, pers. comm. 2012.
[m] Siepel, pers. comm. 2012.

The USFWS (2014) identified climate change as a new threat to the Chorro Creek bog thistle. 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). 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), and it was the most severe drought in California in the past 1,200 y (Griffin and Anchukaitis 2014). Species with small geographic ranges are more vulnerable to climate change (e.g., Foden et al. 2013), and of particular concern are associated extreme weather events. Because Chorro Creek bog thistle is restricted to seeps and springs in serpentine soil and rock, a severe drought could reduce or eliminate its specialized habitat. In consideration of the life history traits used by Anacker et al. (2013), the plant is moderately to highly vulnerable to climate change because of its relatively small geographic range and its soil and habitat specificity.

The conservation status of Chorro Creek bog thistle has improved substantially since listing in 1994 because of an increased number of known occurrences along with an increased number of occurrences that are protected (Table 3). Only two of nine known occurrences were protected in 1994, whereas 10 of 21 occurrences are protected in 2016. Six of the protected occurrences (2, 4, 14, 15, 16, 17) are in natural reserves owned by the City of San Luis Obispo. One protected occurrence (6) is in a biological reserve owned by California Polytechnic State University. One protected occurrence (13) is on a private property with a conservation easement to the City of San Luis Obispo. Also, one occurrence (3) is protected on Camp San Luis Obispo because the California Army National Guard consults with the USFWS regarding its activities as required under the U.S. Endangered Species Act. These nine occurrences are on properties that range in size from 65 to 2,271 ha. In addition, one occurrence (12) is on private property (8.1 ha) with an open-space easement (0.8 ha) to the County of San Luis Obispo, however, we do not know the conservation status or immediate threats.

Regarding the non-protected occurrences of Chorro Creek bog thistle, occurrences 1 and 20 are each on two private properties, and with one of each pair of landowners wishing to conserve the plants. Occurrence 5 is in a roadside drainage ditch above underground lines, and it is at risk by road and utility maintenance. Occurrence 7 (along Froom Creek just below mouth of Froom Canyon) is on private property and near existing development, and potentially at risk from future channelization and residential development. We saw no plants here in 2012 and 2016. Occurrence 8 is on the adjacent private property and at risk from existing development and potentially future residential development. Occurrence 19 is on a property owned by the California Army National Guard, and it is at risk from nearby agriculture by California Polytechnic State University. However, we are communicating with the California Army National Guard and California Polytechnic State University in an effort to gain protection for this occurrence. Occurrence 21 (southeast Irish Hills) is on private property and is presently safe because of its location on a steep rocky slope and away from development. Four additional occurrences (9, 10, 11, 18) are on private properties for which we do not know the conservation status or immediate threats. Because there are potentially many locations with habitat on private properties and public lands that have not been searched, it is highly likely that additional occurrences exist in San Luis Obispo County, and possibly also in Monterey and Santa Barbara Counties.

The U.S. Endangered Species Act and the California Endangered Species Act have little ability to protect the Chorro Creek bog thistle on private property. Invasive plants are a threat or potential threat at five occurrences and native plants at two occurrences. Stochastic events remain a threat to all occurrences. The Eurasian flower-head weevil and climate change with severe drought are newly identified threats. In consideration of the available information, we conclude that Chorro Creek bog thistle is still endangered. However, when using the international

Table 3. Conservation status of the 21 known occurrences of Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* in western San Luis Obispo County, California, in 2016.

Occurrence	Location	Landowner	Protected	Status	Immediate threats
1	San Simeon Creek	two private	no	unknown	water extraction, cattle trampling, Eurasian flower-head weevil[f]
2	Laguna Lake Natural Reserve	City of San Luis Obispo	yes	robust, healthy 2016[a]	invasive plant species
3	tributary of Chorro Creek, Camp San Luis Obispo	Calif. Army Natl. Guard	yes	reduced number 2014[b]	native and invasive plant species
4	four tributaries of Prefumo Creek in Irish Hills Natural Reserve	City of San Luis Obispo	yes	healthy 2012[a]	none
5	drainage ditch along Prefumo Canyon Rd and tributary of Prefumo Creek	County of San Luis Obispo private	no no	at risk[a]	road and utility maintenance
6	East Fork of Pennington Creek, El Chorro Biological Reserve	Calif. Polytech. St. Univ.	yes	healthy 2012[c]	none
7	Froom Creek just below mouth of Froom Canyon	private	no	no plants 2012[a] 2016[a]	near + potential development
8	Seep and tributary of Froom Creek	private	no	at risk 2016[a]	near + potential development
9	tributary of San Bernardo Creek	private	no	unknown	unknown
10	slope above Miossi Creek	private	no	unknown	unknown
11	near Reservoir Canyon Creek and Hampton Creek, location unknown	likely private	no	unknown	unknown
12	near Serpentine Lane, W of Prefumo Canyon	private	legally yes	unknown	unknown
13	slope near Loma Bonita Drive in the city of San Luis Obispo	private w/conservation easement to City of San Luis Obispo	yes	reduced number 2015[a]	none

Table 3. Continued.

Occurrence	Location	Landowner	Protected	Status	Immediate threats
14	tributary of Froom Creek near old mine, central part of Irish Hills Natural Reserve	City of San Luis Obispo	yes	healthy 2011[a]	potentially, invasive plant species
15	tributary of Froom Creek, central part of Irish Hills Natural Reserve	City of San Luis Obispo	yes	at risk 2015[a]	few plants $n = 3$
16	Poppy Spring, central part of Irish Hills Natural Reserve	City of San Luis Obispo	yes	healthy 2015[a]	none
17	Reservoir Canyon Natural Reserve	City of San Luis Obispo	yes	healthy 2013[d]	shade from native trees
18	Cambria Mine near San Simeon Creek	private	no	unknown	development
19	tributary of and along Chorro Creek, SW of confluence with Pennington Creek	Calif. Army Natl. Guard	no	at risk 2015[a]	nearby agriculture
20	seep and spring along a tributary of San Luisito Creek	two private	no	unknown	potentially, invasive plant species[e,g]
21	tributary of San Luis Obispo Creek	private	no	healthy 2012[a]	potentially, invasive plant species

[a] pers. obs.
[b] Merk, pers. comm. 2016.
[c] Chipping, pers.comm. 2012.
[d] Lutz (2013).
[e] Siepel, pers. comm. 2012.
[f] California Department of Fish and Wildlife (2016a).
[g] Schweitzer, pers. comm. 2015.

standards of IUCN (2012, 2014), we assign the category data deficient because of the limitations of our data.

Recommendations

We make the following recommendations to help conserve the Chorro Creek bog thistle. The USFWS with its partners should survey and census all 21 occurrences during one calendar year, and special efforts should be made for gaining access to the relevant private properties (in particular those with occurrences 1, 9, 10, 11, 12 and 18). The relevant land managers and biologists should monitor the occurrences for invasive plants, and the invasive plants should be removed promptly. The relevant land managers should strictly control and monitor any cattle grazing in the habitat of Chorro Creek bog thistle. Strictly-controlled cattle grazing could possibly benefit Chorro Creek bog thistle by reducing other vegetation (invasive and native) and by providing favorable sites for germination of its seeds. However, uncontrolled cattle grazing in the habitat could cause severe damage. The relevant land managers and biologists should be aware that the Eurasian flower-head weevil is a threat to Chorro Creek bog thistle, and they should monitor for and report this invasive insect to USFWS and the San Luis Obispo County Department of Agriculture. Additional occurrences of Chorro Creek bog thistle likely exist in San Luis Obispo County, and possibly also in Monterey and Santa Barbara Counties. Searches should be conducted in habitat with serpentine soil and rock in San Luis Obispo, Monterey and Santa Barbara Counties (Figures 2, 4 and 5).

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Appendix 1

The 21 known occurrences of Chorro Creek bog thistle *Cirsium fontinale* var. *obispoense* in western San Luis Obispo County, California.

Occurrence 1. 35.62530, -121.05453 (CDFW 2016a); 107 m. This occurrence is in springs at the foot of a serpentine landslide in the San Simeon Creek watershed (Chipping in USFWS 2014) in northwest San Luis Obispo County. It is along San Simeon Creek, 0.3 km by road (San Simeon Creek Road) downstream of the confluence of the North and South Forks and with the colonies on two private properties (Chipping in USFWS 2014; 12 ha; 5 ha). We viewed images of the properties using Google Earth (dated 2 April 2015) on 23 August 2016, and both were partially developed: one with an avocado farm and clearings, and the other with a house, garage, carport and barn. Both properties are zoned for agriculture. More than 1,000 plants were reported in 1984, and 285 plants in 1993, which is the most recent information (Chipping in USFWS 2014). In the early 1990's the Nature Conservancy assisted the private landowners with fencing to protect some colonies, and one private landowner is protecting the plants under a voluntary agreement (CDFW 2016a). Road maintenance, water diversions and cattle were potential threats in the 1990's (Chipping in USFWS 2014; Wikler and Morey in USFWS 2014). The CDFW (2016a) record states that introduced weevils are heavily infesting the flower heads, water is being extracted from the seep, and cattle are trampling the plants. Chipping (USFWS 2014) referred to this site as the San Simeon "Bianchi" complex. Up until 2014 this occurrence also included six sites to the west on the adjacent private property, which subsequently became occurrence 18 (Cambria Mine near San Simeon Creek; CDFW 2016a) because the separating distance is >0.4 km.

Occurrence 2. 35.266453, -120.682235; 35.266862, -120.682499; 35.266922, -120.682589; 35.267021, -120.682793; 35.267148, -120.683091; 35.268814, -120.684751; 35.269886, -120.683706; 35.270353, -120.684086; 35.270658, -120.683897; 53 to 85 m (pers. obs.). This occurrence is in Laguna Lake Natural Reserve (152 ha) on land owned by the City of San Luis Obispo. The Chorro Creek bog thistle are in 14 seeps spanning 635 m on a hillslope 340 m east of Laguna Lake. Most colonies are enclosed by fences, although some colonies are expanding beyond the fences and into the landscape that is subject to controlled grazing by horses and cattle for fuel reduction. Some fences are collapsing in 2016. More than 2,000 plants were recorded in 1999 (CDWF 2016a). Although the serpentine substrate is not conducive for most invasive species (Harrison et al. 2006), pampas grass *Cortaderia* became established in the habitat (and competed with Chorro Creek bog thistle), which we and the County of San Luis Obispo removed in 2010. In 2016 and after 4 y of drought, the occurrence appeared healthy and robust with 1,716 plants. However, at one particular seep (lower down the hillslope and with more soil) the colony had disappeared, and invasive species (bull thistle *Cirsium vulgare*, rye grass *Festuca*,vervain *Verbena*) predominated. We identify this seep (35.268814, -120.684751) for a needed restoration effort. Otherwise, invasive plants were under control in 2016 and with a noteable absence of pampas grass. This occurrence is protected. We and the City of San Luis Obispo monitor irregularly and informally.

Occurrence 3. 35.34302, -120.68178; 244 m (CDFW 2016a). This occurrence is at seeps adjacent to a tributary of Chorro Creek (0.8 km northeast of Chorro Reservoir) on Camp San Luis Obispo (2271 ha), which is owned by the California Army National Guard. It is protected because the California Army National Guard consults with the USFWS (e.g., USFWS 1997, 2015) regarding its actions on the installation that may affect federally listed species, as required by the U.S. Endangered Species Act. The California Army National Guard conducted annual and formal monitoring from 1994 to 2008, then irregular and informal monitoring from 2009 to 2013, and then formal monitoring in 2014 (Merk, pers. comm. 2016). This occurrence has experienced substantial annual variation in numbers of reported plants, ranging from 250 (1993) to 4,644 (1999) individuals (Holland in USFWS 2014, CDFW 2016a). We suspect that the lowest numbers reflect relatively less survey effort. Merk (pers. comm. 2016) recorded 1,782 plants in 2014 during the most recent census. The USFWS (1997) issued a biological opinion for controlled cattle grazing because several species of native (spikerush *Eleocharis macrostachya*, bulrush *Scirpus*) and invasive plants (rye grass) were becoming dense in the habitat. Although controlled grazing from 15 April to 14 May 1998 removed <5% of vegetation, the total number of Chorro Creek bog thistle increased 68% following the disturbance. Juvenile plants increased 727% (Mardesich and Laughlin in USFWS 2014), but established plants decreased. Later in 2006, Magney (USFWS 2014) reported that invasive prickly sow thistle *Sonchus asper* had invaded the habitat and was being removed. In 2012 the occurrence was threatened by dense vegetation in and near the habitat, including native (salt grass *Distichlis spicata,* spikerush) and invasive species (purple star-thistle *Centaurea calcitrapa*, bristly ox-tongue *Helminthotheca echioides*, prickly sow thistle; Jody Olson, Camp San Luis Obispo, pers. comm. 2012). In 2014, Merk (pers. comm. 2016) observed excessive accumulation of thatch, especially from native species (spikerush, sneezeweed, *Helenium* sp., salt grass). To manage thatch and potentially competitive plants in and near the habitat, the California Army National Guard (USFWS 2015) intends to conduct controlled cattle grazing during fall from 1 September to 15 October. Cattle grazing could possibly benefit Chorro Creek bog thistle by reducing potentially competitive plants in and near the habitat, and by providing favorable

sites for germination of seeds (Bransfield in USFWS 2014; California Army National Guard in USFWS 2014). However, cattle grazing in and near the habitat must be strictly controlled and monitored to achieve benefits and to minimize adverse effects (USFWS 2015).

Occurrence 4. 72 to 96 m (pers. obs.). This occurrence is at the northern edge of Irish Hills Natural Reserve (south of Prefumo Canyon Road; 381 ha), which is owned by the City of San Luis Obispo. The colonies are in four tributaries of Prefumo Creek: a waterfall (35.263558, -120.715975) and the creek above for ≥500 m (Chipping in USFWS 2014), two nearby gullies to the southeast (150 m and 250 m distance; 5.263206, -120.714431; 35.26265, -120.713492), and another creek further to the southeast along the Bog Thistle Nature Trail (1 km southeast of the waterfall; 35.261344, -120.711639; pers. obs.). Chipping (USFWS 2014) recorded 557 plants in 1993. This occurrence is protected. We and the City of San Luis Obispo monitor irregularly and informally. In addition, the City of San Luis Obispo has placed interpretive signs along the nature trail, and it conducts guided hikes that include viewing the Chorro Creek bog thistle in its habitat.

Occurrence 5. 35.264806, -120.721775; 88 m (pers. obs.). This occurrence is 547 m northwest of the waterfall in occurrence 4. The plants are mostly in the drainage ditch along the south side of Prefumo Canyon Road, which is owned by the County of San Luis Obispo, and also in a steep tributary of Prefumo Creek on the adjacent private land (42 ha). Additional colonies may exist further upstream along the precipitous, rocky slope, which is covered with dense chaparral vegetation. Numbers of reported plants were 150 in 2011 (pers. obs.), and previously 70 in 1993, and 50 in 1986 (Chipping in USFWS 2014). In 2011 a sign among the plants in the drainage ditch identified underground lines (pers. obs.). The plants in the drainage ditch are threatened by road and utility maintenance. Although this occurrence is not protected, the County of San Luis Obispo intends to manage in consideration of the endangered plants (Kate Ballantyne, County of San Luis Obispo, pers comm. 2016). We monitor irregularly and informally.

Occurrence 6. 35.36213, -120.70998; 335 m (CDFW 2016a). This occurrence is along the east fork of Pennington Creek in the El Chorro Biological Reserve (81 ha), which is owned by California Polytechnic State University. It is 1.0 to 1.4 km west of Whiskey Spring, which is near the headwaters of Pennington Creek. In 2012 the occurrence was in "good shape" (Chipping, pers. comm. 2012). Numbers of reported plants were 2,200 in 1993 (Chipping in USFWS 2014), and <1,000 in 1986 and 1981 (CDFW 2016a). This occurrence is protected from cattle grazing, development, water diversions and road maintenance. California Polytechnic State University monitors irregularly and informally.

Occurrence 7. 35.24805, -120.68683 (Chipping in CDFW 2016a; pers. obs.); 38 m. This occurrence is along Froom Creek just below the mouth of Froom Canyon on flat land on one private property (14 ha). It is adjacent to and east of Irish Hills Natural Reserve. CDFW (2016a) has a record of 15 plants in 1987, and Chipping (USFWS 2014) reported 10 plants in 1992. We saw no plants in 2012 and 2016, however, we have seen scattered individuals upstream. The landscape here is especially dry and without a perennial seep or spring. We viewed images of the property using Google Earth (dated 2 April 2015) on 23 August 2016. At least six buildings occupy the property, and it is greatly disturbed by vehicles including bulldozers and graders. The stream bed is next to a dirt road. The property is zoned for commercial retail and agriculture, and the City of San Luis Obispo is considering annexation of the property for residential development.

Occurrence 8. 39 to 64 m; (pers. obs.). This occurrence is at a seep and two tributaries of Froom Creek on one private property (30 ha) adjacent to and east of Irish Hills Natural Reserve. Chipping (USFWS 2014) recorded 250 plants at three locations in 1993, which he referred to as Froom Ranch South, Froom Ranch North Spring and Froom Ranch Gully Confluence. In 2016 we observed 50 plants at Froom Ranch South (35.242601, -120.688929), 200 plants at Froom Ranch North Spring (35.243755, -120.689998) and 0 plants at Froom Ranch Gully Confluence (35.244093, -120.687286). Previously in 2012 we observed 500, 300 and 0 plants, respectively, at the three sites. We viewed images of the property using Google Earth (dated 2 April 2015) on 23 August 2016. Although the property is undeveloped, the location of Froom Ranch South is 54 m downslope of a dirt road and a building on the adjacent private property. The property with occurrence 8 and the adjacent private property are zoned for agriculture and as rural lands. The City of San Luis Obispo is considering annexation of the property with occurrence 8 for residential development.

Occurrence 9. 35.40309, -120.74930; 302 m (Chipping in CDFW 2016a). This occurrence is at seeps and springs along a tributary of San Bernardo Creek on one private property (297 ha), 1.6 to 2.1 km southwest of Cerro Alto Peak. The Chorro Creek bog thistle are in bogs near an inactive, open-pit chromite mine and other excavations. Chipping (USFWS 2014) is the primary source of information, who recorded 500 plants and heavy grazing in the bogs. We viewed images of the property using Google Earth (dated 2 April 2015) on 26 August 2016, and it was mostly undeveloped with exception of mined areas (10%). The property is zoned for agriculture. Based on similar geology and landscape, Chipping (USFWS 2014) surmised that additional occurrences likely

exist nearby to the east, including a "probable site" on two private properties 1.3 km to the southeast along a tributary of San Bernardo Creek.

Occurrence 10. 35.30310, -120.64356; 171 m (CDFW 2016a). This occurrence is in seeps and springs on a northeast slope above Miossi Creek (a tributary of San Luis Obispo Creek) on one private property (141 ha) that is 0.4 km east of California Polytechnic State University and 0.8 km north of Cuesta Canyon County Park. The primary source of information is a report dated 1997 (CDFW 2016a) with observation of >1,000 plants along with cattle in the habitat. We viewed images of the property using Google Earth (dated 2 April 2015) on 20 September 2016, and it was undeveloped. The property is zoned for agriculture. Based upon apparently similar landscape features, there is high potential for additional colonies and occurrences on the adjacent and nearby undeveloped properties.

Occurrence 11. ≈35.27573, -120.60414 (CDFW 2016a). This "lost" occurrence is known from only two specimens collected in 1987 (Consortium of California Herbaria in USFWS 2014): "on S slope of Reservoir Canyon, 1/8 mi SE of Reservoir and Hampton Cr. junction, Reservoir Rd., 1 mi. N of San Luis Obispo off Hwy 101. 280 m." Approximately 25 individuals were observed in a spring on a north facing slope in 1987. Nic Huber (USFWS, Ventura, pers. comm. 2011) searched for the occurrence in the Reservoir Canyon Natural Reserve in 2006 but without success. The collector (Brad Penkala, Santa Barbara, pers. comm. 2012) was unable to provide any additional details. We suspect the occurrence is likely on a private property.

Occurrence 12. 35.256738, -120.765841; 318 m (our determination). This occurrence is at three seeps on one private property (8.1 ha; LynneDee Althouse, Paso Robles, pers. comm. 2012 [CDFW 2016a is incorrect] near the junction of Serpentine Lane and Prefumo Canyon Road (6 km west of the city of San Luis Obispo), with a small open-space easement (three parcels, 0.8 ha) to the County of San Luis Obispo. Specifically, the occurrence is north of benchmark 1336, north side of Prefumo Canyon Road, and west of Prefumo Canyon. It is the only occurrence in the Los Osos Creek watershed and at its headwaters. Some colonies are on the north part of the property near the boundary with the adjacent private property (Althouse, pers. comm. 2012), and some colonies are on the southern half of the property according to records of the County of San Luis Obispo. We viewed images of the property using Google Earth (dated 2 April 2015) on 20 September 2016. It was mostly undeveloped, and with one building in its southwest corner. We suspect that Chorro Creek bog thistle likely occurs also on the two private properties immediately north and east because of seemingly similar landform and geology. The property with the occurrence is zoned as rural lands. Althouse (CDFW 2016a) recorded >4,000 plants in 2001, and the occurrence has not been visited by a biologist since then.

Occurrence 13. 35.26189, -120.66533; 75 m (pers. obs.). This occurrence is on one private property (16 ha), 60 m northeast of Loma Bonita Drive in the central part of the city of San Luis Obispo (the urban area) with a conservation easement to the City of San Luis Obispo (the local government). Although the property is used for cattle grazing, trampling is not a threat because the plants are at a seep on a steep, rocky slope. We and the City of San Luis Obispo monitor irregularly and informally, and it has authority to conduct management activities. We found this occurrence in 2005 at which time we estimated 300 plants. In 2011 the colonies appeared healthy with 500 plants. In 2015 and after several years of drought we observed at least 200 plants, which is a reduced number. Chipping (USFWS 2014) searched this area in 1993 and saw no Chorro Creek bog thistle. We viewed images of the property using Google Earth (dated 2 April 2015) on 25 August 2016, and it was undeveloped with exception of communication facilities on 0.5 ha. The property is zoned for conservation/open space. It is west of and adjacent to South Hills Open Space (20 ha), which is owned by the City of San Luis Obispo, and another private property with an open-space easement (29 ha) to the City of San Luis Obispo. The combined total area for conservation/open space of the three contiguous properties is 65 ha. This occurrence is protected.

Occurrence 14. 35.24435, -120.70457; 267 m (pers. obs.). We found this occurrence along a tributary of Froom Creek near an old mine in the central part of Irish Hills Natural Reserve, and we estimated at least 500 plants in 2011. Pampas grass was in the habitat, which we removed in 2010 and 2011. We and the City of San Luis Obispo monitor irregularly and informally. This occurrence is protected.

Occurrence 15. 35.25044, -120.70581; 189 m (pers. obs.). We found this very small occurrence in 2011 along a tributary of Froom Creek (120 m south of Froom Creek;) in the central part of Irish Hills Natural Reserve. In 2015 we counted three plants along a 200-m stretch of stream with little to no soil and debris in the stream bed likely due to large stormflows. The location is in steep terrain on a hillslope with dense chaparral vegetation. We suspect that a source population exists nearby upstream where the hillslope is less steep, and this should be investigated. We and the City of San Luis Obispo monitor irregularly and informally. This occurrence is protected.

Occurrence 16. 35.25262, -120.71388; 207 m (pers. obs.). We found this occurrence in 2011 at Poppy Spring (50 m from Froom Creek) in the central part of Irish Hills Natural Reserve. In 2015 and after several years of

drought, we estimated 86 plants and at which time the occupied area comprised 13 m x 0.5 m along a small stretch of stream. In 2011 we estimated 63 plants. We and the City of San Luis Obispo monitor irregularly and informally. This occurrence is protected.

Occurrence 17. 35.278584, -120.621042; 318 to 380 m (Lutz 2013). This occurrence is on a north-facing slope in a steep canyon immediately east of the city of San Luis Obispo in Reservoir Canyon Natural Reserve (210 ha). It comprises four colonies in a seep and tributary of Reservoir Canyon Creek (Carter 2002, Lutz 2013), which is a tributary of San Luis Obispo Creek. Carter (2002) observed 270 plants in 2001 and a patchy overstory (California bay *Umbellularia californica,* Brewer's willow *Salix breweri*). Lutz (2013) counted 689 plants in 2013 along 131m of stream with an extensive overstory (Brewer's willow, California bay, California coffee berry *Frangula californica*, toyon *Heteromeles arbutifolia*) and shade that appeared to be adversely impacting Chorro Creek bog thistle. He trimmed part of the overstory, and the City of San Luis Obispo is monitoring for effects. This occurrence is protected.

Occurrence 18. 239 to 313 m (Chipping in USFWS 2014). This occurrence (Cambria Mine near San Simeon Creek) was separated out of occurrence 1 in 2014. It is 1.1 km west of occurrence 1 on an adjacent private property (167 ha) in a rural area zoned for agriculture. The occurrence is based upon field survey records in 1988, 1989, 1991 (CDFW 2016a) and 1993 (Chipping in USFWS 2014). Chipping (USFWS 2014) reported 792 plants in 1993 and colonies at six sites in springs and bogs, which he designated as A Upper Spring Site (35.629594, -121.065679), B North Roadside Spring (35.630918, -121.066138), C Stock Pond (35.634259, -121.062773), D Stock Reservoir (35.633339, -121.062740), E Big Seep (35.633228, -121.064237), and F Cambria Mine Site (35.628308, -121.066337). Chipping (USFWS 2014) observed cattle in the habitat, and also weevils in the flowers of Chorro Creek bog thistle that he suspected were Eurasian flower-head weevils. We viewed images of the property using Google Earth (dated 2 April 2015) on 23 August 2016. Although the property is mostly undeveloped, it contains a house, a garage, a barn, four parking areas, an orchard and two areas for livestock. Further, D Stock Reservoir has been replaced with a lake (0.4 ha), and it appears likely that the colonies reported here no longer exist. This occurrence is at risk from development, water diversions and cattle grazing.

Occurrence 19. 35.324094, -120.753916; 63 m (Peter Waldburger, Camp San Luis Obispo, pers. comm. 2012). This occurrence is at a seep and tributary of Chorro Creek on a hillslope immediately southwest of the confluence of Pennington Creek and Chorro Creek. The property (18 ha) is owned by the California Army National Guard as part of Camp San Luis Obispo, and it is zoned for agriculture. In January 2012 the colony comprised >100 plants and appeared "healthy" when viewed across a fence line and with no evidence of cattle grazing (Waldburger, pers. comm. 2012). David Keil (Calif. Polytech. St. Univ., pers. comm. 2012) previously observed Chorro Creek bog thistle in this vicinity along Chorro Creek. Chipping (USFWS 2014) had searched this area in 1993 and found no plants. We viewed images of the property with the occurrence using Google Earth (dated 2 April 2015) on 8 August 2016, and it was mostly undeveloped. However, a small area (0.6 ha) of the property on the north side of Chorro Creek had row crops, and likewise the adjacent property to the north that is owned by California Polytechnic State University. This agriculture is in close proximity to any Chorro Creek bog thistle in Chorro Creek and is not compatible with its survival. We are communicating with the California Army National Guard and California Polytechnic State University and seeking protection for this occurrence.

Occurrence 20. 35.370836, -120.779905; 103 m (Siepel, pers. comm. 2012); 35.372239, -120.778903; 125 m (Jake Schweitzer, Berkeley, Calif., pers. comm. 2016). This occurrence is at a seep and along a tributary of San Luisito Creek on two private properties (129 ha; 150 ha) that are north of Chorro Creek and in its watershed. Siepel (pers. comm. 2012) visited one property several times and estimated 200 individuals in July 2011. She stated that the plants there were "doing well" and appeared stable at the perennial seep and spring. The landowners identified the plants on this property in 2000. They wish to conserve the plants, and they monitor irregularly and informally. Light, controlled cattle grazing occurs in and near the habitat, which appears to benefit Chorro Creek bog thistle by reducing invasive plants (Siepel, pers. comm. 2012). Invasive species included poison hemlock *Conium maculatum* in the habitat and purple star-thistle nearby, which the landowners were attempting to eradicate. Schweitzer (pers. comm. 2016) visited the other property twice in 2015. He estimated 40 Chorro Creek bog thistle along 14 m of stream, and he also observed plants across the fence line on the adjacent property. Schweitzer saw evidence of light cattle grazing in the habitat, and he removed several bull thistle that were growing in the habitat. We viewed images of the two properties using Google Earth (dated 2 April 2015) on 20 September 2016, and they were undeveloped. The two groups of Chorro Creek bog thistle are separated by 170 m. The two properties are zoned for agriculture. The Chorro Creek bog thistle on the former property are presently safe from destructive cattle grazing, development, water diversions and road maintenance, while the plants on the latter property are at risk. Based upon apparently similar landscape features, there is high potential for additional colonies and occurrences on the nearby undeveloped properties.

Occurrence 21. 35.239909, -120.699012; 179 m (pers. obs.). We found this occurrence at a seep and small stream (a tributary of San Luis Obispo Creek) on a steep hillslope on private property (89 ha) between Irish Hills Natural Reserve and Johnson Ranch Open Space. We recorded 300 plants in 2012. Although cattle grazing occurs on the property, the location with Chorro Creek bog thistle is not accessible. Pampas grass was growing near the habitat in 2012, which we and the City of San Luis Obispo removed. We are not aware of any additional threats. We viewed images of the property using Google Earth (dated 2 April 2015) on 24 August 2016, and it was undeveloped with exception of a winery (2 ha) 1.1 km downslope at the property boundary. This is the southernmost occurrence of the Chorro Creek bog thistle.