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Christopher P. Kofron

U.S. Fish and Wildlife Service, Ventura, chris.kofron@charter.net

Connie Rutherford

U.S. Fish and Wildlife Service, Ventura, connie_rutherford@fws.gov

Lisa E. Andreano

California Department of Parks and Recreation, San Simeon, lisa.andreano@parks.ca.gov

Michael J. Walgren

California Department of Parks and Recreation, San Simeon, mike.walgren@parks.ca.gov

Heather Schneider

Santa Barbara Botanic Garden, hschneider@sbbg.org

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Status of the Endangered Indian Knob Mountainbalm *Eriodictyon altissimum* (Namaceae) in Central Coastal California

Christopher P. Kofron,^{1*} Connie Rutherford,¹ Lisa E. Andreano,²
Michael J. Walgren,² and Heather Schneider³

¹*U.S. Fish and Wildlife Service, 2493 Portola Road, Suite B, Ventura, CA 93003*

²*California Department of Parks and Recreation, 750 Hearst Castle Road,
San Simeon, CA 93452*

³*Santa Barbara Botanic Garden, 1212 Mission Canyon Road, Santa Barbara,
CA 93105*

Abstract.—Indian Knob Mountainbalm *Eriodictyon altissimum* (Namaceae) is a shrub endemic to western San Luis Obispo County in central coastal California, and little has been published regarding it. The species was listed as endangered under the California Endangered Species Act in 1979 and the U.S. Endangered Species Act in 1995. At Federal listing in 1995, Indian Knob mountainbalm was known from six occurrences, two of which were in protected areas, with a total population estimate of <600 individuals. As of 2019, Indian Knob mountainbalm is known from seven occurrences, six of which are in protected areas and one (the largest) mostly in a protected area, with a total population count of 6,489+ individuals in 2016. Two occurrences are likely extirpated. Indian Knob mountainbalm is considered a fire-adapted chaparral plant. Reproduction is reported to be primarily vegetative by underground rhizomes, and it is specialized for substrates with physical disturbances, including: steep rocky slopes, cliff faces, fallen rock debris, sand dunes (shifting sand), roadsides, old graded substrates such as dirt/rock roads, the talus of graded substrates, and trails. We report the species grows up to 5.5 m tall and at 98 to 263 m elevation. In consideration of the life history traits used by Anacker et al. (2013) for rare plants in California, Indian Knob mountainbalm would be considered highly vulnerable to climate change. Using the international standards of IUCN, Indian Knob mountainbalm meets the criteria for classification as endangered including the following: geographic range, fragmented; extent of occurrence, 34 km² (<100 km²); area of occupancy, <2.3 km² (<10 km²); and quality of habitat, continuing to decline (dense vegetation, lack of recent fire). Coordinated conservation and research are needed to further understand the species, and to restore and maintain the five extant occurrences.

Indian Knob mountainbalm *Eriodictyon altissimum* (Namaceae, Luebert et al. 2016; Fig. 1) is a shrub endemic to western San Luis Obispo County in central coastal California (Fig. 2). The species was listed as endangered under the California Endangered Species Act in 1979 (CDFW 2016) and the U.S. Endangered Species Act in 1995 (USFWS 1994). It is recognized also as a 1B.1 rare plant (seriously threatened) by the California

* Corresponding author: chris_kofron@fws.gov



Fig. 1. Left: A tall individual of Indian Knob mountainbalm *Eriodictyon altissimum* with flowers in Morro Dunes Ecological Reserve East in Los Osos, San Luis Obispo County, California (occurrence 6), 20 April 2016. Right: An extraordinarily tall individual of Indian Knob mountainbalm rising above the mature chaparral comprised predominantly of Santa Margarita manzanita *Arctostaphylos pilosula* at Baron Canyon Ranch Estates (previously occurrence 7, now part of occurrence 5), San Luis Obispo County, California, 27 July 2016. The foreground is recently cleared and graded. Brandon Sanderson of California Department of Fish and Wildlife is 1.88 m tall. By extrapolation, the individual of Indian Knob mountainbalm is determined to be ~5.5 m tall.

Native Plant Society¹. At Federal listing in 1995, Indian Knob mountainbalm was known from six occurrences, two of which were in protected areas, with a total population estimate of <600 individuals (USFWS 1994). Five of the occurrences were small and reported to each comprise <50 individuals, and the largest occurrence on the private Guidetti Ranch was reported to comprise <350 individuals (USFWS 1994). Three of these occurrences were on private properties, two were on land owned by the State of California

¹ California Native Plant Society. 2018. *Eriodictyon altissimum*. In: Inventory of rare and endangered plants of California. Available (July 2018): <http://www.rareplants.cnps.org/detail/623.html>.

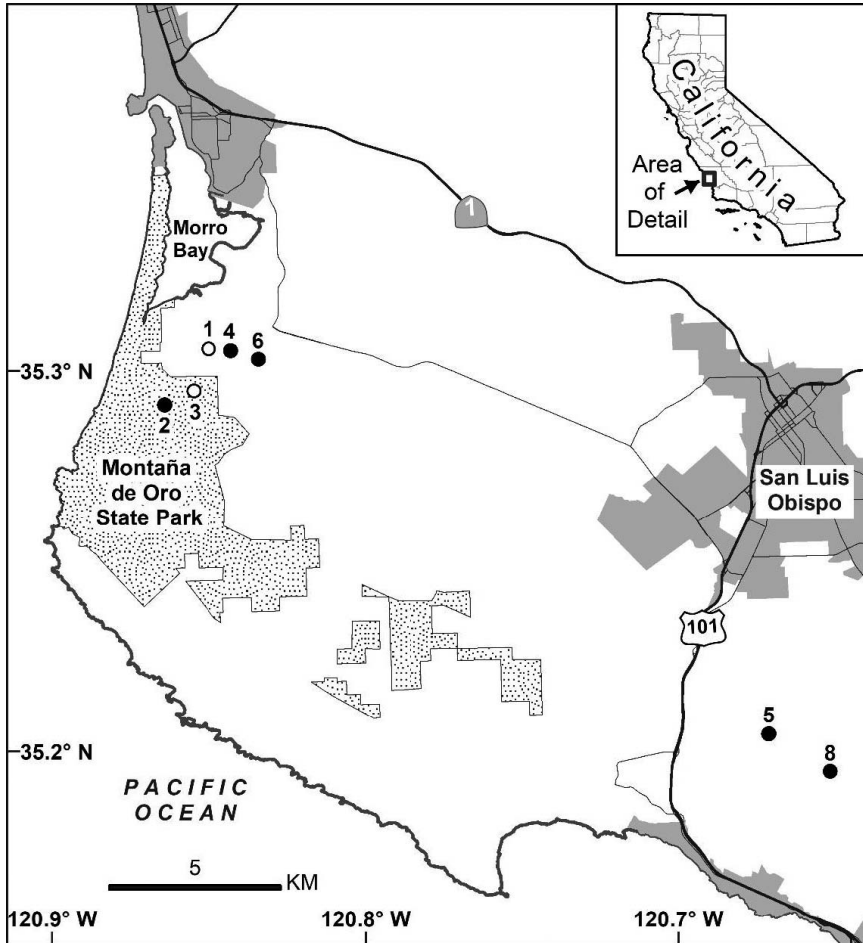


Fig. 2. The known geographic distribution of Indian Knob mountainbalm *Eriodictyon altissimum* in western San Luis Obispo County in central coastal California. Each occurrence is indicated by a black dot (extant) or black circle (likely extirpated) with the number assigned by the California Natural Diversity Database. Occurrence 8 is new.

(Montaña de Oro State Park), and one was on land owned by the County of San Luis Obispo and used for wastewater treatment. The primary threat at the time of listing was habitat loss as a result of potential development (USFWS 1994), specifically potential surface mining at the largest occurrence on Indian Knob mountain, and potential residential development at two small occurrences in Los Osos. Our purpose is to review and enhance the knowledge of Indian Knob mountainbalm, in particular its distribution, ecology, abundance, threats, management and conservation status in 2019. Herein we present the first comprehensive survey and census of the species throughout its geographic range.

Materials and Methods

Little has been published regarding Indian Knob mountainbalm (but see Wells 1962; Carlquist et al. 1983; Hannan 2012). We use our newly-collected data, along with the sparse

published literature, information in the California Natural Diversity Database (CDFG 2006; CDFW 2017), unpublished reports and other documents in files of the USFWS to provide a status review of the species. We searched for Indian Knob mountainbalm, and censused and mapped the known occurrences in 2016, 2017 and 2018. Our searches included nearby and potential habitat, and we state the specific dates of our searches in Appendix 1. In accordance with IUCN (2014) recommended guidelines for colonial and modular organisms, we counted the numbers of stems (including ramets) of Indian Knob mountainbalm as we walked along the trails and through the open areas at each known occurrence. In addition, at previous occurrence 7 (Baron Canyon Ranch Estates, now part of occurrence 5), we used binoculars to count the number of stems in the distance rising above the vegetation canopy, and we also counted the number of stems along the primary ridge road (Balm Ridge Way) as we drove slowly on it (due to time limitation). In order to determine potential pollinators, we opportunistically collected insects inside the corolla tubes of flowers of Indian Knob mountainbalm during April and May 2016. We measured the stem height and basal diameter of several extraordinarily large individuals that were accessible to us. Using all available information, we summarize the body of knowledge of Indian Knob mountainbalm, including its distribution, known occurrences, ecology, abundance, threats, management and conservation status in 2019. We considered a location with the species as a separate occurrence if it was >0.4 km from the nearest occurrence (CDFG 2011). Latitude, longitude and elevation were determined with a global positioning system (GPS) device in the field, or they were determined using Google Earth aerial imagery. Common and Latin names of plants follow Baldwin et al. (2012). Stated areas (ha) of properties are from records of the County of San Luis Obispo. In Appendix 1, we discuss each occurrence in sequence according to its assigned number in the California Natural Diversity Database (CDFG 2006; CDFW 2017). Thus, there may be no numerical sequence for neighboring occurrences. Our stated numbers of plants are the numbers that we recorded but they should be considered best approximates due to the counting methods and difficult landscapes, and in this context we refer to plants, individuals and stems interchangeably. 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

Review of Indian Knob Mountainbalm.—Indian Knob mountainbalm is one of 11 species (plus additional subspecies and varieties) in the genus *Eriodictyon* that occurs in southwest United States and Mexico (Hannan 2012). It is a diffusely-branched, evergreen shrub with a main stem, long narrow leaves (5 to 9 cm by 2 to 4 mm), and lavender bell-shaped flowers (11 to 16 mm long; USFWS 1998; Hannan 2012; Fig. 3). The species possesses underground rhizomes and aboveground stems. Although reported heights of stems are up to 4 m and basal stem diameters up to 12 cm (Wells 1962; CDFG 2005; Hannan 2012), we observed one individual that was ~ 5.5 m tall (Fig. 1) and another individual with basal stem diameter of ~ 20 cm. Individuals just several centimeters tall are capable of producing flowers (Fig. 3). We collected a total of 56 insects inside the corolla tubes of flowers of Indian Knob mountainbalm, with ants (43%) and beetles (23%) comprising 66% of the sample. The insect species were diverse and included 24 ants (individuals), 13 beetles, 8 bumblebees, 6 flies (5 bee flies + 1 other fly), 4 butterflies, and 1 aphid. These data indicate that Indian Knob mountainbalm receives many floral visitors but it is unknown which are effective pollinators.



Fig. 3. Upper: Flowers of Indian Knob mountainbalm *Eriodictyon altissimum* on a tall individual, southwest Guidetti Ranch, San Luis Obispo County, California (occurrence 5), 4 May 2016. Lower: An individual of Indian Knob mountainbalm that is only several centimeters tall and with flowers at southwest Guidetti Ranch (occurrence 5), San Luis Obispo County, California, 5 May 2016.

Wells (1962) described Indian Knob mountainbalm as rapidly growing and short lived, although USFWS (1998) considered the species long lived in light of the slow growing lichens on some individuals. We and Dr. Jon Keeley (U.S. Geological Survey) examined the growth rings in the dead stems of several large individuals. Despite wood rot destruction, one individual had >50 visible growth rings. Although we do not know if one growth ring equates to 1 yr, J. Keeley (pers. comm. 2018) speculated the stems were >50 yr of age. Carlquist and Eckhart (1984) reported that the underground rhizomes of *Eriodictyon* are the more permanent parts of the plant, and they may be older than the aboveground stems.

Indian Knob mountainbalm is a pioneer, early successional or edge species in chaparral communities. At Indian Knob, Wells (1962) referred to it as a pioneer species that is “aggressive on roadsides with numerous young plants invading such disturbed sites.” CDFW (2017) summarized the habitat as ridges in open disturbed areas within chaparral on sandstone and shale, and openings in chaparral on stabilized sand dunes. Specifically, we observed the species on sandstone and sand, including steep rocky slopes, cliff faces, fallen rock debris, sand dunes, roadsides, old graded substrates such as dirt/rock roads, the talus of graded substrates, and trails. In particular, we did not observe the species on shale at any occurrence.

Although Indian Knob mountainbalm is considered to be fire-adapted (Wells 1962; USFWS 1994, 1998, 2013b; CDFG 2005), there is no direct evidence because of the absence of recent fire at the known occurrences. However, in general, establishment of seedlings of chaparral plants is abundant after fire but uncommon under mature chaparral (Keeley 1984). Reproduction of Indian Knob mountainbalm is believed to be primarily vegetative by underground rhizomes (USFWS 1994, 1998, 2013b; CDFG 2005; Fig. 4), although there is no direct evidence to support this. Because little is published about Indian Knob mountainbalm, information is frequently extrapolated from what is known about other species in the genus, such as Lompoc yerba santa *E. capitatum* and California yerba santa *E. californicum*. Lompoc yerba santa, which occurs in Santa Barbara County, is self-incompatible, meaning that pollen from genetically different plants is needed to produce seeds (Elam 1994). This species exhibits low seed production, which is attributed to the combined effects of self-incompatibility and some single-clone populations (Elam 1994). Likewise, Indian Knob mountainbalm is expected to be self-incompatible². California yerba santa is a fire-following species. Seeds stored in the soil for decades germinate readily during the first spring after a fire, and new stems sprout from underground rhizomes following disturbances such as fire (Immel 2006). Further, in the absence of fire to cue seed germination, *Eriodictyon* species most often reproduce vegetatively by rhizomes (USFWS 2013b). Carlquist et al. (1983) described species in the genus *Eriodictyon* as resistant to fire and drought because of their morphology composed of underground rhizomes and aboveground stems. They reported Indian Knob mountainbalm to be adapted to dry habitats, with the underground rhizomes functioning as succulent water-storage and stem innovation organs.

Wells (1962) suspected that the rhizomes of Indian Knob mountainbalm serve for reproduction when the aboveground structures are destroyed by fire, which seems likely. In addition based upon our observations, the rhizomes appear to be the primary source of reproduction where the substrate is physically disturbed, such as by a rock slide or

² Knapp, D. 2016. 2015 annual report to U.S. Fish and Wildlife Service. Santa Barbara Bot. Garden, Calif., 16 pp.



Fig. 4. Upper: Ramets (the vertical stems) produced from underground rhizomes (indicated by black arrows) of Indian Knob mountainbalm *Eriodictyon altissimum* at southwest Guidetti Ranch, San Luis Obispo County, California (occurrence 5), 5 May 2016. Lower: A collapsed individual of Indian Knob mountainbalm growing in an open area along the old graded dirt/rock road on the main ridge of Indian Knob mountain, southwest Guidetti Ranch, San Luis Obispo County, California (occurrence 5), 5 May 2016. New vertical stems have sprouted from the primary stem, which is now horizontal on the ground.

grading, and where there is an absence of recent fire. When the stem is removed or destroyed, a new stem may be produced from the underground rhizome if present. We observed that the stems of Indian Knob mountainbalm initially stand erect. However, because the stems and branches are pliable, taller plants bend outward when not supported by adjacent vegetation (Fig. 5). This results in some stems and branches touching the ground, and eventually collapsing to become horizontal on the ground (Fig. 5). This presents an ideal situation for horizontal stems on the ground to be covered by falling rocks or shifting sand and to become contact points for layering (subsequent rooting and sprouting of shoots). We observed many stems in this horizontal position and with new vertical stems arising from the horizontal stems (Fig. 4), although we did not specifically see or search for new roots. Thus, Indian Knob mountainbalm appears well-adapted for substrates with physical disturbances, including: steep rocky slopes (Fig. 6), cliff faces, fallen rock debris (Fig. 6), sand dunes (shifting sand; Fig. 5), roadsides (Fig. 7), old graded substrates such as dirt/rock roads, the talus of graded substrates, and trails.

Indian Knob mountainbalm can reproduce also by seeds, which are minute (~0.4 mm length, mean 0.2 mg mass; Wells 1962). Wells (1962) observed a large production of seeds in individuals at the largest occurrence at Indian Knob mountain. However, John Chesnut (Los Osos, Calif., pers. comm. to Diane Steeck, USFWS, 1997) observed a low ratio of seeds/ovules (structures that develop into seeds when fertilized; 10% or less) in the western occurrences in the Los Osos area and also a low number of seeds per ramet. Some occurrences may have low genetic diversity due to rhizomatous reproduction² and could consist of only a single clone (USFWS 1998, 2013a). Although the role of fire in reproduction is not known, it obviously reduces dense mature vegetation and removes debris litter, and it may be needed to somehow revitalize mature stands of Indian Knob mountainbalm^{2,3} (USFWS 1998) or to cue seed production or germination (USFWS 2013b). USFWS (2013b) discussed the potential roles of fire in the species' ecology in a status report.

As of 2019, Indian Knob mountainbalm is known from seven occurrences, with a total population count of 6,489+ individuals in 2016 (Table 1). The seven occurrences comprise a geographic range of 34 km², which spans a distance of 23 km from southeast of Indian Knob (5.1 km south of the city of San Luis Obispo), northwest to Hazard Canyon (400 m south of Los Osos) in Montaña de Oro State Park (Fig. 2). This area has a Mediterranean climate (warm dry summers, cool wet winters). The dry season is May to August, with most rain falling from December to March. Mean annual temperature and rainfall are ~15.1 °C and ~536 mm, respectively (Ryan 1994). We document the occurrences at 98 to 263 m elevation. The known occurrences are at the two ends of the geographic range, and the Irish Hills comprise most of the intervening area. We suspect the species occurs at additional locations in the intervening area, however, access is difficult because of distance from roads, lack of trails, steep terrain and/or private ownership.

Six occurrences (1, 2, 3, 4, 6, 8) of Indian Knob mountainbalm are in protected areas (Table 2), and one occurrence (5) is mostly in a protected area. Two occurrences (1, 3) are likely extirpated, one occurrence (5) contains a large number of plants (6,346+ stems in 2016), and four occurrences (2, 4, 6, 8) contain low numbers of plants (≤80 stems in 2016) of which two (occurrences 2, 4) are in decline. The likely extirpations and declines may be linked to the altered fire regime, specifically the lack of recent fire (fire suppression) in the

³ Bittman, R. 1985. Element preservation plan for *Eriodictyon altissimum* (Indian Knob mountain balm). Nature Conserv., San Francisco, Calif., 5 pp.



Fig. 5. Upper: An individual of Indian Knob mountainbalm *Eriodictyon altissimum* growing in an open area on the main ridge of Indian Knob mountain, southwest Guidetti Ranch, San Luis Obispo County, California (occurrence 5), 4 May 2016. This tall plant (3 to 4 m height) is supported behind by the adjacent vegetation, however, it is collapsing in front where there is no support. Lower: A collapsed individual of Indian Knob mountainbalm on a sand dune in Morro Dunes Ecological Reserve East, Los Osos, San Luis Obispo County, California (occurrence 6), 20 April 2016. This previously tall plant (3 to 4 m) is now horizontal on the ground and growing in an open area along the trail. Michael J. Walgren of California Department of Parks and Recreation is collecting insects while David Chipping of California Polytechnic State University observes.



Fig. 6. Upper: A colony of Indian Knob mountainbalm *Eriodictyon altissimum* growing on an old rockslide on a steep slope of Indian Knob mountain, southwest Guidetti Ranch, San Luis Obispo County, California (occurrence 5), 5 May 2016. Lower: A colony of Indian Knob mountainbalm growing in fallen rock debris of a crumbling cliff face on Indian Knob mountain, southwest Guidetti Ranch, San Luis Obispo County, California (occurrence 5), 4 May 2016.

STATUS OF THE ENDANGERED INDIAN KNOB MOUNTAINBALM
ERIODICTYON ALTISSIMUM

Table 1. Reported numbers of Indian Knob mountainbalm *Eriodictyon altissimum* in the seven known occurrences in western San Luis Obispo County, California. Occurrence 7 was combined into occurrence 5 in 2018. Occurrence 8 is new. X = species observed. Italics indicate the words as used by the footnoted references. (Continued on next page).

Year	Occurrence							
	1	2	3	4	5	7 before 2018	6	8
2018	0 ^A			X ^{A,A}				
2017	not found ^A		0 ^A	X ^A			X ^A	
2016	not found ^A	20 ^A	not found ^A	23 ^A	5,720 ^{+A}	626 ^{+A}	20 ^A	80 ^A
2015	not found ^J			not found ^J	200 ^L		X ^U	
2012	not found ^J	X ^E		not found ^J	<i>somewhat common</i> ^Y		15 ^{J,T}	
2011		X ^M						
2010		X ^M						
2009	not found ^J	37 ^A	not found ^A	not found ^J		X ^F	10 ^V	
2008	not found ^J	28 ^P		not found ^J			11 ^A	
2006	not found ^J			not found ^J			20-25 ^J	
2005		37 ^A						
1999						X ^G		
1998		40 ^N						
1991								
1988								
1986					350 ^S			
1985	<i>might have washed away</i> ^Z	62-150 ^D	7 ^D	25 ^K				
	not found ^D	51-100 ^H		X ^I			11-50 ^D	
1982				30 ^D				
1981				X ^I				
1979	<i>about 30</i> ^C	<i>slightly larger than 30</i> ^C	7 ^B	6 ^B	12 ^C			
1974	X ^Z	24 ^B		X ^B	<i>grows abundantly</i> ^W			
1972		<i>frequent in rocky places along road</i> ^O						

Table 1. Continued.

Year	Occurrence						
	1	2	3	4	5	6	8
1966					5 before 2018		
1960					7 before 2018		
					locally plentiful ^R		
					large population ^X		
<p>A pers. obs. B McLeod 1981 in CDFW 2017. C CDFG 1979. D McLeod 1985 in CDFW 2017. E Sayer in USFWS 2013b. F Langley 2010 in CDFW 2017. G Althouse and Meade. 1999. April 1999 botanical survey parcel map CO 90-080, parcel 2 per mitigation agreement for parcel 2, COAL 89-374 doc. no.: 1997-071413, San Luis Obispo County. Paso Robles, Calif., 19 pp. H Holland 1985 in CDFW 2017. I Consortium of California Herbaria. 2017. UC/JEPS: Consortium search results for <i>Eriodictyon altissimum</i>. Available (Nov. 2017): http://ucjeps.berkeley.edu/consortium, 2 pp. J USFWS 2013b. K Gams and Holland 1988. L Knapp, D. 2016. 2015 annual report to U.S. Fish and Wildlife Service. Santa Barbara Bot. Garden, Calif., 16 pp. M David Chipping (Calif. Polytech. St. Univ., San Luis Obispo, pers. comm. 2016). N Hickson and Hillyard in CDFW 2017. O Anderson 1972. P Sayers 2008 in CDFW 2017. Q LynneDee Althouse (Paso Robles, Calif., pers. comm. 2017). R CDFW 2017. S USFWS 1994. T Winchell, C. 2012. Photo of <i>Eriodictyon altissimum</i> Indian Knob mountaintalm, with information, 12 June 2012. Available (Nov. 2017): https://calphotos.berkeley.edu/cgi/img_query?seq_num=414939&one=T,1pp. U Chesnut, J. 2015. <i>Eriodictyon altissimum</i> Indian Knob mountaintalm, 8 Mar.2015. Available (Nov. 2017): https://calphotos.berkeley.edu/cgi/img_query?seq_num=637393&one=T,1p. V Butterworth 2010 in CDFW 2017. W Vanderwier 1987. X Wells 1962. Y Harms, M. 2012. <i>Eriodictyon altissimum</i>, Indian Knob mountain balm, Guidetti Ranch, Indian Knob. Available (Nov. 2017): https://www.flickr.com/photos/marlinharms/7213654930/in/photostream/, 1 p. Z McLeod 1986 in CDFW 2017. AA Melissa Mooney (Calif. Native Plant Soc., San Luis Obispo, pers. comm. 2018).</p>							

STATUS OF THE ENDANGERED INDIAN KNOB MOUNTAINBALM
*ERIODICTYON ALTISSIMUM*Table 2. Conservation status of the seven known occurrences of Indian Knob mountainbalm *Eriodictyon altissimum* in western San Luis Obispo County, California. Occurrence 8 is new.

Occurrence	Location	Landowner	Protected Area	Status	Immediate threats
1	Broderson site in Los Osos	County of San Luis Obispo	Y	likely extirpated	dense vegetation, altered fire regime/fire suppression
2	Montaña de Oro State Park	California Department of Parks and Recreation	Y	20 stems in 2016, in decline	low number of plants, dense vegetation at one colony, altered fire regime/fire suppression
3	Montaña de Oro State Park	California Department of Parks and Recreation	Y	likely extirpated	dense vegetation, altered fire regime/fire suppression
4	Morro Dunes Ecological Reserve East	California Department of Fish and Wildlife	Y	23 stems in 2016, in decline	low number of plants, altered fire regime/fire suppression
5	southwest Guidetti Ranch	private w/conservation easement to City of San Luis Obispo	Y	6,346+ stems in 2016	dense vegetation, altered fire regime/fire suppression, unauthorized clearing of vegetation
	Baron Canyon Ranch Estates adjacent land south	multiple private private Pacific Gas and Electric Company	N		
6	Morro Dunes Ecological Reserve East	California Department of Fish and Wildlife	Y	20 stems in 2016	low number of plants, dense vegetation, hikers trampling plants, unauthorized trimming of vegetation, altered fire regime/fire suppression
8	south central Guidetti Ranch	private w/conservation easement to City of San Luis Obispo	Y	80 stems in 2016	low number of plants, vehicles running over plants, road maintenance



Fig. 7. A colony of Indian Knob mountainbalm *Eriodictyon altissimum* beside the dirt/rock road in south central Guidetti Ranch, San Luis Obispo County, California (new occurrence 8), 1 December 2016. The colony is 1.14 km southeast of the nearest colony of occurrence 5 on southwest Guidetti Ranch (below Indian Knob). The stretch of road at occurrence 8 was covered with soil/rock from below Indian Knob. It seems likely the plants at occurrence 8 originated from individuals that were transported with soil/rock extracted from occurrence 5.

habitat (Gambus and Holland 1988; USFWS 2013b). Regarding occurrence 5 that is mostly in a protected area, 53% (32 ha) is on the private Guidetti Ranch with a conservation easement to the City of San Luis Obispo, 40% (24 ha) is on multiple private properties in Baron Canyon Ranch Estates, and 8% (5 ha) is on private property of Pacific Gas and Electric Company.

The primary threat to the species identified in 1994 has been eliminated: habitat loss as a result of potential development (USFWS 1994), specifically potential surface mining at the largest occurrence on Indian Knob mountain, and potential residential development at two small occurrences in Los Osos. At the private Guidetti Ranch (occurrence 5; Tables 1, 2) that includes much of Indian Knob mountain and where the bulk of the largest population exists, the City of San Luis Obispo purchased a conservation easement in 1996 that allows continued operation of the ranch for livestock grazing while protecting Indian Knob mountainbalm and its habitat, and it also allows limited access for natural resource conservation and public education. At listing in 1995, occurrences 4 and 6 were on two private properties (83 ha) in Los Osos owned by a development corporation that intended to build houses. These two properties were purchased by the State of California in 2001, and they now comprise CDFW's Morro Dunes Ecological Reserve East. In 2019, dense vegetation is a threat at all occurrences except occurrence 8 (see details for each occurrence in Appendix 1). Also in 2019, four of the five extant occurrences of Indian Knob

mountainbalm are threatened by stochastic events because small numbers of individuals comprise them (each ≤ 80 plants), and also because of their isolation (distance) from other extant occurrences. These threats were recognized previously by USFWS (1994).

In addition to the immediate threats (Table 2), climate change could be a long-term threat to Indian Knob mountainbalm because California is becoming hotter and drier. The summers of 2017 and 2016 were each the warmest in California since record keeping began in the late 1800's⁴. Considering data up to 2015, most of the warming occurred in the past 35 years with 15 of the 16 warmest years occurring since 2001⁵. The 3-yr period from 2012 to 2014 was the hottest and driest in California in the 100-yr time frame considered by Mann and Gleick (2015), and it was the most severe drought in California in the past 1,200 yrs (Griffin and Anchukaitis 2014). In consideration of the life history traits used to assess climate change vulnerability for rare plants in California (Anacker et al. 2013), Indian Knob mountainbalm would be considered highly vulnerable to climate change. These traits include low dispersal ability, an apparent narrow historical climate exposure, dependence on particular disturbance regimes, habitat specialization, and likely low genetic diversity.

Based upon our field observations, the several statements by USFWS^{6,7,8} (2013a) that invasive nonnative grasses, particularly perennial veldt grass *Ehrharta calycina*, pose the strongest threat to Indian Knob mountainbalm are not correct. To the contrary, no occurrence of Indian Knob mountainbalm is immediately threatened by non-native grasses. Although perennial veldt grass exists in the surrounding landscapes, we observed it only at occurrence 5 with just a few clumps at one location. Although perennial veldt grass could become a threat in the future by invading an occurrence after fire (USFWS 2013a), it is more abundant in coastal sage scrub and ruderal and disturbed plant communities than in chaparral.

Using our information and international standards (IUCN 2012, 2014), Indian Knob mountainbalm in 2019 meets the IUCN criteria for endangered including the following: geographic range, fragmented; extent of occurrence, 34 km² (<100 km²); area of occupancy, <2.3 km² (<10 km²); and quality of habitat, continuing to decline (dense vegetation, lack of recent fire). Considering these attributes, Indian Knob mountainbalm faces an extremely high risk of extirpation at four of the five extant occurrences. Four of the five extant occurrences are small with ≤ 80 individuals each, and two other occurrences are likely extirpated. One occurrence is large with >6,000 individuals, and it is mostly in a protected area.

⁴ NOAA National Centers for Environmental Information. 2018. Climate at a glance: U.S. time series, average temperature. Available (Feb. 2018): <https://www.ncdc.noaa.gov/cag/time-series/us>.

⁵ Brown, D., M. Cabbage, and L. McCarthy. 2016. NASA, NOAA analyses reveal record-shattering global warm temperatures in 2015. Press release available (Jan. 2016): <http://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-record-shattering-global-warm-temperatures-in-2015>.

⁶ U.S. Fish and Wildlife Service. 2011. Indian Knob mountainbalm. Photo with information, 21 May 2011. Available (Nov. 2017): https://www.flickr.com/photos/usfws_pacificsw/11177193066/in/photolist-i2G36h-HraCuj-i2ER6H-c91K3d-i2E28B-HtxhRz-HtxgkD-GPHFev, 1 p.

⁷ U.S. Fish and Wildlife Service. 2011. Indian Knob mountainbalm. Photo with information, 31 May 2011. Available (Nov. 2017): https://www.flickr.com/photos/usfws_pacificsw/11176960975/in/photostream/, 1 p.

⁸ U.S. Fish and Wildlife Service. 2012. Indian Knob mountainbalm and habitat. Photo with information, 12 May 2012. Available (Nov. 2017): https://www.flickr.com/photos/usfws_pacificsw/11176799613/, 1 p.

Recommendations.—Despite increased attention in recent years, little is known about the biology and ecology of the endangered Indian Knob mountainbalm in 2019. Therefore, coordinated conservation and research are needed to further understand the species, and to restore and maintain the five extant occurrences. These efforts should include management actions to benefit the occurrences, searches for additional locations, studies of genetic diversity and reproductive biology, introduction of Indian Knob mountainbalm into living collections at botanic gardens, investigations of potential barriers to recruitment, and investigations of the species' relationship with fire. Specifically, we intend to make a conservation seed collection for seed banking in the near future, and a subset of these seeds will be used to investigate germination requirements, including cues associated with fire-following species. In addition, cuttings will be collected and cultivated along with seeds to develop protocols for propagation of the species. Finally, a study of population genetics is planned to investigate genetic diversity within and among the occurrences.

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Appendix 1

The seven known occurrences of Indian Knob mountainbalm *Eriodictyon altissimum* in western San Luis Obispo County in central coastal California.

Occurrence 1. ~35.303567, –120.846864; 119 m elevation. The coordinates that we give are in a former gully ~119 m E of the intersection of Travis Drive and Houston Drive in Los Osos. The location is on the Broderson site (32 ha), which is owned by the County of San Luis Obispo and used as a leach field (3 ha) for recycled water from the Los Osos wastewater treatment plant. The occurrence is in the area (29 ha) protected by deed restriction executed in 2017, and managed per a habitat management plan approved by the California Coastal Commission in 2017 (Kate Ballantyne, Co. of San Luis Obispo, Calif., pers. comm. 2017). It is on Baywood Fine Sand comprising ancient stabilized sand dunes of windblown origin during the late to middle Pleistocene Epoch (Carpenter and Storie 1928; CDFG 2005; Wiegiers 2009). We searched on 22 June 2018, 10 April 2017 and 20 April 2016, and we found no Indian Knob mountainbalm. There is confusion

regarding this occurrence. The only records are CDFG (1979) and McLeod (1986 in CDFW 2017). CDFG (1979) states the following: “Three populations. The Indian Knob population consists of 12 individuals, the Broderson Road site includes about 30, and the Hazard Canyon population is slightly larger. Development activities following existing high volume recreational uses have caused significant decline in the Roderson [sic] Road population.” The maps of CDFG (1979) and McLeod (1986 in CDFW 2017) both depict a circle immediately E of the bend of Travis Drive, which is part of Cabrillo Estates (~250 homes). McLeod (1986 in CDFW 2017) stated the following: “Population 1 was originally discovered by Dirk [Walters] in the early ’70s. He and I tramped over the whole area last year and couldn’t locate it. Dirk said recently that it might have been washed away as it was along a gully. I’m sorry we couldn’t find it as that was the population with which you would probably be most concerned.” This occurrence and occurrence 4 are on properties that in the 1980’s were proposed for the community sewage system⁹. Gambs and Holland (1988) conducted a vegetation survey of the properties with occurrences 1 and 4. Although Gambs and Holland (1988) discussed occurrence 4, they did not mention occurrence 1. Using Google Earth aerial imagery (dated 27 May 1994), we observed that a gully previously existed in the mapped area for occurrence 1 (CDFG 1979; McLeod 1986 in CDFW 2017) and parallel to Travis Drive, but which is not obvious in 2017 because of dense vegetation. Unconfirmed word of mouth is that the Indian Knob mountainbalm were located ~100 m northeast of the intersection of Travis Drive and Houston Drive, which is in the mapped areas of CDFG (1979) and McLeod (1986 in CDFW 2017), and also in the former gully reported by McLeod (1986 in CDFW 2017). Because of multiple unsuccessful attempts to locate occurrence 1, USFWS (2013a, b) considered occurrence 1 to be extirpated. In contrast, CDFW considered occurrence 1, which is west of Broderson Avenue extended, to be a mis-mapping of occurrence 4, which is in the same landscape but east of Broderson Avenue extended. Consequently, CDFW combined occurrences 1 and 4 in 2013. However, instead of removing occurrence 1 from the California Natural Diversity Database, CDFW removed occurrence 4 while retaining occurrence 1 but with coordinates for occurrence 4 (K. Gross, pers. comm. 2017). Although no herbarium specimens document occurrence 1, it appears to be valid as indicated by CDFG (1979) and McLeod (1986 in CDFW 2017).

Occurrence 2. 35.290381, -120.859230; 35.290216, -120.859599; 35.290156, -120.859721; 35.291068, -120.864935; 154 to 210 m elevation. The coordinates that we give are from our GPS device next to the plants. Also, Sayers 2008 (in CDFW 2017; Lazar 2018 pers. comm.) reported two additional colonies at the following two locations that are along or near the same trail: 35.290202, -120.860118; 35.290336, -120.860566; 208 to 212 m. We surveyed and censused this occurrence on 21 April 2016. It comprises six disjunct colonies (we refer to them as A, B, C, D, E and F, from east to west) along the old Manzanita Trail on a south-facing ridge on the south side of Hazard Canyon in Montaña de Oro State Park, ~384 m south of Los Osos. The trail is an old dirt/rock road between the east section of the Hazard Peak Trail and the Bloody Nose Trail that was graded likely in the 1940’s or 1950’s when the land was private property. The trail is closed to the public. The location of this occurrence as mapped by McLeod (1981 in CDFW 2017) is off by > 500 m. The greatest number of recorded individuals for this occurrence was 62 to 150 plants by McLeod (1985 in CDFW 2017), and the recorded numbers have declined since then: 40 plants in 1998 (Hickson and Hillyard 1998 in CDFW 2017), 37 plants in 2005 (pers. obs.), 28 plants in 2008 (Sayers 2008 in CDFW 2017), 37 plants in 2009 (pers. obs.), and 20 plants in 2016 (pers. obs.). In 2016 this occurrence comprised 20 plants (15 big individuals with woody stems, 5 small leafy sprouts) in four colonies (A, B, C, F), while two colonies (D, E) reported by Sayers (2008 in CDFW 2017) were not observed. The six colonies are separated by 38 m, 10 m, 33 m, 44 m and 402 m, respectively, spanning a straight-line distance of 530 m with a total area of 11,121 m². Colony A is two big plants at the top of a cliff face (road cut). Sayers (2008 in CDFW 2017), likewise, reported two plants here in 2008. Colony B (six large stems, one little stem) and colony C (three large stems) are in the fallen rock debris of a collapsed cliff face (road cut) that fell in 2011, and the bulk of the two colonies were covered. Additional plants previously grew on the downslope adjacent to the trail and were covered by the fallen rock debris. The rock is very old cemented dune sand (D. Chipping, pers. comm. 2016), and it is friable and relatively soft (Wiegiers 2009). Colony F comprised seven plants (three big individuals with woody stems, four small leafy sprouts) in an area of 38 m² in 2016. Four small stems were growing in the sandstone road (shale according to McLeod 1985 in CDFW 2017 is incorrect) and three big plants in the rock talus pushed down the slope. Sayers (2008 in CDFW 2017) reported

⁹ Gambs, R.D. 1986. Biological assessment: the effects of a proposed wastewater system in the communities of Los Osos and Baywood Park, California on the endangered Morro Bay kangaroo rat (*Dipodomys heermanni morroensis*). Report to Morro Group, Inc., San Luis Obispo, Calif., 26 p.

17 stems here in 2008, and McLeod (1985 in CDFW 2017) reported 51-100 stems in 1985. With only seven stems in 2016, this colony is in decline and near extirpation. As an urgent recovery action for this colony, we recommend that the vegetation within a radius of 8 m be thinned and that the potential for a controlled miniburn be evaluated. We attribute herbarium specimen CDA17581, which was collected “ca. 2 mi E of Pecho Road along S leg of East Hazard Canyon loop trail,” to this occurrence¹⁰. The overland distance from Pecho Valley Road to occurrence 2 is ~3.2 km when using Hazard Canyon Road and the ascending Manzanita Trail.

Occurrence 3. ~35.294023, -120.850953; 239 m elevation. The coordinates that we give are from our GPS device in the field. This occurrence is on the north side of Hazard Canyon in Montaña de Oro State Park in southwest Los Osos. McLeod (1981 and 1985 in CDFW 2017) reported seven plants at this occurrence in 1981 and 1985, but no one has reported on this occurrence since. Although McLeod (1981 in CDFW 2017) provided a map, the precise location has remained unknown. We searched for this occurrence on 25 April 2017, and we are confident that we found the general location. However, we saw no plants. The soil at the general location is Baywood Fine Sand on a ridge top. The vegetation is now dense, predominantly chamise and manzanita, and with some open areas. We suspect that in the 1980’s the vegetation was less dense, and in the ensuing decades the vegetation has become denser and crowded out the Indian Knob mountainbalm, which is now likely extirpated at occurrence 3. We searched also along Cable Trail from Pecho Valley Road to the ridge with occurrence 3. We found no plants, although conditions appeared suitable in several places. In addition, we identified a nearby area (405 m west of occurrence 3) with collapsed cliff faces that appeared to be habitat. We tried but without success to access the fallen rock debris from Cable Trail above and from Hazard Canyon Road below. Using binoculars we saw no Indian Knob mountainbalm. In brief, unknown colonies of Indian Knob mountainbalm may exist along the north side of Hazard Canyon.

Occurrence 4. 35.305865, -120.837545; 35.304063, -120.838908; 35.302020, -120.836210 (M. Mooney, pers. comm. 2018); 98 to 118 m elevation. The coordinates that we give are from GPS devices next to the plants in three colonies. This occurrence is in southwest Los Osos in CDFW’s Morro Dunes Ecological Reserve East, and it is on Baywood Fine Sand. D. Walters identified this occurrence in 1974 (McLeod 1981 in CDFW 2017). Recorded numbers of plants were six individuals in 1979 (McLeod 1981 in CDFW 2017), 30 in 1985 (McLeod 1985 in CDFW 2017), 25 in 1988 (Gambis and Holland 1988), and 23 in 2016 (pers. obs.). There is confusion regarding this occurrence, whose specific location became “lost” after 1988. McLeod (1981 in CDFW 2017) mapped the location of occurrence 4 at 73 to 85 m elevation between the sand extensions of Palisades Avenue and Ravenna Avenue, but closer to the former. McLeod (1985 in CDFW 2017) described the location as “south of the end of Palisade St Los Osos 100 yds W of stand of Bishop pine [*Pinus muricata*]” at 91 m elevation but marking 79 to 85 m elevation on his map. Gambis and Holland (1988) mapped the location of Bishop pine in the landscape, showing two stands near Palisades Avenue sand extension and the most relevant one at 98 m elevation (35.304162, -120.837298). Gambis and Holland (1988) described the location of occurrence 4 as two groups: one group of 25 individuals ~100 m west of the sand extension of Palisades Avenue at ~76 m elevation, and “an isolated individual discovered by Dirk Walters in the early 1970’s south of the end of Ravenna Avenue” that they could not find. CDFG (2006) recognized occurrence 4 with coordinates 35.30563, -120.83734 at 83 m elevation. We are not able to reconcile the previously stated elevations and maps for occurrence 4 with our own observations. Because of the multiple unsuccessful attempts to find this occurrence, USFWS (2013a, b) considered occurrence 4 to be extirpated. Also in 2013, CDFW combined occurrence 4 with occurrence 1 because they believed that occurrence 1 (35.30467, -120.84598; CDFG 2006) was a mapping error. CDFW removed occurrence 4 from the California Natural Diversity Database and retained occurrence 1 but with the new coordinates 35.30556, -120.83771 at 79 m elevation, which is 35 m southwest of the former occurrence 4 (CDFG 2006). However, we affirm that our occurrence 4 is separate and distinct from our occurrence 1. J. Chesnut of the California Native Plant Society (San Luis Obispo) led us to occurrence 4 on 20 April 2016. We observed 23 individuals in two colonies separated by 40 m: colony A with 21 plants (10 big individuals with woody stems, 11 small sprouts; 14 m²) in a clearing, and a more western colony B with two big individuals with woody stems (3 m²) at the edge of California live oak woodland *Quercus agrifolia* with ceanothus *Ceanothus*, manzanita *Manzanita* and chamise *Adenostoma fasciculatum*. J. Chesnut (pers. comm. 2016) had observed the two colonies previously during field work in 1986, and he recalled there were other individuals on the

¹⁰ Consortium of California Herbaria. 2017. UC/JEPS: Consortium search results for *Eriodictyon altissimum*. Available (Nov. 2017): <http://ucjeps.berkeley.edu/consortium>, 2 p.

sand ridge extending north. We subsequently searched the sand ridge on 10 April 2017 but saw no other plants. We observed colony B again on 10 April 2017, and one plant was dead and the other dying. The coordinates that we give for colony A are 139 m west of the stand of Bishop pine at 98 m elevation near the end of the sand extension of Palisades Avenue (Gambas and Holland 1988), which is likely the location referred to by McLeod (1981 and 1985 in CDFW 2017) and Gambas and Holland (1988). Colony B is at the edge of dense vegetation, and it is 40 m west of colony A and even closer to the sand extension of Ravenna Avenue. In August 2018, M. Mooney (pers. comm. 2018) observed one individual ~30 cm height at a new location (colony C), 330 m southeast of colony A and in chaparral. Five herbarium specimens document occurrence 4: CHSC69826 and HSC77146 collected in 1982; and RSA522505, SBBG95658 and UC1583847 collected in 1986¹⁰. The total area is 0.62 ha.

Occurrence 5. Based upon the information for occurrences 5 and 7 in a draft of this paper that was reviewed by CDFW, in 2018 they officially combined occurrence 7 into occurrence 5 because the two occurrences were no longer separated by >0.4 km (K. Lazar, pers. comm. 2018). However, because of the different land ownerships and different management, we present the separate information for occurrences 5 and 7 prior to 2018 (see also Table 1). The total known occupied area is ~60 ha: Guidetti Ranch, 32 ha; Baron Canyon Ranch Estates, 24 ha; and Pacific Gas and Electric Company, 5 ha. The approximate center of occurrence 5 is now 35.200234, -120.669741. The total count in 2016 was 6,346+ stems. USFWS (1994) reported 350 stems in 1991.

Occurrence 5 before 2018. 35.200538, -120.669342 to 35.198472, -120.657299; and 35.201136, -120.662712 to 35.196987, -120.662644; 197 to 263 m elevation. The coordinates that we give are from our field observations and Google Earth aerial imagery. The approximate center of the occurrence is at 35.199150, -120.663379. This occurrence is narrowly situated on Indian Knob mountain and the nearby ridges and upper slopes, primarily on the private Guidetti Ranch and extending south onto property of Pacific Gas and Electric Company. The substrate is sandstone (Chipping, pers. comm. 2016). We surveyed and censused this occurrence on 4 and 5 May 2016. We counted 5,720 stems (4,610 woody stems, 1,110 leafy sprouts; and 205 dead stems) on the Guidetti Ranch and adjacent property of Pacific Gas and Electric Company. This is a minimum number because there were many areas we did not search due to steepness of slopes or lack of paths through dense vegetation. The plants are primarily on the ridges and south-facing slopes. Previous reports regarding numbers of plants were 12 in 1979 (CDFG 1979), >100 in 1985 (McLeod 1985 in CDFW 2017), and 200 in 2015². Our substantially higher number is likely the result of greater effort, using a systematic method, and the counting of every stem. The known occupied area comprises at least 32 ha, which is mostly on the Guidetti Ranch (30 ha) but also extending south and west onto private property owned by the Pacific Gas and Electric Company (3 ha). Wells (1962) described Indian Knob mountainbalm on Guidetti Ranch as a pioneer species in chaparral dominated by Santa Margarita manzanita *Arctostaphylos pilosula*, being aggressive along roads and confined to shallow sandy soils on the sandstone ridges. CDFW (2017) described the microhabitat as sandstone ridges in open disturbed areas in chaparral at 90 to 270 m elevation. In addition to the roadsides, old graded dirt/rock roads and ridges, we observed the species in the open areas on the steep slopes usually with a disturbed substrate, and also in the talus of graded dirt/rock roads, on cliff faces, in the fallen rock debris of collapsed cliff faces, on rock slides, and along trails. We searched several disturbed areas in the chaparral created by tree falls, which were characterized by a thin layer (15 cm) of fine organic debris over sandy soil, but found no Indian Knob mountainbalm there. On Guidetti Ranch it appears that Indian Knob mountainbalm is adapted for areas with disturbed soil and rock where, in the absence of recent fire, reproduction seems most likely by rhizomes. We suspect that reproduction by seeds may need fire, and there have been no wildfires on Guidetti Ranch since before the 1950's (Terry Guidetti, pers. comm. 2016).

Occurrence 7 before 2018. 35.209470, -120.677157 to 35.200040, -120.670969; and 35.203853, -120.670995 to 35.205170, -120.676575; 193 to 235 m elevation. The coordinates that we give are based on our field observations and using Google Earth aerial imagery. The known occupied area comprises ~28 ha, with the center at 35.203840, -120.674061. This occurrence is mostly on Baron Canyon Ranch Estates (277 ha), which is a private gated community in the mountains and hills 2.25 km south of the city of San Luis Obispo. The community comprises 29 parcels of land for houses (0.4 to 34.0 ha) and three common areas (172 ha). Most houses are on the ridges and hills, which are mostly undeveloped and with predominantly native vegetation. The section of the primary mountain ridge with Indian Knob mountainbalm is oriented mostly in a northwest to southeast direction, and Balm Ridge Way is the paved road that extends along it. This occurrence of Indian mountainbalm is on the primary mountain ridge and adjacent slopes, spanning a distance of 1.2 km. It is on the same primary mountain ridge as occurrence 5, which is mostly on Guidetti Ranch and immediately southeast of Baron Canyon Ranch Estates. Occurrence 7 extends for a

short distance S onto property owned by Pacific Gas and Electric Company and east onto Guidetti Ranch. The southern part of occurrence 7 adjoins occurrence 5. We observed Indian Knob mountainbalm primarily in a belt of Santa Margarita manzanita that appeared to stretch continuously across the several ridges and slopes. We counted 626 plants (598 woody stems, 28 leafy sprouts) on 27 July 2016, and there were likely many more plants that we did not observe because of the large occupied area, the steepness of some slopes, and the lack of access through the dense vegetation. We saw many tall individuals of Indian Knob mountainbalm growing within and rising above the dense mature chaparral, including one individual that was ~5.5 m tall. Similarly, Wells (1962) observed Indian Knob mountainbalm “often overtopping by five feet or more the even-statured young manzanitas dating from the last chaparral fire.” LynneDee [Oyler] Althouse (1991 in CDFW 2017; Paso Robles, Calif., pers. comm. 2017) reported > 500 plants (350 flowering, 150 vegetative) in 1991. Current threats include clearing of the native vegetation by private landowners. In 2016 we observed illegal clearing of at least 310 m² of native vegetation on one private property contrary to ordinance of San Luis Obispo County, and it included destruction of some Indian Knob mountainbalm, which was being investigated by CDFW.

Occurrence 6. 35.301508, -120.830263; 35.301639, -120.830129; 115 to 118 m elevation. This occurrence is in south Los Osos in Morro Dunes Ecological Reserve East on Baywood Fine Sand. It is 25 m northwest of the white water tank near Calle Cordoniz Road. The coordinates are from our GPS device next to the plants. We surveyed and censused this occurrence on 20 April 2016, and we counted 20 plants: 11 big individuals with woody stems, and nine small sprouts. The plants are in two colonies (20 m², 32 m²) separated by 11 m, and with a total area of 63 m². Much of Los Osos is underlain by old, stabilized sand dunes (Wieggers 2009), and this occurrence is near the crest of a sand dune. The plants are along several well-established trails and at the edge of dense mature chaparral. Several of the taller individuals had collapsed and were growing with the primary stems horizontal across the ground. Previous records for this occurrence are 15 plants in 2012 (USFWS 2013b), 10 in 2010 (Butterworth 2010 in CDFW 2017), 20 to 25 in 2009 (USFWS 2013b), and 11 to 50 plants in 1985 (McLeod 1985 in CDFW 2017). We identify two primary threats to this occurrence: the dense vegetation immediately surrounding the plants, and the removal of Indian Knob mountainbalm by hikers and equestrians who trim the vegetation in an effort to keep the trails passable (pers. obs. 2017). Therefore, we recommend that CDFW (or their authorized agents) thin the vegetation in vicinity of the Indian Knob mountainbalm, and also place educational signs at strategic locations to inform hikers and equestrians about sensitive plants in the habitat.

Occurrence 8 (new). 35.190008, -120.650146; 124 m elevation. The coordinates that we give are from Google Earth aerial imagery. While working with vegetation contractors of the Pacific Gas and Electric Company on 1 December 2016, we encountered a disjunct colony of Indian Knob mountainbalm (78 woody stems, 2 leafy sprouts) that is 1.14 km southeast of the nearest colony of occurrence 5 below Indian Knob on Guidetti Ranch. The new occurrence is beside the dirt/rock road and in the south central part of Guidetti Ranch (Fig. 7), which is in the area protected by conservation easement to the City of San Luis Obispo. The soil/rock at occurrence 8 and occurrence 5 below Indian Knob appear similar using Google Earth aerial imagery. Although the landscape between the two occurrences is intact and mostly vegetated, there appears to be no similar soil/rock in this intervening area. The location below Indian Knob was previously surface mined, and the extracted soil/rock was used locally for road fill and road repair. T. Guidetti (pers. comm. 2018) stated that the stretch of road at occurrence 8 was covered with soil/rock from below Indian Knob. Thus, it seems likely the plants at occurrence 8 originated from individuals that were transported with soil/rock extracted from occurrence 5. Threats to this occurrence include low number of plants, vehicles running over the plants, and road maintenance.