CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

California Endangered Species Act

5-Year Species Review for Monterey clover (*Trifolium trichocalyx*)

Report to the Fish and Game Commission

AUGUST 2023

Cover banner (Alternative text: forest habitat image overlaid by CDFW shield and text "California Department of Fish and Wildlife [line break] California Endangered Species Act")

Cover photo by Mariel Boldis (Alternative text: A closeup photograph of a small, green plant with a cluster of four pea-like purple and white flowers at the end of the stem that are subtended by bracts, which are green, linear leaves that are longer than the petals. The lower part of the stem shows the stipule, which is a leaf-like appendage that is toothed, green, and with multiple linear leaves. The bracts, stem, and stipule are full of white, short, spreading hairs.)

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III. EXECUTIVE SUMMARY

Monterey clover (*Trifolium trichocalyx*) is currently listed as endangered under the California Endangered Species Act (CESA). Pursuant to Fish and Game Code section 2077, subdivision (a), the California Department of Fish and Wildlife (Department) has prepared this five-year species review (Species Review) to evaluate whether conditions that led to the original listing of Monterey clover are still present. This Species Review is based on the best scientific information currently available to the Department regarding each of the components listed under Section 2072.3 of the Fish and Game Code, and Section 670.1, subdivisions (d) and (i)(1)(A), of Title 14 of the California Code of Regulations. In addition, this document contains a review of the identification of habitat that may be essential to the continued existence of the species, and the Department's recommendations for management activities and other actions for recovery of the species (Fish & G. Code, § 2077, subd. (a)).

Monterey clover is a low spreading annual herb that typically grows in moist depressions in open, moderately disturbed areas of low vegetation cover along the margins of roads and trails. The historical extent of Monterey clover is not known. The species current range includes the western, coastal portions of Monterey and Mendocino counties. The distribution of Monterey clover consists of six populations at three sites that are extremely small and fragmented. While the soil seedbank appears to be long-lived (± 60 years), no more than 1,000 individuals have ever been documented on the Monterey Peninsula. The species appears to be more abundant at the Mendocino sites, yet annual counts continue to drastically vary 50-7,000 plants.

At the time of listing in 1979, the Department identified the main threat to Monterey clover as insufficient number of individuals for a stable population. The Department's five-year species review from the late 1980's recommended no change to the status due to an additional threat of modification or destruction of habitat. This Species Review identifies three additional threats: altered disturbance regimes, competition, and climate change. At present, the low number of individuals and ongoing human activities related to modification or destruction of habitat pose the most immediate threats of extinction. The original management efforts included land protection, and most populations are on conservation easements. Current management efforts are only focused on populations in Mendocino County. Recommendations for management of the species include monitoring, planned disturbance to reduce encroaching vegetation, surveys for new populations and for suitable habitat, and seed collection.

After reviewing the best available scientific information, the Department finds there is sufficient scientific information to indicate that the conditions that led to the original listing of Monterey clover as endangered, are still present. The Department recommends no change to the status of Monterey clover at this time.

IV. INTRODUCTION

A. Five-Year Species Review

This five-year species review (Species Review) addresses Monterey clover (*Trifolium trichocalyx* A. Heller), which is designated as an endangered species under the California Endangered Species Act (CESA) (Fish & G. Code, § 2050 et seq.; Cal. Code Regs., tit. 14, § 670.2, subd. (a)(15)(M)). Upon a specific appropriation of funds by the Legislature, or if other funding is available in the absence of a specific appropriation, the California Department of Fish and Wildlife (Department) may review species listed as endangered or threatened under CESA every five years to determine if the conditions that led to the original listing are still present (Fish & G. Code, § 2077, subd. (a)). Monterey clover is also listed as endangered under the Federal Endangered Species Act. The Department contacted the United States Department of the Interior, U.S. Fish and Wildlife Service (USFWS) on April 15, 2022, to request coordination with their five-year review for Monterey clover (Fish & G. Code, § 2077, subd. (b)); however, the USFWS completed a species review for Monterey clover in 2020 and are not due to complete another review at this time (pers. comm. Lemein 2022a).

Using the best scientific information available to the Department, this Species Review includes information on the following components pursuant to Section 2072.3 and Section 2077, subdivision (a), of the Fish and Game Code and Section 670.1, subdivision (d), of Title 14 of the California Code of Regulations: species' population trend(s), range, distribution (including a detailed distribution map), abundance, life history, factors affecting the species' ability to survive and reproduce, the degree and immediacy of threats, the impact of existing management efforts, the availability and sources of information, identified habitat essential for the continued existence of the species, and the Department's recommendations for future management activities and other recovery measures to conserve, protect, and enhance the species.

B. Listing and Review History

On July 11, 1979, the Department proposed to list Monterey clover as endangered. On October 5, 1979, the Fish and Game Commission (Commission) voted to list Monterey clover as endangered under the Native Plant Protection Act (NPPA) of 1977 (Fish & G. Code, § 1900 et seq.), and formally listed Monterey clover as endangered on October 17, 1979 (CDFG 1979*a*, *b*). At the time of listing, the threat to the species was listed as low number of individuals for a stable population (inbreeding depression) (CDFG 1979*b*).

In 1984, plants listed as endangered under the NPPA were newly designated as endangered under CESA and added to the CESA list of endangered plants (Fish & G. Code, § 2062). The

Department completed a five-year species review, likely between 1985 and 1990, for Monterey clover with a recommendation to retain the listing of endangered status (CDFG n.d.). In the five-year species review, the Department identified an additional threat to the species: modification or destruction of habitat (e.g., urban expansion, golf courses, recreation).

On August 12, 1998, USFWS listed Monterey clover as endangered. The USFWS identified the following threats to the species: altered fire regime, inbreeding depression, susceptibility to stochastic disturbance, and previous and continued habitat loss and fragmentation (e.g., residential development, golf courses, recreation) (USFWS 1998). In 2009, USFWS completed a five-year species review for Monterey clover and identified climate change as an additional threat (USFWS 2009). In 2020, USFWS completed an additional five-year species review and recognized a new population of Monterey clover in Mendocino County. USFWS identified the following threats to Monterey clover in 2020: suppression of natural disturbance cycles (e.g., frequency and intensity of fire and road maintenance), competition from invasive species, habitat loss, stochastic disturbance, and climate change (USFWS 2020).

This Species Review was prepared by Mariel Boldis, in the Department's Habitat Conservation Planning Branch, Native Plant Program.

C. Notifications and Information Received

On November 26, 2019, the Department notified persons who had expressed their interest in CESA actions and had provided contact information to the Commission (Fish & G. Code, § 2077(a)). The e-mail notification included a link to the Department's dedicated web page for five-year species reviews of threatened and endangered species at https://www.wildlife.ca.gov/Conservation/CESA/Five-Year-Reviews.

The Department also conducted a literature review and contacted local botanists, consultants, and private landowners in the areas where Monterey clover occurs. In Spring 2022, the Department surveyed for Monterey clover within the historical and current range in Monterey County and Mendocino County, California.

V. BIOLOGY

A. Taxonomic and Physical Description

Monterey clover was first documented and collected on May 13, 1903, near Pacific Grove on the Monterey Peninsula, and the species was first described by Amos Arthur Heller in 1904 (Heller 1904). Monterey clover is a low, spreading, annual herb with short, branching stems that grow up to 50 cm (19.7 in) (Figure 1a). Monterey clover has three leaflets per leaf, with

leaflets 5-10 mm (0.2-0.4 in) long, and stipules (leaf-like appendage at base of leaf) that are often toothed (Figure 1b, Heller 1904, Heise 2017). Monterey clover flowers are pale pink to lavender purple and are pea-like with papery white tips (Figure 1c). Flowers are grouped together at the ends of the stem (terminal inflorescences) and can have up to 20 flowers clustered together in optimal conditions. The calyx (the outermost whorl of the flower) consists of five green lobes (6-7 mm; 0.2-0.3 in) that are bristle-tipped and generally longer than the tube of flower petals (6 mm; 0.2 in; Figure 1c). The base of the calyx has a narrow, fused, and irregularly lobed involucre (whorl of small leaves) where the pointed lobes cut past the middle (Figure 1c, Vincent and Isely 2012). The long hairs on the calyx are its most defining feature for positive identification (Figure 1c, CDFG 1979a, Vincent and Isely 2012, Heise and Hulse-Stephens 2017). The fruits are cylindrical pods (5-7 mm; 0.2-0.3 in), deciduous at maturity, with up to six seeds per pod (Figure 1d, Yadon 1984, Vincent and Isely 2012, Heise 2017).

Monterey clover is known from three sites in two widely separated areas in Monterey and Mendocino counties, California (see Range and Distribution section of this Species Review). When Monterey clover was first documented in Mendocino County in 2011, ribosomal DNA and chloroplast DNA sampled from the Mendocino County plants were sequenced (Ellison et al. 2006) and verified as identical to DNA sequences from the plants in the Monterey Peninsula (Heise 2012, Odegard et al. 2012). Faint chevron patterns on the leaves of the Mendocino County plants that are not known to be present on the Monterey Peninsula plants, suggests the Mendocino County plants are not recent introductions (Heise 2012, Heise and Hulse-Stephens 2012).

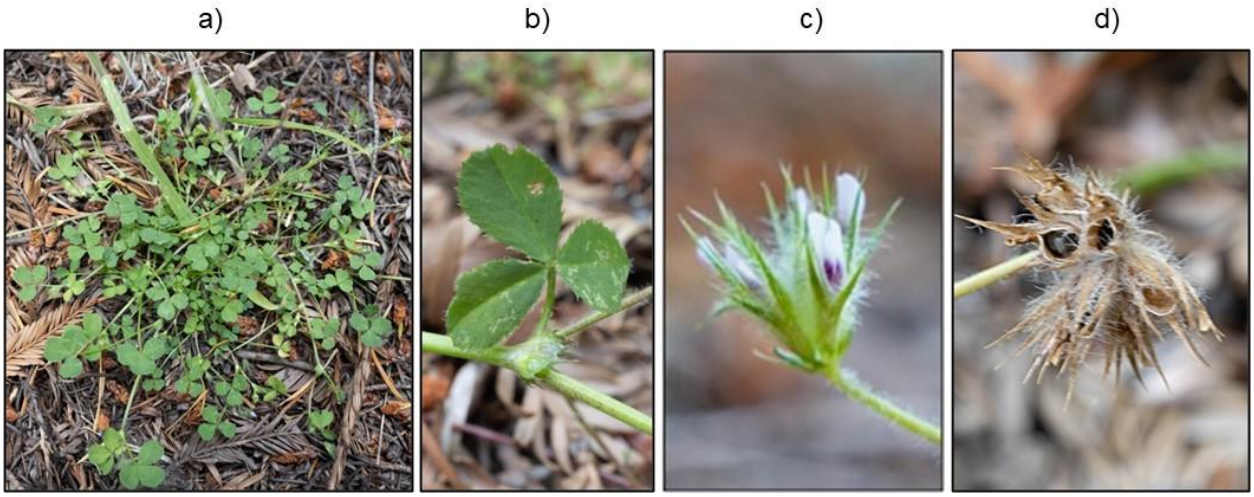
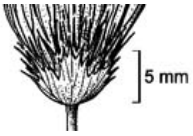


Figure 1. A Monterey clover plant showing the a) spreading vegetative habit, b) leaf with three leaflets, and stipule, c) flowers and hairy calyxes subtended by a small involucre, and d) fruits. Photos by Mariel Boldis and Kristi Lazar.

Monterey clover has been taxonomically challenged as a cross between small-head clover (*Trifolium microcephalum*) and variegated clover (*Trifolium variegatum*) (Axelrod 1982, Ferreira 1995). Gillett (1981) reasoned that even with little evidence of hybridization, the physical attributes of Monterey clover appeared to be intermediate. However, these three species have reliably distinct morphological traits (Table 1, Yadon 1983, Vincent and Isely 2012). Monterey clover's characteristics are consistent when germinated and grown under a controlled setting (Yadon 1983, Heise and Hulse-Stephens 2012). The flowers of Monterey clover typically have translucent white tips, but flowers of small-head clover and variegated clover generally have solid lavender-white to white tips. In addition, Monterey clover is a many-seeded species, while both small-head clover and variegated clover are reliably two-seeded (Yadon 1984).

Table 1. Traits to distinguish between Monterey clover, small-head clover, and variegated clover (Vincent and Isely 2012). Involucre illustrations are from the Regents of the University of California included in the Jepson eFlora (2023). Leaflet shape photo for Monterey clover by Mariel Boldis. Leaflet shape photos for small-head clover and variegated clover are from Creative Commons contributors (2018, 2020).

Trait	Monterey clover (*Trifolium trichocalyx*)	small-head clover (*Trifolium microcephalum*)	variegated clover (*Trifolium variegatum*)
Flower color	papery-translucent white tips	solid lavender-white tips	solid white tips
Calyx	hairy, small, lobes > flower, long bristle-tips	lobes >1/2 flower, short bristle-tips	glabrous, lobes generally > flower, entire or toothed,
Involucre	small, lobes cut passed middle 	bowl shaped, entire lobes 	wheel shaped, well developed 
Seed	many (~7-8) seeded	two-seeded	two-seeded
Leaflet	oblanceolate/obovate 	obovate and notched tip 	obovate to elliptic 
Stipule	toothed or lobed, glabrous	entire to serrated, bristly	entire and toothed, glabrous

B. Life History and Ecology

Monterey clover blooms from early to late spring in April and May, and can produce fruit well into late May and mid-June based on observations of plants in Mendocino County. The Department has no information on pollinators of Monterey clover; however, native bees (which play an essential role in native plant biodiversity) have been observed pollinating other *Trifolium* species growing with Monterey clover (USFWS 2009). This suggests native pollinators may be just as important for Monterey clover as they are with other clovers (Davies 1971, Colteaux et al. 2013, Kanduth et al. 2021). Monterey clover was initially considered to be a fire follower due to its seemingly exclusive appearance following fires. Fires burned in the Monterey Peninsula in 1901 and 1987 within the Huckleberry Hill Natural Habitat Area (Huckleberry Hill) and Samuel Finley Brown (SFB) Morse Reserve, and in 1990, south of State Route 68 (Vogl et al. 1988, Jones and Stokes Associates Inc 1996*a*). Post-fire germination numbers were high for a few years before declining to zero, which might be expected for a fire-following species (Florence 1987, Tyler 1995, Doak et al. 2000, CNDDB 2022). Based on observations of plants from Mendocino County, Monterey clover is now understood to germinate in response to non-fire disturbance (USFWS 2020, pers. comm. Lemein 2022b). The species is found along the center and shoulders of roads subject to various disturbance (e.g., grading, vehicle use, foot traffic) (Heise and Hulse-Stephens 2017, Heise 2021, pers. comm. Heise 2022). Connell's Intermediate Disturbance Hypothesis indicates that the greatest species diversity is maintained by moderate forms of disturbance (Connell 1978), and may be important in maintaining rare plant richness (McIntyre and Lavorel 1994, Nagata and Ushimaru 2016). The consistent monitoring of Monterey clover (2011-2021) in Mendocino County provided a better understanding of species' response to disturbance; however, additional information is still needed to better identify what the appropriate levels of disturbance are required for long-term species' resiliency. Generally, the species is known to persist with light-moderate disturbance, strategically timed grading, encroaching vegetation removal (e.g., California blackberry), low litter layer, and maintaining local micro-topography (i.e., depressions for water accumulation).

As an annual plant, Monterey clover depends entirely on its annual seed production to replenish the soil seedbank. In the 1980's, Yadon collected Monterey clover seed and cultivated it easily in pots at the Pacific Grove Natural History Museum to better understand its taxonomy and germination needs (Yadon 1984, CDFG 1988). Under cultivation, Yadon indicated only water, space, and removal of moss was necessary to grow the species (Yadon 1984). Light is the only known germination cue for Monterey clover (Doak et al. 2000). Additional specific germination cues necessary for Monterey clover are not well understood, and the longevity of a soil seedbank between disturbance periods is also unknown. However, Monterey clover's episodic emergence suggests seeds may possibly persist in the soil seedbank up to 60 years or more. Monterey clover is also inconspicuous when it emerges, which may cause the plant to be

easily overlooked. While the possibility exists of a long-lived soil seedbank, additional evidence is still needed to understand the range in seed survival for Monterey clover.

VI. HABITAT NECESSARY FOR SPECIES SURVIVAL

Monterey clover is currently known entirely from trail margins, roadsides, the centerline of roads, and open areas with low vegetation cover and moderate disturbance. Monterey clover grows in disturbed areas (e.g., trail margins, roadbeds) with dappled sunlight through canopy openings like on north facing slopes, and prefers areas with a sparse litter layer and low competition from other species (Table 2, Heise and Hulse-Stephens 2017, pers. comm. Heise 2022, pers. comm. Lemein 2022a). Monterey clover is found on flat and moist soil depressions, rolling microtopography, and water bars (i.e., shallow channels or raised barriers of soil across road surfaces to prevent erosion) (Hendrix 2015, Heise and Hulse-Stephens 2017, McCabe 2017). The higher water holding capacity of soils with a clay hardpan at the Monterey Peninsula site (CDFG 1995, Jones and Stokes Associates Inc 1996*b*), and the loamy-clay soils at both Mendocino County sites (Soil Survey Staff 2022), seem to be important soil characteristics for Monterey clover (Table 2). Jones and Stokes Associates Inc. (1996*b*) also recognized that inland alluvial deposits support coast redwood and Monterey Pine, which may partially explain why Monterey clover is found in the coast redwood/tanoak forests in Mendocino County.

Table 2. Primary Monterey clover habitat characteristics between sites in Monterey and Mendocino counties. The Garcia River Forest (GRF) and Big River Forest (BRF) are the two sites in Mendocino.

Primary Habitat	Monterey Peninsula Sites	Mendocino (GRF, BRF) Sites
Vegetation	Monterey pine and manzanita species	coast redwood, Douglas fir, and blackberry species
Climate	annual high/low temps: 18°C/9°C (65°F/48°F), annual precip: 54 cm (21 in)	annual high/low temps: 16-19°C/9°C (61-66°F/48°F), annual precip: 119-127 cm (47-50 in); BRF warmer and drier than GRF
Geology	clayey marine terraces from sedimentary rock, granite	loose soils from sedimentary rock, sandstone
Soils	well-drained soils above a claypan	well-drained soils, where water accumulates

A. Vegetation

Monterey clover is currently known to occur in the Monterey Peninsula of Monterey County and in the Garcia River and Big River Forests of Mendocino County (CNDDB 2022). Vegetation in the Monterey Peninsula and Big River Forest have not been mapped yet using the California Vegetation Classification System (CNPS 2022), but vegetation mapping has been conducted for the areas where Monterey clover occurs in the Garcia River Forest (Keeler-Wolf et al. 2019). During a site visit to the Monterey Peninsula in 2022, Department staff determined that potential suitable habitat remains along the trails and existing fire roads in the SFB Morse Botanical Reserve where vegetation was sparse.

a. Monterey Peninsula Vegetation

In the Monterey Peninsula, Monterey clover occurs in the open understory of coastal Monterey pine (*Pinus radiata*) forest, and may be found in Bishop pine *(Pinus muricata*), Gowen cypress (*Cupressus goveniana*), and brittleleaf manzanita (*Arctostaphylos crustacea* ssp. *crustacea*) chapparal forests along the margins of hiking/biking trails and fire roads (CDFG 1979*b*, McCabe 2017, Mcgraw 2021). Herbaceous forbs found with Monterey clover include thimble clover (*Trifolium microdon*), tomcat clover (*T. willdenovii*), small head clover (*T. microcephalum*), round leaved Heermann's lotus (*Acmispon heermannii* var. *orbicularis*), cudweed (*Gnaphalium* spp.), and poison oak (*Toxicodendron diversilobum*) (USFWS 2009, McCabe 2017). Woody species most associated with Monterey clover include Monterey pine, Hooker's manzanita (*Arctostaphylos hookeri*), woolly leaf manzanita (*Arctostaphylos tomentosa* ssp. *tomentosa*), and huckleberry (*Vaccinium ovatum*) (Jones and Stokes Associates Inc 1996*a*, USFWS 2009, 2020, Mcgraw 2021). Monterey clover occurs near areas with populations of the state-listed endangered Menzie's wallflower (*Erysimum menziesii*), coastal dunes milkvetch (*Astragalus tener var. titi*), and beach layia (*Layia carnosa*); the state-listed threatened Monterey gilia (*Gilia tenuiflora ssp. arenaria*), and state-listed rare Pacific Grove clover (*Trifolium polyodon*). Monterey clover was last seen in the Monterey Peninsula in 2016, in a slight depression alongside clover spp., cudweed spp., lotus spp., and poison oak (McCabe 2017).

b. Mendocino Vegetation

In Mendocino County, the Garcia River Forest vegetation has been mapped to the alliance level. A vegetation alliance is a vegetation classification category at a broader scale than a vegetation association, that describes repeating patterns of plants across a landscape (CNPS 2022). In the Garcia River Forest, Monterey clover occurs on the margins and centerline of maintained logging roads on mesic, north-facing slopes in coast redwood (*Sequoia sempervirens*)/Douglas fir (*Psuedotsuga menziesii*)/tanoak (*Notholithocarpus densiflorus*) alliance, coast redwood/Douglas fir alliance, Douglas fir/tanoak alliance, Douglas fir alliance, and coast

whitethorn (*Ceanothus incanus*) alliance (TNC 2005, Sawyer et al. 2009, CNPS 2022). Monterey clover is found under the same mixed forests of coast redwood, Douglas fir, and tanoak in the Big River Forest (USFWS 2020, Heise 2021). Associated herbaceous species found with Monterey clover in the Big River Forest may include: variegated clover (*Trifolium variegatum*), little hop clover *(T. dubium),* clustered clover (*T. glomeratum*), rough cat's ear (*Hypochaeris radicata*), smallflower lotus *(Acmispon parviflorus),* purple cudweed (*Gamochaeta ustulata*), Pacific sanicle (*Sanicula crassicaulis*), redwood violet (*Viola sempervirens*), varied leaved collomia (*Collomia heterophylla*), modesty (*Whipplea modesta*), Douglas iris (*Iris douglasiana*), slender hairgrass (*Deschampsia elongata*), common brome (*Bromus vulgaris*), California brome (*B. sitchensis* var. *carinatus*), small quaking grass (*Briza minor*), sweet grass (*Athoxanthum* spp.), common velvet grass (*Holcus lanatus*), sweet bedstraw (*Galium triflorum*), and rush (*Juncus* spp.) (Heise and Hulse-Stephens 2012, Heise 2021). In addition to these species, associated species with Monterey clover in the Garcia River Forest may also include: small head clover, thimble clover, few flowered clover (*T. oliganthum*), tomcat clover, notchleaf clover (*T. bifidum*), western fescue (*Festuca occidentalis*), nodding trisetum (*Trisetum canescens*), and the rare Santa Cruz clover (*T. buckwestiorum)* (Heise and Hulse-Stephens 2016, 2017). California blackberry (*Rubus ursinus*) or black-cap raspberry (*R. leucodermis*) may encroach into Monterey clover habitat along the edges of roads that are already occupied by Monterey clover at both Mendocino County sites (Figure 2, Heise and Hulse-Stephens 2016).

Figure 2. Monterey clover habitat with blackberry species and herbaceous vegetation encroaching along the road margins in the Garcia River Forest. Pink and blue flags circled in red show where Monterey clover was observed during a site visit by the Department in 2022. Photo by Kristi Lazar.

B. Geology and Soils

The Department's previous Monterey clover five-year species review from the late 1980s (CDFG n.d.) noted that Monterey clover occurred in the nutrient-poor, older podzol-like soils that were dominated by Gowen cypress in the Monterey Peninsula. Monterey clover populations in Mendocino County were not documented until 2011 and occur on moderately well-draining soils of weathered sandstone (Heise and Hulse-Stephens 2012). The Department's current understanding of geologic and soil preferences for Monterey clover is that it prefers sandy to gravelly loam soils above a claypan or feature where water may accumulate.

a. Monterey Peninsula Geology and Soils

In the Monterey Peninsula, Monterey clover is restricted to low elevations (100-215 m, 325-700 ft) associated with nutrient-depleted soils and weathered soil horizons of the fifth and sixth marine terraces that are at least 400,000 years-old (CDFG 1995, Jones and Stokes Associates Inc 1996*a*, *b*). Marine terraces are wave-cut platforms in bedrock formed because of geologic uplift and changes in sea-level over time (Schulz et al. 2018). Monterey clover occurs on poorly drained Narlon loamy fine sand soils described as having thin or no A horizon (i.e., topsoil) with bright red mottles in the B horizon (i.e., accumulation of clay and minerals below topsoil) before hitting a compact sandy claypan at about 33 cm (13 in) below the surface (Soil Survey Staff 2003*a*, 2022). Monterey clover also occurs on well-drained Sheridan coarse sandy loam soils (Jones and Stokes Associates Inc 1996*a*, Soil Survey Staff 2003*b*, 2022). Geologic parent materials consist of residuum weathered from granitoid or clayey marine deposits from sedimentary rock (Soil Survey Staff 2022). In the Monterey Peninsula, Monterey clover occasionally appears to prefer moist areas of "deep granitic" soils beneath Monterey pine, rather than in nutrient poor soils directly under Gowen cypress and Bishop pine (Morey 1988*a*, Schulz et al. 2018).

b. Mendocino Geology and Soils

In Mendocino County, Monterey clover occurs on moderate to well-drained loam, gravelly-loam, and gravelly loam-clay soils (Soil Survey Staff 2022). The soils from both the Garcia River Forest and Big River Forest Monterey clover sites are derived from parent materials consisting of colluvium (i.e., material accumulated at base of slope) or residuum (i.e., material weathered in place) from sedimentary rock (Soil Survey Staff 2022). Where Monterey clover is found in the Garcia River Forest, soils (from largest to smallest area occupied) include the: the Vandamme-Irmulco-Tramway complex (loam – clay), Dehaven-Hotel complex (gravelly loam – very gravelly sandy clay loam), Irmulco-Tramway complex (loam – gravelly loam), and Ornbaun-Zeni complex (loam – clay loam). In the Big River Forest, Monterey clover occurs on well-drained Vandamme loam soils. Vandamme soils, which may be most relevant to Monterey clover since they are

found on marine terraces, are described as having a pale to yellowish-brown, moderately acidic (pH 5.0 to 5.7) loamy topsoil before hitting hard sandstone at about 1.1 m (3.5 ft) (Soil Survey Staff 2003*c*). Monterey clover that is found on the other soil series are generally described as having loamy topsoils and accumulation of clay-loam below the topsoil before hitting sandstone at 0.7 m (2.3 ft) to 1.5 m (5 ft) (Soil Survey Staff 2003*d*, *e*, *f*, *g*, *h*, *c*, *i*).

C. Climate and Hydrology

Monterey clover grows in a Mediterranean climate that is characterized by warm to hot, dry summers, and cool, wet winters. The species occurs in transitional ecological zones between the hot, dry systems of the Central Coast of California and the temperate, wetter systems of the North Coast of California (Zander Associates 2001). Annual precipitation primarily arrives in the winter, but Monterey clover sometimes experiences summer fog due to a coastal influence. Monterey clover is flowering and fruiting April to June which is also right before the driest and warmest months of the year. While temperature variation is relatively similar at all the populations during any given month (±3°C, ±37°F), variations in monthly precipitation are more notable between Monterey clover sites (Figure 3).

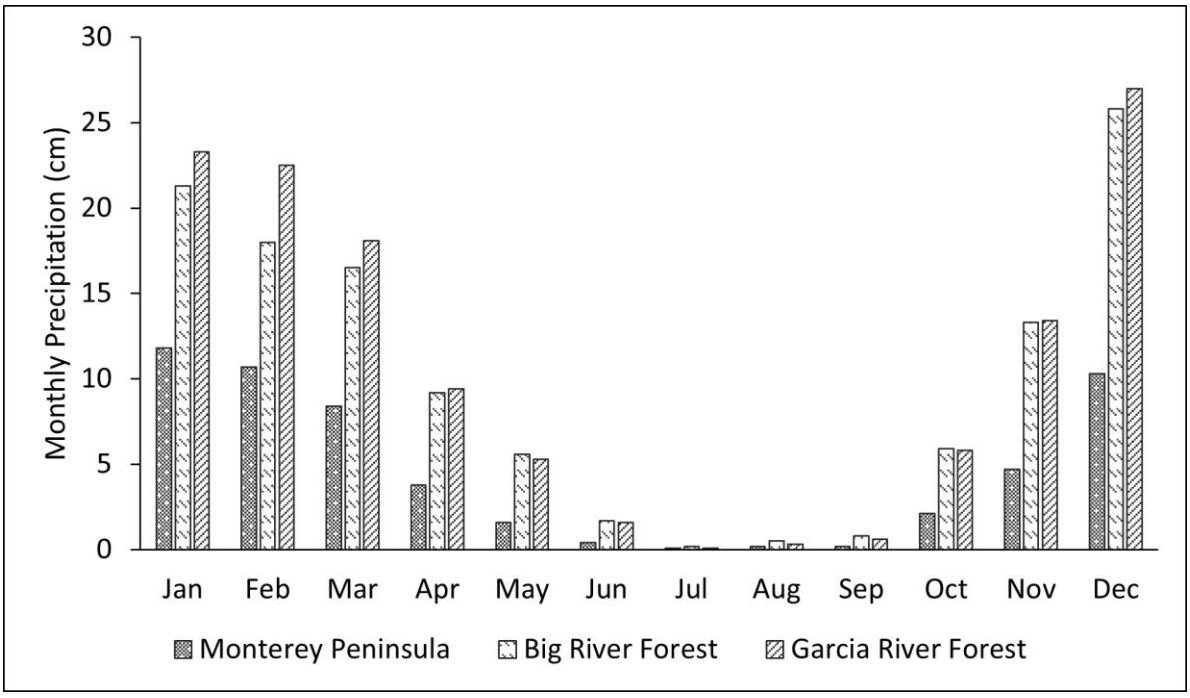


Figure 3. The monthly 30-year normal precipitation for the three Monterey clover sites. The PRISM time series uses the Norm91m dataset based on 1991-2020 normals (PRISM Climate Group 2021).

a. Monterey Peninsula Climate and Hydrology

In the Monterey Peninsula, the estimated annual precipitation total is 54 cm (21 in), and the estimated annual high/low temperatures are 18°C/9°C (65°F/48°F). The clay hardpan below the soil surface helps accumulate and retain moisture for Monterey clover during winter floods (Yadon 1984, 1987, CDFG 1987, Jones and Stokes Associates Inc 1996*a*, McCabe 2017). Even where a hardpan is not characteristic of the soils, like on Huckleberry Hill located near Pebble Beach (Soil Survey Staff 2003*b*), Monterey clover is still found in depressions where water may accumulate (McCabe 2017).

b. Mendocino Climate and Hydrology

In the Garcia River and Big River Forests, there are slight differences in climate. In the Garcia River Forest, the estimated annual precipitation total is 127 cm (50 in) and the estimated mean annual high/low temperatures are 16°C/9°C (61°F/48°F) (Figure 4, PRISM Climate Group 2021). Compared to the Garcia River Forest, the Big River Forest is drier and warmer. The estimated annual rainfall total in the Big River Forest is 119 cm (47 in) and the estimated mean annual high/low temperatures are 19°C/9°C (66°F/48°F) (Figure 5, PRISM Climate Group 2021). During good precipitation years, the species forms clusters or dense mats along the roadbed (Heise 2021).

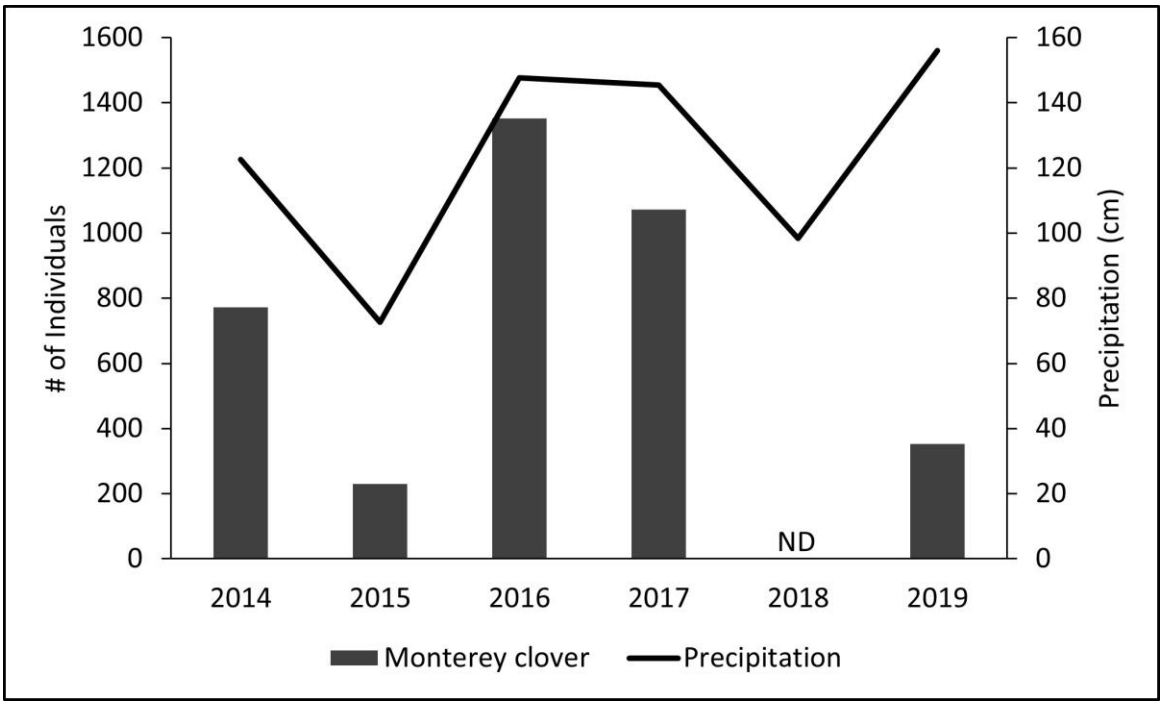


Figure 4. Estimated Monterey clover population counts and total mean annual precipitation in the Garcia River Forest 2014-2019. No data (ND) is available for 2018. Fall grading occurred

2014-2016 after the seed set and before germination in at least one subpopulation (PRISM Climate Group 2021).

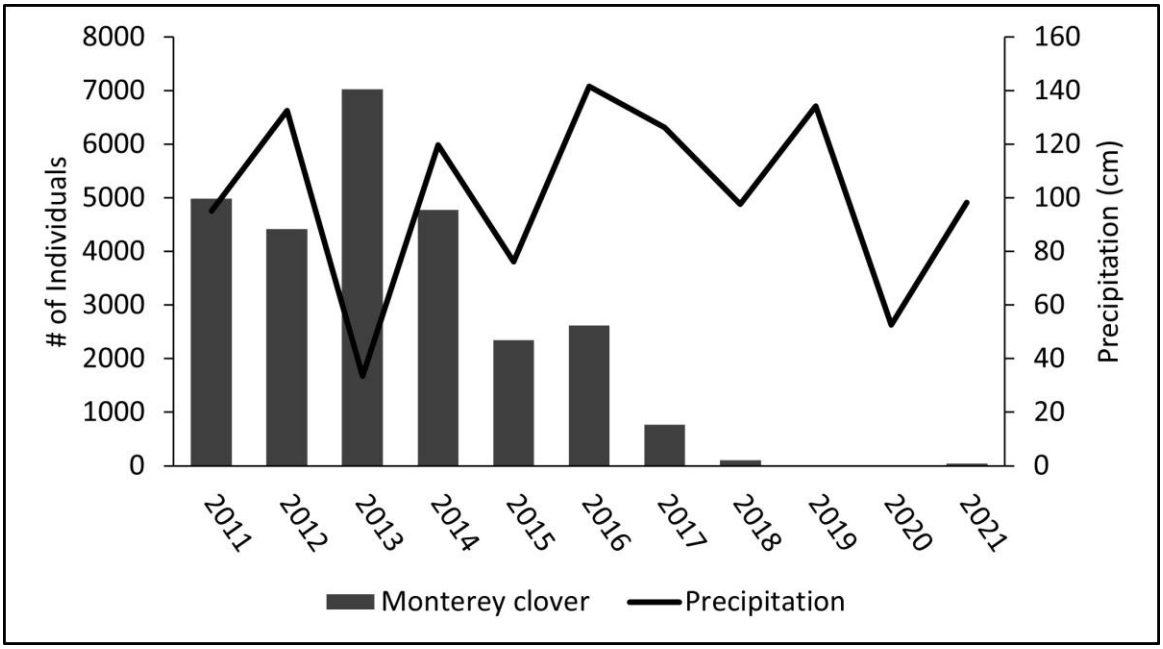


Figure 5. Estimated Monterey clover population counts and total mean annual precipitation in the Big River Forest (BRF) 2011-2021. Fall grading occurred 2011, 2015, and 2017 after the seed set and before germination in at least one subpopulation (PRISM Climate Group 2021).

VII. DISTRIBUTION AND ABUNDANCE

A. Range and Distribution

Range is the general geographical area in which an organism occurs. For purposes of CESA the range is the species' California range only (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal.App.4th 1535, 1551). Species distribution describes the actual sites where individuals and populations of the species occur within the species' range.

The historical range of Monterey clover is not known. The current range of Monterey clover includes the western, coastal portions of Monterey County (Griffin 1979, TNC 1984, Yadon 1984, USFWS 2009) and Mendocino County (USFWS 2020) at elevations between 100 and 215 m (325 and 700 ft). The distribution of Monterey clover consists of six documented California Natural Diversity Database (CNDDB) Element Occurrences (EOs) (i.e., populations), which are mapped populations greater than 0.4 km (0.25 mi) apart. These six EOs have been grouped into three isolated sites in this Species Review (Figure 6, Table 3, CNDDB 2022). One site is the Monterey Peninsula in Monterey County, and two sites (Garcia River Forest and Big River Forest) are in western Mendocino County. Although the range expanded into Mendocino

County in 2011 (Figure 8), little is known about specific habitat conditions that connect this species between Monterey and Mendocino counties and where else this species may occur (USFWS 2020, pers. comm. Lemein 2022b). Surveys in large areas are often incomplete since smaller species (e.g., clovers) can be overlooked and the timing of surveys may not correspond with Monterey clover's flowering.

Table 3. Three sites with six Element Occurrences (EOs) of Monterey clover. The Monterey Peninsula site has two EOs in Monterey County. The Samuel Finley Brown (SFB) Morse Reserve EO includes nine subpopulations (sub-pop) and the State Route (SR) 68 EO includes one population. In Mendocino County, there are two sites with four EOs. The Big River Forest (BRF) site has one EO with one population, and the Garcia River Forest (GRF) site has three EOs with 12 sub-pops.

Site Name	EO	Occurrence	Sub-pop	Species Status	Last Seen
Monterey Peninsula	1	SFB Morse Reserve	9	Extant (presumed); parts possibly extirpated	2016
Monterey Peninsula	5	SR 68	1	Extant (presumed)	1990
Big River Forest	6	BRF	1	Extant (presumed)	2021
Garcia River Forest	7	Central GRF	2	Extant (presumed)	2019
Garcia River Forest	8	South GRF	6	Extant (presumed)	2019
Garcia River Forest	9	North GRF	4	Extant (known)	2022

a. Monterey Peninsula Range and Distribution

Monterey clover was documented in the Monterey Peninsula on May 1903. The Monterey Peninsula site consists of two CNDDB occurrences (EOs 1 and 5). The area Monterey clover may have occupied was estimated to be around 710 ha (1,754 ac) based on Jones and Stokes (1996a) assessment of geological and soil associations with fifth and sixth marine terraces. Monterey clover may have also once occupied now-developed areas of Pacific Grove based on vague 1903 and 1907 collections from "sandy pine woods" (Calflora 2022, CCH2 2022); however, these collections may also be referencing the same area as EOs 1 and 5, which is adjacent to Pacific Grove (Ferreira 1995).

i. <u>Samuel Finley Brown (SFB) Morse Reserve (EO1)</u>

EO 1 contains nine subpopulations of Monterey clover with a scattered distribution limited to about 83 ha (206 ac, Table 3), occurring on private lands owned by the Del Monte Foundation Inc., Pebble Beach Company, Poppy Holding Inc., and private homeowners (Figure 7). Subpopulation 1a is not on protected lands. The entirety of subpopulations 1c to 1f and 1h, and most of subpopulations 1b, 1g and 1i, are located within the SFB Morse Reserve and

Huckleberry Hill. These are Environmentally Sensitive Habitat Areas (ESHAs) and are permanently protected from development (Monterey County 2012) as conservation easements within designated Open Spaces outlined in the Del Monte Forest Area Land Use Plan (DMF LUP, Appendix A).

ii. State Route 68 (EO 5)

EO 5 is a single population of Monterey clover growing along the road margins after a 1990 fire that burned south of Holman Highway. This occurrence is about 1.2 km (0.75 mi) north of EO 1. EO 5 also occurs on land designated as a conservation easement owned by Pebble Beach Company and is permanently protected from development under the DMF LUP (Monterey County 2012).

b. Mendocino Range and Distribution

In Mendocino County, Monterey clover was first documented during botanical surveys for timber harvesting plans (THPs) in the Big River Forest in 2011 and in the Garcia River Forest in 2014. The Big River Forest site and Garcia River Forest site are designated as conservation easements, and consist of four CNDDB occurrences (EOs 6-9). The Big River Forest site contains one occurrence (EO 6), with a single population, and is about 320 km (200 mi) north of the Monterey Peninsula site. The Garcia River Forest site contains three occurrences (EOs 7-9) with 12 subpopulations (Figure 8, Table 3, Heise 2021). This site is about 300 km (186 mi) north of the Monterey Peninsula site and about 45 km (28 mi) south of the Big River Forest site, near the North Fork of the Garcia River (Heise and Hulse-Stephens 2017). Monterey clover is found on active logging roads that are managed and owned by The Conservation Fund. Surveys in 2016, 2017, and 2019 at the Garcia River Forest site documented new areas where Monterey clover spread further east for EO 7, southeast for EO 8, and north for EO 9 (Figure 8, Heise 2019).

The number of Monterey clover plants generally increased in 2016 in all Mendocino County occurrences. The distribution of plants also expanded down the length of the road along the margins and on the roadbeds in both forests (Heise and Hulse-Stephens 2017, Heise 2021). This expanded distribution and increase in population size may be due to a combination of the following factors: (1) more available habitat from road grading in 2015 that occurred in EO 6, 7, 8, and portions of 9, and (2) an unusually high precipitation year in 2016 (Figure 4).

iii. Big River Forest (EO 6)

EO 6 contains a single population that occurs across the width of a seasonally used road, linearly covering approximately 84 m (275 ft) of road (Heise 2021). EO 6 quickly declined to less than 150 individuals by 2018, and the population did not rebound (Figure 5).

iv. Central Garcia River Forest (EO 7)

EO 7 contains two subpopulations (7a and 7b) of Monterey clover. In 2014 and 2015, the species covered less than 0.1 m (0.3 ft) of road. In 2016, additional Monterey clover plants were found and they covered 2.1 m (7 ft) of roadbed. In 2017, up to 3 m (10 ft) of road was covered with plants before reducing to 1 m (3.3 ft) in 2019.

v. South Garcia River Forest (EO 8)

EO 8 contains six subpopulations (8a to 8f) of Monterey clover. In 2014 and 2015, plants covered about 10 m (33 ft) of road along the margins and roadbed. In 2016, Monterey clover expanded its distribution and covered up to 74 m (243 ft) of road. Although subpopulations 8c to 8f were not surveyed in 2017, surveys in subpopulations 8a and 8b documented Monterey clover along 46 m (151 ft) of road. In 2019, all subpopulations were located along the margins and roadbed, occupying 50 m (164 ft) of road.

vi. North Garcia River Forest (EO 9)

EO 9 contains four subpopulations (9a to 9d) of Monterey clover. Subpopulation 9d includes the only two areas in the Garcia River Forest site (EOs 7-9) that did not experience road grading during monitoring. In 2014 and 2015, Monterey clover covered 52 m (170 ft) of road along the margins and roadbed. In 2016, Monterey clover's distribution increased to 126 m (413 ft) of road, and in 2017 increased to 230 m (755 ft) of road, before reducing to about 88 m (289 ft) in 2019. No survey was performed in 2018. In 2016, 9d was the only subpopulation where zero plants were observed (Heise and Hulse-Stephens 2017, Heise 2019). Department staff visited subpopulations 9a and 9c in 2022 (Figures 8, 9). The species did not cover as much area along the length of the road than in previous years, likely due to encroaching vegetation since the last known grading in fall of 2016 (Heise 2019, pers. comm. Heise 2022).

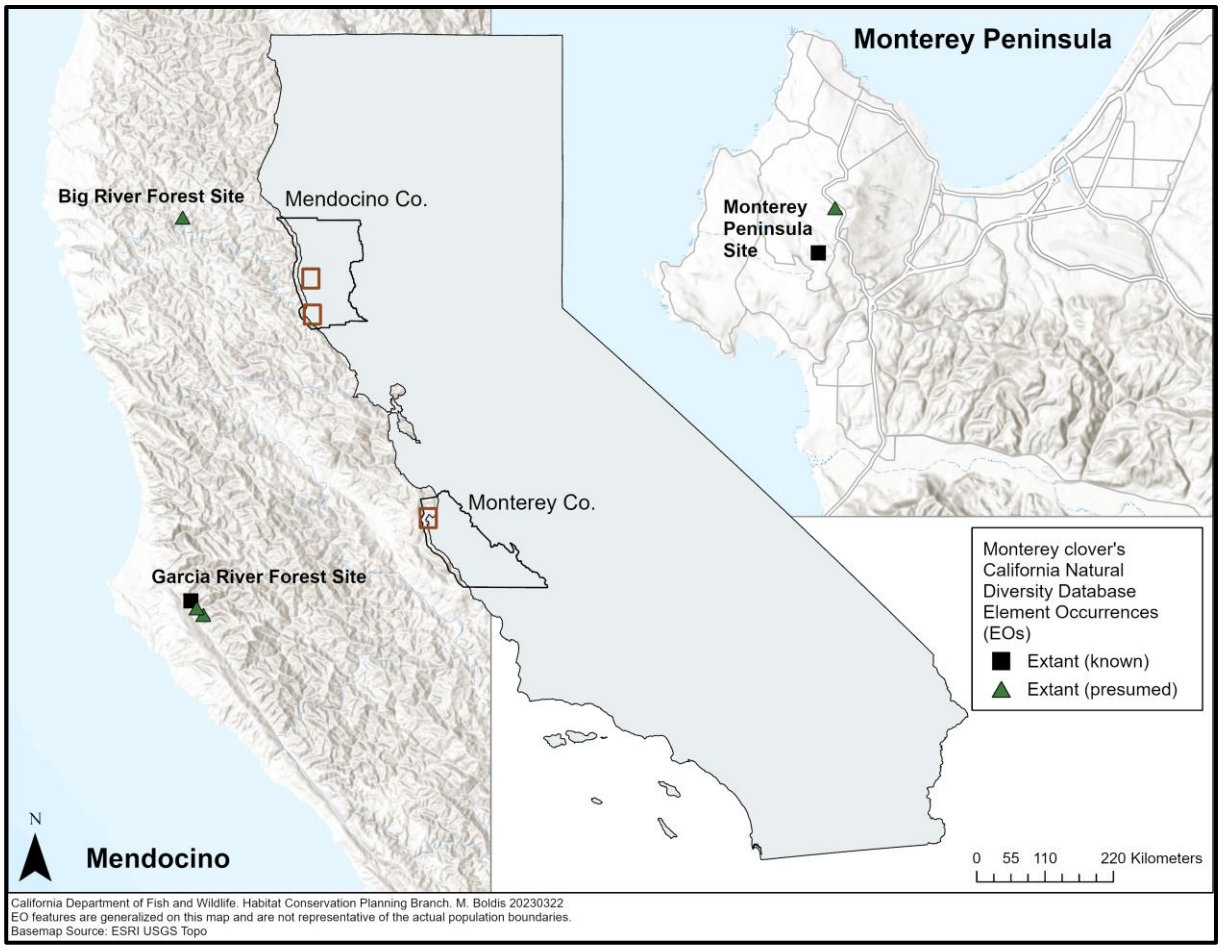


Figure 6. Distribution and range map of the three Monterey clover sites. Within the three sites, there are six documented CNDDB Element Occurrences (EOs). Known extant EOs are shown with black squares and presumed extant EOs are shown as green triangles (CNDDB 2022).

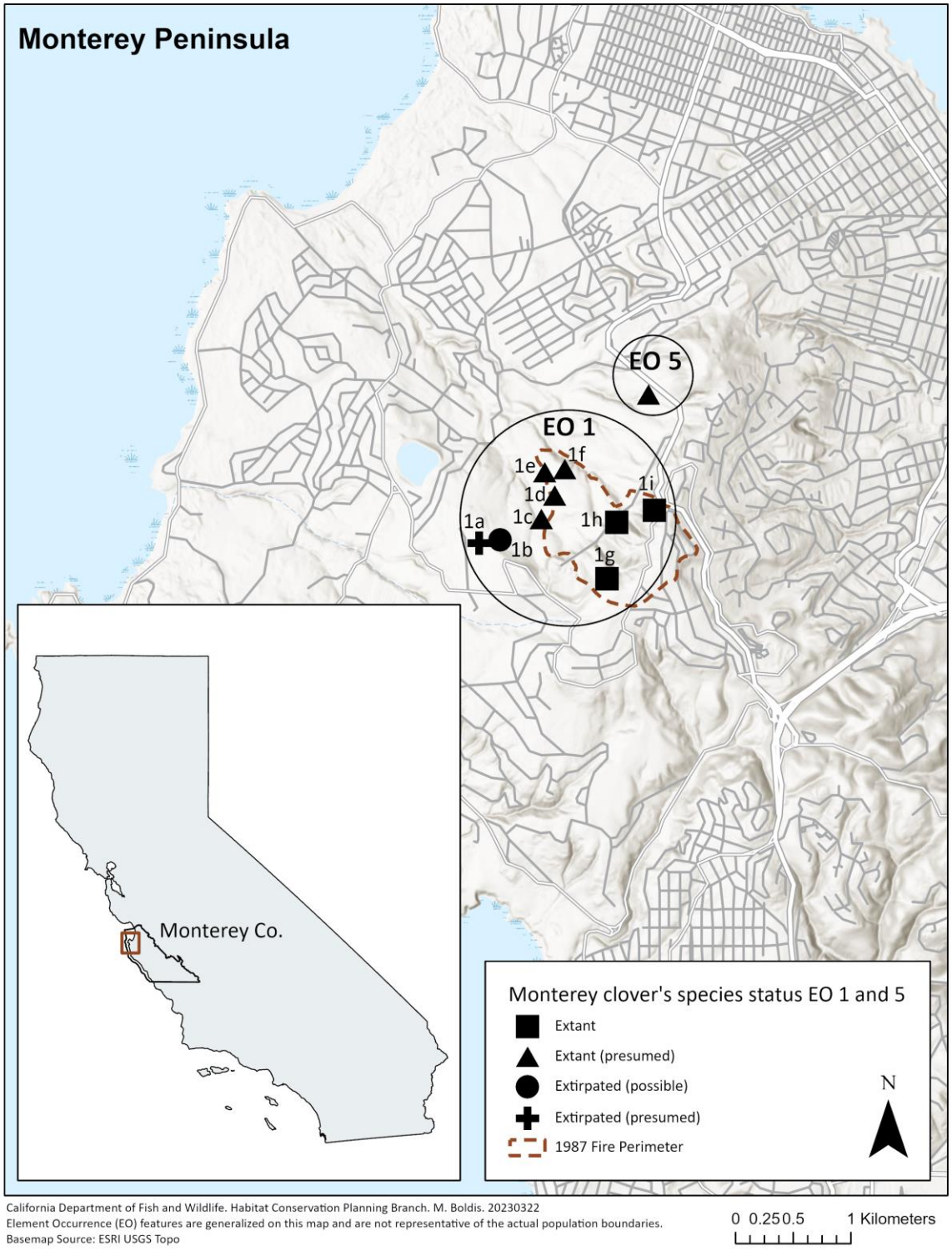


Figure 7. Element Occurrences (EOs) 1 and 5 of Monterey clover within the Monterey Peninsula site. The status of each subpopulation is indicated by different symbology. The boundary of the 1987 Huckleberry Hill fire is also shown on this figure.

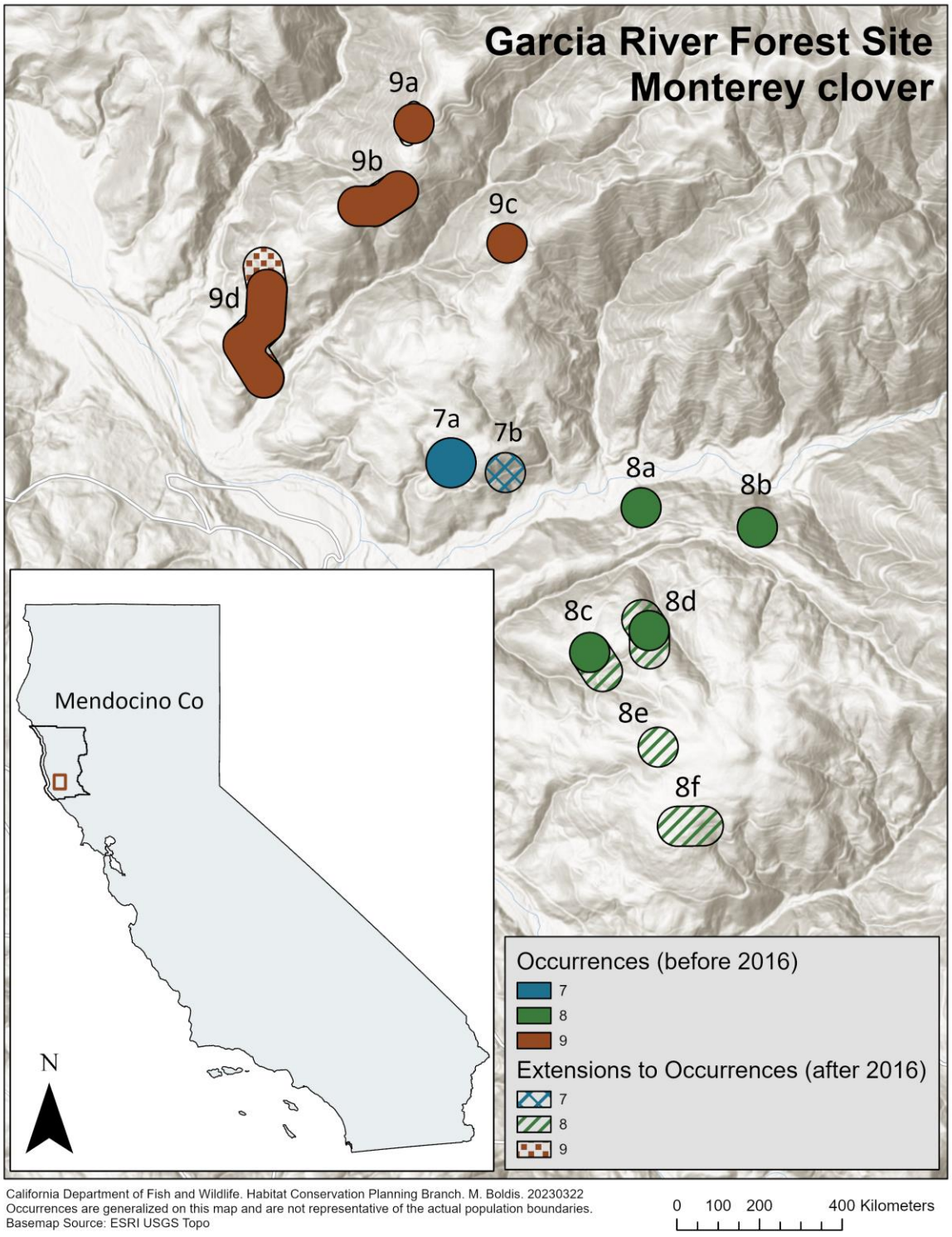


Figure 8. Changes in distribution by subpopulation for Element Occurrences (EOs) 7-9 of Monterey clover in the Garcia River Forest site, Mendocino County. EOs show the species' distribution from 2014 (first documented) to 2016, and extensions to EOs after 2016. EOs are generalized on this map and are not representative of the actual population boundaries.

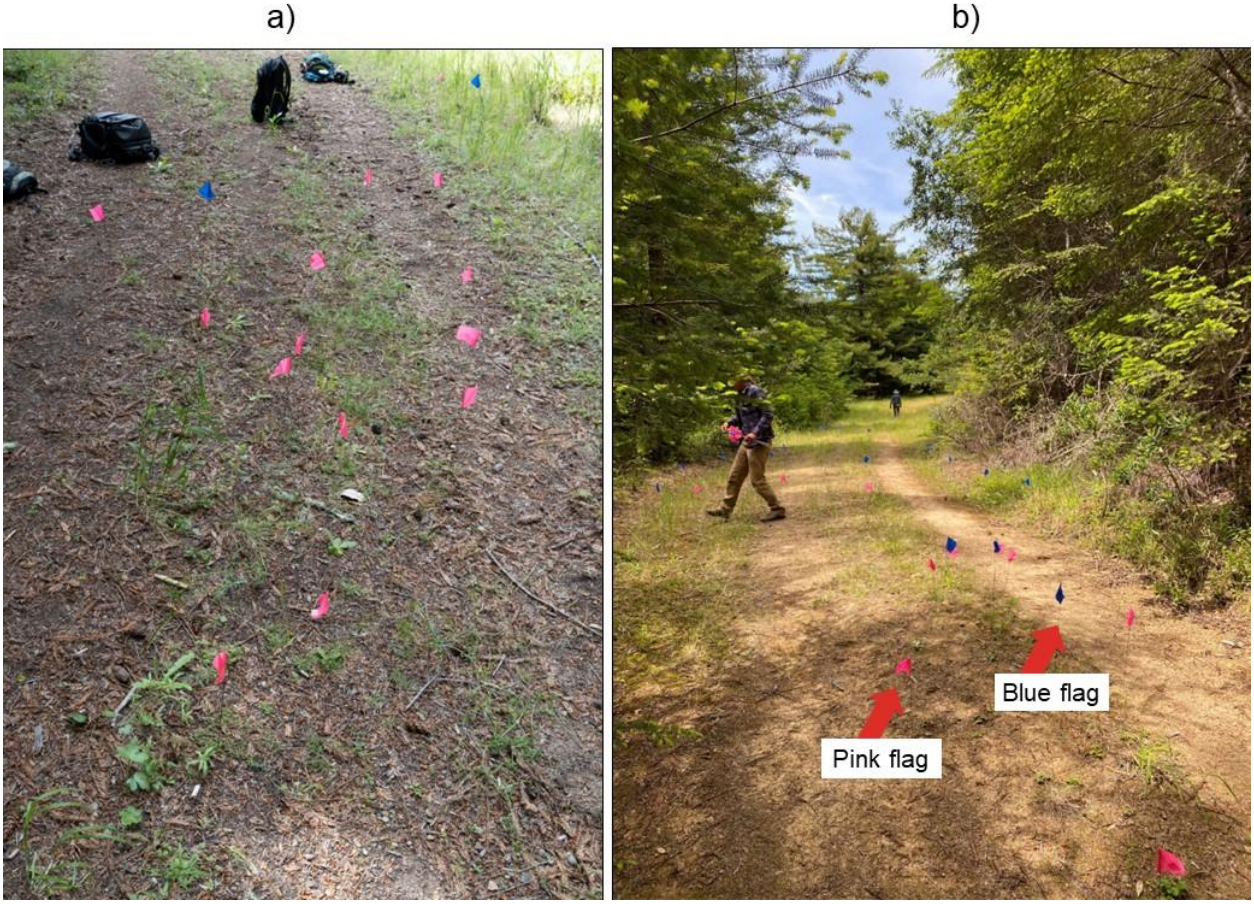


Figure 9. Monterey clover (pink flags) and the rare Santa Cruz clover (blue flags) growing along the center and outer margins of the road within Element Occurrence (EO) 9 in a) subpopulation 9a, and b) subpopulation 9c, during a Department site visit of the Garcia River Forest site, Mendocino County in 2022. **M**onterey clover at subpopulation 9a was observed in moist and shaded areas, while Monterey clover at subpopulation 9c was observed in drier, bare areas. Photos by Mariel Boldis and Kristi Lazar.

B. Population Trend and Abundance

Monterey clover population sizes have fluctuated since the species was first documented in 1903 in Monterey County, and only since 2011 in Mendocino County. The Monterey Peninsula site (EOs 1, 5) has been surveyed infrequently between 1973 and 2022 (Table 4). When Monterey clover was found in Mendocino County in 2011 (EO 6) and in 2014 (EOs 7-9), it renewed interest in the species after a lack of surveys for 13 years (Table 4). While the soil seedbank appears to be long-lived (possibly up to 60 years or more), no more than 1,000 individuals have ever been documented on the Monterey Peninsula. Population sizes for Monterey clover in Mendocino County range between 50-7,000 individuals. Trends and abundances of individual populations are discussed below.

a. Monterey Peninsula Site

Following a fire in 1901, Monterey clover specimens were collected from unspecified locations in Pacific Grove in 1903 (Ferreira 1995). No known Monterey clover surveys were recorded in the Monterey Peninsula between 1907 and 1973, and the species was not found during surveys between 1980 and 1987. Monterey clover is considered extant at SFB Morse Reserve and was last seen there in 2016. Monterey clover was observed along State Route 68 in 1990 after a small fire, observed again in 1995, and has not been seen at that site since then (Figure 7, Yadon 1987, Jones and Stokes Associates Inc 1996a, CNDDB 2022)

i. SFB Morse Reserve (EO 1)

Surveys in 1973 documented only a few individuals of Monterey clover, and the species was not found during surveys for eight years (1980-1987). After the Huckleberry Hill fire of 1987 which burned approximately 65 ha (160 ac, Figure 7), Mary Ann Griggs observed hundreds of Monterey clover plants growing mostly on north-facing slopes (Yadon 1987, Morey 1988*a*). This population was threatened by development on the east side of 17-mile Drive on the lower boundary of the area that burned (Niehaus 1977, Elliot 1988, USFWS 2009, CNDDB 2022). Post-fire surveys in 1988 documented the largest count of Monterey clover (100-1,000 individuals) in EO 1 subpopulation 1g near Costanilla Way. Monterey clover was surveyed for again in 1995 and only 22 individuals were found in subpopulations 1g and 1h. No plants were found in 1998, 2017, and 2020-2022 surveys; however, 23 plants were counted in 2016 in the southern-most portion near Costanilla Way of subpopulation 1g (McCabe 2017, Mcgraw 2021, CNDDB 2022).

In the two western-most subpopulations (1a and 1b) near the Poppy Hills Golf Course, Monterey clover has only been observed in small numbers prior to the 1987 fire. Subpopulation 1a has been replaced by the golf course and is presumed extirpated, and subpopulation 1b is limited to patches under Monterey pine and Gowen cypress stands adjacent to the golf course and is possibly extirpated (Figure 7, Yadon 1987, Mcgraw 2021). Small numbers of Monterey clover have been observed in clearings scattered along fire break roads in subpopulations 1c and 1d before 1987, and 1e, 1f, and 1i in 1988. Monterey clover has not been observed in these subpopulations since (Figure 7, CNDDB 2022).

ii. State Route 68 (EO 5)

A few scattered Monterey clover individuals along State Route 68 of Holman Highway were observed following a small fire in 1990, and again in 1995 (Jones and Stokes Associates Inc 1996*a*). Monterey clover was not found in this area during surveys in 2016-2017 and 2020-2022 (McCabe 2017, Mcgraw 2021, CNDDB 2022).

b. Mendocino Site

Following the first encounter of Monterey clover in Mendocino County during botanical surveys for THPs, long-term monitoring was recommended to support conservation and management of Monterey clover in the Big River and Garcia River Forests (Heise and Hulse-Stephens 2012, 2016, Hendrix 2015). To track yearly variation in species presence and abundance within each occurrence, nine permanent monitoring plots were established by Heise and Hulse-Stephens in 2011 in the Big River Forest (EO 6) (Heise and Hulse-Stephens 2012). In the Garcia River Forest (EOs 7-9), nine permanent monitoring plots were established in 2014, 12 additional plots in 2016, and one more plot in 2017 (Heise and Hulse-Stephens 2016, 2017). Surveys occurred once per year between May and July across permanent transects to ensure the entire range of habitat was sampled (Table 4). While not all plots experienced road grading during the monitoring period (only within EO 9d), all plots were regularly disturbed (i.e., logging truck and vehicle use). Subpopulations 7a, 8a, 9b to 9d of EOs 7-9 were first documented in 2014 and monitored yearly through 2017 and again in 2019 to understand how differing levels of road disturbance (e.g., vehicle use, grading) may influence population size (Heise and Hulse-Stephens 2016). Based on data provided, EOs 7-9 peaked in 2016 with about 1,400 plants and the subpopulations generally increased in abundance in response to moderate disturbance (Heise 2019). Areas where Monterey clover abundance was low between years, an increase in encroaching vegetation (e.g., California blackberry, tansy ragwort) was observed (Table 4, Heise and Hulse-Stephens 2017, pers. comm. Heise 2021, 2022).

iii. <u>Big River Forest (EO 6)</u>

EO 6 is the first known population of about 5,000 individuals of Monterey clover found outside of the Monterey Peninsula as part of a botanical survey for a THP along the upper East Branch Little North Fork Big River (Heise and Hulse-Stephens 2012, 2017, Odegard et al. 2012, USFWS 2020). This population was monitored regularly for ten years (2011-2021), peaking in 2013 with more than 7,000 plants. Monterey clover averaged 5,300 plants per year (2011-2014), before declining to below 1,000 plants beginning in 2017. While more Monterey clover plants were counted in 2013, Heise (2021) noted the individual plants were smaller and single-stemmed compared to plants in 2011 and 2012. This steep decline and smaller plant size may be attributed to species composition changes in competing vegetation (e.g., increasing California blackberry), precipitation and drought at a micro-habitat scale, and timing/frequency of road disturbance (pers. comm. Heise 2022). Between 2019 and 2021, EO 6 averaged 34 individuals which is approximately 1% of the original population (Heise 2021, 2022). In the last year of monitoring (2021), there were only 55 individuals observed in open areas with little to no competing vegetation (Heise 2021).

iv. Central Garcia River Forest (EO 7)

Subpopulation 7a of EO 7 is relatively small with only a single plant or a few individuals documented each year between 2014 and 2016, eight plants observed in 2017, and none observed in 2019. Subpopulation 7b is also relatively small with five or fewer plants documented when surveyed 2016-2017, and in 2019.

v. South Garcia River Forest (EO 8)

Subpopulation 8a of EO 8 is the first known subpopulation documented for this occurrence and the only subpopulation for EO 8 surveyed during the entire monitoring period for the Garcia River Forest site (2014-2017, 2019). Less than 50 individuals were documented for each visit before declining to just 4 plants in 2019. Subpopulation 8b was surveyed in 2016-2017 with more than 120 plants the first two years before declining below 100 plants in 2019. Subpopulations 8c to 8f were only surveyed in 2016 and 2019. Subpopulation 8c contained the largest plant count (349 plants) in 2016 and declined to zero plants in 2019.

vi. North Garcia River Forest (EO 9)

EO 9 is the most consistently monitored occurrence in the Garcia River Forest site. Subpopulations 9b to 9c and most of 9d were surveyed during the monitoring period (2014-2017, 2019). Subpopulation 9b averaged 82 plants the first two survey years, peaked in 2016 with 541 plants, followed by a decline in 2017 (318 plants), and only 21 plants in 2019. Subpopulation 9c was first counted in 2014 and had 215 plants. Each subsequent visit, 50 or more plants were observed, averaging 64 plants per year (2015-2017, 2019). Monterey clover in subpopulation 9a was first documented in 2016 with 24 individuals observed, followed by 250 in 2017, and 150 in 2019. During a 2022 site visit, Department staff documented about 200 individuals in subpopulation 9a and about 41 individuals in subpopulation 9c (Figure 9), which was dominated by Santa Cruz clover (*T. buckwestiorum*). Monterey clover individuals were generally robust with many branches. At least eight *Trifolium* spp. were found co-occurring with Monterey clover. The two plots in subpopulation 9d that were surveyed in 2016-2017, and again in 2019, recorded 6 or fewer plants each year.

Table 4. Monterey clover population estimates and specimens collected from 1903 to 2022. Estimates are from the following: (1) periodic surveys, seed, and herbarium specimens collected 1903-2022 in the Monterey Peninsula (Doak et al. 2000, McCabe 2017, Mcgraw 2021, CCH2 2022, CNDDB 2022), (2) periodic monitoring (2014-2017, 2019) in the Garcia River Forest (Heise 2017, pers. comm. Heise 2022), and (3) a 10-year monitoring period (2011-2021) in the Big River Forest (Heise 2021). Hyphens mean there is no survey or no known collection of Monterey clover specimen or seed on record.

Year	Monterey Peninsula	Big River Forest	Garcia River Forest
1903	6 specimens	-	-
1904 - 1906	-	-	-
1907	5 specimens	-	-
1908 - 1972	-	-	-
1973	few plants, specimen	-	-
1974 - 1975	specimen(s)	-	-
1976 - 1977	-	-	-
1978	specimen	-	-
1979	few plants, 2 specimens		
1980 - 1987	-	-	-
1988	100-1000 plants, 2 specimens	-	-
1989	-	-	-
1990	small no. plants	-	-
1991	specimen	-	-
1992	0	-	-
1993 - 1994	-	-	-
1995	22	-	-
1996 - 1997	-	-	-
1998	viable seed	-	-
1999 - 2010	-	-	-
2011	-	5000 plants, 6 specimens	-
2012	-	4433	-
2013	-	7040	-
2014	-	4793	775
2015	-	2361	233
2016	23	2634	1355
2017	0	783	1074
2018	-	120	-
2019	-	26	356
2020	0	21	-
2021	0	55	-
2022	0	-	241

VIII. THREATS AND SURVIVAL FACTORS

A. Factors Affecting Ability to Survive and Reproduce

At the time Monterey clover was listed as endangered under the NPPA in 1979, and later listed as endangered under CESA in 1984, threats to the species included: a) low number of

individuals (inbreeding depression), and b) modification or destruction of habitat (CDFG 1979*b*). At the time of listing, Monterey clover was only known from the Monterey Peninsula and very few plants had been documented, making it highly susceptible to local extirpation (CDFG 1979*b*). Habitat loss has been primarily in the form of urban residential and non-residential expansion and golf course development. For this Species Review, the Department identified three additional threats: c) altered disturbance regimes, d) competition, and e) climate change. Explanation of how these factors currently threaten the species' survival are described below.

a. Low number of individuals (inbreeding depression)

Monterey clover populations likely experienced several genetic bottlenecks. From 1903, and before the species was first documented in Mendocino County in 2011, Monterey clover had only been known from two occurrences along trails, roadsides, and seasonally moist depressions in Pebble Beach and Huckleberry Hill within the SFB Morse Reserve. No more than 1,000 individuals have ever been documented on the Monterey Peninsula. The Mendocino sites first documented in 2011, contain populations that are more widely distributed and abundant. However, annual population counts continue to be drastically variable (50-7,000 individuals). For instance, approximately 1% of the original population was observed in the final three years (2019-2021) of a 10-year monitoring period for the Big River Forest population (Heise 2021). A persistently low abundance could contribute to a loss of genetic diversity. This may further impact Monterey clover's resiliency to stochastic events, such as those listed under the present or threatened modification or destruction of habitat, and altered disturbance regimes sections.

b. Present or threatened modification or destruction of its habitat

In the Monterey Peninsula, Monterey clover habitat has been modified or destroyed through conversion to residential use, recreational use (a golf course), and mineral extraction (Sullivan and Chambers 1992). In the 1930s, a rock quarry that primarily produced decomposed granite was established near Sunridge Road and Costanilla Way, which is near the Huckleberry Hill Monterey clover population (EO 1). In 1985, the site was terraced and stabilized, and part of the decomposed granite quarry was redeveloped into what is now a green-waste composting facility (Page &Turnbull Inc. 2013). Regular mowing of fire roads, herbicide use in the nearby golf course, inadvertent trampling by recreational use, yard waste disposal, and excess mulching continue to potentially threaten Monterey clover. Trail development and expanded use of existing hiking trails for mountain bikes may be a growing threat for plants on the Monterey Peninsula (McCabe 2017, Mcgraw 2021). In Mendocino County, Monterey clover continues to be threatened by road grading, logging, and slash piles. Monterey clover is also primarily found along logging roads with varying levels of use and maintenance. Vehicle use (e.g., ruts formed from road use during or after inclement weather, off-roading) and road

maintenance activities (i.e., grading, erosion control) can negatively impact Monterey clover by altering local hydrology, increasing non-native species cover (e.g., French broom (*Genista monspessulana*), rough cat's ear, annual grasses), and promoting encroachment by woody species (e.g., California blackberry). All present-day occurrences of the species are on private lands, and most are protected from development under conservation easements. In the Monterey Peninsula within EO 1, the entirety of subpopulation 1a and a portion of subpopulation 1b are not protected and are likely extirpated (Figure 7). The small residential sections and road margins of subpopulations 1g and 1i are also not protected. Monterey clover was previously observed next to the road on Costanilla Way (subpopulation 1g) which is in a high vehicle use area. Both Mendocino sites have Monterey clover populations that occur on seasonal or permanent roads that are regularly used by logging trucks and heavy vehicles (TCF 2017).

c. Altered disturbance regimes

Fire previously played a major role in the disturbance regime of Bishop pine, coast redwood, Douglas fir, and tanoak forests, which are found in the California coastal range of Monterey clover habitat (Vogl et al. 1988, Keeley 2002). Over 30 ha (74 ac) of a Gowen cypress grove burned in Huckleberry Hill in the Monterey Peninsula in 1901 (Vogl et al. 1988). This was a few years before the first documented collections of Monterey clover in 1903 (Heller 1903*a*, *b*, *c*). Huckleberry Hill burned again in 1987 (CalFire 2023) where approximately 65 ha (160 ac) were impacted. The area has not burned since that fire and is now dominated by Monterey pine, Bishop pine, and manzanita chaparral. The increase in shrub and tree densities where Monterey clover plants occur in the Monterey Peninsula, has likely contributed to the decline of Monterey clover (Griggs 1988). Monterey clover surveys in 2020-2021 also noted high shrub and tree densities due to altered fire regimes are a continuing threat to Monterey clover (Mcgraw 2021). In the Big River and Garcia River Forests, no known fires in recent history have burned through Monterey clover occurrences. However, less than 1.6 km (1 mi) southeast of EO 8, a fire burned about 2,064 ha (5,100 ac) in 1945 (CalFire 2023). Aerial imagery indicates the area is now densely forested.

Fire suppression continues to contribute to greater forest density, lower biological diversity, reduced sunlight to the forest floor, increases in non-native invasive plant cover, and greater wildfire risk (Borchert and Davis 2018, Stephens et al. 2018, Sugihara et al. 2018). Fuel break maintenance and vegetation management activities (e.g., road grading, grazing, tree felling, prescribed burns) that do not consider the timing, frequency, and intensity optimal for Monterey clover also threaten the species' survival in both the Mendocino and Monterey Peninsula sites (Hendrix 2015, Heise 2021, Mcgraw 2021). This in turn limits the species' access to sunlight under closed-cone conifer canopies which may lead to low germination and prohibit

recruitment (Morey 1988*b*, Doak et al. 2000), and is discussed further in the Competition section below.

The exclusion of California Native and Indigenous Peoples' cultural practices have contributed to altered disturbance return intervals integral to the ecology of Monterey clover habitat in Bishop pine, redwood, and Douglas fir-tanoak forests in the North Coast (Stephens et al. 2018), and Gowen cypress, Monterey pine, and Bishop pine forests in the Central Coast (Borchert and Davis 2018). Cultural burning with frequent low- to moderate-intensity surface fires in the aforementioned forests is a traditional practice used for millennia to support food, culture, and livelihoods of California Native and Indigenous Peoples (Anderson 2018, Borchert and Davis 2018, Stephens et al. 2018, STACCWG 2021). Cultural burning practices may also secondarily enhance biodiversity and rare plant habitat. Patches of clover (*Trifolium* spp.) in the North Coast were regularly burned to produce quality, edible herbs (Anderson 2018), which Monterey clover may have indirectly benefited from. Targeted burning, pruning, and whole plant removal are cultural practices used to improve quality and production of desired plants, which may have benefited Monterey clover. The combination of federal and state policies, changes in land use after European settlement (e.g., ungulate grazing, fire exclusion), and the forced removal of California Native and Indigenous Peoples and their cultural practices, have had unintended negative impacts on the North and Central Coast forests (Keeley 2002, Williams and Analyst 2002).

Climate-change induced drought may exacerbate litter buildup and other plant encroachment into Monterey clover's habitat from continued fire suppression. Although fire continues to play an important ecological role in the regeneration of closed-cone forests, the relationship of fire as an ecosystem driver and Monterey clover's specific needs to disturbance (which may include fire), is complex and requires further discussion. With how little is known about Monterey clover's disturbance requirements, it is important to recognize the type and intensity of any disturbance regime to manage Monterey clover populations. Without the reintroduction of some targeted low- to moderate-intensity disturbance for the Monterey Peninsula site (e.g., cultural burns, prescribed fires, grading, other) and continued targeted disturbance for the Mendocino sites, the risk of random catastrophic events (e.g., wildfire) may be too great for Monterey clover to recover from.

d. Competition

Monterey clover in both counties is vulnerable to competition from encroaching native (e.g., Monterey pine, California blackberry) and non-native vegetation (e.g., French broom, jubata grass (*Cortaderia jubata*), bird's foot trefoil (*Lotus corniculatus*)). This impacts the species' ability to access light and nutrients to complete its lifecycle and recruit into the soil seedbank.

Following the last observation of Monterey clover in the Monterey Peninsula in 2016, the density of woody plants and *Lotus* spp. increased in 2017 (McCabe 2017). Increases in competing vegetation for light or soil resources may reduce the likelihood of germination of Monterey clover (Figure 10). On a visit to the Monterey Peninsula site in 2022, flowering and bare stalks of French broom were dense along trail margins. Early stages of vegetative French broom also proliferated across the forest floor, which is considered to be the largest threat to Monterey clover (pers. comm. Burrell and Hawbaker 2022). A deep layer (5-13 cm (2-5 in)) of duff (i.e., partially decomposed forest litter that sits above topsoil) was prominent. The duff layer is likely from the mastication of felled Monterey pine and the spreading of the mulch because of periodic forest thinning for fuels reduction (pers. comm. Burrell and Hawbaker 2022). The buildup of the duff layer may block Monterey clover's access to light. It may also be shifting soil-nutrients and microbiology that creates habitat more suitable for French broom seeds and seedlings than for Monterey clover. Jubata grass and small quaking grass also appear to be growing threats (Mcgraw 2021). In the Mendocino County sites, California blackberry, black-cap raspberry, and rough cat's ear encroach on roadside populations of Monterey clover (Heise and Hulse-Stephens 2016, 2017, Heise 2017). On a site visit in 2022 to EO 9 (subpopulations 9a and 9c in the Garcia River Forest), Monterey clover plants were robust in size but occupied a smaller area along the road than in previous years (pers. comm. Heise 2022). This was likely due to competition from encroaching vegetation along the road margins (Figure 9). French broom, jubata grass, and yellow star thistle (*Centaurea solstitialis*), all rated as highly invasive plants (Cal-IPC 2023), are potential threats to nearby Monterey clover populations in both forests. Highly invasive plants have severe ecological impacts on physical, chemical, and structural processes in native plant communities, and can spread and establish readily (Cal-IPC 2023). These highly invasive plants compete with Monterey clover for disturbed areas (Heise 2017). To a lesser extent, the presence of English ivy (*Hedera helix*) nearby may decrease Monterey clover's access to light. Overall, changes in plant species composition, especially where invasive plants increase in numbers between growing seasons, can dramatically alter Monterey clover abundance (Heise 2021).

Figure 10. Monterey pine habitat in the Monterey Peninsula where Monterey clover has been observed within Element Occurrence 1, subpopulation 1g. The forest floor is covered in Monterey pine litter, annual vegetation, and French broom seedlings. Photo by Mariel Boldis.

e. Climate change

Monterey clover is susceptible to environmental changes associated with climate change (e.g., change in temperature ranges, extended drought). The Climate Change Vulnerability Index (CCVI) Assessment (NatureServe 2016) is a species-specific tool that measures the vulnerability of a species under current climate change models based on the species ecological needs and threats (Young et al. 2016). Two separate CCVIs were completed to account for the variation in habitat, urbanization and other anthropogenic barriers limiting dispersal, stability in abundance, and distance from the ocean between the Monterey Peninsula and both Mendocino sites. Monterey clover is rated as “Highly Vulnerable” in the Monterey Peninsula site (CDFW 2022*a*) and as “Moderately Vulnerable" in the Mendocino sites (CDFW 2022*b*). These vulnerability ratings mean the species’ “abundance and/or range are likely to substantially decrease (Highly Vulnerable), or decrease (Moderately Vulnerable) by 2050” (NatureServe 2016, Young et al. 2016).

Populations of Monterey clover in both counties are highly vulnerable to deviations from the historical hydrological niche, which is the mean annual rainfall from the last 50 years across the species’ range (1.5-3.0 cm, 0.6-1.2 in) (Young et al. 2016, CDFW 2022*a*, *b*). Anthropogenic barriers to dispersal (e.g., residential, commercial, and recreational development surrounding the population) and a low historical mean temperature of 14.4°C (58°F), greatly increase the vulnerability of Monterey clover in the Monterey Peninsula, but not in Mendocino County. The species may not be as well adapted to changes in thermal niche in the Monterey Peninsula due to its proximity to the coast (Mcgraw 2021) compared to Monterey clover in Mendocino

County. However, to understand the full breadth of climate change impacts, it is important to consider whether Monterey clover occurs exclusively as disjunct populations or if the species' distribution is dispersed between the 320 km (200 mi) distance. It is imperative to further assess the range in the ecological niche and microclimate conditions that Monterey clover can tolerate as ocean temperatures and sea level continue to rise and impact the frequency and intensity of prolonged drought and extreme precipitation events (Sievanen et al. 2018, STACCWG 2021). The potential to lose the Monterey Peninsula site from a single stochastic event is significant and would overall lower species' resiliency and chances of recovery.

B. Degree and Immediacy of Threats

The most immediate threats at the time of listing were low number of individuals (inbreeding depression) and destruction of habitat due to urbanization and development. Since listing, Monterey clover populations have become less susceptible to the threat of habitat destruction through development since most of the occurrences are protected under conservation easements (discussed further in the Management and Recovery section below). However, low number of individuals and ongoing human activities related to modification or destruction of habitat are at present considered the most immediate threats to extinction. The degree (intensity) of the aforementioned threats are compounded with the interaction of competition, altered disturbance regimes, and climate change.

a. Monterey Peninsula Degree and Immediacy of Threats

Monterey clover in the Monterey Peninsula is immediately threatened with extinction due to its consistently small population size (Table 4). Constant low plant counts during the species' episodic emergence means fewer plants are flowering, which results in lower soil seedbank recruitment. Even if conditions become optimal for Monterey clover to germinate from its presumably long-lived soil seedbank, this does not guarantee reproductive success or recruitment of viable seed. The area occupied by the species is regularly used for recreation (e.g., mountain biking, hiking, golfing), experiences vehicle traffic, and is close to residential landscaping which may have contributed to the introduction of non-native species like the highly invasive French broom (Cal-IPC 2023). At reproductive age (2-3 years), a single medium-sized French broom shrub can easily produce up to 8,000 seeds per year and its soil seedbank can persist for up to 30 years (DiTomaso et al. 2013), which can dominate an already dwindling Monterey clover soil seedbank. Subsequently, any viable Monterey clover seeds left in the soil seedbank are not guaranteed to both successfully germinate and reproduce. Without targeted low to moderate disturbance to remove encroaching vegetation and duff layer buildup, non-native plants may continue to thrive while Monterey clover may continue to decline. In addition to long periods without disturbance, the magnitude and duration of grazing and tree

felling/mastication to mitigate forest fuel loads, grading of fire roads to reduce French broom and other encroaching vegetation, and residential development nearby, can remove topsoil containing seeds, prohibit germination, and trample germinated Monterey clover individuals. Although the Department's understanding of Monterey clover's ability to adapt to climate change is unknown, the frequency and intensity of prolonged drought and extreme weather (Sievanen et al. 2018, STACCWG 2021) can indirectly threaten the already low Monterey clover population size through altered soil-water conditions and competition with vegetation that could easily adapt to changing conditions.

b. Mendocino Degree and Immediacy of Threats

Monterey clover is immediately threatened with extinction in the Mendocino sites by ongoing human activities related to vehicle use (e.g., ruts formed from road use during or after inclement weather, off-roading) and road maintenance (i.e., grading, erosion control). The degree of competition related to encroaching native and non-native plants may intensify Monterey clover's threat of extinction. Encroaching plants (e.g, California blackberry, rough cat's ear) competing with Monterey clover for the same disturbed area, sunlight, and soil resources may cause lower Monterey clover population sizes and/or smaller-sized individuals. Fewer or smaller plants subsequently results in fewer seeds entering the soil seedbank, which lowers the ability of the species to persist. The areas of road occupied by the species are periodically graded for recontouring and reducing encroaching vegetation, and regularly used by logging trucks and other vehicles. These disturbance activities could inadvertently trample plants and lower soil seedbank recruitment. The threat of extinction for Monterey clover may also be intensified due to its small population size. While small population size is a threat not as immediate to the Mendocino sites compared to the Monterey Peninsula site (Table 4), Monterey clover still needs to successfully reproduce most years to continue building a stable viable soil seedbank. Monterey clover occurrences in Mendocino County have lower plant counts, with notable differences between subpopulations as discussed under the Population Trend and Abundance section. Monterey clover's small population size, when combined with cumulative disturbance (e.g., road use and grading) and competition of encroaching vegetation, may contribute to the local extinction of the species. Subsequently, genetic diversity may be lost and the species' ability to adapt to physical environmental pressures and survive stochastic disturbances may become too great for Monterey clover to recover (Heise 2022).

IX. MANAGEMENT AND RECOVERY

A. Impact of Existing Management Efforts

Initial management efforts included land protection and current management efforts focus on tracking Monterey clover populations. All present-day occurrences of the species are on private lands. Within the Monterey Peninsula site, EO 5 and portions of EO 1 (Figure 8, Appendix A) are within permanent conservation easements protected from development under the DMF LUP (Monterey County 1984, 2012, Zander Associates 2001, 2010). Botanical surveys for THPs located Monterey clover populations in Mendocino (EOs 6-9), and are on conservation easements protected from development under the Garcia River Forest Integrative Resource Management Plan (Garcia River IRMP) and the Big River and Salmon Creek Forests Integrative Resource Management Plan (Big River IRMP) (Monterey County 2012, TCF 2017, 2019). Monterey clover relies on some type of disturbance to persist, and the largest booms in population abundance for this species were following the fire that burned in Huckleberry Hill and the SFB Morse Reserve in the Monterey Peninsula in 1987 (Morey 1988*a*, Jones and Stokes Associates Inc 1996*a*), and the year after grading occurred in the Garcia River and Big River Forests in Mendocino County in 2015 (Heise and Hulse-Stephens 2016, 2017). As part of the THPs in the Big River and Garcia River Forests, the required monitoring provided data that highlights the importance of disturbance for Monterey clover populations; however, additional data is still needed to better identify the appropriate levels of disturbance needed for long-term species' resiliency.

a. Monterey Peninsula Management Efforts

As part of the requirements for protecting coastal resources under The California Coastal Act (1976), The DMF LUP was developed and originally adopted on July 17, 1984, for private lands largely owned by Pebble Beach Company, Del Monte Foundation Inc., and Poppy Holding Inc. Part of the purpose of this LUP is to protect sensitive biological resources and habitat, including the areas occupied by Monterey clover (Zander Associates 2001, Monterey County 2012). This LUP is updated as needed when new information relating to planning and regulation of land use and development in the Del Monte Forest becomes available (Monterey County 2012). The DMF LUP includes the Environmentally Sensitive Habitat Areas (ESHAs) of Huckleberry Hill and the SFB Morse Preserve, which are permanently designated as Open Space (Appendix A) for Monterey clover and other special-status species in the Monterey Peninsula (Monterey County 1984, Zander Associates 2001). In 1998, Doak et al. (2000) carried out a small-scale soil seedbank study with seeds sourced from USDA Agricultural Research Service and Huckleberry Hill, to better understand Monterey clover presence belowground, potential germination cues for the species, and to provide research recommendations. The results of the study

emphasized the difficulty in understanding Monterey clover's presence in the soil seedbank, and recommended further greenhouse germination work and burn box experiments (e.g., 2x2 m (7x7 ft) plots cleared of vegetation) (Doak et al. 2000)

A 2001 Biological Resources report indicated Monterey clover would be "actively managed for recovery" and directed species-specific management actions for the species that include "experimental ecological management to regenerate the seed bank" and "prescribed burning treatment for Monterey pine forest" (Zander Associates 2001). These recommendations were made specifically because Monterey clover responded positively after the 1987 fire on the ESHAs (EO 1) where up to 1,000 plants were observed blooming in subsequent years (Table 4, Jones and Stokes Associates Inc 1996*a*, USFWS 2009), and a small number of plants were observed after a smaller fire in 1990 south of State Route 68 (EO 5). However, re-introducing fire to help manage Monterey clover has previously been met with apprehension due to the dense urban area and surrounding properties potentially being impacted (Elliot 1988, USFWS 1998). In addition, the discovery of Monterey clover in Mendocino County suggests that the species responds to general disturbance. In 2010, a Biological Resources Review update in the DMF LUP was provided for Pebble Beach Company (Zander Associates 2010). While there were no modifications to the Monterey clover management actions, the mitigation section specified that the Pebble Beach Company proposed to implement a forest-wide ecological resource management program to "increase ecological functions and promote long-term sustainability" for permanently conserved areas of special status species. In the 1980s, Yadon indicated that Monterey clover cultivated in pots only required water, space, and removal of moss (Yadon 1984, CDFG 1988). In 1994, Monterey clover seed that was collected from the Monterey Peninsula population by Yadon years prior, was provided to Norman Taylor, Professor of the University of Kentucky, to add to the U.S. National Plant Germplasm System Project, which supports research related to conserving genetic diversity for agriculturally-important plants (Quesenberry and Taylor 1995).

All current management activities within SFB Morse Reserve do not directly manage Monterey clover populations. The Pebble Beach Company and Del Monte Forest Conservancy implement wildfire risk mitigation management activities that may be indirectly or directly impacting Monterey clover. No long-term monitoring has been established for these populations of Monterey clover to assess the impact of current management activities. Fire abatement activities include winter or early spring grazing by goats for weed control of species like the highly invasive French broom (pers. comm. Burrell and Hawbaker 2022, Cal-IPC 2023). The goats graze up to about 245 m (800 ft) in from the road based on observations of goat feces and evidence of browsing by Department staff during a site visit in 2022. Additional activities include foot and bike path maintenance, regular fire road mowing since the Huckleberry Hill fire of 1987, and periodic forest thinning and mulching for fuels control (USFWS 2020, pers. comm.

Burrell and Hawbaker 2022). Monterey pines were thinned in 2017 and 2018 within EO 1 subpopulations 1a-1c (Table 3, Figure 7) near Costanilla Way up to Los Altos Drive; and thinning continues on an as-needed basis followed by mastication of felled trees into wood chips (i.e., mulch), which is then spread in same area (pers. comm. Burrell and Hawbaker 2022). Mulch is known to alter soil chemistry (Olayinka and Adebayo 1985, Tiquia et al. 2002) and soil microbial communities (Tiquia et al. 2002, Yang et al. 2003) so these activities may be shifting the soil-nutrient levels, soil composition, and creating habitat less suitable for Monterey clover and the historic native plant community. The mulch covering the topsoil blocks sunlight from reaching Monterey clover seeds, which are generally observed growing on bare soils with low competition. Although mulch can help retain soil moisture, it also may create conditions that French broom seeds and seedlings can exploit and benefit from far better than Monterey clover. During a site visit with Department staff in Spring 2022, early seral stages of vegetative French broom were prominent on the forest floor and are the largest threat to Monterey clover in this area (pers. comm. Burrell and Hawbaker 2022). Monterey clover may be unlikely to emerge and recover without new disturbance (e.g., cultural burns, prescribed fire) or removal of thatch, mulch, and the deep Monterey pine litter and duff layer (~5-13 cm, 2-5 in to topsoil) that continues to build up. The Department has reached out to Pebble Beach Company and Del Monte Forest Foundation Inc. to consider adaptive management practices and discuss the benefits of fuels mitigation efforts on rare native plant diversity (pers. comm. Burrell 2022, pers. comm. Vaughan 2022).

b. Mendocino Management Efforts

The acquisition of 9,623 ha (23,780 ac) of the Garcia River Forest in 2004 and 4,735 ha (11,700 ac) of the Big River Forest in 2006 by The Conservation Fund sought to protect coastal forests from further habitat fragmentation and conversion while sustainably harvesting timber. The Garcia River IRMP and Big River IRMP were established to manage forest resources and to meet required conditions under the terms of the Conservation Easements where Monterey clover occurs (TCF 2017, 2019). The IRMPs do not contain management objectives specific to Monterey clover; however, both IRMPs apply an adaptive management approach for forest resources and are updated every ten years. Monterey clover was encountered in Mendocino during botanical surveys for three different THPs in 2011 and 2014. Monterey clover populations are managed and monitored within these THPs (Heise and Hulse-Stephens 2012, 2016, 2017, Heise 2017, 2021), and data collected may better inform timber harvesting and fuels mitigation efforts. Monterey clover shows a high resilience to periodic grading which appears to reduce competition from other plant species. However, brambles of California blackberry and more competitive herbaceous vegetation eventually re-occupy areas where Monterey clover was once growing. Competition reduces the number, and likely the size, of germinating Monterey clover which reduces the number that ultimately flower. This results in

fewer seeds entering the soil seedbank, decreasing the resilience of the species. The stochastic annual distribution of Monterey clover may be attributed to consecutive years of low germination and poor seed set coupled with vigorous growth of other herbaceous species filling all available space, displacing Monterey clover.

The Conservation Fund monitor Monterey clover as required by the THPs in the Big River and Garcia River Forests. The THPs require road grading plans one year in advance, which are based on the need for timber harvest or restoration projects (pers. comm. Newberger 2022). The THPs include requirements to protect Monterey clover, which include the following conditions: (a) skid trails (temporary trails used to remove logs from a timber stand) are to be pre-flagged for incidental tree harvest if they fall within a 15 m (50 ft) buffer of Monterey clover, (b) no slash piles are allowed to be left, (c) blades on grading equipment must be lifted in rare plant zones where grading is prohibited, and (d) road recontouring is allowed to maintain topography and hydrological integrity (Hendrix 2015, Heise and Hulse-Stephens 2016, Heise 2019). Records for road grading within known Monterey clover occurrences, prior to 2011, were requested by the Department, but The Conservation Fund indicated that this information was not tracked (pers. comm. Newberger 2022). The Big River Forest site (EO 6) underwent monitoring and grading over the course of ten years (2011-2021), and the Garcia River Forest site (EOs 7-9) underwent monitoring and grading for five years (2014-2017, 2019). Grading was scheduled after seed set (mid-July or later) to minimize impact to the soil seedbank (Heise and Hulse-Stephens 2016, Heise 2019). In the fall of 2011, fencing was installed to guide equipment operators around the species in the Big River Forest, and in 2012 Monterey clover was found growing on the newly graded area. The fencing was removed due to changes in hydrology with the formation of a berm, which would have redirected water flow if left unchanged (Heise 2021). In general, the species appears to respond best to light-moderate disturbance (e.g., regular vehicle use) in combination with periodic grading that maintains local hydrology and reduces non-native plant cover and competing vegetation (Heise and Hulse-Stephens 2017, pers. comm. Heise 2022). For these Monterey clover populations, it is important to maintain disturbance that mitigates encroaching woody vegetation and to continue removing any slash piles or thatch and litter buildup.

Permanent plots for long-term monitoring were established in 2011 in the Big River Forest and in 2014 in the Garcia River Forest, which helped track changes in species abundance and composition through 2021 (Heise 2017, 2021, Heise and Hulse-Stephens 2017). Monitoring results of the Big River Forest site reinforced the importance of periodic light-moderate disturbance (e.g., grading) to the species' ecology, how available habitat was continually present for Monterey clover to expand into (especially when competition was reduced from grading), and how species' resiliency likely decreases when favorable conditions are not met for Monterey clover to germinate and reproduce (Heise 2021).

B. Recommendations for Management Activities and Other Recommendations for Recovery of the Species

The Department recognizes that effective management and road maintenance practices that maintain or increase Monterey clover and seed bank densities requires better understanding of population size, distribution, community composition, and habitat quality through long-term monitoring (Elzinga et al. 1998, Heise and Hulse-Stephens 2017). It is important to identify if the populations are truly disjunct, or where else the species may be occurring between Monterey and Mendocino counties (pers. comm. Lemein 2022b, pers. comm. Patten 2022).

The goal of management and recovery is to alleviate threats, stabilize populations, and protect the self-sustaining populations of Monterey clover. The most urgent action to take for the survival of Monterey clover is to remove encroaching vegetation, non-native invasive plants, and thatch/litter buildup from its preferred habitat along trail and road margins. The USFWS established a Recovery Plan for Five Plants from Monterey County, California in 2004, which includes downlisting criteria for Monterey clover (USFWS 2004). This criterion establishes minimum number of viable populations that are stabilized, protections from disturbance that would impact recruitment and reproduction of Monterey clover, and seed banking. Delisting criteria were added as an amendment to USFWS's Recovery Plan in 2019 (USFWS 2019). In general, a federal delisting for Monterey clover must meet the downlisting criteria, and threats to protected populations must be reduced, potential suitable habitat must be assessed, two new protected populations must be established, and all populations must be self-sustaining and remain viable for an established threshold.

The Department recommends that the following actions and tasks be conducted in coordination with collaborators (including researchers, non-profit organizations, government agencies, Tribes, land managers, and other relevant partners) consistent with California's goals of preventing the extinction of rare, threatened, and endangered species (Fish & G. Code, § 2055). Recommended tasks and activities to implement suggested recovery actions are further described below:

1. Expand the size and number of self-sustainable populations

a. Conduct research that expands knowledge of Monterey clover's ecology to help fine-tune habitat suitability assessments for searching for additional natural populations and identifying new potential habitat for experimental introductions. More information is needed on: germination requirements, species interactions (e.g., pollination), disturbance range tolerance, and longevity of soil seedbank viability.

b. Conduct a thorough population genetic analysis of the extant populations to quantify current genetic diversity and identify any evidence of potential hybridization with closely related clovers (i.e., small-head clover, variegated clover).

c. Conduct soil seedbank assessments and germination trials under various disturbance treatments and germination cues. Research trials mimicking natural soil conditions can complement monitoring data, inform habitat and roadway management, and facilitate Monterey clover recruitment and recovery.

d. Create educational materials, trail signage, and opportunities to foster public support and awareness for conservation in the recreational spaces (e.g., hiking/biking/running trails) within the SFB Morse Reserve, Monterey County.

2. Establish redundant collections of seed in long-term conservation storage and for use with re-introductions

a. Consider collaborations with the Pacific Grove Natural History Museum, local California Native Plant Society chapters, and other relevant stakeholders to collect seed in late June to mid-July for re-introduction at existing sites in autumn following the first rains. This will help to expand and stabilize natural extant populations that occur exclusively on privately-owned, high traffic use areas (Hendrix 2015).

b. The populations at the Monterey Peninsula site are especially at-risk of extirpation and may benefit the most from seeding (compared to the Mendocino sites) where numbers are consistently fewer than 30 individual plants in a given year.

c. Collect seeds following protocols that consider genetic diversity and rarity across each subpopulation, such as the protocols provided by the California Botanic Garden (RSABG 2009), and place them in long-term conservation storage at Department-approved facilities.

d. Consider re-introductions of wild-collected seed in areas away from high foot and vehicle traffic. Multiple self-sustaining populations to increase resiliency to stochastic disturbance should be established with the help of local collaborators, including Pebble Beach Company, The Del Monte Forest Conservancy, Poppy Holdings Inc., The Conservation Fund, local tribal governments, local tribal land trusts, and additional relevant stakeholders which may include Monterey Peninsula Regional Park District, Monterey County Parks, Pacific Grove Natural History Museum, University of California (UC) Santa Cruz, and land conservancies.

3. Implement and establish funding for long-term adaptive management plans

a. To control for competition from invasive and native plant species (e.g., California blackberry, French broom, rough cat's ear, jubata grass), encourage all landowners

managing habitat where Monterey clover occurs to maintain schedules of disturbance and disturbance type on a yearly basis. While it is well understood that Monterey clover requires some form of disturbance to persist, less is known about the patterns and variability in disturbance (e.g., type, intensity, frequency) most optimal for the species. Disturbance scheduling in combination with yearly Monterey clover abundance data can inform the next scheduled grading, grazing, forest thinning, and all other disturbance activities.

b. All planned disturbance activities should be done outside of the species' mid-February through mid-July aboveground life cycle window and should be careful to minimize soil erosion and changes to hydrologic function. Since light is the only known germination cue for Monterey clover (Doak et al. 2000), road grading activities rocking (i.e., a dust reducing method) should be avoided (pers. comm. Heise 2022).

c. Pursue incentivized recovery tools such as cooperative Safe Harbor Agreements (Fish & G. Code, § 2089.2 et seq.) for possible experimental introductions. Experimental introductions could benefit species' resiliency and its connectivity to extant populations if Monterey clover is found between the Mendocino and Monterey Peninsula sites.

d. Continue long-term monitoring for the Mendocino sites. Although the Big River Forest population monitoring formally concluded in 2021, continuing to monitor changes in Monterey clover abundance, non-native invasive plant cover, and disturbance type and intensity to maintain habitat suitable for the species is recommended.

e. Develop more consistent long-term monitoring efforts for the Monterey Peninsula site. Although the Monterey Peninsula site has been periodically monitored since 1973, regular monitoring should be established. The Monterey Peninsula site is most at risk of extinction due to consistently low population numbers and adjacency to high use recreational and residential areas.

f. Identify management recommendations that support climate change resiliency for multiple species (including other rare plants) that co-occur with Monterey clover (e.g., Santa Cruz clover). For example, management recommendations made for Mendocino sites of Santa Cruz clover co-existing with Monterey clover may benefit both species where vulnerabilities overlap (Heise and Hulse-Stephens 2016). Monterey clover and Santa Cruz clover also have similar habitat requirements—short lived annuals, occupy recent disturbed areas, prefer areas with reduced competition—and may benefit from similar management recommendations (Heise and Hulse-Stephens 2012). Additional climate assessments are needed that include weighing indirect exposure and life history traits more heavily, incorporating specific soil requirements as natural barriers, and

integrating Indigenous people and their traditional ancestral knowledge (Anacker et al. 2012, STACCWG 2021).

4. Establish partnerships to fund surveys throughout the species' range and assessment of experimental disturbance regimes

a. Develop habitat suitability models to identify possible habitat between the Monterey Peninsula and Mendocino sites. Habitat characteristics such as an open tree canopy, low to moderate topsoil disturbance, and little to no litter layer (e.g., no pine needles, duff, or thatch) should be considered (Jones and Stokes Associates Inc 1996*a*). Habitat suitable for Monterey clover may exist in two remaining native mainland Monterey pine forests (Año Nuevo and Cambria) and remaining legacy Monterey pine in Point Lobos State Reserve on soils with geologic histories of marine terraces four and five (400,000-500,000 years old) (CDFG 1995, Jones and Stokes Associates Inc 1996*b*, Hayes and Taylor 2015, Schulz et al. 2018). The nutrient-poor soils of the species' habitat in the Monterey Peninsula are similar to the more extensive pygmy forest soils in Mendocino County (CDFG n.d.), which may be habitat to further explore for suitability. Additional habitat with natural stands of Monterey pine that could support the species may include areas on Santa Ynez soils with a geologic history of the fourth marine terrace (Jones and Stokes Associates Inc 1996*a*). This habitat includes the California Protected Areas of Jack's Peak Park (~364 ha, 900 ac) owned by Monterey County and the Joyce Stevens Monterey Pine Preserve (~336 ha, 830 ac), which was previously Rancho Aguajito) owned by Monterey Peninsula Regional Park District. Attributes for the habitat suitability models should include information from the following:
    i. Associations with natural stands of Monterey Pine, Bishop pine, Gowen cypress, coast redwood, tanoak, manzanita spp., and other plants within these coastal forested communities;
    ii. Density of tree canopy (open vs. closed)
    iii. Topsoil characteristics (e.g., litter layer density, compaction);
    iv. Soil profiles and composition of areas within older marine terraces;
    v. Type, timing, and intensity of disturbance regimes needed (e.g., fire, grading, raking, mowing);
    vi. Hydrological regime, and microtopography required for germination
b. Survey areas identified by the habitat assessment (informed by habitat suitability models) to locate new occurrences across the species' range. Surveys may help narrow down habitat characteristics, distribution, and range of the species (pers. comm. Lemein 2022b, pers. comm. Patten 2022).

c. Plan and track disturbance to reduce encroaching plants at all sites. To maintain open habitat for Monterey clover, hand pulling non-native species and reducing California blackberry should be performed yearly when grading is not scheduled.

d. Encourage implementation of alternative disturbance regimes (e.g., clearing with hand tools, cultural burns in collaboration with local Tribes and relevant stakeholders) that elicit a positive Monterey clover response and facilitate recruitment into the soil seedbank.

e. Consider timing, intensity, and frequency of grazing and other practices to target French broom, especially in the Monterey Peninsula. The best method and time to control French broom may be through hand-pulling and weed wrenches outside of Monterey clover's mid-February through mid-July life cycle window, when the soil is wet and before French broom sets seed (Haley 1998, Road and Haley 2004). It is important to minimize soil disturbance to the hardpan beneath the soil that supports water accumulation for Monterey clover (CDFG 1987, Yadon 1987, Odegard et al. 2012).

f. Test the effects of removing thick layers of thatch, mulch, and deep Monterey pine litter in Monterey clover habitat in the Monterey Peninsula. Monterey clover may benefit from repeated thatch removal in the fall using thatch rakes, considering this practice has benefited populations of the endangered Santa Cruz tarplant (*Holocarpha macradenia*) (Haley 1998).

5. Seek help from Tribes and Indigenous people to identify additional actions, tasks, and to exchange knowledge

a. Encourage, facilitate, and support engagement between Tribes and private landowners for management opportunities that promote the conservation of cultural values, traditional knowledge systems, relationships, biodiversity, and ecological requirements tied to Monterey clover and its habitat, to the maximum extent possible.

X. RECOMMENDATION TO THE COMMISSION

Pursuant to Fish and Game Code section 2077, the Department has prepared this Species Review based upon the best scientific information available to the Department to determine if conditions that led to the original listing are still present. Based on the information in this Species Review, the Department submits the following recommendation to the Commission:

NO CHANGE TO ENDANGERED STATUS

In completing this Species Review for Monterey clover, the Department finds there is sufficient scientific information to indicate that the conditions that led to the listing of Monterey clover as endangered are still present, and recommends no change to the status of Monterey clover on the list of endangered species at this time.

XI. LITERATURE SOURCES AND COMMUNICATIONS CITED

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XII. LIST OF APPENDICES

Appendix A. Figure 5 in the 2012 update of the Del Monte Forest Area Land Use Plan (LUP) land use designations in the Monterey Peninsula, Monterey County. Monterey clover is located within sub-planning areas G and H which are designated as Open Spaces. SFB Morse Reserve and Huckleberry Hill Natural Habitat Area are demarcated on the map and are permanently protected conservation easements.