Bureau of Land Management
Hollister Field Office
Clear Creek Management Area (CCMA)

Annual Summary Report for the 2009 – 2010 Season
Monitoring and Status of *Camissonia benitensis*
and Implementation of the 2006 Record of Decision

Ryan O'Dell, BLM Natural Resources Specialist – Botany/Soils

This document describes and summarizes ongoing management to protect San Benito evening primrose (*Camissonia benitensis*) occurrences and potential habitat within the Clear Creek Management Area (CCMA). A quarterly report was completed and forwarded to the Fish and Wildlife Service (FWS) for the time period June 1, 2009 – September 30, 2009. This report summarizes management and monitoring activities for that period and the remainder of the season. Compliance monitoring was conducted from June 1, 2009 to June 1, 2010 by BLM staff in accordance with the Compliance Monitoring Plan and guidance in the 2005 BO.

The Serpentine ACEC within the CCMA remained closed to the public June 1, 2009 – June 1, 2010. The BLM instituted an emergency closure of BLM lands within the Serpentine ACEC on May 1, 2008 in response to public release of the CCMA Asbestos Exposure and Human Health Risk Assessment by the Environmental Protection Agency which showed that typical recreation activities conducted within the Serpentine ACEC, including OHV riding, exposed the visiting public to levels of asbestos greater than considered acceptable by the EPA. San Benito County followed suit with the BLM shortly thereafter and closed the county roads on May 13, 2008. On April 6, 2010, the San Benito County Board of Supervisors voted to reopen the roads (Resolution # 2010-36). The public is now permitted to travel the county road system within the CCMA (R1, R11, R15, and T158), but both BLM land and BLM routes connecting to the county roads remain closed.

The BLM Hollister Field Office continues work on the Clear Creek Management Area Resource Management Plan which is now in its administrative draft stage with a final RMP and EIS anticipated by January 2011. The draft RMP evaluated seven alternatives (A – G) ranging from managing the area as it was prior to the closure with OHV activity on the designated route system (Alternative A) to continuing to manage the area in its current closed state with no OHV use permitted (Alternative G). The BLM has selected Alternative E as their preferred alternative. Alternative E proposes to allow touring of highway-licensed full-sized vehicles and highway-licensed motorcycles (street and dual-sport bikes) on a limited route system through the Serpentine ACEC, but would no longer permit green-sticker motorcycle (dirt bike) activity on the designated route system. Individuals would be limited to $\leq$ 5 days that they may enter the Serpentine ACEC under motorized use, so as to maintain their asbestos exposure below acceptable limits. Management of the CCMA under Alternative E should substantially reduce OHV impacts to San Benito evening primrose and other sensitive species habitat, as compared to historic management practices.

Recovery of San Benito evening primrose is a high priority for the BLM Hollister Field Office. San Benito evening primrose was recently identified within the California BLM Threatened and Endangered species program as having one of the highest probabilities of recovery of all federally-listed species in the state and has been prioritized for funding. This year, the BLM Hollister Field Office was pledged $200,000 by the BLM California State Office and BLM Washington Office to be added over the course of this and the next two years to our base T&E funding, in pursuit of recovery of the species. Recovery of the species is being pursued through a combination of protection, monitoring, habitat restoration, introduction/reintroduction, and habitat surveys. Protection has involved OHV route designation (2006 Record of Decision) and installation of barriers to prevent OHV impacts. Monitoring has been conducted in accordance with the Compliance Monitoring Plan (2005 FWS Biological Opinion) prior to closure of the CCMA and continues to occur, however, at a reduced frequency (coincident with reduced OHV activity). Alluvial terrace habitat type restoration is planned following the closure of Staging Areas 1 - 5 (scheduled 2010). Introduction/reintroductions and associated research studies have occurred in the past (Taylor 1992) and were recently reinitiated (see Annual Report 2008 – 2009). Habitat surveys have been ongoing since the species was listed in 1985, with major surveying efforts undertaken in 2008 (serpentine alluvial terrace habitat; 5 new suboccurrences found) and 2010 (serpentine geologic transition zone habitat; 174 new suboccurrences found).

Endangered Species Act Compliance

The BLM analyzed, adopted, and is implementing decisions that conserve and promote the recovery of species listed as threatened or endangered under the Endangered Species Act (ESA). As the expert agency responsible for regulating ESA compliance, the FWS determined that the BLM's management practices conducted at the CCMA are not likely to jeopardize the San Benito evening primrose. By consulting, communicating, and coordinating with FWS, and implementing the management actions identified below, the BLM is fulfilling its independent duty to avoid jeopardy under the ESA. FWS' "no jeopardy" opinion was partially based on the continuation of many actions that BLM is currently implementing and will continue to implement in the future, including the following:

<u>Activities postponed due to CCMA closure and pending Record of Decision for the CCMA RMP</u>

- Route signing. Serpentine ACEC of the CCMA is currently closed to OHV use.
- Corridor fencing all remaining routes through closed mine areas and closed barren areas.
- Fencing, barricading, and signing closed routes that provide access to San Benito evening primrose. Under the closure, there has been no significant OHV activity or trespass to necessitate further fencing or barricading to protect San Benito evening primrose populations.
- Annual recurring and corrective route maintenance. Dramatically reduced vehicle use within CCMA has reduced the need for route maintenance.

<u>Activities completed 2009 - 2010 season</u>

- New asbestos decontamination facility constructed at CCMA.
- Research Natural Area Management Plan for the SBMRNA prepared and included in the CCMA RMP (Recovery action 3).

- San Benito evening primrose habitat monitored according to the compliance monitoring plan, with reduced monitoring intervals (Recovery actions 3.2 and 3.2.2).
- Regular law enforcement patrol (Recovery actions 1.1.5 and 1.1.5.1).
- Sixty-six (66) previously known San Benito evening primrose suboccurrences visited with plant counts made for each (Recovery actions 3.2 and 3.2.2).
- Surveyed 10,000 acres of geologic transition zone habitat. One hundred seventy-four (174) new San Benito evening primrose suboccurrences found with plant counts made for each (Recovery actions 3.2.1, 3.4, and 1.3.3).
- San Benito evening primrose (Clear Creek Canyon accession) grown in horticultural setting to produce seed for introductions (permit TE163671-1; Recovery action 3.3.2 and 4).
- Serpentine riparian zone revegetation studies (Recovery action 2).
- Control of yellow starthistle (*Centaura solstitialis*) and tocalote (*Centaurea melitensis*; Recovery action 1.2) with herbicide (Transline) and control burns (Recovery action 3.3.5) between the Clear Creek confluence and Staging Area 1.

<u>Activities planned for 2010 -2011 season in addition to regular monitoring activities</u>

- Continue surveying geologic transition zone habitat (Recovery action 3.2.1). Determine range limit for San Benito evening primrose.
- Close and restore Staging Areas 1 - 5 under American Recovery and Reinvestment Act (ARRA) of 2009 grant funding received (Recovery actions 1.1.3 and 2.2).
- Closed route restoration (Recovery action 2).
- Serpentine riparian zone revegetation (Recovery action 2).
- San Benito evening primrose seedbank quantification and dynamics studies (Recovery action 3.3.1), introductions into suitable potential habitat (Recovery action 3.3.2) which may include restored Staging Areas 1 – 5, and predator identification study (Recovery action 3.3.4).

<u>Implementation of the 2006 CCMA ROD</u>

1). *Management of off-highway vehicle recreation and restoration*

Management of off-highway vehicle recreation

All activities associated with management of OHV recreation (signing, trail maintenance, fencing/barricading) are postponed since the Serpentine ACEC of the CCMA remains closed.

Serpentine riparian zone restoration

Clear Creek is classified as an impaired watershed due to elevated concentrations of mercury, heavy sediment loads, and poor riparian vegetative cover. Riparian revegetation test plots were continued in the 2009 – 2010 season at the same location as study plots established in the 2008 – 2009 season (see 2008 – 2009 Annual Report). The 2008 – 2009 study plots including native sod, plugs, and direct seeding revealed that the mixed species native sod was the only effective revegetation treatment of stream banks along Clear Creek which experiences high seasonal variability of flow and carries heavy sediment loads. The native sod rooted firmly into the underlying substrate, endured prolonged submergence during high winter flow, protected the stream bank from erosion, and captured sediment. In contrast, plugs failed to protect the bank from erosion and direct seeding completely failed to establish at all. Within the mixed species sod, spike bentgrass (*Agrostis exarata*) displayed high tolerance of the conditions at Clear Creek and dominated all other species. Since spike bentgrass outcompeted most other species within the sod, it was difficult to determine if any other species would also be effective revegetation species. As a result, studies in 2009 – 2010 focused on sod composed of single species.

In fall 2009, single species sod strips were produced using the same methods as the 2008 – 2009 season. Species included spike bentgrass (*Agrostis exarata*), slender wheatgrass (*Elymus trachycaulus*), common yarrow (*Achillea millefolium*), blue-eyed grass (*Sisyrinchium bellum*), sneezeweed (*Helenium puberulum*), and Guirado's goldenrod (*Solidago guiradonis).* Since the sod strip produced in the 2008 – 2009 season only displayed vigorous plant growth on the 18 inches nearest the stream edge (highest water availability in summer), the sod strip width was reduced to 18 inches wide.

Of the species used, only spike bentgrass, slender wheatgrass, and common yarrow effectively produced sod during the three month growing period. The coarse root structure of common yarrow resulted in sod with relatively poor integrity that tended to disintegrate upon handling. Guirado's goldenrod displayed satisfactory germination, but grew very slowly and did not produce sod during the three month growing period. Blue-eyed grass and sneezeweed exhibited very low germination on the high-organic rooting medium and failed to produce sod. The spike bentgrass, slender wheatgrass, and common yarrow sod strips were planted along the stream bank of Clear Creek in the same vicinity as the 2008 – 2009 strip and evaluated in summer, 2010. During the winter, high flow in Clear Creek disintegrated the poorly-bound common yarrow sod and washed it away. Both spike bentgrass and slender wheatgrass sod strips endured high winter flows and have become well established (**Figures 1 and 2**). Both species appear equally well suited for use in sod strips and equally tolerant of high stream flow conditions. Now that production and field establishment parameters have been established, serpentine riparian zone revegetation can be pursued on a larger scale. Establishment of riparian vegetation along stream banks should help reduce sediment entry into the stream channel and prevent stream bank erosion.

Figure 1. Sod strips. February 2010.

Figure 2. Sod strips. June 2010.

2) ***San Benito evening primrose protection measures***

Invasive species including yellow starthistle (*Centaurea solstitialis*), tocalote (*Centaurea melitensis*), and medusa head (*Taeniatherum caput-medusae*) present a significant threat to occupied and potential San Benito evening primrose habitat near the Clear Creek/San Benito River confluence. Most occupied and potential habitat is currently free of yellow starthistle, but adjacent areas are heavily infested. Control methods for yellow starthistle implemented this year included Transline herbicide application with ATV and backpack sprayers, hand pulling, and control burns. Approximately 50 acres of yellow starthistle between the Clear Creek/San Benito River confluence and Staging Area 1 were control burned in June 2010. The long-term goal is eradication of yellow starthistle followed by seeding and establishment of native, perennial grassland which will provide high quality wildlife habitat while excluding invasive species.

3) *San Benito evening primrose OHV compliance monitoring*

This report summarizes the monitoring period from June 1, 2009 to June 1, 2010 (**Table 1**). Monitoring is being conducted at 60 individual suboccurrences. Closure of CCMA has greatly reduced the frequency of trespass into San Benito evening primrose occupied or potential habitat. As a result, monitoring frequency has been reduced. A total of 22 citations were issued for trespass on closed BLM land within the CCMA.

Only one instance of noncompliance was noted this season. The incident consisted of several motorcycle tracks through potential habitat of suboccurrences 121000 and 122000 and a single track through occupied habitat of suboccurrence 121000. The single track had negligible adverse impact on plants within the suboccurrence or the habitat.

Table 1. OHV compliance monitoring data June 1, 2009 – June 1, 2010.

			Date→	8/15	9/21, 9/23, 9/24	3/16	4/14, 4/15, 4/16	4/22, 4/23, 4/25	5/1
Descriptor	**Occ/ Subocc**	**UTM E**	Initials→ **UTM N**	REO	REO	DM	REO	REO	REO
HIGH PRIORITY									
mouth CC new long	291000/ 291100	699177	4025805	√	√	√	.	.	√
mouth CC new patch	291000/ 291200	699280	4025853	√	√	√	.	.	√
1/mouth CC exc	291000/ 291300	699092	4025954	√	√	√	.	.	√
no synonomy	291000/ 291400	699017	4025861	√	√	√	.	.	√
no synonomy	291000/ 291500	699303	4025914	√	√	√	.	.	√
POTENTIAL HABITAT				√	√	√	.	.	√
1B/Fence crosses CC	11000/ 11100	700813	4026106	√	√	√	√	.	.
11/Lower CC young terrace	111000/ 111100	699768	4025926	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
1C/Culvert Camp	281100/ 281100	701218	4026715	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
14/High Terrace	141000/ 141100	701519	4026858	√	√	√	√	.	.
POTENTIAL HABITAT	141000			√	√	√	√	.	.
Jade Mill	251000/ 251100	701726	4027091	√	√	√	√	.	.
Jade Mill below	251000/ 251200	701779	4027186	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
2/SA 1 S of Road	21000/ 21100	702103	4027300	√	√	√	√	.	.
2/SA 1N of Road	21000/ 21200	702132	4027306	√	√	√	√	.	.
2/SA 1 Slope	21000/ 21300	702069	4027368	√	√	√	√	.	.
2/SA 1 parking	21000/ 21400	702000	4027318	√	√	√	√	.	.
SA 1 edge	21000/ 21500	702074	4027314	√	√	√	√	.	.
SA1 N of road - East	21000/ 21600	702113	4027326	√	√	√	√	.	.
Fork R1-T106	21000/ 21700	702184	4027328	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
3/pipe barrier past SA2	31000/ 31100	702858	4027604	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
4/S Slot	41000/ 41100	704658	4028924	√	√	√	√	.	.
16/S Slot intro	41000/ 41200	704730	4028818	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
6/Trail bisects	51000/ 51100	705115	4028590	√	√	√	√	.	.
5/mega	51000/ 51200	705025	4028573	√	√	√	√	.	.
New/saddle btwn 5-7	51000/ 51300	705091	4028448	√	√	√	√	.	.
7/Indian Hill	51000/ 51400	705385	4028403	√	√	√	√	.	.
17/Intro beyond Indian Hill	51000/ 51500	705659	4028502	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
8/Stage 5 chap	81000/ 81100	706013	4028444	√	√	√	√	.	.
8.5/Stage 5 rest	81000/ 81200	706057	4028395	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
12/Upper CC Cyn,	121000/ 121100	708856	4027789	√	√	√	**OTL**	.	.
23/Upper CC, first approach	121000/ 122100	708399	4027967	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	**PTH**	.	.
Larious Trib	61000/ 61100	702788	4030910	√	√	√	√	.	.
Larious Trib	61000/ 61200	702916	4030630	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
KCAC/Sawmill Cr. (PVT)	181000/ 181100	710161	4024476	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
Upper SB upstrm (PVT)	261000/ 261100	712559	4023394	√	√	√	√	.	.
Upper SB upstrm (PVT)	261000/ 261110	712777	4023254	√	√	√	√	.	.
Upper SB upstrm (PVT)	261000/ 261120	712522	4023544	√	√	√	√	.	.
Upper SB upstrm (PVT)	261000/ 261130	712498	4023587	√	√	√	√	.	.
Upper SB upstrm	261000/ 261140	712476	4023727	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
10/Upper SB downstream	101000/ 101100	711732	4023928	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.

Table 1 continued.

Descriptor	Occ/ Subocc	UTM E	Date→ Initials→ UTM N	8/15 REO	9/21, 9/23, 9/24 REO	3/16 DM	4/14, 4/15, 4/16 REO	4/22, 4/23, 4/25 REO	5/1 REO
MEDIUM PRIORITY									
Picacho Meadow	271000/ 271100	707849	4025039	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
13/Pines	131000/ 131100	709149	4025019	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
9/San Carlos md	91000/ 91100	710120	4029157	√	√	√	√	.	.
9/san Carlos ch	91000/ 91200	710090	4029169	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
Scazghinni	71000/ 71100	708056	4020631	No access	No access	No access	√	.	.
Scazghinni	71000/ 71200	708013	4020478	No access	No access	No access	√	.	.
Scazghinni	71000/ 71300	708026	4020333	No access	No access	No access	√	.	.
Scazghinni	71000/ 71400	707717	4020265	No access	No access	No access	√	.	.
POTENTIAL HABITAT				No access	No access	No access	√	.	.
Rambler's	161000/ 161100	704045	4022816	√	√	√	√	.	.
Upstream from Ramblers	161000/ 161200	704924	4022404	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
Condon Meadows	301000	711990	4022136	√	√	√	√	.	.
POTENTIAL HABITAT				√	√	√	√	.	.
LOW PRIORITY									
20/White Creek BLM	201000/ 201100	717904	4019819	√	√	√	.	√	.
White Creek	201000/201110	717763	4019930	√	√	√	.	√	.
White Creek	201000/201120	717800	4019901	√	√	√	.	√	.
White Creek	201000/201130	717908	4019796	√	√	√	.	√	.
21/White Creek (PVT)	201000/ 201200	718061	4019529	√	√	√	.	√	.
White Creek new	201000/ 201300	717810	4019336	√	√	√	.	√	.
White Creek new	201000/ 201400	718141	4019622	√	√	√	.	√	.
White Creek new	201000/ 201500	717529	4019131	√	√	√	.	√	.
White Creek	201000/ 201600	717463	4019034	√	√	√	.	√	.
Archer Mine	201000/201700	718768	4019828	√	√	√	.	√	.
POTENTIAL HABITAT				√	√	√	.	√	.

OHV NON-COMPLIANCE RUNNING TOTALS

Location			Date→	8/15	9/21, 9/23, 9/24	3/16	4/14, 4/15, 4/16	4/22, 4/23, 4/25	5/1
Suboccurence BLM				0	0	0	1	1	1
Suboccurrence PVT				0	0	0	0	0	0
Potential BLM				0	0	0	1	1	1
Potential PVT				0	0	0	0	0	0

LEGEND

Initials: REO = Ryan O'Dell, DM = David Moore

[white box] = Suboccurrences/Potential habitat on BLM land

[blue box] = Suboccurrences/Potential habitat on Private land

POTENTIAL HABITAT = Potential habitat occurs on both BLM and Private land

[grey box] = Monthly monitoring per biological opinion

√ = OHV Compliance

OTL = Occupied habitat, track, one incident

OTM = Occupied habitat, track, two incidents

OTH = Occupied habitat, track, three or more incidents

PTL = Potential habitat, track, one incident

PTM = Potential habitat, track, two incidents

PTH = Potential habitat, track, three or more incidents

NOTE: Numbers reflect the OHV non-compliance (compliance) in protected *Camissonia benitensis* habitat per monitoring visit. Numbers of monitoring visits vary year to year due to weather and accessibility. Annual monitoring begins June 1 and ends June 1 the following calendar year.

4) *San Benito evening primrose survey*

San Benito evening primrose survey history

In 1960, Peter Raven discovered San Benito evening primrose growing on a serpentine alluvial stream terrace adjacent to Clear Creek at or very near current suboccurrence 111100. It was not until 1969, however, that Raven scientifically described the species and its habitat (Raven 1969). Most descriptions of the species since its discovery have described serpentine alluvial stream terraces (**Figures 3 and 4**) as being its primary habitat (Griffin 1978, 1981; Kiguchi, 1983; Taylor 1990, 1992; Hickman 1993; USFWS 2006). Jim Griffin (1978) stated in his Rare Plant Status Report that "it is not clear if the species can grow on serpentine uplands or if it is restricted only to alluvial terraces." Reports by BLM biologists between 1978 and 2009 indicate that most surveying efforts were focused on serpentine alluvial terraces. The species was not found on any habitat type other than serpentine alluvial stream terraces until Dean Taylor (1992) found the species occurring on serpentine debris flows (old/prehistoric landslides) at the BLM Section 8 Administrative site (suboccurrence 191100) and Lorenzo Vasquez Canyon (suboccurrence 151100). Taylor (1992) recognized from the habitat conditions present at these new suboccurrences that the species may have a less strict physiographic requirement than once believed and that the species may have a broader range than just the vicinity of San Benito Mountain. He later suggested that the range of the species may include the southern portion of the Laguna Ranch (Oat Canyon) and Lewis Creek, but again, the focus appears to have only been serpentine alluvial stream terrace habitat (Taylor 1995).

Figure 3. Serpentine alluvial stream terrace habitat within the New Idria serpentine mass (Serpentine ACEC). Suboccurrence 51200.

Figure 4. Serpentine alluvial terrace habitat outside of the New Idria serpentine mass (Serpentine ACEC). White Creek.

Serpentine geologic transition zone habitat

When I began with BLM Hollister Field Office in spring 2007, I generally accepted that the only habitat for San Benito evening primrose consisted of serpentine alluvial stream terraces, based on the habitat descriptions for the species. For the next three years, I focused virtually all of my surveying efforts only on drainages originating from- or including serpentine masses. The drainages were primarily those surveyed by previous BLM biologists such as Clear Creek, Larious Creek, San Benito River, Sawmill Creek, San Carlos Creek, White Creek, and Laguna Creek. In April 2008, I intensively surveyed all of these drainages, yielding several new suboccurrences of San Benito evening primrose, but nothing of great significance. All of the new suboccurrences were generally within close proximity of previously discovered suboccurrences**.** **Figure 5** shows how the number of documented San Benito evening primrose suboccurrences has increased over time.

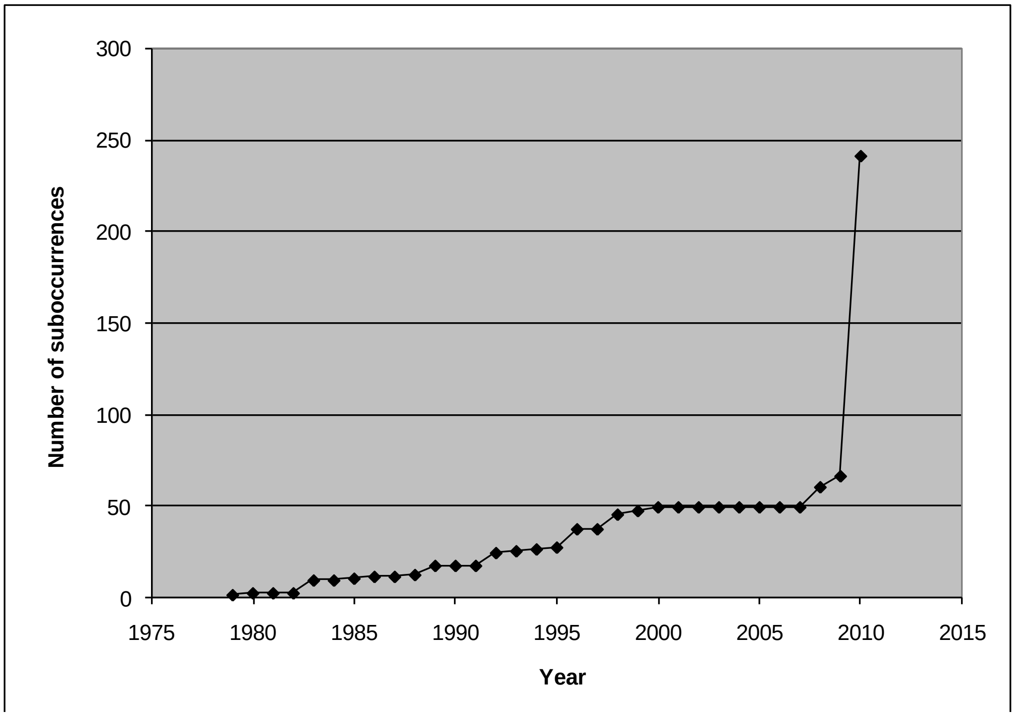

Figure 5. Number of documented San Benito evening primrose suboccurrrences over time.

The highest topographic position above the adjacent drainage that San Benito evening primrose that had been found before 2010 was suboccurrence 251100 (Jade Mill) at + 60 feet. During monitoring and plant counts of the species in early May 2010, I discovered the species at Upper Jade Mill (+ 160 feet relative to drainage) growing on serpentine soil at the very edge of the New Idria serpentine mass (Serpentine ACEC). Although the soils are derived from serpentine, the vegetation type more closely resembles blue oak (*Quercus douglasii*) and California juniper (*Juniperus californica*) woodland common on adjacent nonserpentine areas than the serpentine chaparral and conifer forest typically found growing on serpentine soils of the New Idria serpentine mass. Adjacent to R2 on the ridge top (+ 830 feet), I again found the species growing on serpentine soils at the edge of the New Idria serpentine mass. Like Upper Jade Mill, the vegetation is also blue oak and California juniper woodland with scattered shrubs as opposed to dense serpentine chaparral and conifer forest. It was then that I realized that the species does not have a topographic limitation and that this upland "serpentine geologic transition zone" habitat comprises a new habitat type for the species that was not previously recognized. The serpentine geologic transition zone is the boundary between serpentine and nonserpentine rock types. Serpentine masses (tectonically emplaced), serpentine landslides (structural failures of serpentine masses), and serpentine alluvium (eroded sediment from serpentine masses moved by streams and rivers) that interface with nonserpentine soils and rock types create the opportunity for serpentine geologic transition zone habitat to occur.

Over the course of the next two months, I intensively surveyed serpentine geologic transition zone habitat within the CCMA and at nearby serpentine masses (Laguna Mountain, Hepsedam Peak, Sweetwater, BLM Section 8, Black Mountain, and Johnson Canyon), resulting in the discovery of 174 new suboccurrences of San Benito evening primrose, tripling the number of known suboccurrences and doubling the total number of plants (**Tables 2 – 4; Figures 6 and 7**). New suboccurrence finds extended the known range to include Johnson Canyon north of Hernandez Reservoir and Black Mountain to the east of the reservoir. Three suboccurrences found near HWY 198 at Mustang Grade in far eastern Monterey County represent a major range extension 10 miles to the south-southwest of the New Idria serpentine mass (Serpentine ACEC). In addition to the geologic transition zone habitat, two other minor habitat types were identified where San Benito evening primrose occurs including serpentine rock outcrop and shale outcrop/barren. **Table 5** summarizes the characteristics of each habitat type.

Geologic transition zone habitat shares many characteristics with serpentine alluvial stream terrace habitat including serpentine soils with loam – sandy loam texture (often gravelly or rocky), relatively high level of stability (little to no surface erosion), low density woody overstory (full sunlight), and increased diversity of native herbaceous species (companion species) distributed at a low density (low level of competition). The two habitat types differ with alluvial stream terrace habitat being topographically constrained to toe slopes in drainage bottoms and geologic transition habitat having no topographic constraint. Alluvial stream terrace habitat within the New Idria serpentine mass (Serpentine ACEC) has woody overstory consisting of serpentine chaparral (*Quercus durata* var. *durata*, *Arctosatphylos glauca*, *A. pungens*,, *Ceanothus cuneatus*, *Adenostoma fasciculatum*) and conifer forest species (*Pinus sabiniana*, *P. coulteri*, *P. jeffreyi*, *Calocedrus decurrens*), whereas the woody overstory of the geologic transition zone habitat is typically blue oak (*Quercus douglasii*) and California juniper (*Juniperus californica*) woodland with occasional shrub species commonly associated with nonserpentine chaparral (*Quercus berberidifolia, Adenostoma fasciculatum, Ceanothus cuneatus*). Serpentine alluvial stream terraces outside of the New Idria serpentine mass have habitat characteristics of both alluvial stream terraces located within the serpentine mass (soil and topographic characteristics), as well as habitat characteristics associated with geologic transition zone habitat found at the edge of the serpentine mass (vegetation type). At present, 36 suboccurrences are associated with serpentine alluvial stream terrace habitat within the New Idria serpentine mass (Serpentine ACEC), 160 suboccurrences are associated with serpentine geologic transition zone habitat, and 38 suboccurrences are associated with serpentine alluvial stream terraces outside of the New Idria serpentine mass (**Table 4**). In terms of occupied and potential habitat area, suboccurrence numbers, and plant numbers, the geologic transition zone habitat is at least as important, if not of greater importance to the species, than serpentine alluvial stream terrace habitat.

Serpentine geologic transition zone habitat is generally found as a narrow band, up to 500 feet wide, on the edge of serpentine masses and landslides (**Figures 8 – 13**). Vegetation in the interior of the serpentine masses is typically serpentine chaparral with very sparse to nonexistent native herbaceous understory cover, whereas vegetation on nonserpentine rock types adjacent to the serpentine mass is typically nonserpentine chaparral or blue oak-California juniper woodland with dense invasive annual grassland understory cover. Geologic transition zone habitat is found on the very edge of the serpentine chaparral where the vegetation type abruptly changes to blue oak-California juniper woodland. In that zone, both woody overstory cover and herbaceous understory cover are reduced. Towards the serpentine mass, woody overstory cover is generally too dense (partial/full shade) and soil properties become increasingly too stressful (low nutrient and water availability) to support herbaceous species. Towards the nonserpentine rock type, invasive herbaceous species cover becomes too dense (intense competition) as serpentine soils gradate strongly into nonserpentine soils and become more fertile. San Benito evening primrose is frequently associated with other companion native herbaceous plant species (**Table 6**) and the presence of those species is often a strong indicator that the habitat is suitable for San Benito evening primrose. Most of the same companion species were also found by Taylor (1990) to be frequently associated with San Benito evening primrose on serpentine alluvial stream terraces.

Most of the new geologic transition zone suboccurrences and potential habitat are located within areas where human impacts are minimal to nonexistent. The majority of the new suboccurrences within the CCMA are located outside of the core OHV use area (network of designated open OHV routes) and therefore have had little to no impacts from OHVs. Some of the new suboccurrences outside of the CCMA are located within areas grazed by cattle (dominant land use of the region), however, the lack of dense forage on the low-productivity serpentine soils has largely deterred grazing within occupied or potential habitat. Invasive red brome and tocalote present minor threats to San Benito evening primrose habitat, but their invasion and growth is greatly limited by the adverse chemical and physical properties of serpentine soil.

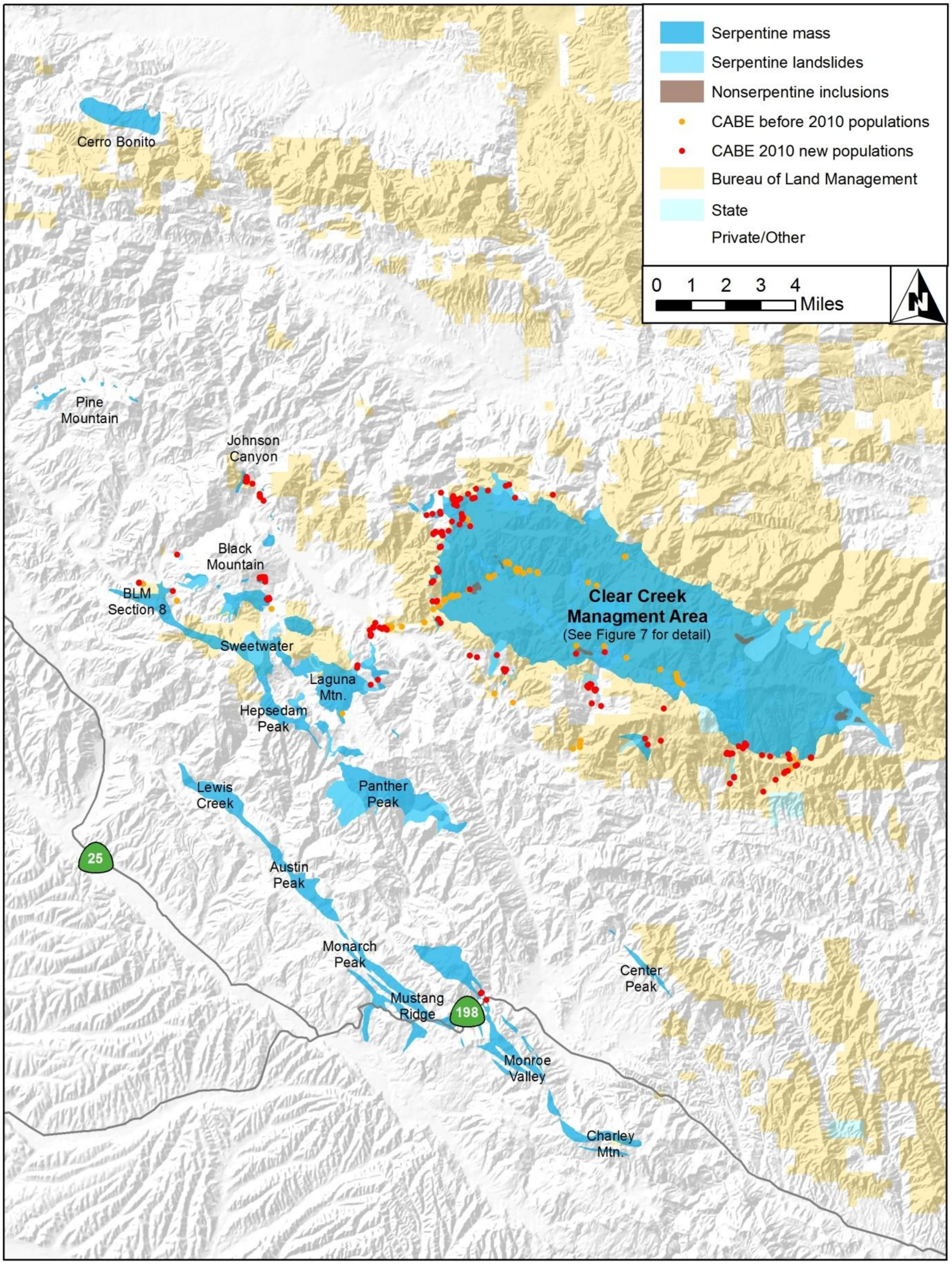

Figure 6. Estimated range for San Benito evening primrose showing San Benito evening primrose suboccurrences found prior to 2010 (CABE before 2010 populations) and new suboccurrences found this season (CABE 2010 new populations).

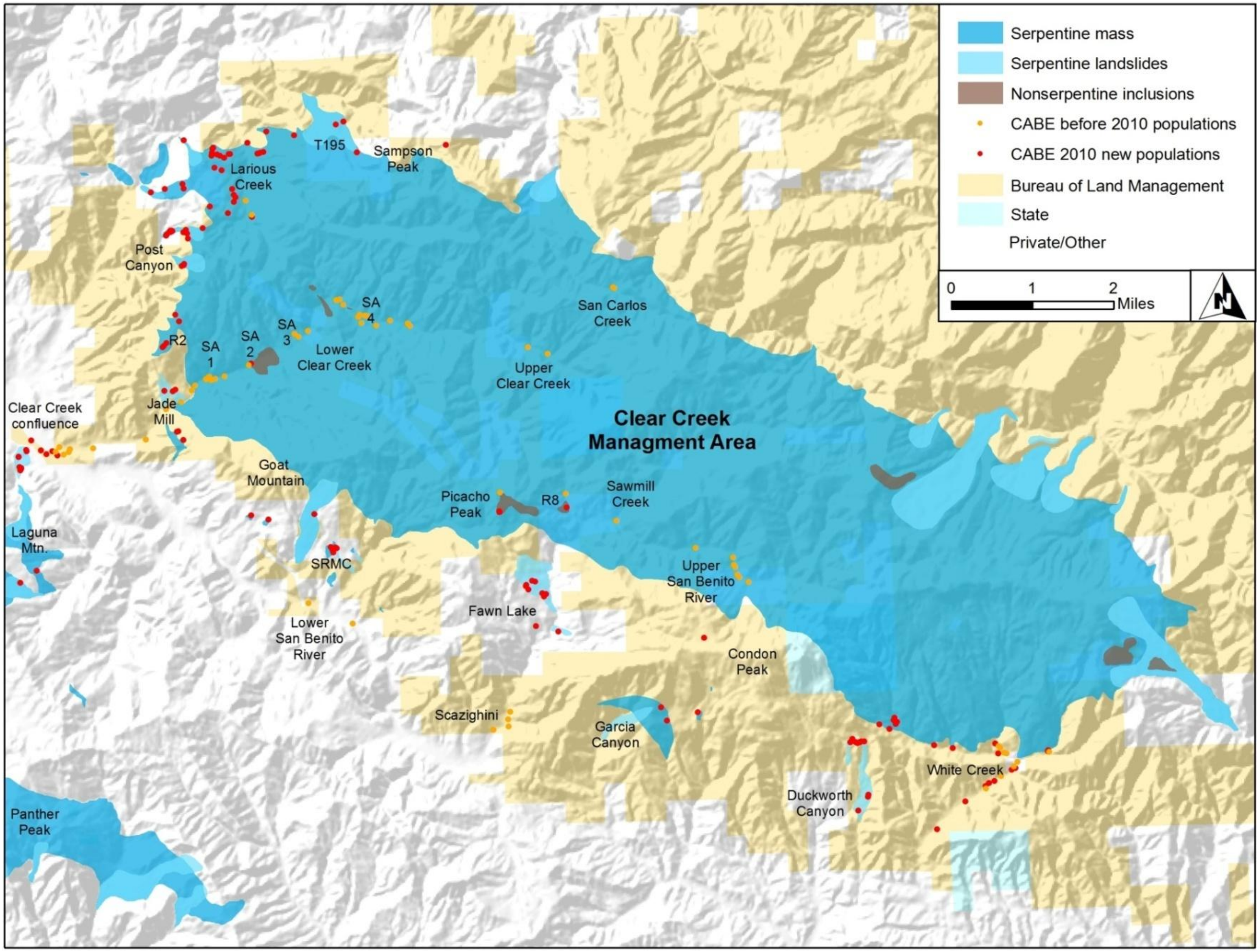

Figure 7. Detail of Clear Creek Management Area showing San Benito evening primrose suboccurrences found prior to 2010 (CABE before 2010 populations) and new suboccurrences found this season (CABE 2010 new populations).

Figure 8. Geologic transition zone in the Larious Creek area. CCMA. BLM land.

Figure 9. Geologic transition zone habitat near Black Mountain. Private land.

Figure 10. Geologic transition zone habitat near Larious Creek. CCMA. BLM land.

Figure 11. Geologic transition zone habitat near Post Canyon. CCMA. BLM land.

Figure 12. Geologic transition zone habitat near Laguna Mountain. Private land.

Figure 13. San Benito evening primrose on geologic transition zone habitat.

Serpentine rock outcrop and shale outcrop/barren habitat

Serpentine rock outcrop (**Figure 14**) and shale outcrop/barren (**Figure 15**) near the geologic transition zone are two other distinct habitat types where San Benito evening primrose was found. Two suboccurrences were found on serpentine rock outcrops and five suboccurrences were found on shale outcrops/barrens. All suboccurrences were located with close proximity to the geologic transition zone. The serpentine rock outcrop habitat has characteristics similar to the serpentine geologic transition zone habitat with pockets of rocky, sandy loam soil and sparse woody overstory cover. Woody overstory cover is dense around the outcrops. Serpentine rock outcrop is the typical habitat of another rare serpentine endemic, rayless layia (*Layia discoidea*). The New Idria serpentine mass is pervasively, tectonically sheared/pulverized, therefore, there are very few true hard rock outcrops to provide this type of habitat. The serpentine barrens do not provide the same type of habitat as serpentine rock outcrop due to instability caused by naturally sparse vegetative cover and high erosion rates. Serpentine rock outcrop habitat is widespread on nearby Laguna Mountain and Hepsedam Peak, however, San Benito evening primrose has not been found growing on that habitat type there. Rayless layia is frequent on serpentine rock outcrop habitat at both Laguna Mountain and Hepsedam Peak. The lack of San Benito evening primrose on serpentine rock outcrops suggests that it is a very minor or anomalous habitat type for the species.

Four of the five shale suboccurrences are located on shale outcrop (inclusions) within the New Idria serpentine mass. The other suboccurrence is located on shale barrens near the geologic transition zone at Condon Peak. Suboccurrence 271100 (Picacho Meadow) is a previously discovered suboccurrence associated with shale outcrop habitat. Although derived from shale, soils of this habitat type appear to mimic serpentine soils by having chemically and/or physically adverse characteristics. San Benito evening primrose is regarded as a strict serpentine endemic (Safford et al. 2005), therefore, finding it growing on soil that is clearly not derived from serpentine was a surprise. San Benito evening primrose was not the only strict serpentine endemic found growing on the shale outcrop/barrens habitat type (see section *Serpentine endemic infidelity in the CCMA* below).

The shale barren habitat was previously discussed in the 2007 – 2008 Annual Report. The report described six suboccurrences (301100, 301200, 301300, 301400, 301500, and 301600) that were believed to be new. A specimen collected from suboccurrence 301100 was positively identified as San Benito evening primrose by Dean Taylor in 2008. Subsequent specimens collected from the same population, however, were identified as contorted evening primrose (*Camissonia strigulosa*), and the statement that all six suboccurences were San Benito evening primrose was retracted in the 2008 – 2009 Annual Report. These populations were revisited this season and it was confirmed that some plants in the vicinity of 301100 and 301200 are in fact San Benito evening primrose. The species grows sparsely with large numbers of contorted evening primrose which lead to confusion in identification of San Benito evening primrose. Suboccurrences 301300, 301400, 301500, and 301600 were confirmed to be entirely contorted evening primrose. San Benito evening primrose often occurs with contorted evening primrose and intermediate suncups (*Camissonia intermedia*) on the shale outcrop/barren habitat. Since the majority of San Benito evening primrose suboccurrences are associated with serpentine soils, it is likely that shale outcrop/barren is a very minor or anomalous habitat type for the species.

Figure 14. Serpentine outcrop habitat near the geologic transition zone.

Figure 15. Shale barren habitat near the geologic transition zone,

Table 2. San Benito evening primrose populations known before 2010. Suboccurrence number, UTM location, population group, habitat type, location, land ownership status, and 2010 plant counts.

Occurrence number	Suboccurrence number	UTM (zone 10) E	UTM (zone 10) N	Population group	Habitat type: Alluvial terrace	Habitat type: Geologic transition	Habitat type: Rock outcrop Serp.	Habitat type: Rock outcrop Shale	Location: CCMA Inside	Location: CCMA Outside	Location: Serpentine ACEC Inside	Location: Serpentine ACEC Outside	Land ownership BLM	Land ownership Private	Plant counts 2010
151000	151100	.	.	Black Mountain											.
191000	191100	687792	4027829	BLM Section 8											2088
111000	111100	699768	4025926	Clear Creek confluence											0
291000	291100	699131	4025780	Clear Creek confluence											144
291000	291200	699280	4025853	Clear Creek confluence											0
291000	291300	699078	4025951	Clear Creek confluence											0
291000	291400	699016	4025861	Clear Creek confluence											0
291000	291500	699302	4025913	Clear Creek confluence											97
11000	11100	700813	4026106	Jade Mill											2308
141000	141100	701519	4026858	Jade Mill											0
251000	251100	701725	4027090	Jade Mill											87
251100	251200	701779	4027186	Jade Mill											13
281000	281100*	701218	4026714	Jade Mill											0
221000	221100	.	.	Laguna Mountain											.
61000	61100	702788	4030910	Larious Creek											4400
61000	61200	702825	4030643	Larious Creek											81
161000	161100	704045	4022816	Lower San Benito River											0
161000	161200	704924	4022404	Lower San Benito River											0
271000	271100	707897	4025019	Picacho Peak											53
131000	131100	709149	4025019	R8											1
21000	21100	702103	4027300	SA 1											0
21000	21200	702132	4027306	SA 1											0
21000	21300	702069	4027368	SA 1											1191
21000	21400	702000	4027318	SA 1											175
21000	21500	702074	4027314	SA 1											58
21000	21600	702113	4027326	SA 1											0
21000	21700	702184	4027328	SA 1											111
21000	21800*	702372	4027375	SA 1											7
31000	31100	702858	4027604	SA 2											235
241000	241100*	704030	4028293	SA 3											4
241000	241200*	703873	4028165	SA 3											9
241000	241300*	703764	4028230	SA 3											51
41000	41100	704658	4028924	SA 4											24
41000	41200	704730	4028818	SA 4											138
51000	51100	705028	4028620	SA 4											565
51000	51200	704982	4028560	SA 4											758
51000	51300	705091	4028448	SA 4											30
51000	51400	705385	4028403	SA 4											42
51000	51500	705659	4028502	SA 4											189
51000	51600*	705326	4028518	SA 4											0
81000	81100	706013	4028444	SA 4											0
81000	81200	706073	4028393	SA 4											373
81000	81300*	705931	4028418	SA 4											8
91000	91100	710128	4029166	San Carlos Creek											7849
91000	91200	710090	4029169	San Carlos Creek											7
181000	181100	710161	4024461	Sawmill Creek											21
71000	71100	708056	4020631	Scazighini											1
71000	71200	708013	4020478	Scazighini											0
71000	71300	708026	4020333	Scazighini											326
71000	71400	707717	4020265	Scazighini											0
121000	121100	708798	4027824	Upper Clear Creek											118
122000	122100	708399	4027967	Upper Clear Creek											197
101000	101100	711794	4023940	Upper San Benito River											118
261000	261100	712558	4023394	Upper San Benito River											54
261000	261110	712777	4023254	Upper San Benito River											59
261000	261120	712521	4023544	Upper San Benito River											48
261000	261130	712497	4023587	Upper San Benito River											71
261000	261140	712476	4023726	Upper San Benito River											409
201000	201100	717876	4019795	White Creek											312
201000	201110	717763	4019929	White Creek											44
201000	201120	717799	4019900	White Creek											271
201000	201130	717907	4019795	White Creek											926
201000	201200	718060	4019528	White Creek											582
201000	201300	717809	4019335	White Creek											16
201000	201400	718133	4019585	White Creek											298
201000	201500	717512	4019071	White Creek											1419
201000	201600	717516	4019152	White Creek											127
201000	201700	718768	4019828	White Creek											51
													TOTAL -		26564

Table 3. New San Benito evening primrose populations found in 2010. Suboccurrence number, UTM location, population group, habitat type, location, land ownership status, and 2010 plant counts.

					Habitat type				Location						
Occurrence number	Suboccurrence number	UTM (zone 10)		Population group	Alluvial terrace	Geologic transition	Rock outcrop		CCMA		Serpentine ACEC		Land ownership		Plant counts 2010
		E	N				Serp.	Shale	Inside	Outside	Inside	Outside	BLM	Private	
Not assigned	Not assigned	689126	4027574	Black Mountain											50
Not assigned	Not assigned	689326	4029249	Black Mountain											19
Not assigned	Not assigned	693157	4028194	Black Mountain											33
Not assigned	Not assigned	693162	4028166	Black Mountain											8
Not assigned	Not assigned	693216	4028191	Black Mountain											783
Not assigned	Not assigned	693262	4028219	Black Mountain											559
Not assigned	Not assigned	693362	4028218	Black Mountain											503
Not assigned	Not assigned	693390	4028216	Black Mountain											34
Not assigned	Not assigned	693408	4028121	Black Mountain											2
Not assigned	Not assigned	693417	4027996	Black Mountain											3
Not assigned	Not assigned	693503	4027190	Black Mountain											5
Not assigned	Not assigned	693536	4027165	Black Mountain											212
Not assigned	Not assigned	693554	4027231	Black Mountain											18
Not assigned	Not assigned	693587	4027244	Black Mountain											18
Not assigned	Not assigned	693609	4027204	Black Mountain											932
231000	231100	698536	4026085	Clear Creek confluence											183
291000	291600	699055	4025787	Clear Creek confluence											273
291000	291700	698840	4025812	Clear Creek confluence											484
291000	291800	698949	4025873	Clear Creek confluence											208
291000	291900	698728	4025886	Clear Creek confluence											85
Not assigned	Not assigned	698281	4025765	Clear Creek confluence											32
Not assigned	Not assigned	698281	4025752	Clear Creek confluence											3
Not assigned	Not assigned	698303	4025554	Clear Creek confluence											159
Not assigned	Not assigned	698315	4025488	Clear Creek confluence											70
Not assigned	Not assigned	698315	4025507	Clear Creek confluence											5
Not assigned	Not assigned	698335	4025520	Clear Creek confluence											76
Not assigned	Not assigned	698336	4025538	Clear Creek confluence											51
Not assigned	Not assigned	698430	4025894	Clear Creek confluence											28
Not assigned	Not assigned	698441	4025873	Clear Creek confluence											688
Not assigned	Not assigned	711908	4022116	Condon Peak											64
Not assigned	Not assigned	714817	4020016	Duckworth Canyon											80
Not assigned	Not assigned	714845	4020056	Duckworth Canyon											188
Not assigned	Not assigned	714856	4020085	Duckworth Canyon											154
Not assigned	Not assigned	714871	4020039	Duckworth Canyon											57
Not assigned	Not assigned	714919	4020015	Duckworth Canyon											11
Not assigned	Not assigned	714957	4020004	Duckworth Canyon											114
Not assigned	Not assigned	714976	4018641	Duckworth Canyon											5
Not assigned	Not assigned	714986	4020017	Duckworth Canyon											68
Not assigned	Not assigned	715006	4020021	Duckworth Canyon											70
Not assigned	Not assigned	715032	4020034	Duckworth Canyon											16
Not assigned	Not assigned	715094	4020032	Duckworth Canyon											93
Not assigned	Not assigned	715169	4018920	Duckworth Canyon											33
Not assigned	Not assigned	715173	4018965	Duckworth Canyon											14
Not assigned	Not assigned	708362	4023155	Fawn Lake											6
Not assigned	Not assigned	708371	4023179	Fawn Lake											144
Not assigned	Not assigned	708413	4023093	Fawn Lake											451
Not assigned	Not assigned	708493	4023269	Fawn Lake											423
Not assigned	Not assigned	708550	4023250	Fawn Lake											38
Not assigned	Not assigned	708564	4022357	Fawn Lake											398
Not assigned	Not assigned	708694	4023016	Fawn Lake											583
Not assigned	Not assigned	708722	4022949	Fawn Lake											432
Not assigned	Not assigned	708746	4022994	Fawn Lake											79
Not assigned	Not assigned	708766	4023002	Fawn Lake											55
Not assigned	Not assigned	709007	4022242	Fawn Lake											39
Not assigned	Not assigned	711052	4020721	Garcia Canyon											84
Not assigned	Not assigned	711169	4020456	Garcia Canyon											28
Not assigned	Not assigned	711782	4020620	Garcia Canyon											150
Not assigned	Not assigned	702904	4024578	Goat Mountain											65
Not assigned	Not assigned	703252	4024496	Goat Mountain											385
Not assigned	Not assigned	704160	4024610	Goat Mountain											8
251000	251300	701401	4027113	Jade Mill											200
251000	251400	701350	4027079	Jade Mill											128
251000	251500	701181	4027086	Jade Mill											19
Not assigned	Not assigned	701431	4026266	Jade Mill											38
Not assigned	Not assigned	701459	4026274	Jade Mill											20
Not assigned	Not assigned	701558	4026096	Jade Mill											12
Not assigned	Not assigned	692518	4032646	Johnson Canyon											131
Not assigned	Not assigned	692528	4032681	Johnson Canyon											1
Not assigned	Not assigned	692541	4032704	Johnson Canyon											23
Not assigned	Not assigned	692545	4032645	Johnson Canyon											82
Not assigned	Not assigned	692547	4032710	Johnson Canyon											17
Not assigned	Not assigned	692555	4032856	Johnson Canyon											26
Not assigned	Not assigned	692560	4032673	Johnson Canyon											263
Not assigned	Not assigned	692560	4032715	Johnson Canyon											7
Not assigned	Not assigned	692564	4032805	Johnson Canyon											420
Not assigned	Not assigned	692571	4032667	Johnson Canyon											77
Not assigned	Not assigned	692822	4032548	Johnson Canyon											68
Not assigned	Not assigned	693157	4032047	Johnson Canyon											6
Not assigned	Not assigned	693160	4032071	Johnson Canyon											29
Not assigned	Not assigned	693163	4031949	Johnson Canyon											3
Not assigned	Not assigned	693181	4031928	Johnson Canyon											8
Not assigned	Not assigned	693346	4031747	Johnson Canyon											261
Not assigned	Not assigned	697690	4024007	Laguna Mountain											63
Not assigned	Not assigned	697694	4024130	Laguna Mountain											5
Not assigned	Not assigned	697704	4024136	Laguna Mountain											51
Not assigned	Not assigned	698319	4023222	Laguna Mountain											253
Not assigned	Not assigned	698642	4023469	Laguna Mountain											1158

Table 3 continued.

Occurrence number	Suboccurrence number	UTM (zone 10) E	N	Population group	Habitat type: Alluvial terrace	Geologic transition	Rock outcrop: Serp.	Shale	Location: CCMA Inside	Outside	Serpentine ACEC Inside	Outside	Land ownership BLM	Private	Plant counts 2010
61000	61300	702924	4030584	Larious Creek											224
61000	61400	702563	4030888	Larious Creek											274
61000	61500	702593	4030981	Larious Creek											182
61000	61510	702560	4031028	Larious Creek											199
61000	61600	702531	4031147	Larious Creek											449
61000	61800	702321	4031527	Larious Creek											74
61000	61810	702177	4031570	Larious Creek											22
61000	61900	702448	4030661	Larious Creek											73
Not assigned	Not assigned	701569	4032127	Larious Creek											119
Not assigned	Not assigned	702118	4031813	Larious Creek											20
Not assigned	Not assigned	702127	4031873	Larious Creek											82
Not assigned	Not assigned	702132	4031948	Larious Creek											21
Not assigned	Not assigned	702151	4031973	Larious Creek											256
Not assigned	Not assigned	702229	4031840	Larious Creek											410
Not assigned	Not assigned	702287	4031815	Larious Creek											505
Not assigned	Not assigned	702367	4031778	Larious Creek											108
Not assigned	Not assigned	702462	4031850	Larious Creek											54
Not assigned	Not assigned	702483	4031850	Larious Creek											67
Not assigned	Not assigned	702830	4032077	Larious Creek											6
Not assigned	Not assigned	703032	4031859	Larious Creek											174
Not assigned	Not assigned	703064	4031869	Larious Creek											34
Not assigned	Not assigned	703080	4031874	Larious Creek											33
Not assigned	Not assigned	703150	4031895	Larious Creek											5
Not assigned	Not assigned	703208	4032299	Larious Creek											25
Not assigned	Not assigned	703758	4032225	Larious Creek											62
Not assigned	Not assigned	703429	4008906	Mustang Ridge											295
Not assigned	Not assigned	703456	4008947	Mustang Ridge											75
Not assigned	Not assigned	703674	4008618	Mustang Ridge											70
Not assigned	Not assigned	707842	4024669	Picacho Peak											24
Not assigned	Not assigned	707850	4024652	Picacho Peak											57
61000	61700	702083	4030792	Post Canyon											54
Not assigned	Not assigned	700910	4031083	Post Canyon											26
Not assigned	Not assigned	701185	4031145	Post Canyon											149
Not assigned	Not assigned	701217	4030207	Post Canyon											36
Not assigned	Not assigned	701228	4030234	Post Canyon											10
Not assigned	Not assigned	701284	4030283	Post Canyon											50
Not assigned	Not assigned	701300	4030306	Post Canyon											146
Not assigned	Not assigned	701304	4030285	Post Canyon											534
Not assigned	Not assigned	701321	4030312	Post Canyon											28
Not assigned	Not assigned	701337	4030297	Post Canyon											96
Not assigned	Not assigned	701525	4029599	Post Canyon											144
Not assigned	Not assigned	701542	4031247	Post Canyon											214
Not assigned	Not assigned	701558	4030274	Post Canyon											420
Not assigned	Not assigned	701562	4029615	Post Canyon											352
Not assigned	Not assigned	701565	4031155	Post Canyon											85
Not assigned	Not assigned	701573	4029636	Post Canyon											19
Not assigned	Not assigned	701607	4030322	Post Canyon											126
Not assigned	Not assigned	701635	4030250	Post Canyon											25
Not assigned	Not assigned	701652	4030146	Post Canyon											22
Not assigned	Not assigned	702081	4030790	Post Canyon											122
171000	171100	701171	4027988	R2											445
171000	171200	701144	4027959	R2											46
171000	171300	701222	4028045	R2											15
Not assigned	Not assigned	701401	4028618	R2											29
Not assigned	Not assigned	701475	4028480	R2											18
Not assigned	Not assigned	709180	4024740	R8											249
Not assigned	31200	702909	4027641	SA 2											9
Not assigned	Not assigned	706773	4032038	Sampson Peak											43
191000	191200	687562	4027959	BLM Section 8											280
191000	191300	687562	4027938	BLM Section 8											324
Not assigned	Not assigned	704487	4023942	SRMC											15
Not assigned	Not assigned	704526	4023884	SRMC											55
Not assigned	Not assigned	704541	4023835	SRMC											4
Not assigned	Not assigned	704579	4023938	SRMC											2
Not assigned	Not assigned	704604	4023923	SRMC											10
Not assigned	Not assigned	704588	4032441	T195											1695
Not assigned	Not assigned	704735	4032507	T195											47
Not assigned	Not assigned	705006	4031885	T195											191
200000	200100	716541	4018268	White Creek											10
200000	200200	717097	4018830	White Creek											162
201000	201140	717691	4019989	White Creek											113
201000	201210	718016	4019460	White Creek											160
201000	201220	718100	4019501	White Creek											133
201000	201800	717565	4019195	White Creek											757
211000	201900	717677	4019239	White Creek											170
211000	211100	717755	4019790	White Creek											108
211000	211200	716850	4019900	White Creek											310
211000	211300	716479	4019962	White Creek											518
Not assigned	Not assigned	715394	4020381	White Creek											22
Not assigned	Not assigned	715596	4020282	White Creek											326
Not assigned	Not assigned	715676	4020459	White Creek											1
Not assigned	Not assigned	715696	4020508	White Creek											3
Not assigned	Not assigned	715716	4020388	White Creek											10
Not assigned	Not assigned	715741	4020429	White Creek											15
Not assigned	Not assigned	718743	4019835	White Creek											25
Not assigned	Not assigned	718747	4019844	White Creek											6
Not assigned	Not assigned	718747	4019857	White Creek											8
													TOTAL -		**26210**

Table 4. Summary of number of populations and plant counts according to habitat type, location, and land ownership.

	----------------Habitat type ----------------					----------------- Location -----------------					
	Alluvial terrace	Geologic transition	Terrace & transition	Rock outcrop		CCMA		Serpentine ACEC		Land ownership	
				Serp.	Shale	Inside	Outside	Inside	Outside	BLM	Private
Number of populations	36	160	38	2	5	167	74	109	132	150	91
Plant counts 2010	12929	24841	14249	308	447	39216	13558	26769	26005	36750	16024

Table 5. Comparison of topographic and soil characteristics of serpentine alluvial stream terrace, geologic transition zone, serpentine outcrop, and shale outcrop/barren habitat.

Habitat type	Topographic position	Slope	Aspect	Parent material	Soil texture	Soil Ca:Mg molar ratio
Serpentine alluvial terrace	Toeslope	0° - ~10°	Any	serpentine/mixed	loam - sandy loam	< 1.0
Geologic transition zone	Any	0° - ~60°	Any	serpentine	loam - sandy loam	< 1.0
Serpentine outcrop	Any	0° - ~60°	Any	serpentine	loam - sandy loam	< 1.0
Shale outcrop/barren	Any	0° - ~60°	Any	shale	loam - sandy loam	> 1.0

Table 6. Native herbaceous species frequently associated with San Benito evening primrose in serpentine alluvial stream terrace, geologic transition zone, serpentine outcrop, and shale outcrop/barren habitat types. * = strict serpentine endemic (Safford et al. 2005). Presence of a strict serpentine endemic is a strong indicator that the soil it is growing in is derived from serpentine.

			----------------Habitat type ----------------			
			Alluvial terrace	Geologic transition	Rock outcrop	
Common name	Species	Family			Serp.	Shale
common yarrow	*Achillea millefolium*	Asteraceae	X	X		
goldfields	*Lasthenia californica*	Asteraceae	X	X		
rayless layia	*Layia discoidea* *	Asteraceae	X		X	
woolly dandelion	*Malacothrix floccifera*	Asteraceae	X	X		
pygmyflower cryptantha	*Cryptantha micromeres*	Boraginaceae	X	X	X	
western wallflower	*Erysimum capitatum*	Brassicaceae	X	X	X	
San Benito jewelflower	*Streptanthus insignis* ssp. *insignis*	Brassicaceae		X	X	
Chilean bird's foot trefoil	*Lotus wrangelianus*	Fabaceae	X	X		
Indian breadroot	*Pediomelum californicum*	Fabaceae	X			
San Benito monardella	*Monardella antonina* ssp. *benitensis* *	Lamiaceae	X	X	X	
Douglas' monardella	*Monardella douglasii*	Lamiaceae	X	X		
chia	*Salvia columbariae*	Lamiaceae		X		X
Coast Range dwarf flax	*Hesperolinon disjunctum* *	Linaceae	X	X		
intermediate suncup	*Camissonia intermedia*	Onagraceae				X
contorted primrose	*Camissonia strigulosa*	Onagraceae	X			X
chaparral willowherb	*Epilobium minutum*	Onagraceae	X	X	X	X
California poppy	*Eschscholzia californica*	Papaveraceae	X	X		
Fremont's monkeyflower	*Mimulus fremontii*	Phrymaceae	X	X	X	
squirreltail	*Elymus elymoides*	Poaceae	X	X		
California melic	*Melica californica*	Poaceae	X	X		
bluegrass	*Poa secunda*	Poaceae	X	X		
small fescue	*Vulpia microstachys*	Poaceae	X	X		
false babystars	*Leptosiphon androsaceus*	Polemoniaceae	X	X		
true babystars	*Leptosiphon bicolor*	Polemoniaceae	X	X		
pygmy linanthus	*Leptosiphon pygmaeus*	Polemoniaceae	X	X		
Coville's buckwheat	*Eriogonum covilleanum*	Polygonaceae	X	X		
rigid bird's beak	*Cordylanthus rigidus*	Scrophulariaceae	X	X		

San Benito evening primrose range evaluation and surveying challenges

With the discovery of new habitat types for San Benito evening primrose along with major range extensions, it is unclear what the actual range limit is for the species. Before the discovery of the suboccurrences this season near HWY 198 on Mustang Grade in far eastern Monterey county at 11 airline miles south-southwest of the New Idria serpentine mass, suboccurence 191100 (BLM Section 8) was the furthest from the New Idria serpentine mass at 9 miles east. The actual range of the species relative to the New Idria serpentine mass is estimated to be 16 miles north to Panoche Valley (Cerro Bonito), 11 miles east to Old Hernandez Road (Pine Mountain), 9 miles southwest to Lewis Creek., and at least 13 airline miles south to Priest Valley (Charley Mountain) with perhaps a maximum limit of up to 25 miles south to the Parkfield Grade/Mine Mountain/Castle Mountain area. I surveyed a few small areas of suitable serpentine geologic transition zone habitat near Parkfield Grade road on the north side of the summit this season, but did not find any San Benito evening primrose plants. To date, only about half of the serpentine geologic transition zone within the estimated range of the species has been surveyed. Areas remaining to be surveyed are primarily on private land and include Cerro Bonito, Pine Mountain (Rock Springs Ranch), Panther Peak (southern portion of the Laguna Ranch), Lewis Creek, Austin Peak, Monarch Peak, Mustang Ridge, Monroe Valley, Charley Mountain, and Parkfield Grade/Mine Mountain/Castle Mountain area.

Since most of the remaining area to survey is located on private land, a major challenge to conducting future surveys will be obtaining access permission from private landowners. Another major survey challenge has been the lack of precise geologic maps. Patches of serpentine soil or serpentine outcrops as small as a few hundred square feet can provide habitat for San Benito evening primrose. Soil or geologic units this small are often not represented on maps since they are below the minimum map unit size. Geologic boundaries are often not mapped precisely and therefore, the mapped boundary can deviate from the actual boundary by over 1000 feet. Additionally, landslides are often not represented on maps or mapped without identification as serpentine (i.e "Quaternary landslide"). I have begun to more precisely map serpentine masses and landslides as depicted in **Figures 6 and 7**. Remapping is based upon field surveys and Google Earth imagery (virtual globe, map, and geographic information computer application; Google, Inc., Menlo Park, California, USA). The following serpentine masses and associated flanking smaller masses and landslides are now mapped in GIS with greater accuracy (however still not absolutely precise): New Idria (Serpentine ACEC; CCMA), Laguna Mountain, Hepsedam Peak, Panther Peak, Sweetwater, Black Mountain, BLM Section 8, Johnson Canyon, and Pine Mountain. The following serpentine mass map polygons still require refinement: Cerro Bonito, Lewis Creek, Austin Peak, Monarch Peak, Mustang Ridge, Monroe Valley, Charley Mountain, and Center Peak.

Soil and geologic maps provide good starting points to identify areas for habitat surveys, but ultimately, smaller serpentine masses and landslides must be located by examining aerial imagery and conducting field surveys. Google Earth has proven to be an invaluable tool in locating small serpentine masses not depicted on geologic maps (**Figure 16**). A trained eye can spot small serpentine masses on Google Earth based on color of sparsely vegetated areas (bluish hue), vegetation type changes (oak woodland to chaparral), and sometimes vegetation color (dominant grayish-green color of chaparral = leather oak [serpentine endemic] = serpentine soil).

Vegetation color difference is best perceived in the field. When conducting surveys, it is particularly useful to have some geology and soil science experience to verify that the soils being surveyed are derived from serpentine. Much time can also be saved by becoming well-acquainted with the soil characteristics, woody vegetation types, and companion herbaceous species that are strongly associated with San Benito evening primrose. This can allow the surveyor to rapidly eliminate areas by sight that have little to no chance of supporting the species, while targeting those that could support the species for intensive survey.

Figure 16. Small serpentine mass on Black Mountain not depicted on geologic maps found with the use of Google Earth.

5) *San Benito evening primrose plant counts and state of the species*

Tables 2 – 4 summarize plant counts for the 2009 – 2010 season. A total of 52,774 plants were counted. Of that, 26,210 of the plants are from new suboccurrences found this season, mostly within the geologic transition zone habitat. This year represents a boom year in the boom and bust cycle population dynamics of the species (**Figure 17**). The reason for the regular cyclic pattern (cycle time = 2 – 3 years) in plant numbers has not been identified. The pattern is not correlated with precipitation or other weather parameters. Boom and bust cycle population dynamics of species are typically highly correlated with population cycles of other species that it interacts with (predator-prey cycles). The boom and bust cycle of San Benito evening primrose (**Figure 17**) closely resembles examples of the Lotka-Volterra predator-prey model (**Figure 18**). In the case of San Benito evening primrose, the predator may be an insect or other invertebrate (possibly a specialist on *Camissonia* or Onagraceae), having the same cyclic population dynamics exhibited by San Benito evening primrose. No patterns of invertebrate infestation or herbivory damage have been observed on San Benito evening primrose at the flowering stage. Such a cryptic invertebrate herbivore may be feeding on San Benito evening primrose at the seedling or juvenile stage (November – mid-March) when plants are very small and difficult to identify. In a field study, Taylor (1990) observed in 1988 (the highest peak year ever measured for the species) that of the 20% of dead San Benito evening primrose seedlings for which a mortality factor could be assigned, 31% of the seedlings perished due to insect predation with the remaining 69% having succumbed to soil-related factors including drought and frost heave. Based on the Lotka-Volterra model, predator numbers peak shortly after prey numbers peak. Since this year likely represents a peak year for San Benito evening primrose plant numbers, the next two years should provide the greatest opportunity in identifying the potential invertebrate predator. Field studies will be established next year to identify potential invertebrate predators of San Benito evening primrose.

The San Benito evening primrose Recovery Plan identifies four Recovery Criteria for deslisting:
1) Research studies completed including habitat restoration and seedbank dynamics
2) Adequate protection of suboccurrences from OHV and other adverse human impacts
3) Habitat restoration
4) Population stable for at least 20 years

The trendline (**Figure 17**) for the 15 core suboccurrences that we have long term data for dating back to 1989 continues to show that although plant numbers exhibit an apparently natural boom and bust cycle from year to year, over the long term, plant numbers have been stable for more than 20 years, thus meeting Recovery Criterion 4. Long term stability, not short term (annual) variability, is the ultimate measure of annual plant species population viability. San Benito evening primrose was listed Threatened in 1985 when few populations of the species were known and most of the known populations (primarily in Clear Creek canyon) were located within high-impact OHV areas. This plant number data, combined with substantial new suboccurrence finds (particularly the geologic transition zone habitat) in low to no impact areas, indicates that the species is not nearly as imperiled as once believed. Both the range, suboccurrence numbers, and plant numbers are generally either equal to or greater than several CNPS List 1B and List 4 serpentine endemic species in the region including rayless layia (List 1B; annual), talus fritillary (*Fritillaria falcata*; List 1B; perennial), San Benito fritillary (*Fritillaria viridea*; List 1B; perennial), and San Benito monardella (*Monardella antonina* ssp. *benitensis*; List 4; perennial), all four of which occupy similar habitat and have also been subject to the same human impacts (mining, logging, OHV) as San Benito evening primrose. Continued research of habitat restoration and seedbank dynamics (Recovery Criterion 1), restoration of impacted serpentine stream terrace habitat (SA 1 - 5; Recovery Criterion 3), continued surveys within the geologic transition zone habitat (which may yield up to an additional 150 suboccurrences, further benefitting Recovery Criterion 4), and proposed CCMA RMP Alternative E (dramatically reduced level of OHV activity; Recovery Criterion 2) should make San Benito evening primrose a strong candidate for delisting within at least the next 5 years.

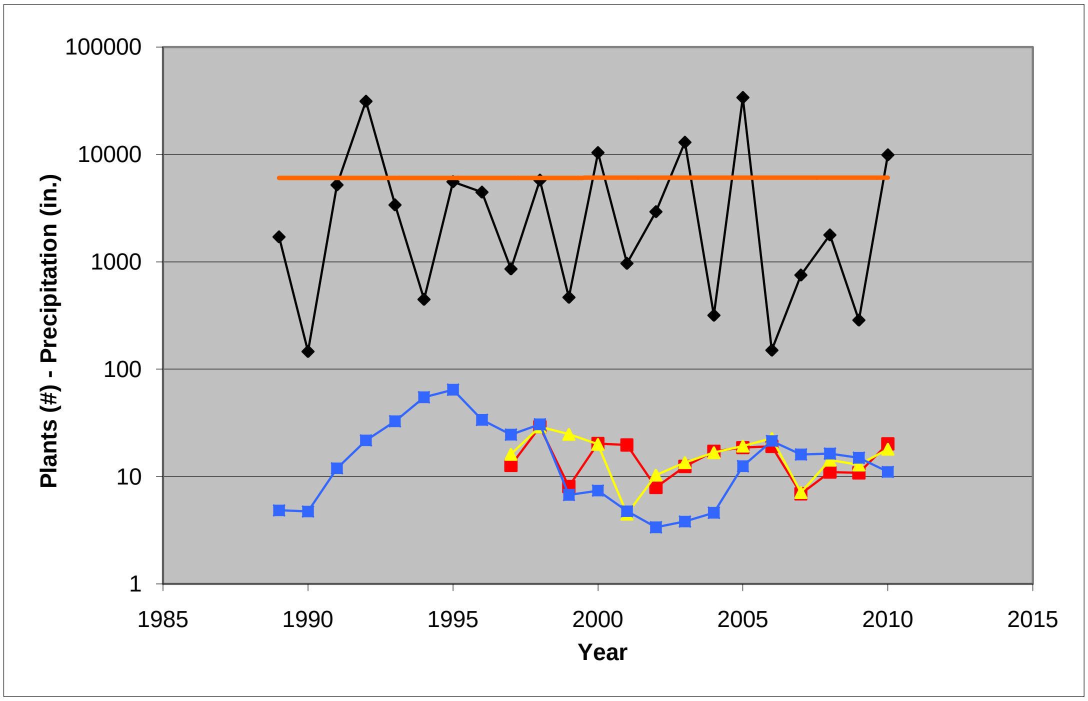

Figure 17. San Benito evening primrose plant numbers from 15 core suboccurrences (11100, 21200, 31100, 41100, 51100, 51200, 51400, 51500, 81100, 91100, 101100, 111100, 121100, 131100, and 141100) for which there has been continuous plant number data between 1989 and 2010 (**Black line**). Plant number for the species continues to be relatively stable over the long-term (**Orange trendline**). **Red line** = total annual precipitation from Hernandez rain gauge (western CCMA); **Yellow line** = total annual precipitation from Santa Rita Peak rain gauge (central CCMA); **Blue line** = total annual precipitation from Spanish Lake rain gauge (southern CCMA). Note log scale on Y-axis.

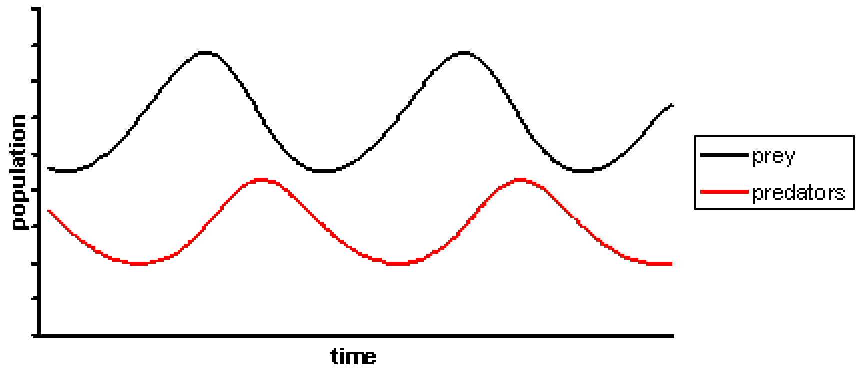

Figure 18. Lotka-Volterra predator-prey model.

6) *San Benito evening primrose research studies*

San Benito evening primrose serpentine alluvial stream terrace habitat mapping revision
San Benito evening primrose is currently being remapped at a higher level of detail **(Figure 19**) than existing GIS maps. Existing GIS maps, only display roughly delineated potential habitat for the species, often including elevated upland terrain and sloping barrens which do not meet potential habitat criteria for the species or would ever be expected to support the species. All remapping has involved on-the-ground classification (subjective) of habitat. All mapped habitat meets the basic habitat requirements of the species including serpentine parent material and level to gently sloping topography. The revised San Benito evening primrose habitat map should be complete by late 2010.

Rather than mapping all potential habitat in the same class, potential habitat is now divided into five habitat classes to highlight suitability and condition differences (**Table 7**). Class "3" represents the highest quality habitat with advanced soil development (organic matter accumulations), low or no disturbance, and moderate woody overstory vegetative cover with large gaps (open areas) between shrubs. San Benito evening primrose is not shade tolerant and typically grows in gaps between shrubs. Some habitat contains all of the class "3" qualities, however, dense woody overstory vegetative cover renders it uninhabitable by San Benito evening primrose. Habitat of that type is mapped as class "3, brushy." Class "2, 3 if restored" is potential habitat which has all of the characteristics of class "3", but has been adversely impacted by human disturbance such as staging areas and roads. The habitat differs from class "3" by having sparse or no vegetative cover and compacted and/or erosive soils. Class "2" moderate quality habitat exhibits some soil development, but experiences moderate levels of erosion and sediment deposition by virtue of it position downhill of natural barrens and other unstable landscape features, resulting in soil erosion and sediment deposition. Class "1" poor quality habitat consists of stream beds and fresh alluvium deposits with little to no soil development and are high susceptibility to erosion and sediment deposition due to its low topographic position.

One of the most important features of the revised maps is the identification of candidate habitat for restoration. Class "3, brushy" habitat could be converted to class "3" habitat with selective brush removal and/or control burns. Class "2, 3 if restored" habitat could be converted to class "3" habitat with removal of vehicle impacts (closure), soil ripping to relieve compaction, and organic soil amendment to boost fertility for San Benito evening primrose establishment and productivity. Class "2" conversion to class "3" would only be accomplished with great difficulty, requiring major erosion control efforts on natural serpentine barrens above the habitat. Class "1" conversion to class "2" or "3" would be short-lived and largely ineffective as the habitat would be rapidly degraded by natural erosion and sediment deposition.

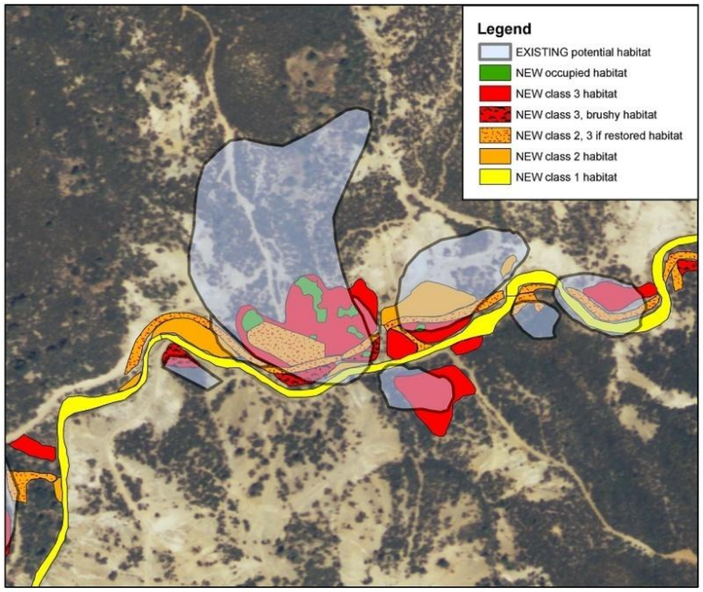

Figure 19. An example of habitat remapping in GIS. Staging Area 1 is located immediately left of the figure center. The existing mapped potential habitat (rough, partially inaccurate mapping) polygons are shown in light blue. These polygons include large amounts of upland habitat that would not support San Benito evening primrose and exclude areas of potential habitat. Remapped potential habitat with extent of occupied habitat is mapped in green. Habitat classes are mapped in red, orange, and yellow.

Table 7. San Benito evening primrose habitat mapping classes in GIS. All mapped serpentine alluvial stream terrace habitat meets the basic habitat requirements of the species including, serpentine soil/substrate and level to gently sloping topography.

Class	Soil development	Disturbance	Vegetative cover
3	Advanced	Low	Moderate
3, brushy	Advanced	Low	High
2 , 3 if restored	Advanced, but compacted/eroding	High; human induced	Low - None
2	Some development	Moderate; natural	Moderate - Low
1	Fresh alluvium	High; natural	Low

San Benito evening primrose seed production

San Benito evening primrose grown in a horticultural setting at the BLM Hollister Field during the 2008 – 2009 season, produced approximately 1 quart of ground plant material containing hundreds of thousands to millions of seeds. San Benito evening primrose is highly conducive to being grown in a horticultural setting on potting soil. When grown on potting soil with regular fertilizer applications and watering to maintain the soil at field capacity (no water stress), plants grow much larger and produce more seed than they do on serpentine soil in natural field conditions. Growing plants in a horticultural setting allows a large amount of seed to be produced with little space or plant care requirements. The seed is used in research studies and introductions.

San Benito evening primrose was again grown in a horticultural setting at the BLM Hollister Field Office during the 2009 – 2010 season. Growing conditions were the same as the 2008 – 2009 season (see 2008 – 2009 Annual Report), except that growing area was increased from 8 to 28 square feet with the number of plants grown within the area, increased accordingly (**Figure 20**). Several hundred San Benito evening primrose plants grew together to form a solid cover (**Figure 21**). Mature plants bearing seed were harvested, dried, and processed using the same methods as the 2008 – 2009 season. Plants grown this year yielded 2 gallons of ground plant material containing millions of seeds.

Figure 20. San Benito evening primrose grown in potting soil at the BLM Hollister Field Office during the 2009 – 2010 season.

Figure 21. Dense cover of San Benito evening primrose grown at the BLM Hollister Field Office during the 2009 – 2010 season.

San Benito evening primrose soil amendment field study follow-up

A field study was initiated in the 2008 – 2009 season in order to examine the response of introduced San Benito evening primrose to soil amendment of disturbed serpentine stream terrace habitat (see 2008 – 2009 Annual Report). Three plots were established of each treatment in **Table 8**. Each plot was surface broadcast seeded with approximately 3000 San Benito evening primrose seeds on October 31, 2008. The study site is now known as suboccurrence 241300.

Table 8. Field study treatments.

Treatment	Surface amendment	Depth amendment	Tillage depth (in.)
Control	None	None	10
30% compost[1]	None	Compost (30%)	10
30% peat[2]	None	Peat (30%)	10
30% native OM[3]	None	Native OM (30%)	10
Serp. topsoil[4]	Serp. topsoil	None	10

[1] - Yard waste (garden clippings) compost screened to ¼ inch (5 mm).
[2] - Miracle-Gro® Enriched Sphagnum Peat Moss (Scotts Miracle-Gro Company, Marysville, Ohio, USA; peat moss + .10 -.05-.10 fertilizer)
[3] - Native organic matter humus collected from underneath local shrubs and screened to ¼ inch (5 mm).
[4] – Locally-collected serpentine topsoil (B horizon). Screened to ¼ inch (5 mm).

San Benito evening primrose counts were made in April 2009 and April 2010 (**Table 9**). All three compost amended plots continue to support San Benito evening primrose plants. All three peat amended plots supported plants in 2009, but only one of three plots did in 2010, suggesting that the fertilizer component of the peat is exhausted. No plants were seen in 2009 or 2010 in the relatively nutrient-poor control (no treatment), native organic matter (low C:N ratio), or topsoil (B horizon) plots. Results of this study continue to indicate that organic amendment (compost) of heavily-impacted serpentine stream terrace habitat is necessary to reestablish and sustain San Benito evening primrose. Although no invasion by nonnative plant species has been observed in the research plots since establishment, amendment of serpentine soils carries a risk of invasion, as demonstrated by the *San Benito evening primrose soil amendment pot study* presented in the 2008 – 2009 Annual Report. When a nonnative herbaceous species such as red brome (*Bromus madritensis*) grows in high densities, it can effectively outcompete San Benito evening primrose.

Table 9. Number of established San Benito evening primrose plants.

Soil treatment	Replicate	Plant count 2009	Plant count 2010
Control	1	0	0
Control	2	0	0
Control	3	0	0
Compost 30%	1	7	39
Compost 30%	2	2	2
Compost 30%	3	3	4
Peat 30%	1	3	2
Peat 30%	2	1	0
Peat 30%	3	3	0
Native OM	1	0	0
Native OM	2	0	0
Native OM	3	0	0
Topsoil	1	0	0
Topsoil	2	0	0
Topsoil	3	0	0

Fire effects on San Benito evening primrose

The BLM has been controlling yellow starthistle, tocalote, and medusahead grass at CCMA with prescribed fire since 2005. Invasive species control has occurred primarily from Clear Creek confluence to Jade Mill. Prescribed fire, in combination with herbicide application, mowing, and hand-pulling have dramatically reduced yellow starthistle and tocalote within the project area. This season, new suboccurrences were found on serpentine soils at the Clear Creek confluence that do not appear to have existed prior to the use of prescribed fire on the project. No San Benito evening primrose plants were found in this habitat when it was surveyed in 2008, but were found during surveys in 2010 (UTM 10S 698728, 4025886 and 698840, 4025812). Fire appears to improve habitat for San Benito evening primrose by reducing the density of competing plant species.

Historic vegetation cover within San Benito evening primrose habitat

The 2008 - 2009 Annual Report includes a discussion on: *The relationship between prehistoric/historic human habitation sites and San Benito evening primrose suboccurrences*. This section discusses the use of historic aerial photography to determine historic vegetation conditions on San Benito evening primrose habitat within the CCMA.

The New Idria serpentine mass (Serpentine ACEC) of the CCMA has a long history of human impacts, beginning with cinnabar mining at New Idria in 1854. Mining for cinnabar (mercury ore), magnesite (talc), chromite (chromium ore), and chrysotile asbestos have had major impacts to vegetation and soils in the area. Thousands of trees and shrubs were cut to supply timber and firewood to New Idria (Sloane 1914). Relatively level serpentine alluvial stream terraces adjacent to perennial streams were favored for cabins as well as areas to stage logging and mining activities. In recent decades, OHV recreation has replaced mining and logging as the largest human impact within the area. As described in the 2008 – 2009 Annual Report, not all human impacts are detrimental to San Benito evening primrose and some level of disturbance actually appears to beneficial to the species by reducing woody overstory cover and enriching soils with organic matter. High levels of disturbance, however, are clearly detrimental as vegetation is completely lost and soils become compacted and erosive. High levels of disturbance are evident at Staging Areas 1 – 5. Comparison of aerial photography taken in 1939 with recent aerial photography reveals complete woody vegetation loss within Staging Areas 1 and 5 (**Figures 22 and 23**). Based upon topographic location and close proximity to known San Evening primrose suboccurrences, both staging areas likely supported suboccurrences of the species historically. Staging Areas 1 – 5 are proposed to be closed and restored (tillage to relieve compaction and compost amendment), followed by possible introductions/reintroductions of San Benito evening primrose.

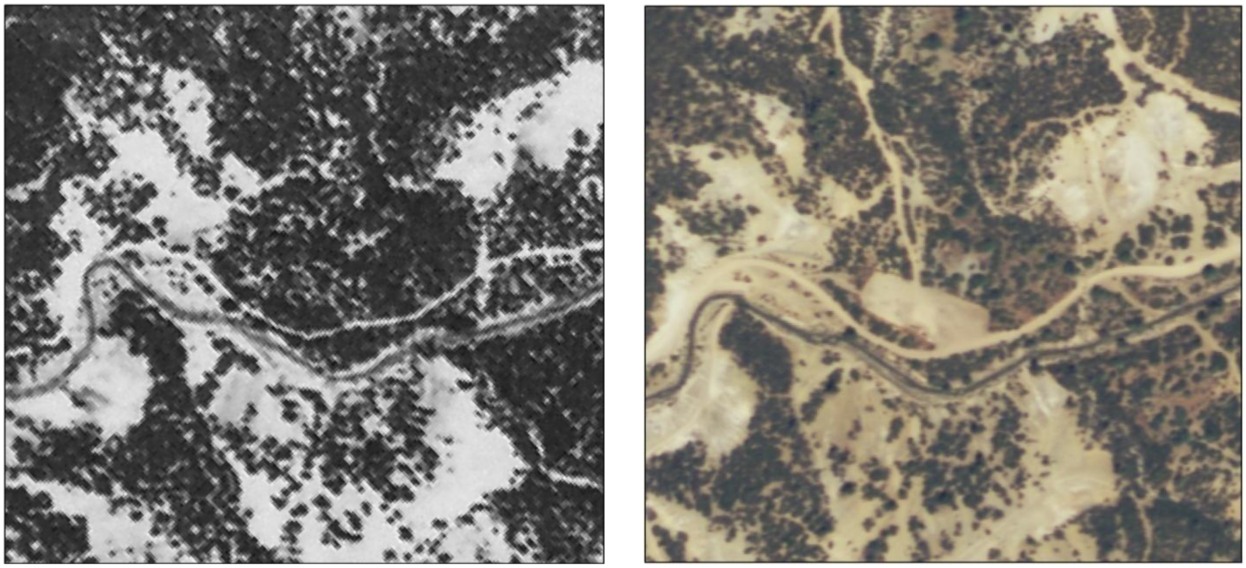

Figure 22. Staging Area 1 (center of photos) in 1939 (L) and 2005 (R). Note the large rectangular bare area in the 2005 photo and the well-vegetated condition of that same location in the 1939 photo.

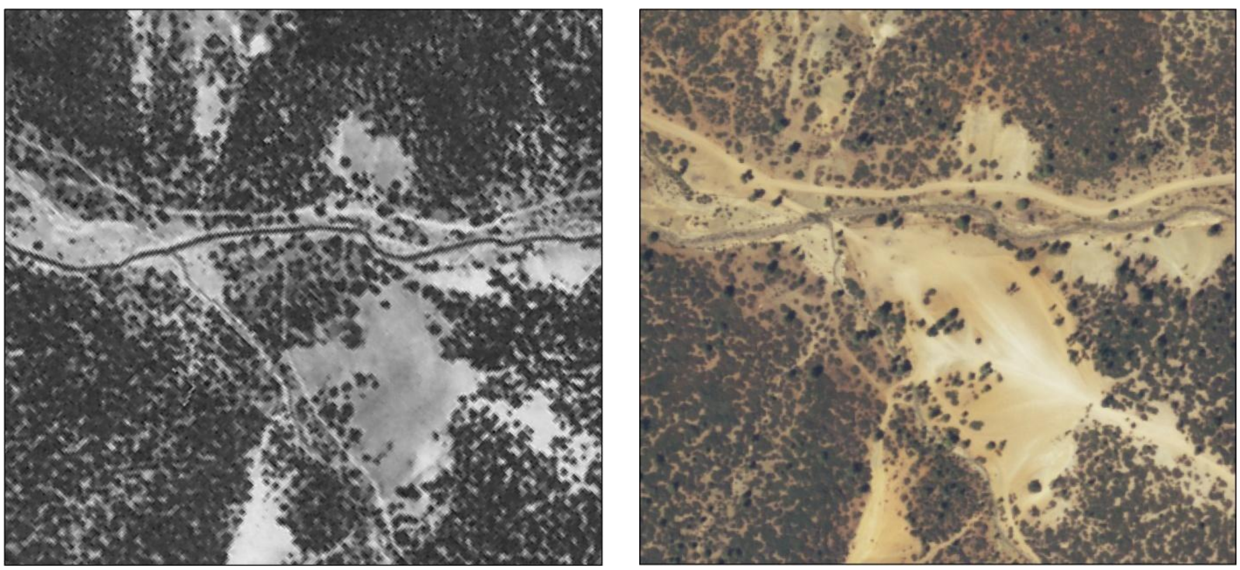

Figure 23. Staging Area 4 (center of photos) in 1939 (L) and 2005 (R). Note vegetation loss in the center of 2005 photo center as compared to the same well-vegetated area in the center of the 1939 photo.

Serpentine endemic infidelity in the Clear Creek Management Area

Plant ecologists have long theorized about why some plant species are entirely limited to specific soil types, referred to as edaphic endemism. One leading theory is that edaphic endemic species have tolerance traits, such as inherently slow growth rate, that allow them to tolerate the extreme adverse physical and chemical characteristics of stressful soil types, but those same tolerance traits make them poor competitors with generalist species (faster growth rate) that do not tolerate stressful soil types and typically grow on more normal (fertile) soils (Kruckeberg 1950, 1991).

The edaphic endemic species are effectively outcompeted in any environment other than the stressful soil type where they are able to tolerate conditions that generalist species are not able to.

About 160 plant species in California are regarded as strict serpentine endemics (Safford et al. 2005). The New Idria serpentine mass (Serpentine ACEC) of the CCMA harbors several strict serpentine endemic species including talus fritillary, San Benito fritillary, San Benito monardella, San Benito evening primrose, rayless layia, and leather oak. Within the CCMA, San Benito evening primrose, rayless layia, and leather oak are restricted to serpentine except near Picacho Peak and Condon Peak, where all three species have populations that occur on shale outcrops or shale barrens. Five suboccurrences of San Benito evening primrose (**Figure 15**) and one suboccurrence of rayless layia (**Figures 24 and 25**) grow on shale outcrops near the geologic transition zone in that area. Leather oak grows on shale soils up to a few thousand feet away from the geologic boundary in the same area (**Figure 25**). The species is markedly stunted on some areas of the shale soil. Analysis of the shale soils shows a Ca:Mg molar ratio of 1.6 – 3.8 typical of a nonserpentine soil type and much greater than that of serpentine soils (Ca:Mg molar ratio < 1) which exhibit Ca deficiency and Mg toxicity. Soil pH is moderately acidic (5.6 – 6.2) which may be exacerbating nutrient deficiency. Nutrient deficiency is a common feature of serpentine soils. The shale outcrops and barrens are expressing some of the stressful soil conditions associated with serpentine soils. Presence of strict serpentine endemic species on shale outcrops and barrens, suggests that Kruckeberg's theory on the origin of serpentine endemic species is at least partially correct.

Figure 24. Rayless layia growing on shale outcrop 3600 feet from the serpentine – nonserpentine geologic boundary (UTM 10S 711730, 4021578)

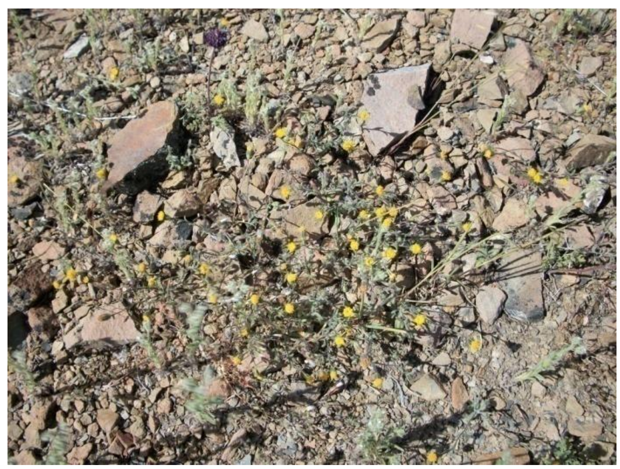

Figure 25. Rayless layia growing on shale outcrop (UTM 10S 711730, 4021578).

Figure 26. Leather oak growing on shale 2000 feet from the serpentine – nonserpentine geologic boundary (UTM 10S 711935, 4022060)

Literature cited

Griffin, J.R. 1978. Rare plant status report (1978 supplement). 6 pp.

Griffin, J.R. 1979. Survey of rare and endangered plants. Clear Creek Recreation Area, San Benito-Fresno counties. 6 pp.

Hickman, J.C. 1993. The Jepson Manual. Higher plants of California. University of California Press, Berkeley, California, USA. 1400 pp.

Kiguchi, L.M. 1983. Sensitive plant survey. Clear Creek Recreation Area. San Benito Mountain Natural Area. 5 pp.

Kruckeberg, A.R. 1950. An experimental inquiry in the nature of endemism on serpentine soils. PhD dissertation. University of California, Berkeley, California, USA.

Kruckeberg, A.R. 1991. An essay: Geoedaphics and island biogeography for vascular plants. Aliso 13:225-238.

Raven, P.H. 1969. A revision of the genus *Camissonia* (Onagraceae). Contributions to the U.S. National Herbarium 37:155-396.

Safford, H.D., Viers, J.H., and Harrison, S.P. 2005. Serpentine endemism in the California flora: A database of serpentine affinity. Madroño 52:222-257.

Sloane, N.H. 1914. Resources and plan of operation of Monterey National Forest. Unpublished U.S. Forest Service document.

Taylor, D. 1990. Ecology and life history of the San Benito evening-primrose (*Camissonia benitensis*). Biosystems Analysis, Inc., Santa Cruz, California, USA July 1990. 87 pp.

Taylor, D. 1992. Ecology and life history of the San Benito evening-primrose (*Camissonia benitensis*). 1992 final supplemental report. Biosystems Analysis, Inc., Santa Cruz, California, USA. September 1992. 20 pp.

Taylor, D. 1995. Ecology and life history of the San Benito evening-primrose (*Camissonia benitensis*). 1995 supplemental report. Biosystems Analysis, Inc., Santa Cruz, California, USA February 1995. 13 pp.

U.S. Fish and Wildlife Service. 2006. Recovery plan for *Camissonia benitensis* (San Benito evening-primrose). U.S. Fish and Wildlife Service, Sacramento, California. ix + 97 pp.