CHORRO CREEK BOG THISTLE RECOVERY PROJECT

FINAL REPORT

SUBMITTED BY
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ABSTRACT

The goal of the project was to increase knowledge of the distribution of populations of the Chorro Creek Bog Thistle, Cirsium fontinale var.obispoense, and to seek out sites suitable for restoring or adding new populations. The thistle was listed as Endangered by the California Fish and Game Commission in January 1993. It occupies a very limited habitat in bogs and wetlands that have developed above substrates dominated by serpentinites or by landslides of serpentinite debris. Existing populations are all within San Luis Obispo County in areas of coastal climatic influence that experience some summer fog. These populations occur in the hills south of the city of San Luis Obispo, and along the western foothills of the Santa Lucia Mountains between the city of San Luis Obispo and San Simeon. A summary of the plant numbers and conditions at each site is given in a table at the end of this abstract. Each site was surveyed for the numbers and condition of the plants, the associated plant community, hydrologic conditions, soil type, slope, slope aspect, and indications of disturbance or threat. Influences such as grazing and competition from other plants were noted. It is evident that the most important environmental factor controlling the success of a population is the persistence of wetness throughout the year, and a soil typical of serpentinites that lacks potassium and enriched in magnesium. Grazing at normal levels does not appear to adversely impact the plant, although there are evident differences between grazed and ungrazed areas. In order to seek out possible restoration sites, and to assess the full distribution of the plant, the serpentinite ridges and outcrops throughout coastal San Luis Obispo County were explored. Three new plant populations were discovered. Several possible restoration sites were found and are described and prioritized. Many other springs were visited but found not be suitable due to lack of the required soil type, and some of these are described. The site conditions encountered in the field are summarized, and the results of soil chemistry analysis are given. One population at Laguna Lake was tracked throughout the project, and plant height was measured monthly for 125 plants. The results are given in Appendix A. The thistle is a biennial, but may live longer. The great majority of plants die after flowering in the second or third year, but a small majority appear to persist after flowering. Threats to existing populations include development near the city of San Luis Obispo, and appropriation of spring waters near San Simeon. There may be some future risk from the application of biological controls to pest thistles in lands near the bogs, but this is not a problem at this time.

NDDB#	Name of site	cty	dt last obs	ownership	protected?	size	status	comments
					key in			
					footnotes			
	San Simeon (known)	SLO						
1	_upper spring	SLO		Winsor + Denio	No (3)	Sp.93(200)	healthy/increasing	possible water diversion
1	_Bianchi	SLO	Sp.93/Sp.94	Bianchi+others	Yes(1,2)	Sp.93(285)Sp.94(280)	healthy/stable	possible property dispute
	San Simeon (new)	SLO						
new	_seep	SLO	Sp.93	Winsor	No	Sp.93(170)	healthy/increasing	not seen before 1993
new	_stock pond	SLO	Sp.93	Winsor	No	Sp.93(49)	healthy	some grazing damage
new	_big seep	SLO	Sp.93	Winsor	No	Sp.93(340)	healthy	not seen before 1993
new	_reservoir	SLO	Sp.93	Winsor	No	Sp.93(36)	insect damage	risk reservoir maintenance
new	_mine	SLO	Sp.93	Winsor + ?	No	Sp.93(7)	healthy	marginal habitat
	Laguna Lake Park	SLO						
2	_East	SLO	Sp.94	City of SLO	Yes (1,2)	Sp.93(550) Sp.94 (510)	healthy	frequent CNPS monitoring
2	_Middle	SLO	Sp.94	City of SLO	No (2)	Sp.93(25)	healthy	frequent CNPS monitoring
2	_West	SLO	Sp.94	City of SLO	No (2)	Sp.93(450)Sp94.(440)	healthy	frequent CNPS monitoring
	Pennington Creek	SLO						
6	_main	SLO	Sp.94	Cal Poly State Univ	Yes (1,2)	Sp.93(>2000)Sp.94(1900)	healthy/stable	frequent CNPS monitoring
?new	_satellite	SLO	Sp.94	Cal Poly State Univ	Yes (1,2)	Sp.93(200)Sp.94(150)	healthy/stable	frequent CNPS monitoring
	Prefumo Canyon	SLO						
4	_Waterfall	SLO	Sp.93	SLO County/Private	No	360	healthy/increasing	
5	_Roadside	SLO	Sp.93/Sp.94	SLO County/Private	No (5)	Sp.93(70)Sp.94(50)	healthy	some mowed along road
new	_Gully A	SLO	Sp.93	Silviera + Charles	No	Sp.93(150)	healthy	
new	_Gully B	SLO	Sp.93	Silviera + Charles	No	Sp.93(40)	healthy	
	Froom Ranch	SLO						
7?	_Froom Ranch South	SLO	Sp.93	Madonna	No (4)	>155	healthy/stable	active development plans
7?	_Froom.N.Spring	SLO	Sp.93	Madonna	No (4)	95	healthy/stable	active development plans
7?	_Gully Confluence	SLO	Sp.92/Sp.93	Madonna	No (4)	Sp.92(1)Sp.93(0)	extirpated	active development plans
7?	_Froom Creek	SLO	Sp.92	Madonna	No (4)	10	unknown	active development plans
3	Chorro Creek	SLO	Sp.93	Cal Natl Guard	Yes (2)	Sp.93(250)	healthy	newly recovered
new	San Bernardo Creek	SLO	Sum.93	O'Reilly	No	Sum.93(>500)	healthy	poorly studied
	START OF 1993/1994 GROWING SEASON				TOTAL PLANTS ABOUT 5,700			

(1) Grazing exclosure in place (2) Active monitoring program in place (3) Water diversion likely
(4) Development plans (5) Recently mowed

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INTRODUCTION

In January 1993,Chorro Creek bog thistle, Cirsium fontinale var. obispoense was listed as Endangered by the California Fish and Game Commission. The object of the listing process is to ensure the survival and to promote the recovery of this species. This project is in response to the need to (1) preserve and enhance existing populations, and (2) locate potential sites for the possible re-establishment of populations or the creation of new populations of the plant, in order to safeguard the plant against threat of extinction.

The existing population sites are springs and seeps underlain by serpentinite-derived soils. These populations may be better protected through an understanding of the environmental stresses on existing populations and sites. The existing sites are compared to potential re-establishment sites where new populations could be established, to aid in the site prioritization and selection process.

SCOPE OF WORK

The scope of work, as defined by the Endangered Plant Program of the Department of Fish and Game, included the following components:

1) Survey and map potential sites from San Simeon Creek to Perfumo Canyon to determine potential for recovery.

2) Investigate the possibility for protection of potential seep sites. Prioritize sites in terms of potential for permanent protection, and resilience to drought.

3) Characterize habitat of existing sites in terms of associated species, slope, aspect, soil/water chemistry, period and degree of inundation, and microtopography. Record observations on pollinators, threats, disturbances, etc.

4) Determine phenology of individuals at Pennington Creek site (germination, growth, establishment, flowering, fruiting, seed set, seed dispersal).

5) Monitor grazed and ungrazed plots at Laguna Lake site to obtain information on how grazing affects germination, establishment, flowering, seed set, and seed dispersal. Investigate interactions between grazing and microsite factors such as level of mulch, associated species, competition, and shading.

6) Develop annual monitoring program for Chorro Creek Bog Thistle. Implement monitoring, including use of photogrids, at Laguna Lake and Pennington Creek sites in 1993.

7) Collect seeds from Pennington Creek site for germination trails. This will be done under an M.O.U. with the Department of Fish and Game's Endangered Plant Program.

8) Perform germination trials in reintroduction site and/or in greenhouse.

CHORRO CREEK BOG THISTLE TAXONOMY

In their introduction to the listing report authored by the California Department of Fish and Game for the California Fish and Game Commission, Wikler and Morey (1992), the following information on the taxonomic origin of the plant was presented.

> "There are twenty-eight species in the genus Cirsium that are native to California, covering a broad range of habitats from dry dunes to serpentine seeps. C. fontinale var. obispoense is one of two rare varieties of a species that was first described in 1887 by Edward L. Greene. Greene originally called the taxon Cnicus fontinalis, and six years later transferred it to the genus Carduus. In 1901, Jepson named it Cirsium fontinale. J.T. Howell described the variety C. f. obispoense in 1938 from a collection he made at Chorro Creek in 1936, hence the common name. Both C. fontinale var. obispoense and C. fontinale var. fontinale, whose common name is fountain thistle, are endemic to serpentine seeps and have extremely localized distributions. The two varieties are separated by over 200 miles (U.S. Fish and Wildlife Service 1991, Niehaus 1977, Pilz 1967). Fountain thistle, which occurs in San Mateo County, was added to the State endangered species list in 1979.
>
> Chorro Creek bog thistle is a short-lived, herbaceous, perennial plant of the sunflower family (Asteraceae)....."

Cirsium fontinale var. obispoense occurs only in San Luis Obispo County where its habitats are very localized in wetlands on serpentinite or serpentinite-derived soils. These include springs and permanently wet sites in stream channels. It occurs in the vicinity of San Luis Obispo and in one site east of San Simeon.

Included verbatim for botanic reference is the description of the variety obispoense by the plant's discoverer, J.T. Howell, taken from the original card.

Cirsium fontinale (Greene) Jeps. var. obispoense J. T. Howell (1938), Type, 6 May 1936, A. Eastwood & J. T. Howell 2218: CAS.

Distribution: Type collection from Chorro Creek, San Luis Obispo Co., Calif. Known only from type locality and three other highly localized sites within San Luis Obispo Co.: San Simeon Creek, upper Pennington Creek, and Perfumo Canyon. CIF00 occurs at low elevations below 1000 ft Maps: USGS SPn Luis Obispo and Pebblestone Shut-In 7.5'.

Description: Perennial herb with stout, erect, reddish stems 0.5-2 m tall and spiny leaves that are variously glandular-pubescent on upper and lower surfaces. Lowermost stem leaves deeply divided. Flower buds nodding. Heads single or more usually in close clusters and slightly nodding. Strongly purple-hued bracts of flower heads broadly egg-shaped (ovate) and less hairy than in C. fontinale var. fontinale. Central spine of head bracts rarely drawn out into a slender, lance-like tip. Flower head bracts strongly recurved (reflexed) and lacking a distinct central ridge on the back. Flowers more-or-less pinkish becoming sordid brown with age. Flowering time: Feb-Jul (vague).

Most other Cirsium species in area lack glandular hairs on upper leaf surface and nodding flower head buds. See key in Hoover (1970) clearly to differentiate species.

The original Jepson description that defines the variety in terms of the original species description is also given:

Cirsium fontinale (Greene) Jepson

"Perennial 3-6 dm. high, with widely spreading branches; stems and upper lf. surface - glandular pubescent, lower surface - tomentose; basal leaves 1-2 dm. long, deeply pinnatifid, petioled, the lobes broadly deltoid, spine-tipped; cauline somewhat reduced, the upper sessile; heads clustered, - paniculate, ca. 2.5-3cm. high, roundish, a little nodding; phyllaries glandular-puberulent, very broad below, ciliate-fimbriate, spreading recurved form near the middle and then drawn out into slender lanceolate tips; fls. white, well exserted; aks. smooth, shining, brown, - oblong, ca. 5mm.10ng.--In wet spots in clay overlaying serpentinite, near Crystal Springs Lake, San Mateo, Co. June-Oct.

Var. obispoense J. T. Howell. More obviously tomentose especially on under side of Lvs.; phyllaries less pubescent and the cent. ones rarely drawn out into lanceolate tips; fls. - pinkish; aks. more turgid sparsely roughened near apex. - Boggy places near serpentine, Chorro Creek, San Luis Obispo Co "(Munz & Keck, 1973).

GEOLOGIC SETTING

All known populations of Chorro Creek bog thistle (CCbt) are located in soils derived from serpentinite bedrock; from landslide materials derived from serpentinite bedrock, or, in relatively rare cases, directly on the bedrock.

Serpentinite is a metamorphic rock that contains serpentine $Mg_3Si_2O_5(OH)_4$, in the form of at least two distinct minerals, antigorite and chrysotile. The rock is formed from the hydration of peridotite and related rocks deep within the crust, and most probably during the process of subduction. The serpentinite in the Coast Ranges of California is found in close association with other geologic features considered typical of the subduction process, which took place well over 100 milion years ago. Nearby bedrock, adjacent to the serpentinites, is usually melange of the Franciscan Formation, which was formed at approximately the same time.

In the San Luis Obispo area the serpentinites are typically found on the west side of the main ridge of the Santa Lucia Mountains. The bedrock serpentinites can be found either as extensive blocks of rock that are overlain by volcanic rocks of the same age, or as rather narrow outcrops that appear to have been intruded plastically along faults. Serpentinites are well known for being plastic under pressure, with sections of the rock sliding over neighboring blocks toward the surface much in the manner that glass marbles might move in a cloth sack when the sack is squeezed. Long and narrow outcrops of serpentinite result, and can be seen in the bedrock ridges that (1) lie on the north and east sides of San Luis Obispo, (2) separate the Los Osos and Chorro Valleys; and(3) form several rocky ridges between San Luis Obispo and the Cambria area (Figure 1A and 1B).

A very extensive area of serpentinite is found on the Cuesta Ridge, west of the Highway 101 Cuesta Grade. Due to rapid erosion of nearby Franciscan Formation melanges, combined with possible uplift of the Santa Lucia Mountains, this serpentinite deposit developed a very steep south-west facing slope. Massive landslides then cascaded down this slope within the last milllion years or so. In some areas these landslides are derived almost solely of serpentinite debris, and this terrain has produced both the soil and the groundwater springs of the largest CCbt populations. These are the Pennington Creek, San BernardoCreek and Chorro Creek populations. Very similar terrain in the San Simeon area supports all the populations in that region.

The long, narrow serpentine outcrops have supported CCbt populations at Laguna Lake; at Froom Ranch at the south end of the city of San Luis Obispo; and in Prefumo Canyon to the southwest of the city. These populations are generally associated with perennial springs at the base of the outcrops and, in most cases, with black soil bogs. The bogs are very similar to those encountered with the landslide-associated assemblages. However the Prefumo Canyon population seems to be in serpentinite gully wash debris or in serpentinite-bedrock derived soils, rather than bogs, and is therefore somewhat different.

The bedrock that adjoins the serpentinites is typically the melange of the Franciscan Formation. There are frequently springs associated with this melange, being composed of of firm rock blocks of different composition in a matrix of sheared shale. It has a very heterogenous makeup in both lithology and the transmission of groundwater. As part of this study, many of these non-serpentinite springs were explored, and none of them contained populations of CCbt.

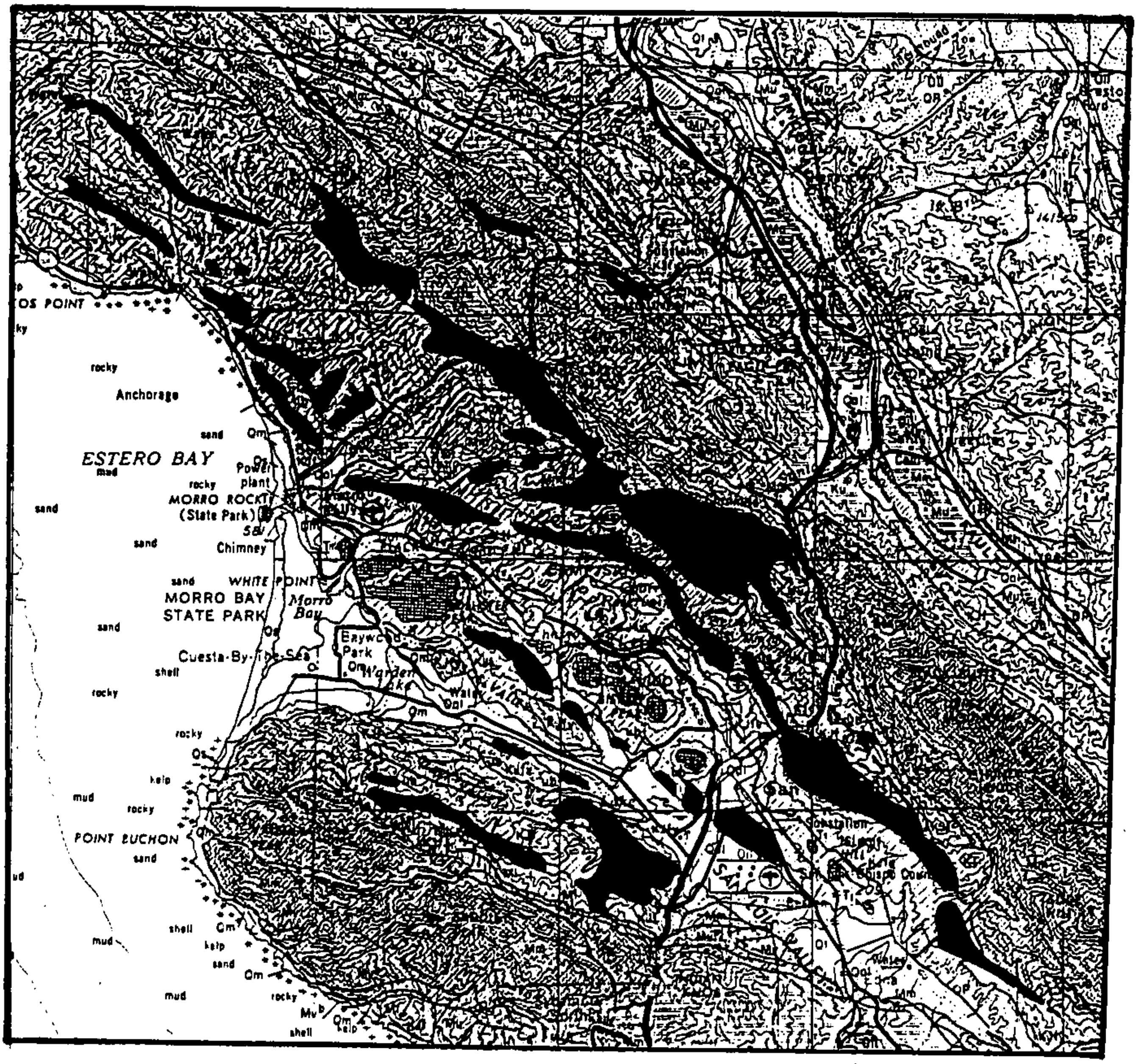

Figure 1A. Distribution of Serpentinite and other Ultramafic Rocks in Central San Luis Obispo County. (Shown as darkest shade)
Base map is a portion of the San Luis Obispo Sheet, Geologic Map of California, California Division of Mines, 1958

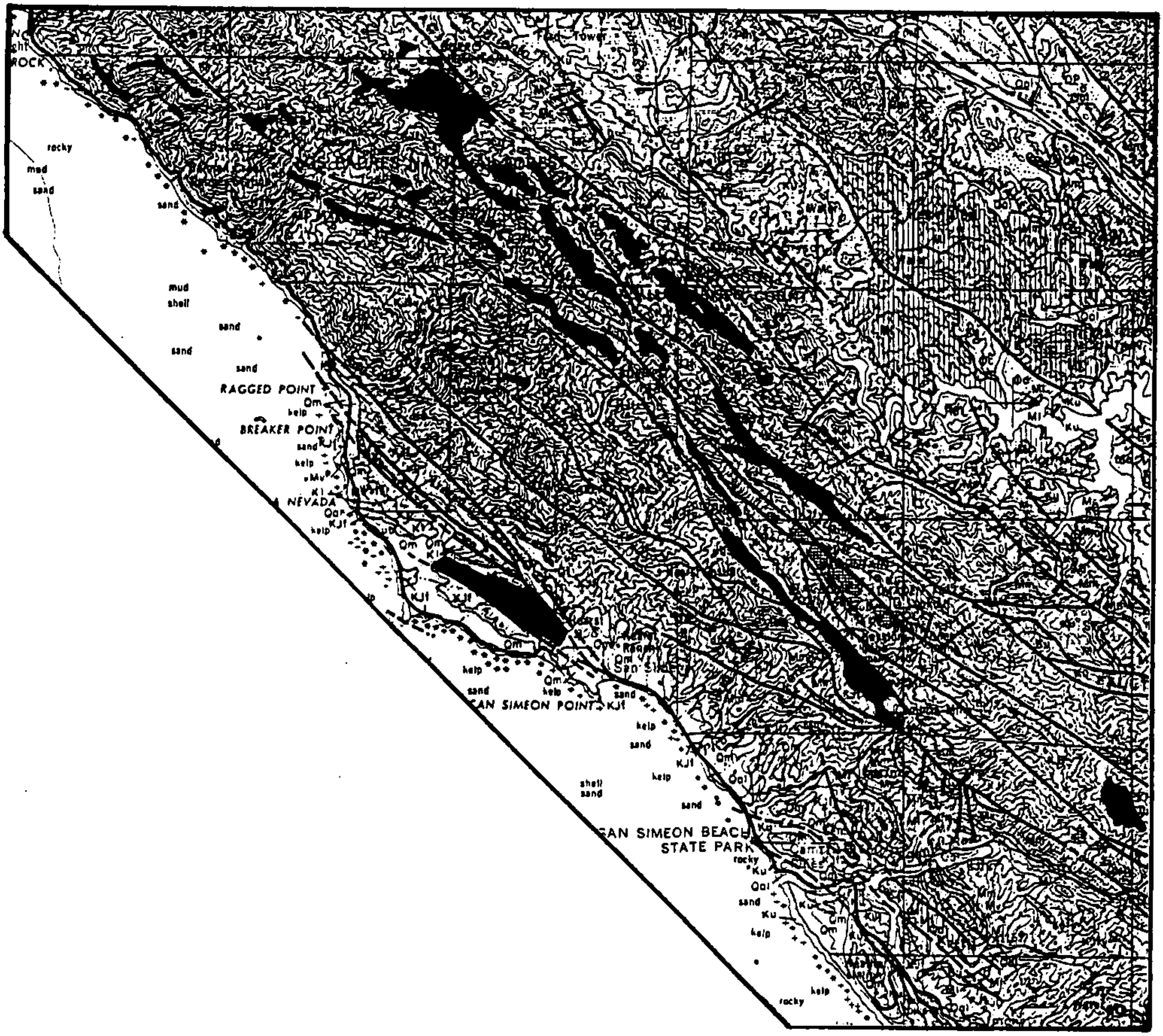

Figure 1B. Distribution of Serpentinite and other Ultramafic Rocks in Northern San Luis Obispo County. (Shown as darkest shade)
Base map is a portion of the San Luis Obispo Sheet, Geologic Map of California, California Division of Mines, 1958

CLIMATIC RANGE OF KNOWN SITES

All of the known CCbt sites have similar climatic conditions: mild summer temperatures that rarely exceed 80 degrees; mild winter temperatures which seldom fall below freezing, and coastal fog cover during part of the day during the summer months. The fog also raises humidity during the night. On this basis, it is suspected that success for the CCbt may be dependent on the marine influenced climate described.

No populations occur on the east side of the crest of the Santa Lucia Mountains, although otherwise suitable habitat associated with serpentinite seeps occurs there. Summer temperatures on the east side of the ridge routinely exceed 100°F, with no summer fog. On the west side of the Santa Lucia Mountains, no plants have been found in the summer-warm microclimates of the Reservoir Canyon area, which lies just east of the City of San Luis Obispo, where fog penetration is limited and temperatures somewhat higher than in locations closer to the coast. However the microclimate variations between known thistle locations are considerable, with populations found on both north-facing and south-facing slopes, in shade and in the open.

SEARCH AREA FOR STUDY

The search area chosen for this study was defined by the known extreme northern and southern populations of the thistle variety. Serpentinites within a few miles of the known locations were examined. Successful finds were made near San Simeon that slightly extend the known northern limit of the variety. The southern edge of the serpentinite body that supports the Froom Ranch and Prefumo Canyon populations was investigated with no new discoveries south of Froom Ranch. No discoveries were made in searches on the east side of the Cuesta Ridge, and in the Reservoir Canyon area east of the City of San Luis Obispo.

Extensive field time was required to investigate springs throughout the area, including those that were not in serpentinite. As a result, there was no attempt made to extend the search into the area of ultramafic rocks and serpentinites owned by the Hearst Ranch north of San Simeon, or into the serpentinites of the High Mountain-Rinconada area in the Pozo Area. Although this study cannot be considered the 'last word' on the existing range of the CCbt, the probability that the search area covered all populations is very high.

STATUS OF POPULATIONS KNOWN PRIOR TO CURRENT STUDY

FROOM RANCH GROUP OF POPULATIONS

Froom Ranch South

The Froom Ranch South population is the southernmost station known for CCbt, shown in Figure 2. The population is located along a small stream channel with associated bogs that flows from the Irish Hills. The flow is toward the northeast, approximately toward the intersection of Los Osos Valley Road and the US 101 Freeway. CCbt are found scattered along the channel. Most of the population is found where the channel approaches the brush line on the upper side of the grass covered terrace . There were about 130 plants in the population on the grassland, with 40 plants in flower in the 1993 season.

The channel continues up the hill through the dense brush. There is a second population of the thistle about two hundred meters up the channel, located in moist soils bordering the creek and in serpentinite-derived gravels on the floor of the creek. Of the 25 plants in this population, only 2 were in flower and the majority were very small. A substantial number of these plants were in very small soil pockets which dried out, and did not survive through the summer. However, it is possible that this location is the source of seed for the larger population on the grassland below. Based on observations on similar Prefumo Canyon sites, it is very likely that further populations exist higher on the hill, but brush within the channel was too dense to allow further passage.

Froom Ranch 'North Spring'

Another population occurs in a spring about 100 meters to the north of the Froom Ranch South grassy terrace (Figure 2). There were approximately 95 plants in thick, tall grass with very few young plants. About 40 of the plants were in flower in 1993. The spring occupies a flat region at the back of the terrace. The geology consists of serpentinite bedrock with a mantle of colluvial and alluvial serpentinite debris. Soils in the bog around the spring were typically black.

Froom Ranch 'Gully Confluence'

The drainages of the Froom Ranch South and 'North Spring' populations become two narrow streams that merge in a marshy area that occupies much of Lots 22 and 23 of a proposed subdivision (Morro Group, 1988). The location appears to be an excellent habitat for CCbt, but in 1992 only one plant occupied the site (Morro Group, 1988) and in 1993 no plants could be found in the marsh (Figure 2).

Froom Creek

The Environmental Impact Report on proposed development of Froom Ranch (Morro Group, 1988) mentions the presence of plants along the channel of Froom Creek. As of this writing it has not been possible to visit this site, which lies between the known populations of Froom Ranch and Prefumo Canyon populations. The channel is floored with serpentinite, and contains perennial water sources. In 1992 there were 10 individuals along the lower portion of the Froom Creek watercourse as it crossed the flatter lands at the mouth of the canyon (Figure 2).

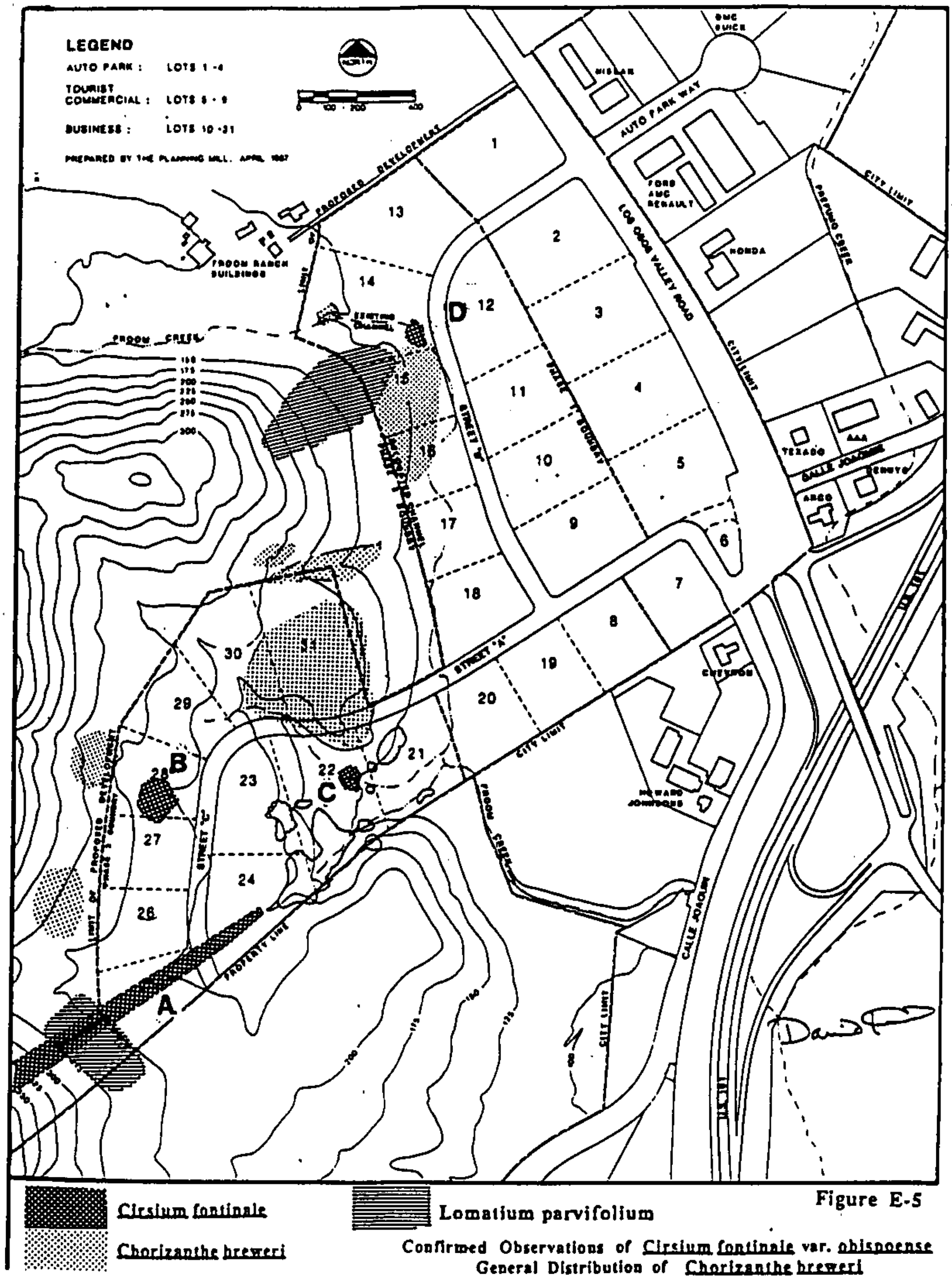

Figure 2. Froom Ranch Populations. South (A), North Spring (B), Gully Confluence (C), and Froom Creek (D). From Froom Ranch Environmental Impact Report (Morro Group, 1988)

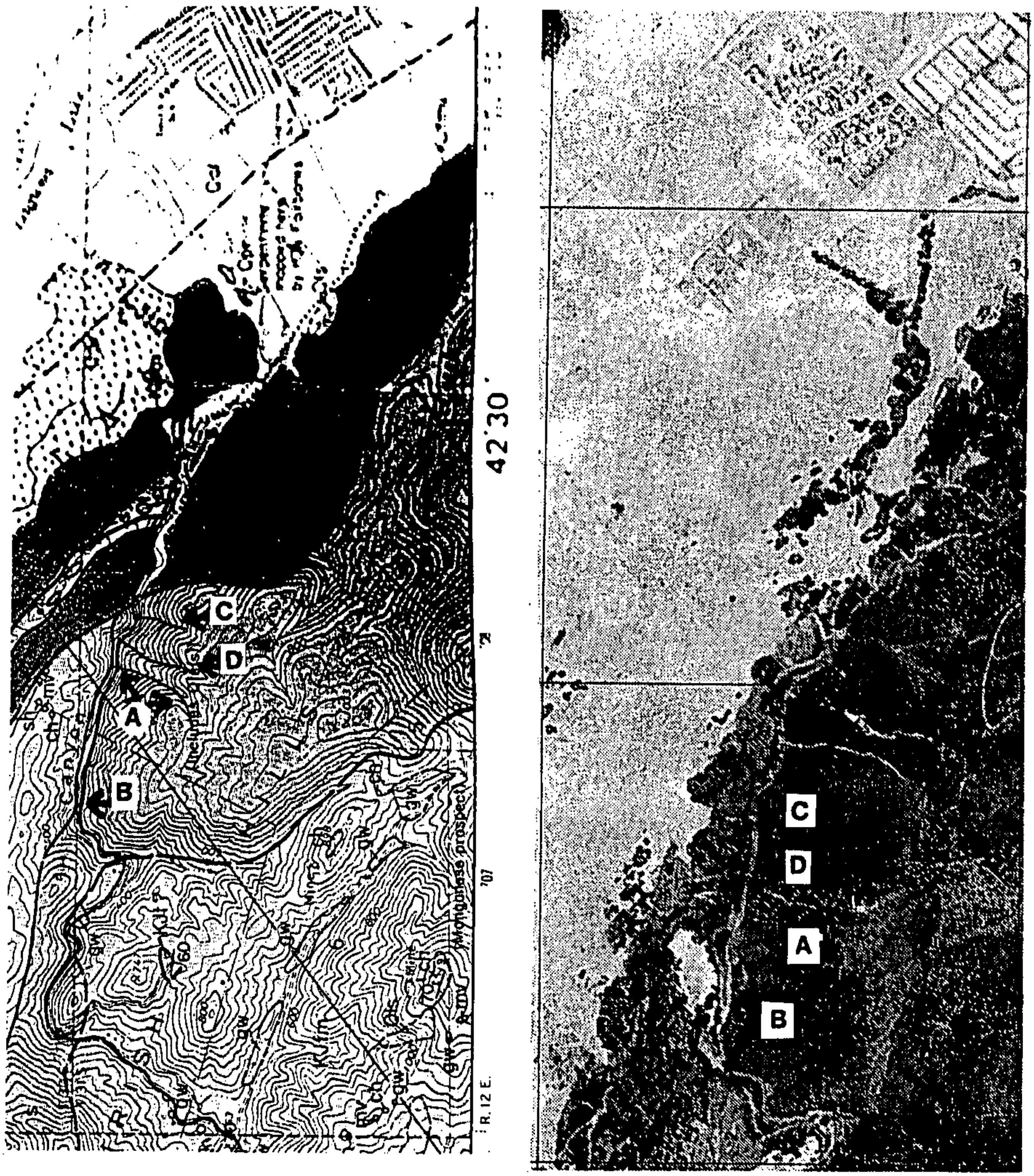

Figure 3. Prefumo Populations. Site A is the Waterfall Site, Site B is the Roadside Site, Site C is newly discovered population 'Gully A', Site D is newly discovered population 'Gully B'. Geologic Map from USGS Map I-1097. Orthophoto 200x magnification from the San Luis Obispo 7.5' Quadrangle.

PREFUMO CANYON GROUP OF POPULATIONS

Prefumo Waterfall

This population appears to be Natural Diversity Data Base Occurence #4, described as "about 1.1 airmile (sic) west of arm of Laguna Lake in Prefumo Canyon near waterfall." The description in 1984, based on Dr. Malcolm McLeod observations, indicates "up to 50 plants seen, over a 10 sq meter area. Serpentinite. N-facing slope in shaded area. Chaparral/Oak Woodland". The location described in this report is shown in Figure 3.

In a botanic survey for Tentative Map CO89-209 (APN 67-221-29) to the Office of the Environmental Coodinator, dated December 4, 1989, Dr. McLeod stated

> "There is apparently only one location for the Chorro Creek bog thistle along the very steep water channel above the riparian woodland in the coast live oak woodland in the northwestern part of the parcel. This is near the riparian area west of Parcel 1."
>
> "The San Luis Mariposa lily and the San Luis sedge are widespread in the leather oak woodland and thus add value to that part of the tract. The Brewer's spineflower is found on the margins of the southeastern knoll at 1028 feet in the southeastern part of Parcel 4."

This site is hereafter called the Prefumo Waterfall, which was resurveyed as part of this project. A plant inventory on May 6th, 1993 showed 125 plants in the immediate vicinity of the waterfall that can be seen just south of Prefumo Canyon Rd. At the time of the survey, eight of these plants were developing stems and showed buds, but no open flowers. The plants are growing in soil-filled niches and ledges, and in cracks within serpentinite bedrock in the walls of a small, almost vertical cliff that forms and flanks the waterfall. Some plants also grow in serpentinite gravels and rubbles at the foot of the cliff.

The stream channel above the cliff is a smooth bottom bedrock chute with very little sediment stored on the channel floor. Scattered CCbt plants occur where soils at the edge of the channel were damp, and in accumulations of sand and fine gravel on the floor of the channel. At a distance of about 500 meters along the channel, the chute becomes a series of boulder dams and pools, where CCbt was common in the sunnier locations.

A CCbt plant count of the channel above the falls revealed 207 rosettes with no stems, 28 with stems, 9 of which were in flower. It is certain that more plants are located higher on the hill, but further movement along the channel was blocked by very dense serpentine chaparral.

Prefumo - Roadside

This population appears to be Natural Diversity Data Base Occurence #5. Rocco (1981) describes the population as being "along Perfumo Canyon Rd. approx. 1.2 mi from gate near residence area", and composed of " Riparian, oak woodland, & chaparral on steep hillside assoc w/Umbellaria, Plantanus, Salix. Approx. 100 plants, N-facing slope". The location is shown in Figure 3.

As part of the listing package, a survey by California Department of Fish and Game showed about 50 plants at the site. The current study in May 1993 counted about 70 plants in all stages of growth.

The plants are growing along the southern edge of Prefumo Canyon Road: (1) both in the edge strip and a small gully, (2) in the walls of the steep road cut and, (3) a natural rocky outcrop that existed prior to the road. In some cases the plants are growing out of the rock wall like ferns, or are in thin zones of soil in the road cut. All occur in areas that are either damp or are wet with dripping water.

The population does not extend north of the road, which has been filled with a mix of rock types. There are thick willow clumps north of the road that shade any potential habitat. However, it is very likely that the original population extended further into the road right-of-way.

Prefumo Canyon Group- New Populations

Two new populations, 'Gully A' and 'Gully B', will be discussed later.

LAGUNA LAKE GROUP OF POPULATIONS

These populations occur in the city of San Luis Obispo on the north side of Laguna Lake at the base of the serpentinite ridge. The seeps occur in serpentinite bedrock that is partly covered with a patchy distribution of soils. The CCbt grows on the bedrock, where it utilizes small dirt-filled cracks for rooting, and in saturated soils around the springs. The populations extend down-slope from the springs, following the water as it flows south toward Laguna Lake. CCbt rarely occurs on the flatlands at the base of the hill. Since the springs remain wet year round, the thistle populations are sustained. The degree to which the populations extend down slope depends on the amount of seasonal dryout each year below the spring. There are three groups of springs which are shown in Figure 4.

Laguna Lake East Springs Group

The easternmost springs (East Spring Group) is the best known, occuring within Laguna Lake Park and just north of the service road termination point and a eucalyptus grove. Springs are spaced along the contour of the hill, over a distance of about 100 meters, and just above the base of the hill. The greatest flow comes from springs close to the ends of the zone. All but one of the springs lies within a grazing exclosure that was constructed to protect the thistles.

This group was the subject of a survey that followed the life history of 117 plants that were located at the easternmost spring of the group, and were present at the start of this study. The total number of plants in this group of springs is approximately 550, with the densest concentrations at the west end of the complex.

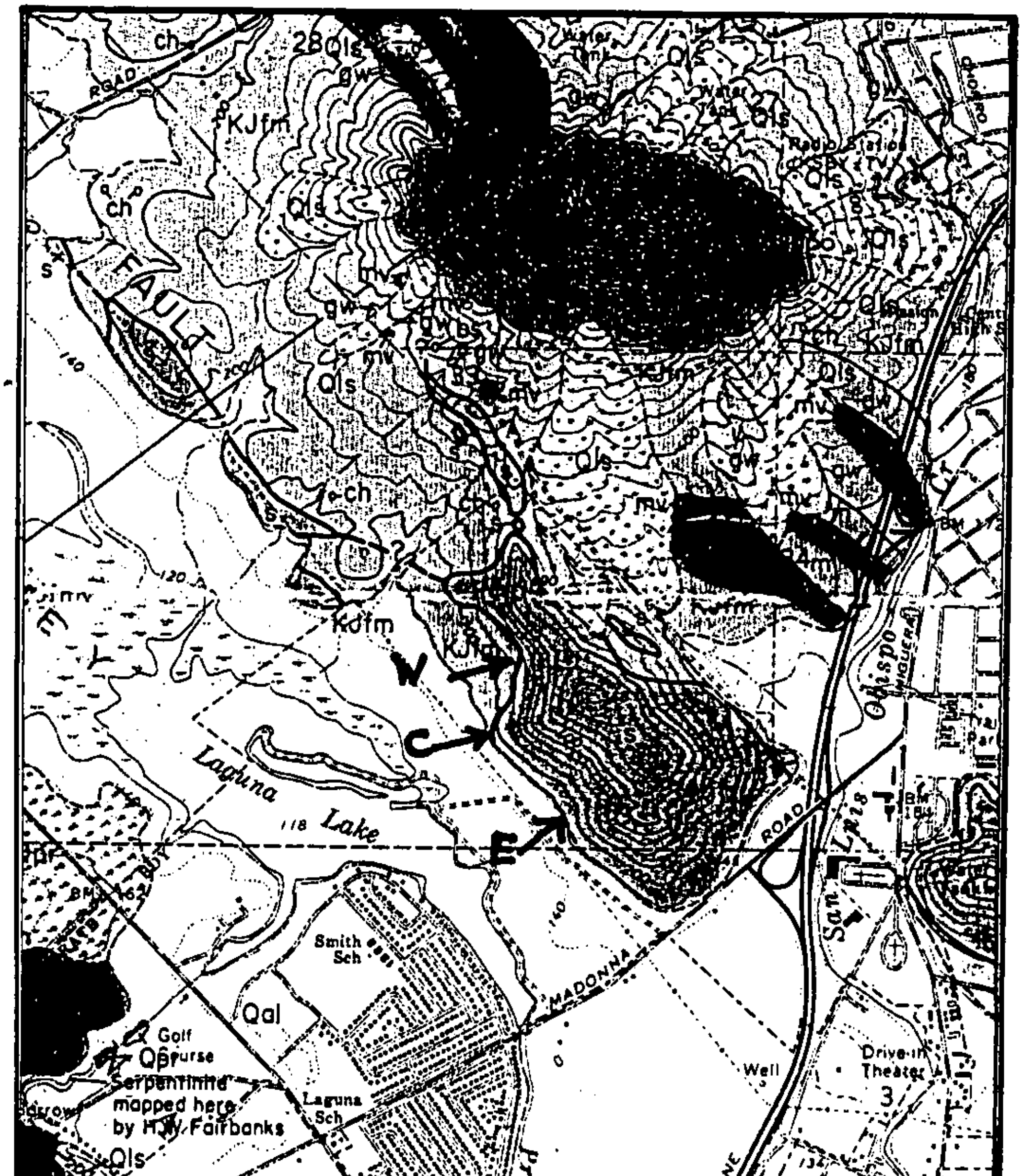

Figure 4. Laguna Lake Populations, showing the West Springs Group(W), Central Spring (C) and East Springs Group (E) Populations.. Base Map is USGS Map I-1097, with unit 'S' being serpentinite.

Laguna Lake Central Spring

The central area lies where the line of the hillside sweeps to the north, about one quarter mile west of the East Group. This spring lies in land that is grazed, although no grazing damage could be specifically identified. The spring is small, and more of a seep than a spring. The population of CCbt is small, numbering about 25 plants of which only 5 flowered.

Laguna Lake West Springs Group

The 'West Group' of springs lies close to the western edge of Laguna Park but at a similar position on the ridge and with very similar charactaristics as the 'East Group'. It lies in grazed lands, is very similar to that of the East Group, and has a population of about 450 plants. There appeared to be little difference between the grazed West Group and the ungrazed East Group regarding the number of young plants, the percentage of plants that flowered, or the expanse of the population over suitable habitat. Some knocked-down plants were present, with signs that they were damaged by cattle. Most survived and continued to flower and set seed, but 2 exceptions were kicked out of the ground and died. The plants grow: (1) on bedrock, with roots using small cracks, (2) on the thin soil patches between the bedrock, and (3) in the thicker soils further down the slope. Plant growth was most vigorous in the thicker soils. Approximately one-third of the plants in this population flowered.

CHORRO CREEK RESERVOIR

This is listed as NDDB Occurence #3, and is shown as having been seen in 1956 and 1973. The Rarefind database indicates that CCbt was not seen when the site was visited on May 3,.1981, although it is possible that the wrong location was investigated at that time. The population was listed as "presumed extant". However in the 1992 Department. of Fish & Game Report on the Status of the Chorro Creek Bog Thistle, the population is listed as "extirpated". The possibility exists that the wrong site was repeatedly visited in declaring the population extirpated. A large spring exists in the vicinity that may have never supported the plant, but is an obvious target for those seeking a 'bog' for the thistle. A sketch from Rocco's 1981 study of the CCbt shows that she travelled beyond the military boundary to her identified spring, but the spring supporting the thistle is within the military boundary.

A survey was made of the possible original site. It lies a short distance along the east side of the middle road of the three roads that converge on the north side of the Chorro Reservoir. The locality was 'rediscovered' on August 5, 1993. About that same time biologists from the Department of the Military had become curious about the plant and identified it from herbarium specimens in the Bay Area. The CCbt populations lie in the crook of a long bend in the middle road, which climbs to the northeast below the spring, bends around its eastern end, and climbs to the southwest along the northeastern flank of the spring (Figure 5)

The site consists of a series of wide, terraced bogs that are linked by narrow zones with defined channels. The bogs are wide, covered by high grasses and sedges, contain deep sink holes that were probably caused by cattle, and were difficult to traverse for accurate counts of small plants. It is estimated that there are 200-300 plants in the complex, of which 200 are large enough to be counted. Only 10-20% of the plants had flowering stems, but the flowering season was clearly almost over. There is evidence that the

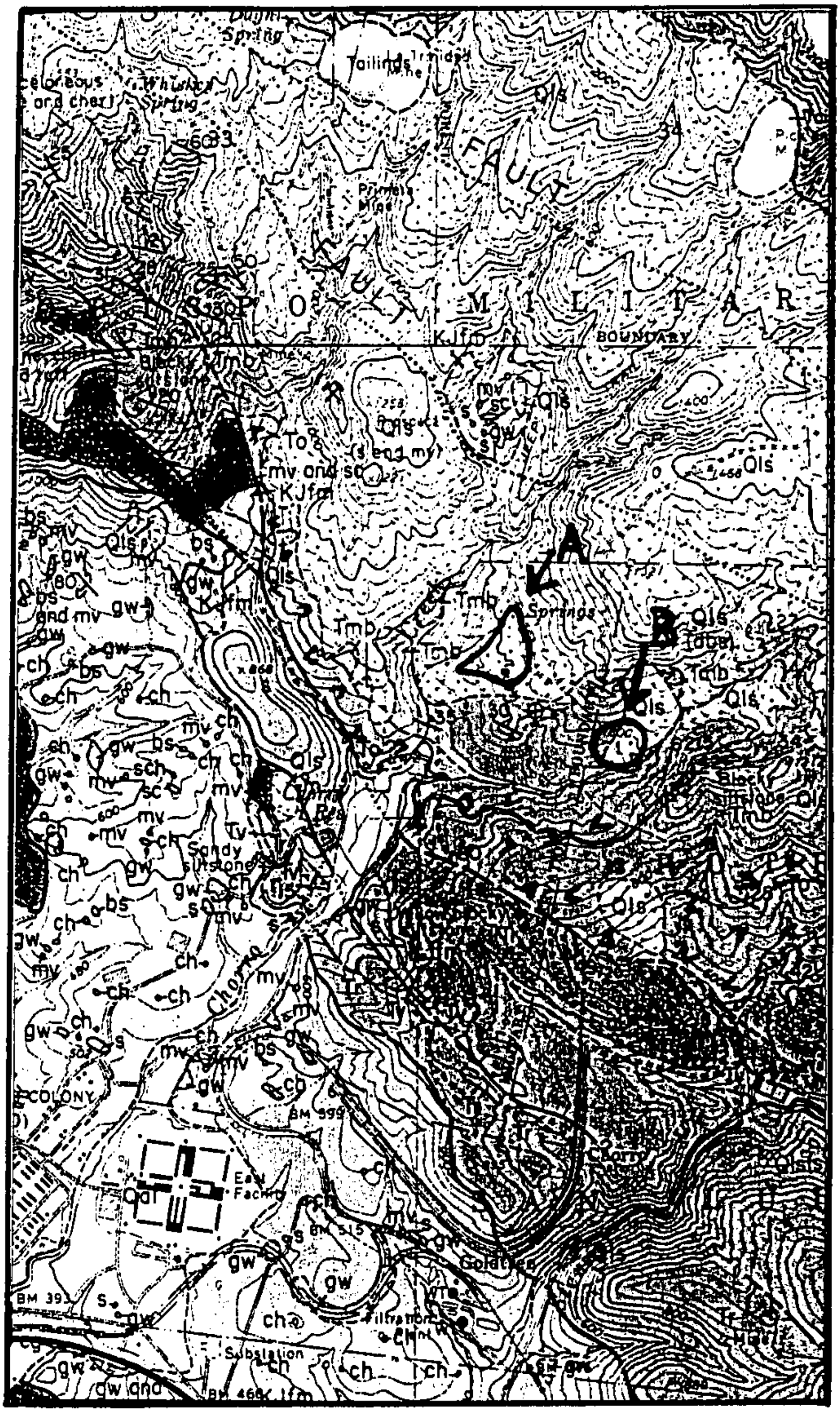

Figure 5. Chorro Creek Population. Area 'A' is the wetland containing the thistle population. Area 'B' is a wetland that does not contain thistle, but which may have been confused with 'A' by other investigators. Base Map is USGS Map I-1097, with unit 'Qls' being serpentine landslide deposits.

population of young plants is high compared to that of mature plants, and that the population may therefore be expanding.

The geology of the site appears to be similar to that of the Pennington Creek population. The springs are located on the surface of an old serpentinite landslide complex that had formed at the base of the main Santa Lucia -West Cuesta Ridge area. There are several springs on the low elevation surface, and in some areas the water is sufficiently deep for tules to exist. The surface of the old landslide is uneven, causing the poor drainage from the surface and allows bogs to form. The surrounding areas are grasslands, with willow patches around some springs and along some channels that connect the springs.

Another spring lies at the head of the easternmost road that converges at the Chorro Reservoir, and is the only spring clearly seen from the road junction. The spring contains some of the same plant assemblage as the Occurence #3 population. However, exotic thistles are present, the soils are somewhat browner, and the seep appears to be floored in Franciscan melange rather than serpentinite. No CCbt was seen at the site.

PENNINGTON CREEK COMPLEX

Pennington Main Complex

This population is NDDB Occurence #6. A NDDB report, updated Rocco's 1981 observations that the population is

> ".... near creek in seep overlaid by serpentinite. Up to 1000 plants seen in 1981. In sun on S-facing slope. Associated w/ Helenium bigelovii & Carex obispoensis. Threatened by grazing."

The population lies near the toe of a complex of landslides that moved southward from the Santa Lucia-West Cuesta Ridge area. The location is shown in Figure 6. The permeable landslides overlie melanges of the Franciscan Formation, which tend to be impermeable, and thus have springs at several locations along their base. The landslide material is composed of serpentinite blocks in a matrix of reworked, reddish, weathered serpentinite debris that may originally have been part of a soil profile. The springs occur in dark muds in bogs that resemble those on in-place bedrock.

The basal portion of the landslide has several terraces. One spring on the upper terrace supports a population of several hundred thistles, but the plants and the flowing water are confined to the inner portion of the terrace. Neither CCbt nor flowing water are found in the damp ground on the outer edge of the terrace, where the water percolates down to reappear in larger springs on the adjacent, lower terrace. Two main springs at the rear of the lower terrace coalesce, then the waters divide and flow partly to the west and, with more volume, to the east of the site.

The western lobe of the bog that supports CCbt passes into a bog with no CCbt, then into a green grassy area that is no longer boggy, suggesting groundwater flow continues to the south but at increasing depth. The absence of CCbt in boggy areas that otherwise seem capable of supporting the plant may be due to reduction of the bog during the recent extended drought. The water reemerges about 1/4 mile to the south in the Pennington West Satellite population that may, or may not, be a newly discovered population of this report.

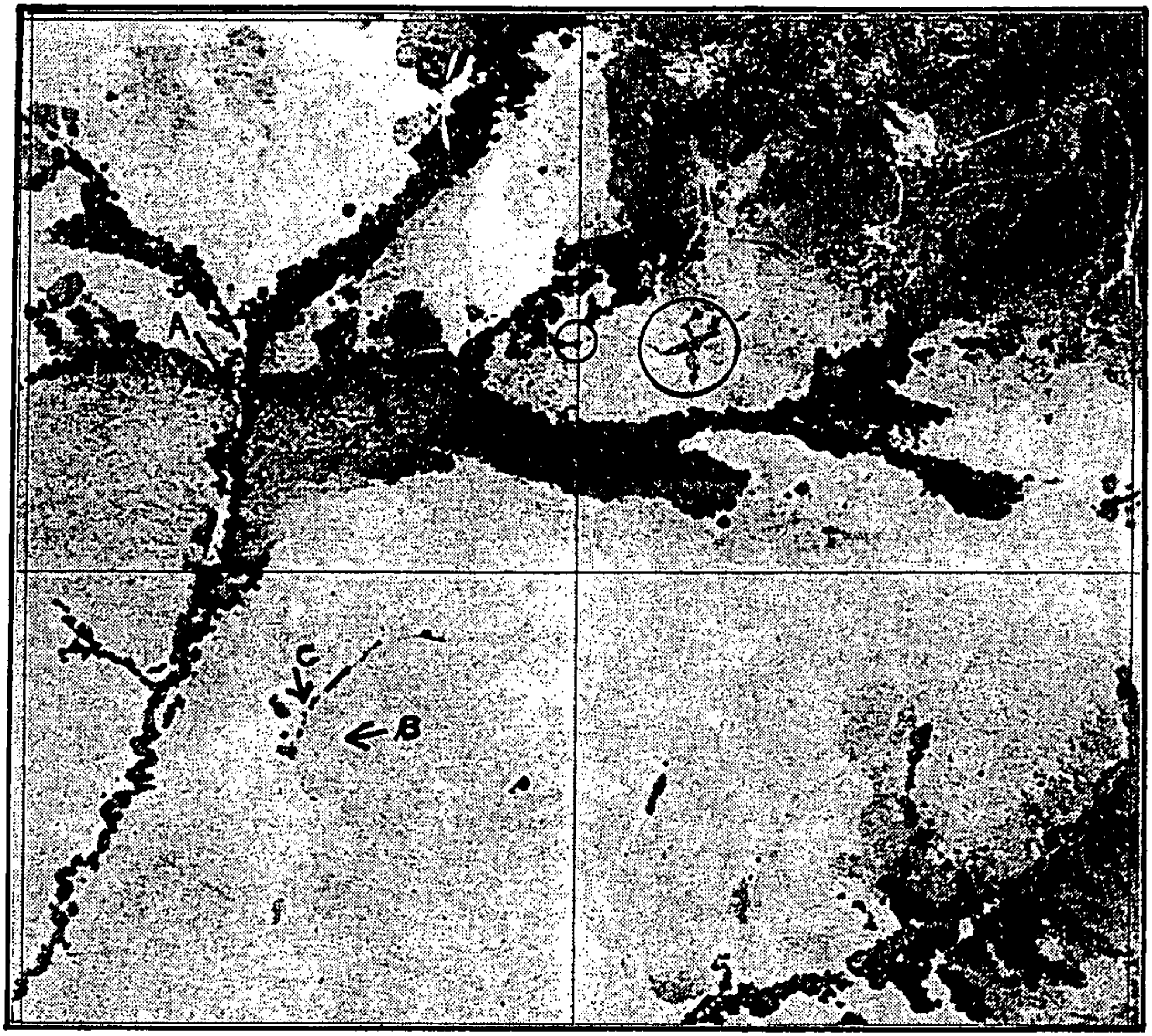

Figure 6. Pennington Creek Populations. Large circle is 'Main Complex' population, small circle is 'Western Satellite' population. Point 'A' is the Pennington Creek Road Access, and Points 'B' and 'C' are the Pennington East Access Track - Old Camp San Luis Range restoration site locations. Base is San Luis Obispo Quad. 7.5' Orthophoto.

The eastern lobe of plants exists in a perennial bog with an abundance of water. Plants can be found almost the entire way to the confluence of the bog complex with the eastern fork of Pennington Creek. The bog is more extensive than the thistle population, strongly suggesting that the saturated area was not much diminished during the recent extended drought, and the that the CCbt has not reoccupied much of the revived bog. There are so many thistles at this site that they could not be easily counted. On the basis of several transects through the population, the number of plants is estimated at about 2,000, with about 700 flowered. In January 1994, new seedlings were abundant and indicated that the edges of the population were about to expand by a few feet. New seedlings were sometimes so abundant that fifty or more could be found in a square meter, but these were not counted among the 2,000 plants which had leaves greater than 2 inches in length.

Pennington Western Satellite

This small group of plants is separated from the main Pennington Creek population, and is located about 1/4 mile to the west, along one of the two streams that are fed by the main Pennington Creek springs. It is located at the head of a wooded gully where the track that traverses the slope below the main Pennington Complex, passes from east to west across the gully (Figure 6). Detailed description of the spatial distribution of the Pennington populations, as described by earlier workers, is not available. This is possibly a newly discovered population.

This population only occurs in a bog at the head of the gully, partly situated below a canopy of oak and bay. The slope aspect of the population is 70 degrees west of north. The bulk of the population receives full sun during much of the day, and the bog, while being no wider than about 5 meters, has a 60% cover of CCbt in the flowering season. The population extended into the shaded area below the trees in the spring and summer of 1993. Some of these rather rangy plants were absent in January 1994, and the area occupied by the population was diminished. The area in total is 5 meters by 16 meters, and contains about 200 plants in all stages of growth. On April 4, 1993, there were 67 flowering stems developing, with only five in flower at the time.

SAN SIMEON CREEK AREA

San Simeon 'Bianchi' complex

This is listed as NDDB Occurence #1, and is described as follows:

> "About 0.1 mi S of confluence of North and South Forks of San Simeon Creek On water-saturated slope above rd. & creek. Assoc w/Salix, umbellaria, mimulus guttatus, carex in riparian, oak woodland & chaparral. >1000 plants seen. Cattle trampling is threat."

This population was inventoried on June 12, 1993. There were approximately 250 plants on the north side of San Simeon Creek Road, between the fence and a Bianchi spring box. About 15 plants were in flower, or had just finished flowering, based on the presence of fresh stems. Around the spring box were a preponderance of small plants with 5-7 leaves between 10-20 inches in length, and a number of very young plants. The population has extended in recent years to the south of San Simeon Creek Road, extending along the drainage from the spring to the edge of San Simeon Creek. It continues on to the

Stepladder Ranch and possibly a portion of the Gil Steel property. There are about 35 plants south of the road.

The CCbt population at the site appears to be stable. It numbered about 375 individuals in 1992. This may be a slight over-estimation, since it is very difficult to count the plants accurately when bunched close together. There is no consensus that a recent decline in the population has occurred. The populations have been known to members of the California Native Plant Society for a number of years.

The site is located at the foot of a serpentinite landslide complex, and the geology is very similar to that of the Pennington Creek and Chorro Creek populations. The surrounding terrain consists of a Bay Laurel and Coast Live Oak woodland surrounding a seep and spring with some willows and persistent wetland plants. The site is an old school location, presumably situated there because of the year round water supply. The Bianchi family utilizes this spring, but abundant surplus overflow forms a small bog on the north side of the road and a somewhat less extensive bog and channel complex on the south side of the road. Some CCbt can be seen along the channel to the point where it joins San Simeon Creek.

The Bianchi family is actively protecting this population, by participating in The Nature Conservancy Landowner Contact Program. The spring is fenced, and there was no indication of trespass from cattle. Deer tracks were common.

This population is also of interest to Dr. Charles Turner of the Department of Agriculture at Albany, California. He has studied this population relative to possible conflicts with biological control agents used against exotic thistles. This is further discussed in the section on insect herbivory.

As of April 1994, a possible property line dispute relative to the positioning of a fence along the edge of the Bianchi Spring has the potential of introducing cattle to some portion of the spring. The other side of the fence is controlled by Mr. T. Winsor, the owner of land on which newly discovered thistle populations will be described later.

San Simeon Upper Spring

This population is called the "upper" site in the 1992 Department of Fish & Game Report on the Status of the Chorro Creek Bog Thistle, where the population was counted as 75 plants. The author counted a similar number of plants in 1991, when the spring was surveyed during the drought as a possible water source for development. In June 1993 the population had increased to about 180-200 plants, with a large number of, and much increased percentage of very small plants. The discharge from the spring had increased, as had the size of the bog, but the population increase had developed largely in the area formerly occupied by the smaller drought-time population. The status of this population as an NDDB "occurence" is not known, but apparently the location was filed.

The location is on the drainage that that crosses San Simeon Creek road about one quarter of a mile west of the Bianchi house, and just uphill of the Cambria Mine Road, a gated, private dirt road that climbs the ridge on the north side of the Bianchi house. The drainage runs along the base of the workings of the Cambria Mine, with the water emerging from a spring higher on the hill and north of the mine. This spring contains the CCbt population, although a couple of plants occur at the base of the mine workings and appear to have seeded down from the spring.

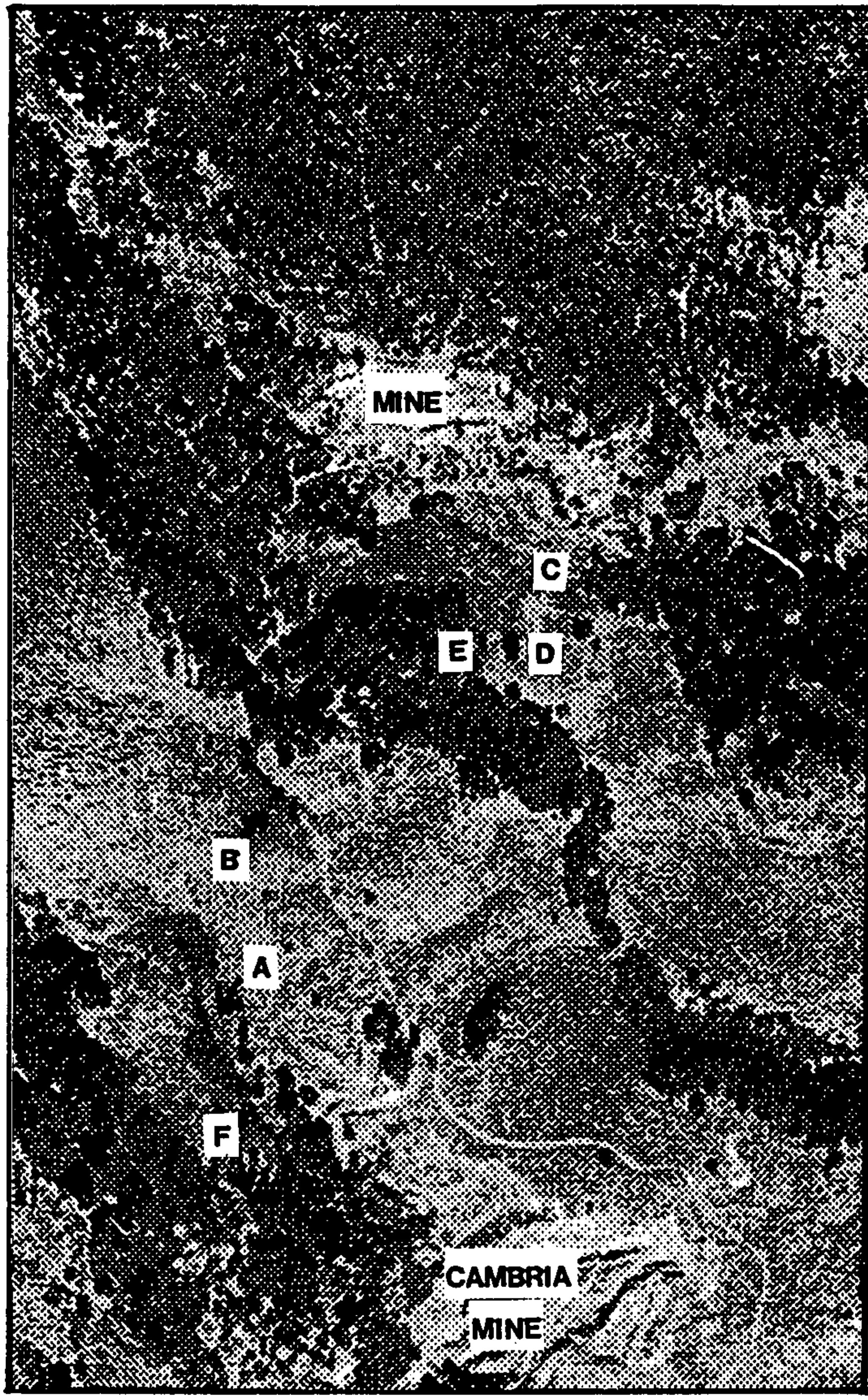

Figure 7. 'San Siméon Creek Sites. 'A' is the Upper Spring site. The newly described sites are 'B', the 'North Roadside Spring'; 'C', the 'Stock Pond'; 'D', the 'Stock Reservoir'; 'E', the 'Big Seep'; and 'F' the 'Cambria Mine Site'

The geology of this spring is similar to that of the Pennington site, as the water emerges from the base of a serpentinite landslide complex that slid southwestward from the Santa Lucia Mountain ridge. The geology to the west of the spring consists of Franciscan Formation melanges that are relatively impermeable, causing water to flow along the base of the landslide complex and emerge at the toe. The few plants that occur downstream of the spring occur in serpentinite debris washed from the mine workings, and which has also been involved in a series of muddy landslides below the workings.

The waters in this drainage system were tested for possible potability, and found to have a high cadmium content (Walter Stuckey, landowner, oral communication). The mine itself was worked for mercury, extracting hydrothermal mercury in the serpentinite that was probably introduced to the deposit during the Tertiary period.

There are newly discovered sites located higher on the hill above the "Upper Spring." These are discussed in the next section.

NEWLY DISCOVERED CHORRO CREEK BOG THISTLE SITES FOUND DURING THIS STUDY

PREFUMO CANYON AREA

Prefumo Gully 'A'

This site lies two gullies to the west of the Prefumo 'waterfall' site (NDDB Occurence #4). The gully parallels both Gully 'B' and the 'waterfall site', and is largely invisible from the highway, where it is marked by a small boulder fan (Figure 2) The site extends up the hill from the top of a dry waterfall, formed from a bedrock ridge that causes water to rise in the bed of the gully. There are three steps on the floor of the channel above the waterfall, the uppermost of which contains a pool of water. Located on the first step were 25 plants of which six were flowering. On the second step were 35 plants of which 10 were flowering. One flowering plant was located on the waterfall's rim. In the gully above the pool are two channels, separated by a boulder bar. The eastern channel contained 80 plants, most of them young with only 7 showing flowering stems. The western channel had a floor of bare rock with 13 small plants in tiny crevasses. At the head of this gully were 3 large plants with many flowering stems growing in the mulch of the remains of former generations of the plant. This indicates that plants had flowered at this location in the seep throughout the recent extended period of drought. The bedrock and sedimentary debris in the entire site are composed of serpentinite or its weathered derivatives.

Prefumo Gully 'B'

This site lies one gully to the west of the Prefumo 'waterfall' site (NDDB Occurence #4). The gully parallels that of the waterfall site, with a smaller, narrower drainage, and less water flow. This CCbt population is located just above a steep wall/waterfall that crosses the drainage about 100 yards above the highway, and continues up the gully for another 100 yards. The thistles occupy seeps in the walls of the gully and sediment bars on the floor of the gully. The total number of plants of all sizes numbered 40, nearly all being small plants or seedlings. Only 3-4 plants were large enough to support flowering stems, located at the lower and upper end of the population distribution along the gully. The hydrology of the gully indicates these are two locations where water persists. Thus the bulk of the population may have seeded from parent plants at these locations. The gully above the site continued some distance up the hill, but was dry and supported no thistles or seeps. Similarly, the gully below the population was dry, as the spring water passed below a thick rubble mantle where seedlings could not survive. The gradient of the gully floor was steep throughout the area of the population, with step-like serpentinite boulders dams holding back serpentine-derived sediments that supported the CCbt. Several of the plant groups appear to have 'self-mulched' in the dead debris of former generations of the plants. The step-like gully floor and the boulder dams have allowed water to reach soil horizons in the walls of the gully. Where these are damp, they support CCbt seedlings.

CHORRO CREEK RESERVOIR

Although this site was still listed as a NDDB location, the population had been presumed extirpated. The site description is given in the previous section on known sites.

SAN BERNARDO CREEK COMPLEX

This springs occur at the head of San Bernardo Creek at the foot of an open pit mining complex (Locations A in Figure 8). The mine is located about one mile southwest of the summit of Cerro Alto Peak, and lies on a straight line connecting the long straight lower reach of the creek with the summit.. It lies in the exact center of Section 13, T29S R11E MDM, within the Atascadero 7.5 min quadrangle. The chromite mine was developed in serpentinite landslide deposits, but the workings do not contain any CCbt. Springs and seeps from the mine emerge at several locations, with the waters feeding two tributaries to the main channel of San Bernardo Creek. The sites occur in bogs that are surrounded by grasslands, and the bogs themselves are similar to those of Pennington Creek, having a gentle slope and very poorly defined channels. The geology downhill of the springs is dominated by melanges of the Franciscan Formation. The bogs are as extensive as those of Pennington Creek, but much more heavily grazed: There are several hundred plants scattered throughout the bog areas, nearly all in areas with full sunlight most of the day. The bogs feed wooded gullies that are deeply shaded and become deeply incised and so they contain no plants.

Due to the logistics of reaching the site, the inventory of plants for this area is incomplete. A very approximate count is about 500 plants, but there could be some satellite populations that have not been counted. All of the plants appear to be on private land located just west of the Los Padres National Forest Boundary.

As of this writing permission has not been obtained to explore springs that are further to the east of this complex ('B' in Figure 8). These appear to be identical in geology and landform to those just described, and it is extremely likely that they contain CCbt populations. They are located in the SW1/4 of the SW1/4 of Section 18, T29S R12E MDM, within the Atascadero 7.5 min quadrangle.

SAN SIMEON CREEK AREA

San Simeon North "Roadside" Spring

This site is higher on the hill than the "Upper Spring" site, just above the intersection of the North Cambria Ranch Association jeep road and a very poorly graded service road that extends northward from the vicinity of the "Upper Spring". The spring forms a bog on the

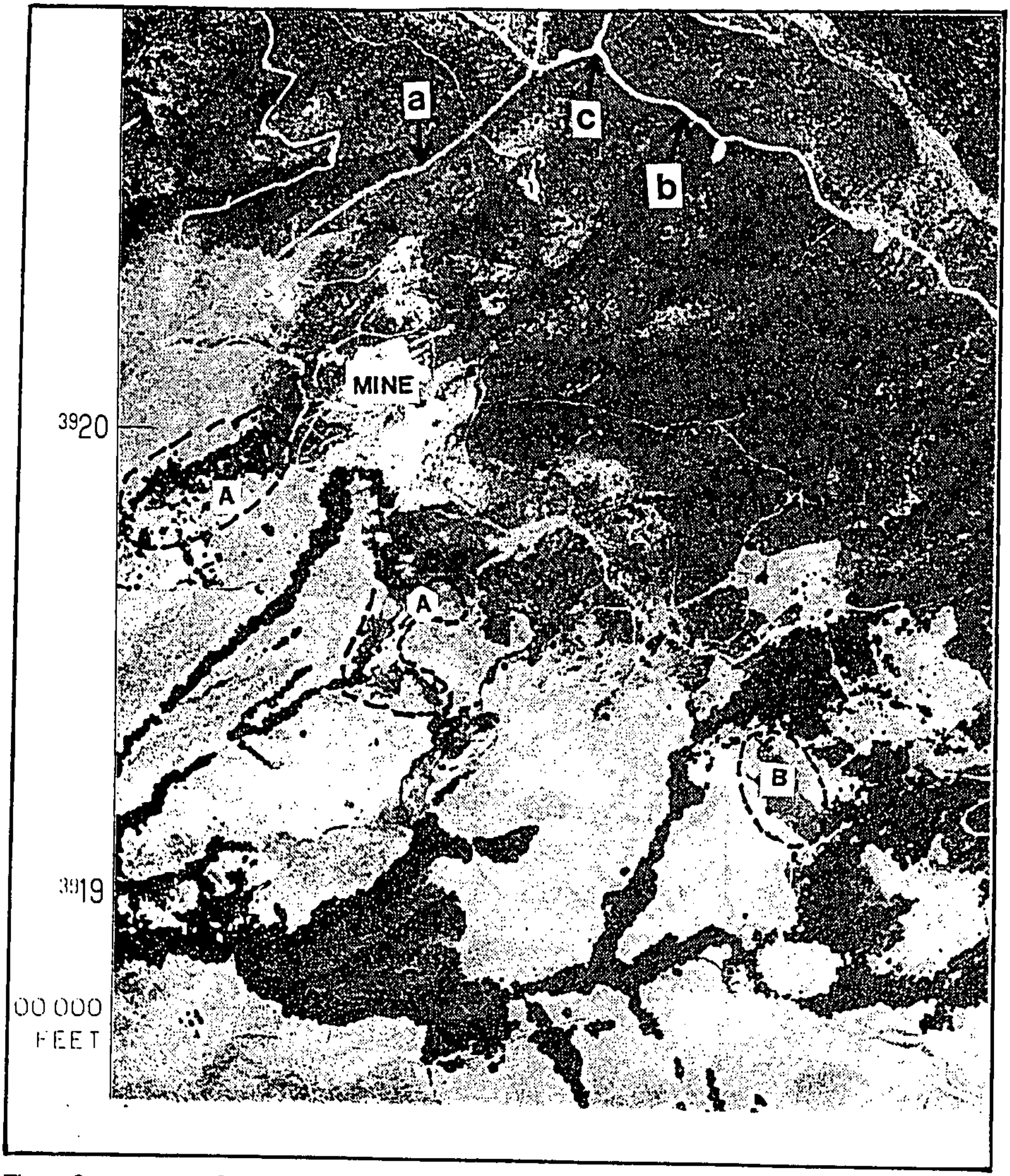

Figure 8. Location of the San Bernardo Creek populations, noted as 'A', and the probable site of a population 'B'. (a) is a buried cable route; (b) is the West Cuesta Ridge Forest Service Road; (c) is the junction of the track to the summit of Cerro Alto. Photobase is the USGS Orthophoto for the Atascadero Quadrangle.

west side of the jeep road at a point where it begins to go below tree cover at the top of extensive serpentinite grasslands that extend between the "Upper Spring" and this site. The wetland is about 50 metres by 50 metres in area, and lies entirely within the serpentinite debris of a massive landslide complex. This landslide, together with the landslide complex seen at the "Upper Spring" and the "San Simeon 'Bianchi' complex", should be considered stable and does not constitute a risk to the survival of the population. It is identified as 'B' in Figure 7.

Apparently some botanic surveys had been performed at the site, and the property owners were not aware of any CCbt in 1991 and 1992. When the site was visited in June 1993, the CCbt count was about 170 plants. At that time, 90 rosettes had not flowered and 80 plants had flowered with 60% having gone to seed. Some plants on the upper side of the spring had been browsed but all had flowers remaining on their lower branches. Two plants had been trampled but survived, and were going to seed in the horizontal position.

The large population at this site may reveal much about the adaptability of CCbt. It is unlikely that such a large seed base was introduced from elsewhere, and more probable that a seed bank was able to survive many years of drought. Thick rushes and sedges in the core of the marsh might have hidden some plants that went unnoticed during the drought, especially if drought inhibits flowering.

Stock Pond

The stock pond is located on the opposite, east side of the main jeep track from the "Roadside Spring", and higher on the hill. There is an open grassy meadow in the angle formed by the curve of this road and a service road to an old mercury mine that lies on the east side of the meadow. The pond is also located on the east side of the meadow, at the edge of the tree line, and at the base of the slope below the mine workings. It is identified in Figure 7 as 'C'. The heavily grazed site had 40 unstemmed rosettes and 9 flowering plants that had 6 of their tops browsed off. All but one of the plants had some flowers remaining and would probably set seed. The plant with no flowers was relatively small plant with just one stem and was eaten at a more juvenile stage than the others. Seeds were present in 2 of 3 flowers, with an average of 7 seeds per flower head.

Large Round Stock Reservoir

The reservoir is situated downslope of the Stock Pond described above, is quite large, and is fed in part by drainage from the Stock Pond area. The reservoir lies behind a dam, and there is a small marsh on its north shore in association with an incoming stream. It is indicated as 'B' in Figure 7. The marshy portion of the site had 11 flowering and 25 immature plants. Weevils were living in all or most of the flowers and only one of 4 flowers had seeds. Some of the weevils were collected for identification, but unfortunately were destroyed before thay could be identified. They strongly resembled those of Rhinocyllus conicus, which is used as a biological control agent for Yellow Star Thistle.

The rancher had not previously seen thistle at this site, and suggested that he had created the habitat by constructing the dam. He was not particularly pleased to have the CCbt population there because as he needed to clean out the pond and intended to grade out over the population at some future time.

'Big Seep'

This site lies on the west side of the Large Round Stock Reservoir described above. The seep drains partly into the stock reservoir, and partly in the opposite direction to a gully further west. It is shown in Figure 7 as location 'E'. The seep is on serpentinite materials, but the exact identity of the unit is uncertain, either being on sheared bedrock or on serpentinite landslide. The substrate has been buried under a mat of precipitated materials that were developed from algal or bacterial slimes. There were about 340 plants in the complex, of which 220 were immature rosettes and about 120 bore flowering stalks. Plants were better developed over the thicker patches of soil, more poorly developed on the mats and bare rock that dominate the seep. These poorer habitats had no plants in flower, and may not be able to support plants to maturity later in the season. Plants were found for a considerable distance along the drainage flowing to the west, and a few very 'leggy' plants were found in the relatively thick overstory of bay and oak trees further down the hill.

Cambria Mine

The "Upper Spring" site was known prior to this study, but no plants had been reported along the drainage downstream of the site. A detailed survey was made of the channel.

Below the big open pit workings of the Cambria Mine, 6 immature plants were found where a spring at the base of workings enters the drainage from "Upper Spring". The location is at a cattle path that crosses the drainage through a gap in the willows. The area is shown very generally as 'F' in Figure 7.

Just below the cattle path, the drainage drops down a steep 5 meter high chute or waterfall, located at the head of an active landslide immediately below the mine complex. One plant was found at the top of the waterfall, with 1 flowering stem bearing 20 flowers. It is possible there could be an extension of the plant population in future years, although the habitat below the waterfall did not offer very much suitable habitat.

UNOCCUPIED SITES WITH RELATIVELY HIGH POTENTIAL FOR RESTORATION

Systematic exploration of seeps and springs for possible CCbt restoration sites was initiated as a major part of this study. Sites were revisited several times during the year to monitor site conditions such as water levels, grazing pressure, shading, and ecologic relationships. The potential sites are prioritized in terms of their potential for offering permanent protection for a CCbt population, using such factors as the persistence of the water during drought.

South Street Hills Springs-San Luis Obispo

The site (Figure 9) is located in a geologic, topographic, and climatic setting very similar to the populations from Laguna Lake. The serpentinite ridge continues east, across Highway 101 and San Luis Obispo Creek, to the South Street Hills. The springs lie on the south side of the hills, above the flood plain at an elevation about one quarter of the height of the

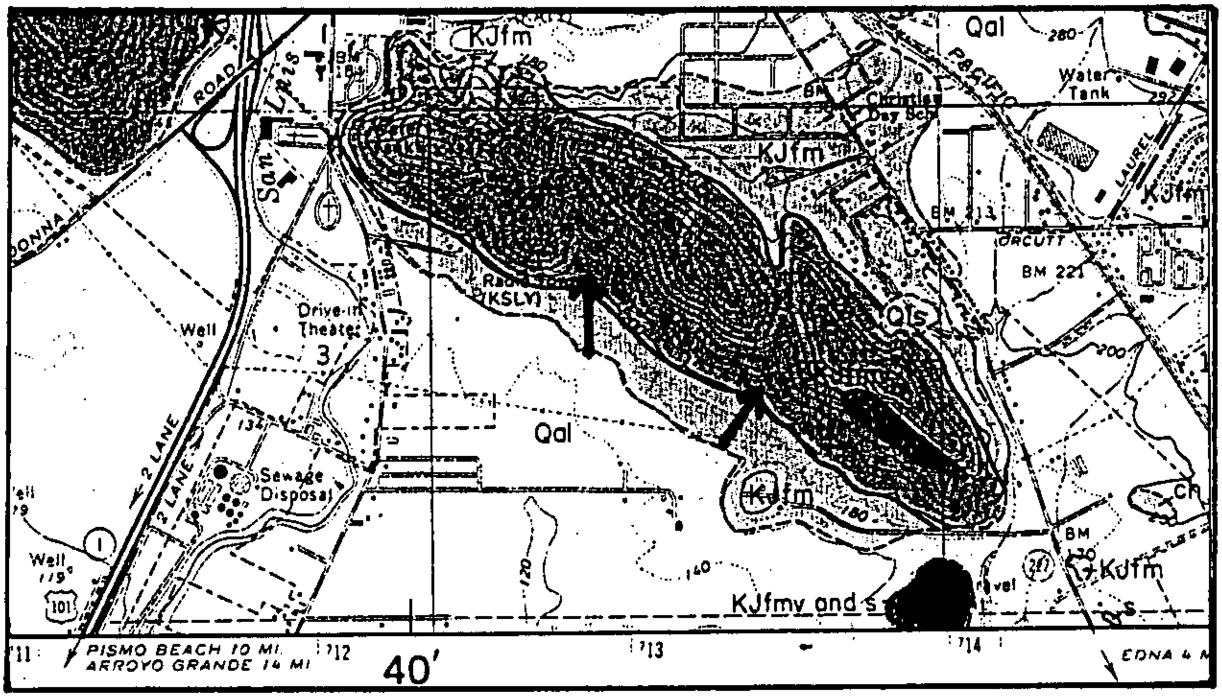

Figure 9. South Street Hills Restoration Sites (arrows). The rock 'S' is serpentinite. The US 101/ Madonna Rd. interchange is in the northwest corner. Base Map is USGS Map I-1097.

hill. The springs flow year round, and according to nearby residents, provided sufficient water to support a CCbt population. Based on observations of plant densities at Laguna Lake, the site may have a carrying capacity of 100-200 plants.

Currently the site is quite heavily grazed. Some of the water is diverted to cattle troughs, but sufficient quantity exists to support plants. The city of San Luis Obispo is considering development plans for this area, but those submitted to date would keep this section free of building. Development might subject the site to disturbance from children, hikers, and possibly invasive weeds.

A bottled water business called 'Crystal Springs' uses wells at the extreme eastern end of the South Street Hills. This does not seem to have any effect on the springs discussed for restoration potential.

Lower Poly Canyon

This site is located on the California State Polytechnic University campus. It is on the east side of a serpentinite ridge that forms the north side of Brizziolari Canyon, known locally as Poly Canyon (Figure 10). There is a stone archway entrance to a trail that parallels the base of the ridge. The bog is located approximately 100m northwest of the stone arch, and is clearly visable on the south side of the small tributary creek that parallels the trail. The bog is associated with a relatively low volume seep that has not dried in the last 20 years, and is approximately 10m x 10m in side.. The bog contains most of the same plants seen in the Laguna Lake and Pennington Creek populations, has soils apparently identical to those of other CCbt bogs. Therefore the site has a great potential for restoration, with a carrying capacity of about 50 plants.

The site is moderately grazed under an intensely managed university program. The spring is not the only water source for cattle and could be developed as an exclosure with little difficulty. It is likely that continued grazing at the current level would allow a population of thistle to prosper.

Upper Poly Canyon

A small, perennial seep and wetland is situated very high on the hill at the north end of the canyon at the head of the valley that also contains the Lower Poly Canyon Site (Figure 10). The seep is located higher on the hill than an area that is used for experimental architectural projects. The seep has similar flora to the Poly Canyon site, with very few exotic thistles, and is partly fenced from cattle. There used to be a spring box for water supply in the seep, but it appears to be disconnected. The site slopes to the south, is of low gradient, and may have a carrying capacity of 30-50 plants.

'Cuesta College Hills': East End

From Laguna Lake a serpentinite ridge continues westward and forms part of the divide that separates the Chorro Creek and Los Osos drainages. The distinctive ridge can be seen on the southern edge of the Cuesta College campus. Several small streams flow northward from the ridge, merging with a tributary of Chorro Creek (Locations 'E' in Figure 11). There is abundant suitable habitat along these streams, and within the small bogs on the sides and bottom of each stream gully. The north-facing slope is similar to Prefumo Canyon. There are two gullies, and possibly some satellite seeps closely associated with

Figure 10. Upper Poly Canyon (U) and Lower Poly Canyon (L) Restoration Sites.

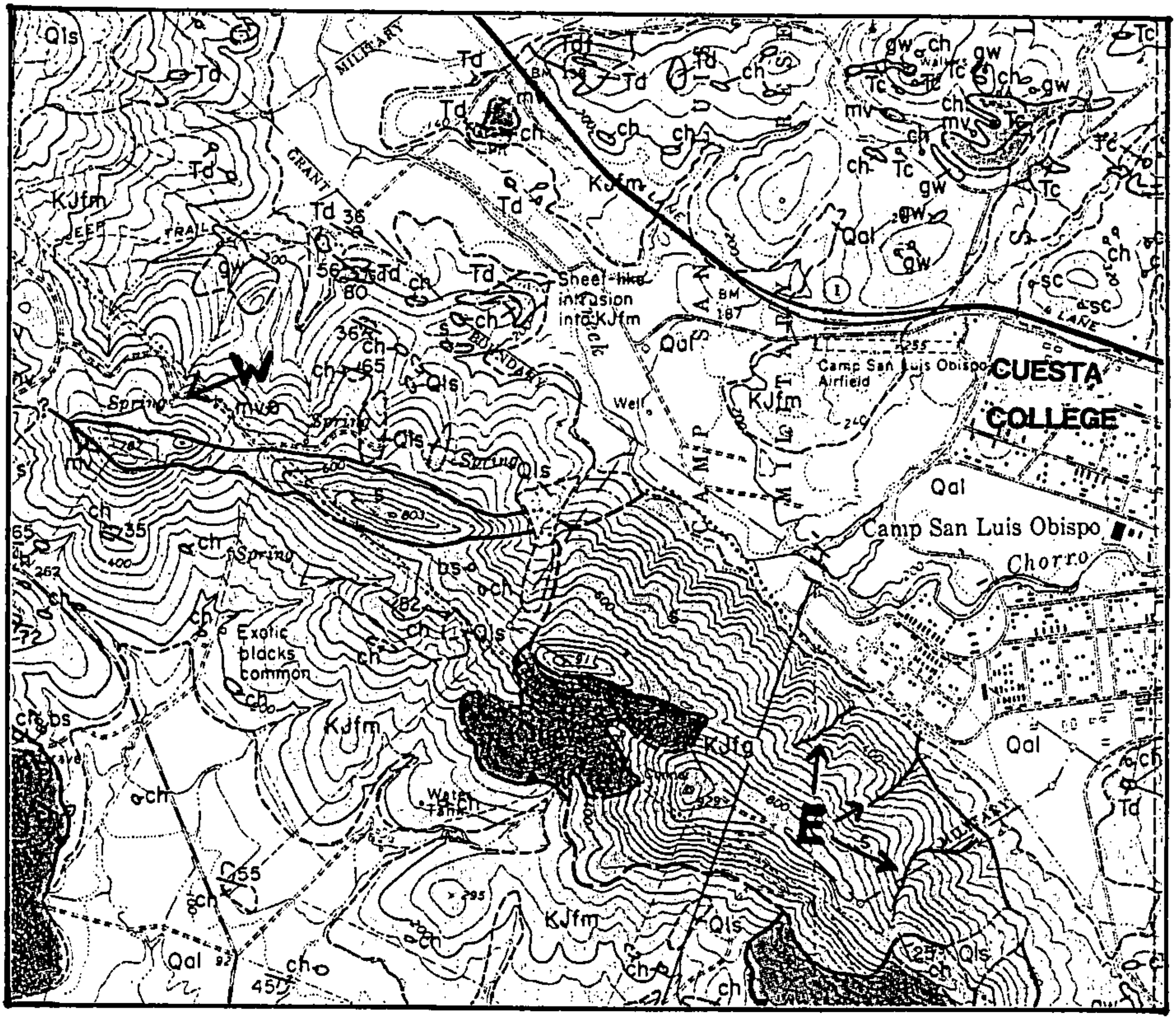

Figure 11. East End (E) and West End (W) Cuesta College Hills restoration sites. Base Map is USGS Map I-1097, with unit 'S' being serpentinite.

the gullies that could support several hundred plants. The area is moderately grazed, some fencing may be required because cattle tend to concentrate in some areas best suited to CCbt restoration.

'Cuesta College Hills': West End

The Cuesta College Hills extend west to the flanks of Hollister Peak. A spring is located just below the prominent saddle at the western end of the ridge, and just east of the obvious termination of the serpentinite rock mass (Location 'W' in Figure 11). The spring lies on the north facing slope, supports a cattle trough, and contains much of the same flora seen at the Pennington Creek and Laguna Lake sites. Below the spring is the bog with soils almost identical in apearance to those seen at CCbt sites, although chemical analysis of the soils reveals some differences with the San Bernardo and Pennington Creek CCbt sites. The spring is floored in serpentinite rocks and their weathered derivatives. The spring box dates from the 1930's, which is evidence of a sustained flow from the spring for a large number of years. The spring is very heavily grazed.

UNOCCUPIED SITES WITH LOW POTENTIAL FOR RESTORATION

Pennington East Access Track - Old Camp San Luis Range

A former Army firing range lies on west side of the Dairy Creek Drainage. A jeep track used to access the Pennington Creek population from the east side runs along the divide between Pennington and Dairy Creeks. A thin serpentine ridge crosses part of the Dairy Creek drainage and intersects the track about a mile northeast of the Cal Poly corrals on Pennington Creek. A small spring on the southern flank of the serpentinite ridge has the capability of supporting a few plants (Location B on Figure 6). It is very similar in size to the Laguna Lake Central Spring. It is moderately grazed, and may dry out during an extended drought.

In close association with the spring is a wetter drainage channel that passes through the serpentinite ridge to the west (Location C on Figure 6). This drainage rises in two springs within Franciscan melange above the serpentinite ridge. While the springs have no restoration potential, parts of the channel that are floored in serpentinite may. However the sediments in the channel are partly derived from non-serpentine rocks, and the chemistry may not favor CCbt.

"Del Mar Park Canyon"

This unnamed canyon emerges from the hills at Del Mar Park in north Morro Bay (Figure 12). It passes through two blocks of serpentinite, but also includes Franciscan Formation melange and younger Tertiary strata in the small watershed. While the sediments in the perennial stream are possibly 'tainted' with non-serpentinite materials, the soils bordering the creek at many localities are pure serpentinite derivatives that should support CCbt. Of particular interest is a side drainage that enters the canyon from the south at the point where a pipeline enters the canyon from the north. It is located about 2 km above Del Mar Park. This too has 'tainted' bedload sediments but also has an abundance of suitable soils at the side of the creek.

The location is closer to the ocean than any known site, and is likely to have more persistent fog cover than other known sites during the summer.

Figure 12. "Del Mar Canyon" which has some potential for restoration. North Morro Bay is at the base of the picture, the Standard Oil Tank Farm lies to the north of the canyon. Side drainage mentioned in text is marked with (*). Base is USGS Morro Bay North Orthophoto Map.

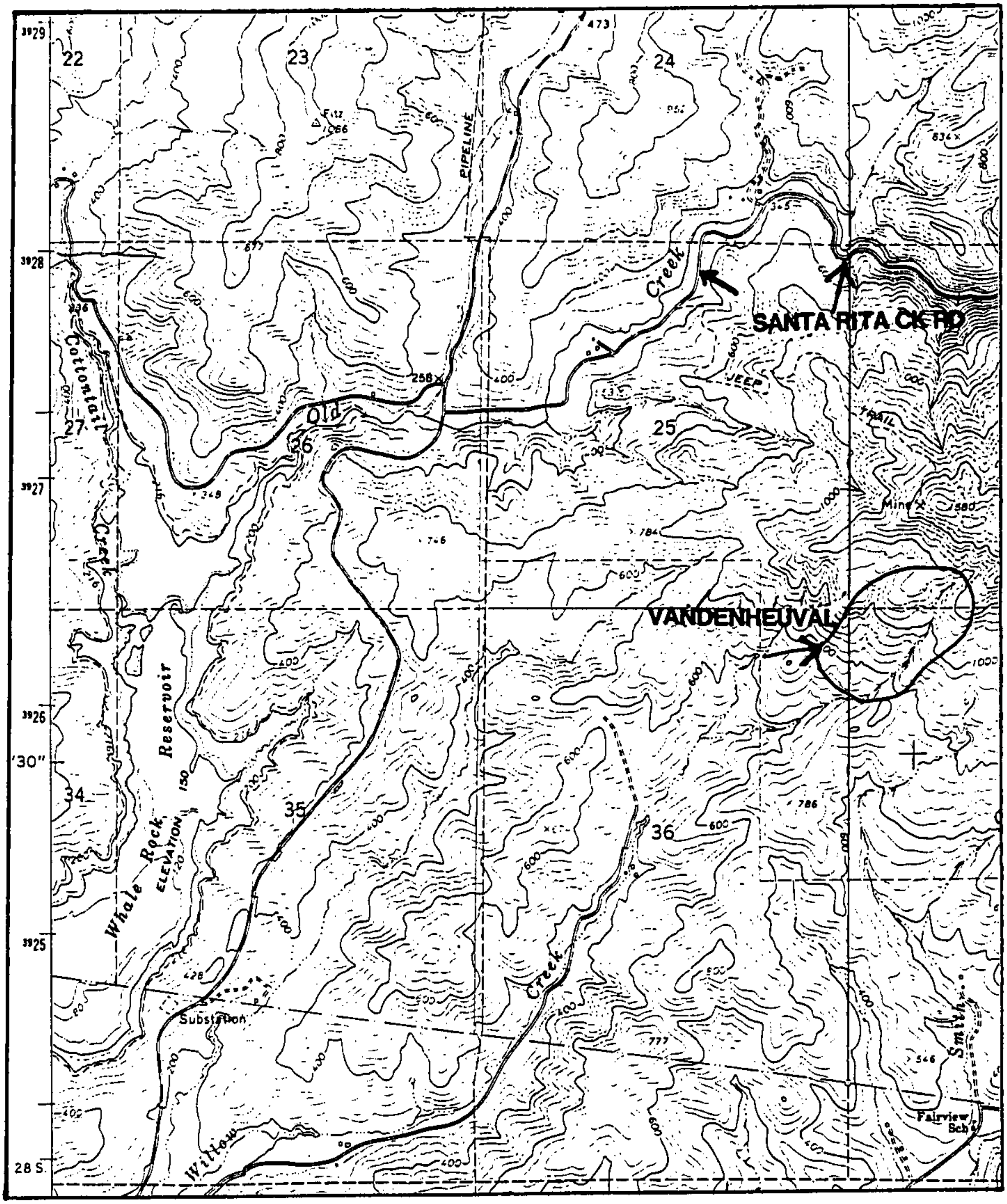

Figure 13. General Locations of the Vandenheuval Property and the Santa Rita Creek Rd. Potential Restoration Areas

Vandenheuval Property

This is located between Whale Rock Reservoir and Toro Creek in the headwaters of Willow Creek (Figure 13). The site was visited in 1993 as part of another project, and springs were observed that resembled those of Pennington Creek. Reexamination of the springs was not possible during the duration of this study, as the land was the subject of litigation, and that access is denied to all. The headwaters of Willow Creek contain serpentinite landslides that are similar to those of Pennington and San Simeon Creeks, and therefore this may be a feasible site. It is possible that CCbt already exists here. The land appeared moderately to heavily grazed.

Santa Rita Creek Road

There is a small spring located on Santa Rita Creek Road about two miles from the intersection with Old Creek Road, and upstream of Whale Rock Reservoir (Figure 13). It is located at the edge of a body of serpentinite and is known for its population of orchids. Only a small CCbt population could be supported at the site but climate may be a limiting factor. Although it is on the shaded north slope of the creek, the location may have too much summer heat.

Stenner Floodplain

Stenner Creek is a tributary of San Luis Obispo Creek, flowing through a serpentinite ridge north of Cal Poly State University (Figure 14). It shares the pass with a Southern Pacific Railroad line. The floor of the pass and much of the rocky debris on the creek bed is in serpentinite. There is also a significant contribution of sediment from Franciscan Formation rocks that occur higher in the watershed. The creek bed is subject to high energy floods, but plant populations could be established in some locations along the banks.

Chorro Creek East Spring Complex

The newly rediscovered CCbt population on Chorro Creek may have been 'lost' due to the visual predominance of a spring northeast of the Chorro Reservoir, which is visible from the road intersection just above the reservoir (Location B in Figure 5). The bog associated with this spring resembles that of the CCbt-bearing population, which lies a short distance to the west, but the surrounding geology appears to be Franciscan melange. The melange shows some evidence of serpentinization, and therefore there is some possibility that a CCbt population could be supported. The bog and surrounding lands are very heavily grazed and trampled by cattle. The bog does contain other thistle species, which generally are not found in bogs supporting CCbt.

Reservoir Canyon

The eastern edge of the San Luis Obispo city is flanked by a serpentinite ridge On the opposite side of the ridge is Reservoir Canyon (Location A in Figure 15). The creek running through the canyon is a major source of water for San Luis Obispo Creek. The city water supply was once stored in a reservoir at the lower portion of the canyon.

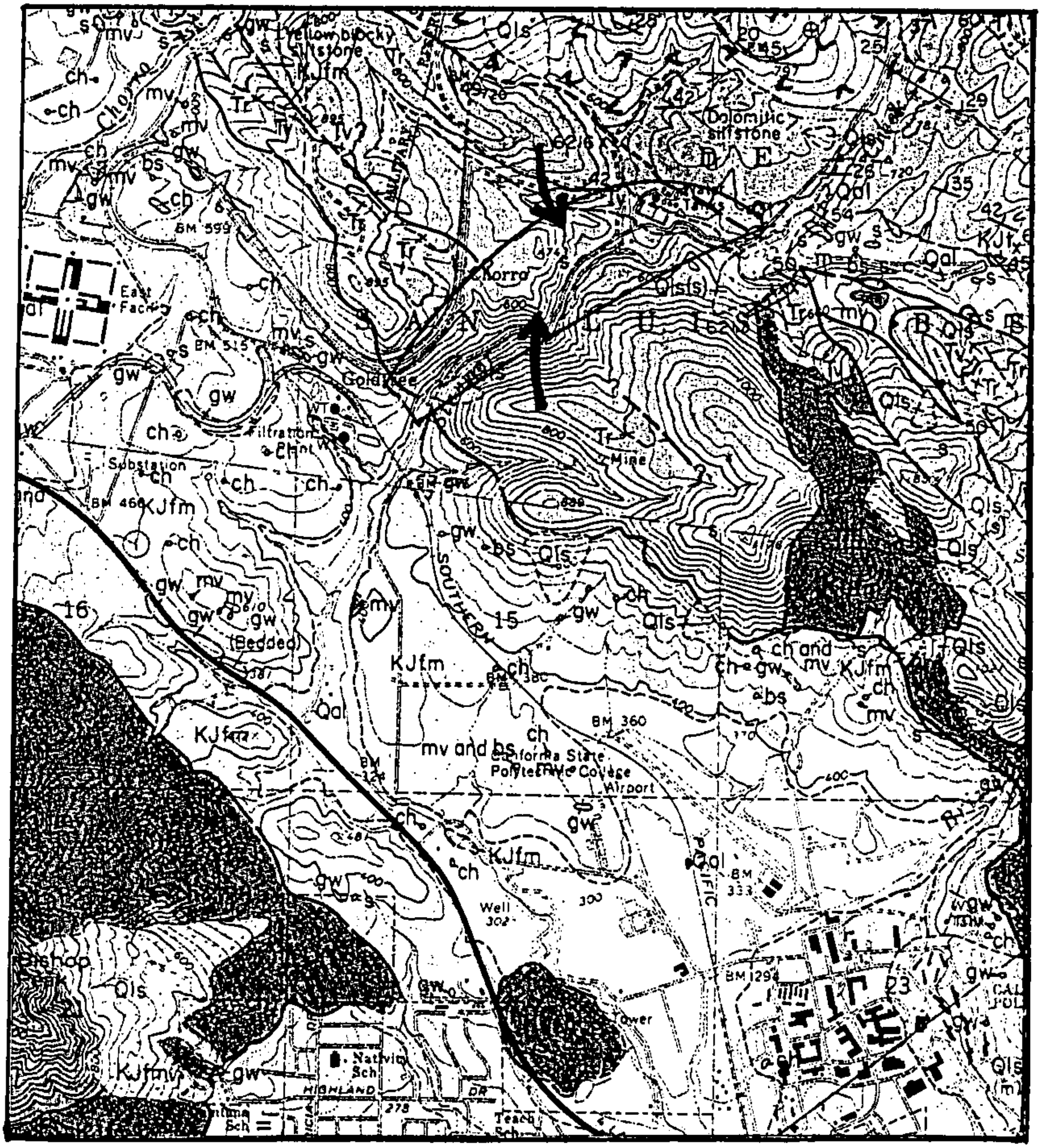

Figure 14. Stenner Creek restoration site. Arcuate area marked with two arrows marks the area along the creek with serpentinite bedrock.

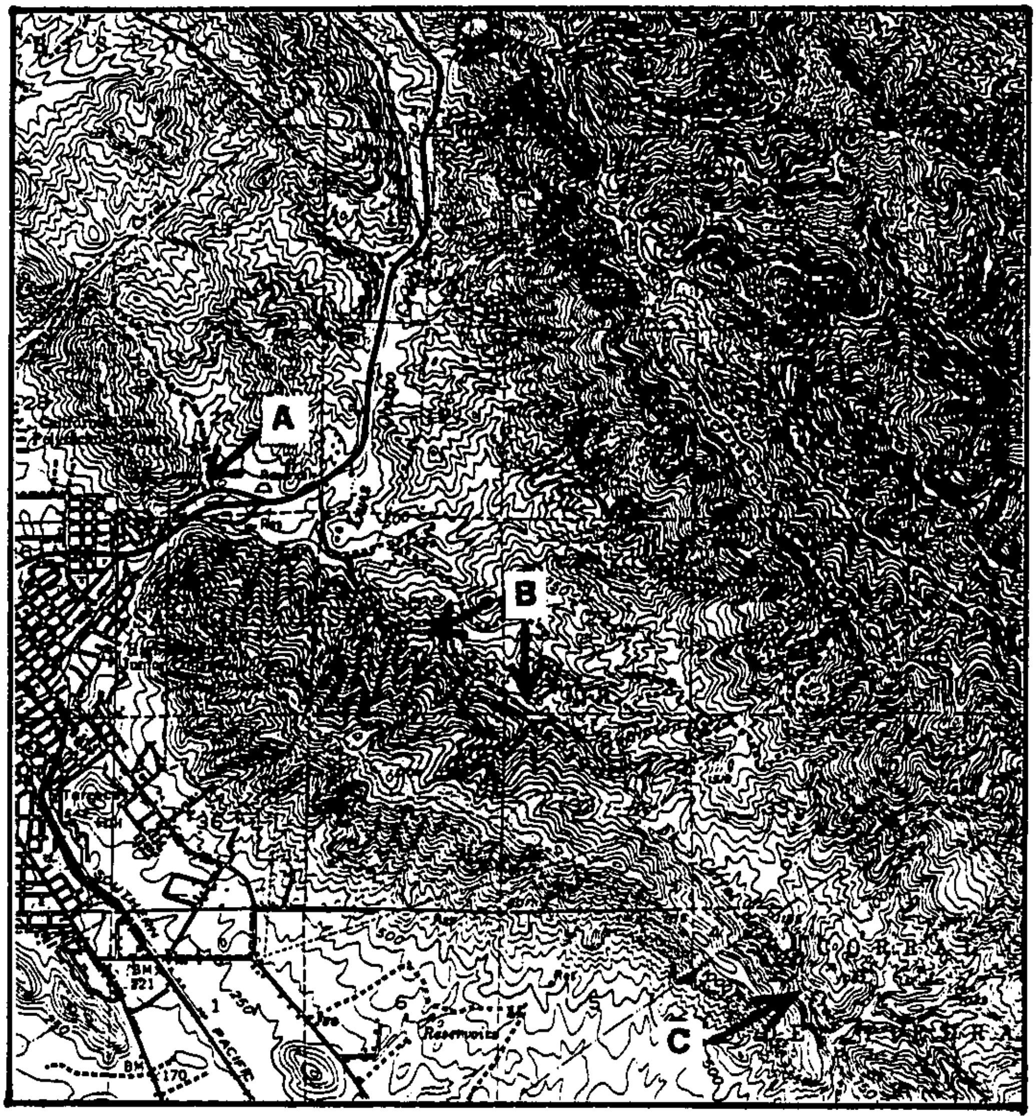

Figure 15. Locations of Cuesta Park (A), Reservoir Canyon (B), and Corral de Piedra Creek (C). Base Map is San Luis Obispo 15' Quadrangle.

Potential habitat exists in the wet sediments along the main creek, and along some side drainages that run year round. These side drainages are very steep and subject to flashy runoff, and do not contain many sediments. They are similar to CCbt-bearing drainages in the Prefumo Canyon area, southwest of the city. Thus it is likely that a population of thistles, concentrated in just a few suitable places along the otherwise rocky channels, could persist to disperse seed along the creek.

Little is known about CCbt's tolerance limit for summer heat. This canyon is subject to marine influence summer fog, but morning burn-off is faster than for other sites. Summer temperatures may also be higher.

The area is only lightly grazed. .Cattle should not impact the sites, which are too steep and brushy for cattle to concentrate.

Cuesta Park

Cuesta Park is at the north end of San Luis Obispo city, north of Highway 101 and adjacent to San Luis Obispo Creek. The bedrock surrounding the banks of San Luis Obispo Creek within the park is serpentinite, and there are springs on a very steep road cut on the south side of Highway 101. Some areas of the Park and the road cut could be used to establish a very small population. The road cut site along Highway 101 is similar to a CCbt population site in Prefumo Canyon. The cut would be difficult to service, and the routine maintenance of the cut may conflict with preservation of the species (Location B in Figure 15).

Upper Corral de Piedra Creek

Southeast of San Luis Obispo city, at the southern flank of the Reservoir Canyon serpentinite ridge, is the upper end of the north fork of Corral de Piedra Creek. The reach of the creek above the Ernest Righetti Reservoir may be suitable for establishing CCbt, as the conditions are very similar to those in Reservoir Canyon (Location C in Figure 15).

Pennington Creek Road Access

A serpentinite outcrop lies just above the ford on the jeep trail that runs up Pennington Creek to the vicinity of the Cal Poly Ecological Preserve. Several seeps support a dense stand of vegetation, with those most suitable for establishing CCbt occuring in and next to the road (Location 'A', Figure 6). There is no doubt that CCbt could grow in this location, but the site is small and would be subject to disturbance during periodic regrading of the road. A population could succeed if it were to spread beyond the area of grading.

UNOCCUPIED SITES WITH LITTLE OR NO CCbt HABITAT POTENTIAL: SERPENTINITE AREAS

Department of Fish & Game Chorro Valley Firing Range

The range lies on the north side of Highway 1, about half way between the cities of San Luis Obispo and Morro Bay. Small seeps on the firing range were found to be too small to support a CCbt population.. There was serpentinite associated with the seeps, but the outcrops were small and the soils were largely derived from melanges that flanked the serpentinites.. The site is both too dry and appears to lack the required soil chemistry.

Serpentinites of Cayucos

The town of Cayucos lies on a coastal terrace that extends into serpentinite hills. Springs located in the hills, but none contain CCbt, and all springs appear to be ephemeral and probably dry up in drought. These include (1) a spring at the rear of the Cayucos Cemetery, (2) a spring on the hill north of Whale Rock Dam, and (3) five springs on the north side of Toro Creek Road along the flank of the hills, within 1 mile of the first bridge.

A spring is located on the south side of Old Creek Road in association with a serpentinite landslide just east of existing houses. The landslide and surrounding outcrops of serpentinite and Franciscan Formation melange and metavolcanic rock are crisscrossed with a network of bulldozed roads, the remnants of a failed attempt to sell home parcels on the landslide-ridden land. It appears that the landslide incorporated some melange debris and the chemistry may not be suited for CCbt restoration. Several other species of thistle exist in the bog and channel, which is atypical of CCbt habitat sites.

Serpentinites of North Morro Bay

A block of serpentinite is located north of the city of Morro Bay between Highway 41 and the Toro Creek Oil Tank Farm. About 1 km due east of the San Jacinto Avenue stoplight on Highway 1, a spring occurs in a gully in the serpentinite. It drains toward Highway 41, just east of some houses and a large water storage tank. The gully floor is serpentinite and contains some water during normal rainfall years. The spring is small, and may dry out during an extensive drought. The site is heavily grazed, and exotic thistles are common, a contra-indicator of CCbt suitability. The geology gives the site some potential if the spring were perennial.

Chorro Creek Serpentinite at Chorro Reservoir

On the south side of Chorro Reservoir, on the opposite side from the Chorro Creek population, is a prominent ridge of serpentinite.. The ridge is devoid of significant springs, but it does extend toward Pennington Creek, where a small spring of some potential exists (Pennington East Access Track). In contrast to this bedrock ridge, the Chorro Creek population is located in serpentinite landslide deposits.

Cal Poly 'P' Hill Serpentinite

The serpentinite ridge due east of Cal Poly State University and south of Poly Canyon has no springs of significant size or persistence.

West Cuesta Ridge

West Cuesta Ridge is the local name for a portion of the Santa Lucia Mountains to the north side of the city of San Luis Obispo. The serpentinite on this ridge is part of the Cuesta Ophiolite and is associated with gabbroic rocks, altered basaltic rocks, and marine sediments of deep-ocean affinity. It is the source rock for the large landslides that support the Pennington Creek, Chorro Creek, and San Bernardo Creek populations. The ridge does not support springs of any significant size in the area of the parent rock body.

Prefumo Canyon-See Canyon Divide

Extending west from the Prefumo Canyon sites, a large serpentinite body occupies the divide between Prefumo and See Canyons. An extensive search of both sides of the ridge revealed no significant springs within the serpentinite, although several occurred in nearby melange units.

Serpentinites East of Montana de Oro State Park

In the ridges south of Montana de Oro State Park, a narrow zone of serpentinites is exposed east of Hazard Canyon, and approximately parallel to the power transmission line to Diablo Canyon. No springs or habitats suitable for CCbt were found.

Rinconada Mine Area

Serpentinite deposits are associated with the mercury deposits at Rinconada Mine, located approximately midway between Santa Margarita and Pozo. No CCbt was found at this site. The area experiences sustained temperatures of 90 degrees over much of the summer.

Arroyo de la Cruz

Arroyo de la Cruz is located north of San Simeon. Although not surveyed as part of this study, serpentinites and other ultramafic rocks in the Arroyo de la Cruz drainage were surveyed by Dr. David Keil, botanist, of California Polytechnic State University at San Luis Obispo. No CCbt were found, and the plant has never been reported that far north. The existence of suitable boggy habitat is uncertain. No such habitats were noted by the author during a visit in 1988. The land managers have not welcomed botanic investigation of these lands in recent years.

UNOCCUPIED SITES WITH LITTLE OR NO CCbt HABITAT POTENTIAL: OTHER SPRINGS

Irish Hills Springs

Several springs in the Irish Hills were investigated, as they are climatically similar to the Prefumo Canyon populations, but have different geological substrates as they lack serpentinite. Many other thistles were present, the soils in the bogs are generally brownish rather than the typical black soils that support CCbt, and therefore their potential for supporting CCbt is considered very low.

Upper Dairy Creek Springs

Dairy Creek runs parallel to, and east of Pennington Creek. Springs along Dairy Creek occur in about the same geological relationship tas the Pennington Creek Springs. The main spring, Whiskey Spring, is surrounded by non-serpentinite rocks.

Central Chorro Creek Valley Springs

Approximately thirty seep and spring sites in the Chorro Valley between San Luis Obispo and Morro Bay were visited. These were located in Franciscan Formation rocks, and developed along permeability contrasts in the melange. This geology underlies most of the grassland strip between the Santa Lucia Mountains and the ocean. Although several of these springs were located very close to CCbt sites, the soils in the bogs were brown in color rather than black; other thistle species were usually present; and the flora in the springs lacked the disinctive associations seen in the serpentine seeps. No CCbt were found, and the springs are not considered candidates.

San Simeon Creek Area Springs

Located between San Simeon and Van Gordan Creeks, the large acreage subdivision known as North Cambria Ranch supports several CCbt populations. There are other springs in the area, but examination showed them to be in Franciscan melanges, or in landslide material that was not dominated by serpentinites, and they did not support CCbt.

PHYSICAL CHARACTERISTICS OF THE HABITAT

Soils

Based on the existing populations, CCbt appears to be a serpentinite-dependent plant. Some of the charactaristics of serpentinite soils are summarized by Kruckeberg (1985) and are shown in table 1.

TABLE 1

Analysis Of Serpentinite Soils
From The Western United States And Canada

BEC*		Ca*		Mg*		Ca/Mg		pH
17.2		4.1		11.1		0.4		7.0
15.0		2.4		11.4		0.2		7.2
9.0		1.5		5.2		0.3		7.2
5.9		0.5		3.9		0.1		7.5
16.0		2.8		11.8		0.2		7.0
43.0		5.0		32.5		0.2		8.8
17.0		2.8		12.7		0.2		6.7
14.0		2.8		7.1		0.4		7.1
15.0		2.4		10.1		0.2		5.6
25.0		2.3		15.2		0.15		6.6
18.4		4.7		11.1		0.4		7.0
19.9		3.9		14.8		0.3		6.2

BEC = Base Exchange Capacity

*Values expressed as millequivalents per 100 grams, 2 mm fraction, air-dry soil; all samples by Kruckeberg of serpentinite soils from California, Oregon, Washington, and British Columbia: From Kruckeberg (1985) California Serpentines: Flora, Vegetation, Geology, Soils And Management Problems.

Soil Chemistries For Selected CCbt Sites

As part of the study, four sites were analysed for soil chemistry. Three sites contained CCbt populations, and the fourth apparently has a high potential for CCbt introduction. Two previously discovered CCbt sites were at different locations on Pennington Creek, and one was the newly discovered Bernardo Creek population. The potential introduction site is previously described as the "Cuesta College Hills-West End". The analyses were made at the Soil Science Department Analytical Laboratory at California Polytechnic State University at San Luis Obispo.

The results of the soil chemistry analyses are shown in tables 2, 3 and 4.

TABLE 2

Mineral Content and pH of Selected Sites
All values expressed in mg/L

SITE NAME	K	Ca	Mg	Na	Fe	Mn	Zn	pH
Pennington Main	232	505	4540	52	36	30.6	0.8	7.63
Pennington Satellite	165	600	5540	105	131	9.08	2.38	7.80
Bernardo	282	810	2280	182	66.8	22.3	0.52	7.78
West Cuesta Hills	285	3100	4695	310	137.4	52.86	0.32	7.10

All values expressed in mg/L

The iron levels are high, due to the liberation of Fe that occurs in bogs. Normal Fe content for soils would seldom exceed 5-10 mg/L. Soil pH was similar to those recorded by Kruckeberg (1985). The Ca and Mg balances are typical for serpentinite, with Mg very high and Ca elevated relative to many soils. K and Na values are both low compared with that needed for most plants, which is again typical for serpentinites.

TABLE 3

Phosphorus Content, pH, and Conductivity of Selected Sites
Phosphorus values expressed in mg/L

SITE NAME	Organic Matter %	P	Conductivity mmhos/cm
Pennington Main	13.59	13.5	0.65
Pennington Satellite	9.3	19	0.6
Bernardo	3.99	23	1.2
West Cuesta Hills	8.04	5.5	0.74

P values expressed in mg/L

Most plants need a Phosphorus content of 12 mg/L or greater. The phosphorus content at West Cuesta Hills is considered marginal for many plants, and this may prove to be a problem if this site is used for restoration purposes. The organic content of the soils is not unusual, and should not be considered a significant factor in defining the species of plant in the bogs. Conductivities are usually measured in the soils analyses, and as they appear to be within normal range, are reported here only for informational purpose.

TABLE 4

Calcium to Magnesium and Sodium to Salts Ratios of Selected Sites

SITE NAME	Ca/Mg	100* Na / (Na+Ca+K+Mg)
Pennington Main	0.11	0.98
Pennington Satellite	0.11	1.63
Bernardo	0.36	5.12
West Cuesta Hills	0.66	3.69

The calcium to magnesium ratios of the soils at sampled sites are similar to those recorded by Kruckeberg (1985) for serpentinite-derived soils. In general, most plants require a Calcium-Magnesium ratio of greater than 1 (Table 4). As with the phosphorus levels, the West Cuesta Hills site stands out from the rest. In general plants require a ratio of sodium to the combined content of sodium, potassium, calcium, and magnesium of less than 5%. This was found in two of the three CCbt sites, and it does not appear to have any relationship to site occupation by CCbt.

Geochemists may prefer the comparisons between the key soluble ions Mg, Ca and K to be presented in the form of a Ternary Chart

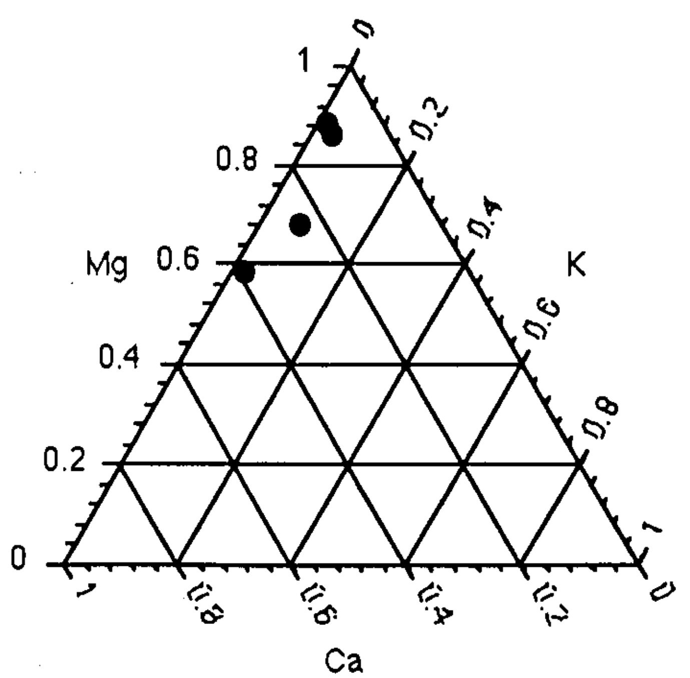

Figure 16: Mg:Ca:K Ratios For Selected Sites

United States Soil Conservation Service Soil Type Correlation

The Soil Conservation Service (SCS) has mapped soil types of Coastal San Luis Obispo County on a series of 7.5 minute orthophoto overlay maps. The described soil types were taken from the overlay for each location and are shown in the table 5. The SCS soil description for each soil series numbers is given in Appendix C. The commonest soils are Diablo-Lodo complex on 15 to 50 percent slopes (Soil series number 133), and Obispo-Rock outcrop complex on 15 to 75 percent slopes (Soil Series number 183). The former are developed on serpentinite-derived landslide complexes, while the latter are more characteristic of bedrock-dominated sites. The other 13x numbers are closely related Diablo-Lodo Series soils, and the 19x numbers are related to soil series number 183 at rocky sites. The Los Osos-Diablo soil complex (Soil series numbers 162 and 164) is closely related to the Diablo-Lodo Complex, with both complexes being developed over the Franciscan Formation and the associated serpentinites. One suggested restoration site has Lodo clay loam, (Soil series number 150) which is atypical and a possible contraindication of suitability, except that these soil series are mapped at a very broad scale and make no attempt to include very small areas.

Soil Thickness and Soil Wetness

Most sites, including Laguna Lake, Pennington Creek, San Bernardo Creek, and San Simeon Creek, have thick, boggy soils in which an unwary walker can sink to mid-calf with ease. These appear to be the preferred habitat and support the largest populations and the most robust plants. Plants bordering the bogs appeared to survive in dry grasslands, but it was evident that soils were saturated within reach of the roots.

Some sites are very different. Some of the Laguna Lake, Froom Ranch and Prefumo Canyon populations are on rocky sites; the plants utilize the finer-grained sediments between cobbles, or utilize the cracks in bedrock for their roots. These sites were either wet or damp. Seeding can take place in bedrock cracks, but usually the plants remained dwarfed relative to those in other sites unless abundant water was available.

Site Slope And Aspect

For each site, the range of slope is given in degrees from horizontal (Table 6). The aspect of the slope is given in compass degrees, with 0^{o}being north and 180^{o} being south (Table 7). It can seen from the tables that slope and aspect do not appear to be important factors for CCbt habitat selection.

TABLE 5

Soil Series Mapped By United States Soil Conservation Service
at Each Chorro Creek Bog Thistle Site

SITES	SOIL CONSERVATION SERVICE MAP I.D.#											
	130	131	132	133	142	150	162	164	165	183	194	195
Froom Ranch South							•	•				
Froom Ranch 'North Spring'								•				
Froom Ranch 'Gully Confluence'								•				
Froom Creek										•	•	
Prefumo Waterfall										•		
Prefumo- Roadside										•		
Laguna Lake East Group										•		
Laguna Lake Central Spring										•		
Laguna Lake West Group										•		
Chorro Creek Reservoir	•											
Pennington Main Complex					•							
Pennington Southern Satellite					•							
San Simeon 'Bianchi' Complex				•								
San Simeon Upper Spring				•								
Prefumo Gully 'A'										•		
Prefumo Gully 'B'.										•		
San Bernardo Creek Complex					•							
San Simeon North "Roadside" Spring				•								
Stock Pond				•								
Large Round Stock Reservoir				•								
The 'Big Seep'				•								
Cambria Mine				•								
South Street Hills Springs										•		
Poly Canyon										•		
'Cuesta College Hills': East End										•		
'Cuesta College Hills': West End			•							•		
Pennington East Access Track												•
Del Mar Park Canyon										•		
Vandenheuval Property						•						
Santa Rita Creek Rd									•			
Stenner Floodplain										•	•	
Chorro Creek East Spring Complex		•										
Reservoir Canyon										•	•	
Cuesta Park										•	•	
Upper Corral de Piedra Creek										•	•	
Pennington Creek Road Access												•

TABLE 6

Slope Value For Sites

SITES	SLOPES IN DEGREES							
	0to9	10to19	20to29	30to39	40to49	50to59	60to79	80to90
Froom Ranch South	•	•	•	•	•	•		
Froom Ranch 'North Spring'	•	•						
Froom Ranch 'Gully Confluence'	•							
Froom Creek	•							
Prefumo Waterfall		•	•	•	•	•	•	•
Prefumo- Roadside		•	•	•	•	•	•	•
Laguna Lake East Group	•	•	•	•	•	•	•	
Laguna Lake Central Spring	•	•						
Laguna Lake West Group		•	•	•	•	•	•	
Chorro Creek Reservoir	•	•	•	•				
Pennington Main Complex	•	•	•	•	•	•	•	
Pennington Southern Satellite	•	•						
San Simeon 'Bianchi' Complex	•	•	•					
San Simeon Upper Spring	•	•						
Prefumo Gully 'A'	•	•	•	•	•	•	•	•
Prefumo Gully 'B'.	•	•	•	•	•	•	•	•
San Bernardo Creek Complex	•	•	•	•	•	•	•	
San Simeon North "Roadside" Spring	•							
Stock Pond	•							
Large Round Stock Reservoir	•							
The 'Big Seep'	•	•	•	•	•			
Cambria Mine	•	•					•	
South Street Hills Springs	•	•	•	•	•	•		
Poly Canyon	•	•						
'Cuesta College Hills': East End	•	•	•	•	•	•		
'Cuesta College Hills': West End		•	•					
Pennington East Access Track	•	•	•					
Del Mar Park Canyon	•	•	•	•	•	•		
Vandenheuval Property		•	•					
Santa Rita Creek Rd	•					•	•	
Stenner Floodplain	•							
Chorro Creek East Spring Complex		•						
Reservoir Canyon	•	•	•	•	•			
Cuesta Park	•						•	•
Upper Corral de Piedra Creek	•	•	•					
Pennington Creek Road Access	•						•	

TABLE 7

Slope Aspects For Sites

SITES	SLOPE ASPECT IN DEGREES							
	0-45	46-90	91-135	136-180	181-225	226-270	271-315	316-360
Froom Ranch South	•	• •	•					
Froom Ranch 'North Spring'	•	•						
Froom Ranch 'Gully Confluence'		•						
Froom Creek								
Prefumo Waterfall	• •	•					•	• •
Prefumo- Roadside	• •							• •
Laguna Lake East Group			•	•	• •	•		
Laguna Lake Central Spring					•	•		
Laguna Lake West Group			•	•	• •	•		
Chorro Creek Reservoir					•	• •	•	
Pennington Main Complex				•	• •	• •		
Pennington Southern Satellite					•	• •	•	
San Simeon 'Bianchi' Complex			•	•				
San Simeon Upper Spring				•	•	•		
Prefumo Gully 'A'	• •	•					•	• •
Prefumo Gully 'B'.	• •	•					•	• •
San Bernardo Creek Complex				•	• •	• •	•	
San Simeon North "Roadside" Spring					•	•		
Stock Pond				•	•			
Large Round Stock Reservoir					•			
The 'Big Seep'			•	•	•	•		
Cambria Mine					•			
South Street Hills Springs			•	•	• •	•		
Poly Canyon		•						
'Cuesta College Hills': East End	•							•
'Cuesta College Hills': West End	•							
Pennington East Access Track			•					
Del Mar Park Canyon	•	•	•			•	•	•
Vandenheuval Property				• ?				
Santa Rita Creek Rd	•							•
Stenner Floodplain					•	•		
Chorro Creek East Spring Complex				•	•			
Reservoir Canyon	• •	•				•	•	• •
Cuesta Park					•		•	
Upper Corral de Piedra Creek			•	•				
Pennington Creek Road Access				•	•			

PLANT ASSOCIATIONS

Jan Barber, a botany student from Cal Poly State University, completed two transects over the Laguna Lake East Springs Group, and one at Pennington Creek Main Complex. The California Native Plant Society 50 meter line transect procedure was used. The results are presented in tables 8. 9 and 10

TABLE 8

Transect 1: Laguna Lake Eastern Springs Group (within grazing exclosure)

PLANT	NUMBER OF HITS*
Lolium perenne	38
Distichlis spicata	33
Lotus corniculatus	18
Juncus phacocephalus	17
Cirsium fontinale var. obispoense	14
Carex serratodens	13
Sisyrinchium bellum	10
Stachys ajugoides	8
Anagallis arvensis	8
Lactuca saligna	7
Eleocharis sp.	4
Verbena lasiostachys	4
Epilobium ciliatum	3
Lythrum californicum	3
Ranunculus californicum	2
Gnaphalium sp.	2
Scirpus sp.	1
Hordeum brachyantherum	1
Sonchus olaraceus	1
Hemizonia cogesta var. lazulifolia	1

Also observed in the 5m x 50m plot but not sampled in transect were Calystegia macrostegia, Achillea millefolium, Mimulus guttatus, Potentilla answerina, Hemizonia fasiculata, Plantago sp., Melilotus indicus, Centaurium davyi and Agrostis exarata.

* The California Native Plant Society Point Transect Method records the 'hits' or contacts of a thin rod dropped vertically every 0.5 meters along a 50 meter transect line (see Appendix D for a description of the method).

TABLE 9

Transect 2: Laguna Lake Eastern Springs Group (outside grazing exclosure)

PLANT	NUMBER OF HITS *
Carex serratodens	36
Cirsium fontinale var. obispoense	27
Nassella pulchra	25
Hemizonia cogesta var. lazulifolia	12
Calystegia macrostegia	12
Sisyrinchium bellum	12
Lolium perene	11
Juncus phacocephalus	6
Astragulus curtipes	4
Hordeum brachyantherum	4
Agrostis exarata	3
Lotus scoparius	3
Chorizanthe palmeri	3
Hazardia squarrosa	2
Distichlis spicata	2
Dudleya lanceolata	1
Achillea millefolium	1
Eriophyllum concertiflorum	1
Lessingia filaginifolia	1

Also observed in the 5m x 50m plot but not sampled in transect were Eschscholzia californica, Scrophularia californica, Mimulus guttatus, Polypogon monospeliensis, Hemizonia fasiculata, Lomatium sp., Stachys ajugoides, Verbena lasiostachys, and Phacelia sp.. Close to the site but not in the plot were Calochortus obispoensis, Chloragalum pomeridianum, and Popogyne douglasii. (* See Table 8)

TABLE 10

Transect 3: Pennington Main Population

Cirsium fontinale var. obispoense	60
Juncus phacocephalus	37
Carex serratodens	16
Mimulus guttatus	15
Helenium bigelovii	13
Lolium perenne	7
Polypogon monospeliensis	6
Eschscholzia californica	5
Stachys ajugoides	4
Elymus glaucus	3
Castilleja minor ssp. spirales	2
Unknown herb	1

Also observed in the 5m x 50m plot but not sampled in transect were Lupinus sp., Yucca whipplei, Phalaris sp. and Hemizonia congesta var. luzulifolia.

PHENOLOGY

Growth Histories of Plants at Laguna Lake

The growth histories of a selected groups of CCbt plants within the Laguna Lake East Springs Group population was followed during this year of the project. The limited observation time resulted in many questions remaining about the life cycle, as the plant is generally considered a biennial. Details of the Laguna Lake population are given in Appendix A. A similar monitoring project at Pennington Creek was abandoned due to logistic difficulties.

Seedlings

Plants of all sizes were present on the site when surveys started in March, 1993. These included many 2-4 leaved seedlings which had axial leaf lengths of 10 cm or less. They were almost always located within 3 feet of larger plants. The seedlings were (1) growing in wet soils, often with water seeping past their stems, and (2) in the damp cracks of serpentinite rock that was otherwise dry and soil-free at the surface. The rate of growth of some plants was rapid, with leaf lengths doubling in size and more, smaller leaves added to the rosette by May 1993. Other seedlings showed no signs of growth, but otherwise appeared healthy. Many of these 'stunted' plants eventually died. However, a few persisted through the summer to the start of the Fall/Winter rainy season, and began to show more growth. In some close seedling groupings under seemingly similar growth conditions, one or two might remain stunted while the remainder grew normally. This may be a survival strategy for the plants, since the seedlings seem hardy, a small plant with a well developed root system may possibly survive dry conditions and summer heat better than a large plant under the same conditions. It was evident that certain seedlings were doomed due to their dependence on ground wetted more by the winter rains than by the springs. Relatively few seeds seemed to be 'wasted' in this manner. Seed wastage is probably low due to the small seed dispersal distance, which keeps most seeds inside the area of wet ground occupied by the parent.

It is clear that CCbt is essentially a biennial. The majority of seedlings that survive the first winter will increase in size rapidly during the winter and spring, will flower in the second spring, and in most cases will die after flowering (see Appendix A for growth histories).

There is some evidence that a minority of plants may live into and flower a third year. The evidence of three year plants is speculative. The presence of plants with 25 cm leaves at the start of the project was taken to indicate that they were second year plants which had germinated in the winter of 1991/2, and they had been expected to flower that spring (1993). Many of them remained about the same size during the whole of 1993 and did not flower. At the close of the project in the spring of 1994 they either developed flowering stalks or were rapidly increasing in size. Perhaps, rather than germinating in the 1991/92 winter, these plants actually germinated very early in 1993 compared to the smaller seedlings, and were in fact first year plants when seen. If this is true, it appears that for unknown reasons germination developed two cohorts of seedlings.

Bart O'Brien, Director of Horticulture at Rancho Santa Ana Botanic Garden, notes that Cirsium fontinale ssp. campylon, a closely related species, can exist for many years prior to blooming, and also may persist after blooming. The above observations may indicate a similar phenology for Cirsium fontinale ssp. obispoense.

Flowering

When CCbt flowers, it first sends up a single stalk. In some cases, secondary stalks will branch from the base of the primary stalk before it has developed open flower heads. The stalks will fork several times throughout their development, developing buds and flower heads over a period of three months, so that there may a few open flower heads on the plant at all times. Bud development continues even during the final weeks of the plant's life. When the leaf rosette starts dying back, the stalk browns and upper leaves brown and shrivel. Plants that die after flowering usually have shrivelled buds.

Stalk development is more vigorous in those plants with access to abundant water, and is smaller in plants with marginal amounts of soil water. In drought-stressed plants, budding and development of flower heads is apparently much faster compared to plants growing in more optimal conditions. This could be a survival strategy to produce seed quickly before the bog dries out, either for marginal locations in normal years, or for normal locations in a drought year. The number of flower heads also depends on the amount of stress on a plant. Small stemmed, water stressed plants may develop approximately ten flowering buds, of which only four or five will flower and have a chance to set seed. Frequently the stressed plants die before some of the buds can develop into flower heads, and in some cases, the plant dies before any of the flower heads can set seed. In contrast, healthy plants can develop over fifty buds, and can have at least half as many flower heads that produce seed.

Some flower head stalks may be in excess of 2.0 meter in height, although 0.5 - 1.0 meter stalks are most common. In 1994, stem growth started in March, later than in 1993 when stems were actively growing by late February. Stem growth continues through May, and in a few cases, into early June. Flowering is usually completed by mid-June, although in shaded places a very small number of flower heads may persist through July. The stems brown and tend to lean after flowering, but may remain somewhat upright through the entire next winter. In most cases stems fall over, are trampled down, or blow down by the end of the following summer.

During 1993, plant populations on the north facing slopes of Prefumo Canyon were at growth stages about three to four weeks behind plants in the south facing Laguna Lake populations. At all locations plants growing in shade grew slower and higher than those in open sun. Plant mass development was usually higher in open sun, as plants growing in shaded places put more energy into stem elongation rather than leaf mass.

Pollination

The flowers were seen to be visited by flies, solitary bees, honey bees, sphinx moth, bush tits, sparrows, blackbirds and hummingbirds, and several butterflies of which the Monarch and Cabbage White were the most common. Aphids and the ants which tended them were also abundant on certain plants; it is conceivable that ants are pollinators. There was no obvious difference in plant visitation between sites, and no obvious specialized pollinator associated with the plant. Flowers remained open 24 hours, but no night surveys were made for nocturnal pollinators.

Seed Numbers and Dispersal

A permit was issued for limited seed collection from several CCbt populations. Seeds were collected in May and June, after flower heads dried on the plant, and before the basal rosette was completely dead. At this stage, seeds are firmly attached in the seed head and can only be removed with difficulty. Some flower heads were recovered from stems that died the previous year, and the seeds were still well attached. Dissection of the flower heads revealed a maximum seed content of 25 apparently fertile seeds. Between 15-25 seeds were common in healthy plants from healthy populations such as Laguna Lake and Pennington Creek. One San Simeon Creek population contained only a couple of seeds in the four selected seed heads, which were also infested with weevils. Based on my limited collection, and observations of the plant populations themselves, it appears that seed development is best in flowers developed early in the flowering season. (Seeds were stored in plastic bags, which were then stored in a cool dark drawer.)

Although the 'nodding' nature of the dried out flowers of CCbt suggests that seeds could drop directly from the flower, this appears to be uncommon, and the seeds remain in place in the flower head. Animals and breezes topple the dried stalks, and the flowers may either remain fixed to the fallen stalk or detach. This study did not evaluate the fate of any particular flower heads, but there was no indication that rodents or similar agents spread the seed any great distance from the parent plant. Cattle and deer probably play an important role in 'trample-planting' either portions or whole flower heads. This may contribute to the clumping nature seen in many groups of plants. The thistles produce thistle down, but the seeds are too large and weighty to be dispersed any significant distance by the wind. Thistle stalks and seed heads could become attached to animal coats and be dragged to other sites, and may be the chief mechanism by which new sites are occupied. Seed or seed heads can also be washed down stream beds and occupy new sites. Where seedlings could be associated with a parent plant, the typical expansion of habitat through seed dispersal was seldom more than 3-4 feet, except where running water serves as a dispersal agent.

There is no indication that grazing animals utilize the plants at a time when mature plant seeds could be dispersed through feces. Grazing damage was limited to relatively succulent younger plants, and the heavily thorned seed heads and leaves of mature plants render them unpalatable.

Speculations on Natural Seed Banking and Resprouting

From the observations at San Simeon Creek, and possibly from Chorro Creek, it is apparent that populations can rebound from adverse conditions when the plant seemed to be extirpated. Long term survival of the seed is probable, but not proven. The possibility also exists that seed from a single flower head may be banked; a plant can grow from a buried seed head and die, then be followed by another plant from the original seed head at the same location as the first plant. This may produce the appearance that a single plant can live longer than two years when it dies back after flowering and then resprouts from old root stock.

In several cases, plants at the Laguna Lake site appeared to die, and were reduced to a tattered rosette of brown and blackened leaves. Subsequently a new plant appeared in the heart of the dried rosette of leaves, at the location of the original stalk. It appears that the plant never died, and was resprouting from the root rather than from banked seed below the rosette. There also remains a possibility that a seed from the first plant had germinated in the exact center of the dead leaves of its parent. However it appears that a related variety of the species var. campylon, can resprout from old root stock.

Perennial Thistles?

The speculations above suggest that, when a young plant is seen growing in the core of a dead rosette, it is the result of delayed seed germination. However many plants, especially those in optimal growing conditions with plentiful year round water, grow on top of large piles of dead leaves from former growing seasons. The dead leaves may belong to ancestors of the present plant, or may represent many episodes of die-back and regrowth from the same root stock. The possibility exists that CCbt could be a perennial under ideal growing conditions. Bart O'Brien, of Rancho Santa Ana Botanic Garden, notes that a closely related subspecies, Cirsium fontinale ssp. campylon, persists after blooming.

Germination Experiments

Germination experiments were originally part of this study. However, due to the logistical problems of finding a suitable reintroduction site, the investigation could not be concluded. Therefore the Department of Fish and Game cancelled this experiment. Resources were allocated to support further field work. A seed collection was made from several sites. The seeds were removed from the seed heads in December, 1993, and stored in plastic bags in a dark place. They are still in storage.

POTENTIAL THREATS TO DISCOVERED POPULATIONS

Water Diversion

Diversion of water from springs poses a potential risk to CCbt populations in the San Simeon Creek area. The only water source for some of the individual parcels in the area north of San Simeon Creek is the springs. The Upper Spring is to be shared by two adjoining properties, and a former owner of one (Walter Stuckey) believes the other property owner plans to irrigate an orchard from that spring. No development plan has been submitted at this time.

Grazing

Grazed and ungrazed plots at Laguna Lake were monitored to obtain information on how grazing affects germination, establishment, flowering, seed set and seed dispersal. Interactions between grazing and microsite factors such as level of mulch, associated species, competition, and shading were also investigated. Very little difference was seen between the grazed western eastern and the ungrazed eastern populations. Some stem knockdown was observed in part of the grazed population, where several densely flowered stems were knocked over. About 70% of the knocked-down plants were apparently still alive and had flowers going to seed. There did not appear to be any significant grazing by cattle on the thistles themselves. There was an indication of very limited browsing on one plant in the ungrazed population from an unknown herbivore, probably deer. Significant grazing damage was observed in a small population in the San Simeon Creek area. It appeared that cattle had nibbled on a number of plants, but in only one small plant had completely grazed off all of the flowering parts.

The fence that protects the eastern Laguna Lake population from cattle does no protect a small spring and bog on the west side of the fence. The spring is close to a cattle trough and experiences relatively high use by cattle. The site is rocky, but similar to portions of the protected populations in geomorphology and substrate. Plant growth during 1993 was very similar between grazed and ungrazed sites. In the spring of 1994 there was a higher recruitment of young plants in the grazed bog than in the grazed bog, but a slightly lower density of mature plants at the flowering stage. Flowering stalk heights were slightly lower in the grazed bog, but this may be due to microenvironmental factors other than grazing. It is clear that seed production in the grazed bog will be more than adequate to maintain the population. .The vegetative composition of the grazed and ungrazed bogs is given in Tables 8, 9, and 10.

At Pennington Creek, cattle have accessed the eastern end of that CCbt population because of the failure to maintain fencing at the Biological Preserve. The cattle cause significant damage at the borders of the marsh, walking along its edge to avoid the bog. Over most of the bog perimeter, the losses were tolerable. However, on the eastern end, a well developed cattle path had destroyed a number of mature plants, and the loss is considerable. Although continued grazing at current levels will not affect the viability of the population, it would be enhanced if the fence were repaired and maintained and cattle were removed from the site.

The relationship of cattle to the survival of the thistle is a complicated one. Most of the sites that presently support the thistle have been grazed for over a century. The presence or absence of the thistle is more dependent on the persistence of the wetland than the presence of cattle. On one interesting newly discovered location on North Cambria Ranch, there were apparently no thistles in past years of drought. No CCbt were observed when the location was surveyed in the late 1980's for the possible presence of CCbt, relative to development plans for North Cambria Ranch. The site was grazed during the drought, but after a return of normal rainfall in 1992/93, and under continued grazing, a large number of the plants were present in 1993. This suggest seeds may stay viable for considerable time, and can survive the more intense grazing pressure that often impacts wetlands during time of drought.

In the total absence of grazing it is possible, but not proven, that CCbt population densities would be higher than at present. However grazing may facilitate the creation of habitat within a bog through hoof-planting seed, creation of habitat around hoof prints, seed dispersal and elimination of competing vegetation.

Competition

The survival of the plant may also depend on competition with grasses and other plants for both seed germination space and growing room. In general, grasses such as <u>Rabbits Foot Grass</u> may occupy much of the potential seeding space and thus limit the numbers of new seedlings. Competition for space controls CCbt numbers at many sites. Grazing may be of some advantage to the plant if it selectively removed competitive species, but the adverse tradeoff is plants killed by trampling, and a possible positive gain from seed dispersal and from hoof penetration 'planting' in the bog. Much may also depend on the climate of a particular season in terms of which species started their spring growth first, and which grows fastest. At the Laguna Lake population, thick grasses grow at the lower end of several seeps and within the grazing exclosure. The grasses grew thickly in 1993, and many thistles were unable to spread their leaves in a typical rosette. Instead they began to resemble spiny romaine lettuce and most of these plants flowered and set seed. As the grasses died back in mid summer, the CCbt leaves fell outward to form a carpet around the center of the old plant and repress grass growth in the spring of 1994. As a result, there was a significant amount of thistle germination within this circle of old leaves, but very little germination beyond the circle. On a grazed plot at the western edge of the Laguna Lake eastern population, there were larger numbers of seedlings in the spaces between plants that had set seed in the previous year than were seen in the ungrazed portion of the population where the grasses were very thick. Seedling germination and density was about the same in ungrazed areas that did not support thick grasses and in grazed areas of the Laguna Lake population.

There does not appear to be any significant competition from other thistle species within the serpentinite-based bogs. The presence of large numbers of other thistle species is usually an indicator that no CCbt are to be found at the site. This is probably due to the inability of other species to survive in the nutrient-poor serpentinite environment, which Kruckeberg (1984) has noted has protected endemic species in many serpentinite environments. The apparent lack of ability of CCbt to survive in nutrient-rich environments may also be due to competition pressure rather than a genetic inability to survive in chemically different environments. The thistle appears to be aggressive in those bogs where it occurs, and has developed dense monocultures at some sites.

Herbivorous Insects

Charles Turner of the U.S. Agricultural Research Service surveyed some CCbt sites, especially the Bianchi San Simeon Creek site. This study was performed partly to monitor the effects of introducing the Mediterranean-Eurasian weevil, Rhinocyllus conicus for the purposes of controlling European exotic thistles in California. The San Simeon CCbt population was found to be host to that weevil, as well as a native moth, Platyptilia carduidactyla, and possibly another native moth, Rotruda mucidella (not confirmed as of 3.25.94). Turner also observed the fruit fly, Paracantha gentilis, and the native weevil Baris monticola, on the related Cirsium fontinale campylon, the latter also being found on C. fontinale fontinale. Although his study is not complete, Turner does not consider any of the insects using the plant or its close relatives to be a significant threat to the population, and this was borne out by observation during this study. Only one sub population in the San Simeon Creek area appeared to be significantly impacted by a weevil, but some seed was being produced and most plants were healthy.

Development

At present, the Froom populations are at risk from development. The land is (1) owned by a developer, and (2) situated at the southern edge of the city of San Luis Obispo. In the late 1980's, an Environmental Impact Report was prepared for the County of San Luis Obispo for a development that could have impacted the CCbt populations, but the project was not approved. Plans for an expansion of auto dealerships, office space, and a 'big box' store are in a preliminary discussions with the city of San Luis Obispo Planning Department, and the city will probably annex the land.

Road improvement threatens one Prefumo Canyon population, as the road is narrow and some CCbt grow in the ditch beside the road. The roadside plants at the Prefumo Canyon site were mowed by the County Engineering Department in the last week of March, 1994. Their action did not destroy the entire population or immature rosettes close to the ground.

Other populations in Prefumo Canyon may be at risk from development occuring higher on the hill, potentially changing the flow charactaristics of the channels that support the plants. No development proposals have been submitted within those plant populations. Administrative action was recently taken by San Luis Obispo County against a developer for illegal grading on the slope above the populations. The developer was ordered to restore the land. The illegal grading does not, at this time, put any of the CCbt populations at risk.

Development could also threaten one of the potential reintroduction sites on the south side of the South Street Hills. The city is reviewing a large development proposal between the Hills and Tank Farm Road, and, although it is city policy to protect wetlands, the sites may still be at risk.

The potential for development on North Cambria Ranch was noted in association with water diversion. In early 1994, a lot line adjustment was approved by San Luis Obispo County Planning Commission for three lots that would remove some of the pressure on the springs by rearranging housing toward the San Simeon Creek area, where water would be available. The lot line adjustment was successfully appealled by residents along San Simeon Creek, and the decision was reversed in April, 1994. Therefore the pressure on the springs remains as before.

Summary of Protection and Risk Status

Table 11, on the following page, summarizes the current status of the known populations. Further information on the property owners can be found in Appendix E.

NDDB#	Name of site	cty	dt last obs	ownership	protected?	size	status	comments
					key in			
					footnotes			
	San Simeon (known)	SLO						
1	_upper spring	SLO		Winsor + Denio	No (3)	Sp.93(200)	healthy/increasing	possible water diversion
1	_Bianchi	SLO	Sp.93/Sp.94	Bianchi+others	Yes(1,2)	Sp.93(285)Sp.94(280)	healthy/stable	possible property dispute
	San Simeon (new)	SLO						
new	_seep	SLO	Sp.93	Winsor	No	Sp.93(170)	healthy/increasing	not seen before 1993
new	_stock pond	SLO	Sp.93	Winsor	No	Sp.93(49)	healthy	some grazing damage
new	_big seep	SLO	Sp.93	Winsor	No	Sp.93(340)	healthy	not seen before 1993
new	_reservoir	SLO	Sp.93	Winsor	No	Sp.93(36)	insect damage	risk reservoir maintenance
new	_mine	SLO	Sp.93	Winsor + ?	No	Sp.93(7)	healthy	marginal habitat
	Laguna Lake Park	SLO						
2	_East	SLO	Sp.94	City of SLO	Yes (1,2)	Sp.93(550) Sp.94 (510)	healthy	frequent CNPS monitoring
2	_Middle	SLO	Sp.94	City of SLO	No (2)	Sp.93(25)	healthy	frequent CNPS monitoring
2	_West	SLO	Sp.94	City of SLO	No (2)	Sp.93(450)Sp94.(440)	healthy	frequent CNPS monitoring
	Pennington Creek	SLO						
6	_main	SLO	Sp.94	Cal Poly State Univ	Yes (1,2)	Sp.93(>2000)Sp.94(1900)	healthy/stable	frequent CNPS monitoring
?new	_satellite	SLO	Sp.94	Cal Poly State Univ	Yes (1,2)	Sp.93(200)Sp.94(150)	healthy/stable	frequent CNPS monitoring
	Prefumo Canyon	SLO						
4	_Waterfall	SLO	Sp.93	SLO County/Private	No	360	healthy/increasing	
5	_Roadside	SLO	Sp.93/Sp.94	SLO County/Private	No (5)	Sp.93(70)Sp.94(50)	healthy	some mowed along road
new	_Gully A	SLO	Sp.93	Silviera + Charles	No	Sp.93(150)	healthy	
new	_Gully B	SLO	Sp.93	Silviera + Charles	No	Sp.93(40)	healthy	
	Froom Ranch	SLO						
??	_Froom Ranch South	SLO	Sp.93	Madonna	No (4)	>155	healthy/stable	active development plans
??	_Froom.N.Spring	SLO	Sp.93	Madonna	No (4)	95	healthy/stable	active development plans
??	_Gully Confluence	SLO	Sp.92/Sp.93	Madonna	No (4)	Sp.92(1)Sp.93(0)	extirpated	active development plans
??	_Froom Creek	SLO	Sp.92	Madonna	No (4)	10	unknown	active development plans
3	Chorro Creek	SLO	Sp.93	Cal Natl Guard	Yes (2)	Sp.93(250)	healthy	newly recovered
new	San Bernardo Creek	SLO	Sum.93	O'Reilly	No	Sum.93(>500)	healthy	poorly studied
	START OF 1993/1994 GROWING SEASON				TOTAL PLANTS ABOUT 5,700			

(1) Grazing exclosure in place (2) Active monitoring program in place (3) Water diversion likely
(4) Development plans (5) Recently mowed

TABLE 11

SUMMARY OF PROTECTION AND RISK STATUS OF THISTLE SITES

RECOMMENDATIONS ON REINTRODUCTION: FIVE INITIAL SITES

The most promising sites are the two in Poly Canyon. The springs resemble those that support healthy populations, and the site can be protected and actively managed by Cal Poly State University. There will be an incentive to use the population for education and research, as the area is already used for classes, and grazing can be controlled as needed.

The South Street Hills resemble the Laguna Lake sites, but could be more prone to disturbance, and historically have been heavily grazed. However restoration of a CCbt population is likely to be successful.

Cuesta Hills- East End has some good sites that resemble those at Prefumo Canyon. Grazing and land use can be actively managed through Cal Poly State University.

Cuesta Hills- West End has a good spring and is apparently a suitable site, although the landowner may not cooperate as the spring is actively exploited as a cattle water source.

PRIORITIZATION OF SITES WITH LOWER POTENTIAL FOR RESTORATION

The Stenner Floodplain and the Pennington Creek Road access, which are both at least part owned by Cal Poly State University, may provide the easiest sites for restoration experimentation. .The latter is small but offers some ideal habitat, while the former could have some hydrologic and soil chemistry problems. Upper Corral de Piedra Creek offers some suitable habitat, although I do not know the degree to which the proivate land owners would welcome the project, and the weather may be too hot during the summer. At a slightly lower level is "Del Mar Park Canyon" which could be too foggy and summer-cool, but otherwise has some suitable habitat. All the other sites are very different from each other, and cannot be ranked until we learn a little more of the habitat limitations for CCbt.

RECOMMENDATIONS ON SELECTING SITES

The selection procedure should emphasize (1) finding a climate within the climatic range of known sites; (2) year-round moist soil conditions, even during dry years; (3) serpentinite or serpentinite-landslide bedrock below the spring; and (4) the typical black boggy soils of serpentinite bogs. The suitable soils typically do not support populations of other thistles. There is probably no reason to perform a chemical analysis if the geological relationships are evident in the field. .The grazing pressure on the site should only be an issue in site selection if the site has clearly been overpriced.

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TOPOGRAPHIC AND ORTHOPHOTO QUADRANGLES AT 1:24,000 SCALE

(These maps cover areas explored during the study)
Atascadero, Cayucos, Morro Bay North, Morro Bay South, Pebblestone Shut-In, Pismo Beach, Port San Luis,
San Luis Obispo, San Simeon,

APPENDIX A

GROWTH HISTORIES OF PLANTS FROM THE LAGUNA LAKE EAST SPRINGS GROUP

A large group of 125 plants was monitored throughout the project, and for a month after the termination of the project. . The following spreadsheet (Table A-1) shows plant heights measured in centimeters each month from the start of the project. Those cells with bold font represent months in which flowering was observed. Figure A-1 shows the locations of the original plants that were seen on the first survey. They are numbered, and the following letter shows the size status of the plant, where S indicates that the plant is less than 30 cm in height, L indicates that the plant is more than 30 cm in height, and F indicates that the plant was flowering or was about to flower. The symbol 'X' indicates plants that developed after the first survey, and which were not tracked through the project. Figure A-2 shows that status of plants at the end of the project, using the same letter code.

The site was surveyed using a 3 meter grid. The grid lines are shown in Figures A-1 and A-2. The grid was anchored on the fifth fence post on the fence at the north side of the population, as measured from the northeast corner of the exclosure fence at a distance of 18m to the west of that corner. The southwest corner is 41m from the northern fence line, and lies on the southern fence line 19.3 m from the southeast corner of the exclosure.

Several of the flowering plants appeared to resprout after dying back, but most died. The problem of distinguishing a resprout from a new seedling makes it difficult to quantify the process with any accuracy. This study should be used with caution. .The grid layout was reset each time from tape, and some confusion over individual plant identification resulted. These problems were apparently resolved, although it is possible that some misidentifications are present within the plant histories presented within the spreadsheet.

TABLE A-1 (PART 1)

HEIGHTS OF PLANTS IN THE LAGUNA LAKE EAST POPULATION

LAGUNA LAKE EASTERN POPULATION-PLANT HEIGHTS (CM)

MONTH>	Apr-93	May-93	Jun-93	Jul-93	Aug-93	Sep-93	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	May-94	Jun-94
PLANT #														
1	80	115	115	30	30	30	30	35	40	45	45	60	90	115
2	8	8	7											
3	30	35	40	30	20	20	22	28	29	40	42	72	90	120
4	30	32	30	30	30	28	28	32	40	45	50	50	55	60
5	20	20	20	20	20	18	16	23	30	33	40	90	110	110
6	25	25	24	25	25	26	25	24	25	30	36	40	45	50
7	16	23	20	17	18	15								
8	33	45	45											
9	20	20	22	22	20	18	18	20	18	23	30	35	32	36
10	20	25	30	28	25	25	25	25	34	40	42	58	60	67
11	30	30	39	32	20	18								
12	30	35	20											
13	40	70	89											
14	50	80	130											
15	18	18	20	20	20	20	22	25	25	30	32	32	34	35
16	22	25	25	25	22	22	20	28	35	40	42	43	80	120
17	12	10	10											
18	10													
19	10	10	8	10	9	10	10	15	17	20	22	25	27	29
20	12	12												
21	4	6	6	6	5	6	7	7	18	20	23	25	25	25
22	6													
23	4	4	8	7	8	8	9	10	10	10	15	14	20	20
24	4	5	5	10	10	10	10	10	20	23	28	27	28	30
25	6	10	12	10	12	12	15	20	22	22	32	33	32	40
26	3													
27	20	20	17											
28	20	23	20	20	20	20	22	23	23	33	35	40	40	42
29	3	3												
30	4													
31	2	2	5	7	7	7	8	10	12	15	18	20	25	25
32	4	4	5	6	6	8	8	8	8	12	10	10	12	20
33	3	3	3	3	4	3	4	3	4	6	8	10	10	10
34	3	5	5	6	6	6	6	6	6	12	15	16	20	22
35	3	5	5	5	5	4	8	10	6	5	7	8	10	10
36	20	22	20	25	25	27	30	25	25	32	35	40	42	40
37	7	8	5											
38	7	6	6											
39	20	23	25	30	32	25	23	25	35	42	48	50	52	56
40	18	20	25	25	23	20	20	22	25	28	30	35	40	42
41	10	10	20	22	20	20	23	23	30	35	35	40	45	45
42	26	29	30	30	32	30	30	35	40	44	50	57	60	70
43	30	50	50											
44	42	80												
45	3													
46	6	6	6	6	6									
47	2													
48	3	3												
49	3													
50	4	7	10	10										
51	6	6	7	7	10	12	12	10	10	20	29	30	30	30
52	20	25	30											
53	22	25	25	25	20	20	20	17	20	40				
54	35	50	70	70										
55	4	6	6	10	15	16	15	15	20	40	42	43	43	70
56	40	80	80											
57	30	80	85											
58	140	160												
59	140	170												
60	20	20	18	6	6	6	6	10	16	20	22	25	25	25
61	10													
62	10	10												
63	58	70	70	30	20	20	20	25	23	25	27	30	35	35
64	30	37	40	32	30	30	35	35	40	42	48	50	60	60
65	8	10	10	10	10	8	10	20	22	25	25	27	30	30
66	15	17	20	17	17	17	20	20	25	25	40	40	45	45
67	10	10	10	10	10	10	10	12	15	20	25	28	30	30
68	10	20	22	20	15	15	15	15	18	25	28	28	30	30
69	10	15	15	12	12	10	10	12	20	20	30	35	40	40
70	20	30	30											
71	15	20	20											
72	20	20	25	20	20	20	20	23	23	23	25	28	30	40
73	20	18	18	18	18	18	15	20	25	25	25	28	32	30
74	20	18	20	20	15	15	15	20	20	20	18	18	20	20
75	20	20	22	22	25	25	26	30	35	38	45	50	55	80
76	20	20	20	20	20	20	20	25	25	25	25	28	30	30
77	20	20	20	25	25	26	27	30	35	38	40	45	52	60

LAGUNA LAKE EASTERN POPULATION-PLANT HEIGHTS (CM)													
MONTH>	Apr-93	May-93	Jun-93	Jul-93	Aug-93	Sep-93	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	May-94	Jun-94
78	15	15	14	12	10	10	10	16	17	18	18	20	20	20
79	50	70	110	70										
80	15	20	20	15	15	14	15	15	30	32	35	40	65	95
81	4	10	10	8	8	8	8	15	20	25	25	30	35	35
82	3	3	3											
83	5	10	8	7	7	7	7	7	10	20	25	30	35	40
84	4	3	4	4	7	7	10	14	15	20	23	25	30	35
85	15	15	20	20	18	18	18	20	22	23	25	25	30	32
86	4	4	5	5	6	6	8	10	10	10	20	20	25	35
87	10	20	20											
88	10	10	15	10	10	10	10	12	15	20	25	30	35	40
89	20	22	22	25	25	28	28	30	30	35	40	40	70	110
90	10													
91	50	80	110	110										
92	6	6												
93	25	25	28	30	30	30	30	30	35	40	50	80	120	130
94	25	25	28	30	32	35	35	40	45	50	65	70	80	80
95	35	35	35	35	35	35	40	48	48	50	63	70	90	110
96	25	28	35	34	30	32	35	35	40	48	60	75	90	115
97	60	110	120	80										
98	20	23	25	25	25	25	25	30	28	30	30	32	35	40
99	5	5												
100	55	80	80											
101	5	8	10	10	10	10	10	10	12	10	12	14	14	15
102	25	25	25	25	17	17	17	15	15	15	15	18	18	20
103	70	90	100											
104	110	110	90	90										
105	80	90	90											
106	15	15	15	15	15	18	20	20	32	35	35	40	60	80
107	5	8	8	8	10	12	12	20	35	38	40	48	59	79
108	5	10	10	10	15	18	20	24	25	30	36	43	60	100
109	95	95	95											
110	35	39	30	30	32	30	30	35	40	40	50	57	65	70
111	65	85	117											
112	54	65	65	65	50									
113	13	13	14	15	15	15	15	22	28	32	36	40	75	80
114	70	80	80											
115	30	30	29	30	35	33	33	35	38	38	42	60	78	90
116	13	20	25	25	24	25	20	25	28	29	32	35	40	40
117	40	40	40	40	38	40	45	40	40	40	38	40	90	125
118	35	30	18	20	20	20	22	25	28	32	35	35	70	80
119	40	40	43	45	50	45	50	50	53	55	58	60	95	100
120	10	10	12	15	15	15	15	18	25	32	40	48	50	60
121	10	10	15	13	17	18	22	27	30	35	36	42	60	60
122	10	12	12	12	12	12	15	20	25	30	32	38	43	65
123	10	14	14	16	16	17	22	23	28	30	32	37	43	63
124	8	8	10	10	10	12	15	17	19	22	26	28	29	33
125	12	12	14	12	13	14	16	17	22	27	30	32	37	40

TABLE A-1 (PART 2)

HEIGHTS OF PLANTS IN THE LAGUNA LAKE EAST POPULATION

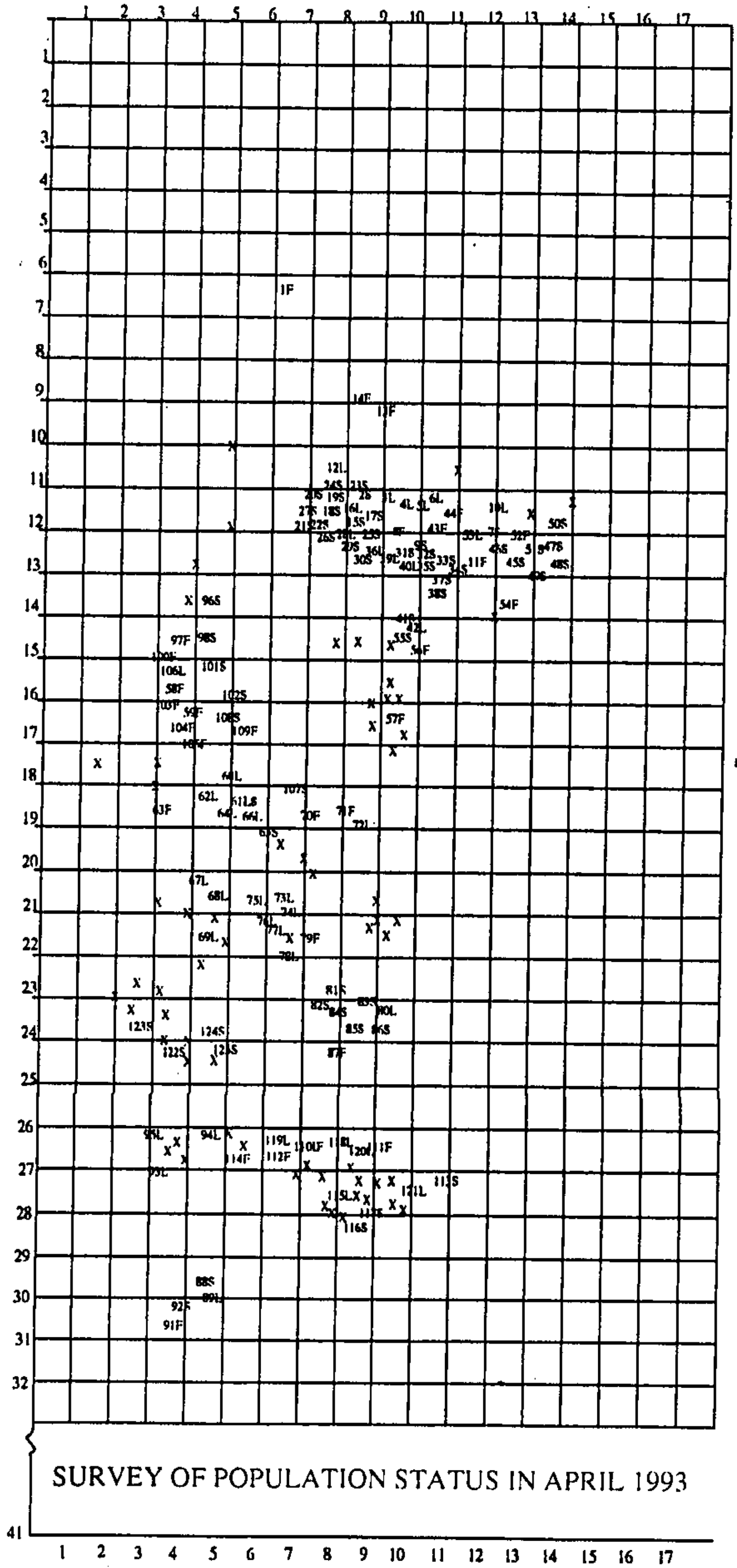


FIGURE A-1

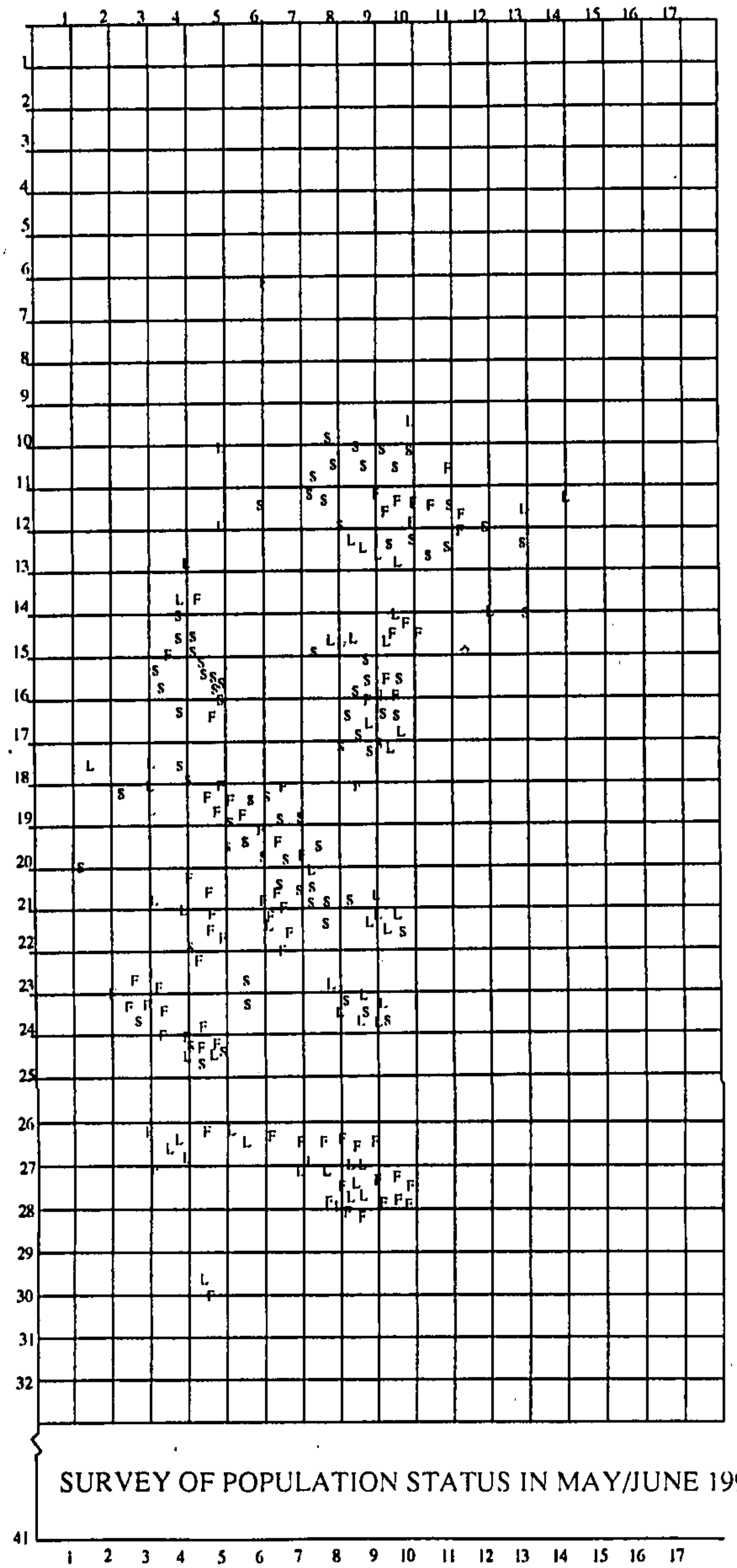


FIGURE A-2

APPENDIX B

From the Sun Bulletin, April 19, 1990

"Back in 1987 the Bianchis were approached by The Nature Conservancy's Lynn Lozier, director of landowner contact. "I wanted them to know that they had something very special " said Lozier. "This plant isn't exactly a beautiful wildllower. Annually with its thick spiny stems and artichoke type flowers, it's more of an 'ugly duckling', but it is very rare. Beautiful or not, it should be preserved."

Lozier explained that The Nature Conservancy operates a program designed to encourage private landowners to preserve rare species which occur on their land. Owners who are willing to protect what they have are invited to add their property to the California Nature Conservancy's Register of Natural Areas as an owner-protected site. The Bianchis agreed, thus establishing an informal relationship in which The Nature Conservancy was able to assist with technical biological expertise while the owners managed the property in a way beneficial for the species. In this case it meant excluding grazing animals from the ggy spring area where the thistles grow."

This year Lozier, the Bianchis and a crew of local volunteers will be intensively studying this rare thistle. Armed with notebooks and heavy garden gloves, they will take careful notes on all aspects of this spiny plant's entire blooming cycle. Individual flower heads will be followed from bud to seed set, and insect visitors will be collected and identified.

With flowering beginning in early April and expected to run until July, it's a tall order, but Lozier is optimistic. With the commitment of the Bianchis and dedicated volunteers, I'm confident that we can learn what we need to know to kep the plants healthy and happy for the present and the future"

APPENDIX C

SOIL TYPES FOUND AT CCbt SITES

Soil Descriptions Of Soils Mapped At Sites Supporting Chorro Creek Bog Thistle.
Taken From Orthophotos At 1:24,000 Scale from Soil Survey Of San Luis Obispo County-Coastal Part, U.S. Soil Conservation Service, 1977

130—Diablo and Cibo clays, 9 to 15 percent slopes. These strongly sloping soils are on low lying foothills. Areas are irregular in shape and range from 15 to 400 acres. The natural vegetation is mainly annual grasses and forbs. Elevation ranges from 200 to 600 feet. The average annual precipitation ranges from 14 to 25 inches, and the average annual air temperature is about 50 degrees F. The frost-free season ranges from 275 to 350 days, depending on location.

Diablo soil differs from Cibo soil by being deep, having a darker surface layer, being calcareous in the underlying material, and overlying softer, weathered rock.

Included in this undifferentiated group are a few small areas of Zaca soils. Also included in the Los Osos and Chorro Valleys are areas where the underlying rock is at a depth of more than 60 inches.

The Diablo soil is deep and well drained. It formed in residual material weathered from sandstone, shale, or mudstone. Typically, the surface layer is very dark gray clay about 38 inches thick. The underlying material to a depth of about 58 inches is olive gray clay. This is underlain by weathered mudstone. The profile is neutral in the surface layer and becomes moderately alkaline and calcareous as depth increases. Some areas have a clay loam or silty clay surface layer.

Permeability of the Diablo soil is slow, and the available water capacity is moderate to very high. Surface runoff is medium, and the water erosion hazard is moderate. The effective rooting depth ranges from 45 to 58 inches. This soil has high shrink-swell potential and

The Cibo soil is moderately deep and well drained. It formed in residual material weathered from hard sandstone or shale. Typically, the surface layer is dark brown clay about 31 inches thick. The underlying material to a depth of about 39 inches is dark brown clay loam. This is underlain by hard sandstone. The profile is neutral throughout. Some areas have a clay loam surface layer.

Permeability of the Cibo soil is slow, and the available water capacity is very low to moderate. Surface runoff is medium, and the hazard of water erosion is moderate The effective rooting depth ranges from 20 to 40 inches. This soil has high shrink-swell potential and is subject to slippage when wet.

Most areas of these soils are used as rangeland. A few areas are used for urban development.

These soils are well suited to rangeland. The clay texture, however, increases the hazard of surface compaction. This hazard can be reduced by grazing when the surface layer is moderately dry. The high available water capacity of the Diablo soil influences a rather long, slow growing forage season. Erosion can be controlled by maintaining adequate plant residue on the soil surface. These soils typically produce annual plants, including burclover and other annual legumes. Purple needlegrass is a common perennial forage grass. If the range is overgrazed, the proportion of preferred forage plants decreases and the proportion of less preferred plants increases. Livestock grazing should be managed so that the desired balance of plant species is rhaintained. Undesirable plants include milkthistle, poison-hemlock, cheeseweed, and mustard.

These soils are increasingly important for urban development. The main limitations are the high shrink swell potential, low strength, and slow permeability. The soil is hard to pack because of the high clay content. These limitations can require that special design considerations be used for urban development and most other engineering practices. Foundation and footing design should consider these limitations. Shallow excavations are difficult to perform because of the high clay content. Septic tank absorption fields do not function properly because of the slow permeability and depth to rock. Using sandy backfill for trench lines and increasing the size of the absorption field help to compensate for the slow permeability.

Local road and street design can require that the base material be replaced or covered with a more suitable material so that maintenance is minimized. Pond reservoir areas are poorly suited to these soils because the slope causes a reduction in the storage capacity. When irrigated, the amount of water applied must be controlled to prevent excessive runoff. Because of the slope and the slow permeability, sprinkler or drip methods of irrigation are best suited to these soils.

The Diablo and Cibo soils in this undifferentiated group are in capability units IIIe-5, irrigated and nonirrigated.

131—Diablo and Cibo clays, 15 to 30 percent slopes. These moderately steep soils are on foothills and mountains. Areas are irregular in shape and range from 5 to 250 acres. The natural vegetation is mainly annual grasses and forbs. Hardwoods are common in swales. Elevation ranges from 200 to 3,000 feet. The average annual precipitation ranges from 14 to 28 inches, and the average annual air temperature is about 59 degrees F. The average frost-free season ranges from 275 to 350 days, depending on location.

Diablo soil differs from Cibo soil by being deep, having a darker surface layer, being calcareous in the underlying material, and overlying softer, weathered rock.

Included in this undifferentiated group are minor areas of Lodo clay loam, Los Osos loam, and Zaca clay. Also included are small areas of Rock outcrop.

The Diablo soil is deep and well drained. It formed in residual material weathered from sandstone, shale, or mudstone. Typically, the surface layer is very dark gray clay about 38 inches thick. The underlying material to a depth of about 58 inches is olive gray clay. Below this is weathered mudstone. The profile is neutral in the surface layer and becomes moderately alkaline and calcareous as depth increases. Some areas have a clay loam or silty clay surface layer.

Permeability of the Diablo soil is slow, and the available water capacity is moderate to very high. Surface runoff is rapid, and the hazard of water erosion is moderate. The effective rooting depth ranges from 45 to 58 inches. The soil has high shrink-swell potential and is subject to slippage when wet.

The Cibo soil is moderately deep and well drained. It formed in residual material weathered from hard sandstone or shale. Typically, the surface layer is dark brown clay about 31 inches thick. The underlying material to a depth of about 39 inches is dark brown clay loam. Below this is hard sandstone. The profile is neutral throughout. Some areas lhave a clay loam surface layer.

Permeability of the Cibo soil is slow, and the available water capacity is very low to moderate. Surface runoff is rapid, and the hazard of water erosion is moderate. The effective rooting depth ranges from 20 to 40 inches. This soil has high shrink-swell potential and is subject to slippage when wet.

Most areas of these soils are used as rangeland.

These soils are well suited to rangeland. The clay texture, however, increases the hazard of surface compaction. This hazard can be reduced by grazing when the surface layer is moderately dry. The high available water capacity of the Diablo soil influences a rather long, slow growing forage season. These fine textured soils respond to fertilizer or amendment applications that increase forage production. Erosion can be controlled by maintaining adequate plant residue on the soil surface. These soils typically produce annual plants that include burclover and other annual legumes. Purple needlegrass is a common perennial forage grass. If the range is overgrazed, the proportion of preferred forage plants decreases and the proportion of less preferred plants increases. Livestock grazing should be managed so that the desired balance of plant species is maintained. Undesirable plants include milkthistle, poison-hemlock, cheeseweed, and mustard.

Homesite development and most other engineering practices require special designs because of the slope, high shrink-swell potential, low strength, slow permeability, hardness to pack, and the susceptibility of these soils to slippage when wet. Foundation and footing designs should consider these limitations. The high clay content makes shallow excavations difficult. Septic tank absorption fields do not function properly because of the slow permeability and depth to rock. Using sandy backfill for trench lines and increasing the size of the absorption field help to compensate for the slow permeability. Local road and street design can require that the base material be replaced or covered with a more suitable material so that maintenance is minimized. Pond reservoir areas are poorly suited to these soils because the slope causes a reduction in the storage capacity. If the soils are irrigated, excessive runoff can be prevented by controlling the amoun: of water applied. Because of the slope and the slow permeability, sprinkler or drip methods of irrigation are best suited to these soils.

The Diablo and Cibo soils of this undifferentiated group are in capability unit IVe-5 (15), nonirrigated.

132—Diablo and Cibo clays, 30 to 50 percent slopes. These steep soils are on foothills and mountains. Areas are irregular in shape and range from 10 to 400 acres. The natural vegetation is mainly annual grasses and forbs; hardwoods are common in swales. Elevation ranges from 200 to 3,000 feet. The average annual precipitation ranges from 14 to 28 inches, and the average air temperature is about 59 degrees F. The frost-free season ranges from 275 to 350 days, depending on location.

Diablo soil differs from Cibo soil by being deep, having a darker surface layer, being calcareous in the underlying material, and overlying softer, weathered rock.

Included in this undifferentiated group are minor areas of Lodo clay loam and Los Osos loam. Also included are small areas of Rock outcrop.

The Diablo soil is deep and well drained. It formed in residual material weathered from sandstone, shale, or mudstone. Typically, the surface layer is very dark gray clay about 38 inches thick. The underlying material to a depth of about 58 inches is olive gray clay. Below this is weathered mudstone. The profile is neutral in the surface layer and becomes moderately alkaline and calcareous as depth increases. Some areas have a clay loam or silty clay surface layer.

Permeability of the Diablo soil is slow, and the available water capacity is moderate to very high. Surface runoff is rapid, and the hazard of water erosion is high. The effective rooting depth ranges from 45 to 58 inches. This soil has high shrink-swell potential and is subject to slippage when wet.

The Cibo soil is moderately deep and well drained. It formed in residual material weathered from sandstone or shale. Typically, the surface layer is dark brown clay about 31 inches thick. The underlying material to a depth of about 39 inches is dark brown clay loam. Below this is hard sandstone. The profile is neutral throughout. Some areas have a clay loam surface layer.

Permeability of the Cibo soil is slow, and the available water capacity is very low to moderate. Surface runoff is rapid, and the hazard of water erosion is high. The effective rooting depth ranges from 20 to 40 inches. This soil has high shrink-swell potential and is subject to slippage when wet.

Most areas of these soils are used as rangeland.

These soils are well suited to rangeland. The clay texture, however, increases the hazard of surface compaction. This hazard can be reduced by grazing when the surface layer is moderately dry. The high available water capacity of the Diablo soil influences a rather long, slow growing forage season. These fine textured soils respond to fertilizer or amendment applications that increase forage production. Erosion can be controlled by maintaining adequate plant residue on the soil surface. These soils typically produce annual plants, including burclover and other annual legumes. Purple needlegrass is a common perennial forage grass. If the range is overgrazed, the proportion of preferred forage plants decreases and the proportion of less preferred plants increases. Livestock grazing should be managed so that the desired balance of plant species is maintained. Undesirable plants include milkthistle poison-hemlock, cheeseweed, and mustard.

Homesite development and most other engineering practices require special design considerations because of the slope, high shrink-swell potential, low strength, slow permeability, hardness to pack, and the susceptibility of these soils to slippage when wet. Foundation and footing designs need to compensate for the high shrink-swell potential and low strength. Septic tank absorption fields do not function properly because of the slow permeability and slope. The septic tank absorption field trench lines should be placed on the contour and can be lengthened. Excavation can result in water erosion. This hazard can be reduced if minimum grading and runoff and sediment control structures are utilized and a permanent cover is established on the side slopes.

These Diablo and Cibo soils in this undifferentiated group are in capabilitv subclass VIe (15), nonirrigated

133—Diablo-Lodo complex, 15 to 50 percent slopes. These moderately steep and steep soils are on foothills and mountains. Areas are irregular in shape and range from 10 to 650 acres. The natural vegetation is mainly annual grasses and forbs with areas of brush . Hardwoods are present along some drainageways. Elevation ranges from 300 to 3,000 feet. The average annual precipitation ranges from 15 to 28 inches, and the average annual air temperature is about 59 degrees F. The frost-free season ranges from 275 to 350 days, depending on location.

This complex is about 45 percent Diablo soil and about 35 percent Lodo soil. Diablo soil differs from Lodo soil by being deep and having a clay texture throughout.

Included in this complex are small areas of Cibo clay, Lopez very shaly clay loam, Los Osos loam, Millsap loam, Obispo clay, and Rock outcrop. Also included are small areas of soils that are similar to Lodo soil but are underlain by softer rock. Included areas make up about 20 percent of the total acreage.

At the Monterey-San Luis Obispo County line, this complex joins with Monterey's Climara-Montara complex. Neither of these soils was extensive enough to map in this survey area; therefore, the areas of Climara and Montara soils are included in this Diablo-Lodo complex. Use and management of this complex and the Climara Montara complex is similar.

The Diablo soil is deep and well drained. It formed in residual material weathered from sandstone, shale, or mudstone. Typically, the surface layer is very dark gray clay about 38 inches thick. The underlying material to a depth of about 58 inches is olive gray clay. Below this is weathered mudstone. The profile is neutral in the surface fractured, hard sandstone. Some small areas of this soil have a sandy loam or loam surface layer and contain as much as 35 percent gravel.

Permeability of the Lodo soil is moderate, and the available water capacity is very low or low. Surface runoff is rapid, and the hazard of water erosion is high. The effective rooting depth ranges from 6 to 20 inches.

Most areas of these soils are used as rangeland.

These soils are moderately suited to rangeland. The clay texture of the Diablo soil increases the hazard of surface compaction. The Lodo soil has very low or low available water capacity; it produces less forage and is often overgrazed. This often causes excessive sheet erosion of the Lodo soil. Erosion can be controlled by maintaining adequate plant residue on the soil surface. Major forage plants are annuals, including burclover and other legumes. Purple needlegrass is a common perennial forage grass. If the range is overgrazed, the proportion of preferred forage plants decreases and the proportion of the less preferred plants increases. Livestock grazing should be managed so that the desired'balance of plant species is maintained. Undesirable plants include milkthistle, poison-hemlock, cheeseweed, and mustard.

Homesite development and most other engineering practices require special design considerations. The main limitations are the high shrink-swell potential, low strength, slow permeability, and hardness to pack; the susceptibility to slippage when wet for the Diablo soil; the shallow depth to rock for the Lodo soil; and the moderately steep and steep slopes. Foundations and footings should be designed to offset the high shrink swell potential of the Diablo Soil. Care should be taken to avoid exposing the rock by removal of the surface layer on Lodo soil in areas that are to be landscaped. Septic tank absorption fields do not function properly because of the slow permeability and shallow depth to rock. Septic tank absorption field trench lines should be placed on the contour and can be lengthened. Excavating for urban development and roads can result in water erosion. This hazard can be reduced if minimum grading and runoff and sediment control structures are utilized and a permanent cover is established on the side slopes.

The Diablo and Lodo soils in this complex are in capability subclass VIe (15), nonirrigated.

142—Gaviota fine sandy loam, 15 to 50 percent slopes. This shallow, well drained, moderately steep and steep soil is on foothills and mountains . It formed in residual material weathered from sandstone. Areas are irregular in shape and range from 20 to 350 acres. The natural vegetation is mainly brush, scattered hardwoods, and annual grasses and forbs. Elevation ranges from 250 to 3,000 feet. The average annual precipitation ranges from 16 to 28 inches, and the average annual air temperature is about 59 degrees F. The average frost-free season /ranges from 275 to 350 days, depending on location.

Typically, the surface layer is light brownish gray fine sandy loam 13 inches thick. This is underlain directly by hard sandstone. The profile is slightly acid or neutral. Some minor areas have a loamy sand surface layer.

Included in this map unit are a few small areas of Briones and Pismo loamy sands. Also included are small areas of a similar soil that contains higher amounts of organic matter and areas that are medium acid throughout the profile.

Permeability of this Gaviota soil is moderately rapid, and the available water capacity is very low. Surface runoff is rapid, and the hazard of water erosion is high. The effective rooting depth ranges from 10 to 20 inches.

Most areas of this soil are used as rangeland. A few small areas are used for urban development.

This soil is poorly suited to rangeland. Coarse texture shallow depth, and steep slopes make this droughty soil subject to sheet and gully erosion. The characteristic dense stand of old growth brush with small amounts of grasses and forbs does not adequately protect against soil erosion and is susceptible to wildfire. Old growth brush provides poor habitat for wildlife and is a barrier to movement of livestock and big game animals. Normally, wildfires on this soil are extremely hot and destroy the vegetation. This is the main cause of accelerated soil erosion. Following a cool fire or controlled burn, an area is most productive and can provide a combination of grass, browse, fruit, and cover for wildlife and livestock. Brushland management and properly engineered fuel breaks and access roads are necessary to limit wildfires and soil erosion. The natural terrain barriers associated with this soil should be utilized as livestock management area boundaries. The major browse species are buckbrush, California coffeeberry, toyon, and deerweed. Undesirable plants include chamise and black sage.

Homesite development is increasingly important on this soil. However, because of the slope, erosion hazard, and depth to rock, most engineering practices require special design considerations. Road construction should include runoff and sediment control structures, minimum grading, and establishment of permanent plant cover on side slopes. Foundation and footing designs may need to be modified or building site grading may be necessary to compensate for slope. Septic tank absorption fields should be installed on the contour and trench lines lengthened to compensate for slope and shallow depth to rock.

This Gaviota soil is in capability subclass VIIe (15), nonirrigated.

150—Lodo clay loam, 50-75 percent slopes. This shallow, somewhat excessively drained, very steep soil is on foothills and mountains. It formed in residual material weathered from red rock, shale, or sandstone. Areas are irregular in shape and range from 5 to 150 acres. The natural vegetation is mainly brush with a few areas of annual grasses and forbs. Elevation ranges from 300 to 3,000 feet. The average annual precipitation ranges from 15 to 35 inches, and the average annual air temperature is about 59 degrees F. The average frost-free season ranges from 250 to 365 days, depending on location.

Typically, the surface layer is dark brown clay loam about 12 inches thick. This is underlain directly by fractured, hard sandstone. Some small areas of this soil have a sandy loam or loam surface layer and contain as much as 35 percent gravel.

Included in this map unit are a few small areas of Cibo clay, Diablo clay, Gazos clay loam, and Los Osos loam.

Permeability of this Lodo soil is moderate, and the available water capacity is very low or low. Surface runoff is very rapid, and the hazard of water erosion is very high. The effective rooting depth ranges from 6 to 20 inches.

Most areas of this soil are used as rangeland.

This soil is poorly suited to rangeland. Because of the clay loam surface layer and steep slopes, this soil is subject to sheet and gully erosion and soil compaction. These problems can be reduced by grazing when the surface layer is moderately dry and by allowing greater amounts of plant residue to remain. Uniform utilization is difficult because of the very steep slopes. Properly engineered access roads and proper placement of livestock watering facilities and salt promote good distribution of grazing. The major forage plants are annuals. Purple needlegrass and, in the drier areas, foothill needlegrass are locally abundant perennial forage grasses. Because the soil is shallow, plants mature early and become dry and flammable. Dense stands of chamise often dominate this soil following fire. Undesirable plants, which indicate soil disturbance, are black sage, California sagebrush, and tarweed. Livestock grazing should be managed so that the desired balance of plant species is maintained.

Most engineering practices require special design considerations because of the steep slopes and shallow depth to rock. Road construction and other excavations should include runoff and sediment control structures and minimum grading. A more suitable base material may need to be brought in from an outside source. Because of the high erosion hazard, a permanent plant cover should be maintained at all times.

This Lodo soil is in capability subclass VIIe (15), nonirrigated.

162 Los Osos -Diablo complex, 5 to 9 percent slopes. These gently rolling soils are on foothills and mountain ridgetops. Areas are irregular in shape and range from 10 to 350 acres. The natural vegetation is mainly annual grasses and forbs. Elevation ranges from 200 to 1,500 feet. The average annual precipitation ranges from 15 to 25 inches, and the average annual air temperature is about 59 degrees F. The average frost free season ranges from 275 to 350 days, depending on location.

This complex is about 35 percent Los Osos soil and 30 percent Diablo soil. The Diablo soil differs from the Los Osos soil by being deep and having a clay texture throughout.

Included in this complex are small areas of Cibo clay, Lodo clay loam, and Millsap loam. Also included are a few areas of soils that are similar to Los Osos soils but are deeper or are underlain by harder rock. Included areas make up about 35 percent of the total acreage.

The Los Osos soil is moderately deep and well drained. It formed in residual material weathered from sandstone or shale. Typically, the surface layer is brown loam about 14 inches thick. The subsoil is yellowish brown clay and light yellowish brown clay loam about 18 inches thick. This is underlain by pale yellow sandy loam to a depth of 39 inches. Weathered, fractured sandstone is at a depth of 39 inches. Some areas have a clay loam surface layer.

Permeability of the Los Osos soil is slow, and the available water capacity is low or moderate. Surface runoff is medium, and the hazard of water erosion is moderate. The effective rooting depth ranges from 20 to 40 inches. This soil has high shrink-swell potential in the subsoil.

The Diablo soil is deep and well drained. It formed in residual material weathered from sandstone, shale, or mudstone. Typically, the surface layer is very dark gray clay about 38 inches thick. The underlying material to a depth of about 58 inches is olive gray clay. Below this is weathered mudstone. This soil is neutral in the surface layer and becomes moderately alkaline and calcareous as depth increases. Some areas have a clay loam or silty clay surface layer.

Permeability of the Diablo soil is slow, and the available water capacity is moderate to very high. Surface runoff is medium, and the hazard of water erosion is slight. The effective rooting depth ranges from 45 to 58 inches. This soil has high shrink-swell potential.

Most areas of these soils are used for hay crops and small grains or as rangeland. A few areas are used for urban development.

The most common dryfarmed crops are grain barley and oat hay. Management practices that include crop rotation, cover crops, fertilization, crop residue utilization, and proper tillage help to maintain soil tilth, structure, fertility, and water holding capacity. Tilled areas should be worked on the contour or across the slope if contour farming is not possible. Leaving stubble and crop residue in place after harvest helps to control erosion. Structural measures, such as grassed waterways and water diversions, help to control erosion. The Diablo soils are difficult to work when excessively wet or dry. Tillage operations should be timed to periods when soil moisture is slightly below field moisture capacity.

These soils are well suited to rangeland. The clay subsoil of the Los Osos soil, however, restricts uniform movement of water and penetration of plant roots. The clay subsoil and the loam surface layer make this soil subject to gully erosion. For this reason, it is important to maintain a permanent plant cover and leave adequate plant residue on the soil surface. The clay texture of the Diablo soil increases the hazard of soil compaction. This hazard can be reduced by grazing when the surface layer is moderately dry. The clay texture of Diablo soil and the Los Osos subsoil influences a rather long, slow growing forage season.

These soils are typically under annual grasses, although the Los Osos soil occasionally supports groves of live oak and such understory plants as bush monkeyflower, blue elderberry, and California peony. Major forage components on both soils include burclover and other annual legumes. Purple needlegrass produces over 50 percent of the dry weight forage in many areas. Undesirable plants include coyotebush, black sage, and cheeseweed. Near the coast, milkthistle, poison hemlock, and mustard are undesirable and increase following soil disturbance, especially on the Diablo soil. If the range is overgrazed, the proportion of preferred forage plants decreases and the proportion of less preferred plants increases. Livestock grazing should be managed so that the desired balance of plant species is maintained.

These soils are increasingly important for urban development. The main limitations are high shrink-swell potential, low strength, and slow permeability. The high clay content of the Diablo soil and the Los Osos subsoil makes these soils hard to pack. These limitations can require special design considerations for urban development and most other engineering practices. Foundations and footings should be designed to offset these limitations. Septic tank absorption fields do not function properly because of slow permeability and depth to rock. The use of sandy backfill for the trench and long absorption lines helps to compensate for these limitations.

Local road and street design can require that the base material be replaced or covered with a more suitable material in order to minimize maintenance. If pond reservoir areas are located on these soils, the slope limits storage potential. and the depth to rock of the Los Osos soil can create seepage problems. The high shrink-swell potential, low strength, and hardness to pack make these soils a poor material for the construction of embankments, dikes, and levees. This can be corrected by using a more suitable base material, carefully placing the material in the embankment, mixing the soil with more desirable material, and maintaining a high degree of compaction and moisture control. When irrigated controlling the amount of water applied prevents excessive runoff. Because of the slope and slow permeability, sprinkler or drip methods of irrigation are best suited to these soils.

The Los Osos and Diablo soils in this complex are in capability units IIIe-3 (15), irrigated and nonirrigated.

164—Los Osos-Diablo complex, 15 to 30 percent slope. These moderately steep soils are on foothills and mountains. Areas are irregular in shape and range from 15 to 300 acres. The natural vegetation is mainly annual grasses and forbs with brush in a few areas and hardwoods along drainageways. Elevation ranges from 200 to 3,000 feet. The average annual precipitation ranges from 15 to 28 inches, and the average annual air temperature is about 59 degrees F. The frost-free season ranges from 275 to 350 days, depending on location. ·

This complex is about 35 percent Los Osos soil and 30 percent Diablo soil. Diablo soil differs from Los Osos soil by being deep and by having a clay texture throughout.

Included in this complex are small areas o~Rock outcrop, Cibo clay, Gazos and Lodo clay loams, and Lompico and McMullin loams. Also included are a few areas of soils that are similar to Los Osos soil but deeper or underlain by harder rock. Included areas make up about 35 percent of the total acreage.

The Los Osos soil is moderately deep and well drained. It formed in residual material weathered from sandstone or shale. Typically, the surface layer is brown loam about 14 inches thick. The subsoil is yellowish brown clay and light yellowish brown clay loam to a depth of about 32 inches. The underlying material is pale yellow sandy loam to a depth of 39 inches. This lies directly over weathered, fractured sandstone. Some areas have a clay loam surface layer.

Permeability of the Los Osos soil is slow, and the available water capacity is low or moderate. Surface runoff is rapid, and the hazard of water erosion is high. The effective rooting depth ranges from 20 to 40 inches This soil has high shrink-swell potential in the subsoil and is subject to slippage when wet.

The Diablo soil is deep and well drained. It formed in residual material weathered from sandstone, shale, or mudstone. Typically, the surface layer is very dark gray clay about 38 inches thick. The underlying material to a depth of about 58 inches is olive gray clay. This is underlain by weathered mudstone. The profile is neutral in the surface layer and becomes moderately alkaline and calcareous as depth increases. Some areas have a clay loam or silty clay surface layer.

Permeability of the Diablo soil is slow, and the available water capacity is moderate to very high. Surface runoff is rapid, and the hazard of water erosion is moderate. The effective rooting depth ranges from 45 to 58 inches. This soil has high shrink-swell potential and is subject to slippage when wet.

Most areas of these soils are used as rangeland. Some areas are used for urban development.

These soils are well suited to rangeland. The clay subsoil of the Los Osos soil, however, restricts uniform movement of water and penetration of plant roots. Because of the clay subsoil and the loam surface layer, this soil is subject to gully erosion. This increases the importance of maintaining a permanent plant cover and leaving adequate plant residue on the soil surface. The clay texture of the Diablo soil creates a hazard of soil compaction. This hazard can be reduced by grazing when the surface layer is moderately dry. The clay texture of Diablo soil and of the Los Osos subsoil influences a rather long, slow growing forage season. These soils are typically under annual grasses, although Los Osos soil occasionally supports groves of live oak with such understory plants as bush monkeyflower, blue elderberry, and California peony. Major forage plants on both soils include burclover and other annual legumes, with purple needlegrass producing over 50 percent of the dry weight forage in many areas. Undesirable plants include coyotebush, black sage, and cheeseweed. Near the coast, milkthistle, poison-hemlock, and mustard are undesirable and increase following soil disturbance, especially on the Diablo soil. If the range is overgrazed, the proportion of preferred forage plants decreases and the proportion of less preferred plants increases. Livestock grazing should be managed so that desired balance of plant species is maintained.

Urban development is increasingly important on these soils. However, foundation and footing designs should take into consideration the moderately steep slopes and the high shrink-swell potential and low strength of the Diablo soil and the Los Osos subsoil. Because of these limitations, the subgrade often needs to be removed and replaced with a more suitable material, or a high degree of compaction and moisture control needs to be maintained during construction. Septic tank absorption fields do not function properly because of the slope, slow permeability, and depth to rock. Install septic tank absorption lines on the contour. The use of sandy backfill for the trench and long absorption lines helps to compensate for the slow permeability and depth to rock. Local road and street design can require that the base material be replaced or covered with a more suitable material so that maintenance is minimized. The erosion hazard can be reduced by minimum grading, using runoff and sediment control structures, and establishing a permanent plant cover on sides slopes.

The Los Osos and Diablo soils in this complex are in capability unit IVe-1 (15), nonirrigated.

165—Los Osos-Diablo complex, 30 to 50 percent slopes. These steep soils are on foothills and mountains. Areas are irregular in shape and range from 10 to 400 acres. The natural vegetation is mainly annual grasses and forbs with a few areas of brush and hardwoods along drainageways. Elevation ranges from 200 to 3,000 feet. The average annual precipitation ranges from 15 to 28 inches, and the average annual air temperature is about 59 degrees F. The frost-free season ranges from 275 to 350 days, depending on location.

This complex is about 40 percent Los Osos soil and 35 percent Diablo soil. Diablo soil differs from Los Osos soil by being deep and by having a clay texture throughout.

Included in this complex are small areas of Cibo clay, Gaviota sandy loam, Gazos clay loam, Obispo clay, Rock outcrop, and a soil that is similar to Los Osos soil but is deep or is underlain by harder rock. Also included are small areas of Lompico and McMullin loams in areas that have a dense hardwood canopy. Included areas make up about 25 percent of the total acreage.

The Los Osos soil is moderately deep and well drained. It formed in residual material weathered from sandstone or shale. Typically, the surface layer is brown loam about 14 inches thick. The subsoil is yellowish brown clay and light yellowish brown clay loam to a depth of about 32 inches. The underlying material is pale yellow sandy loam to a depth of 39 inches. This lies directly over weathered, fractured sandstone. Some areas have a clay loam surface layer.

Permeability of the Los Osos soil is slow, and the available water capacity is low or moderate. Surface runoff is rapid, and the hazard of water erosion is high. The effective rooting depth ranges from 20 to 40 inches. This soil has high shrink-swell potential in the subsoil and is subject to slippage when wet.

The Diablo soil is deep and well drained. It formed in residual material weathered from sandstone, shale, or mudstone. Typically, the surface layer is very dark gray clay about 38 inches thick. The underlying material to a depth of about 58 inches is olive gray clay. This is underlain by weathered mudstone. The profile is neutral in the surface layer and becomes moderately alkaline and calcareous as depth increases. Some areas have a clay loam or silty clay surface layer.

Permeability of the Diablo soil is slow, and the available water capacity is moderate to very high. Surface runoff is rapid, and the hazard of water erosion is high. The effective rooting depth ranges from 45 to 5 inches. This soil has high shrink-swell potential and is subject to slippage when wet.

Most areas of these soils are used as rangeland.

These soils are moderately suited to rangeland. The steep slopes, clay subsoil, and loam surface layer of the Los Osos soil increase the hazard of gully erosion. Erosion can be controlled by maintaining adequate plant residue on the soil surface. The clay surface layer of the Diablo soil is subject to compaction. This problem can be reduced by grazing when the surface layer is moderately dry. Proper grazing use and the use of properly engineered access roads and fuel breaks improve livestock distribution, reducing the hazards of soil erosion and wildfire. These soils have a rather long, slow growing forage season. The soils are typically under annual grasses, although Los Osos soil supports groves of live oak with such understory plants as bush monkeyflower, blue elderberry, and California peony. Major forage plants on both soils include burclover and other annual legumes, with purple needlegrass producing over 50 percent of the dry weight forage in many areas Undesirable plants include coyotebush, black sage, and cheeseweed. Near the coast, milkthistle, poison hemlock, and mustard are undesirable and increase following soil disturbance, especially on the Diablo soil. If the range is overgrazed, the proportion of preferred forage plants decreases and the proportion of less preferred plants increases. Livestock grazing should be managed so that the desired balance of plant species is maintained.

Urban development and most other engineering practices require special design considerations because of the erosion hazard, steep slopes, and the high shrink swell potential, low strength, and slow permeability. of the Diablo soil and the Los Osos subsoil. Foundation and footing designs need to compensate for the high shrink swell potential and low strength caused by the high clay content of these soils. Subgrade material sometimes needs to be removed and replaced with a more suitable material, or a high degree of compaction and moisture Control needs to be maintained during construction. Septic tank absorption fields do not function properly because of the slow permeability and slope. Septic tank absorption field trench lines should be placed on the contour. Increasing the length of the lines helps to compenSate for the slow permeability. The high erosion hazard can be reduced with minimum grading, installing runoff and sediment control structures, and establishng a permanent plant cover on side slopes.

The Los Osos and Diablo soils in this complex are in capability subclass Vle (15), nonirrigated.

183—Obispo-Rock outcrop complex, 15 to 75 percent slopes. This moderately steep to very steep soil and Rock outcrop are on mountain ridges and side slopes (fig. 15). Areas are irregular in shape and range from 5 to 1,500 acres. The natural vegetation is mainly annual and perennial grasses and forbs with a few areas of brush. Elevation ranges from 200 to 2,500 feet. The average annual precipitation ranges from 16 to 35 inches, and the average annual air temperature is about 58 degrees F. The frost-free season ranges from 275 to 350 days, depending on location.

This complex is about 50 percent Obispo soil and 30 percent Rock outcrop.

Included in this complex are a few small areas of Diablo clay, which is commonly in swales, and Henneke clay loam. Also included is a small area on the Hearst Ranch that has slopes of 5 to 9 percent. In some areas there is as much as 35 percent serpentine gravel and cobbles throughout the profile. Included areas make up about 20 percent of the total acreage.

The Obispo soil is shallow and well drained. It formed in residual material weathered from serpentine rock. Typically, the surface layer is very dark gray clay about 11 inches thick. This is directly underlain by firm to hard serpentine.

Permeability of the Obispo soil is slow, and the available water capacity is very low or low. Surface runoff is rapid or very rapid, and the hazard of water erosion is high or very high. Effective rooting depth ranges from 8 to 20 inches.

The Rock outcrop is exposed, hard serpentine at or near the soil surface.

Most areas of this complex are used as rangeland and watershed.

This complex is poorly suited to rangeland. Because of the clay surface layer and steep slopes, the Obispo soil is subject to sheet erosion. The exposed cobbles and Rock outcrop hinder livestock movement and increase soil erosion hazards. The rocks prevent water infiltration, increasing the amount of surface runoff. Natural terrain barriers should be utilized as management area boundaries. The serpentine parent material causes a calcium-magnesium imbalance, which prevents the normal growth of many plants. The forage produced on this soil is often of low palatability. The major forage plants are perennial bunch grasses, including squirreltail and purple needlegrass. Undesirable plants include California sagebrush, locoweed, and tocalote.

Most engineering practices require special design considerations because of the slope, shallow depth, and high clay content. Septic tank absorption fields do not ~unction properly because o~ the high clay content and shallow depth of this soil. Increasing the size of the absorption field can minimize these problems. Placement of the absorption field can be difficult because of the high amount of rock at or near the surface. Excavations for foundations and road construction are also hindered. The base material may need to be replaced with a more suitable material. All disturbed areas should be protected from erosion by minimum grading, using runoff and sediment control structures, and establishing a permanent plant cover on side slopes.

This complex is in capability subclass VIIe (15), nonirrigated.

194—Riverwash. This miscellaneous area is active stream and river channels that consist of excessively drained, water-deposited sand, loamy sand, and sandy loam that have varying amounts of gravel and cobbles. The soil material is highly stratified; most features are too variable to characterize. Areas are subject to flooding during and immediately after every storm, with subsequent scouring and deposition. These areas are essentially barren but include areas that have scattered clumps of sage or water-tolerant plants.

Included with Riverwash in mapping are small areas of Psamments and Fluvents, occasionally flooded, and Corralitos soils.

Riverwash generally is excessively drained, but it ranges to somewhat poorly drained in some low lying areas. Permeability is very rapid. Surface runoff is very slow. The hazard of erosion is variable. The available water capacity is very low.

Areas of Riverwash are used mainly for recreation or as wildlife habitat.

Onsite investigation is needed to determine practices needed to control erosion and prevent flooding.

Riverwash is in capability subclass VIIIw (14), nonirrigated.

195—Rock outcrop-Lithic Haploxerolls complex, 30 to 75 percent slopes. This steep and very steep complex is on mountains. Areas are irregular in shape or long and narrow and range from 10 to 2,000 acres. The natural vegetation is sparse annual grasses or brush. Elevation ranges from 20 to 2,500 feet. The average annual precipitation ranges from 15 to 45 inches, and the average annual air temperature is about 58 degrees

This complex is about 55 percent Rock outcrop and 25 percent Haploxerolls.

Included in this complex are small areas of Arnold, Briones, Diablo, Gaviota, and Gazos soils. Included areas make up about 20 percent of the total acreage.

The Rock outcrop is varous types of bedrock that are exposed throughout the survey area.

The Lithic Haploxerolls are typically soils of the Lodo, Lopez, and Obispo series. They each are less than 20 inches deep to hard rock. The Lodo Soils are clay loam throughout The Lopez Soils are very shaly clay loam, and the Obispo Soils are clay.

The shallow depth to rock of the Lithic Haploxerolls, the steepness of slope, and the high percentage of rock outcrop make this complex pooly suited to most agricultural or engineering uses.

This complex is in capability subclass VIIIs (15), nonirrigated.

APPENDIX D

FIELD SAMPLING PROTOCOL

California Native Plant Society
Rare Plant Communities of California
Rev. 93/2/9

INTRODUCTION

This document describes the procedures used for vegetation sampling by CNPS. The samples will provide information for the classification and description of selected plant communities in California. The sampling method is based on a 50 m long point-transect centered in a 50 m x 5 m *plot*. At each 0.5 m interval along the transect (beginning at the 50 cm mark and ending at 50.0 m), a point is projected vertically into the vegetation. Each species intercepted by a point is recorded, providing a tally of hits for each species in the herb, shrub, and tree canopies. In so far as it is possible, it is important to take care to stretch the tape taut, in order to maintain a consistent sampling area. Percent cover for each species according to vegetation layer (herb, shrub, and tree) can be calculated from these data. Finally, a list of all additional species within the 250 m^2 plot is made.

Often, the composition and abundance of the species within a type will vary with seasonality or in response to disturbance, such as fire. The optimal time to sample vegetation is determined by flowering dates such that as many species as possible can be identified. This becomes of greater concern in herbaceous vegetation types as opposed to those dominated by woody species.

PLOT LOCATION

Plots are located within subjectively chosen patches of homogeneous vegetation. Once such an area has been chosen and approximate boundaries defined, the transect is objectively located. The observer may walk to the center of the patch and then determine the center of the transect in an arbitrary manner (e.g. by tossing an object over the shoulder). The direction of the transect line from this center point is chosen randomly, using a wrist watch: the position of the second hand can refer to a compass direction, with noon equivalent to north.

For unusual cases such as narrow bands or small patches of vegetation which do not lend themselves to the placement of a straight 50 m long transect, the transect may be bent or curved. However, this should be avoided whenever possible in order to maintain consistency among the plots and to avoid observer bias in establishing the transects.

REPLICATION

Determining how many plots to establish in a given patch of vegetation involves an assessment of the size and floristic variability of the patch, the time available to the field team, and the proximity of additional patches of the same vegetation type. Here the volunteers must make a decision, which will be based on these considerations after spending enough time in the field to gain a familiarity with the type. In some patches, one plot will adequately capture the composition and structure of the vegetation type; in others, additional plots will be necessary. For example, if a team establishes a plot in a patch of forest vegetation, and it is evident to the members of the team that the floristic composition and structure of the plot does not adequately represent that of the patch, additional plots should be established. If there are a number of individual patches of the same type in an area, it may be preferable to spread the sampling among them, thus capturing the variability among adjacent stands. The CNPS ecologist may be able to assist with developing a strategy for sampling a given vegetation type.

GENERAL PLOT INFORMATION

The following items are included on each datasheet. As a rule, please avoid the use of abbreviations.

<u>Temporary field plot number</u>: Assigned in the field, using a unique number for each patch and for each replicate plot within a patch. Final plot numbers will be assigned by CNPS.

<u>Date</u>: Date of sampling.

<u>Contact Person</u>: Name, address and phone number of individual responsible for data collection on the plot.

<u>Observers</u>: Names of individuals assisting on the plot.

<u>County</u>: County plot is located in.

<u>Topographic Quad</u>: The name of the USGS map the plot is located on; note series (15' or 7½').

<u>Township/Range/Section/Quarter section/Quarter section/Meridian name</u>: Legal map location of site; this is useful for land ownership determination.

<u>UTMN and UTME</u>: Northing and easting coordinates using the Universal Transverse Mercator (UTM) grid as delineated on the USGS topographic map; to the nearest 0.01 of a km. See sample map for an example of determining coordinates.

<u>Elevation</u>: Recorded in feet.

<u>Slope</u>: Degrees, read from clinometer or compass or estimated; averaged over plot.

<u>Aspect</u>: Degrees from true north, read from a compass or estimated; averaged over plot.

<u>Photographs</u>: (optional). Describe view direction of color slides taken of the site.

<u>Site Location</u>: A careful description which makes revisiting the vegetation patch and plots possible; give landmarks and directions. Indicate location on a photocopy of a USGS topographic map (preferably 7.5') and attach to field survey form.

<u>Site and Vegetation Description</u>: A thorough narrative description of the patch being sampled, including the vegetation structure, physical setting of the site, adjacent vegetation types, and phenology. Information on soils and geology are included if available.

VEGETATION DATA

<u>Point-intercept transect</u>: A 50 m long tape is laid along the center of the plot and secured at both ends. The observer uses a 1 meter length of steel roundbar to sight along a vertical line at every 0.5 m interval from the 0.5 to the 100 meter mark.. Each species intercepted by the vertical line is tallied by vegetation layer. A total of 100 points along the transect are thus sampled.

Assessment of Layers. Estimates of the maximum height of the herb and shrub layers, and the minimum height of the tree layer, are recorded. These estimates are made after a quick assessment of the vegetation and its structure; these need not be overly precise, and will vary among vegetation types. Some types will have more than three layers (e.g. two tree layers of different maximum height); this should be indicated in the plot description. However, data are recorded for only three layers (herb, shrub and tree) whenever possible. The manner in which a species is recorded on the data sheet depends on the layer it occupies. The layer a species occupies will usually be determined by growth form, but exceptions will occur. For instance, a plot may contain a shrubby, multi-stemmed form of a tree species which occupies the shrub layer.

Because the species occupies the shrub layer, even though nominally a tree, it is treated as a shrub and recorded in the shrub layer on the data sheet. Similarly, a shrub occupying space in the tree canopy is recorded in the tree layer. Seedlings of woody plants, shorter than the maximum height of the herb layer, are recorded in the herb layer. An individual plant is recorded within only one layer, depending on the height of the tallest part of the individual. A species may, however, be represented in more than one layer on a plot depending on the height of each individual. For example, a single transect may contain seedlings of a tree species in the "herb", or lowest layer; saplings in the "shrub", or second layer; and mature trees in a third layer.

Determining Hits. It is important not to bias the location of the point to include a plant; this will result in overestimation of plant cover. This bias is most likely to be a problem with the herbaceous species. Take care to record hits along the same side of the tape within a plot; which side is unimportant, as long as one is consistent. The roundbar provides a line which can be projected into the vegetation layer; for the tree canopy, a canopy densiometer (a hand-held sighting device similar to a small periscope) may be used. Only hits which fall within the canopy outline (delineated by visually rounding out the canopy edges) of a tree, shrub, or herb, or which directly hit a grass, are valid (see Figure 1a). If two species within a single layer are intercepted by a point, both are recorded for that layer (see Figure 1b). If no vascular plant is hit by a point, a non-plant category (bare, rock, or litter in the herb layer; sky in the shrub or tree layers) is recorded as a hit for that layer. If the tree and shrub layers are both bare, *and* the herb layer is either bare or occupied by a non-vascular plant (rock, moss, lichen, litter) then the category BARE at the top of the page also receives a tally. Although this may seem redundant, recording non-hits in this manner allows for the calculation of absolute plant cover for the entire plot as well as for each separate layer. Plant names are recorded as Latin binomials (not common names) and should be consistent with Munz and Keck (Jepson after 1993).

It may be helpful to consider the above as a series of decision rules. In the herb layer: IF the point intercepts a grass, or the canopy outline of an herbaceous or woody species, record a hit for that plant. If more than one species is intercepted, record a hit for each within that layer. IF AND ONLY IF no vascular plant is intercepted in the herb layer, one and only one non-vascular plant category receives a hit: the options are bare, litter, rock or moss/lichen.

In the shrub and tree layers: IF the point intercepts the sphere of influence of a live individual, that species receives a hit for the layer which the highest point of the individual occurs within. Cover of dead plants is not recorded; however, if a site has a significant number of dead individuals this should be noted in the site description. An individual need not be rooted in the plot to be counted; intercepts of overhanging vegetation are included in the tally.

Data Sheets: In order to accommodate different styles of recording, two types of datasheet have been prepared. Many observers find it more convenient to use the long form, which provides a prompt for which point is being recorded. This form must then be summarized on the short form by summing the hits for each species and recording them by layer. After one is comfortable with the sampling method, the short form may be used directly; please take the time to sum the tallies as indicated on the sample data sheet.

Additional Species: All vascular plants not recorded for the transect are listed by layer after searching the entire 250 m^2 plot (2.5 m on each side of the 50 m transect). A careful and exhaustive search is required to be sure that no species are missed.

Unknown specimens: Plant specimens which cannot be determined to species in the field, or which need further verification, are collected and pressed according to standard procedure. Each specimen is assigned a field unknown number made up of the plot number and a sequential number unique to each unknown plant on the plot. For example, unknown number CNPS4-2-6 is the sixth unknown specimen collected on the second plot established in patch number 4. This number is recorded on the datasheet in lieu of a species name. When in doubt, it is preferable to record a species as unknown rather than guessing.

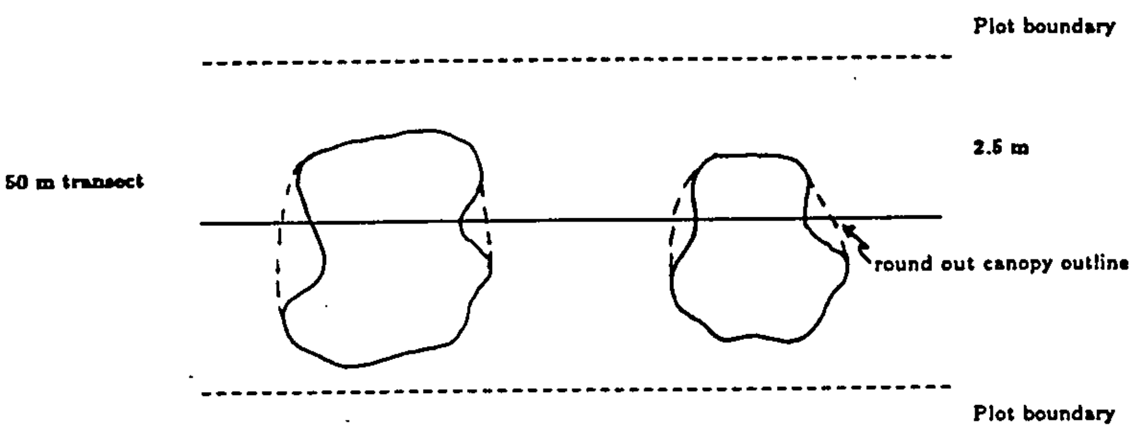
EQUIPMENT

50 m tape
steel roundbar
compass
clipboard/data sheets
topographic map
surveyor stakes (for marking corners)

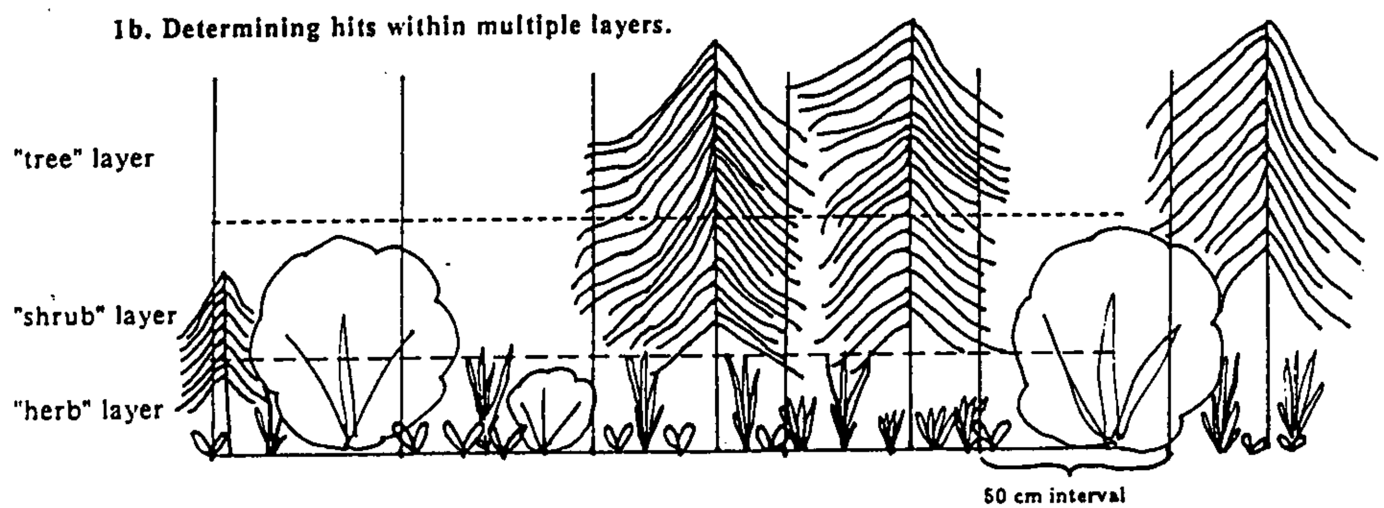
Optional
clinometer
watch with second hand
canopy densiometer

Figure 1. Determining hits along a transect

1a. Determining canopy outline (bird's eye view of plot).



1b. Determining hits within multiple layers.



species 1 ( ): 4 hits in herb layer

species 2 ( ): 2 hits in herb layer

species 3 ( ): 4 hits in tree layer, 1 hit in shrub layer

species 4 ( ): 2 hits in shrub layer, 1 hit in herb layer

APPENDIX E
OWNERSHIP SURVEY

EXISTING POPULATIONS

Froom Ranch

APN: 67-241-19
Owner: Alex Madonna et. al.
P. O. Box 3910, San Luis Obispo, CA 93406
Population Protected: No.
Risk to Population: High, due to proposed development below and possibly on site.

Prefumo Canyon Group Of Populations

APN: 67-211-05
Owner: Silviera Louis M. Tre. et. al.
2891 Prefumo Cn. Rd., San Luis Obispo, CA 93405-8026
Population Protected: No.
Risk to Population: Low, but moderate if slopes are developed at head of drainage.

APN: 67-211-30
Owner: Charles M.P. & D.M.
P. O. Box 3109, San Luis Obispo, CA 93403-3109
Population Protected: No.
Risk to Population: Low, but moderate if slopes are developed at head of drainage.

Laguna Lake Group Of Populations

APN:
Owner: City of San Luis Obispo.
995 Palm St., San Luis Obispo, CA 93401
Population Protected: Partly fenced, partly grazed. Populations are passively managed.
Risk to Population: Low.

Chorro Creek Reservoir

APN:
Owner: California National Guard, Camp San Luis Obispo
San Luis Obispo, CA 93405
Population Protected: No, (but renewed interest in protecting plant from Eva Begley, National Guard HQ, Sacramento).
Risk to Population: Low.

Pennington Creek Complex

APN:	
Owner:	California Polytechnic State University San Luis Obispo, CA 93407
Population Protected:	Yes (grazing exclosures in disrepair).
Risk to Population:	Low.

San Simeon 'Bianchi' Complex

APN:	11-291-12
Owner:	Bianchi, Shirley and William 4375 San Simeon Creek Road, Cambria, CA 934028
Population Protected:	Yes, Lynn Lozier's The Nature Conservancy Homeowner Contact Program.(see Appendix B).
Risk to Population:	Low.

San Simeon Upper Spring

APN:	011-291-03
Owner:	Wajona Inc., c/o W. Stuckey P. O. Box 832, Cambria 93428-0832 There may be an interest in the spring from Denio, Dale W. 940 Camino del Oiste, Bakersfield CA 93309-2709. The property was recently purchased by Winsor, Tim P. O. Box 556, Cambria, CA 93428-0556.
Risk to Population:	High. There are plans to develop this spring as a water source for two home sites. The use by Stuckey may be removed if a lot-line-adjustment is successful and allows relocation of the house site to San Simeon Creek Road. As of March 1, 1994 the lot line adjustment has been denied by County Supervisors. Risk would remain with development by Denio.

New Sites above San Simeon Upper Spring

APN:	011-291-030 and 011-291-29
Owner:	Winsor, Tim P. O. Box 556, Cambria, CA 93428-0556 Ellis, R.H.,Jr. 1422 Stratford Ave., S. Pasadena, CA 91030
Risk to Population:	Low at present. Moderate to high if springs are developed. One site might be graded for stock reservoir maintenance.

San Bernardo Creek Complex

APN:	73-041-05
Owner:	O'Reilly, Leland P. P. O. Box 12560, San Luis Obispo, 93406-2560
Risk to Population:	Unknown

POSSIBLE INTRODUCTION SITES

South Street Hills Springs

APN:
Owner: City of San Luis Obispo
995 Palm Street, San Luis Obispo, CA 93401
Risk to Site: Low-Moderate from disturbance

Poly Canyon

APN:
Owner: California Polytechnic State University
San Luis Obispo, CA 93407
Risk to Site: Low, from grazing

Cuesta College Hills': East End

APN:
Owner: California Polytechnic State University
San Luis Obispo, CA 93407
Risk to Site: Low, from grazing

Cuesta College Hills': West End

APN: 67-021-04
Owner: Tomasini, Homer A., Estate of. c/o Tomasini, Glenn E.
250 Beniamino Way, San Luis Obispo, CA 93405
Risk to Site: Low, from grazing

Pennington East Access Track

APN:
Owner: California National Guard, Camp San Luis Obispo
San Luis Obispo, CA 93405
Risk to Site: Moderate, from grazing, dessication.

Pennington Creek Road Access

APN:
Owner: California Polytechnic State University
San Luis Obispo, CA 93407
Risk to Site: Moderate- High, from road grading, grazing