# ECOLOGY AND LIFE-HISTORY OF THE SAN BENITO EVENING PRIMROSE (*Camissonia benitensis*)

## 1992 Final Supplemental Report

**Submitted to:**

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# 1.0 BACKGROUND

This report constitutes a final supplemental report on continued monitoring of populations of the San Benito evening primrose (*Camissonia benitensis* Raven), a narrow endemic of serpentine soils in the South Coast Ranges of central California. *Camissonia benitensis* is a federally-listed Threatened plant that occurs primarily on public land. The species is biologically endangered, a status which is not reflected by its formal listing status.

A Bureau of Land Management (BLM) funded life-history and ecology study of this species was completed in 1990 (Taylor 1990). At the completion of that study, additional monitoring and field habitat inventory was recommended. The Bureau of Land Management provided funding for an additional two years of study on the species.

# 2.0 METHODS

## 2.1 POPULATION MONITORING

We conducted field visits to all known or historic population sites in the San Benito Mountain region. Field work was conducted by Dean Taylor and Roy Buck of BioSystems, accompanied in many instances by Bruce Delgado, BLM botanist (Hollister Area Office). A field trip in conjunction with the Monterey Chapter of the California Native Plant Society also assisted with the field work, and their voluntary efforts are gratefully acknowledged.

Rainfall during the 1992 growing season was approximately 90 percent of the long-term average over the San Benito Mountain region (California Cooperative Snow Surveys 1992), representing the first year of non-drought observations during these studies. During our previous work, precipitation averaged between 40 percent and 80 percent of long-term average.

## 2.2 POPULATION CENSUS

At the majority of *C. benitensis* populations, we censused individual plants by direct count. At two populations (Population 1B and Population 9), the number of plants was estimated visually, predicated on direct counting census results at other sites.

At Population No. 5, we used transect sampling to estimate population size. Transects were laid across the population at 7 m intervals (7 m was chosen at random from a range of between 5 and 10). Quadrats were then placed at 7 m intervals along the transects: all plants within 1 $m^2$ quadrats were counted.

## 2.3 1992 SUITABLE HABITAT SEARCHES

We visited suitable habitat for *C. benitensis* throughout the San Benito Mountain region. In many instances, we revisited sites that we previously inspected and judged as suitable for the species. During these revisits, we discovered several new populations. Botanists systematically visited the majority of suitable serpentine terraces in the San Benito Mountain region during these surveys.

Quite by chance, another non-terrace population of *C. benitensis* was discovered in 1992. In 1991, also quite by chance, a population of *C. benitensis* was discovered on a debris flow (derived from serpentine) well outside the previous known geographic range for the species. No systematic survey of this type of physiographic setting was conducted in 1992, however.

## 2.4 ECOLOGICAL OBSERVATIONS

We collected data on vegetation composition of many of the known populations of *C. benitensis* utilizing methods given in Taylor (1990). We inventoried vegetation composition within all newly discovered populations.

## 2.5 REINTRODUCTION STUDIES

Seeds of *C. benitensis* were artificially introduced into suitable habitat in an attempt to establish experimental populations. In 1991, approximately 100,000 seeds were obtained from plants cultivated in a garden (under U.S. Fish and Wildlife Service permit, see Taylor 1990). Seed number was estimated by counting the volume occupied by 300 seeds, and applying this volume to the total volume of seed available. The genotype utilized was derived from Population 5. Three sites were utilized in the initial 1991 introduction trials. Approximately 33,000 seeds were spread over ca. 200-300 $m^2$ at each site. The seed was thoroughly mixed with ca. 10 liters of washed sand to facilitate dispersal by hand.

The three 1991 introduction sites were:

(1) Population 7, in the far southwestern portion of the exclosure;

(2) the pipe-fenced exclosure directly opposite Population 4 (Site A), in the far eastern portion; and,

(3) the *Layia discoidea* exclosure ca. 300 m opposite and upstream from Population 7, in the central portion centering on the wooden "Vegetation Study Area" sign.

In November 1992, a fourth introduction trial was conducted using approximately 60,000 seeds. A site adjacent to the historic location of Population 1B was seeded using the methods given above. Deborah Hylliard, California Department of Fish and Game, is gratefully acknowledged for assistance in this phase of the study.

# 3.0 RESULTS

## 3.1 POPULATION TRENDS

*Camissonia benitensis* plants appeared at all historically extant populations during 1992. This is in direct contrast to past years, when plants appeared at some but not all known sites. Table 1 summarizes the results of the 1992 population census. A total of approximately 32,000 individuals of *C. benitensis* grew to flowering in 1992.

Figure 1 (below) depicts the yearly variability in population size data for *C. benitensis*. Total population size has fluctuated through a range of three orders of magnitude: only several hundred plants appear in poor years, while a hundred-thousand plants appear in good years.

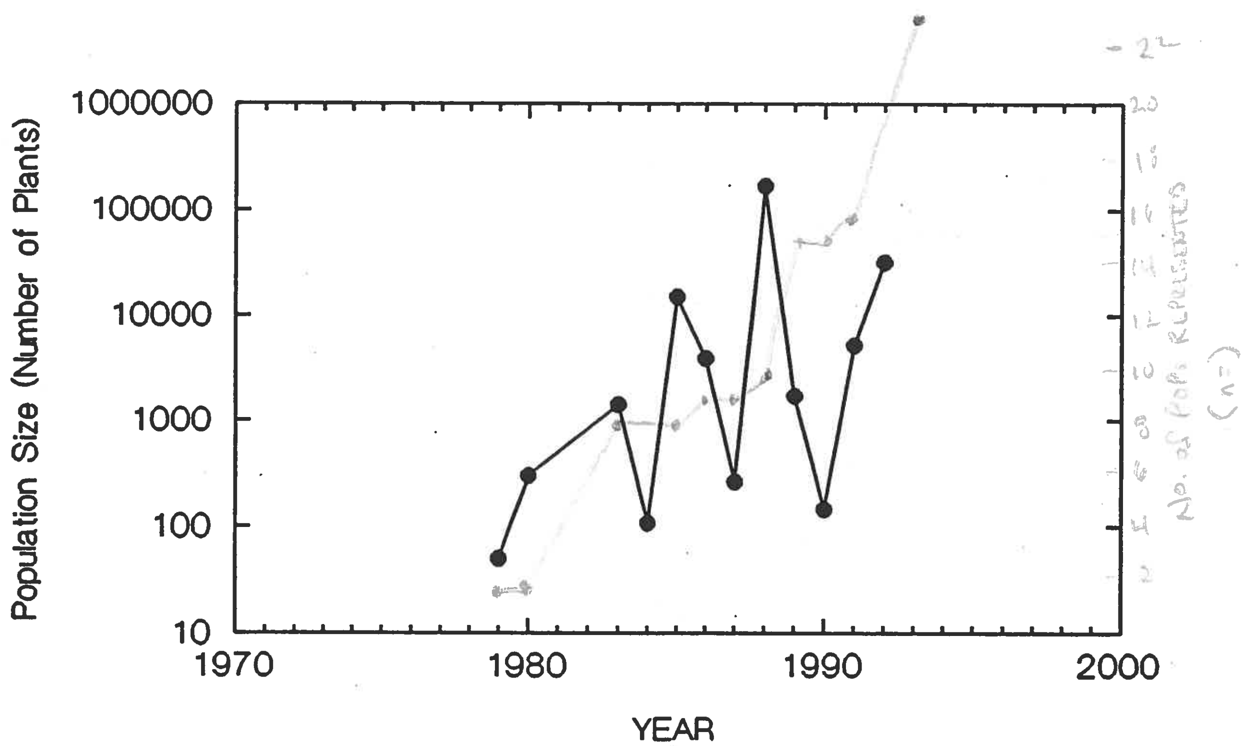


**Figure 1.** Summary of 12 years of population estimates for *Camissonia benitensis*. Prior to 1987, the data consist of rough approximations of population size. Since 1987, significant yearly fluctuations have been documented, partially in relation to rainfall totals. The population estimates prior to 1983 are probably numerically inaccurate, but are likely to reflect the correct order of magnitude of population size. Note that population size is plotted on a log scale.

**Table 1.** Summary of population trends for *Camissonia* populations in the Clear Creek Management Area. Data for years prior to 1987 are rough approximations of population size (Kiguchi 1983, 1984, 1985; Kiguchi and Florence 1986). Standard error of the mean is given for those populations where density data were used to derive size estimates. Other values represent direct counts.

| Site | 1979 | 1980 | 1983 | 1984 | 1984 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Camissonia contorta* | | | | | | | | | | | | |
| 1 | — | — | 50–100 | 10–50 | 1500 | 100–200 | 186 | 970 | 4 | 0 | —[3] | —[3] |
| *Camissonia strigulosa* | | | | | | | | | | | | |
| 1C | — | — | — | — | — | <50 | 0 | 3,360±1,023 | 1,200 | 1,000 | —[3] | —[3] |
| 11 | — | — | — | — | — | — | — | — | 430 | 250 | —[3] | —[3] |
| *Camissonia benitensis* | | | | | | | | | | | | |
| 1B | — | — | — | — | — | — | — | 18,691±3,763 | 921 | 84 | 85 | 400 |
| 1C | — | — | — | — | — | <50 | 0 | 0 | 0 | 0 | 0 | 147* |
| 2 | — | — | 50–100 | 4 | 80–90 | 100 | 0 | 1,540 | 0 | 0 | 180 | 354 |
| 3 | — | — | 10–50 | 1 | 65 | 50–100 | 0 | 672±343 | 0 | 0 | 2 | 29 |
| 4 | — | 200–300 | 10–50 | 2 | 158 | <50 | 2 | 357±161 | 27 | 0 | 0 | 82 |
| 5 | — | — | 100–1,000 | <20 | 10,000± | 2,500± | 112 | 133,507±22,173 | 357 | 44 | 4,450 | 28,000 |
| 6 | — | — | 10–50 | 21 | 1,900 | 100± | 1 | 5,976±1,291 | 0 | 0 | 422 | 163 |
| 7 | — | — | 1–10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28* |
| 8 | — | — | 50–100 | 0 | 10 | 15 | 0 | 27 | 0 | 0 | 0 | 40 |
| 9 | <50 | — | 100–1,000 | 10–50 | 1,400 | 500–1,000 | 149 | 4,398±2,690 | 247 | 12 | 0 | 1,355 |
| 10 | — | — | — | — | — | — | — | — | 102 | 0 | 0 | 475 |
| 11 | — | — | — | — | — | — | — | — | 16 | 1 | 40 | 128 |
| 12 | — | — | — | — | — | — | — | — | 3 | 0 | 0 | 8 |
| 13 | — | — | — | — | — | — | — | — | 21 | 0 | 0 | 12 |
| 14 | — | — | — | — | — | — | — | — | 9 | 5 | 7 | 96 |
| 15 | — | — | — | — | — | — | — | — | — | — | 21 | 149 |
| 16 | — | — | — | — | — | — | — | — | — | — | — | 16* |
| 17 | — | — | — | — | — | — | — | — | — | — | — | 3* |
| 18 | — | — | — | — | — | — | — | — | — | — | — | 101 |
| 19 | — | — | — | — | — | — | — | — | — | — | — | 400 |
| 20 | — | — | — | — | — | — | — | — | — | — | — | 88 |
| 21 | — | — | — | — | — | — | — | — | — | — | — | 9 |
| 22 | — | — | — | — | — | — | — | — | — | — | — | 125 |
| Total[1] | <50 | 20–300 | 381–2,450 | 68–148 | 15,113 | 3,565–4,225 | 264 | 169,508±32,414 | 1,703 | 146 | 5,207 | 32,208 |
| Rainfall[2] | — | — | 225% | 75% | 85% | 140% | 60% | 80% | 55% | 40% | 90% | 115% |

[1] For *C. benitensis* populations only; [2] rainfall records from California Cooperative Snow Survey, Bulletin No. 120; * artificial population seeded 1990–1991; [3] not surveyed.

Although there is too little data to demonstrate a strong and direct correlation with rainfall, over the past six years population sizes are lowest in the most extreme drought years, and are intermediate to highest when rainfall totals are only slightly below average to above average. This pattern was again supported by our 1992 observations: rainfall was approximately 90 percent of the long-term average, and plants appeared in high density and at all sites.

Figure 2 (below) plots the relationship between rainfall (expressed as a percentage of the long-term average, as derived from California Department of Water Resources data, cf. California Cooperative Snow Surveys 1992), and *C. benitensis* population size. The Pearson correlation coefficient between the $\log_{10}$ of population size and rainfall for six years of population census data is nonsignificant ($r = 0.75$, $p = 0.08$). Omitting the 1988 data, however, the correlation becomes significant ($r = 0.99$, $p = 0.021$). In 1988, rainfall amount was below normal, but was generally evenly distributed throughout the winter and spring, which may account for the large populations observed.

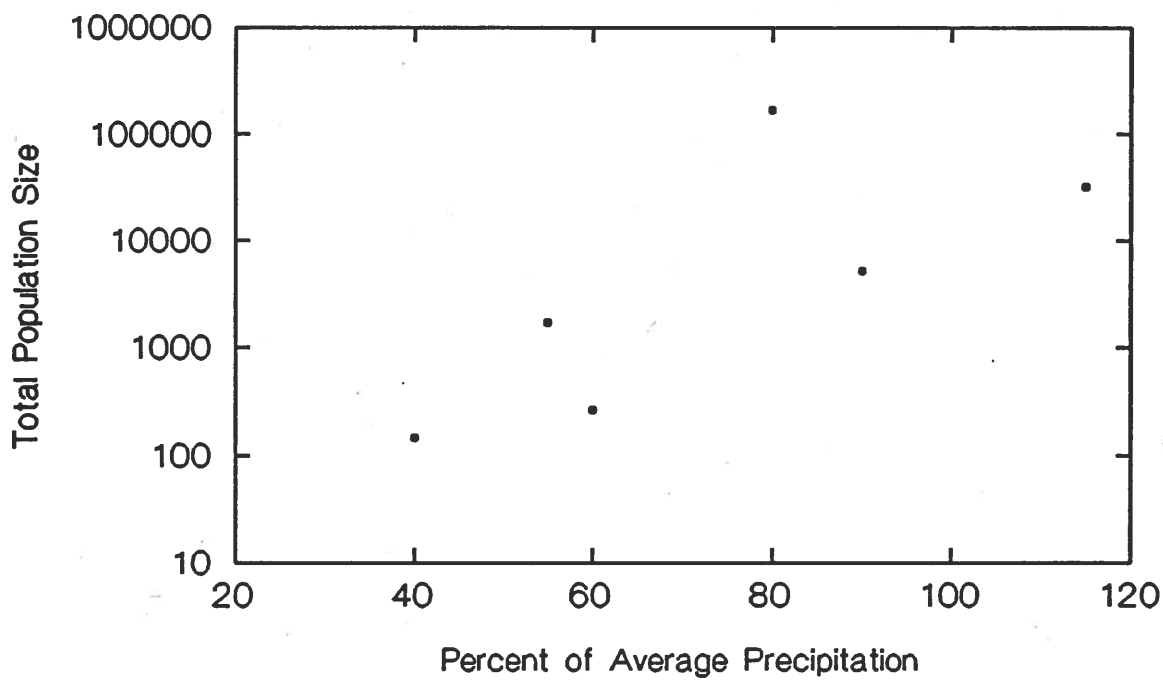


**Figure 2.** Relationship between rainfall (average of long-term mean precipitation) and population size for *C. benitensis*. The relationship, although statistically non-significant, seems to indicate a general positive trend.

As stated in our previous reports, the variable census data over the past six years indicate that many populations of *C. benitensis* may not germinate or flower for several years, making it difficult to judge the vitality of a population without a considerable wait until the next "good" year. Furthermore, a good year may be triggered by a combination of factors, not simply total precipitation. A hypothetical ecological model for population behavior of *C. benitensis* would incorporate precipitation as a driving variable: minimal precipitation is required, but other factors (e.g., the timing of precipitation and winter temperatures) influences population size.

## 3.2 POPULATION SEARCHES

Unlike the previous five years, growing conditions did not significantly hamper field surveys for new populations in 1992. We revisited areas of suspected suitable habitat along the San Benito River and in upper White Creek, and discovered new populations. Similarly, new populations were discovered on Laguna Mountain and in the lower San Benito River drainage. These new populations are geographically more remote from the San Benito Mountain region than previously documented populations.

A total of five new populations were documented in 1992. Over the past 12 years, the number of known occurrences for *C. benitensis* has continued to rise whenever field work is conducted in a year of suitable growing conditions (Figure 3). Given this trend, it is not possible to speculate upon how many more undocumented populations might occur, except to say that most suitable habitat has been surveyed in a good year. Thus, it is unlikely that many more undocumented populations will be located on the San Benito Mountain serpentine area, since most of the suitable terrace habitat there has now been visited.

However, two additional populations were discovered at sites removed from San Benito Mountain, raising questions as to the direction of additional field work. A population was discovered near the confluence of Lorenzo Creek and the lower San Benito River, several miles to the west of Clear Creek. This new site was located by chance on the site of the BLM Section 8 administrative headquarters! A second population was discovered on the Laguna Mountain serpentine area, a separate serpentine area on the next mountain system directly west from San Benito Mountain.

Collectively, these new discoveries raise two questions:

- the Lorenzo Vasquez and Section 8 populations are located on debris flow deposits derived from serpentine, as opposed to serpentine alluvial terraces, suggesting a less strict physiographic habitat selection requirement than had been previously indicated, and;

- collectively, the newly discovered populations of *C. benitensis* that occur in suitable habitat remote from San Benito Mountain indicate other South Coast Range serpentine areas in the vicinity might support undocumented populations.

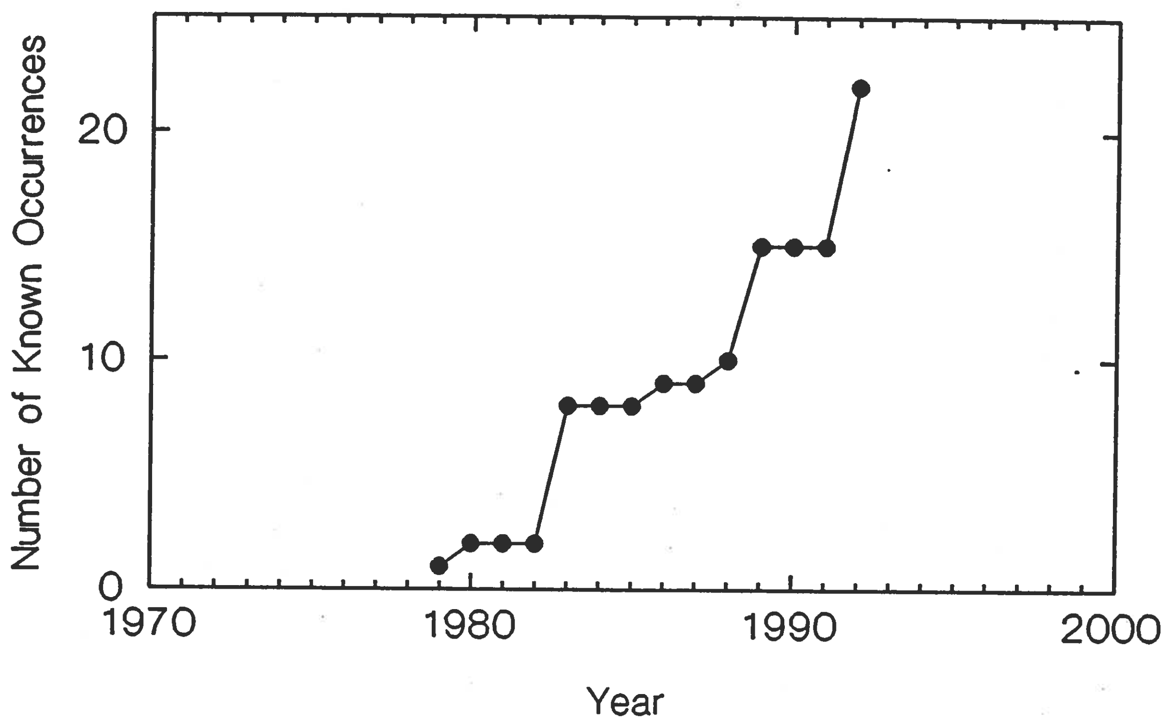


**Figure 3.** Trend in the number of known occurrences of *C. benitensis* over the 12 year period of recent, active monitoring for the species. Several additional populations were discovered in 1992.

In regard to the latter speculation, *C. benitensis* should be sought from along Lewis Creek on the San Benito County-Monterey County line.

### 3.3 NEW POPULATION LOCATIONS

Figures 4 through 8 show the locations of all new populations documented in the 1992 field season. These locations are supplemental to the population locations shown in previous reports (Taylor 1990, 1991).

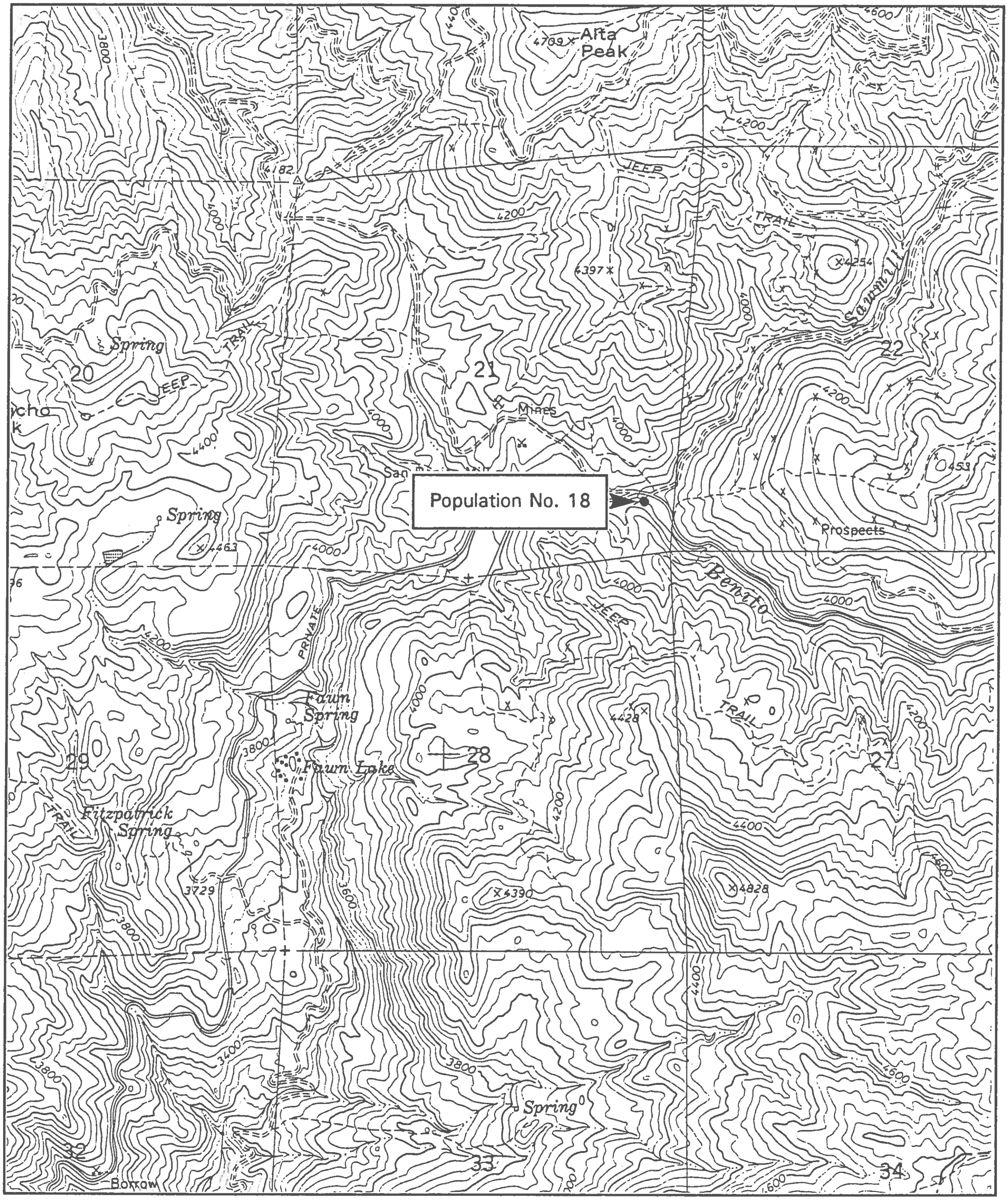


**Figure 4.** Topographic map depicting the location of the Sawmill Creek population of *Camissonia benitensis* (BLM Population No. 18). This population was discovered in 1992 between the KCAC mine road and the San Benito River, on a terrace near the Sawmill Creek confluence. T18S, R12E, SE¼ of SE¼ Section 21, San Benito County (San Benito Mountain 7½' USGS quadrangle, 1984 edition). **Ownership:** Private.

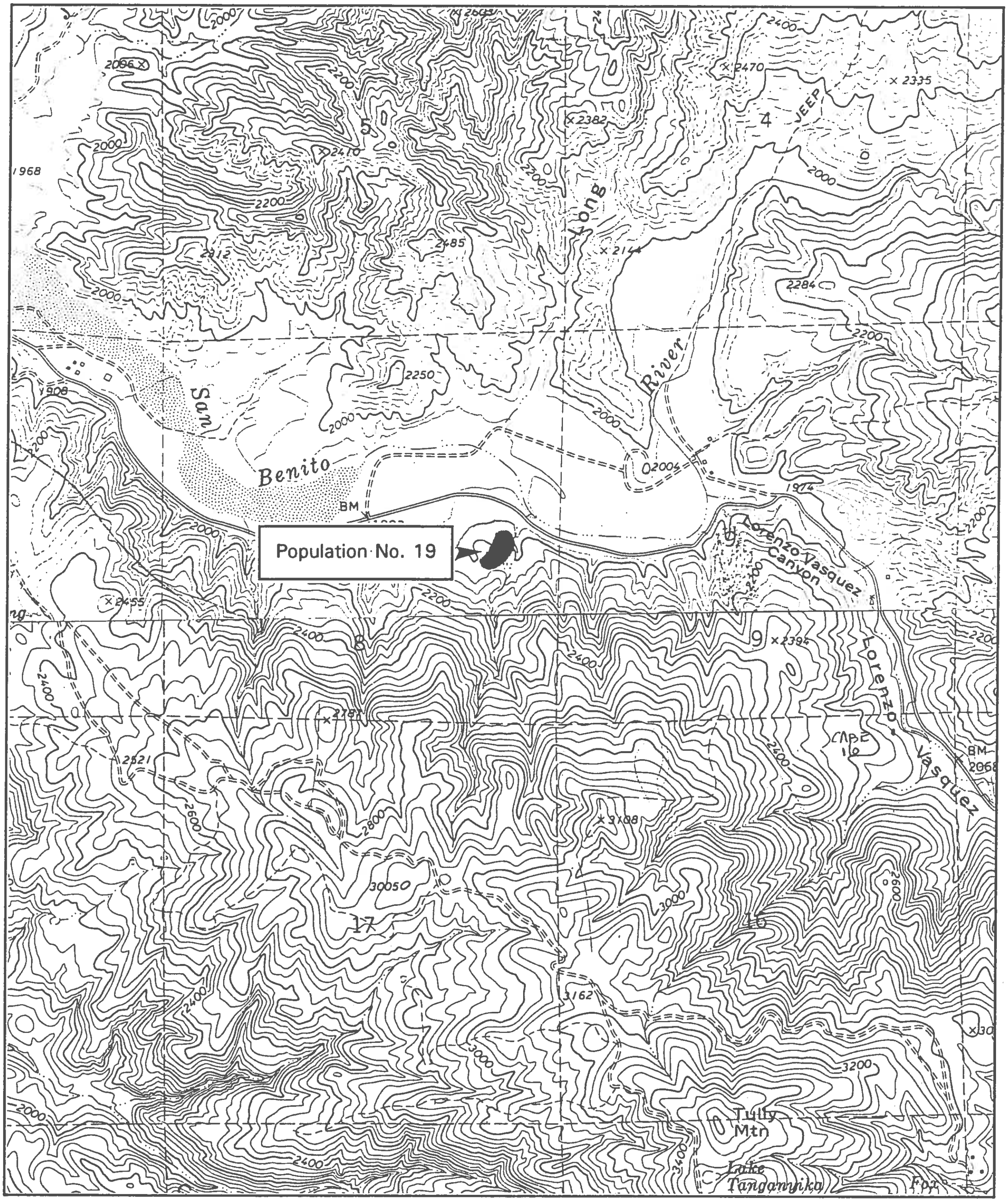


**Figure 5.** Topographic map depicting the location of the Section 8 Site population of *Camissonia benitensis* (BLM population No. 19). This population was discovered in 1992 within the BLM administrative site in the San Benito River, an area well downstream from Hernandez Reservoir. T18S, R10E, NW¼ of SE¼ Section 8, San Benito County (Rock Spring 7½' USGS quadrangle, 1969 edition).

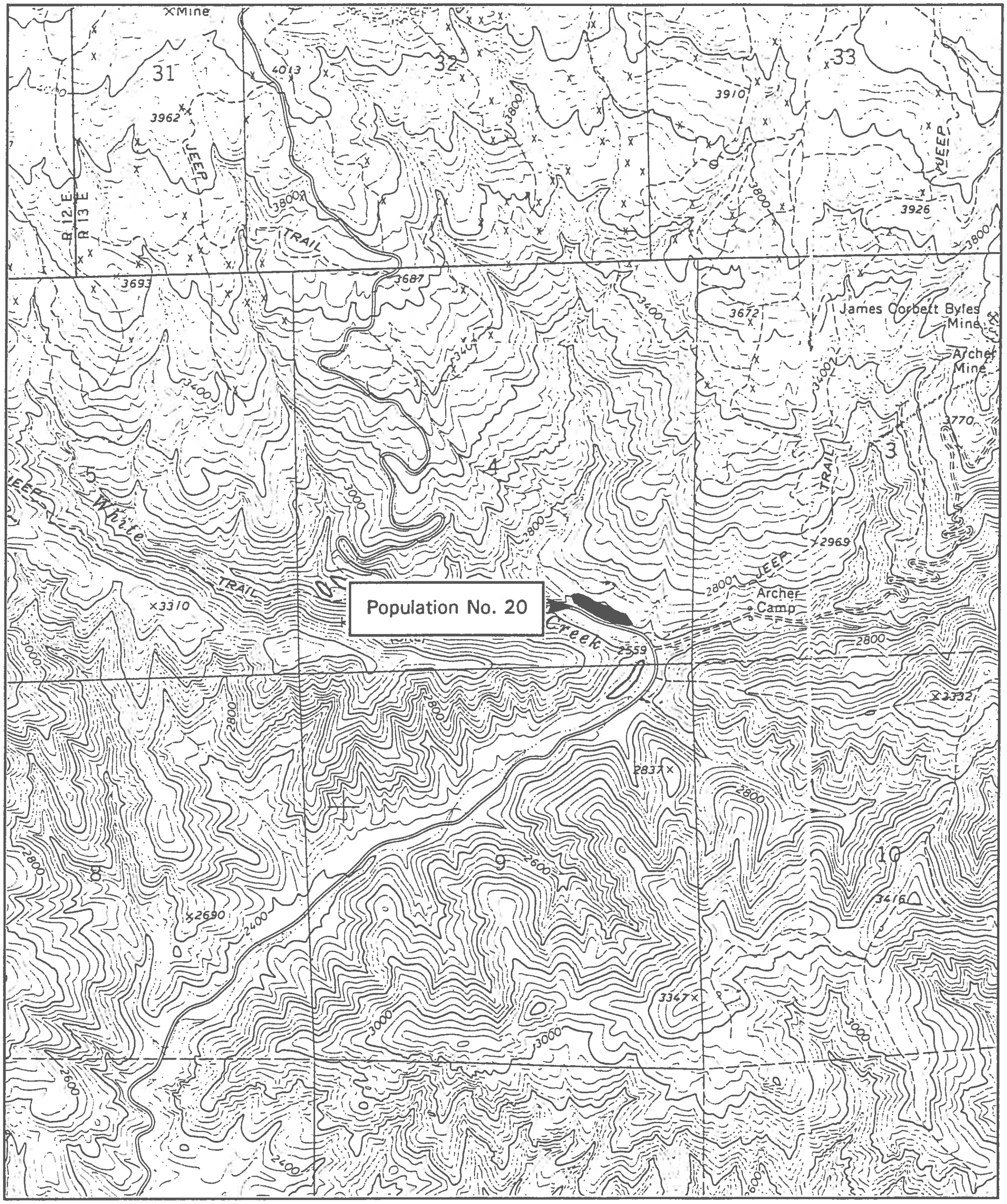


**Figure 6.** Topographic map depicting the location of the upper White Creek population of *Camissonia benitensis* (BLM population No. 20). This population was discovered in 1992, representing a range extension into a new watershed (San Lorenzo Creek, draining into the San Joaquin Valley), and a new county record. T19S, R13E, SE¼ of SE¼ Section 4, Fresno County (Santa Rita Peak 7½' USGS quadrangle, 1984 edition).

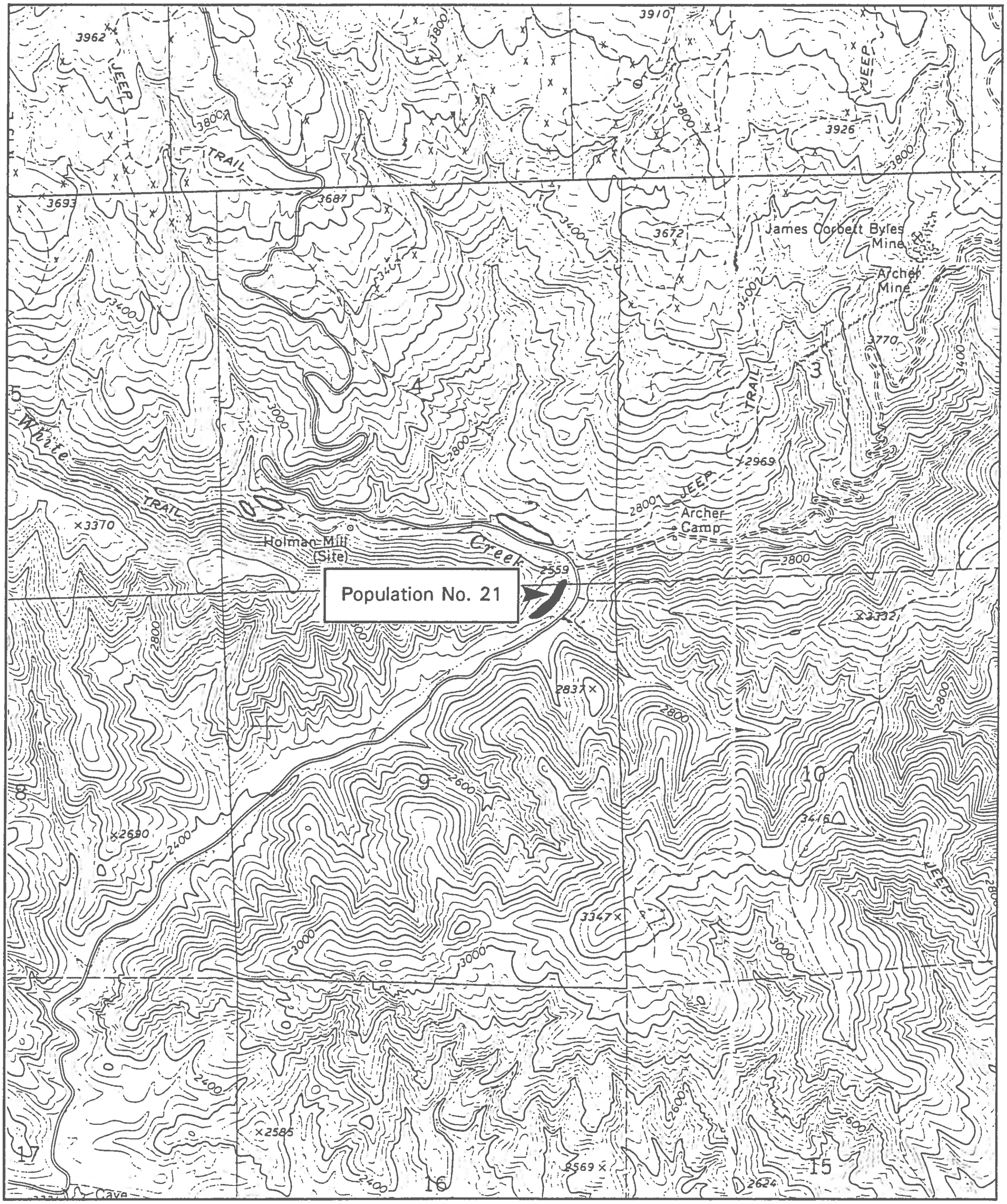


**Figure 7.** Topographic map depicting the location of the lower White Creek population of *Camissonia benitensis* (BLM population No. 21). The White Creek populations were discovered in 1992, representing a range extension into a new watershed (San Lorenzo Creek, draining into the San Joaquin Valley), and a new county record. T19S, R13E, NE¼ of NE¼ Section 9, Fresno County (Santa Rita Peak 7½' USGS quadrangle, 1984 edition). **Ownership**: Private.

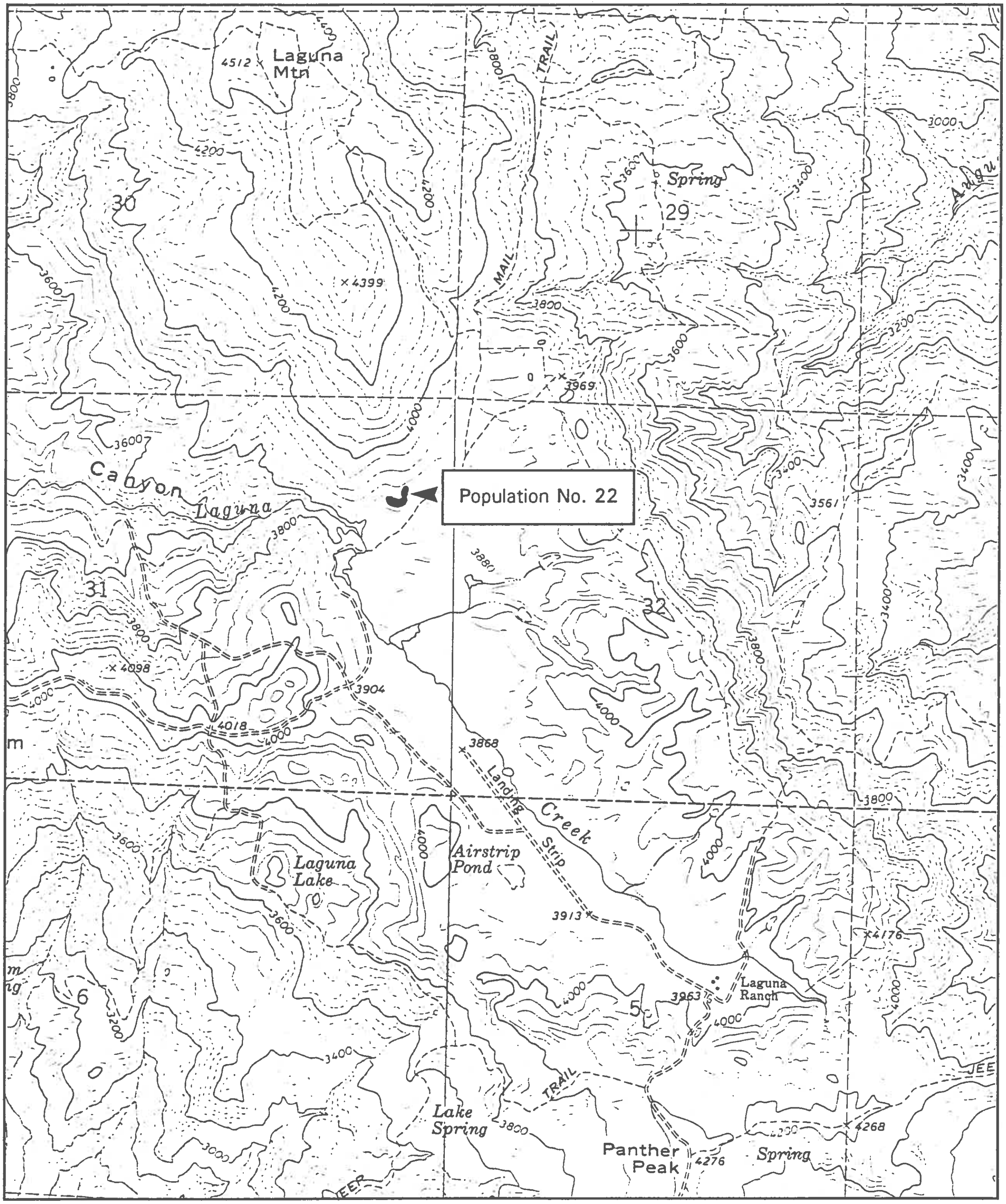


**Figure 8.** Topographic map depicting the location of the Laguna Ranch population of *Camissonia benitensis* (BLM population No. 22). This population was discovered in 1992, and represents the first record for the species on the Laguna Mtn.-Hepsedam Peak serpentine body. T18S, R11E, NE¼ of NE¼ of NE¼ Section 31, San Benito County (Hepsedam Peak 7½' USGS quadrangle, 1969 edition). **Ownership**: Private.

### 3.4 ARTIFICIAL POPULATION INTRODUCTION TRIALS

Artificial populations of *C. benitensis* appeared at all four locations at which seed had been sown between 1991 and 1992. The overall size of the established populations was small (Table 1), particularly in relation to the numbers of seeds sown. At population 1C, 147 plants were observed, originating from circa 60,000 seeds sown—a ratio of 408 sown seeds per established plant. At Population 7, twenty-eight plants were observed originating from circa 30,000 sown seeds—a ratio of 1071 seeds sown per established plant. At Population 16, sixteen plants were observed—a ratio of 1875 seeds sown per established plant. At population 17, but three plants were observed—a total of 10,000 seeds sown per established plant. Collectively for the four sites, a total of 194 plants originated from circa 160,000 seeds sown—a ratio of 824 seeds per established plant.

The observed results of these experimental introductions are somewhat anecdotal, but do suggest several findings:

- rates of plant establishment from artificially sown seed is very low,
- the results of the preliminary introduction trials do not provide sufficient biological information to judge the efficacy of the procedure as a conservation tool,
- the viability of artificially established populations is uncertain, and the available data resulting from our introduction trials is insufficient to formulate even a partial viability analysis,
- in the absence of more specific data on the nature of seed bank dynamics, enhancement, protection, and improvement of natural populations of *C. benitensis* remain the best management option for conservation of the species.

The fate of the ungerminated seed resulting from our artificial introduction trials is unknown. Judging from the density of buried, viable seed in topsoil of natural populations of *C. benitensis*, a sizable fraction of the sown seed probably remains extant. Some of this seed may germinate in more favorable years. We did not, however, undertake studies on the fate of sown seed, so we can not speculate on the mortality of seed and the quantities remaining in the artificial population sites.

The results of these trials indicate that artificial establishment of large populations of *C. benitensis* will not be a matter of simply just sowing seed!

The location of the artificial populations of *C. benitensis* are given in Figures 9 and 10. Artificial Populations 1C and 7 correspond to the historic populations of the same BLM population number, as mapped in Taylor (1990).

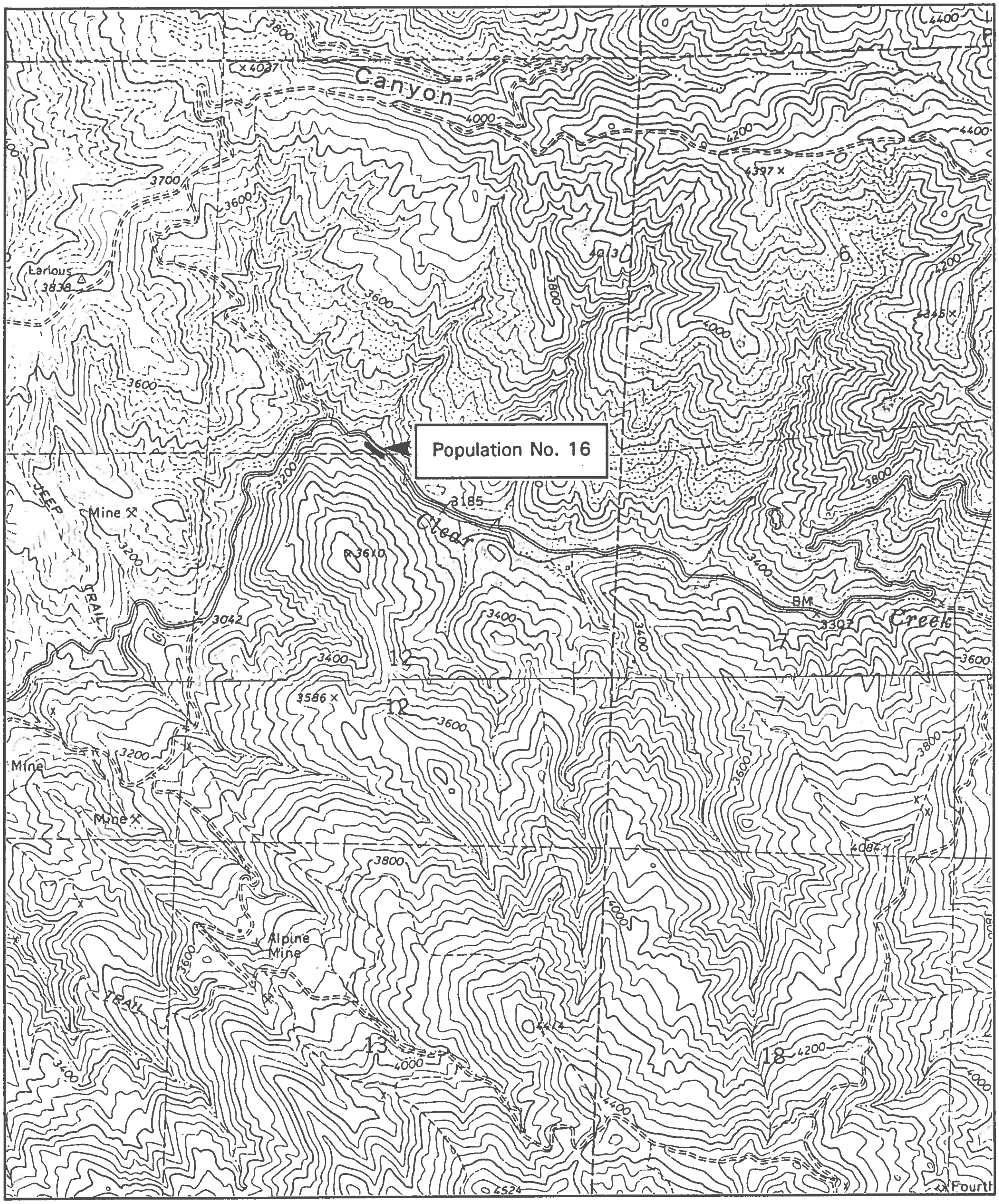


**Figure 9.** Topographic map depicting the location of the artificially established population of *Camissonia benitensis*, BLM population No. 16. This population was established from seed sown in the fall of 1991, and is located on a small terrace enclosed by a pipe barrier fence directly across from Population No. 4.

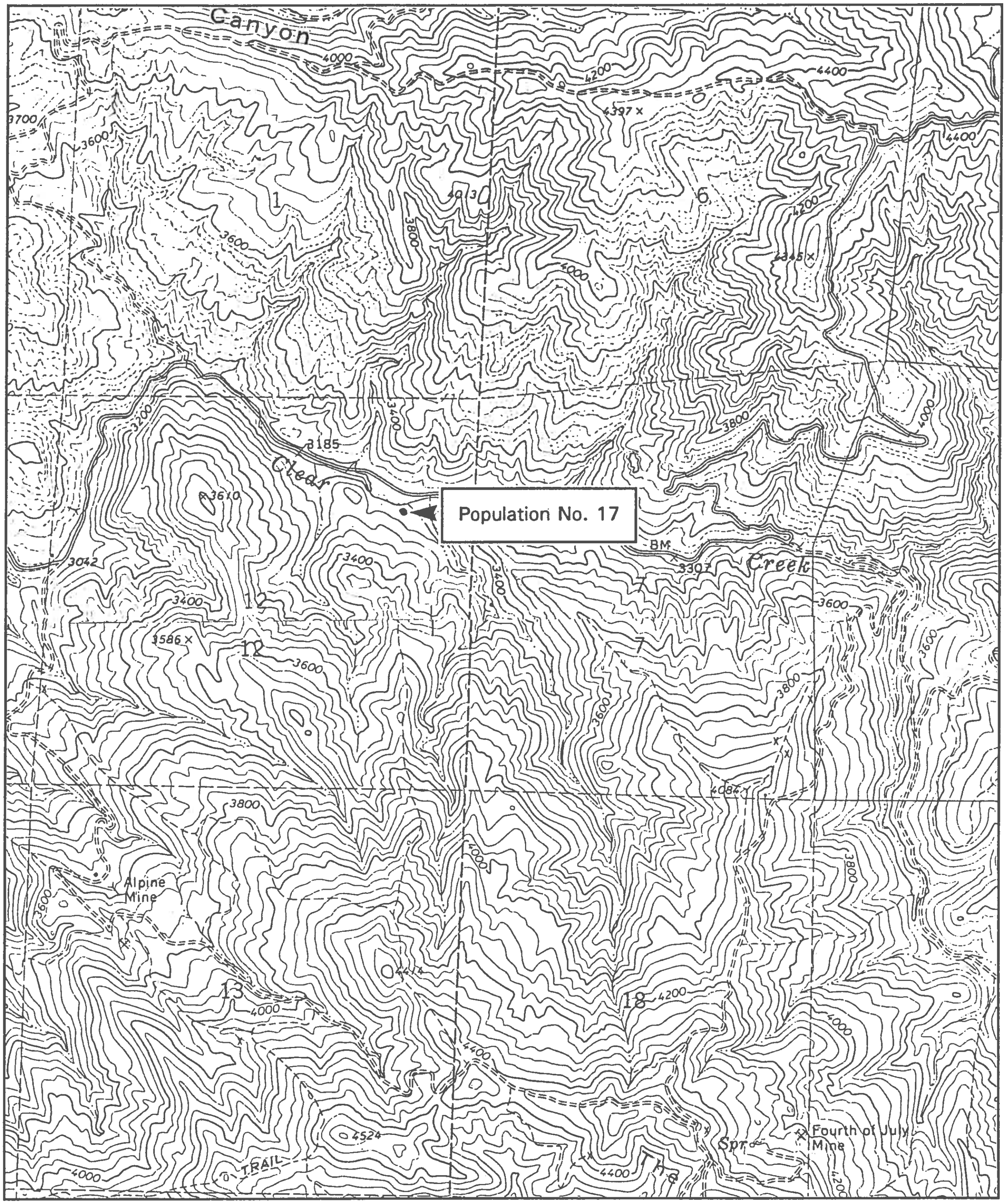


**Figure 10.** Topographic map depicting the location of the artificially established population of *Camissonia benitensis*, BLM population No. 17. This population was established from seed sown in 1991, and is located somewhat upstream and across the creek from BLM Population No. 7.

## 3.5 1992 ANNUAL IMPACT OBSERVATIONS

We observed recent motorcycle tracks within seven natural populations of *C. benitensis* this year. These populations were: 7, 9, 10, 11, 12, 13, and 18, and within the artificially established Population 16. Heavy motorcycle disturbance continued to influence the peripheral portions of Populations 6 and 9, where protection fencing fails to enclose the entire populations.

At Population 6 again this year, *C. benitensis* plants were observed outside the eastern boundary of the western pair of exclosures. In the course of the six years of our monitoring, plants have grown outside the fenced area here in three years. This segment of the population is adjacent to a major motorcycle trail. This segment of Population 6 has continued to decline throughout the six years of our monitoring due to chronic disturbance from vehicles.

Our overall assessment of past management to efforts reduce chronic impacts from off-road vehicles to *C. benitensis* populations is simple: too little, and possibly too late. Several natural populations of *C. benitensis* remain unfenced. The fencing at other populations is incomplete, protecting only one border the population. Fencing at several other populations does not fully protect all suitable habitat. At several sites, motorcycles have continued to enter the population from uphill, unfenced areas.

## 3.6 VEGETATION AND HABITAT

The discovery of *C. benitensis* occurring on debris flow deposits is a new type of physiographic setting for the species. It is, however, not that unexpected, since the two populations so situated are on debris flow deposits that are largely or entirely serpentine. The two debris flow occurrences share the ecological characteristics of alluvial terraces: deep, relatively non-stony soils, openings in chaparral or oak woodland, and a rich flora of native annual herbs, many of which are obligate serpentine species (Kruckeberg 1984).

The discovery of several new *C. benitensis* populations this year has strengthened a habitat trend identified in our 1990 report (Taylor 1990): namely, that the species diversity of native annual herbs on serpentine terraces is strongly correlated with and directly indicative of the vigor and probability of long-term viability of a given population.

*C. benitensis* occupies a very narrow subset of the physiographically unique microsites in the San Benito Mountain landscape. It primarily requires flat areas (primarily alluvial terraces), serpentine (or on partially to completely serpentine dominated debris flow deposits) substrates, topsoil that is of greater fertility than raw serpentine, and open areas free of dense woody vegetation.

In the Clear Creek watershed, very few serpentine terraces are in completely pristine condition. The majority of terraces sites have been subject to mining or recreational disturbances of varying degrees of intensity. Our 1992 observations suggest that the condition of serpentine alluvial terraces in the Clear Creek canyon is worse than we had previously surmised.

The evidence for this conclusion is indicated by patterns of native annual herb diversity on serpentine substrates. Pristine terraces support a diverse assemblage of native annual herbs which consists of a suite of about 35-45 species. Any given terrace might support 20-30 co-occurring serpentine annual herb taxa. Three of the newly discovered *C. benitensis* populations (the two White Creek and Laguna Ranch occurrences) occur on pristine terraces with a high diversity of native annual herb taxa. Similarly, the undisturbed portion of the Section 9 population exhibit a diverse native annual herb community. Population 9 (San Carlos Creek watershed) and Population 5 (Clear Creek watershed), both large and relatively stable populations of *C. benitensis*, also exhibit a diverse native annual herb community. By contrast, many Clear Creek populations, particularly those on small fragmented terrace sites heavily impacted by past or chronic human use impacts, lack an equivalent diversity of native annual herb taxa.

These observations lead us to surmise that the condition of *C. benitensis* at a given site can be directly inferred by the diversity of the serpentine annual herb community. Large stable populations invariably exhibit a high herb diversity. Feeble or vulnerable populations lack such an herb component. Secondly, the condition of unoccupied terraces in the Clear Creek watershed can be inferred by the diversity of annual herbs. Terraces relatively free of human disturbance exhibit high annual herb diversity. Unfortunately, however, the majority of the 60-80 serpentine terraces in Clear Creek are in very poor to poor condition, as indicated by this inference.

For this reason, we conclude that there is a low probability of long-term vigor of many of the Clear Creek *C. benitensis* populations. From our observations, we conclude there is a very slow rate of recovery of annual herb plant communities on terraces which have been fenced to eliminate vehicle use (i.e., Population 7 and Population 16). One decade after fencing, these terraces have not exhibited marked improvement in annual herb diversity. Consequently, we surmise that recovery would take many decades, which would require decades of protection before such sites are suitable *C. benitensis* habitat.

From these observations, we reiterate that a large fraction of available habitat for the plant is severely degraded by human activity. On many terraces in the Clear Creek watershed, the available top soil is being lost at an observable rate. Loss of topsoil from serpentine terrace sites makes these sites unsuitable as habitat for native annual herb communities, including *C. benitensis*. Restoring the topsoil on such sites would be costly, and require many decades or centuries of recovery before these sites could again support self-sustaining *C. benitensis* populations

To date, few BLM management actions have directly contributed to the ongoing decline of *C. benitensis*. However, the lack of action has been a contributing factor. In order for this species to be insured protection required under the Endangered Species Act, all remaining suitable habitat for the species should be protected immediately and without fail. Secondly, all formerly suitable but now degraded terrace sites should also be protected, in order to insure recovery of suitable but now degraded terrace sites should also be protected, in order to insure recovery of these sites over the coming decades. The last requirement will insure that successional changes in chaparral vegetation that are detrimental to *C. benitensis* habitat can be managed. Loss of open serpentine terraces to succession is now a direct threat because few undisturbed terraces remain.

## 3.7 SUMMARY RECOMMENDATIONS

1. *Camissonia benitensis* is biologically endangered. It could become extinct through the combined actions of stocastic events coupled with on-going human impacts operating in conjunction with severe or prolonged drought.

2. Over the 6 years of monitoring conducted under this study, the amount and suitability of available habitat for *Camissonia benitensis* has continued to decline. Past management efforts have been ineffective at arresting the decline or reversing this trend.

3. *Camissonia benitensis* should be listed as Endangered under the 1973 ESA. This recommendation was made in 1990, and is in no way lessened by the subsequent work conducted between 1991-1992.

4. *Camissonia benitensis* should be listed as Endangered under the California State Endangered Species Act. State funding derived from off-road vehicle licensing should be made available to aid in the formulation and implementation of a recovery plan for the species.

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