U.S. Fish & Wildlife Service

# Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area

Bay checkerspot butterfly
from Richard A Arnold. with permission

Bakers manzanita
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San Mateo woolly sunflower
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# RECOVERY PLAN

## FOR

# SERPENTINE SOIL SPECIES

## OF THE

# SAN FRANCISCO BAY AREA


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# GUIDE TO RECOVERY PLAN ORGANIZATION

This recovery plan provides individual species accounts for all of the 28 species covered. Recovery strategies are organized by geographic area (or ecosystem area) whenever possible, thereby combining recovery tasks for multiple species. Because of the length and complexity of this recovery plan, an appendix is provided listing the common name and scientific name of all plants and animals mentioned in the plan (Appendix A). Technical terms are defined at their first use in the text and included in a glossary of technical terms (Appendix B).

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# EXECUTIVE SUMMARY

**Introduction**: This recovery plan features 28 species of plants and animals that occur exclusively or primarily on serpentine soils and serpentine grasslands in the San Francisco Bay Area of California. The 14 federally listed species include 11 endangered plants (coyote ceanothus, fountain thistle, Metcalf Canyon jewelflower, Pennell's bird's-beak, Presidio clarkia, San Mateo thornmint, San Mateo woolly sunflower, Santa Clara valley dudleya, Tiburon jewelflower, Tiburon paint brush, and white-rayed pentachaeta), two federally threatened plants (Marin dwarf-flax, and Tiburon mariposa lily), and one federally threatened animal (bay checkerspot butterfly). In addition, 14 species of concern are addressed which include 6 plants: Baker's manzanita, Crystal Springs lessingia, most beautiful jewelflower, Mount Hamilton thistle, smooth lessingia, and Tamalpais lessingia; and 8 animals: Edgewood blind harvestman, Edgewood microblind harvestman, Fairmont microblind harvestman, Hom's microblind harvestman, Jung's microblind harvestman, Marin blind harvestman, Opler's longhorn moth, and Tiburon microblind harvestman. These species occur in dry, nutrient-poor, serpentine soil grasslands of the greater San Francisco Bay Area and the adjacent foothills and valleys. Conversion of habitat to urban and industrial uses has extirpated the listed species and species of concern from the majority of their historic ranges. The remaining natural serpentine soil grasslands communities are often disjunct, highly fragmented, and many are marginal habitats in which these species may not persist during catastrophic events such as fire or persistent drought. Moreover, natural communities have been altered permanently by the introduction of aggressive, nonnative plants, which now dominate in many of the remaining undeveloped areas.

The Endangered Species Act mandates the preparation of recovery plans for listed species unless such a plan would not contribute to their conservation. Recovery plans detail the actions necessary to achieve self-sustaining, wild populations of listed species so they will no longer require protection under the Endangered Species Act. Species of concern are not required to have recovery plans. However, non-listed species are included in this recovery plan because a community-level strategy provides opportunities for pre-listing conservation of species with needs similar to those of listed species.

**Recovery Objectives**: The ultimate goal of this recovery plan is to delist 6 of the 14 endangered and threatened species, improve the security of 7 of the 14 listed species, and ensure the long-term conservation of the 14 species of concern. An interim goal is to downlist the endangered species to threatened status.

**Community-level Strategy for Recovery and Conservation**: This plan presents a community-level strategy for recovery and conservation because all of the listed species and species of concern co-occur in the same natural community. The likelihood of successful recovery for listed species is increased by protecting entire communities, and by doing so, conservation of species of concern is also possible. The community-level strategy is determined by the available information on biology, distribution, and population statuses of covered species; extent, location, and quality of existing habitats; and how present and anticipated biological and anthropological impacts will affect the covered species in the human-dominated landscape of the San Francisco Bay Area.

The four key elements that compose this community-level recovery and conservation strategy are described below.

**1. Recovery criteria**

The community-level approach facilitates species recovery and conservation but does not negate the need to consider the requirements of each species. Thus, individual downlisting and/or delisting criteria are presented for 13 of the 14 listed species covered in this plan to track their progress towards recovery, further their security or conservation, and to ensure that all of their recovery and conservation needs are addressed. Elements common to the downlisting/delisting criteria of most listed species include:

- protection from development and incompatible uses of the habitat of populations representing the full range of genetic and geographic variation in the species;

- development and implementation of appropriate habitat management plans for each species and area identified for protection; and

- achievement of self-sustaining status in specified populations.

Protection strategies for species of concern are based on the assumptions that if populations are secure from threats, co-occur with listed species, are not declining, and populations remain throughout the species' historical range, their long-term conservation will be ensured.

**2. Habitat protection**

Considering that habitat loss is the primary cause of species endangerment in the San Francisco Bay Area, a central component of species recovery and conservation is to establish a network of conservation areas and reserves that represent all of the important serpentine habitat in the San Francisco Bay Area. Habitat protection does not necessarily require land acquisition or easement. The most important aspect of habitat protection is that land uses maintain or enhance species habitat values. Elements 4 through 6 of the recovery strategy address this issue.

Another recommendation of the plan is that, whenever possible, blocks of conservation lands should be situated so that movement of species between blocks is facilitated. This is especially applicable and important to the bay checkerspot butterfly "metapopulation" which needs these lands to serve as "stepping stones" for dispersal and recolonization events.

**3. Monitoring and research programs**

This recovery plan has been developed based on the best scientific information currently available. However, many important aspects of species biology and management have not yet been studied. Thus, continued research, in conjunction with adaptive management, is a crucial component of this plan. Recovery criteria and tasks must be reevaluated for each species as research is completed.

Primary information needs for the species covered in this plan are:

- surveys to determine species distributions;
- population censusing and monitoring;
- reproductive and demographic studies;
- habitat management research;
- biosystematic and population genetics studies;
- studies of atmospheric deposition of nitrogen from air pollution onto serpentine habitats in the San Francisco Bay Area;
- studies of pesticide effects on the bay checkerspot butterfly; and
- habitat and species restoration trials.

**4. Habitat Management**

In most cases, active management of the land is necessary to maintain and enhance habitat values for the species covered in this plan. However, management strategies have not been investigated for most species. Management research (element #3) may take many years to complete, and few management plans have been developed for protected areas. The only practical approach is adaptive management, where management is applied, population responses are monitored, the outcome is evaluated, and management is readjusted accordingly.

**Implementation Participants**: Although the U.S. Fish and Wildlife Service has the statutory responsibility for implementing this recovery plan, the participation of a variety of groups in both initial plan implementation and the subsequent adaptive management process is essential to successful recovery. Thus, the plan recommends the establishment of a regional, cooperative public/private recovery plan implementation team to enlist the participation of all stakeholder groups and interested parties. This group would develop participation plans, coordinate education and outreach efforts, assist in developing economic incentives for conservation and recovery, ensure that adaptive management is practiced, and define other recovery and management tasks as necessary.

**Total Estimated Cost of Recovery:** The total estimated cost of downlisting, delisting, or improving the security of the 14 federally listed species, and conservation of the 14 species of concern is broken down by priority of tasks. Certain costs, such as securing and protecting specific serpentine habitat areas, have yet to be determined.

Priority 1 tasks: $144,290,000

Those actions that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

Priority 2 tasks: $26,260,000

Those actions that must be taken to prevent a significant decline in the species population or habitat quality, or some other significant negative impact short of extinction.

Priority 3 tasks: $2,390,000

All other actions necessary to meet the recovery and conservation objectives outlined in this recovery plan.

**Date of Recovery:** Because recovery is defined in relation to a climatological cycle for most species covered in this recovery plan, the date of recovery is anticipated for most listed species to be approximately between 15 to 30 years.

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# I. INTRODUCTION

Along the west coast of North America, serpentine soils are found within discontinuous rock outcrops in the Sierra Nevada and in the Coast Ranges from Santa Barbara County, California to British Columbia. The State of California holds approximately 3,000 square kilometers (1,158 square miles) of ultramafic rocks (rocks which are extremely basic, very low in silica, and rich in ferromagnesian minerals) (Kruckeberg 1984*a*). This recovery plan covers serpentine endemic plants and animals that are restricted in the area of serpentine soils near San Francisco Bay, California.

Within the San Francisco Bay Area, serpentine soils are known in the eight Bay Area counties (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, and Sonoma) (Jennings 1977, Figure I-1). Bay Area serpentines are derived from intrusive igneous rocks associated with fault zones in sedimentary Franciscan formations. Serpentines that occur in the western Bay Area counties are associated with the San Andreas Fault, while serpentines found in the east Bay counties are found within the Hayward Fault Zone (McCarten 1987*a*). Serpentine outcrops can be found south of the Bay in Santa Clara County (Figure I-2); west of the Bay in the Edgewood Nature Preserve, near Crystal Springs Reservoir, Jasper Ridge Preserve near Stanford University in San Mateo County, and at the Presidio in San Francisco County; east of the Bay in the Oakland Hills, Sunol Regional Wilderness, Cedar Mountain, and Man Ridge areas of Alameda County and at Mt. Diablo State Park in Contra Costa County; in the north Bay Area on the Tiburon Peninsula in eastern Marin County; at Mt. Tamalpais, Carson Ridge, and near Nicasio Reservoir in western Marin County; and in Sonoma and Napa Counties. The geographic areas mentioned above and in the Stepdown Narrative (Chapter IV) are depicted in Figures I-3 through I-8.

### A. Serpentine Environments

Serpentine soils are formed from weathered ultramafic rocks such as serpentinite, dunite, and peridotite. Serpentine soils are inhabited by a diverse array of plant species. Serpentine endemic plants make up 10 percent of the flora

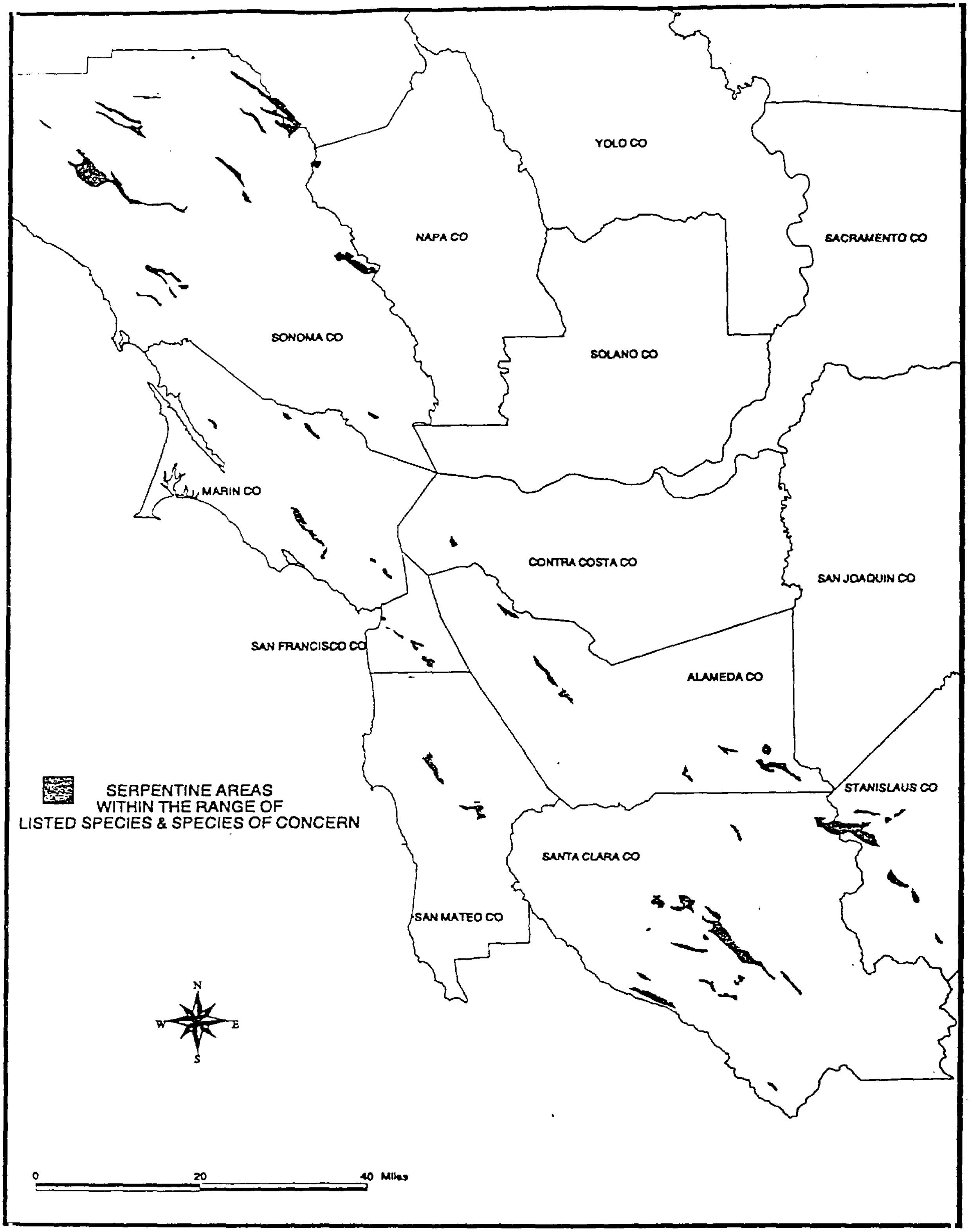


**Figure I-1.** Distribution of serpentine in the San Francisco Bay Area of California (Alameda, Contra Costa, Marin, San Francisco, San Mateo, Santa Clara, Sonoma, and Stanislaus Counties) (Data from California Division of Mines and Geology).

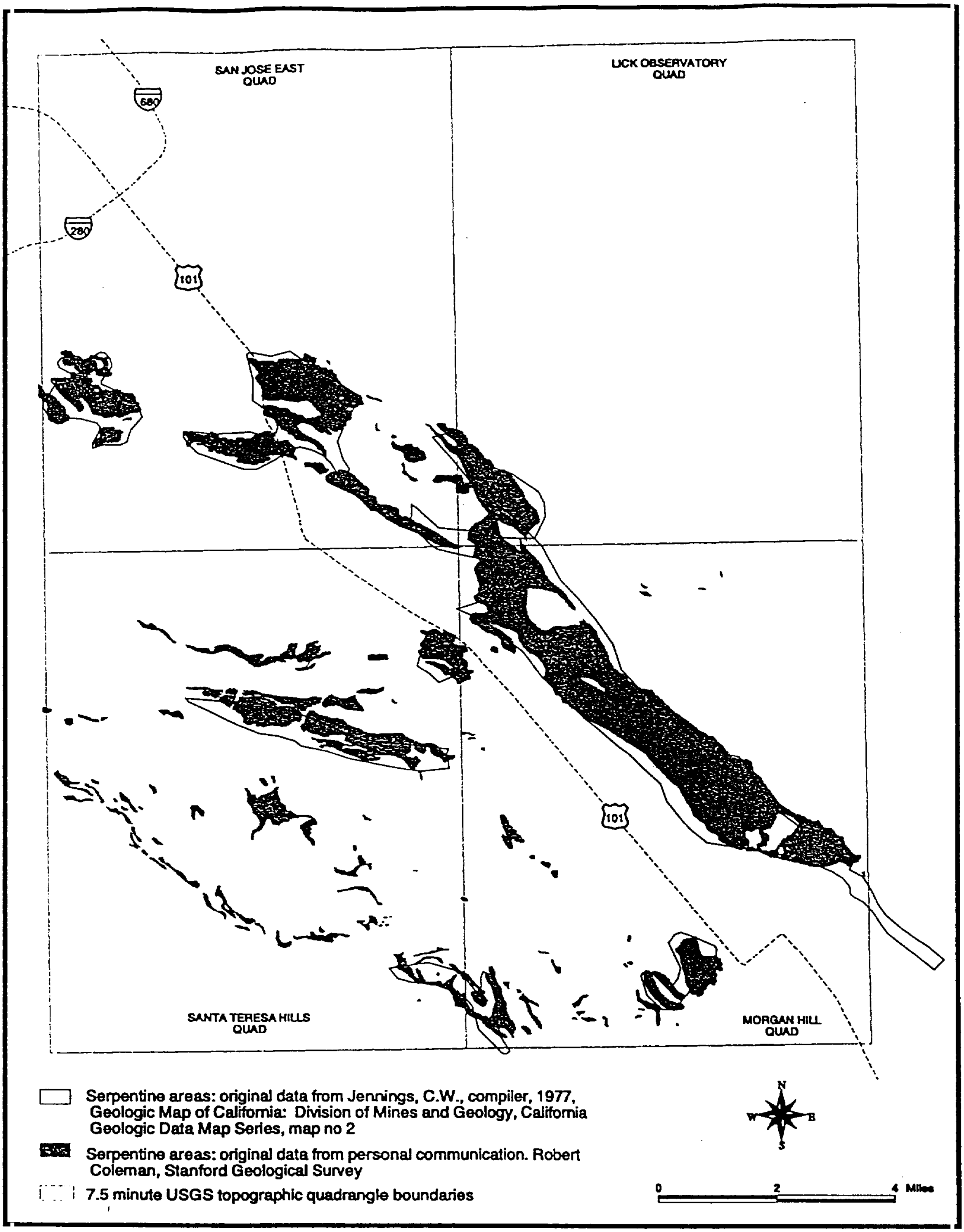


**Figure I-2.** Detailed map of areas of serpentine geology and soils in central Santa Clara County. Heavy lines replicate areas mapped in Figure I-1; shaded areas were compiled by Robert Coleman, Stanford Geological Survey (Data courtesy of Stanford University). Sources vary slightly, so any particular location should be field-checked.

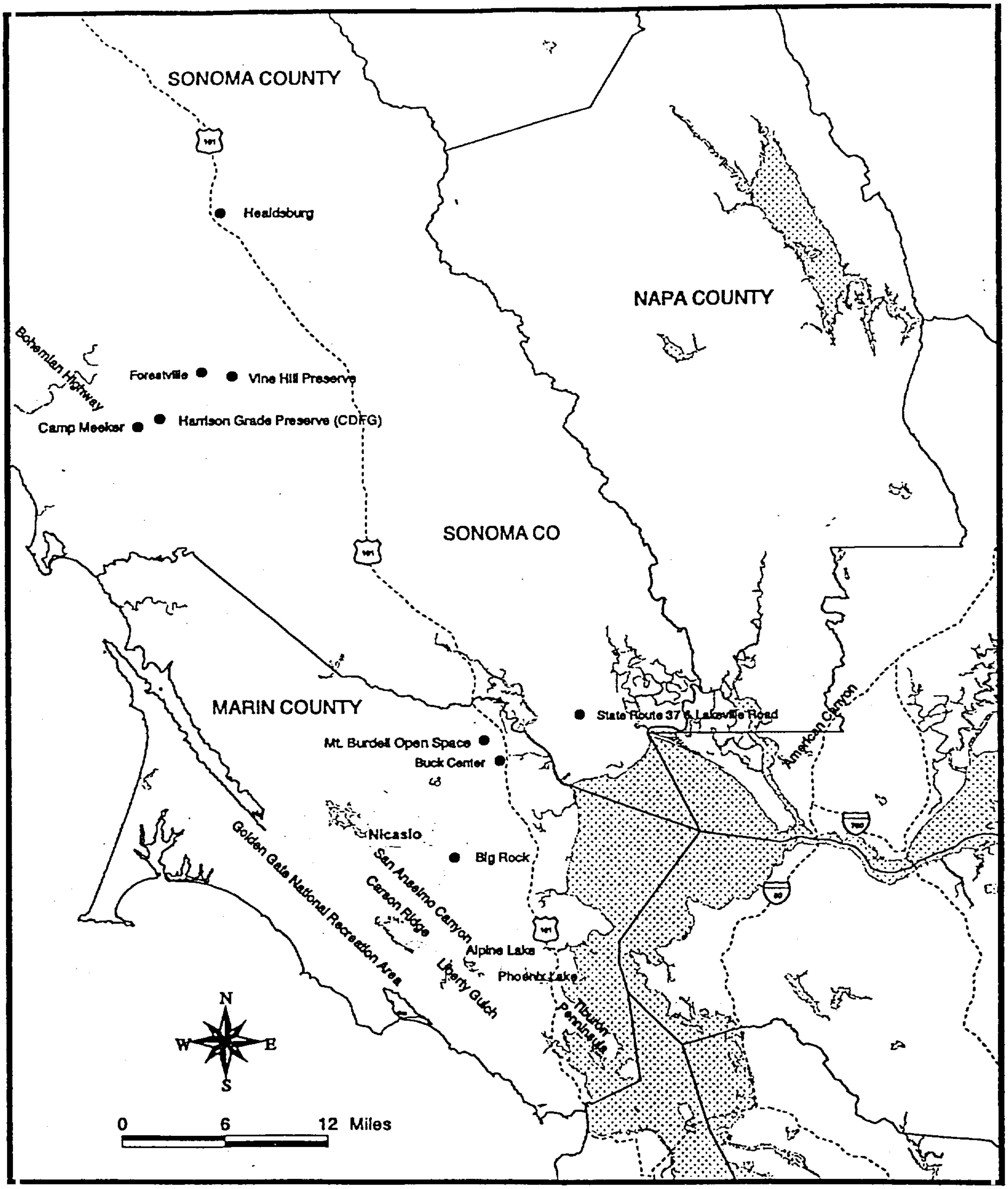


**Figure I-3.** Marin, Napa, and Sonoma county geographic locations referred to in the plan. Locations on the Tiburon Peninsula are in Figure I-4.

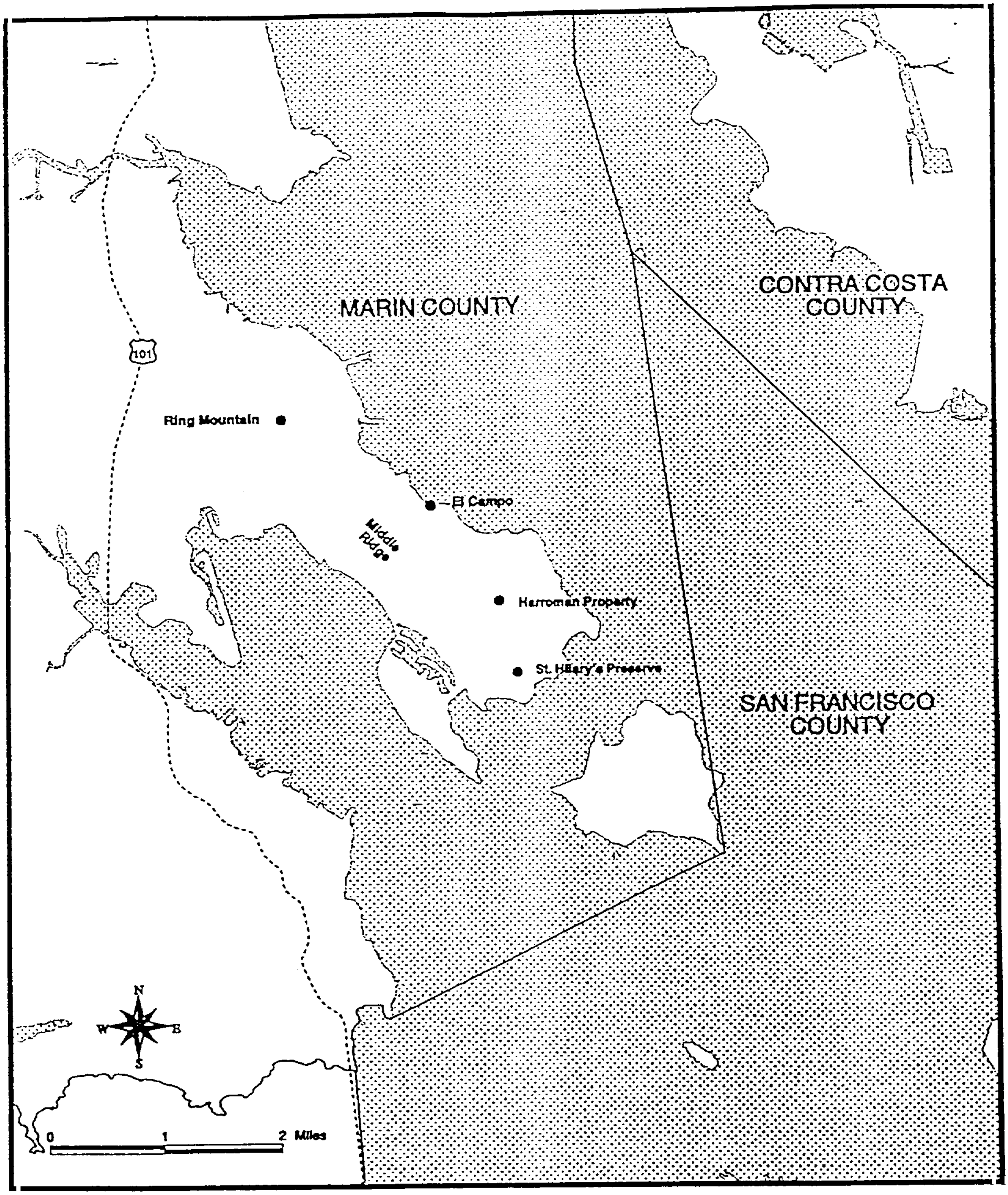


**Figure I-4.** Tiburon Peninsula (Marin County) geographic locations referred to in the plan.

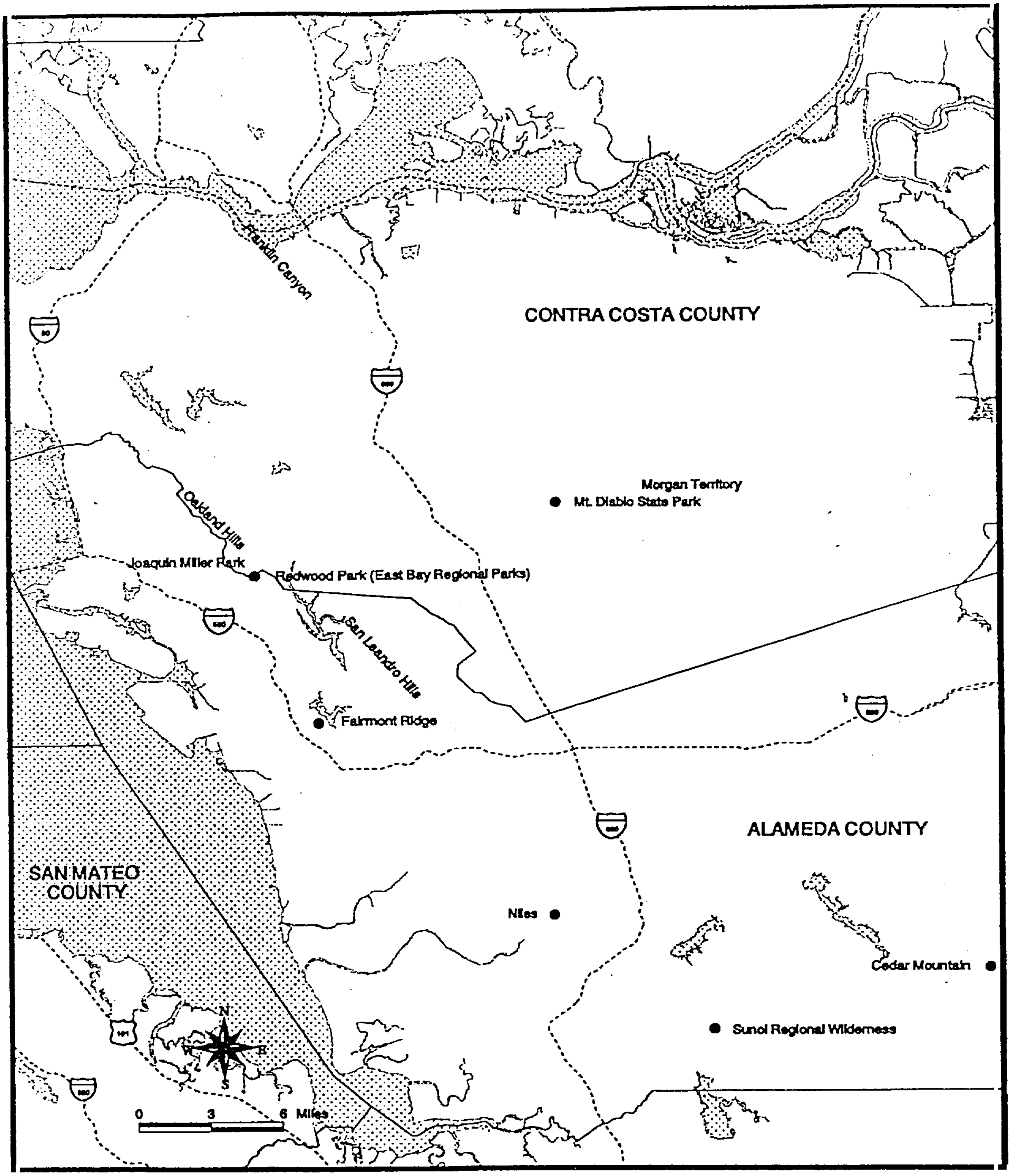


**Figure I-5.** Alameda and Contra Costa county geographic locations referred to in the plan.

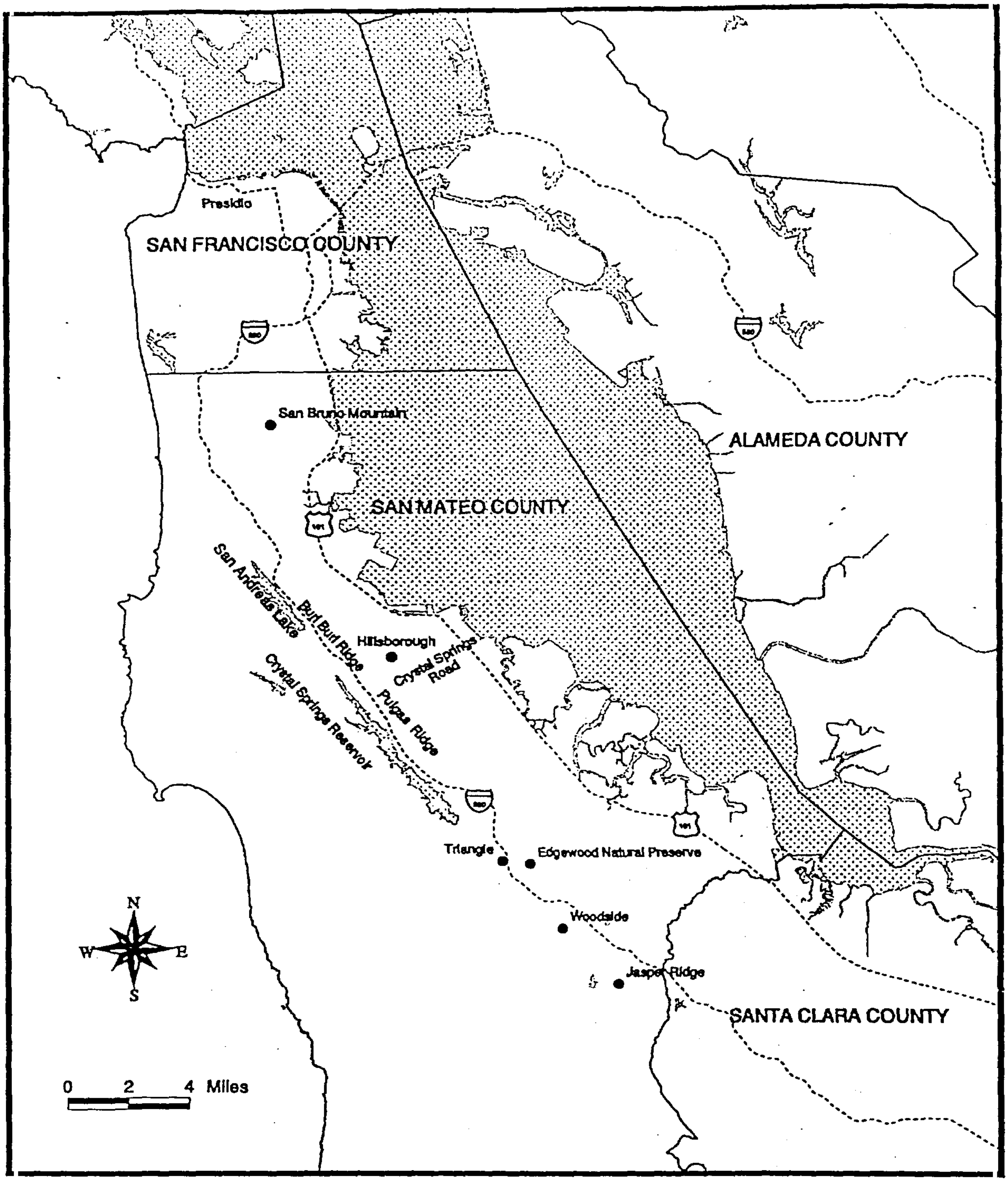


**Figure I-6.** San Francisco and San Mateo county geographic locations referred to in the plan.

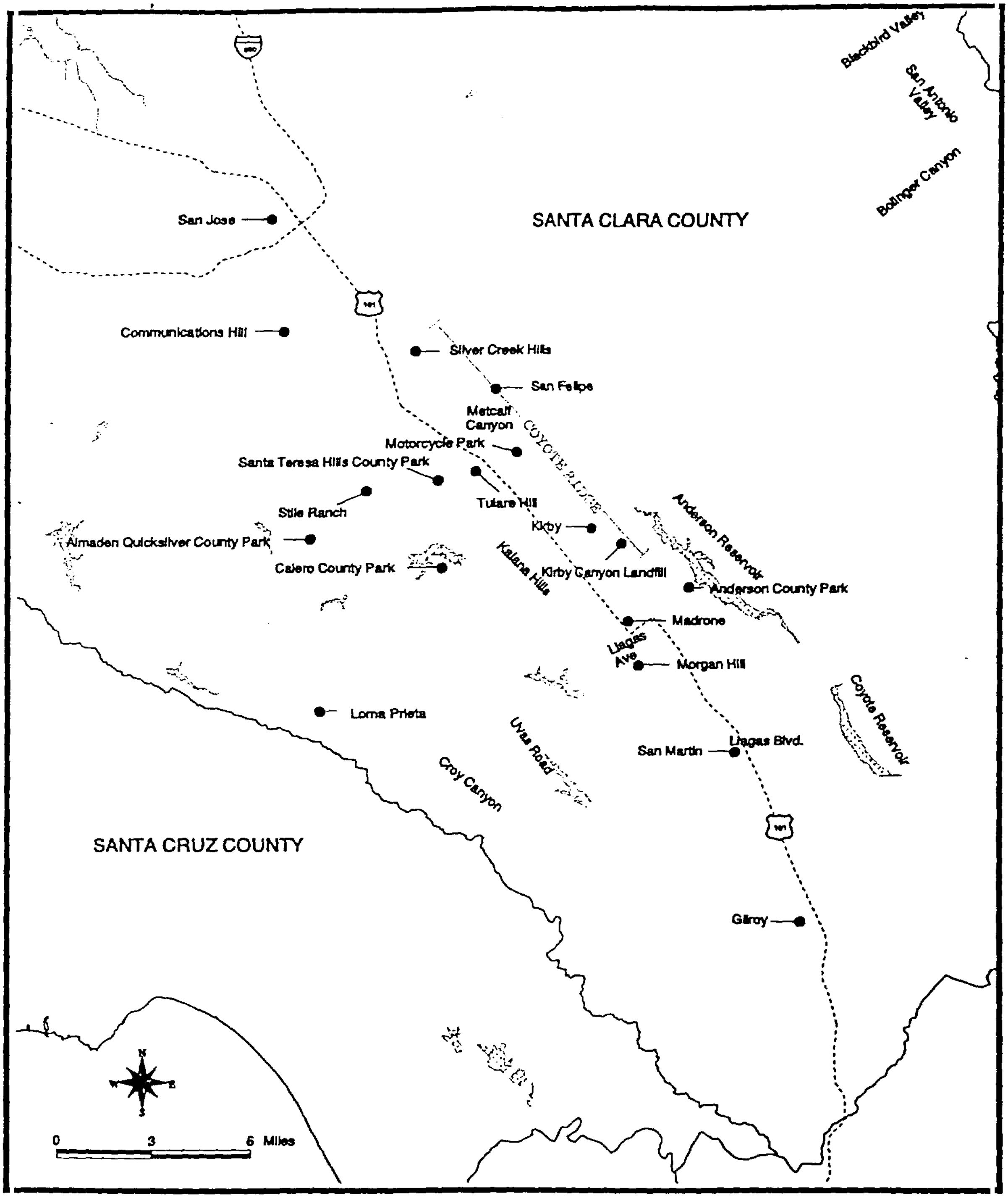


**Figure I-7.** Santa Clara County geographic locations referred to in the plan.

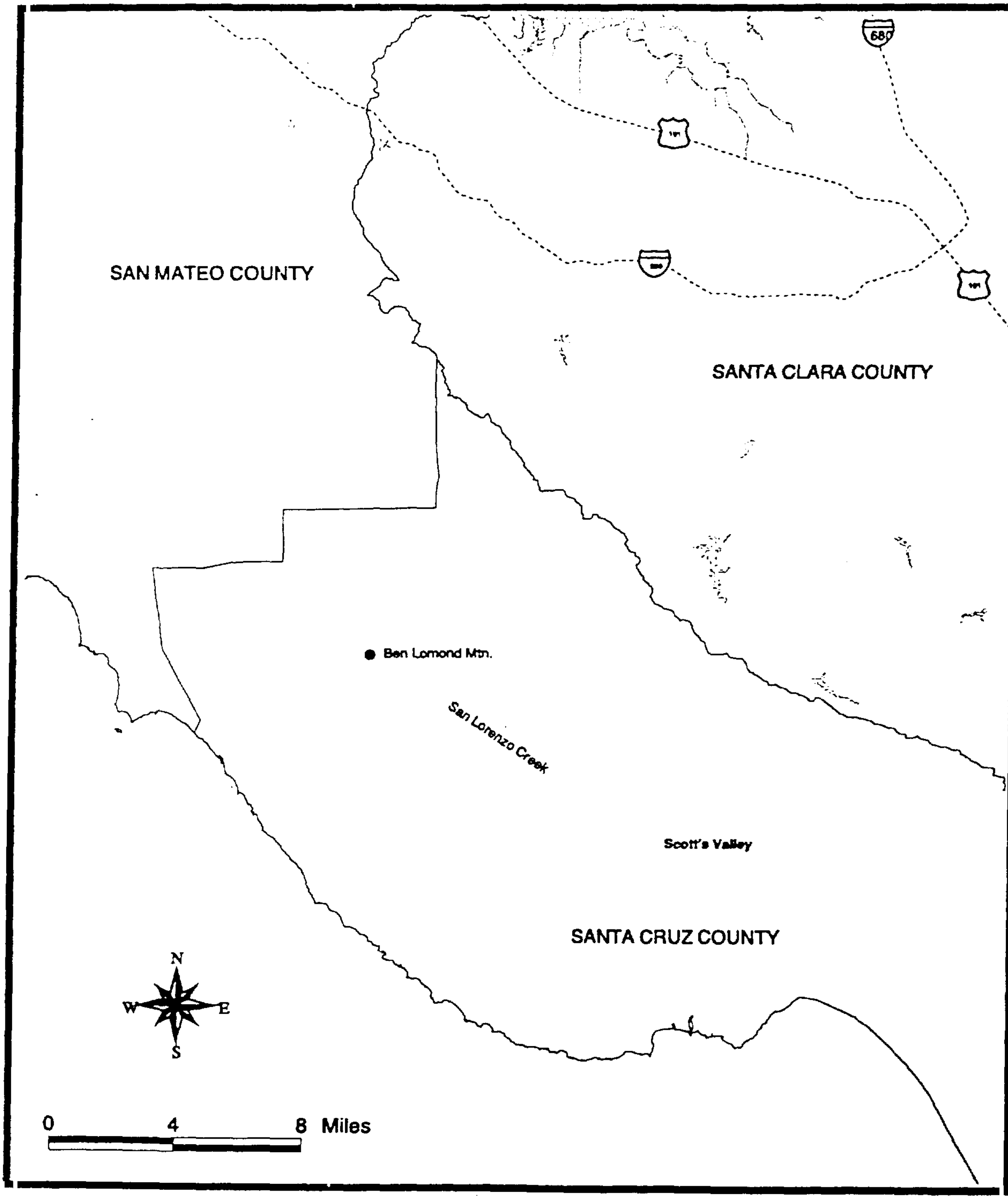


**Figure I-8**. Santa Cruz County geographic locations referred to in the plan.

within the State of California (Kruckeberg 1984*a*). Despite the high diversity of plant species that are known endemics on serpentine soils, serpentine environs support very little total plant biomass. Serpentine soils provide a harsh environment for plant growth. Several factors contribute to the inhospitability of serpentine soils to plant growth including: 1) a low calcium/magnesium ratio; 2) lack of essential nutrients such as nitrogen, potassium, and phosphorous; and 3) high concentrations of heavy metals (mineral toxicity) (Kruckeberg 1984*a*). Each of these factors is discussed in more detail below. These three factors and their effects on plant growth are a phenomenon California soil scientist Hans Jenny called the "serpentine syndrome." The lack of substantial vegetative cover in serpentine habitats results in increased ground level temperatures and heat and wind stress which further exacerbates the serpentine condition (Kruckeberg 1984*a*).

It has been argued that the limiting factor to plant growth on serpentine soils is the low calcium to magnesium ratio. Both elements are essential to plant growth. However, extremely high amounts of magnesium can be toxic to plants while calcium is essential to the development and stability of plant cell membranes and to enzyme activation (McCarten 1987*a*). Soils with a calcium-magnesium ratio greater than 2.0 are considered optimal for plant growth. Serpentine soils typically have a very low calcium to magnesium ratio around 1.0. McCarten (1986*a*) found that the calcium-magnesium ratio within San Francisco Bay Area serpentine soils ranged from 0.04 to 0.7 (i.e. the soils have extremely high concentrations of magnesium).

A second cause of poor plant growth on serpentine soils is the lack of the essential elements nitrogen, potassium and phosphorous. Nitrogen, potassium and phosphorous are the three most important elements for sustaining plant growth. These elements are essential to the production of chlorophyll, enzymes, amino acids, and DNA within plants (Brady 1990).

A third factor contributing to the exclusion of plants from serpentine soils is mineral toxicity. Serpentine soils contain large concentrations of some heavy metals that are toxic to plant life. Chromium and nickel have been cited as the primary heavy metals that are responsible for precluding plant growth on serpentine soils (Kruckeberg 1984*a*). However, data from a number of San Francisco Bay Area serpentine soils indicate broad variation in nickel and chromium levels and show that heavy metals are not present in high concentrations at all rare plant sites or in all serpentine soils (McCarten 1986*a*, 1988; N. McCarten, *in litt.*, 1998).

Despite the inhospitability of serpentine environments, many species are able to grow on serpentine soils. Species dominance and composition can vary considerably over short distances in serpentine grasslands. One study showed that species composition may be strongly correlated with serpentine soil factors, slope aspect, and soil depth (McCarten 1992*a*). There are three generally recognized affinities that plants have for serpentine soils; endemics, local indicators, and indifferent or bodenvag (not restricted to a specific type of substrate) species (Kruckeberg 1984*a*). Serpentine endemic plants grow exclusively on serpentine soils. Reasons for this have not been conclusively determined; however, there is strong evidence to suggest that competition with other common plants may be responsible. Kruckeberg (1954) performed several tests to determine if serpentine endemics could survive on nonserpentine soils. These tests showed that serpentine endemic *Streptanthus* was able to grow on nonserpentine soils when left to colonize the soil without competition (Kruckeberg 1954). However, when seeds from several weedy species such as mustard (*Brassica* sp.), filaree (*Erodium* sp.), perennial rye grass (*Lolium perenne* ssp. *perenne*), burclover (*Medicago polymorpha*), and wild oats (*Avena fatua*) were sown with *Streptanthus* seeds, *Streptanthus* was unable to establish itself (Kruckeberg 1954).

Local indicators are those plants that are able to grow on nonserpentine soils but utilize serpentine soils exclusively in certain geographical locations. Examples of local serpentine indicators include Jeffrey pine (*Pinus jeffreyi*) and incense cedar (*Calocedrus decurrens*) which are restricted to serpentine soils in the north coast range but grow in a variety of habitat types within the Sierra Nevada Mountains (Kruckeberg 1984*b*). In addition, nonwoody species such as Douglas' thistle (*Cirsium breweri*), sulphurflower buckwheat (*Eriogonum umbellatum* ssp. *bahiaeforme*), confusing fescue (*Festuca traci*), bristly jewelflower (*Streptanthus glandulosus* ssp. *glandulosus*), and spring deathcamas (*Zigadenus fontanus*) are local serpentine indicators for the Coast Ranges but are not restricted to serpentine habitats in other locations (Kruckeberg 1984*b*).

Indifferent or bodenvag species refers to those plants that are able to grow on serpentine and nonserpentine soils in the same location. Bodenvag species can be divided into two categories; species that are genotypically preadapted for growth on nonserpentine and serpentine substrates; and species with races that have locally adapted to serpentine environments while their nonserpentine counterparts are unable to grow on serpentine soils (Kruckeberg 1984*a*). Generally, the harsher the serpentine environment, such as the New Idria region of the southern Coast Range, the less likely that indifferent species will be present on serpentine soils (Kruckeberg 1984*a*).

Because of the harsh serpentine environment, many plant that have been able to establish on serpentine soils are quite rare and unique. Serpentine endemic plants have developed many genetic adaptations to tolerate the serpentine substratum. For example, some plant species, such as the milkwort jewelflower (*Streptanthus polygaloides*), are able to concentrate nickel in inordinate amounts (hyperaccumulate) which would be extremely toxic to most biotic life (Kruckeberg 1984*a*). Other serpentine endemics cope with heavy metal toxicity by blocking the accumulation of (excluding) these elements. Some plants, including some that hyperaccumulate or exclude heavy metals, are able to extract key elements such as calcium more efficiently than nonserpentine plants (Koenigs *et al.* 1982).

Serpentine plant species have developed distinctive morphological adaptations. Serpentine endemics typically exhibit xeromorphic foliage, which takes the form of hardened, waxy leaves and stems that are blue and reddish in color with altered pubescence. In addition, serpentine plants are more stunted or dwarfed than nonserpentine plants while their root systems are more developed (Kruckeberg 1984*a*).

Serpentine environments also support a number of endemic or nearly endemic invertebrates. Butterflies such as Muir's hairstreak (*Mitoura nelsoni muiri*) are restricted to serpentine habitats because their caterpillars feed exclusively on serpentine endemic plants such as Sargent cypress (*Cupressus sargentii*) (Harrison and Shapiro 1988). Another example of a serpentine endemic butterfly is the bay checkerspot butterfly (*Euphydryas editha bayensis*) whose primary larval host plant is *Plantago erecta*, an annual native plantain that is highly abundant on Bay Area serpentine soils. There are a number of harvestmen, arachnids that somewhat resemble spiders, in the genera *Microcina* and *Calicina* that are restricted to San Francisco Bay Area serpentine soils. These harvestmen are found exclusively on the undersides of moist rocks situated in serpentine soil grasslands. Horned larks (*Eremophila alpestris*), a California State species of special concern, commonly occur and breed in serpentine grassland habitats in the Bay Area. Both the California red-legged frog (*Rana aurora draytonii*), federally listed as threatened, and the California tiger salamander (*Ambystoma californiense*), a candidate for Federal listing, occur in habitats that may be near serpentine grasslands (D. Wright, U.S. Fish and Wildlife Service, pers. observ.).

**B. Species Represented**

Thirteen species of plants endemic to serpentine soils of the San Francisco Bay Area are federally listed as endangered or threatened. One federally listed threatened invertebrate species, the bay checkerspot butterfly, utilizes serpentine indicator host plants for oviposition (egg laying). This recovery plan also covers six species of plants and eight invertebrates that are Federal species of concern (See Table I-1 for a complete list of all species covered in this plan). Plant taxonomy in this plan generally follows Hickman (1993).

**Table I-1. Serpentine recovery plan species.**

| Scientific name | Common name | Status [1] | Recovery Priority[2] |
|---|---|---|---|
| **Listed Plant Species** | | | |
| *Acanthomintha obovata* ssp. *duttonii* | San Mateo thornmint | FE, SE | 6c |
| *Calochortus tiburonensis* | Tiburon mariposa lily | FT, ST | 14 |
| *Castilleja affinis* ssp. *neglecta* | Tiburon paintbrush | FE, ST | 8c |
| *Ceanothus ferrisiae* | Coyote ceanothus | FE | 14 |
| *Cirsium fontinale* var. *fontinale* | Fountain thistle | FE, SE | 3 |
| *Clarkia franciscana* | Presidio clarkia | FE, SE | 5 |
| *Cordylanthus tenuis* ssp. *capillaris* | Pennell's bird's-beak | FE, SR | 2 |
| *Dudleya setchellii* | Santa Clara Valley dudleya | FE | 2c |
| *Eriophyllum latilobum* | San Mateo woolly sunflower | FE, SE | 8 |
| *Hesperolinon congestum* | Marin dwarf-flax | FT, ST | 8c |
| *Pentachaeta bellidiflora* | White-rayed pentachaeta | FE, SE | 8 |
| *Streptanthus albidus* ssp. *albidus* | Metcalf Canyon jewelflower | FE | 3c |
| *Streptanthus niger* | Tiburon jewelflower | FE, SE | 2c |
| **Listed Animal Species** | | | |
| *Euphydryas editha* ssp. *bayensis* | Bay checkerspot butterfly | FT | 3c |
| **Plant Species of Concern** | | | |
| *Arctostaphylos bakeri* ssp. *bakeri* | Baker's manzanita | SR | |
| *Cirsium fontinale* var. *campylon* | Mt. Hamilton thistle | None | |
| *Lessingia arachnoidea* | Crystal Springs lessingia | None | |
| *Lessingia micradenia* var. *glabrata* | Smooth lessingia | None | |
| *Lessingia micradenia* var. *micradenia* | Tamalpais lessingia | None | |
| *Streptanthus albidus* ssp. *peramoenus* | Most beautiful jewelflower | None | |
| **Animal Species of Concern** | | | |
| *Adela oplerella* | Opler's longhorn moth | None | |
| *Calicina minor* | Edgewood blind harvestman | None | |
| *Calicina diminua* | Marin blind harvestman | None | |

| Scientific name | Common name | Status[1] | Recovery Priority[2] |
|---|---|---|---|
| *Microcina edgewoodensis* | Edgewood microblind harvestman | None | |
| *Microcina homi* | Hom's microblind harvestman | None | |
| *Microcina jungi* | Jung's microblind harvestman | None | |
| *Microcina lumi* | Fairmont microblind harvestman | None | |
| *Microcina tiburona* | Tiburon microblind harvestman | None | |

[1] Status: FE = federally endangered, FT = federally threatened, SE = State endangered, ST = State threatened, SR = State rare

[2] Recovery Priority: See Appendix C for how recovery priorities are assigned for listed species.

## C. Conservation Measures

Areas of serpentine habitat with permanent protection are relatively uncommon in the San Francisco Bay Area and throughout California in general (McCarten 1997, N. McCarten, *in litt.* 1998). Few active conservation efforts are underway to protect special status species in the relatively small amount of serpentine that exists in the greater San Francisco Bay Area. Most of the active conservation measures that are in place are in their infancy. Therefore, with the notable exception of the Presidio, site specific special status species management is in the formulation stage rather than the implementation stage. Specific conservation measures for individual species are covered within the Species Accounts section of this recovery plan. Highlighted here are the most significant serpentine management efforts currently underway in the Bay Area.

The Presidio, which occurs on the northwestern edge of the City of San Francisco, San Francisco County, is managed by the National Park Service. The Presidio is inhabited by populations of *Clarkia franciscana* and *Hesperolinon congestum*. The National Park Service has been actively managing the two Presidio plant populations since 1994. Annual censuses of all *Clarkia franciscana* populations and the single population of *Hesperolinon congestum* have been conducted since 1994. In 1995, fencing was erected to protect the largest population of *Clarkia* and the remaining population of *Hesperolinon*. In 1995 and 1996, several invasive Monterey pine (*Pinus radiata*) trees that grew adjacent to *Clarkia* habitat were removed. After the first year of tree removal, *Clarkia franciscana* was able to colonize the area vacated by the pine trees. Additionally, in 1995 and 1996, several Monterey cypress (*Cupressus macrocarpa*) trees that grew adjacent to *Hesperolinon* habitat were removed. The National Park Service is currently considering removal of invasive non-native grasses from serpentine habitats on the Presidio to reintroduce *Clarkia franciscana*. In addition, potential *Hesperolinon* reintroduction areas are being considered.

Kirby Canyon, which occurs south of Metcalf Road in Santa Clara County provides habitat for five listed species (bay checkerspot butterfly, *Castilleja affinis* ssp. *neglecta*, *Ceanothus ferrisiae*, *Dudleya setchellii* and *Streptanthus albidus* ssp. *albidus)* and three Federal species of concern (*Cirsium fontinale* var. *campylon*, *Lessingia micradenia* var. *glabrata* and *Streptanthus albidus* ssp. *peramoenus*). In 1986, Waste Management of California, Inc., and the City of San Jose entered into a conservation agreement with the U.S. Fish and Wildlife Service to mitigate impacts to bay checkerspot butterfly resulting from the construction of the Kirby Canyon landfill. This agreement concentrated construction of the landfill to lower quality bay checkerspot habitat areas. In addition, this agreement included a 15-year lease of 108 hectares (267 acres) of high quality bay checkerspot butterfly habitat and the establishment of a trust fund to finance a number of measures including the restoration of impacted bay checkerspot habitat, monitoring of bay checkerspot populations and their habitat on the site, and possible acquisition of additional bay checkerspot butterfly habitat. Unfortunately, the most significant portion of the agreement, the protection of 108 hectares (267 acres) of high quality habitat, will expire in less than 3 years.

Edgewood Nature Preserve is located within Redwood City, San Mateo County. This 59- hectare (147-acre) nature preserve is inhabited by populations of five listed taxa (*Acanthomintha obovata* ssp. *duttonii*, *Cirsium fontinale* var.

*fontinale*, *Hesperolinon congestum*, *Pentachaeta bellidiflora*, and bay checkerspot butterfly) and three species of concern (*Lessingia arachnoidea*, Edgewood blind harvestman, and Edgewood microblind harvestman). Efforts to approve the construction of a golf course in the park were unsuccessful in 1993, by virtue of a resolution designating the park as a natural preserve. The main goal of the natural preserve is to protect, preserve, and restore Edgewood's natural resources (San Mateo County 1997). San Mateo County adopted a master plan for the park in 1997. The master plan mandates that several general management techniques be implemented to protect the natural resources that occur there including regulating land use, classifying sensitive habitats, fencing sensitive buffers, education and enforcement (San Mateo County 1997). However, specific actions related to the management of special status species are not included.

Ring Mountain preserve was acquired by The Nature Conservancy in 1982 for the protection of several serpentine endemic plants including the federally-listed endangered *Castilleja affinis* ssp. *neglecta* and the federally-listed threatened *Calochortus tiburonensis* and *Hesperolinon congestum*. Ring Mountain is also inhabited by the Opler's longhorn moth, and Tiburon microblind harvestman, both invertebrate species of concern. Ring Mountain is located on the northern end of the Tiburon Peninsula, Marin County. The Nature Conservancy has actively monitored the three plant populations onsite since 1982. Fencing has been erected around the preserve to deter off-road motorists (C. Bramham, pers. comm., 1996). In 1995, The Nature Conservancy transferred the property to Marin County Open Space District. A conservation easement was placed on Ring Mountain by The Nature Conservancy before its transfer to Marin County Open Space District. The conservation easement requires that the property shall remain as a natural area in perpetuity. The Nature Conservancy transferred the property with the understanding that Marin Open Space District would continue to monitor special status plant populations (L. Serpa, pers. comm., 1996). As of October 15, 1997, Marin County Open Space District has not developed a monitoring plan for the site and is relying upon The Nature Conservancy and California Native Plant Society to monitor special status species (C. Bramham, pers. comm., 1996).

On June 27, 1985, the California Department of Fish and Game acquired the Harrison Grade Ecological Reserve to protect populations of Baker's manzanita (*Arctostaphylos bakeri*) and other serpentine endemic plant populations including federally-listed endangered and state-listed rare *Cordylanthus tenuis* ssp. *capillaris* (McCarten 1987*b*). The reserve is located west of Santa Rosa, along Highway 116, in Sonoma County. In 1987, a management plan was prepared for the reserve. To protect the sensitive plant species, including the *Cordylanthus* population, from chronic off-road vehicle use, the site was partially fenced in 1987 (McCarten 1987*b*). Additional roadside fencing was constructed along the east side of the reserve in 1994 and 1995 (T. LaBlanc, pers. comm., 1997). Several additional management goals were proposed in the 1987 management plan for the site, but have not been implemented as of April 1997 (T. LaBlanc, pers. comm., 1997). These include litter removal, development of a new parking area and enhancement of the existing trail system.

# II. SPECIES ACCOUNTS

## A. San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii* = *Acanthomintha duttonii*)

### 1. Description and Taxonomy

***Taxonomy***. - *Acanthomintha obovata* ssp. *duttonii* (San Mateo thornmint) was first collected by H.A. Dutton in 1900 (Abrams 1951). In 1925, Jepson placed what is now *Acanthomintha obovata* ssp. *duttonii* in *Acanthomintha lanceolata* (Jepson 1925, Thomas 1984). Jepson (1943), however, considered the San Mateo County plants to be a hairy, serpentine form of *Acanthomintha ilicifolia*. Abrams (1951) first described the plants as a separate entity, placing the San Mateo County plants in *Acanthomintha obovata* Jepson ssp. *duttonii*. Jokerst (1991) elevated subspecies *duttonii* to full species status (*Acanthomintha duttonii*).

***Description***. - *Acanthomintha obovata* ssp. *duttonii* (Figure II-1) is an aromatic (strong-scented) annual herb of the mint family (Lamiaceae). The 4 to 20 centimeters (1.6 to 7.9 inches) high plants are typically unbranched, though most populations contain some plants branched from near the base. The plants have squarish stems and opposite leaves. The leaves are 8 to 12 millimeters (0.3 to 0.5 inch) long and are oblong to egg-shaped and may have toothed margins (Jokerst 1991, Hickman 1993). The flowers are white or sometimes tinged with lavender and occur in tight clusters surrounded by almost round prominently spined bracts (California Native Plant Society 1986). Bracts are small leaf- or scale-like structures associated with an inflorescence (Hickman 1993) .

No other species with an appearance similar to *Acanthomintha obovata* spp. *duttonii* occur within the range of San Mateo thornmint (California Native Plant Society 1986). San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii* = *Acanthomintha duttonii*) is most closely related to *Acanthomintha obovata* (San Benito thornmint) and *Acanthomintha ilicifolia* (San Diego thornmint). It differs from *Acanthomintha obovata* and other species in the genus in lacking needlelike spines on the margins of the upper leaves, in having pink-red anthers (male reproductive flower parts), and in its generally unbranched habit with a solitary

**Figure II-1.** Illustration of San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii* = *A. duttonii*) (from Abrams 1951, with permission).

head-like flower cluster per stem (Jokerst 1991).

## 2. Historical and Current Distribution

***Historical Distribution.*** - San Mateo thornmint is endemic to San Mateo County (Figure II-2). The species was never collected outside a narrow strip approximately 10 kilometers (6 miles) long from Woodside north to Lower Crystal Springs Reservoir (Thomas 1961, Jokerst 1991). Because collection locations on early herbarium specimens are vague, the number of historic populations is unclear (Steeck 1995). Three historical occurrences (Menlo Golf Club, Emerald Lake, and Upper Crystal Springs Reservoir) have been extirpated (California Natural Diversity Data Base 1996). An occurrence is defined by the California Natural Diversity Data Base as a location separated from other locations of the species by at least one-fourth mile; an occurrence may contain one or more populations.

***Current Distribution.*** - San Mateo thornmint is known from only two extant (currently existing, not extirpated or destroyed) natural occurrences and one introduced population (California Native Plant Society 1996, N. McCarten, pers. comm., 1996, California Department of Fish and Game 1997*a*). The two natural populations are separated by approximately 1 kilometer (0.6 mile) in Edgewood County Park and adjacent to the park in an area called the "Triangle" (Jokerst 1991, California Natural Diversity Data Base 1996). The only remaining large population, in Edgewood County Park, is a remnant of a more extensive population that was damaged by motor-vehicle use. Edgewood County Park also contains a small subpopulation about 100 meters (328 feet) downslope from the main population (Steeck 1995). The introduced population is at Pulgas Ridge (Pavlik and Espeland 1993, 1994, Pavlik *et al.* 1992).

## 3. Life History and Habitat

***Reproduction and Demography.*** - San Mateo thornmint is an annual herb, living less than 1 year and completing the entire life cycle from seed germination to seed production in a single growing season. Flowers appear from April

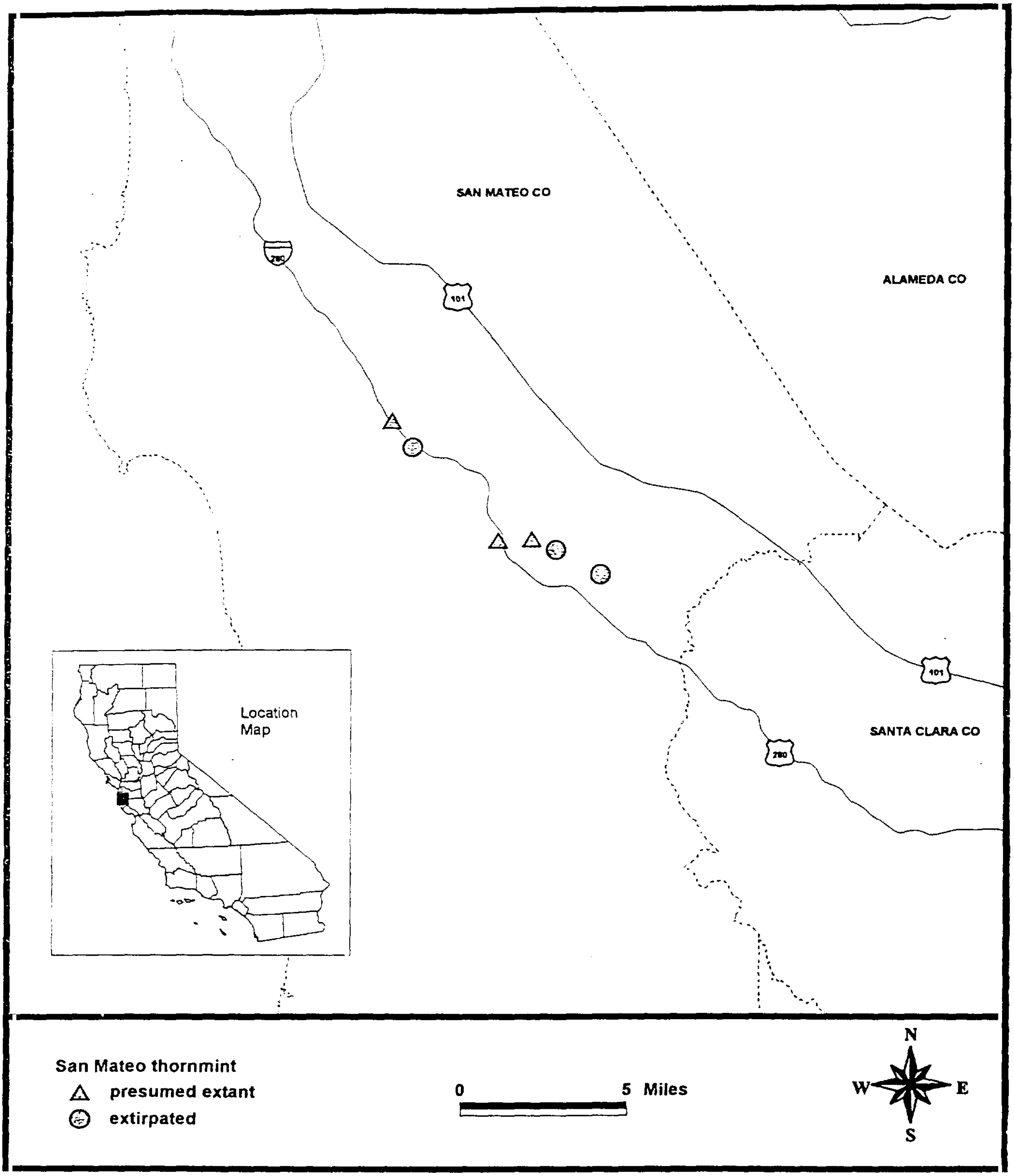


**Figure II-2.** Distribution of San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii* = *A. duttonii*).

through June or July (Thomas 1961, Skinner and Pavlik 1994). Flowers on the lower whorls (groups of flowers) typically open first with flowering proceeding from the center of the whorl (adjacent to the stem) outward. Opening 3 to 5 hours after sunrise, the flowers remain open for 2 to 4 days (Steeck 1995).

*Acanthomintha obovata* ssp. *duttonii* is thought to be insect-pollinated (McCarten 1986*b*, Pavlik and Espeland 1991, Steeck 1995) although no specialized pollinators have been observed (D. Steeck, pers. comm., 1996). Generalist pollinators are likely to include native bees from the families Apidae (bumble bees, honey bees, euglossine bees), Anthophoridae (cuckoo bees, digger bees, carpenter bees), and Megachilidae (leafcutting bees). While flower visitors to *Acanthomintha obovata* ssp. *duttonii* were generally sparse, bumble bees (*Bombus vosnesenskii* and *Bombus californicus*) were the most common and consistent pollinators observed in Steeck's 1993-1994 study (Steeck 1995). *Bombus* (bumble bees), *Osmia* (leafcutting bees), and *Synalonia* (no common name) foraged primarily for nectar and only collected pollen that adhered to their bodies during foraging bouts. In contrast, individuals of the genus *Andrena* (no common name) actively removed pollen from the anthers of *Acanthomintha obovata* ssp. *duttonii* (Steeck 1995).

Although *Acanthomintha obovata* ssp. *duttonii* possesses traits typical of outcrossing plants (open, colorful, nectar-producing flowers), the species also has traits that permit self-pollination and lead to inbreeding. These traits include: (1) the release of pollen at the beginning of, or just prior to, flower anthesis (opening), (2) the presence of receptive stigmas (female reproductive flower parts) at the time of pollen release, and (3) the lack of spatial separation between the anthers and the stigma. The hand pollination and isolation treatments of Steeck (1995) show that *Acanthomintha obovata* ssp. *duttonii* is self-compatible (capable of self-fertilization) and capable of autogamy (self-pollination in the absence of pollinators). Self-compatibility and autogamy along with relatively few visits from pollinators suggest that reproduction in *Acanthomintha obovata* ssp. *duttonii* involves high levels of inbreeding. However, progeny produced as a result of self-pollination did not show any evidence of inbreeding depression when seeds were germinated and seedlings grown in artificial (growth chamber and glasshouse) conditions. Later stages of the life cycle, when inbreeding depression could also be expressed, were not observed (Steeck 1995).

Pavlik and Espeland (1991, 1993, 1994) and Pavlik *et al.* (1992) have monitored seed (nutlet) production, survivorship (the probability that a representative newly born individual will survive to various ages), and population size and area at the Edgewood Park population. The park contains several groups of plants about 90 meters (100 yards) apart. Pavlik and Espeland conducted their research at the one relatively stable, large group of plants (B. Pavlik, pers. comm., 1996). They also studied germination behavior of *Acanthomintha obovata* ssp. *duttonii* nutlets in the laboratory and the greenhouse.

Individual plants of *Acanthomintha obovata* ssp. *duttonii* can produce large numbers of seeds (nutlets). In each year they surveyed, Pavlik and Espeland (1991, 1993, 1994) and Pavlik *et al.* (1992) found a statistical relationship between the number of nutlets produced by an individual plant and both the sum of the stem lengths and the number of glomerules (compact flower clusters) for that plant. This means that it might be possible to monitor nutlet production using non-destructive measures (Pavlik and Espeland 1991). The estimated nutlet output (number of nutlets per square meter = number of nutlets per 10.8 square feet) at Edgewood Park ranged from approximately 10,000 nutlets per square meter in 1990 (Pavlik *et al.* 1992) to 37,000 nutlets per square meter in 1993 (Pavlik and Espeland 1993). Survival of plants (survivorship) until reproduction was more than 50 percent in each year measured (Pavlik and Espeland 1991, 1993, 1994, Pavlik *et al.* 1992). Pavlik and Espeland (1994) feel that the observed high fecundity (production of offspring) and survivorship indicate that the potential for continued population growth exists at Edgewood Park.

Pavlik and Espeland's (1991) work suggests that the nutlets require 6 months of dormancy (with suspended growth, development, or other biological activity; inactive or resting) after production to germinate. In their studies, germination in the greenhouse on native soil was 35 percent and in the lab was 87 percent one year and 63 percent the next. *Acanthomintha obovata* ssp. *duttonii* was the only one of three *Acanthomintha* species to germinate, grow, and flower on serpentine soil. The other two species tested were San Diego thornmint (*Acanthomintha ilicifolia*) and Santa Clara thornmint (*Acanthomintha lanceolata*) (Pavlik and

Espeland 1991). Germination tests conducted by Steeck suggest that a high percentage of *Acanthomintha obovata* ssp. *duttonii* seeds can remain viable for at least 2.5 years under the proper conditions (D. Steeck, *in litt.*, 1996). However, factors such as local climate, soil, and herbivory may profoundly influence germination rate, seedling establishment, and survivorship in nature. For this reason, laboratory and greenhouse studies of *Acanthomintha obovata* ssp. *duttonii* should be supplemented by field studies (N. McCarten, *in litt.*, 1998). The disappearance and subsequent reappearance of two subpopulations at Edgewood Park suggests the presence of a soil seed bank (viable dormant seeds that accumulate in or on the soil) (B. Pavlik, pers. comm., 1996).

Variation in population area at Edgewood Park was observed from the late 1970's into the early 1980's by Suzanne Sommers (1984, 1986). The population area was approximately 42 square meters (452 square feet) in 1990 and 1991, and approximately 69 square meters (742 square feet) in 1992 to 1994 (Pavlik and Espeland 1991, 1993, 1994, Pavlik *et al.* 1992). In 1992, the population expanded downslope by approximately 4.4 meters (14.5 feet), perhaps due to nutlets being carried by storm runoff to the unoccupied area. This expanded the population area by 40 percent (Pavlik *et al.* 1992). The most recent estimates of total number of reproductive individuals in the Edgewood Park population range from 9,660 in 1991 to 53,136 in 1994 (Pavlik and Espeland 1994). The population size dropped to 20,931 in 1995 and again in 1996 (no estimate available for 1996) (B. Pavlik, pers. comm., 1996). Pavlik feels that the Edgewood population may undergo fairly regular cycles of growth and decline; in his opinion, these cycles do not correlate with expected environmental cues such as temperature and precipitation (California Department of Fish and Game 1997*a*).

Since its discovery in the late 1980's, the Triangle population has typically contained fewer than 100 plants (Steeck 1995), having fewer than 20 plants in 1987 (California Natural Diversity Data Base 1996), 34 plants in 1994, and 23 plants in 1995 (D. Steeck, *in litt.*, 1996). The plants observed in 1994 and 1995 occupied an area of no more than 0.2 square meter (2.2 square feet) (Steeck 1995). Most of the plants were small and unlikely to produce many flowers (D. Steeck, *in litt.*, 1996). The Triangle site may have always been composed of few individuals (B. Pavlik, pers. comm., 1996), but soil characteristics suggest that the Triangle contains unoccupied, but potential habitat (California Department of Fish and Game 1997*a*).

***Habitat and Community Associations***. - *Acanthomintha obovata* ssp. *duttonii* is endemic to serpentine soils of chaparral and valley and foothill grassland in San Mateo County (California Native Plant Society 1986, Skinner and Pavlik 1994). The species occupy slopes and flats with deep, heavy-clay soil inclusions (Jokerst 1991). The specific soil habitat in which *Acanthomintha obovata* ssp. *duttonii* occurs is apparently extremely limited (N. McCarten, *in litt*., 1998). The species appear to grow on clays deposited in localized fissures that may be very deep (over 10 meters (32.8 feet) deep at the Triangle site). The soils in the fissures have been characterized by McCarten (*in litt*., 1998) as "serpentine vertisols", a soil not known from California soil surveys. The deep clay soils appear to have a low calcium/magnesium ratio (due to low levels of calcium along with high levels of magnesium), high percent moisture (with a broad range between field capacity and permanent wilting point), and high cation exchange capacity (McCarten 1986*a*). More typical rocky serpentine soil surrounds the areas. The Edgewood Park site also supports annual agoseris (*Agoseris heterophylla*), bull clover (*Trifolium fucatum*), checker mallow (*Sidalcea malvaeflora*), cream sacs (*Castilleja rubicunda* ssp. *lithospermoides*), exserted owl's-clover (*Castilleja exserta*), Italian ryegrass (*Lolium multiflorum*), purple needlegrass (*Nassella pulchra*), royal larkspur (*Delphinium variegatum*), trefoils (*Lotus micranthus* and *L. wrangelianus*), white globe lily (*Calochortus albus*), and yellowflower tarweed (*Holocarpha virgata*) (Jokerst 1991). Also, at Edgewood Park, the species may be associated with fragrant fritillary (*Fritillaria liliacea*), a species of concern (California Native Plant Society 1986). At the Triangle site, San Mateo thornmint occurs with big squirreltail (*Elymus multisetus*) and in the vicinity of two federally listed endangered plants, white-rayed pentachaeta (*Pentachaeta bellidiflora*) and fountain thistle (*Cirsium fontinale* var. *fontinale*) (California Natural Diversity Data Base 1996).

### 4. Reasons for Decline and Threats to Survival

The range of *Acanthomintha obovata* ssp. *duttonii* is limited by its rare and specific habitat (N. McCarten, *in litt*., 1998). Most suitable habitat has been destroyed by urbanization (California Native Plant Society 1986). Urbanization extirpated two populations (California Department of Fish and Game 1997*a*) , and road construction may have destroyed a third (California Natural Diversity Data Base 1996).

The extant populations are threatened by development, vehicles, and vandalism (California Natural Diversity Data Base 1996). The Edgewood Park population is on land owned by San Mateo County. The park has been designated a natural preserve. San Mateo County has adopted a Master Plan for Edgewood (San Mateo County 1997). It is possible that some disturbance could result from changes implemented as a result of the plan, but no decisions about specific actions have been made at this time, and San Mateo County personnel are aware of the population. Currently, development-related threats to this population appear to be indirect (D. Steeck, *in litt*., 1996). The population is approximately 45 meters (50 yards) downslope from a residential development (B. Pavlik, pers. comm., 1996) and used to be more broadly distributed on the slope prior to the expansion of the subdivision. Hydrologic changes have probably been caused by upslope house and road construction (D. Steeck, *in litt*., 1996). Vandalism and off-road vehicle damage have also occurred (Sommers 1986, California Natural Diversity Data Base 1996, D. Steeck, *in litt*., 1996). Recreational disturbance still occurs in the area (B. Pavlik, pers. comm., 1996), and some believe that trail development is a threat (C. Curtis, *in litt*., 1998). *Acanthomintha obovata* ssp. *duttonii* at Edgewood County Park could also easily be eliminated were a fire to occur in its vicinity and construction of a fire line and/or use of heavy equipment occurred on the slope occupied by the species (D. Steeck, *in litt*., 1996).

The Triangle population is on land managed by the San Francisco Water Department. At one time, the Department had fenced the site and was protecting against the use of pesticides (California Natural Diversity Data Base 1996). As discussed in the Species Accounts for fountain thistle (*Cirsium fontinale* var. *fontinale*), Marin dwarf-flax (*Hesperolinon congestum*), and white-rayed pentachaeta (*Pentachaeta bellidiflora*), proposed trail construction on San Francisco Water Department lands in the Triangle could threaten rare plants in the area, including San Mateo thornmint.

Because *Acanthomintha obovata* ssp. *duttonii* is currently limited to only one substantial population that occupies less than 60 square meters (645 square feet) in Edgewood County Park, the species is highly susceptible to chance events (Menges 1991, Primack 1993, Meffe and Carroll 1994, Steeck 1995). An event that substantially damaged the Edgewood County Park population could prove disastrous for survival of the species as a whole (Steeck 1995).

### 5. Conservation Efforts

*Acanthomintha obovata* ssp. *duttonii* was listed as endangered by the State of California in 1979 (California Department of Fish and Game 1992) and was federally listed as endangered in 1985 (U.S. Fish and Wildlife Service 1985). The larger of the two remaining populations occurs in Edgewood Park which San Mateo County intends to manage as a natural preserve. The County has recently adopted a master plan to guide future activities in the park. San Mateo County personnel are aware of the special status plant species at Edgewood, but details of whether and how the County will manage the species are not yet available (San Mateo County 1997). The San Francisco Water Department has no specific management goals for rare plants at this time (California Department of Fish and Game 1997*a*).

Research funded by the California Department of Fish and Game and the U.S. Fish and Wildlife Service on introduction of *Acanthomintha obovata* ssp. *duttonii* has been conducted by Pavlik and Espeland and Pavlik *et al.* since 1990 at Pulgas Ridge. Pulgas Ridge was chosen for three reasons: (1) it was thought to have high quality habitat (i.e. mesic [with a moderate amount of moisture] grassland on serpentine clay soil), (2) it has public status as land operated by the San Francisco Water Department, and (3) it is close to, or within, the historic range of *Acanthomintha obovata* ssp. *duttonii* (Pavlik *et al.* 1992).

In 1991, seeds collected from Edgewood Park in May, 1990, and June, 1991, were sown at Pulgas Ridge in two subpopulations (one north-facing and one south-facing). The seeds were taken from plants that represented the range of sizes and microenvironments of plants in the natural population. This sampling scheme was used to increase the chance of getting a representative sample of the genetic variation in the Edgewood population. The first year, 27 percent (315 of 1,175) of the seeds sown produced seedlings. Of these 315 seedlings, 120 plants (10 percent of the seeds sown) survived to produce fruit. Survival to reproduction was higher at the south-facing subpopulation (44 percent) than at the north-facing subpopulation (29 percent) (Pavlik *et al.* 1992). The introduced population produced plants in each subsequent year (Pavlik and Espeland 1993, 1994) and had 77 plants in 1996 (B. Pavlik, pers. comm., 1996). Since 1995, when Pavlik and Espeland stopped adding new seeds, the population size has declined, suggesting that the introduction effort has not been successful. However, the population does contain some plants that are reproducing, and second-, third-, and fourth-generation plants have been observed (California Department of Fish and Game 1997*a*).

Pavlik feels that there are some critical pieces of information we lack about *Acanthomintha obovata* ssp. *duttonii*. For example, we do not understand the soil seed bank dynamics of the species. Pavlik suspects that there is an interaction between the seeds (nutlets) and the soil chemistry which influences germination, that unique environmental cues are involved in causing the seeds to germinate, and that there is a timing mechanism that controls dormancy as well (B. Pavlik, pers. comm., 1996).

### 6. Recovery Strategy

Recovery of *Acanthomintha obovata* ssp. *duttonii* must first focus on protecting and managing the two remaining populations by working with San Mateo County and the San Francisco Water Department to ensure the long-term survival of the species on their lands. This should involve protection of the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Acanthomintha obovata* ssp. *duttonii* and other special status species in these locations must be developed and implemented. Ideally, standardized annual monitoring of *Acanthomintha obovata* ssp. *duttonii* populations should be incorporated into the plans. This would help determine demographic trends and test Pavlik's hypothesis that *Acanthomintha obovata* ssp. *duttonii* populations undergo regular cycles of growth and decline (California Department of Fish and Game 1997*a*). However, because it has the potential to damage plants or habitat, intensive monitoring should be done with caution, perhaps at the end of the flowering period and when soils have dried out (N. McCarten, *in litt.*, 1998). The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from recreational activities must be eliminated and a strategy to minimize impacts to the species during fire suppression activities (e.g. bulldozing of fire lines) must be developed. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Because the largest remaining natural population of *Acanthomintha obovata* ssp. *duttonii* occurs at Edgewood Natural Preserve, a public park adjacent to a housing development, any management plan developed for Edgewood should include an educational outreach program. First priority ought to be given to protection and management of the two remaining natural populations, one at Edgewood Natural Preserve and one in the Triangle. Protection of the Edgewood Natural Preserve and the Triangle will also benefit other species covered in this plan (bay checkerspot butterfly [*Euphydryas editha bayensis*], fountain thistle [*Cirsium fontinale* var. *fontinale*], Marin dwarf-flax [*Hesperolinon congestum*], white-rayed pentachaeta [*Pentachaeta bellidiflora*]), as well as fragrant fritillary (*Fritillaria liliacea*), a species of concern. Second priority should be protection and management of the introduced population at Pulgas Ridge.

Another high priority in recovery efforts for *Acanthomintha obovata* ssp. *duttonii* is collection and banking of seed in Center for Plant Conservation certified botanic gardens (Pavlik and Espeland 1991, D. Steeck, *in litt.*, 1996). Although some seed has already been stored (California Department of Fish and Game 1997*a*), further collections are prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations (returns to locations formerly occupied), and/or introductions to new sites. In the absence of genetic data for *Acanthomintha obovata* ssp. *duttonii*, seed collection efforts should first focus on the larger population at Edgewood Natural Preserve but should not neglect the smaller Triangle population. The larger population is likely to contain higher levels of genetic variation than the smaller one, but the small population may contain high frequencies of rare alleles if its genetic composition has been influenced by genetic drift. Therefore, collecting from both populations increases the likelihood that species level genetic variation will be represented in the collections (Elam in prep). Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection of and seed collection from the remaining populations of *Acanthomintha obovata* ssp. *duttonii*, historic locations should be surveyed to determine whether suitable habitat remains, the species persists at the sites, and/or the sites may be suitable for repatriation. Suitability for repatriation would depend upon (1) whether potential habitat exists, (2) the presence and magnitude of threats, and (3) whether the sites can be secured and managed for the long-term protection of the species. At least two historic sites are unlikely to contain suitable habitat because of local urbanization (California Natural Diversity Data Base 1996, California Department of Fish and Game 1997*a*). Surveys should also include other potential serpentine habitat such as in the Crystal Springs area (California Department of Fish and Game 1997*a*) to determine whether undiscovered populations may exist. At least some of these surveys would require the cooperation of the San Francisco Water Department because potentially suitable habitat occurs on their land. McCarten (*in litt.*, 1998) feels that the specific habitat of *Acanthomintha obovata* ssp. *duttonii* can be identified if attention is given to soils ecology and subtle variations in soil conditions. Based on field observations of rare soil conditions, the precise location of the known occurrence at the Triangle was identified as potential habitat for *Acanthomintha obovata* ssp. *duttonii* before the species was found there (McCarten 1986*b*, N. McCarten, *in litt.*, 1998). If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Other important, but lower priority recovery activities for *Acanthomintha obovata* ssp. *duttonii* are experimental reseeding or planting of the upslope portions of the Edgewood population, as well as experimental burning and weeding in plots adjacent to the population at Edgewood (California Department of Fish and Game 1997*a*). The latter experiments would address the question of whether the populations might expand into suitable habitat that has been made available by burning or weeding. If *Acanthomintha obovata* ssp. *duttonii* moves into and persists in treated areas, burning or weeding might be appropriate strategies to encourage expansion of existing populations. Any experimental burning or weeding ought to be initially limited to a very small area (e.g., 1 square meter [10.8 square feet]). Other research needs for *Acanthomintha obovata* ssp. *duttonii* include investigations of soil seed bank dynamics, characterization of what constitutes optimal habitat (Pavlik *et al.* 1992), estimation of genetic structure of the populations, and pollination biology (Steeck 1995). Because of the extremely limited habitat and vulnerability to disturbance of the species, potential adverse effects on *Acanthomintha obovata* ssp. *duttonii* populations should be evaluated prior to any research activities. Protection of *Acanthomintha obovata* ssp. *duttonii* should be the first priority, and research that would adversely affect the species should not be conducted (N. McCarten, *in litt.*, 1998).

If five populations (including the remaining two natural populations and the introduced population) of *Acanthomintha obovata* ssp. *duttonii* are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity, (2) shown to be self-sustaining over a minimum of 20 years that include the normal precipitation cycle (or longer depending on whether the data continue to suggest large, cyclical fluctuations in population size are characteristic of the species), (3) seed collected from both remaining natural populations is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Meeting this goal would require locating, restoring, and/or successfully introducing two new populations. Because Pavlik and Espeland (1991, 1993, 1994) and Pavlik *et al.* (1992) had limited success introducing a new population of *Acanthomintha obovata* ssp. *duttonii,* and because repatriation (restoring to the place of origin) and introduction of populations is expensive and experimental (Falk *et al.* 1996), surveying historic sites and potential habitat within the historic range to locate currently unknown populations is preferred. Introduction of additional populations should probably not be considered for *Acanthomintha obovata* ssp. *duttonii* until data suggest that attempts are more likely to be successful (N. McCarten, *in litt.*, 1998). That introducing or creating new populations of *Acanthomintha obovata* ssp. *duttonii* is time-intensive and experimental is exemplified by the attempts of Pavlik and Espeland (1991, 1993, 1994) and Pavlik *et al.* (1992) to introduce a large, self-sustaining population of *Acanthomintha obovata* ssp. *duttonii*. It remains to be seen whether the introduced population will be self-sustaining now that Pavlik and Espeland have discontinued yearly input of nutlets (California Department of Fish and Game 1997*a*). Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993).

The above downlisting criteria constitute a significant improvement in the protection, management, and population size of *Acanthomintha obovata* ssp. *duttonii* throughout its range. Completing these actions would substantially increase the security of the species. However, *Acanthomintha obovata* ssp. *duttonii* should not be considered for delisting because of its location in an area that is highly developed and because of the limited success of attempts to introduce the species.

## B. Tiburon mariposa lily (*Calochortus tiburonensis*)

### 1. Description and Taxonomy

***Taxonomy.*** - Robert West discovered *Calochortus tiburonensis* (Tiburon mariposa lily) in 1971 on Ring Mountain on the Tiburon Peninsula in Marin County, California. Albert Hill collected the type specimen (a specimen or series of specimens chosen when the taxon is described and considered representative of the species, subspecies, or variety) on Ring Mountain the following year, and published the description in 1973 (Hill 1973). A taxon (plural = taxa) is a group that is sufficiently distinct to be considered a separate unit, for example a family, species, subspecies, or variety.

***Description.*** - *Calochortus tiburonensis* (Figure II-3) is a member of the lily family (Liliaceae) with a single persistent, basal, linear-oblong leaf 30 to 60 centimeters (1 to 2 feet) long. The flowering stem, about 50 centimeters (20 inches) tall, is usually branched and bears erect flowers in two's or three's at the ends of the branches. The three petals and three sepals (individual members of the outermost whorl or set of flower parts) are light yellow-green with reddish or purplish-brown markings. The capsule (dry fruit, generally with many seeds) is triangular in cross-section, and about 4 centimeters (2 inches) long (Hill 1973). The long slender hairs on the upper surface and margins of the petals and the lack of wings on the capsule distinguish *Calochortus tiburonensis* from the other two *Calochortus* species that are also found on the Tiburon Peninsula (Oakland star-tulip [*Calochortus umbellatus*] and yellow mariposa lily [*Calochortus luteus*]) (Hickman 1993).

## 2. Historical and Current Distribution

***Historical and Current Distribution.*** - *Calochortus tiburonensis* is known only from Ring Mountain, its type locality, on the Tiburon Peninsula in southern Marin County (Figure II-4). The type locality is the exact geographic location from which the specimen(s) used to describe the taxon were collected. The Ring Mountain population of *Calochortus tiburonensis* occurs on land that was owned and managed by The Nature Conservancy between 1982 and 1995. The property was transferred to Marin County Parks and Open Space in 1995 (California Natural Diversity Data Base 1996).

## 3. Life History and Habitat

***Reproduction and Demography.*** - *Calochortus tiburonensis* is a bulbous perennial (persisting or living for several years with a period of growth each year). Individuals are thought to live 10 years or more (P. Fiedler, pers. comm., 1996). The basal leaf appears above ground after the onset of winter rains (Fiedler 1987). The species flowers from May to June (California Native Plant Society 1988*a*). On average, each reproductive adult bears two to three flowers, but large individuals may produce eight flowers (Fiedler 1984 as cited in Sloop

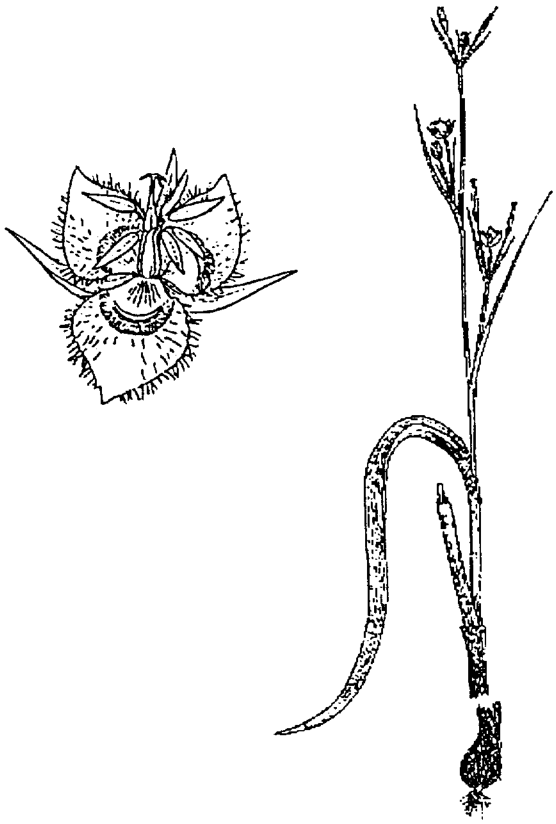

**Figure II-3.** Illustration of Tiburon mariposa lily (*Calochortus tiburonensis*) (from Hill 1973, with permission).

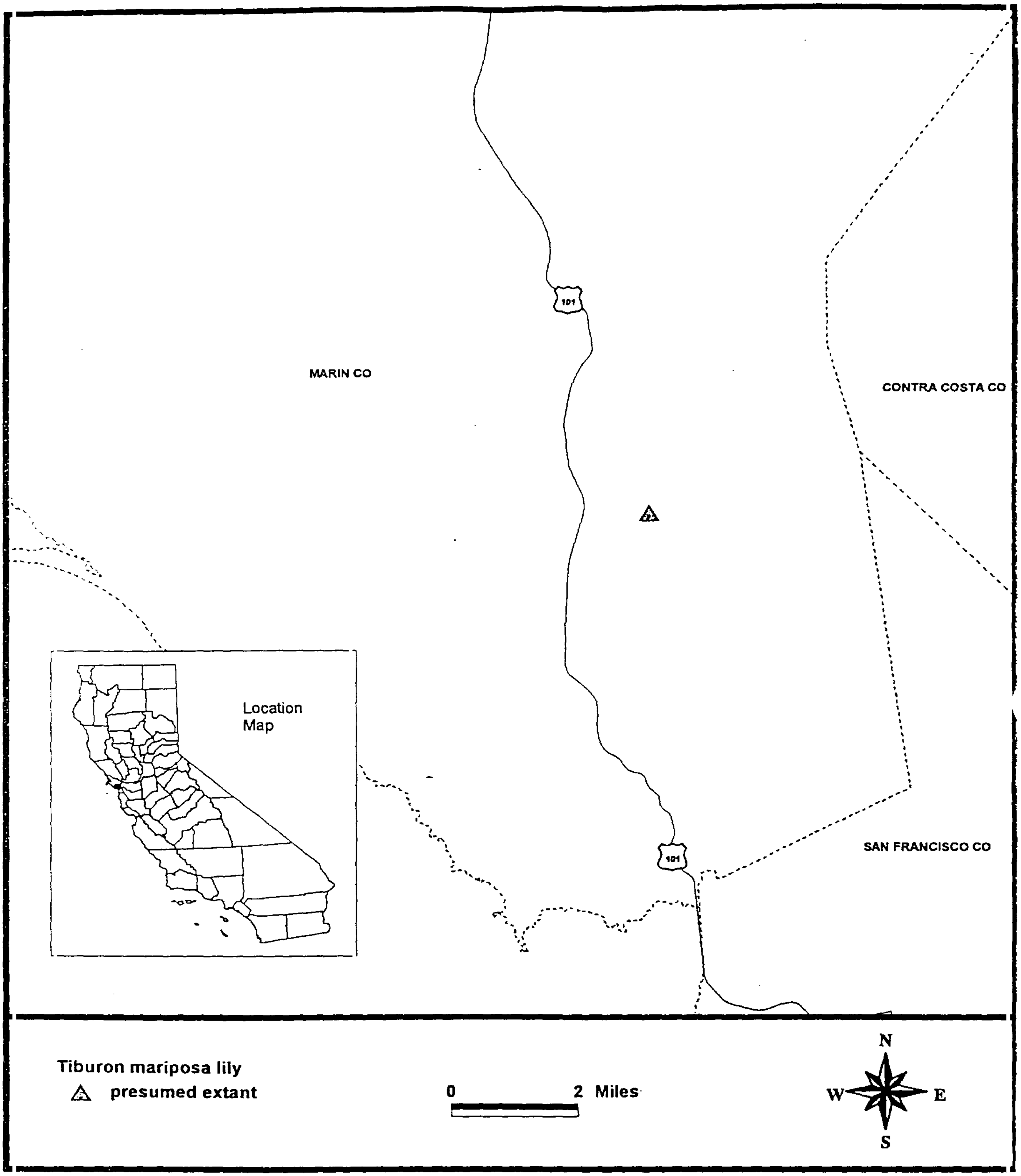


**Figure II-4.** Distribution of Tiburon mariposa lily (*Calochortus tiburonensis*).

1996). Protandry (with male reproductive parts maturing before female parts) likely limits self-pollination in the species (P. Fiedler, pers. comm., 1996) although seed can be produced upon hand self-pollination (i.e. the species is self-compatible). In nature, *Calochortus tiburonensis* appears to be primarily outcrossing (pollen from one plant going to a flower of a different plant, i.e. mating not involving inbreeding) and dependent upon insects for pollination. The flowers are thought to be pollinated primarily by bumble bees (*Bombus californicus*). *Calochortus tiburonensis* appears to be reproductively isolated from the co-occurring *Calochortus umbellatus* (Oakland star-tulip) by flowering later and by having different pollinators. *Calochortus umbellatus* flowers during March and April and is thought to be pollinated by sweat bees (Halictidae) (Sloop 1996).

Often individuals of *Calochortus tiburonenesis* do not reproduce until they are 5 years old (P. Fiedler, pers. comm., 1996) . During the hot, dry portion of the year, the bulbs are dormant, forming a "bulb bank" that persists from year to year. Seeds germinate at the onset of the rainy season. Seed loss may be the major stage of mortality in the life cycle (Fiedler 1987); there is no evidence of a dormant soil seed bank (P. Fiedler, pers. comm., 1996) .

The most detailed study of the reproduction and demography of *Calochortus tiburonensis* was conducted by Fiedler (1987) over three growing seasons between 1981 and 1984. The percentage of plants beginning reproduction varied from 36 to 64 percent, but the percentage of plants successfully reproducing (producing flowers and fruits and shedding seeds) ranged from 0 to 11 percent over the three growing seasons. The number of seeds per capsule averaged approximately 40 and ranged from 6 to 99. *Calochortus tiburonensis* appeared to have low seed survival and seedling establishment, low adult mortality, and slow growth (Fiedler 1987). Vegetative reproduction, through production of bulblets, occurs in the greenhouse but probably not in nature (P. Fiedler, pers. comm., 1996).

*Calochortus tiburonensis* is an example of a rare species that is restricted in distribution but relatively abundant where it does occur (Fiedler 1995). The single population of *Calochortus tiburonensis* is distributed in three major colonies (California Natural Diversity Data Base 1996) separated by 0.2 to 0.4 kilometer

(0.125 to 0.25 mile) (P. Fiedler, pers. comm., 1996). The number of individual plants observed has ranged from the hundreds in 1986 (California Natural Diversity Data Base 1996) to an estimated 40,000 individuals in 1991 (Larry Serpa, pers. comm., 1992). The number of flowering plants counted was 5,783 in 1989, 3,443 in 1990, and 19,875 in 1991 (California Natural Diversity Data Base 1996).

***Habitat and Community Associations.*** - *Calochortus tiburonensis* grows on rocky serpentine slopes and serpentine derived soils (Hill 1973) at an elevation of approximately 140 meters (460 feet) (California Natural Diversity Data Base 1996). The colonies are in open areas (Hill 1973) in a serpentine bunchgrass community (Fiedler and Leidy 1987) associated with serpentine reedgrass (*Calamagrostis ophitidus*), Tiburon buckwheat (*Eriogonum caninum* = *Eriogonum luteolum* var. *caninum*), Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) (California Natural Diversity Data Base 1996), and Marin dwarf-flax (*Hesperolinon congestum*) (California Native Plant Society 1988*a*).

## 4. Reasons for Decline and Threats to Survival

The single known occurrence of *Calochortus tiburonensis* is mostly, if not wholly, within the Ring Mountain Preserve that is part of Marin County Open Space (California Department of Fish and Game 1997*b*). The species is threatened, by virtue of its occurrence in a single population, with chance events such as fire, severe drought, pest or disease outbreak, or other natural or human-caused disasters (Menges 1991, Primack 1993, Meffe and Carroll 1994). The species is also vulnerable due to its proximity to human population centers and intensive development activities. The proximity of the plant to a large human population, along with high visitor use and minimal supervision, increases the likelihood that human-caused disasters, acts of vandalism, and recreational use will affect the plants or their habitat. Unrestricted collecting for scientific or horticultural purposes or excessive visits by individuals interested in seeing rare plants may also be a concern because *Calochortus tiburonensis* is a strikingly unusual member of this much-collected genus (U.S. Fish and Wildlife Service 1995, R. Bittman, *in litt.*, 1998). Non-native invasive plants may be an additional threat. Reportedly, Harding grass (*Phalaris aquatica*) and fennel (*Foeniculum *vulgare*) are increasing in numbers on the lower slopes of Ring Mountain (D. Smith, *in litt*., 1998).

### 5. Conservation Efforts

*Calochortus tiburonensis* was listed endangered by the State of California in 1978. As a result of protection efforts by The Nature Conservancy at Ring Mountain (see below), the species was downlisted to threatened by the State in 1987 (California Department of Fish and Game 1992). The species was federally listed as threatened in 1995 (U.S. Fish and Wildlife Service 1995).

Between 1982 and 1995, *Calochortus tiburonensis* was protected from development because the land on which it occurs was owned and managed by The Nature Conservancy, a group whose management goals are the maintenance of biodiversity and the protection of rare and endangered species (L. Serpa, pers. comm., 1992). In 1988, The Nature Conservancy developed and implemented an annual monitoring plan to provide data on reproductive success and herbivore damage for *Calochortus tiburonensis*. Data on total population size and the percentage of the population that is reproducing were to be collected every 5 years (California Native Plant Society 1988*a*). However, no recent monitoring has been done. The Ring Mountain property was transferred from The Nature Conservancy to Marin County Parks and Open Space in 1995. The Nature Conservancy retained a conservation easement on the property and expects that Marin County will continue monitoring the rare species on the preserve (L. Serpa, pers. comm., 1996). The Nature Conservancy provided Marin County Open Space District with detailed management principles and guidelines (California Department of Fish and Game 1997*b*). At this point, the County has not developed a monitoring plan and is depending on volunteers from The Nature Conservancy and California Native Plant Society for monitoring (C. Bramham, pers. comm., 1996). The preserve is fenced to reduce the incidence of four-wheel drive vehicle and motorcycle use, but is still accessible to bicycles, equestrians, and hikers (C. Bramham, pers. comm., 1997).

## 6. Recovery Strategy

*Calochortus tiburonensis* should not be considered for delisting. However, certain measures should be taken to ensure its survival. Because the species is known only from Ring Mountain, protection and management of the species at Ring Mountain is of highest priority. This protection will involve working with the Marin County Open Space District to ensure the long-term survival of the species by protecting each subpopulation, as well as a 150-meter (500-foot) buffer around each subpopulation, where possible, to reduce external influences and allow expansion of subpopulations. If plants (or additional populations) are discovered on private lands that are not part of the Ring Mountain Preserve, they should be secured through land acquisition, conservation easements, or other means. In addition, unoccupied habitat that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. A management plan emphasizing *Calochortus tiburonensis* and other special status species at Ring Mountain must be developed and implemented. The plan ought to include provisions for standardized monitoring of each *Calochortus tiburonensis* subpopulation every 3 years. Because the species is a perennial, monitoring should include both flowering and vegetative individuals. The management plan should also include strategies to minimize known threats as well as to identify new threats as they may appear. Potential threats include invasion by non-natives, grazing by deer, and trash dumping. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Because the largest remaining natural population of *Calochortus tiburonensis* occurs on public land adjacent to human population centers, any management plan developed for Ring Mountain should include an educational outreach program. Protection of serpentine habitat at Ring Mountain Preserve may also benefit Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) and Marin dwarf-flax (*Hesperolinon congestum*).

Another high priority in conservation efforts for *Calochortus tiburonensis* is collection and banking of seed in Center for Plant Conservation certified botanic gardens. Such collections guard against extinction of the species from chance catastrophic events and provide potential material for enhancement efforts in existing populations and/or introductions to new sites. In the case of a species such as *Calochortus tiburonensis* that has never been known from other locations, introduction to new sites would generally be discouraged. Care should be taken to ensure that seed collection does not adversely affect the population. The best strategy would be to collect on a very small scale (less than 5 percent of the seed crop) and/or only in years with exceptional seed production.

Of lower priority in conservation efforts for *Calochortus tiburonensis* is research into appropriate management strategies. For example, research into whether management techniques such as grazing, mowing, or burning may increase recruitment by removing thatch or otherwise stimulating reproduction would be valuable as would further research on demography to identify limiting life history stages, pollination, and habitat requirements of the species. Sloop (as cited in California Department of Fish and Game 1997*b*) feels that *Calochortus tiburonensis* is highly dependent on bumble bees (*Bombus californicus*) for pollination. Further research to test this hypothesis would elucidate whether managers ought to consider threats to the bees to be threats to *Calochortus tiburonensis* as well. Development of germination and propagation techniques for *Calochortus tiburonensis* is also necessary.

Because it occurs only at Ring Mountain, *Calochortus tiburonensis* should not be considered for delisting. Its status could be reevaluated in the unlikely event that several new populations are discovered at locations other than Ring Mountain.

## C. Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*)

### 1. Description and Taxonomy

***Taxonomy.*** - The type specimen (a specimen that is chosen when the taxon is described and is considered typical of the species) of *Castilleja affinis* ssp. *neglecta* (Tiburon paintbrush) was collected by Katherine Brandegee (Jepson 1925). The plant was described as *Castilleja neglecta* by Zeile in 1925 in Willis Jepson's Manual of the Flowering Plants of California. Chuang and Heckard reduced the species to subspecific status, treating the taxon as *Castilleja affinis* ssp. *neglecta* in The Jepson Manual (Hickman 1993).

***Description.*** - *Castilleja affinis* ssp. *neglecta* (Figure II- 5) is a semi-woody perennial of the snapdragon family (Scrophulariaceae), with erect, branched stems 30 to 60 centimeters (1 to 2 feet) tall and a sparse covering of soft, spreading hairs (Munz and Keck 1959). The lance-shaped leaves are 20 to 40 millimeters (0.8 to 1.6 inches) long and have 0 to 5 lobes (Hickman 1993). The conspicuous floral bracts are yellowish and sometimes red-tipped; the flowers are yellow to red and 18 to 20 millimeters (0.7 to 0.8 inch) long. The simple (unbranched) hairs and the lack of glands below the inflorescence (entire cluster of flowers and associated structures) distinguish *Castilleja affinis* spp. *neglecta* from other species of *Castilleja* on the Tiburon Peninsula (*Castilleja latifolia* var. *rubra* [Monterey Coast paintbrush] and *Castilleja foliolosa* [Texas paintbrush ]) (Munz and Keck 1959, Howell 1970).

## 2. Historical and Current Distribution

***Historical and Current Distribution.*** - *Castilleja affinis* ssp. *neglecta* has never been widespread. Three of the seven populations occur on the Tiburon Peninsula in Marin County, one occurs in Napa County, and one in Santa Clara County (Figure II-6). Recently discovered populations on Golden Gate National Recreation Area and east of Anderson Lake extend the known range to western Marin and Santa Clara Counties, respectively. *Castilleja affinis* ssp. *neglecta* is known from five populations in Marin County, three of which occur on the Tiburon Peninsula, from one population in American Canyon in Napa County, and from one population in Santa Clara County (California Natural Diversity Data Base 1996). The range of this plant is approximately 50 kilometers (30 miles) from east to west, and 112 kilometers (70 miles) from north to south (U.S. Fish and Wildlife Service 1995).

## 3. Life History and Habitat

***Reproduction and Demography.*** - *Castilleja affinis* ssp. *neglecta* is a perennial, flowering from April to June (Munz and Keck 1959). Lawrence Heckard (*in litt.*, 1989) postulated that the yellow flowers were largely bee-pollinated. Seeds are shed in June and July, and the species dies back to its woody base in July and August. New growth from the woody base begins in

**Figure II-5.** Illustration of Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) (from Abrams 1951, with permission).

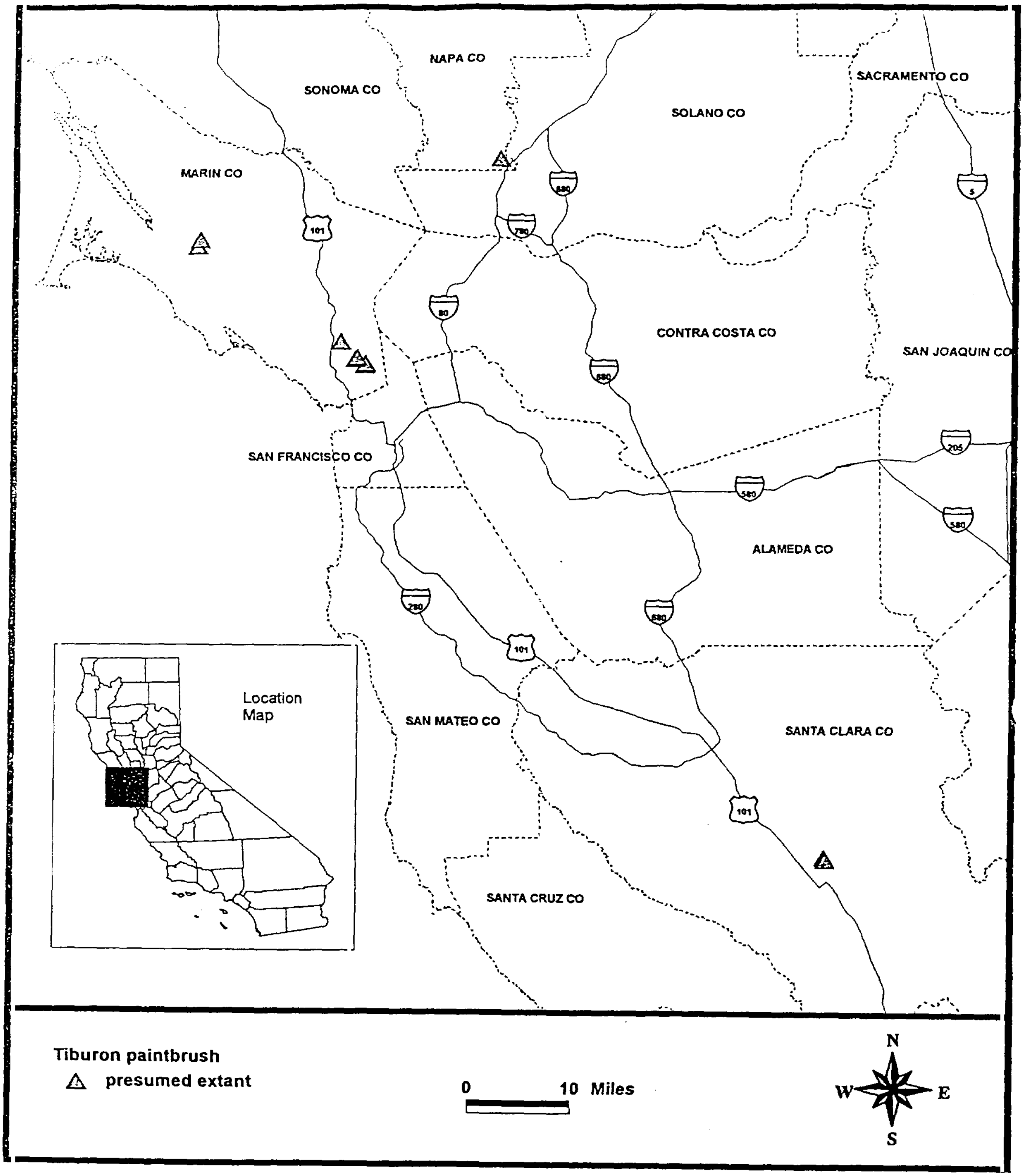


**Figure II-6.** Distribution of Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*).

December or January. Seeds may remain dormant in the soil for several years. Seed germination occurs in January or February and seems to be induced by leaching and low temperatures (5 to 15 degrees Celsius or 45 to 59 degrees Fahrenheit) (Martin 1989).

Martin (1989) observed that 84 percent of the plants she surveyed had three or fewer inflorescences. The mean number of inflorescences per plant was 2.3, the mean number of capsules per inflorescence was 8.8, and the mean number of seeds per capsule was 82.3. Based on these figures, seed production for 1 year was calculated to be 1,666 seeds per plant (Martin 1989). However, Martin (1989) observed no seedlings in the field during her 2 year study. In the laboratory, *Castilleja affinis* ssp. *neglecta* seedlings survived over a wide range of calcium/magnesium ratios (Martin 1989). However, factors such as local climate, soil, and herbivory may profoundly influence germination rate, seedling establishment, and survivorship in nature (N. McCarten, *in litt.*, 1998).

*Castilleja affinis* ssp. *neglecta* is a root parasite on other angiosperm (flowering plant) species. The primary advantage of the parasitic attachment in *Castilleja* and related plants in the figwort family is reportedly an increased water and mineral supply. Though the parasitic relationship is not obligate (hemiparasitic), benefits to species of *Castilleja* from the parasitic habit are manifested in increased vigor with more branching, greater height, and earlier flowering (Heckard 1962). Heckard (1962) showed that a host plant is beneficial to *Castilleja affinis* spp. *neglecta* and increases the species' chance for survival. Experiments (Heckard 1962) and field data (Martin 1989) suggest that *Castilleja affinis* ssp. *neglecta* species may utilize a variety of host species.

Population sizes are small, ranging from less than 20 plants at the Santa Clara County site (California Natural Diversity Data Base 1996) to approximately 600 plants at Ring Mountain Preserve on the Tiburon Peninsula (Hunter 1989*a*).

***Habitat and Community Associations.*** - *Castilleja affinis* ssp. *neglecta* occurs in serpentine bunchgrass communities (Fiedler and Leidy 1987, California Natural Diversity Data Base 1996) at elevations between about 75 and 400 meters (250 and 1,300 feet) (California Natural Diversity Data Base 1996).

Calcium/magnesium ratios of the serpentine soils where *Castilleja affinis* spp. *neglecta* occurs are apparently typical of serpentine soils in general. In one study, ratios at the American Canyon site were higher (0.413) than those at the sampled Tiburon sites (0.1 to 0.255) (Martin 1989, K.F. Martin, *in litt.*, 1998). *Castilleja affinis* spp. *neglecta* occurs in close proximity to Santa Clara Valley dudleya (*Dudleya setchellii*) in Santa Clara County (N. McCarten, *in litt.*, 1998). Other associated rare species include Marin dwarf-flax (*Hesperolinon congestum*), serpentine reedgrass (*Calamagrostis ophitidis*), Tiburon buckwheat (*Eriogonum luteolum* var. *caninum*), and Tiburon jewelflower (*Streptanthus niger*). Other native plants occurring at sites with *Castilleja affinis* ssp. *neglecta* include California gilia (*Gilia achilleifolia* ssp. *multicaulis*), California melic (*Melica californica*), California poppy (*Eschscholzia californica*), dwarf plantain (*Plantago erecta*), foothill needlegrass (*Nassella lepida*), hayfield tarweed (*Hemizonia congesta* ssp. *congesta*), longhorn plectritis (*Plectritis macrocera*), purple needlegrass (*Nassella pulchra*), purple sanicle (*Sanicula bipinnatifida*), royal larkspur (*Delphinium variegatum* ssp. *variegatum*), slender fairyfan (*Clarkia gracilis*), stickywilly (*Galium aparine*), and Torrey's melicgrass (*Melica torreyana*). Associated introduced species include Italian ryegrass (*Lolium multiflorum*), slender wild oat (*Avena barbata*), and soft brome (*Bromus hordeaceus*) (California Native Plant Society 1989, Hunter 1989*a*, Corelli and Chandik 1995, California Natural Diversity Data Base 1996).

### 4. Reasons for Decline and Threats to Survival

Populations of *Castilleja affinis* ssp. *neglecta* occur on public and private land in Marin County, and exclusively on private land in Napa and Santa Clara Counties. The Marin County populations are threatened by residential development, foot traffic, grazing, and soil slumping (Hunter 1989*a*, U.S. Fish and Wildlife Service 1995, California Natural Diversity Data Base 1996). Each of the three occurrences on the Tiburon Peninsula has multiple landowners. Marin Open Space District owns over half of the Ring Mountain occurrence formerly owned by The Nature Conservancy (Hunter 1989*a*, L. Serpa, pers. comm., 1996) and the town of Tiburon owns portions of the occurrence in the Middle Ridge area of the peninsula. The remainder of each of these occurrences is privately-owned. The third occurrence on the peninsula is in the vicinity of St. Hilary's Church in

Tiburon (California Natural Diversity Data Base 1996).

Development on the Tiburon Peninsula has been extensive and rapid; over 60 percent of *Castilleja affinis* ssp. *neglecta* habitat has already been destroyed by development (Hunter 1989*a*). Residential development, apparently observed as early as 1983 by Eva Buxton, is ongoing in the vicinity of the Middle Ridge occurrence (A. Allen, pers. comm., 1997, D. Smith, pers. comm., 1997, E. Buxton, *in litt.*, 1998). A portion of the Middle Ridge occurrence was extirpated by development approximately 8 years ago (E. Buxton, *in litt.*, 1998). The Town of Tiburon is currently considering a proposed development (Easton Point) that could impact the species as well as *Hesperolinon congestum* (see below) in the vicinity of St. Hilary's Church (B. Olson, *in litt.*, 1996, D. Watrous, pers. comm., 1997, D. Smith, pers. comm., 1997). A second proposed development in the same area was denied by the Town of Tiburon (Marinero Estates) (B. Olson, pers. comm., 1996). The area that would have been involved in this second development (Harroman/Marinero Estates) is proposed to be set aside as open space. A ballot measure to secure the funding for the purchase of the property passed in June, 1997; the purchase took place in the fall of 1997 (D. Watrous, pers. comm., 1997). The southernmost occurrence of *Castilleja affinis* spp. *neglecta* on the Tiburon Peninsula, in the vicinity of St. Hilary's Church, is probably located within this proposed open space (D. Smith, pers. comm., 1997). The habitat in the area is also threatened by pedestrian traffic (U.S. Fish and Wildlife Service 1995) and by invasion of non-natives such as pampas grass, broom, and blackberry (California Department of Fish and Game 1997*b*). A subpopulation on Middle Ridge is also threatened by invasion of pampas grass (E. Buxton, *in litt.*, 1998). The plants on Ring Mountain Preserve are protected from development but are threatened by sliding of the slope on which they occur. The toe of the slope was removed to accommodate residential development in the 1960's. Soil material that slides into the street at the base of the slope is removed by the City of Corte Madera, and the slope continues to slump. Managers from The Nature Conservancy estimate that approximately one-third of the population is at risk (L. Lozier, pers. comm., 1992, L. Serpa, pers. comm., 1996). The western Marin populations of *Castilleja affinis* spp. *neglecta* at Golden Gate National Recreation Area are located in areas that are being grazed by cattle; the impact of the grazing needs to be determined (Martin 1991, L. Nelson, *in litt.*, 1996, California Department of Fish and Game 1997*b*).

The Napa County population is threatened by gravel mining and grazing. The Napa County population occurs on private property near a gravel quarry (California Natural Diversity Data Base 1996). The property is used by Syar Industries for the mining of road base materials. The long term effect of ambient dust from mining has the potential to alter soil chemistry and photosynthesis (Jake Ruygt, *in litt*., 1996). Although quarry expansion plans that would result in the destruction of more than 80 percent of the population are no longer actively being pursued, the potential for expansion still exists (U.S. Fish and Wildlife Service 1995). Cattle grazing also has been reported to threaten a portion of the American Canyon occurrence (Hunter 1989*a*). Another source suggests, however, that cattle provide little threat to the American Canyon population because the plants occur on a very steep slope (J. Ruygt, pers. comm., 1992). The Santa Clara County population consists of 13 plants that may also be subject to grazing (R. Bittman, pers. comm., 1993).

**5. Conservation Efforts**

*Castilleja affinis* ssp. *neglecta* was listed as threatened by the State of California in 1990 (California Department of Fish and Game 1992) and was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995). Between 1982 and 1995, over half of the Ring Mountain occurrence of *Castilleja affinis* spp. *neglecta* was protected from development because the land on which it occurs was owned and managed by The Nature Conservancy, a group whose management goals are the maintenance of biodiversity and the protection of rare and endangered species. The Ring Mountain property was transferred to Marin County Parks and Open Space in 1995. The Nature Conservancy retained a conservation easement on the property and expects that Marin County will continue monitoring the rare species on the preserve (L. Serpa, pers. comm., 1996). At this point, the County has not developed a monitoring plan and is depending on volunteers from The Nature Conservancy and California Native Plant Society for monitoring (C. Bramham, pers. comm., 1996). The preserve is fenced to reduce the incidence of four-wheel drive vehicle and motorcycle use, but is still accessible to bicycles, equestrians, and hikers (C. Bramham, pers.

comm., 1997). In addition, two occurrences of *Castilleja affinis* spp. *neglecta* are on Golden Gate National Recreation Area land that is managed by Point Reyes National Seashore. The effect of cattle grazing on these populations is unknown, but at least one population is monitored by the California Native Plant Society (L. Nelson, *in litt.*, 1996). The Santa Clara County population of *Castilleja affinis* spp. *neglecta* is on a reserve for bay checkerspot butterfly conservation (N. McCarten, *in litt.*, 1998). The reserve is a 107-hectare (267-acre) area set aside until the year 2000 as mitigation for the development of the Kirby Canyon Landfill (Murphy 1988, Thomas Reid Associates and Murphy 1992).

## 6. Recovery Strategy

Recovery of *Castilleja affinis* ssp. *neglecta* must first focus on protecting and managing the known populations. Protection and management of populations on public lands will involve working with Marin Open Space District, the town of Tiburon, and the Golden Gate National Recreation Area to ensure the long-term survival of the species on their lands. The populations, or portions of populations, occurring on private lands should be protected by land acquisition, conservation easements, or other mechanisms. Among populations on private land, protection of the only known population in Santa Clara County is a particularly high priority because it is geographically disjunct from other populations. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Castilleja affinis* ssp. *neglecta* and other special status species in each location must be developed and implemented. The plans should include provisions for standardized monitoring of *Castilleja affinis* ssp. *neglecta* populations every other year to determine demographic trends. The plans should also include strategies to minimize known threats (e.g. foot traffic) at the sites as well as to identify new threats should they appear. Removal of non-natives should be a high priority for management of sites on the Tiburon Peninsula such as those on Middle Ridge and in Marin County Open Space near

Old St. Hilary's Church. In addition, soil slumping at the Ring Mountain Preserve needs to be minimized. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. For populations on public lands, any management plan developed should include an educational outreach program.

Another high priority in recovery efforts for *Castilleja affinis* ssp. *neglecta* is collection and banking of seed in Center for Plant Conservation certified botanic gardens. Seed banking guards against extinction of populations from chance catastrophic events and provides potential material for enhancement efforts in existing populations, repatriations, and/or introductions to new sites. In the absence of genetic data for *Castilleja affinis* ssp. *neglecta*, seed collection efforts should represent populations throughout the range of the species, including the Santa Clara County population that is at least 100 kilometers (62 miles) south of the other known populations (Elam in prep). Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection of, and seed collection from, the known populations of *Castilleja affinis* ssp. *neglecta*, other potential serpentine habitat throughout the range of the species should be surveyed to determine if other populations exist. Santa Clara County, in particular, contains habitat that should be surveyed (e.g. to the south of the known occurrence and in Henry Coe State Park east of Anderson Reservoir) (California Department of Fish and Game 1997*a*). If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Certain types of research are also high priority recovery activities for *Castilleja affinis* ssp. *neglecta*. In particular, because (1) *Castilleja affinis* ssp. *neglecta* occurs approximately 100 to 250 meters (328 to 820 feet) from relatively good quality bay checkerspot butterfly habitat (N. McCarten, *in litt*., 1998) in Santa Clara County, and (2) bay checkerspot butterfly habitat benefits from vegetation management, the effect of various vegetation management techniques (e.g. grazing, mowing, and burning) on *Castilleja affinis* ssp. *neglecta* needs to be evaluated. Although cattle and deer grazing of *Castilleja affinis* ssp. *neglecta* has not been observed (N. McCarten, *in litt*., 1998), evaluation of these techniques will ensure that managers select management strategies that maintain bay checkerspot butterfly habitat while not adversely affecting *Castilleja affinis* ssp. *neglecta*. Research on the effects of grazing are also important in recovery efforts for *Castilleja affinis* ssp. *neglecta* because grazing is a concern at the Golden Gate National Recreation Area in Marin County. In addition, because other *Castilleja* species appear to benefit from fire (R. Raiche, cited in California Department of Fish and Game 1997*b*, small scale experimental burning (e.g. using burn boxes) may reveal another possible management strategy. Any experimental burning should initially be limited to a very small area (e.g. 1 square meter [10.8 square feet]). Other research needs include germination and propagation techniques, taxonomic, demographic, and genetic studies as well as mating system and pollination studies. Demographic studies should include field studies of *Castilleja affinis* ssp. *neglecta*'s hemiparasitic nature, the frequency of seed germination and seedling recruitment in nature, and identification of limiting life history stages. Martin (1989) observed no seedlings in the field during a 2-year study. Genetic studies should focus on whether, and to what extent, populations throughout the range of the species are genetically different from one another. These genetic data would be valuable guides as to which populations should be chosen as sources for enhancement of existing populations or introduction of new populations.

When six populations of *Castilleja affinis* ssp. *neglecta* are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity, (2) shown to be stable or increasing with evidence of recruitment over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring), (3) seed collected from natural populations throughout the range of the species is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and

Elam 1993).

*Castilleja affinis* ssp. *neglecta* should not be considered for delisting unless 10 populations throughout its range are shown to meet the criteria above. At least 2 of the 10 should occur in Santa Clara County. Meeting this goal would require locating, restoring, and/or successfully introducing four new populations. Because repatriation and introduction of populations is expensive and experimental (Falk *et al.* 1996), surveying potential habitat within the range to locate currently unknown populations is the preferred strategy.

## D. Coyote ceanothus (*Ceanothus ferrisiae*)

### 1. Description and Taxonomy

***Taxonomy.*** - LeRoy Abrams, professor of botany at Stanford University, collected *Ceanothus ferrisiae* (coyote ceanothus) in 1917 on Madrone Springs Road above Coyote Creek, in Santa Clara County. Howard E. McMinn, professor of botany at Mills College and author of An Illustrated Manual of California Shrubs, described the species in 1933 (McMinn 1933).

***Description.*** - *Ceanothus ferrisiae* (Figure II-7) is an erect evergreen shrub of the buckthorn family (Rhamnaceae) that grows 1 to 2 meters (3 to 6 feet) high, with long stiff divergent branches. Its round leaves are dark green and hairless on the upper surface, and lighter green with minute hairs below. The leaf margins have short teeth or sometimes no teeth at all; the leaf base is abruptly tapering or rounded. The small white flowers are borne in clusters 1.3 to 2.5 centimeters (0.5 to 1.0 inch) long (McMinn 1933). The seed capsules are 7 to 9 millimeters (0.3 to 0.35 inch) in width and have three conspicuous apical horns (protuberances situated at the tip). The related *Ceanothus cuneatus* (buck brush) has entire leaves with wedge-shaped (not rounded) bases and seed capsules only 5 to 6 millimeters (0.2 inch) wide (Munz and Keck 1959).

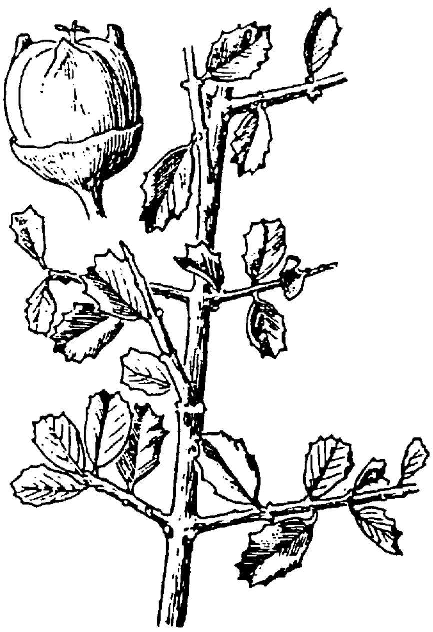

**Figure II-7.** Illustration of coyote ceanothus (*Ceanothus ferrisiae*) (from Abrams 1951, with permission).

## 2. Historical and Current Distribution

***Historical and Current Distribution.*** - *Ceanothus ferrisiae* is known from only three locations: Anderson Dam, Kirby Canyon, and Llagas Avenue north of Morgan Hill (Figure II-8). All the locations are within 6 kilometers (4 miles) of each other in Santa Clara County. The Anderson Dam location includes two of the occurrences in the California Natural Diversity Data Base (1996), Kirby Canyon is one occurrence, and Llagas Avenue north of Morgan Hill is one occurrence. The Anderson Dam occurrences may have been continuous before the dam was built (California Department of Fish and Game 1997*a*). *Ceanothus ferrisiae* has not been observed in Croy Canyon in Santa Clara County, a fifth occurrence in California Natural Diversity Data Base records, since 1929, and the location is possibly erroneous (California Natural Diversity Data Base 1996, California Department of Fish and Game 1997*a*). The species was also thought to occur in San Mateo and Santa Cruz Counties, but these reports are thought to be erroneous (Corelli 1991, C. Schmidt, *in litt.*, 1998).

## 3. Life History and Habitat

***Reproduction and Demography***. - *Ceanothus ferrisiae* is perennial, flowering from January to March (Munz and Keck 1959). Fewer than 6,000 plants are known to exist (U.S. Fish and Wildlife Service 1995). Prior to 1993, Kathy Freas (*in litt.*, 1993) monitored the three populations of *Ceanothus ferrisiae.* She found no evidence of seedling recruitment and observed that all of the populations were composed of mature and senescent individuals (large plants with many dead branches). Freas (*in litt.*, 1993) also conducted germination trials using various heat and disturbance treatments. Her results suggested that *Ceanothus ferrisiae* seeds do not require fire for germination. If the seeds do not require fire for germination, the lack of recruitment in natural populations may be due to seed or seedling mortality (Center for Conservation Biology 1990, K. Freas, *in litt.*, 1993). Possible sources of mortality include seed predation, grazing/browsing, lack of sufficient precipitation to maintain young plants through the dry summer following germination, or some combination of these (K. Freas, *in litt.*, 1993). Despite the results of the germination trials, the only seedlings observed in nature were following a fire in Kirby Canyon (K. Freas, pers. comm., 1996).

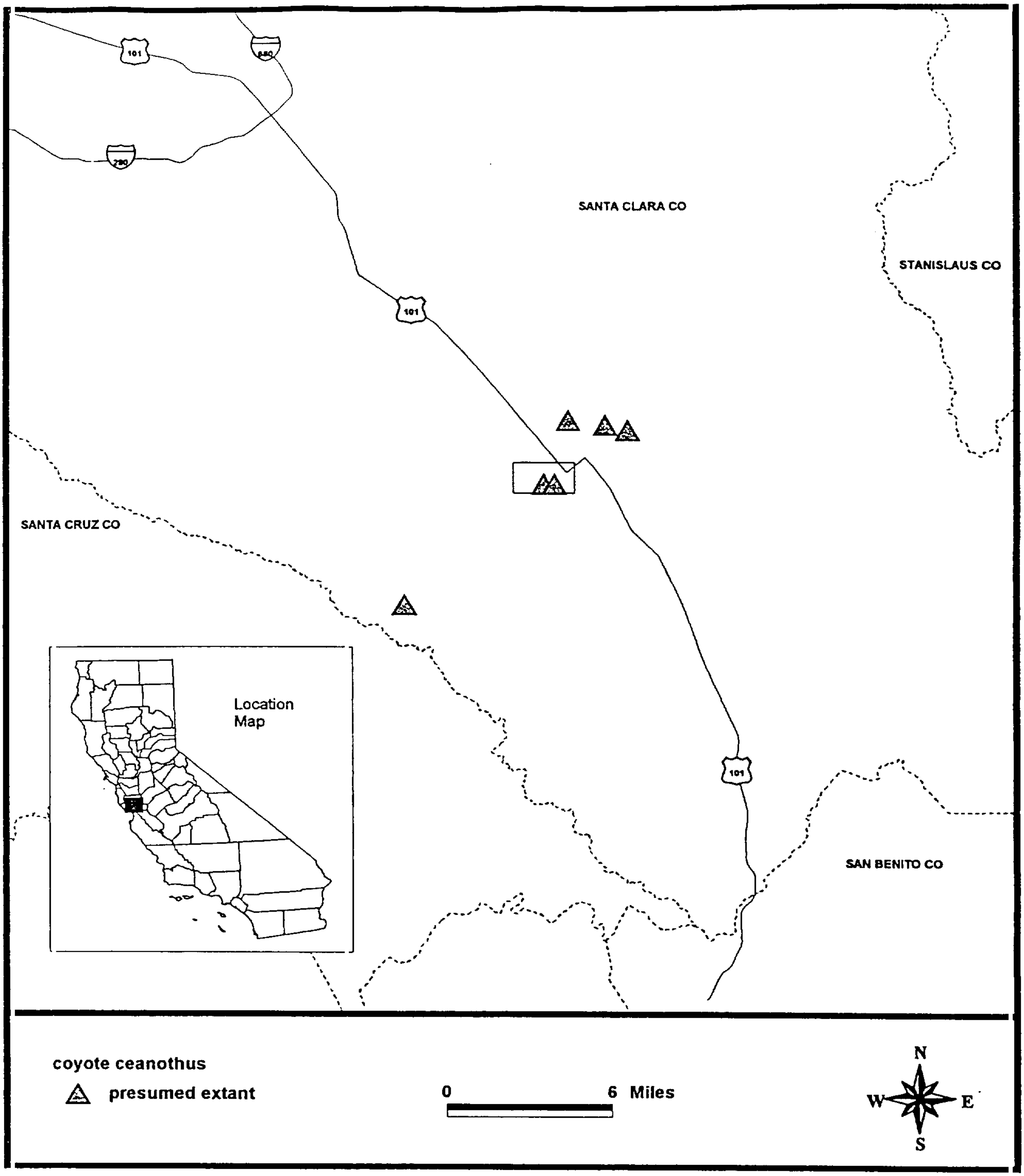


**Figure II-8.** Distribution of coyote ceanothus (*Ceanothus ferrisiae*). Each symbol represents one occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

Another *Ceanothus* expert, Clifford Schmidt, feels that maintenance of a healthy population of *Ceanothus ferrisiae* that includes young shrubs requires some prescription burning. He notes that when he frequented the Anderson Dam site in the late 1980's, there was little or no evidence that the species was reproducing at the site (C. Schmidt, *in litt.*, 1996, 1998). Few young shrubs were present along with the many mature shrubs. The mature shrubs were "annually loaded" with fruits, but reproduction was "virtually nil" (C. Schmidt, *in litt.*, 1996). Schmidt (*in litt.*, 1998) believes that regeneration is necessary because the plants are rather short-lived.

The *Ceanothus ferrisiae* population in Kirby Canyon, the smallest of the three populations, burned during the summer of 1992. Approximately 5 percent of the several hundred individuals survived the fire. All of the surviving individuals were damaged by the fire and supported only one to several live branches at the time of a census in December, 1992. Although flower buds were present and apparently in good condition, potential seed production in the population was severely reduced. Despite sufficient precipitation for germination, no seedlings were observed in 1992 (K. Freas, *in litt.*, 1993). However, the following spring approximately 2,000 seedlings were observed (K. Freas, pers. comm., 1993, 1996). These seedlings were fenced to protect them from grazing until the plants were established (K. Freas, pers. comm., 1993). In addition, because the fence did not prevent deer and rabbit grazing, 100 plants were individually caged. One year later survivorship of the caged seedlings was good (K. Freas, pers. comm., 1996).

***Habitat and Community Associations.*** - *Ceanothus ferrisiae* grows on dry slopes in serpentine chaparral and valley and foothill grassland below 300 meters (about 1,000 feet) (Munz and Keck 1959, Hickman 1993, California Natural Diversity Data Base 1996). Rare species associated with *Ceanothus ferrisiae* include the federally listed bay checkerspot butterfly (*Euphydryas editha bayensis*) and Santa Clara Valley dudleya (*Dudleya setchellii*) as well as most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*) and Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*), two species of concern. It is also associated with bigberry manzanita (*Arctostaphylos glauca*), California coffeeberry (*Rhamnus californica*), California sagebrush (*Artemisia californica*), common yarrow (*Achillea millefolium*), foothill pine (*Pinus sabiniana*), leather oak (*Quercus durata*), and toyon (*Heteromeles arbutifolia*) (Corelli 1991, California Natural Diversity Data Base 1996).

### 4. Reasons for Decline and Threats to Survival

The existing populations of *Ceanothus ferrisiae* are threatened by residential and recreational development, unauthorized dumping, landfill activities, lack of natural recruitment (U.S. Fish and Wildlife Service 1995), altered fire regimes (see above) (C. Schmidt, *in litt.*, 1996, 1998), grazing (California Natural Diversity Data Base 1996), and stochastic (involving random or chance processes) events (e.g. the Kirby Canyon fire) (K. Freas, *in litt.*, 1993). The largest population, consisting of approximately 5,000 plants, occurs near Anderson Dam, partially on Santa Clara County Park property and partially on private property (Corelli 1991). The Santa Clara Valley Water District has an easement for a small area of the County's portion of the Anderson Dam occurrence (California Department of Fish and Game 1997*a*). Several dozen plants were removed when the Santa Clara Valley Water District enlarged the spillway to Anderson Dam (Santa Clara Valley Water District 1993). Two more plants were transplanted as a result of emergency work on the spillway in January 1997 (C. Roessler, *in litt.*, 1997*a*, 1997*b*, C. Roessler, pers. comm., 1997). *Ceanothus ferrisiae* at the Anderson Dam site is also threatened by grazing (California Natural Diversity Data Base 1996, C. Schmidt, *in litt.*, 1998) and unauthorized dumping of litter and larger debris (Corelli 1991). Dumping can degrade or threaten a habitat by directly killing the plants, depriving them of light, or disturbing the soil, thus promoting erosion and invasion of weedy, competitive species (U.S. Fish and Wildlife Service 1995).

The Kirby Canyon population which occurs 3.2 kilometers (2 miles) west of Anderson Dam is on property leased and managed by Waste Management of California, Inc. A portion of this population was proposed to be destroyed for construction of sedimentation ponds as part of landfill activities (LSA Associates, Inc., 1992), but that was not done, and there are no plans to do so (L. Aberbom, pers. comm., 1996). This population is also threatened by cattle grazing and dumping (California Natural Diversity Data Base 1996). The third population (Llagas Avenue north of Morgan Hill), consisting of approximately 500 plants, occurs on private land (Corelli 1991, California Natural Diversity Data Base 1996). Although *Ceanothus ferrisiae* still exists at the site, a portion of the occurrence had been developed as of April, 1997. A portion may be set-aside in a city or county easement. When the site was last visited, the plants seemed to be rather senescent and all of the same age class (California Department of Fish and Game 1997*a*).

### 5. Conservation Efforts

*Ceanothus ferrisiae* was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995); the species is not listed by the State of California (California Natural Diversity Data Base 1996). Waste Management, Inc. and The Nature Conservancy jointly funded the research conducted by Freas (above) on *Ceanothus ferrisiae*. *Ceanothus ferrisiae* is relatively easy to propagate from seed (Center for Conservation Biology 1990, K. Freas, *in litt*., 1993) and from tip cuttings as well. The species may be propagated in nurseries (Hickman 1993, Showers and Wiese 1995, C. Dye, pers. comm., 1996). Several large shrubs are growing in the Tilden Botanic Garden (S. Edwards, pers. comm., 1996).

Both Waste Management and the Santa Clara Valley Water District have experimented with the use of *Ceanothus ferrisiae* for revegetation projects (D. Amshoff, pers. comm., 1997, K. Freas, pers. comm., 1996). Because no impact to the species occurred as a result of their activities, Waste Management did not initiate a larger-scale *Ceanothus ferrisiae* revegetation project (L. Aberbom, pers. comm., 1996). However, the Santa Clara Valley Water District project was launched in December, 1993, as mitigation for the enlargement of the spillway to Anderson Dam (Santa Clara Valley Water District 1993). Santa Clara Valley Water District continues to consider the presence of the species and contacted the U.S. Fish and Wildlife Service in January, 1997, when emergency work along the spillway was necessary. In the course of this work, they expected that two shrubs would be removed (C. Roessler, *in litt*., 1997*a*). The two shrubs were transplanted to a location approximately 6 meters (20 feet) away. In May, 1997, the plants had been browsed, but no disease, insect damage, or vandalism were evident (C. Roessler, *in litt*., 1997*b*).

### 6. Recovery Strategy

Recovery of *Ceanothus ferrisiae* must first focus on protecting and managing the four known occurrences (two at Anderson Dam, one at Kirby Canyon, and one at Llagas Avenue north of Morgan Hill) by working with Santa Clara County, Santa Clara Valley Water District, and private landowners to ensure the long-term survival of the species on their lands. Populations on private land, particularly that at Kirby Canyon, should be protected through land acquisition, conservation easements, or other mechanisms. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Ceanothus ferrisiae* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized monitoring of *Ceanothus ferrisiae* populations every 3 years to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from recreational activities, dumping and landfill activities must be eliminated. Controlled burning should be considered, especially at the Anderson Dam and Llagas Avenue sites (C. Schmidt, *in litt.*, 1998), if research shows that reproduction can be enhanced by fire. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Public education programs should be part of any management plan for plants occurring on public land.

Another high priority in recovery efforts for *Ceanothus ferrisiae* is surveying the possibly erroneous historic location in Croy Canyon. Surveys should also include other potential serpentine habitat from which populations are not currently known. For example, potential habitat exists in some areas east of Anderson Reservoir (California Department of Fish and Game 1997*a*). Additional populations would likely be new locations rather than relocations of former sites (C. Schmidt, *in litt.*, 1998). If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Activities of lower priority in recovery efforts for *Ceanothus ferrisiae* include seed collection and research. Collection and banking of seed in Center for Plant Conservation certified botanic gardens is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations, and/or introductions to new sites. All known populations should be represented in seed collections. Care should be taken to ensure that seed collection does not adversely affect the donor populations. Important research questions include how grazing impacts the reproduction, recruitment, and survival of the species, the role of fire in reproduction of the species, and why so little recruitment is observed in natural populations. In addition, demographic research to identify limiting life history stages and research on reproduction should be conducted.

If the known populations of *Ceanothus ferrisiae* are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity, (2) shown to be stable or increasing including evidence that natural recruitment is occurring over a minimum of 30 years that include the normal precipitation cycle (or longer depending on results of research on the role of fire in reproduction), (3) seed collected from all natural populations is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993).

*Ceanothus ferrisiae* should not be considered for delisting unless eight populations within its historic range and representing its entire historic range are shown to meet the criteria above. Meeting this goal would require locating, restoring, and/or successfully introducing four new populations. Because introduction of new populations is expensive and experimental (Falk *et al.* 1996), surveying potential habitat to locate currently unknown populations is the preferred strategy. However, Waste Management plans on major revegetation work to mitigate for their landfill activities and coordination with them may make introduction of new populations more feasible.

## E. Fountain thistle (*Cirsium fontinale* var. *fontinale*)

### 1. Description and Taxonomy

***Taxonomy.*** - *Cirsium fontinale* var. *fontinale* (fountain thistle) was first described as *Cnicus fontinalis* (Greene 1886*a*). In 1892, Greene reassigned the plant to the genus *Carduus* (Greene 1892). Willis Jepson, in his Flora of Western Middle California (1901), put the taxon in the genus *Cirsium*. In 1938, John Thomas Howell described a close relative of the fountain thistle, *Cirsium fontinale* var. *obispoense* (Chorro Creek bog thistle) (Howell 1938). According to the rules for botanical nomenclature, when a new variety is described in a species not previously divided into infraspecific taxa, a "type" variety is automatically created (Lawrence 1951). In this case, the type variety is *Cirsium fontinale* var. *fontinale*.

***Description.*** - *Cirsium fontinale* var. *fontinale* (Figure II-9) is an herbaceous perennial of the aster family (Asteraceae) with several stout, erect reddish stems 30 to 60 centimeters (1 to 2 feet) high. The basal leaves are 10 to 20 centimeters (4 to 8 inches) long with spine-tipped lobes; the leaves on the stems are smaller. The flowers are dull white to pinkish, becoming brown with age (Munz and Keck 1959, Hickman 1993). The egg-shaped, recurved bracts beneath the flower head of *Cirsium fontinale* var. *fontinale* distinguish it from the most similar thistle in the area, brownie thistle (*Cirsium quercetorum*) (Niehaus 1977*a*). The nearest relative of *Cirsium fontinale* var. *fontinale* is *Cirsium fontinale* var. *obispoense* (Chorro Creek bog thistle), found further south, in San Luis Obispo County (Howell 1938). The related Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*), which grows in serpentine seeps like *Cirsium fontinale* var. *fontinale*

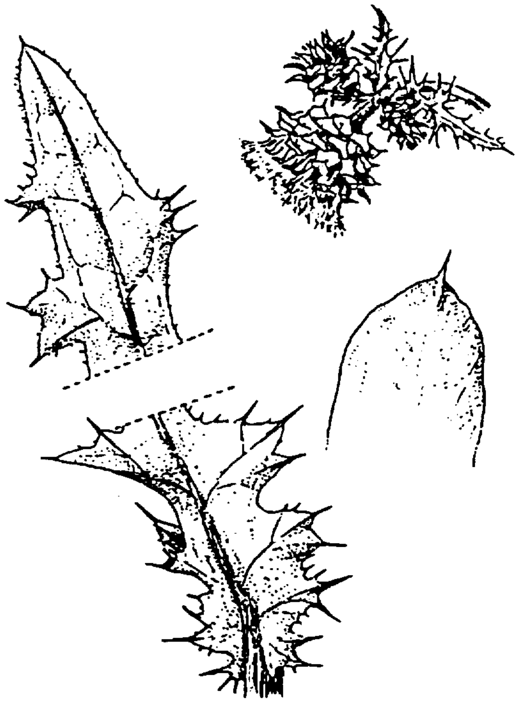

**Figure II-9.** Illustration of fountain thistle (*Cirsium fontinale* var. *fontinale*) (from Abrams and Ferris 1960, with permission).

and *Cirsium fontinale* var. *obispoense*, is found in Alameda, Santa Clara, and Stanislaus Counties (Skinner and Pavlik 1994.).

### 2. Historical and Current Distribution

***Historical and Current Distribution.*** - Historically, *Cirsium fontinale* var. *fontinale* may have occurred in both San Mateo and Santa Clara Counties (Niehaus 1977*a*) although the Santa Clara County location may be erroneous (California Natural Diversity Data Base 1996, D. Kelch, pers. comm., 1996). The species is now found in only three locations in San Mateo County (Figure II-10). One population occurs east of Crystal Springs Reservoir, on both sides of Interstate 280. This location includes three of the five occurrences of *Cirsium fontinale* var. *fontinale* from the California Natural Diversity Data Base. All of the plants in this area may be part of one large population that was originally scattered throughout perennial drainages along the eastern edge of Crystal Springs Lake (D. Kelch, *in litt.*, 1996). A second population occurs 10 kilometers (6 miles) to the south in the "Triangle" area, a triangular piece of land west of Edgewood County Park that is bounded by Interstate 280 to the east, Edgewood Road on the north, and Canada Road on the west. The third location is in Edgewood County Park where a single plant was found in 1987 (California Natural Diversity Data Base 1996). In 1992, one plant remained in this location (S. Sommers, pers. comm., 1992). No plants were seen at the location in 1996 (T. Peterson, *in litt.* 1996, W. Savage, *in litt.*, 1996).

### 3. Life History and Habitat

***Reproduction and Demography.*** - *Cirsium fontinale* var. *fontinale* is a perennial, flowering from June to October (Munz and Keck 1959). It is thought to be pollinated by bees (Apidae) (Lindenmeyer 1980). Seed production may be quite low (D. Kelch, pers. comm., 1996) although seedlings have been observed in recent surveys (D. Kelch, *in litt.*, 1996). The species may hybridize with *Cirsium quercatorum* (McClintock and Danielson 1975, California Native Plant Society 1988*b*, California Natural Diversity Data Base 1996).

Recent survey information suggests that the Crystal Springs Reservoir location

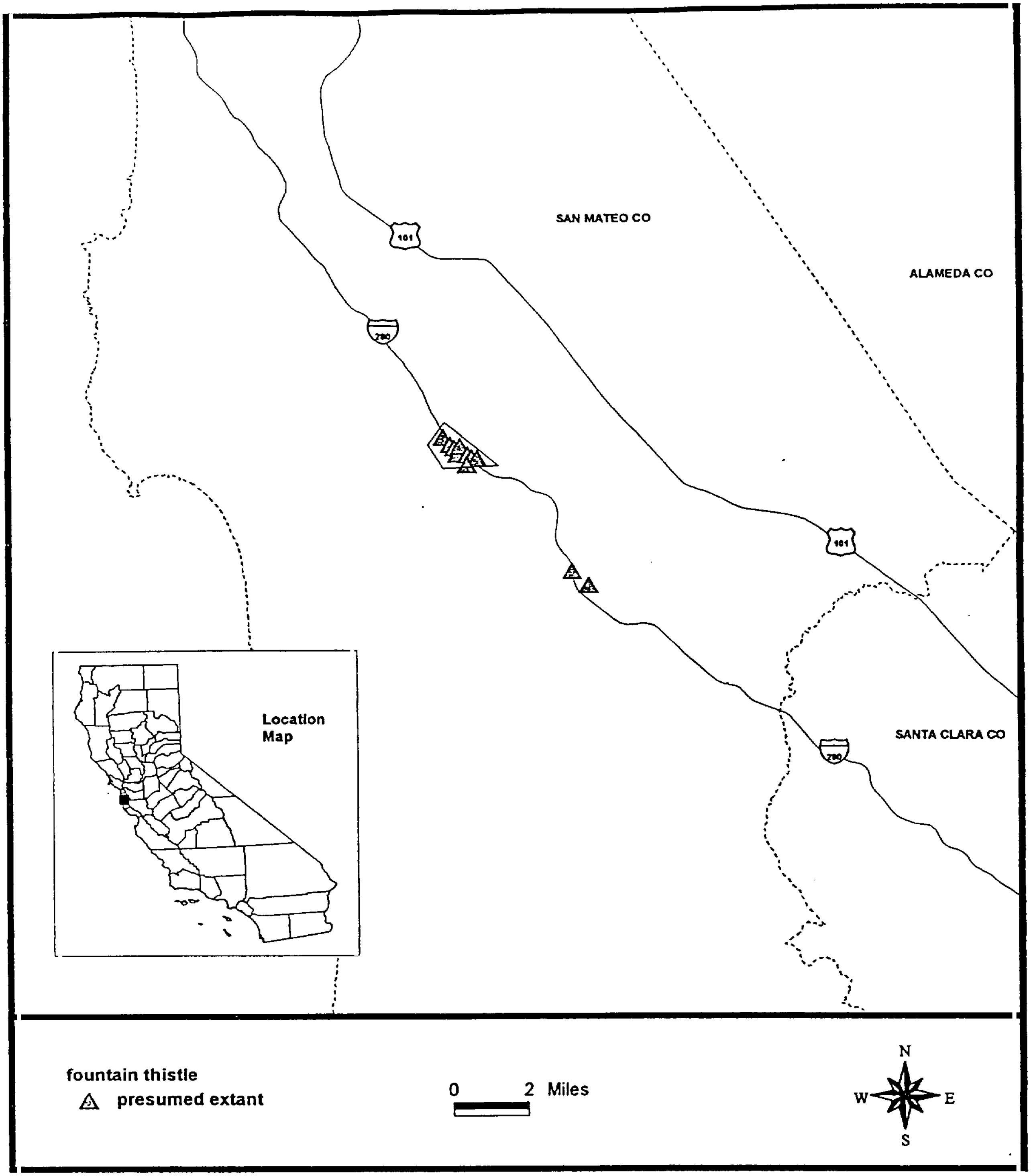


**Figure II-10.** Distribution of fountain thistle (*Cirsium fontinale* var. *fontinale*). Each symbol represents one occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

contains approximately 5,000 plants (D. Kelch, *in litt.*, 1996), and the Triangle population 100 to 200 plants (California Natural Diversity Data Base 1996, D. Kelch, *in litt.*, 1996). The Edgewood Park population consisted of a single plant (California Natural Diversity Data Base 1996), but recently surveys have not found any plants in the location (T. Peterson, *in litt.*, 1996, W. Savage, *in litt.*, 1996). Savage (*in litt.*, 1996) feels that the favorable habitat and the presence of a viable population of *Cirsium fontinale* var. *fontinale* within a mile of the site provide a favorable long-term outlook for the return of the species.

***Habitat and Community Associations.*** - *Cirsium fontinale* var. *fontinale* is restricted to perpetually moist clay openings in riparian or serpentine chaparral (California Native Plant Society 1988*b*) between approximately 90 and 190 meters (300 to 600 feet) in elevation (California Natural Diversity Data Base 1996). Associated rare species include federally listed Marin dwarf-flax (*Hesperolinon congestum*) (California Natural Diversity Data Base 1996) and species of concern fragrant fritillary (*Fritillaria liliacea*) (Niehaus 1977*a*, California Native Plant Society 1988*b*, California Natural Diversity Data Base 1996), San Francisco wallflower (*Erysimum franciscanum*) (California Native Plant Society 1988*b*), and Crystal Springs lessingia (*Lessingia arachnoidea*) (P. Holloran, *in litt.*, 1998). Other associated native species include bugle hedgenettle (*Stachys ajugoides*) (California Natural Diversity Data Base 1996), coyote brush (*Baccharis pilularis*) (California Native Plant Society 1988*b*), deerweed (*Lotus purshianus*), Fremont's death camas (*Zigadenus fremontii*), needlegrasses (*Nassella (=Stipa) pulchra*, *N. lepida*) (California Natural Diversity Data Base 1996), Sandberg's bluegrass (*Poa secunda* = *Poa scabrella*) (California Native Plant Society 1988*b*), and seep monkeyflower (*Mimulus guttatus*) (California Natural Diversity Data Base 1996). Associated introduced species include English plantain (*Plantago lanceolata*), pampas grass (*Cortaderia selloana*), and wild oat (*Avena fatua*) (California Natural Diversity Data Base 1996).

### 4. Reasons for Decline and Threats to Survival

One occurrence of *Cirsium fontinale* var. *fontinale* was reported from Santa Clara County, but the site is thought to have been destroyed by urbanization (Niehaus 1977*a*) or may be erroneous (California Natural Diversity Data Base

1996, D. Kelch, pers. comm., 1996). Decline of populations in the Crystal Springs region of San Mateo County has been attributed to destruction of habitat from urbanization, alteration of local hydrology (California Native Plant Society 1988*b*), dam construction in the 19th century (D. Kelch, *in litt.*, 1996) and highway construction (Niehaus 1977*a*, K. Berg, *in litt.*, 1991). The type locality suffered negative impacts from construction of the Interstate 280 and the Highway 92 interchange. Some seeps were incidentally created in the process of construction and may provide habitat for *Cirsium fontinale* var. *fontinale* (D. Kelch, *in litt.*, 1996). The available information is insufficient to evaluate whether the seeps and drainages in question supported *Cirsium fontinale* var. *fontinale* before construction or were colonized as a result of the project (B. Olson, *in litt.*, 1998).

Three remaining locations of *Cirsium fontinale* var. *fontinale* are in San Mateo County. The taxon is threatened by proposed recreational development, roadside maintenance, competition with non-native plant species, and garbage dumping. The location with the most plants is to the east of Crystal Springs Reservoir and north of State Highway 92, along both sides of Interstate 280. It occurs partly on San Francisco Water Department land and partly on a California Department of Transportation right-of-way (U.S. Fish and Wildlife Service 1995, California Natural Diversity Data Base 1996). Given its proximity to the roadside, it is likely to be affected by any highway projects in the area as well as by highway maintenance (B. Olson, *in litt.*, 1996, R. Vonarb, pers. comm., 1996). Major realignments of Highway 92 planned several years ago have been scaled back and are not expected to impact serpentine grassland. At present, a smaller project to widen Highway 92 east of the reservoir causeway has been dropped (R. Vonarb, pers. comm., 1996). Provisions for the removal of water from the increased road surface may adversely affect some of the plants. Caltrans is aware of the plant locations and vulnerability (R. Vonarb, pers. comm., 1992).

The proposed construction of multi-use recreational trails (e.g. Crystal Springs North and Crystal Springs South trails) on San Francisco Water Department land may present an additional threat to plants in the Crystal Springs area (T. Corelli, *in litt.*, no date, E. Stewart, pers. comm., 1996) as could associated increased public access (M. Wood, *in litt.*, 1996). Trail construction would be done by San

Mateo County (outlined in San Mateo County Trails Plan, San Mateo County 1989) and has not yet begun. An easement with San Mateo County is pending (E. Stewart, pers. comm., 1996). Trail construction has the potential to threaten the plants through direct destruction of habitat or through modification of hydrologic regimes. Because *Cirsium fontinale* var. *fontinale* is dependent upon seeps and springs to provide abundant soil moisture, any disruption in the flow of water (such as that caused by road, trail, or drain construction) would threaten the plants (U.S. Fish and Wildlife Service 1995). However, if trails are carefully planned (including pre-project surveys), routed, and constructed, direct effects of trail construction on sensitive plant species may be eliminated or greatly reduced (B. Olson, *in litt.*, 1998). Trails and their use may also facilitate dispersal of invasive non-native species (P. Holloran, *in litt.*, 1998), an indirect effect more difficult to control.

Non-native plants such as pampas grass (*Cortaderia selloana*) have established near the *Cirsium fontinale* var. *fontinale* in the Crystal Springs Reservoir area and threaten several subpopulations (Z. Chandik, pers. comm., 1992, J. Sigg, *in litt.*, 1995, M. Wood, *in litt.*, 1996) as could attempts to control non-natives (especially pampas grass) (California Natural Diversity Data Base 1996). Garden debris dumped from households located on the ridge above the plants covers plants and renders the habitat unsuitable for plant establishment and growth (Z. Chandik, pers. comm., 1992).

A second and substantially smaller population of *Cirsium fontinale* var. *fontinale* occurs in the Triangle west of Interstate 280 (California Natural Diversity Data Base 1996). One to 200 plants have been observed on San Francisco Water Department lands; an outlying colony of about 25 plants occurs on an easement held by Caltrans (U.S. Fish and Wildlife Service 1995). This colony occupied a smaller territory in 1992 than it had in previous years (S. Sommers, pers. comm., 1992). The plants on San Francisco Water Department land are threatened by proposed trail construction (San Mateo County 1989, 1991), as discussed above and in the Species Account for *Hesperolinon congestum*. Although the occurrence formerly extended onto San Francisco Water Department land, currently the plants are only found on Caltrans property. An April 1997 visit to the site indicated that the number of plants in the Triangle population is probably decreasing; it is possible that changes in hydrology due to construction of Interstate 280 have caused drying at the site (California Department of Fish and Game 1997*a*).

The site of the single individual of *Cirsium fontinale* var. *fontinale* in Edgewood County Park was in a drainage ditch beside a trail. Clearing of the ditch to improve or maintain drainage may threaten any plants in this location (S. Sommers, pers. comm., 1992).

In addition, it has been suggested that *Cirsium fontinale* var. *fontinale* may be threatened due to hybridization with *Cirsium quercetorum* (e.g. McClintock and Danielson 1975, California Native Plant Society 1988*b*). However, because hybridization only occurs rarely, this is not thought to be a serious problem. In addition, seed predation of this species by beetle larvae has been observed. Seedhead weevils (*Rhinocyllus conicus*) introduced for biocontrol of yellow star thistle and other thistles may use rare native thistles such as *Cirsium fontinale* var. *fontinale* as well. The impact on *Cirsium fontinale* var. *fontinale* is unknown but may increase the vulnerability of the species (D. Kelch, pers. comm., 1996, California Department of Fish and Game 1997*a*). Further, because there are only two known extant populàtions of *Cirsium fontinale* var. *fontinale* (Crystal Springs Reservoir and the Triangle) and because these populations occur in relatively close proximity to each other, the species may be at risk of extinction from random events or from natural catastrophes (Menges 1991, Primack 1993, Meffe and Carroll 1994).

### 5. Conservation Efforts

*Cirsium fontinale* var. *fontinale* was listed as endangered by the State of California in 1979 (California Department of Fish and Game 1992). The species was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995). The Crystal Springs Reservoir population of *Cirsium fontinale* var. *fontinale* is threatened by roadside maintenance. However, Caltrans is aware of the rare plants in this area, and the maintenance division submits spraying plans for internal environmental review before spraying in the area where plants are known to occur (R.Vonarb, pers. comm., 1992). Personnel of Caltrans and the San

Francisco Water Department have expressed interest in pampas grass (*Cortaderia selloana*) removal to benefit the species (G. Ciardi, pers. comm., 1997, R. Vonarb, pers. comm., 1997). The San Francisco Water Department conducted a small removal effort in June 1997 (G. Ciardi, pers. comm., 1997, U.S. Fish and Wildlife Service, *in litt.*, 1997), and Caltrans is making plans to do the same (R. Vonarb, pers. comm., 1997). In addition, a general management plan for the San Francisco Water Department lands currently is being developed (E. Stewart, pers. comm., 1992).

Some have suggested that disturbance may be beneficial to *Cirsium fontinale* var. *fontinale* because the species has been known to colonize areas where roadcuts exposed seeps which were suitable habitat (D. Kelch, pers. comm., 1996, D. Kelch, *in litt.*, 1996). Others strongly object to this interpretation (P. Holloran, *in litt.*, 1998). Research evaluating the role of disturbance in colonization of *Cirsium fontinale* var. *fontinale* would be useful.

### 6. Recovery Strategy

Recovery of *Cirsium fontinale* var. *fontinale* must first focus on protecting and managing the remaining populations by working with San Francisco Water Department, Caltrans, and San Mateo County to ensure the long-term survival of the species on their lands. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In some cases, it may be necessary to enlarge the buffer to include the entire local watershed; sites and their watersheds should be evaluated individually (R. Bittman, *in litt.*, 1998). In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Cirsium fontinale* var. *fontinale* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized monitoring of *Cirsium fontinale* var. *fontinale* populations every 3 years to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from invasive non-natives and from recreational activities must be eliminated; the former is an especially high priority for recovery. Where pampas grass (*Cortaderia* spp.) removal is required, cautions must be taken to avoid adverse impacts to federally listed animal species that may occur in the area (e.g. San Francisco garter snake [*Thamnophis sirtalis tetrataenia*]). If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised.

All of the *Cirsium fontinale* var. *fontinale* around Crystal Springs Reservoir should be considered one population (D. Kelch, *in litt.*, 1996, California Department of Fish and Game 1997*a*). First priority ought to be given to protection and management of this population as well as the two remaining sites, one in the Triangle and one at Edgewood Natural Preserve. Because the latest site visit indicated the population was decreasing, monitoring of the Triangle population is especially important to evaluate the status of that population. Until a better understanding of the demographic trend is established, this particular population should be visited annually. The Edgewood Natural Preserve site and other potential habitat at Edgewood should also be visited annually to establish whether *Cirsium fontinale* var. *fontinale* is still extant in the park. If the species has been extirpated from the preserve, repatriation of *Cirsium fontinale* var. *fontinale* at Edgewood should be considered a high priority.

Collection and banking of seed in Center for Plant Conservation certified botanic gardens is also a high priority in recovery efforts for *Cirsium fontinale* var. *fontinale*. Collections are prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriation, and/or introductions to new sites. All known populations should be represented in seed collections. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

Activities of lower priority include surveys of potential habitat and research. Surveys of other serpentine habitat within the species' range should be conducted to determine whether undiscovered populations may exist. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified. At least some of these surveys would require the cooperation of the San Francisco Water Department because suitable habitat occurs on their land. Research topics that need to be addressed include seed predation by the seedhead weevil (*Rhinocyllus conicus*), frequency of and potential threat from hybridization with brownie thistle (*Cirsium quercetorum*), seed germination and propagation techniques, the role of disturbance in colonization, reproduction (mating system and pollination), and demography (e.g. to identify limiting life history stages).

If the remaining natural populations and a repatriation of *Cirsium fontinale* var. *fontinale* at Edgewood Natural Preserve are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity, (2) shown to be stable or increasing over a minimum of 15 years that include the normal precipitation cycle, (3) seed collected representing all natural populations is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). Despite the difficulties of conducting successful repatriations, Edgewood Natural Preserve is a good candidate site because, if *Cirsium fontinale* ssp. *fontinale* is extirpated at the site, the extirpation was a recent occurrence. However, any repatriation at Edgewood would need to be protected from threats due to recreational activities in the preserve. In addition, depending on what demographic trend is observed, introduction of individuals may be necessary to maintain the population of *Cirsium fontinale* var. *fontinale* on the Caltrans portion of the Triangle. It may also be desirable to repatriate the San Francisco Water Department portion of the Triangle that formerly supported *Cirsium fontinale* var. *fontinale*.

The above downlisting criteria constitute a significant improvement in protection, management, and population size of *Cirsium fontinale* var. *fontinale* throughout its range. Completing these actions would substantially increase the security of the species. However, available data suggest that *Cirsium fontinale* var. *fontinale* should not be considered for delisting. The species is known from only three locations in an area that is extensively urbanized. No historic sites are known for repatriation, and the possible success of introduction of the species is not known. In the unlikely event that (1) a significant number of new populations are discovered and/or (2) research shows habitat within the species range is available and introductions are likely to be successful, development of delisting criteria could be considered.

### F. Presidio clarkia (*Clarkia franciscana*)

#### 1. Description and Taxonomy

***Taxonomy.*** - The type specimen of *Clarkia franciscana* (Presidio clarkia) was collected by Peter Raven in 1956. *Clarkia franciscana* was described by Harlan Lewis and Peter Raven (1958*a*).

***Description.*** - *Clarkia franciscana* (Figure II-11) is a slender, erect, herbaceous annual of the evening-primrose family (Onagraceae), 40 centimeters (16 inches) tall with few, very small, and narrow leaves. The lavender-pink petals have a lighter basal portion and a reddish-purple basal spot. The slender capsule is 2 to 4 centimeters (1 to 2 inches) long. *Clarkia franciscana* can be distinguished from *Clarkia rubicunda* (ruby chalice clarkia), a related species that may occur in the same area, by its petals that have irregular teeth on the apical margin (the edge near the tip). *Clarkia rubicunda* has petals that are rounded at the apex (Lewis and Raven 1958*a*) and usually twice the length of *Clarkia franciscana* (Lewis and Raven 1958*a*, Lewis 1977).

#### 2. Historical and Current Distribution

***Historical and Current Distribution.*** - *Clarkia franciscana* was once thought to be restricted to the Presidio in San Francisco County, but about 10 years ago, a

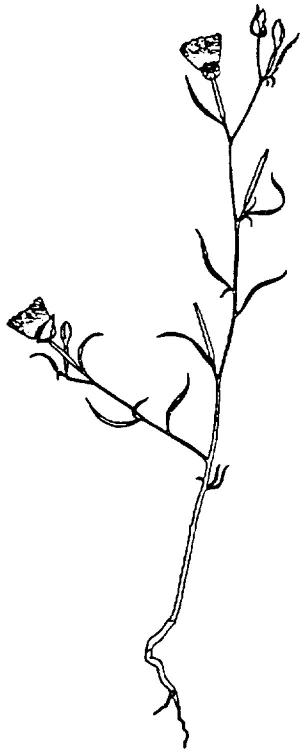

**Figure II-11.** Illustration of Presidio clarkia (*Clarkia franciscana*) (from Brittonia vol. 10, no. 1, fig. 1, copyright 1958, The New York Botanical Garden, with permission).

population was discovered in Alameda County in the Oakland Hills (Figure II-12). *Clarkia franciscana* is now thought to be restricted to San Francisco and Alameda Counties (California Natural Diversity Data Base 1996) and occupied habitat of less than 2 hectares (5 acres) (T.H. Lindenmeyer, *in litt.*, 1993). Two extant populations are known from the Presidio in San Francisco; one of these is probably introduced. A third population at the Presidio is probably extirpated (California Department of Fish and Game 1997*b*). Three populations are known from the Oakland Hills in Alameda County, 27 kilometers (17 miles) east of San Francisco, all within 1.0 kilometer (0.6 mile) of each other (California Natural Diversity Data Base 1996). These have been called the Crestmont, Old Redwood, and Redwood Park sites (B. Olson, *in litt.*, 1993) and are probably the remaining portions of one population that has been fragmented by roads and houses (California Department of Fish and Game 1997*b*, B. Olson, *in litt.*, 1998). A fourth population in the Oakland Hills (the Tennis Club site) was reported in 1988 but could not be relocated during a search conducted in 1991 (D. Bigham, *in litt.*, 1991, B. Olson, *in litt.*, 1993).

The first of the Alameda County populations was discovered in 1980 at Redwood Regional Park. Because this discovery occurred so long after the original discovery of the plant, and because it was relatively far from the previously known population at the Presidio, it was suggested that this population might not be a natural occurrence (Gottlieb and Edwards 1992). The suggestion gained credence because seed collected from the type location in 1964 had been sown in the East Bay Regional Parks Tilden Botanic Garden and plants had grown there for several years (Roof 1971). Seed collected from plants at the botanic garden had been sown in several sites at the Presidio in 1972 (Roof 1972). It was thought that seed might also have been sown at Redwood Regional Park in Alameda County. However, an electrophoretic comparison of the San Francisco and Alameda populations "strongly suggests that the Oakland Hills population did not originate by seed transfer from San Francisco, and that it must be regarded as indigenous to its present locality" (Gottlieb and Edwards 1992). As noted above, all of the Oakland Hills populations of *Clarkia franciscana* may have originally been part of one large population prior to development (B. Olson, *in litt.*, 1998).

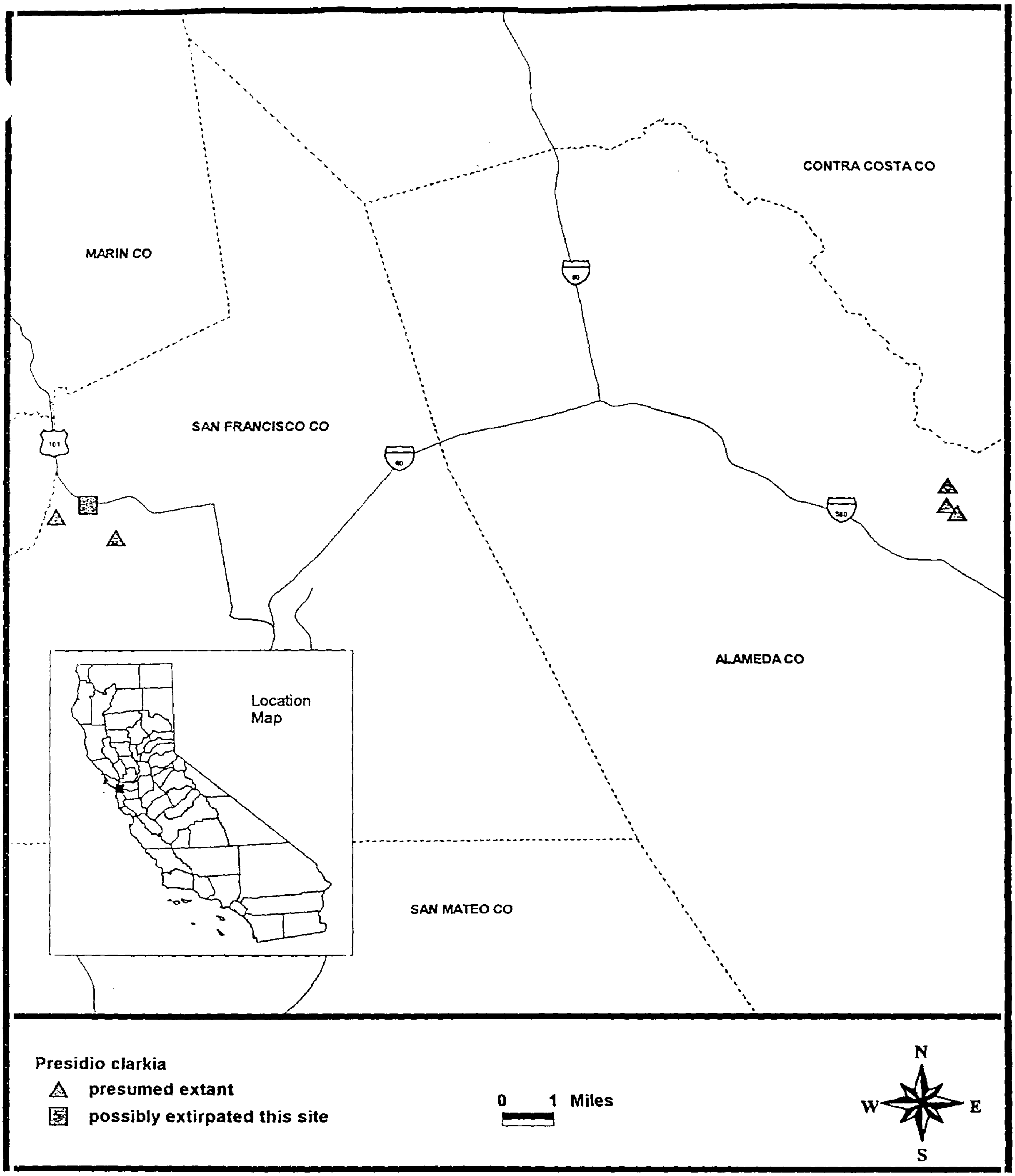


**Figure II-12.** Distribution of Presidio clarkia (*Clarkia franciscana*).

### 3. Life History and Habitat

***Reproduction and Demography.*** - *Clarkia franciscana* flowers from May to July (Munz and Keck 1959). At the Presidio, *Clarkia franciscana* is visited by small halictid bees (sweat bees) which may be pollinators of the species. However, plants can self-pollinate by shedding pollen directly on the stigma (female reproductive part) (Lewis and Raven 1958*a*), and the species is thought to be predominantly self-pollinated in natural populations. Based on electrophoretic evidence, there is little genetic variability within populations of *Clarkia franciscana*. However, the Presidio and Oakland Hills populations, which have been examined, are genetically different from one another (see also above) (Gottlieb and Edwards 1992).

The chromosomal structure of *Clarkia franciscana* led to the proposition that the species developed rapidly, an idea called catastrophic selection (Lewis and Raven 1958*b*). Although subsequent genetic evidence did not support the idea of rapid speciation (Gottlieb 1973), the species remains of interest to biologists interested in mechanisms of speciation (Gottlieb and Edwards 1992).

Population sizes fluctuate greatly (Lewis and Raven 1958*a*) for reasons that are not understood. The total number of individuals of the species is never large (T. Lindenmeyer, *in litt.*, 1993). The upper limit to the total numbers of plants reported in recent years is approximately 8,000 (U.S. Fish and Wildlife Service 1995).

***Habitat and Community Associations.*** - *Clarkia franciscana* is restricted to serpentine soils in grassland communities and coastal scrub in San Francisco and Alameda Counties (Skinner and Pavlik 1994). It is the only species of *Clarkia* restricted to serpentine soils (Lewis and Raven 1958*a*). Known locations span elevations between approximately 23 and 335 meters (75 to 1,100 feet). Other rare species occurring with *Clarkia franciscana* include the federally endangered Presidio manzanita (*Arctostaphylos hookeri* var. *ravenii*) (California Native Plant Society 1988*c*) and most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*), a species of concern (California Natural Diversity Data Base 1996). Other associated native species include blue wildrye (*Elymus glaucus*), blue-eyed grass (*Sisyrinchium bellum*), California brome (*Bromus carinatus*), California oatgrass (*Danthonia californica*) (Lewis and Raven 1958*a*), California poppy (*Eschscholzia californica*) (California Natural Diversity Data Base 1996), coast buckwheat (*Eriogonum latifolium*), coastal onion (*Allium dichlamydeum*) (Lewis and Raven 1958*a*), common yarrow (*Achillea millefolium*) (California Natural Diversity Data Base 1996), dwarf plantain (*Plantago erecta*) (Lewis and Raven 1958*a*), golden yarrow (*Eriophyllum confertiflorum*) (California Natural Diversity Data Base 1996), Ithuriel's spear (*Tritelia laxa*) (Lewis and Raven 1958*a*), junegrass (*Koeleria macrantha*) (California Natural Diversity Data Base 1996), ocean-bluff bluegrass (*Poa unilateralis*) (Lewis and Raven 1958*a*), purple needlegrass (*Nassella pulchra*), seashore bentgrass (*Agrostis pallens*), slender wheatgrass (*Elymus trachycaulus*) (California Natural Diversity Data Base 1996), tidy-tips (*Layia platyglossa*), and wavyleaf soapplant (*Chlorogalum pomeridianum* var. *divaricatum*) (Lewis and Raven 1958*a*). Associated non-native plant species include french broom (*Genista monspessulana*), pampas grass (*Cortaderia jubata*), and slender wild oat (*Avena barbata*) (California Natural Diversity Data Base 1996).

### 4. Reasons for Decline and Threats to Survival

*Clarkia franciscana* is threatened by potential development, roadside maintenance, foot traffic, mowing, competition from non-native plants, and shade from native and introduced shrubs and trees (California Natural Diversity Data Base 1996). The two populations in San Francisco County occur at the Presidio, which was transferred from the U.S. Department of Defense to the National Park Service in October, 1994. The Presidio is currently managed by the National Park Service; however, plans are being made to transfer responsibility for the property from the National Park Service to a Federal trust (T. Thomas, pers. comm., 1996). The Presidio populations are threatened by habitat degradation, including mowing, trampling, roadside maintenance, and presence of non-native species (California Natural Diversity Data Base 1996). The Presidio represents a significant natural and cultural resource within San Francisco city limits and was expected to be widely promoted and heavily used by visitors after transfer to the National Park Service (T. Thomas, pers. comm., 1992). Increasingly heavy use by visitors could increase negative impacts on *Clarkia franciscana* (U.S. Fish and

Wildlife Service, *in litt.*, 1995*a*). Road maintenance and mowing of grasslands before *Clarkia franciscana* has set seed also threatens the Presidio populations (California Department of Fish and Game 1992) as does the encroachment of non-native plant species, including German ivy (*Senecio mikanioides*), iceplant (*Carpobrotus* spp.), blackberries (*Rubus* spp.) (California Native Plant Society 1988*c*, U.S. Fish and Wildlife Service, *in litt.*, 1995*a*), non-native grasses (S. Farrell, *in litt.*, 1996), and natives planted outside their natural range, such as Monterey pine (*Pinus radiata*) (California Native Plant Society 1988*c*). Two years of sampling indicate that serpentine grasslands at the Presidio support nearly 50 percent cover of non-native grasses, particularly soft brome (*Bromus hordeaceus*) and Italian ryegrass (*Lolium multiflorum*) (S. Farrell, *in litt.*, 1996). The population size at the type locality increased following removal of non-native plant species in 1988 (California Natural Diversity Data Base 1996). Removal of Monterey pines in 1995 also allowed *Clarkia franciscana* to move into previously unoccupied habitat (S. Farrell, *in litt.*, 1996).

The three populations of *Clarkia franciscana* in Alameda County are all threatened by non-native species. The smallest of the three (Crestmont), consisting of 30 plants (Olson 1991*a*), occurs on an undeveloped site adjacent to a proposed 32-unit residential development (N. Lamb, pers. comm., 1993) and may be affected by collection, trampling and other human disturbances if the site becomes developed.

At latest report, the largest population of *Clarkia franciscana*, occurring at Redwood Regional Park in Alameda County, consisted of 4,000 to 5,000 plants (Gottlieb and Edwards 1992, Olson 1991*b*). Previous threats to the largest segment of this population, below the former East Bay Regional Parks District headquarters, included proposed expansions of the headquarters, improvements to adjacent equestrian facilities, and invasive non-native species. Most of these threats have apparently been removed. For example, the equestrian facility has been relocated (B. Olson, *in litt.* 1996, 1998). The East Bay Regional Park District is aware of the *Clarkia franciscana* population and has been taking it into account in their management plans (R. Budzinski, pers. comm., 1992). The habitat is still threatened by competition with annual grasses (R. Budzinski, pers. comm., 1992) and other non-native plants, including pampas grass (*Cortaderia* *selloana*) and french broom (*Genista [=Cytisus] monspessulana* (Olson 1991*b*). The portion of this population that occurs off of East Bay Regional Parks District land is threatened by proposed developments, herbicide applications, and invasive non-native plants such as pampas grass (*Cortaderia* spp.) (B. Olson, *in litt.*, 1996).

The two smaller populations in Alameda County, consisting of 200 plants (Old Redwood) (Olson 1991*c*, B. Olson, *in litt.*, 1993) and 30 plants (Crestmont) (Olson 1991*a*, B. Olson, *in litt.*, 1993) respectively, are also threatened by non-native species such as french broom (*Genista [=Cytisus] monspessulana*) and pampas grass (*Cortaderia jubatum*). The larger of these populations is isolated and on a roadcut (Olson 1991*c*) and may be threatened by roadside spraying of herbicides for weed control. The other population site is being rapidly displaced by non-native vegetation and is for sale (California Department of Fish and Game 1997*b*, B. Olson, *in litt.*, 1998). In addition, low viability caused by harmful genetic changes may result from inbreeding in small populations (Barrett and Kohn 1991, Ellstrand and Elam 1993).

### 5. Conservation Efforts

*Clarkia franciscana* was listed as endangered by the State of California in 1978 (California Department of Fish and Game 1992). The species was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995). Presidio populations of *Clarkia franciscana* have been monitored annually since 1994; permanent vegetation transects were established in 1995. The largest population at the Presidio was fenced in 1995, and invasive Monterey pines occupying serpentine soil were removed in 1995 and 1996. Following tree removal in 1995, *Clarkia franciscana* moved into the newly open habitat (S. Farrell, *in litt.*, 1996). Efforts to improve habitat by removing non-natives and removing accumulated acidic soils are ongoing at the Presidio. East Bay Regional Park District has also taken some measures to control non-native invasive species, including removal of Monterey pines, pampas grass, french broom, and acacias. Using prescribed fire is also a possibility to control undesirable vegetation and promote growth of native species (B. Olson, *in litt.*, 1998). Seeds of *Clarkia franciscana* are stored at the University of California Botanical Garden as part of the Center for Plant

Conservation's National Collection of Endangered Plants (P. Olwell, *in litt.*, 1993), and the species is apparently easy to grow (California Department of Fish and Game 1997*b*). As of 1993, the East Bay Regional Parks Botanic Garden had an extensive growing collection of *Clarkia franciscana* (P. Olwell, *in litt.*, 1993).

**6. Recovery Strategy**

Recovery of *Clarkia franciscana* must first focus on protecting and managing the remaining populations by working with the Presidio, East Bay Regional Parks District (for Redwood Park population), and private landowners to ensure the long-term survival of the species on their lands. Populations on private land should be secured through land acquisition, conservation easements, or other means. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Clarkia franciscana* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized annual monitoring of *Clarkia franciscana* populations to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, the very serious threat from invasion of non-natives into *Clarkia franciscana* habitat must be ameliorated if recovery is to be possible. Removal of existing non-natives should be followed by establishment of buffer zones to control reinvasion and surveys to allow early detection of new colonies of non-natives (P. Baye, *in litt.*, 1996). If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Because populations of *Clarkia franciscana* occur at the Presidio and at Redwood Park, any management plan developed for *Clarkia franciscana* at these sites should include an educational outreach program. First priority ought to be given to protection and management of the populations on public land at the Presidio and Redwood Park. Protection of serpentine habitat at the Presidio might also benefit Marin dwarf-flax

(*Hesperolinon congestum*). Second priority should be given to populations on private land.

Another high priority in recovery efforts for *Clarkia franciscana* is evaluation of the status (age, viability) of seeds stored at the UC Botanical Garden at Berkeley and collection of more seed for storage in other Center for Plant Conservation certified botanic gardens. Although some seed has already been stored, further collections may be prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations, and/or introductions to new sites. Genetic differences identified by Gottlieb and Edwards (1992) between plants at the Presidio and plants in the Oakland Hills suggest that seed collection efforts should include populations at both sites to increase the likelihood that species level genetic variation will be represented (Elam in prep). Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection, removal of non-natives, and seed collection from *Clarkia franciscana*, the historic locations should be surveyed to determine whether suitable habitat remains, the species persists at the sites, and/or the sites may be suitable for repatriation. These surveys would include the possibly extirpated population at the Presidio and the "Tennis Club site" in the Oakland Hills. Suitability of historic locations for repatriation would depend upon (1) whether potential habitat exists, (2) the presence and magnitude of threats, and (3) whether the sites can be secured and managed for the long-term protection of the species. Surveys should also include other potential serpentine habitat to determine whether undiscovered populations may exist. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified. Potential introduction sites at the Presidio include the western bluffs, the bluffs above Fort Point, grasslands near Inspiration Point, and other areas with remnant serpentine soils (S. Farrell, *in litt.*, 1996).

Other important, but lower priority, recovery activities for *Clarkia franciscana* include research to evaluate the effectiveness of various techniques for opening new habitat (e.g. soil scraping, removal of duff, burning) and seeding techniques. Additional basic research that is needed includes demography (e.g. to identify limiting life history stages), soil seed bank, and reproductive biology (e.g. mating system and pollination).

If the five known occurrences of *Clarkia franciscana* are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity, (2) shown to be stable or increasing over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring), (3) seed collected from remaining natural populations representing both the Presidio and the Oakland Hills is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993).

The above downlisting criteria constitute a significant improvement in protection and management of *Clarkia franciscana* throughout its range. Completing these actions would substantially increase the security of the species. However, available data suggest that *Clarkia franciscana* should not be considered for delisting. The species is known from only two locations in an area that is extensively urbanized. Only one possible repatriation site is known. In the unlikely event that (1) a significant number of new populations are discovered and/or (2) research shows habitat within the species range is available and introductions are likely to be successful, development of delisting criteria could be considered.

## G. Pennell's bird's-beak (*Cordylanthus tenuis* ssp. *capillaris*)

### 1. Description and Taxonomy

***Taxonomy.*** - *Cordylanthus tenuis* ssp. *capillaris* (Pennell's bird's-beak) was collected by Herbert Mason about 3.2 kilometers (2 miles) north of Occidental in Sonoma County, California, in 1946 (Pennell 1950, Bacigalupi 1966). Francis Whittier Pennell described the plant as *Cordylanthus capillaris* in 1950, using Mason's specimen as the type (Pennell 1950). Pennell was misled by an erroneous label to think that the plants had been collected in Merced County (Bacigalupi 1966), which may have affected his treatment of the taxon (Chuang and Heckard 1986). Munz placed the taxon under *Cordylanthus pallescens* (Munz and Keck 1959). Artificial hybridization studies of *Cordylanthus brunneus* and *Cordylanthus capillaris* (Chuang and Heckard 1975) showed a close relationship between the two plants. The name *Cordylanthus brunneus* ssp. *capillaris* was proposed for *Cordylanthus capillaris* by Chuang and Heckard (Heckard 1977), but was never formally published. In 1986, Chuang and Heckard published a revision of the genus, in which both *Cordylanthus brunneus* and *Cordylanthus capillaris* were treated as subspecies of *Cordylanthus tenuis* (Chuang and Heckard 1986).

***Description.*** - *Cordylanthus tenuis* ssp. *capillaris* (Figure II-13) is a branching herbaceous annual of the snapdragon family (Scrophulariaceae). The plant grows 30 to 60 centimeters (12 to 24 inches) tall, with yellow-green hairless herbage that becomes purplish with age. The leaves are entire (with smooth edges), or those of the primary stem three-parted, and threadlike. The floral bracts are three-parted up to two-thirds of their length, with fine marginal hairs on bracts and calyx (collective term for the sepals or outermost whorl of flower parts). The tubular corolla (collective term for all the petals) is 1.5 centimeters (0.6 inch) long (Chuang and Heckard 1986), and garnet-brown laterally, paler dorsally (Pennell 1950). Each capsule contains 10 to 16 seeds (Chuang and Heckard 1986). The three-lobed outer bracts of *Cordylanthus tenuis* ssp. *capillaris* distinguish it from its nearest relative, *Cordylanthus tenuis* ssp. *brunneus* (serpentine bird's-beak), and from *Cordylanthus pilosus* (hairy bird's-beak), another *Cordylanthus* found in the area. A further distinguishing character is that *Cordylanthus pilosus* is

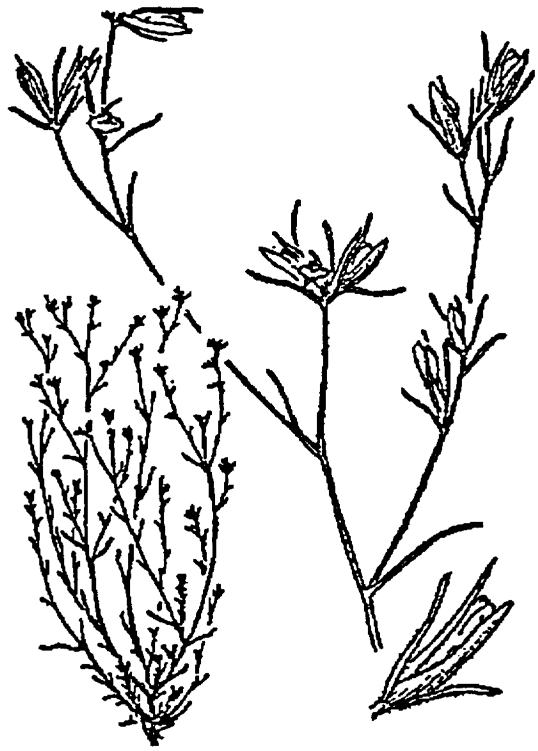

**Figure II-13.** Illustration of Pennell's bird's-beak (*Cordylanthus tenuis* ssp. *capillaris*) (from Abrams 1951, with permission).

densely hairy throughout (Heckard 1977).

## 2. Historical and Current Distribution

***Historical and Current Distribution.*** - *Cordylanthus tenuis* ssp. *capillaris* is known only from the vicinity of Camp Meeker in Sonoma County (California Native Plant Society 1988*d*) (Figure II-14). The species is found in two locations: the type locality which is partially within Harrison Grade Ecological Reserve in western Sonoma County (California Natural Diversity Data Base Occurrence 2) and a second area a few miles to the west near Bohemian Highway (California Natural Diversity Data Base Occurrences 1 and 4) (California Natural Diversity Data Base 1996). A third population may occur on property adjacent to the second location, but permission for botanical surveys on that property has been consistently refused (B. Guggolz, pers. comm., 1992).

## 3. Life History and Habitat

***Reproduction and Demography.*** - *Cordylanthus tenuis* ssp. *capillaris* flowers from June to July (Chuang and Heckard 1986). No data are available on its reproductive biology. The species is a root parasite, forming attachments to shrubs and possibly cypress trees (Heckard 1977).

The Harrison Grade Ecological Reserve location had more than 5,000 plants in 1987 (McCarten 1987*b*). The Bohemian Highway location consists of two populations, one with approximately 200 plants growing on a steep slope in 1987 and the other with 12 plants in a roadside ditch in 1986 (California Natural Diversity Data Base 1996). The total number of plants fluctuates from year to year (California Natural Diversity Data Base 1996), as is typical of annual plants.

***Habitat and Community Associations.*** - *Cordylanthus tenuis* ssp. *capillaris* occupies serpentine flats among chaparral (Chuang and Heckard 1986) at elevations of approximately 45 to 245 meters (150 to 800 feet) (California Natural Diversity Data Base 1996). Associated species include Baker's manzanita (*Arctostaphylos bakeri*), California coffeeberry (*Rhamnus californica*) (Chuang and Heckard 1986), musk brush (*Ceanothus jepsonii*) (California Natural

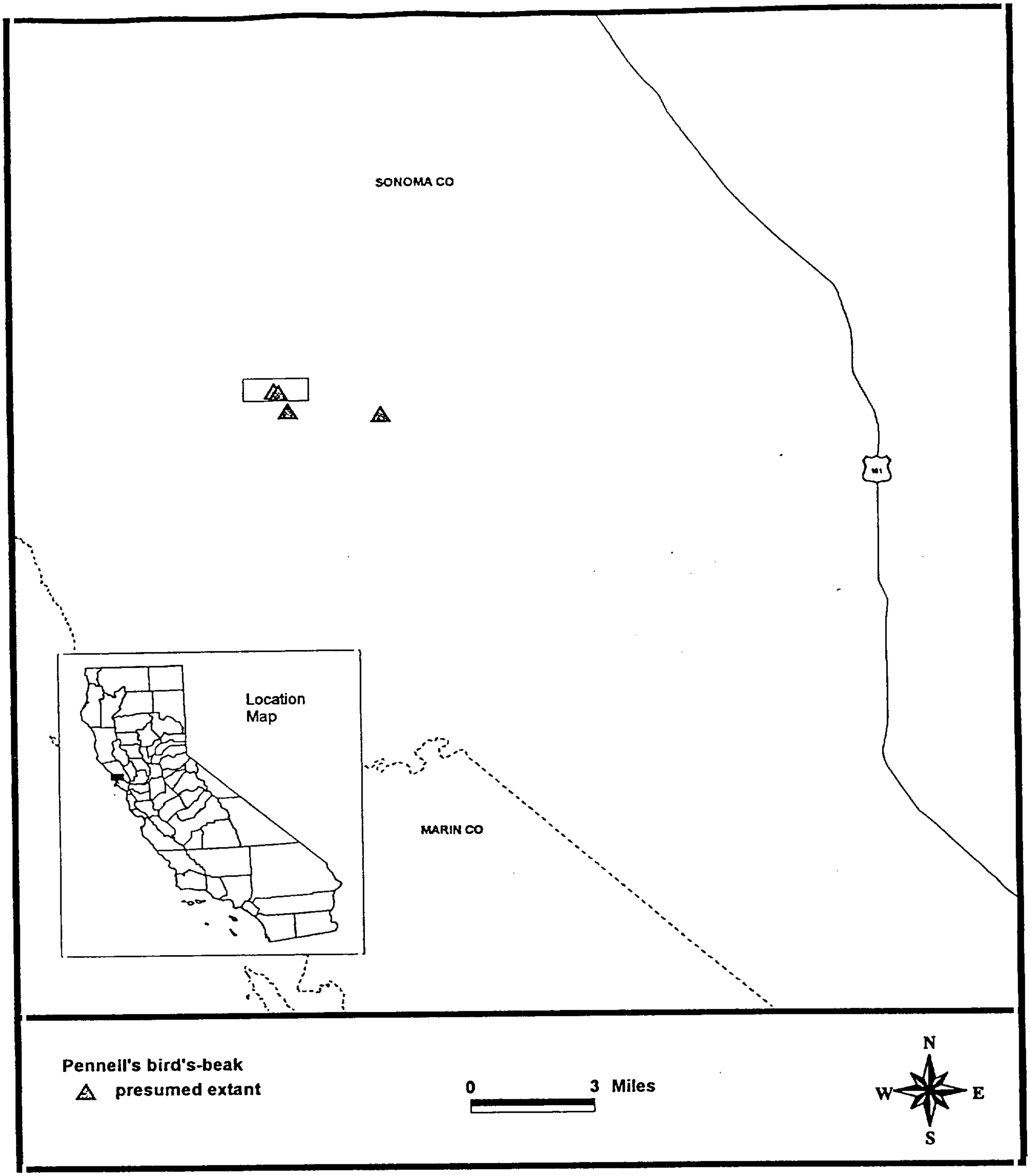


**Figure II-14.** Distribution of Pennell's bird's-beak (*Cordylanthus tenuis* ssp. *capillaris*). Each symbol represents one occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

Diversity Data Base 1996), and Sargent cypress (*Cupressus sargentii*) (Chuang and Heckard 1986). Of these, Baker's manzanita is considered rare (Skinner and Pavlik 1994).

### 4. Reasons for Decline and Threats to Survival

*Cordylanthus tenuis* ssp. *capillaris* is threatened by potential residential development (B. Guggolz, pers. comm., 1992, 1997), timber harvest activities (B. Guggolz, pers comm., 1997), garbage dumping, slope erosion, off-road vehicle use (California Natural Diversity Data Base 1996), and roadside maintenance (L. Lozier, pers. comm., 1992). Ownership of the type locality is mixed; part of the population occurs on the Harrison Grade Ecological Reserve, which is owned and managed by the California Department of Fish and Game (California Natural Diversity Data Base 1996). Habitat on the preserve is threatened by unauthorized activities such as off-road vehicle use (McCarten 1987*b*, California Natural Diversity Data Base 1996). Vehicular traffic threatens plants in and near the parking area at the Harrison Grade Reserve, which is poorly defined and close to the plant population. Unauthorized dumping of items such as bottles, furniture and appliances, and trampling by visitors are also threats to the species at the site (McCarten 1987*b*, R. Bittman, *in litt.*, 1998). Light disturbance at the Harrison Grade Reserve, such as infrequent grading of dirt roads, appears to increase the numbers of *Cordylanthus tenuis* ssp. *capillaris* (L. Lozier, pers. comm., 1992), but higher levels of disturbance may facilitate the invasion of non-native species (McCarten 1987*b*) and result in a decline of *Cordylanthus tenuis* ssp. *capillaris.*

The second location of *Cordylanthus tenuis* ssp. *capillaris* occurs on private property in the vicinity of Bohemian Highway, a few miles to the west of the type locality. At the time of the final rule listing *Cordylanthus tenuis* ssp. *capillaris* (U.S. Fish and Wildlife Service 1995), plans for residential development of this site had been reviewed by the Sonoma County Planning Department (S. Swedenborg, pers. comm., 1993). The owner of the property had been working with the California Department of Fish and Game to minimize impacts to *Cordylanthus tenuis* ssp. *capillaris* (A. Howald, pers. comm., 1992). Plans included the donation of 87 hectares (212 acres), including *Cordylanthus tenuis* ssp. *capillaris* habitat, to the County for use as a park (S. Swedenborg, pers.

comm., 1993). The County was considering restricting the park to passive recreation only; however, no final policy had yet been determined (B. Guggolz, pers. comm., 1993). This donation would have afforded protection to part of the second population of *Cordylanthus tenuis* ssp. *capillaris* (B. Guggolz, pers. comm., 1993). As of 1997, planning for the subdivision and associated park discussed in the final rule had been dropped and the property sold to another party who is currently making plans for a different project that includes both timber harvest activities and development (B. Guggolz, pers. comm., 1997, S. Swedenborg, pers. comm., 1997). Because details of the new plans are not available, the population still should be considered threatened by development as well as by activities associated with timber harvesting.

Both horses and deer have been reported to browse on *Cordylanthus tenuis* ssp. *capillaris* but the number of plants damaged generally appears to be minimal. *Cordylanthus tenuis* ssp. *capillaris* growing along roadsides is threatened by roadside maintenance such as mowing and spraying (L. Lozier, pers. comm., 1992). The limited number and isolated condition of these populations make this species susceptible to extinction from random, catastrophic events (Menges 1991).

### 5. Conservation Efforts

*Cordylanthus tenuis* ssp. *capillaris* was listed as rare by the State of California in 1978 (California Department of Fish and Game 1992). The species was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995). The California Department of Fish and Game developed a management plan for the Harrison Grade Preserve in 1987 (McCarten 1987*b*), and implementation is in progress. In 1995, a fence was built along the eastern edge of the preserve (T. LaBlanc, pers. comm., 1997).

### 6. Recovery Strategy

Recovery of *Cordylanthus tenuis* ssp. *capillaris* must first focus on protecting and managing populations at the two remaining locations by working with the California Department of Fish and Game and private landowners to ensure long-term survival of the species. Populations on private land should be protected by land acquisition, conservation easements, or other means. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Cordylanthus tenuis* ssp. *capillaris* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized annual monitoring of *Cordylanthus tenuis* ssp. *capillaris* populations to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from off-road vehicle use, dumping, and roadside maintenance must be eliminated. If new threats (e.g. invasion of non-natives) are identified or other new information becomes available, management plans need to be reevaluated and revised. Because the California Department of Fish and Game preserve is too small to provide long-term protection for the species as a whole (California Department of Fish and Game 1997*b*), high priority should be given to protection and management of the populations on private land, especially those at the Bohemian Highway site. Protection of the Bohemian Highway populations would establish a secure location that is geographically disjunct from the California Department of Fish and Game preserve at Harrison Grade. Securing a second location is important to guard against extinction of the species from catastrophic events that may destroy entire populations (Menges 1991, Primack 1993, Meffe and Carroll 1994). In addition, protection of the Bohemian Highway site would benefit two other special status plants, Baker's manzanita (*Arctostaphlyos bakeri* ssp. *bakeri*) and Crystal Springs lessingia (*Lessingia arachnoidea*).

Collection and banking of seed in Center for Plant Conservation certified botanic gardens is also a high priority recovery action for *Cordylanthus tenuis* ssp. *capillaris*. Seed banking is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations, and/or introductions to new sites. In the absence of genetic data for *Cordylanthus tenuis* ssp. *capillaris*, seed banking should include collections from all known populations. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection of and seed collection from the known populations of *Cordylanthus tenuis* ssp. *capillaris*, other suitable serpentine habitat should be surveyed to determine whether undiscovered populations exist. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Other important recovery activities for *Cordylanthus tenuis* ssp. *capillaris* include research on seed germination and propagation techniques that take into account the hemiparasitic nature of the plant, the use of burning as a management strategy, and basic research on demography (including soil seed bank) and reproduction (including mating system and pollination). Demographic research would be valuable to identify limiting life history stages.

If the two confirmed populations of *Cordylanthus tenuis* ssp. *capillaris* (Harrison Grade and Bohemian Highway) are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity, (2) shown to be stable or increasing over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring), (3) seed collected from both remaining natural populations is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993).

The above downlisting criteria constitute a significant improvement in protection and management of *Cordylanthus tenuis* ssp. *capillaris* throughout its range. Completing these actions would substantially increase the security of the species. However, available data suggest that *Cordylanthus tenuis* ssp. *capillaris* should not be considered for delisting. The species is known from only two locations in an urbanized area. No historic sites are known for repatriation, and the possible success of introduction of the species is not known. In the unlikely event that (1) a significant number of new populations are discovered and/or (2) research shows habitat within the species range is available and introductions are likely to be successful, development of delisting criteria could be considered.

### H. Santa Clara Valley dudleya (*Dudleya setchellii*)

#### 1. Description and Taxonomy

***Taxonomy.*** - The type specimen of *Dudleya setchellii* (Santa Clara Valley dudleya) was collected by Willis L. Jepson on Tulare Hill in Santa Clara County (Jepson 1901). He described it as *Cotyledon laxa* var. *setchellii* (Jepson 1901). At the same time, he described *Cotyledon caespitosa* var. *paniculata*, which he had collected from Morrison Canyon near what is now Fremont. Britton and Rose (1903) elevated both taxa to full species and transferred them to the newly-created genus *Dudleya*. Subsequently, *Dudleya setchellii* was variously treated as *Cotyledon setchellii* (Fedde 1904), *Echeveria setchellii* (Nelson and Macbride 1913), and *Echeveria laxa* var. *setchellii* (Jepson 1936). Reid Moran (1959) combined the material referred to as *Dudleya setchellii* and *Dudleya paniculata* in *Dudleya cymosa* ssp. *setchellii*. Kei Nakai (1987) separated the two entities into *Dudleya cymosa* ssp. *paniculata* and *Dudleya cymosa* ssp. *setchellii* on the basis of leaf shape, inflorescence branching patterns, and pedicel (stalk of individual flower or fruit) length. Bartel's treatment of *Dudleya* retains Nakai's *Dudleya cymosa* ssp. *paniculata* and resurrects Britton and Rose's *Dudleya setchellii* for the Santa Clara Valley dudleya (Hickman 1993).

***Description.*** - *Dudleya setchellii* (Figure II-15) is a low-growing perennial of the stonecrop family (Crassulaceae) with fleshy, glabrous (hairless) leaves. The oblong to triangular, slightly glaucous (covered with a whitish or bluish waxy or powdery film) leaves are 3 to 8 centimeters (1 to 3 inches) long and 7 to 15

**Figure II-15.** Illustration of Santa Clara Valley dudleya (*Dudleya setchellii*) (from Abrams 1944, with permission).

millimeters (0.3 to 0.6 inch) wide. Two or three flowering stems ascend to heights of 5 to 20 centimeters (2 to 8 inches) in mid to late spring. The pale yellow petals are 8 to 13 millimeters (0.3 to 0.5 inch) long (Hickman 1993).

There are two related species in the area. *Dudleya cymosa* ssp. *cymosa* (canyon liveforever) has bright yellow to red petals rather than pale yellow, and is, therefore, easily distinguished from *Dudleya setchellii* with its pale yellow flowers. *Dudleya cymosa* ssp. *paniculata* (canyon liveforever) can be distinguished from *Dudleya setchellii* by its oblong to oblanceolate (narrowly elongate and widest at the tip) leaves (in contrast to the oblong-triangular leaves of *Dudleya setchellii*), its greater degree of rebranching of the inflorescence branches, and its longer pedicels (Hickman 1993).

### 2. Historical and Current Distribution

***Historical and Current Distribution.*** - *Dudleya setchellii* is found only in the Coyote Valley area, from San Jose south about 30 kilometers (20 miles) to San Martin (McCarten 1993) in Santa Clara County (Skinner and Pavlik 1994) (Figure II-16). *Dudleya cymosa* ssp. *paniculata* (canyon liveforever) ranges from Contra Costa County to Fresno and Monterey Counties; the reports of Moran's combination *Dudleya cymosa* ssp. *setchellii* from Alameda, Contra Costa, and San Benito Counties (Munz and Keck 1959) reflect the distribution of *Dudleya cymosa* ssp. *paniculata* and do not refer to *Dudleya setchellii*, as now recognized (U.S. Fish and Wildlife Service 1995). Field surveys of Mt. Diablo and the Los Vaqueros reservoir site in Contra Costa County and from Sunol Regional Wilderness in Alameda County have located only *Dudleya cymosa* (B. Olson, *in litt.*, 1993). Twenty occurrences are currently documented at the California Natural Diversity Data Base. Almaden Quicksilver County Park contains the three most recent additions to the California Natural Diversity Data Base (California Natural Diversity Data Base 1996). The species was also identified in April 1997 at the Santa Clara County occurrence of *Castilleja affinis* ssp. *neglecta* (Hickson 1997).

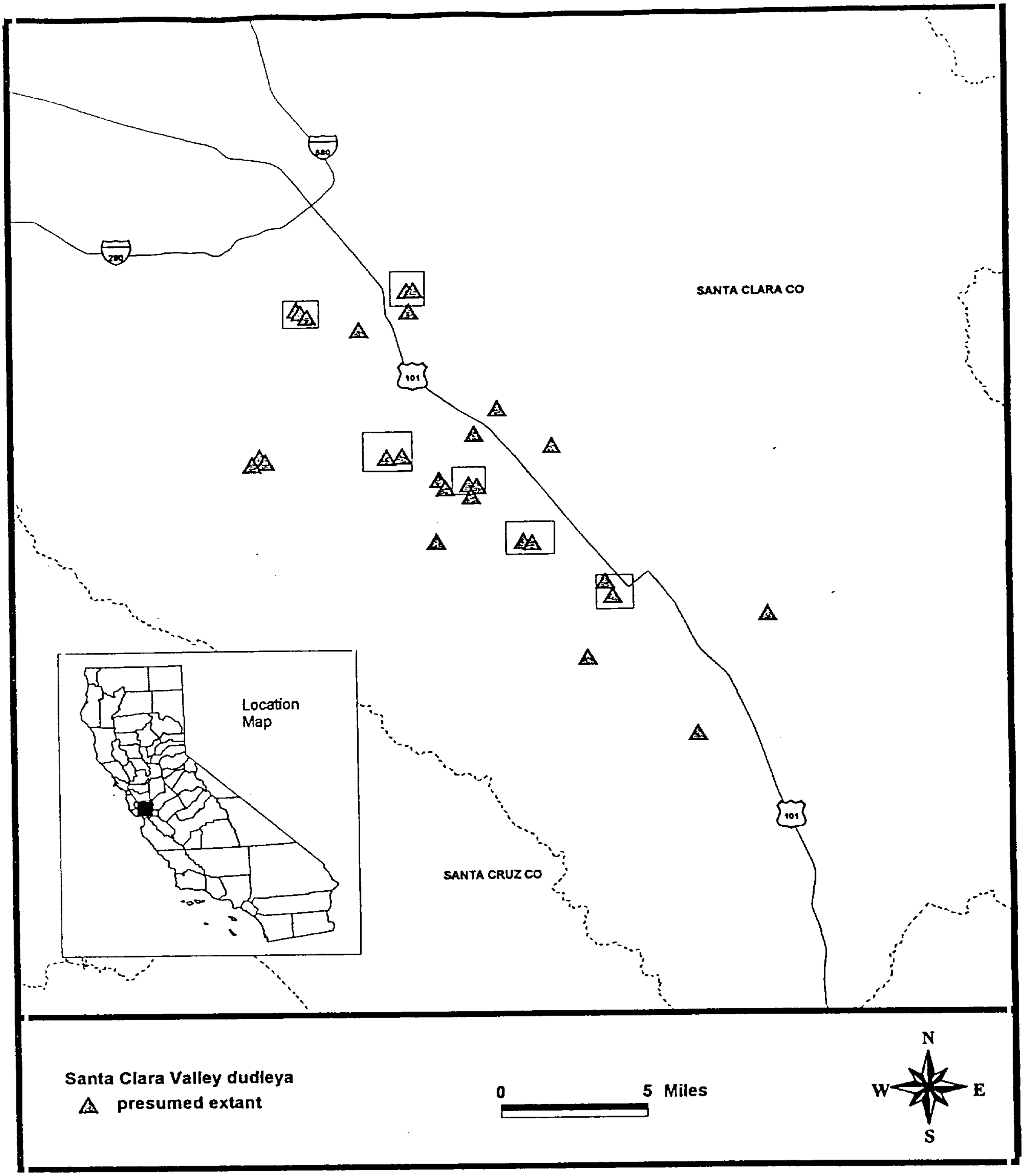


**Figure II-16.** Distribution of Santa Clara Valley dudleya (*Dudleya setchellii*). Each symbol represents one occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

### 3. Life History and Habitat

***Reproduction and Demography.*** - *Dudleya setchellii* is a perennial herb which flowers from May to June (Munz and Keck 1959) and produces wind dispersed seeds (McCarten 1993). The species can also reproduce vegetatively by forming rosettes that can separate from the parent plant or remain attached. Because an individual plant can have up to 10 rosettes attached, obtaining an accurate number of true individual plants can be difficult (P. Boursier, pers. comm. as cited in Jones and Stokes Associates, Inc. 1998). Individual plants may live for approximately 10 years. They are susceptible to heavy frosts but can survive for up to 2 years in inhospitable conditions and still exhibit minimal stress (J. Bartel, pers. comm. as cited in McCarten 1993). Rock outcrops in a *Dudleya setchellii* site usually number from 1 to 100 with 30 to 60 plants on each (McCarten 1993). Few detailed data on the reproductive biology or demography of the species are available. However, McCarten has studied demography of *Dudleya setchellii* at Kirby Canyon Landfill, the Santa Clara County occurrence. He found seedling germination was high in wet years (e.g., 1995 to 1997), but seedling survivorship was often very low in both natural and created habitats. Seedling survival was generally less than 5 percent and may be less than 1 percent after the first year. The highest survival rates observed were on east- and north-facing slopes (Jones and Stokes Associates, Inc. 1998, N. McCarten, *in litt.*, 1998). McCarten (*in litt.*, 1998) suggests the primary cause of low survival is the limited number of rock crevices with enough soil to provide the necessary nutrient and moisture conditions.

***Habitat and Community Associations.*** - *Dudleya setchellii* is restricted to rocky outcrops within serpentine grasslands between 120 and 300 meters (390 to 990 feet) in Santa Clara County (Hickman 1993). The roots of *Dudleya setchellii* are at least 15 centimeters (6 inches) long and often extend into rock crevices of the serpentine outcrops (McCarten 1993). McCarten (*in litt.*, 1998) suggests (1) the narrow distribution of *Dudleya setchellii* may be associated with the limited number of appropriate rock crevices available and (2) potential habitat for *Dudleya setchellii* cannot be determined by counting the number of rock outcrops because only some have crevices deep enough to provide habitat. The rock outcrops themselves have very little vegetative cover (McCarten 1993). However, the serpentine grassland where *Dudleya setchellii* occurs is often dominated by bottlebrush squirreltail (*Elymus elmoides*), California poppy (*Eschscholzia californica*), California goldfields (*Lasthenia californica*), dwarf plantain (*Plantago erecta*), Italian ryegrass (*Lolium multiflorum*), naked buckwheat (*Eriogonum nudum*), purple needlegrass (*Nassella pulchra*), ruby chalice clarkia (*Clarkia rubicunda*), tidy-tips (*Layia platyglossa*), and wavyleaf soapplant (*Chlorogalum pomeridianum*) (McCarten 1993). Italian ryegrass is a non-native species (Hickman 1993). Other rare species found with *Dudleya setchellii* include bay checkerspot butterfly (*Euphydryas editha bayensis*), coyote ceanothus (*Ceanothus ferrisiae*), fragrant fritillary (*Fritillaria liliacea*), Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*), most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*), Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*) (California Natural Diversity Data Base 1996), and Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) (Hickson 1997). Of these rare species, only fragrant fritillary and most beautiful jewelflower are not federally listed (California Natural Diversity Data Base 1996).

### 4. Reasons for Decline and Threats to Survival

*Dudleya setchellii* has always been restricted to the Coyote Valley area of Santa Clara County. The species is threatened by development, landfill activities, unauthorized dumping, quarry expansion, and off-road vehicles. Sixteen of the 20 known occurrences are partially or wholly on private land, and most are subject to various levels of threat from development (California Natural Diversity Data Base 1996, California Department of Fish and Game 1997*a*). The northernmost locations in southeastern San Jose and the southernmost locations in the area around Morgan Hill, approximately 27 kilometers (17 miles) southeast of San Jose, are at greatest risk (McCarten 1993). One of the northern populations is threatened with the proposed Cerro Plata project, consisting of 550 dwelling units and a 67-hectare (164-acre) golf course on a 236-hectare (575-acre) site. One estimate suggested this population contains approximately 20,000 plants; 61 percent of all known plants, of which approximately 2,380 would be directly eliminated by planned construction activities (City of San Jose 1993, D. Mayall, *in litt.*, 1996). All remaining plants would be exposed to human activities during and after construction that would result in significant impacts to the population.

These impacts include potentially harmful runoff from an upslope golf course, introduction of weedy species during construction, and uncontrolled foot traffic (U.S. Fish and Wildlife Service 1995). Another of the northern sites was threatened by the proposed construction of the Valley Christian School and South Valley Christian Church. As originally proposed, this construction would have eliminated 74 percent of the approximately 1,900 *Dudleya setchellii* plants found on the site (City of San Jose 1992). A revised plan indicates that the majority of the plants will be avoided. Approximately 700 additional mature plants have been translocated to an area near the base of the north slope of the project site. *Dudleya setchellii* plants were individually removed from rocks. The serpentine rocks where the plants had grown were moved, a new serpentine rock habitat created, and the plants translocated. This approach was taken because pilot studies showed translocation of rocks to locations having the same slope and aspect had a higher probability of success than transplantations of plants grown in greenhouses or other controlled environments. The latter had low probability of success based on plant physiological differences between greenhouse grown plants and plants that developed in natural conditions. The translocated *Dudleya setchellii* will be monitored for 10 years (Jones and Stokes Associates, Inc. 1998, N. McCarten, *in litt.*, 1998). Other sites also are developing rapidly and have been proposed for development at one time or another (McCarten 1993).

Two of the more centrally located populations of *Dudleya setchellii* are also threatened with imminent development, including residential development adjacent to Tulare Hill and road construction in Metcalf Canyon. One central population, due to its proximity to an off-road motorcycle park, may be threatened by off-road motorcycle traffic and unauthorized dumping (McCarten 1993). The Kirby Canyon Landfill, located approximately 5 kilometers (3 miles) north of Morgan Hill and operated by Waste Management of California, Inc., is expected to eliminate approximately 1,240 plants during its service life of 50 years (R. Schonholtz, pers. comm., 1994). The remaining two populations that occur on private land in the center portion of the species' range are on the grounds of the IBM Bailey Avenue laboratory. The company apparently plans to preserve the habitat (McCarten 1993).

In addition, grazing (McCarten 1993, K. Freas, *in litt.*, 1993, D. Mayall, *in litt.*,

1998) and collecting (U.S. Fish and Wildlife Service 1995) may threaten *Dudleya setchellii.* Grazing occurs on much of the grassland where *Dudleya setchellii* is located (McCarten 1993) and may result in reduced vigor or death of mature *Dudleya setchellii* individuals and the failure of seedling establishment (K. Freas, *in litt.*, 1993). Unrestricted collecting for scientific or horticultural purposes or excessive visits by individuals interested in seeing rare plants could threaten *Dudleya setchellii.* Due to the slow growth rate of this species and the rarity and desirability of large succulents, mature plants found in the wild are particularly susceptible to collection (U.S. Fish and Wildlife Service 1995).

### 5. Conservation Efforts

*Dudleya setchellii* was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995). The species is not listed by the State of California, and to date, no other conservation efforts have specifically targeted *Dudleya setchellii.*

### 6. Recovery Strategy

Recovery of *Dudleya setchellii* must first focus on protecting and managing extant populations. Populations on private land should be protected by land acquisition, conservation easements, or other means. Protection of populations on public land will involve working with the Santa Clara County Parks Department to ensure the long-term survival of the species on their lands. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Dudleya setchellii* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized monitoring of *Dudleya setchellii* populations every 3 years to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Because the majority of known populations of *Dudleya setchellii* occur on private lands, an educational outreach program should be developed for the City of San Jose and surrounding communities in Santa Clara County. Priority areas for protection will include those areas targeted in the bay checkerspot butterfly recovery strategies (e.g. Coyote Ridge) as well as other areas that contain populations on the periphery of the *Dudleya setchellii* range. Other species that might benefit from conservation efforts for *Dudleya setchellii* include coyote ceanothus (*Ceanothus ferrisiae*), Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*), fragrant fritillary (*Fritillaria liliacea*), Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*), most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*), Opler's longhorn moth (*Adela oplerella*), Hom's microblind harvestman (*Microcina homi*), and Jung's microblind harvestman (*Microcina jungi*).

Also of value in recovery efforts for *Dudleya setchellii* is collection and banking of seed in Center for Plant Conservation certified botanic gardens. Seed banking is prudent to guard against decline or extinction of populations from chance catastrophic events and to provide potential material for enhancement efforts in the existing population and/or introductions to new sites. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection of known populations and seed collection of *Dudleya setchellii*, other suitable serpentine habitat should be surveyed to determine whether undiscovered populations exist. Surveys should include the area north of Metcalf Canyon Road, on East Hill Ridge, along Uvas Road, Motorcycle Park (California Department of Fish and Game 1997*a*), and any areas that have been set aside as open space to benefit bay checkerspot butterfly. If new populations are discovered, they should be protected and managed as discussed above.

Certain types of research are also high priority recovery activities for *Dudleya setchellii*. In particular, because *Dudleya setchellii* co-occurs in a number of locations with bay checkerspot butterfly and because bay checkerspot butterfly habitat benefits from vegetation management, the effect of various vegetation management techniques (e.g. grazing, mowing, and burning) on *Dudleya setchellii* needs to be evaluated. Evaluation of these techniques will aid managers in selecting management strategies that maintain bay checkerspot butterfly habitat while not adversely affecting *Dudleya setchellii*. Other important, but lower priority, research areas for *Dudleya setchellii* include seed germination and propagation techniques, and demographic studies to identify limiting life history stages and reproductive biology (mating system, dispersal and colonization, pollination). Because *Dudleya setchellii* apparently has a relatively patchy distribution on rock outcrops (McCarten 1993), research on dispersal and connectivity among individual outcrops at a site would also be valuable.

If 20 populations of *Dudleya setchellii* within and representing its entire range are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity and (2) shown to be stable or increasing over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring), the species should be evaluated for downlisting. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). Protected populations should be distributed throughout the range of the species. At least three populations should be located in the northern portion of the species range approximately north of the Santa Teresa Hills (on the San Jose East U.S. Geological Survey 7.5 minute quadrangle map), at least one population should be located in the southern portion of the species range in the San Martin area (on the Gilroy U.S. Geological Survey 7.5 minute quadrangle map), and at least 14 populations should be in the center of the species range including the areas in and around Almaden Quicksilver County Park, the Santa Teresa Hills, Calero Reservoir, Kirby, Morgan Hill, and Anderson Reservoir (Los Gatos, Santa Teresa Hills, Morgan Hill, Mt. Madonna, and Mt. Sizer U.S. Geological Survey 7.5 minute quadrangle maps). Of the populations in the center of the range, at least one must represent the westernmost extent of the range (e.g. Almaden Quicksilver County Park on the Los Gatos U.S. Geological Survey 7.5 minute quadrangle map) and one the most easternmost extent of the range (e.g. around Anderson Reservoir and eastward on the Mt. Sizer U.S. Geological Survey 7.5 minute quadrangle map). The remaining populations in the center of the range must be distributed with at least half of the total population residing east of Highway 101 and west of Anderson Lake and the other half of the population residing west of Highway 101 and east of Guadalupe Reservoir (i.e. half on the Morgan Hill U.S. Geological Survey 7.5 minute quadrangle map and half on the Santa Teresa Hills U.S. Geological Survey 7.5 minute quadrangle map). If additional surveys indicated that the actual distribution of populations is different (e.g. a greater proportion of populations is found in the southern part of the range), targets for protection should be changed so that they are consistent with the new information. Conserving the target 20 populations may involve a combination of protection of known locations and newly discovered populations.

*Dudleya setchellii* should not be considered for delisting unless 30 populations distributed throughout its entire range (as specified above) are shown to meet the criteria above. Meeting this goal would require locating, restoring, and/or successfully introducing 10 additional populations. Because (1) insufficient data are available to recommend translocation for this species (N. McCarten, *in litt.*, 1998) and (2) repatriation and introduction of populations is expensive and experimental (Falk *et al.* 1996), surveying potential habitat within the species' range to locate currently unknown populations is the preferred strategy. At this time, creation of serpentine rock and soil habitat for *Dudleya setchellii* as a conservation strategy is also discouraged. Studies have shown created substrate is not a reliable source of habitat although *Dudleya setchellii* seedlings germinated in low numbers in 2 years in created habitat (Jones and Stokes Associates, Inc. 1998).

## I. San Mateo woolly sunflower (*Eriophyllum latilobum*)

### 1. Description and Taxonomy

***Taxonomy.*** - The type specimen of *Eriophyllum latilobum* was collected by A.A. Heller in 1907 (Rydberg 1915). The plant was described by Per Axel Rydberg (1915). *Eriophyllum latilobum* is a tetraploid (having four sets of chromosomes) (Carlquist 1956, Mooring 1973) and is believed to have originated as a hybrid between *Eriophyllum confertiflorum* var. *confertiflorum* and *Eriophyllum lanatum* var. *arachnoideum* (Constance 1937, Munz and Keck 1959, Hickman 1993, Mooring 1994).

***Description.*** - *Eriophyllum latilobum* (Figure II-17) is an herbaceous (non-woody) perennial of the aster family (Asteraceae) with leafy stems 30 to 60, exceptionally 90, centimeters (12 to 16 inches) high (J. Mooring, *in litt.*, 1998). The upper surfaces of the deeply cleft leaves are a smooth dark green and the lower surfaces are covered with densely interwoven white hairs. The golden flower heads are borne in loose clusters (Munz and Keck 1959, McGuire and Morey 1992).

*Eriophyllum latilobum* differs from *Eriophyllum confertiflorum* (golden yarrow) in having seven to eight ray flowers (the flowers usually located on the edge of the head of members of the aster family) rather than five ray flowers, and a more open inflorescence (Abrams and Ferris 1960, J. Mooring, *in litt.*, 1998). *Eriophyllum lanatum* var. *arachnoideum* (common woolly sunflower) differs from the other two species in having 13 ray flowers and shallowly cleft leaves (Abrams and Ferris 1960, Hickman 1993). San Mateo woolly sunflower can be mistaken for plants from several populations that seem to be of hybrid origin between *Eriophyllum lanatum* and *Eriophyllum confertiflorum*. Plants of these populations have either four or six sets of chromosomes and are located near Black Mountain and Montebello Ridge (Mooring 1994, J. Mooring, *in litt.*, 1996, 1998).

## 2. Historical and Current Distribution

***Historical and Current Distribution.*** - The single remaining occurrence of *Eriophyllum latilobum* consists of a few hundred plants scattered along 4 kilometers (2.5 miles) of Crystal Springs Road in San Mateo County (California Natural Diversity Data Base 1996) (Figure II-18). The plants are distributed in less than a dozen small subpopulations from the Eugene A. Doran Bridges to just south of the intersection of Crystal Springs Road and Merner Road (McGuire and Morey 1992). These subpopulations are probably the fragments of a

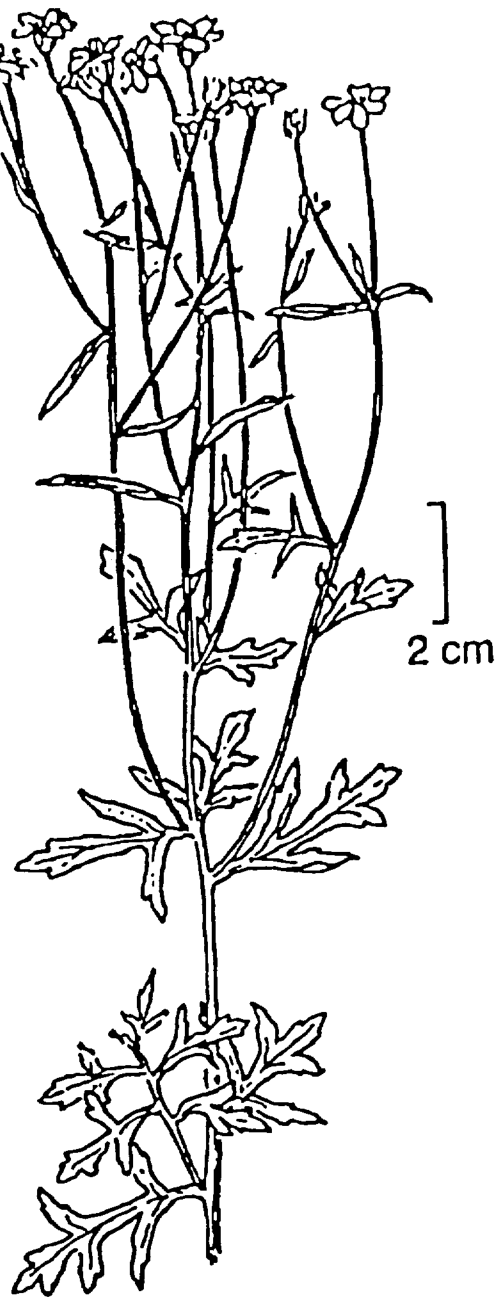


**Figure II-17.** Illustration of San Mateo woolly sunflower (*Eriophyllum latilobum*) (from Hickman 1993, with permission).

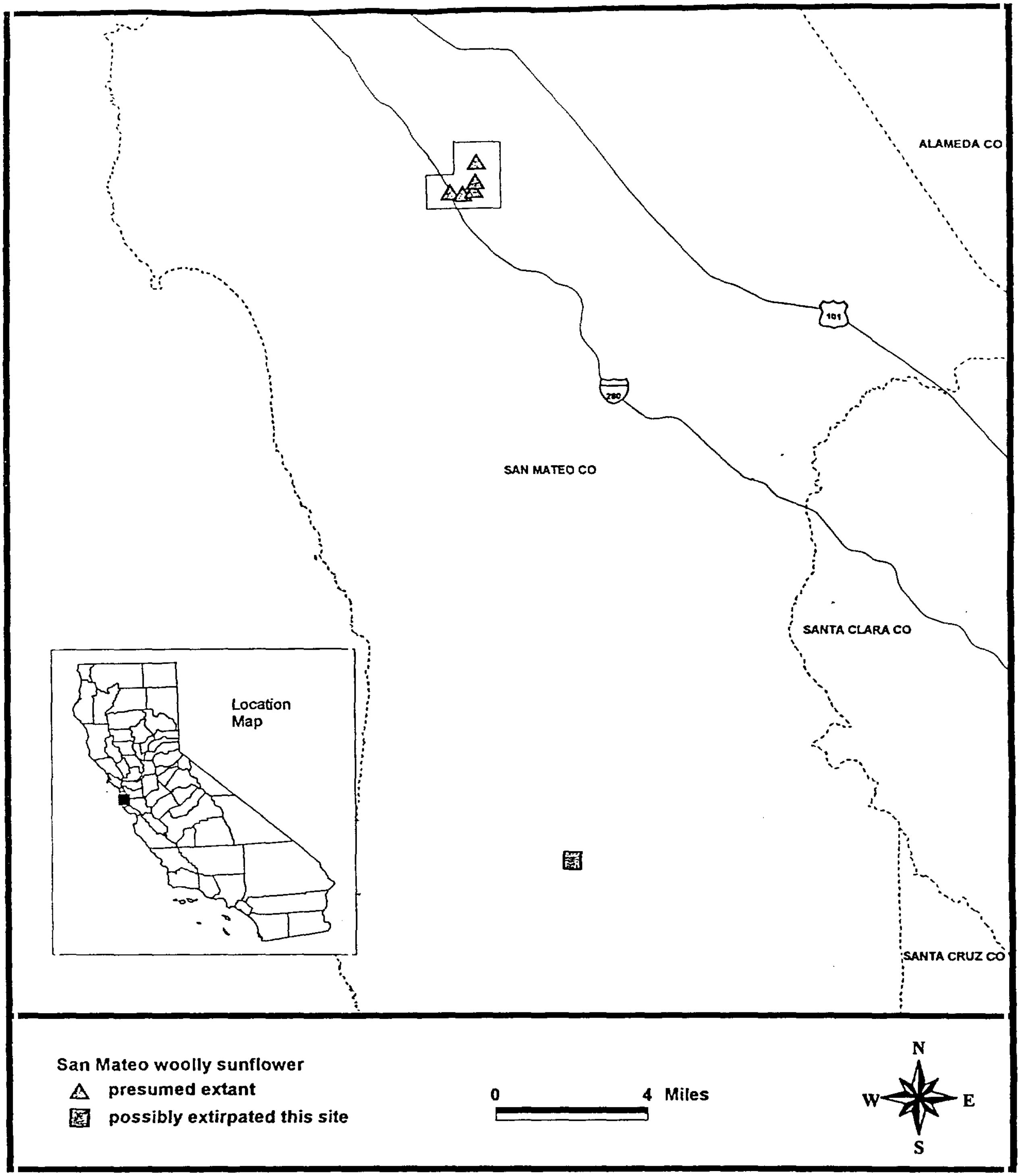


**Figure II-18.** Distribution of San Mateo woolly sunflower *(Eriophyllum latilobum)*. Each symbol represents one occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

once-continuous population (U.S. Fish and Wildlife Service 1995). *Eriophyllum latilobum* has also been reported from southern San Mateo County, on Pescadero Road southwest of La Honda, but this report is most likely erroneous (California Natural Diversity Data Base 1996). At least one of the specimens collected at this site (in 1929) is actually *Eriophyllum confertiflorum* (B. Prigge, pers. comm., 1992), and searches in recent years have found only *Eriophyllum confertiflorum* (T. Corelli, pers. comm., 1992).

### 3. Life History and Habitat

***Reproduction and Demography.*** - *Eriophyllum latilobum* is an herbaceous perennial which flowers from April to June (Munz and Keck 1959, J. Mooring, *in litt.*, 1998). Its pollinators include syrphid flies and bees. Although the species grows side-by-side with one of its presumed progenitors (*Eriophyllum confertiflorum*), no intermediate plants have been found to suggest that on-going hybridization is occurring (J. Mooring, *in litt.*, 1996). Because seed dispersal is by gravity, most seeds fall close to the parent plant (J. Mooring, pers. comm. as cited in McGuire and Morey 1992). Germination rates for *Eriophyllum latilobum* appear to be lower than those of congeners (other species of the same genus, other related species). The species is difficult to grow in the greenhouse because of its susceptibility to white flies (J. Mooring, *in litt.*, 1996).

The remaining occurrence contained 315 plants in 1992, about 60 in 1993, and 163 in 1994 (California Natural Diversity Data Base 1996). Some years the number of plants in some subpopulations ranges from zero to less than five; other years the same subpopulations contain 500 percent more plants. Some subpopulations consistently have higher numbers of plants (for example, 10 to 75 plants) (J. Mooring, *in litt.*, 1996). According to Roman Gankin (pers. comm., 1997), especially large numbers were observed in 1996. Gankin observed 100 or more plants scattered throughout the north facing cliff area along Crystal Springs Road, approximately 100 meters (328 feet) east of the junction of Polhemus and Crystal Springs Roads.

***Habitat and Community Associations.*** - *Eriophyllum latilobum* is found in shaded moist sites on steep grassy or sparsely wooded slopes (McGuire and

Morey 1992), apparently growing best under or very near coast live oak (*Quercus agrifolia*) (J. Mooring, *in litt.*, 1998). The species has been reported on serpentine soils (McGuire and Morey 1992). However, Mooring, who has studied the species for many years, has not found it on soils he considers serpentine (California Department of Fish and Game 1997*a*, J. Mooring, *in litt.*, 1998). The single remaining population occurs at an elevation of 46 meters (150 feet). The federally listed threatened Marin dwarf-flax (*Hesperolinon congestum*) reportedly grows in association with *Eriophyllum latilobum* as do California bay (*Umbellaria californica*) (McGuire and Morey 1992), California broom (*Lotus scoparius*) (California Natural Diversity Data Base 1996), California buckeye (*Aesculus californica*), California sagebrush (*Artemisia californica*), coast live oak (*Quercus agrifolia*) (McGuire and Morey 1992), purple needlegrass (*Nassella pulchra*) (California Natural Diversity Data Base 1996), toyon (*Heteromeles arbutifolia*) (McGuire and Morey 1992), and white globe lily (*Calochortus alba*) (California Natural Diversity Data Base 1996).

### 4. Reasons for Decline and Threats to Survival

*Eriophyllum latilobum* has been reported from only two locations, one of which is likely erroneous (specimen misidentified, according to B. Prigge, pers. comm., 1992). The single remaining population consists of a few hundred plants that occur along 4 kilometers (2.5 miles) of Crystal Springs Road in San Mateo County. Seventy-five percent of the plants occur within 9 meters (30 feet) of the road, where land ownership is poorly defined. The City of Hillsborough, the San Mateo County, and the San Francisco Water Department have varying jurisdictions over the land (McGuire and Morey 1992). *Eriophyllum latilobum* is threatened by erosion and soil slippage, recreational development, road maintenance, and garbage dumping (U.S. Fish and Wildlife Service 1995).

The steep slopes along Crystal Springs Road provide a very risky habitat for *Eriophyllum latilobum*. The slopes are subject to erosion and soil slippage. After soil slippage occurs, the slumped soil, which may contain mature individuals, seedlings, and/or seeds of *Eriophyllum latilobum*, is removed by road maintenance crews. The road cut is then reshaped, which may damage plants remaining on the banks (McGuire and Morey 1992). Slide repair work in 1997 took place along Polhemus Road, but did not impact the *Eriophyllum latilobum* population (R. Gankin, pers. comm., 1997).

The San Francisco Water Department has a recreational easement through the population (M. Skinner, *in litt.*, 1992). The proposed construction of the San Mateo Creek Trail, part of the San Mateo County Trails Plan (San Mateo County 1989), would have adverse impacts on the plant if trail design does not incorporate plant conservation (San Mateo County 1991, California Department of Fish and Game 1992, McGuire and Morey 1992, T. Corelli, *in litt.*, no date). The paved trail, which is 3 meters (10 feet) wide, is expected to run adjacent to Crystal Springs Road from Skyline Boulevard to the San Mateo City boundary. Construction of the trail could damage or eliminate colonies of *Eriophyllum latilobum*, alter site hydrology, accelerate soil erosion through increased pedestrian and bicycle traffic, and allow for the introduction of aggressive non-native plant species (California Department of Fish and Game 1992, McGuire and Morey 1992). However, according to Sam Hertzberg of the San Mateo County Planning Department, the trail is unlikely to be constructed in the near future (S. Hertzberg, pers. comm., 1997).

Road maintenance also threatens *Eriophyllum latilobum* (California Department of Fish and Game 1992, J. Mooring, *in litt.*, 1996). Threats include reshaping of the slope (mentioned above) and periodic mowing to reduce fuel loads (California Department of Fish and Game 1992). Mowing by San Mateo County is probably the main threat to the species at sites outside the Hillsborough City limits (J. Mooring, *in litt.*, 1996). San Mateo County road maintenance crews were alerted to the existence of *Eriophyllum latilobum* in 1990 and were instructed by the San Mateo County Planning Department to avoid the plants; however, road maintenance activities are not monitored to ensure protection (R. Gankin, pers. comm. to T. McGuire, cited in McGuire and Morey 1992). San Mateo County Department of Public Works has eliminated the use of weed sprays along the section of road where the species occurs (R. Sans, *in litt.*, 1993).

Dumping of garden debris and downhill seepage of herbicides and pesticides from homeowners living above the population may have negative impacts on *Eriophyllum latilobum* habitat (California Department of Fish and Game 1992, McGuire and Morey 1992). The plant also is threatened by competition with non-native plants; its habitat is more densely populated with plumeless thistle (*Carduus* sp.) and brome (*Bromus* sp.) than it was 10 years ago (J. Mooring, pers. comm., 1992, 1996). Unrestricted collecting for scientific or horticultural purposes, or excessive visits by individuals interested in seeing rare plants could be a threat to the species. *Eriophyllum latilobum*, with its showy golden flowers and proximity to roads and the proposed San Mateo Creek trail, might prove to be especially tempting to collectors (U.S. Fish and Wildlife Service 1995).

*Eriophyllum latilobum* is not a vigorous reproducer; low germination rates and low seedling survival have been observed under greenhouse conditions (J. Mooring, *in litt.*, 1992 as cited in McGuire and Morey 1992). However, greenhouse conditions do not necessarily represent the situation in nature (N. McCarten, *in litt.*, 1998). Mooring (California Department of Fish and Game 1997*a*) reported that, although many viable seeds are produced, the germination rate is less than 10 percent. In the natural population, competing species such as plumeless thistle (*Carduus* sp.) may affect germination and seedling establishment (J. Mooring, *in litt.*, 1998). Beetle larvae have been observed in seed heads of *Eriophyllum latilobum*; however, the extent of predation is unknown (McGuire and Morey 1992). Because of the existence of only a single population exhibiting low viability and located in an unstable habitat, this species is extremely vulnerable to extinction from random catastrophic events (Menges 1991, Primack 1993, Meffe and Carroll 1994).

**5. Conservation Efforts**

*Eriophyllum latilobum* was listed as endangered by the State of California in 1992 (California Department of Fish and Game 1992). The species was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995). Currently, roadside mowing by San Mateo County in the vicinity of *Eriophyllum latilobum* has been stopped, at least south to the Hillsborough City line. However, because road crews change periodically, this protection may need to be reinforced over time (California Department of Fish and Game 1997*a*). In addition, as noted above, use of weed sprays has been eliminated by the San Mateo County Department of Public Works along the section of road where the species occurs

(R. Sans, *in litt.*, 1993).

## 6. Recovery Strategy

Recovery of *Eriophyllum latilobum* must first focus on protecting and managing the only known population by working with San Mateo County, the San Francisco Water Department and the City of Hillsborough to ensure the long-term survival of the species on their lands. If possible, the population should be protected through a land acquisition, conservation easement, or other means. Protection should involve the population itself as well as a 150-meter (500-foot) buffer, particularly on the upslope side of the population, to reduce external influences and allow expansion of the population. In addition, unoccupied habitat at the site that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Eriophyllum latilobum* must be developed and implemented by the landowners involved. Although monitoring of perennial plants is usually recommended at 3 to 5 year intervals, year-to-year population size fluctuations and the very small population size (California Department of Fish and Game 1997*a*) at the only known occurrence as well as a short life span (perhaps 2 to 3 years) (J. Mooring, *in litt.*, 1998) suggest that annual monitoring would be prudent. Therefore, management plans should include provisions for standardized annual monitoring of the *Eriophyllum latilobum* population to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from roadside maintenance and widening, recreational development, and garbage dumping must be eliminated. If possible, the San Mateo Creek Trail should be rerouted to avoid impacts to *Eriophyllum latilobum* (California Department of Fish and Game 1997*a*). If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Other management strategies that should be considered include (1) planting of young coast live oak trees, (2) elimination of potential competitors, especially those such as plumeless thistle (*Carduus* sp.) that may affect seed germination and seedling establishment, and (3) establishment of new, upslope stands by seeding or hand-planting seedlings (J. Mooring, *in litt.*, 1998).

Another high priority in recovery efforts for *Eriophyllum latilobum* is collection and banking of seed in Center for Plant Conservation certified botanic gardens. Seed banking is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in the existing population and/or introductions to new sites. Care should be taken to ensure that seed collection does not adversely affect the donor populations. Some seed may already be stored at the University of California, Berkeley Botanic Garden (J. Mooring, *in litt.*, 1998). This collection should be confirmed and the viability of the seed evaluated.

In addition to protection of and seed collection from the single population of *Eriophyllum latilobum,* other potential habitat, such as in the Crystal Springs area (California Department of Fish and Game 1997*a*), should be surveyed to determine whether undiscovered populations may exist. Because it is unclear whether *Eriophyllum latilobum* is a serpentine endemic, surveys should include both serpentine and non-serpentine habitat. Areas which need to be surveyed include the south side of San Mateo Creek, land in the vicinity of Hillsborough, and San Francisco Water Department land. If new populations are discovered, they should be protected and managed as discussed above.

Research activities of high priority for *Eriophyllum latilobum* include its affinity to serpentine soils, factors influencing seed germination (including the possible importance of disturbance and competing species), greenhouse propagation techniques (including propagation from cuttings), and the possible impact of beetle predation of seeds. Also important, but of lower priority, is research on demography (including seedling survivorship and identification of limiting life history stages), reproduction (e.g. mating system, pollination), genetics, and phenotypic plasticity (the capacity for marked variation in observable structural and functional properties of an organism as a result of environmental influences during development). Phenotypic plasticity studies should address the observed differences in appearance between plants growing in the sun and plants growing in the shade (California Department of Fish and Game 1997*a*).

If the Crystal Springs Road population of *Eriophyllum latilobum* is (1) fully protected and managed with the primary intention of preserving the population in perpetuity, (2) shown to be stable or increasing over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring), (3) seed is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993).

The above downlisting criteria constitute a significant improvement in protection and management of *Eriophyllum latilobum*. Completing these actions would substantially increase the security of the species. However, available data suggest that *Eriophyllum latilobum* should not be considered for delisting. The species is known from only one vulnerable location on a roadcut. No historic sites are known for repatriation, and the possible success of introduction of the species is not known. In the unlikely event that a significant number of new populations are discovered, development of delisting criteria could be considered.

## J. Marin dwarf-flax (*Hesperolinon congestum*)

### 1. Description and Taxonomy

***Taxonomy.*** - Henry Nicholas Bolander collected the type specimen of *Hesperolinon congestum* (Marin dwarf-flax) in 1863 in Marin County, while working on the State Geological Survey (Sharsmith 1961). Asa Gray described the new species as *Linum congestum*, including it in the section *Hesperolinon* that he described in the same paper (Gray 1865). J. K. Small (1907) established *Hesperolinon* as a distinct genus in 1907. Jepson (1925) treated *Hesperolinon* as a section of the genus *Linum*, and treated *Hesperolinon congestum* as a subspecies of *Linum californicum*. Helen K. Sharsmith (1961) conducted an extensive study of *Hesperolinon* and concluded that it definitely warrants distinction as a separate genus. She also returned *Hesperolinon congestum* to the status of a species (Sharsmith 1961).

***Description.*** - *Hesperolinon congestum* (Figure II-19) is an herbaceous annual of the flax family (Linaceae) with slender, threadlike stems, 10 to 40 centimeters (4 to 16 inches) tall. The leaves are linear. The flowers are borne in congested (crowded together) clusters; the pedicels are 1 to 8 millimeters (0.04 to 3.2 inches) long. The sepals are hairy, and the five petals are rose to whitish (Niehaus 1977*b*). The anthers are deep pink to purple; this character helps distinguish *Hesperolinon congestum* from *Hesperolinon californicum* (California dwarf-flax), found in the same geographic area, which has white to rose anthers as well as hairless sepals. Two other species that are found in the same region are *Hesperolinon micranthum* (smallflower dwarf-flax) and *Hesperolinon spergulinum* (slender dwarf-flax). They differ from *Hesperolinon congestum* in having hairless sepals and a long, open inflorescence, with pedicels 2 to 25 millimeters (0.08 to 1 inch) long (Hickman 1993).

## 2. Historical and Current Distribution

***Historical and Current Distribution.*** - *Hesperolinon congestum* is found on serpentine soils from Marin County south to San Mateo County (Munz and Keck 1959), a range of 80 kilometers (50 miles) (U.S. Fish and Wildlife Service 1995) (Figure II-20). Marin County locations include the Tiburon Peninsula (five extant occurrences), Carson Ridge (three occurrences), Mt. Burdell Open Space (two occurrences) (California Natural Diversity Data Base 1996), Big Rock (one occurrence), and Golden Gate National Recreation Area (one occurrence discovered in June, 1995) (Norris 1995). Two extant occurrences are known from the Presidio in San Francisco County. San Mateo County contains four specific locations near Crystal Springs Reservoir, two in Edgewood County Park, and one near Woodside Glens. Previously identified occurrences, now extirpated, include two from San Mateo County and two from San Francisco County. One additional occurrence on the Tiburon Peninsula in Marin County is possibly extirpated (California Natural Diversity Data Base 1996).

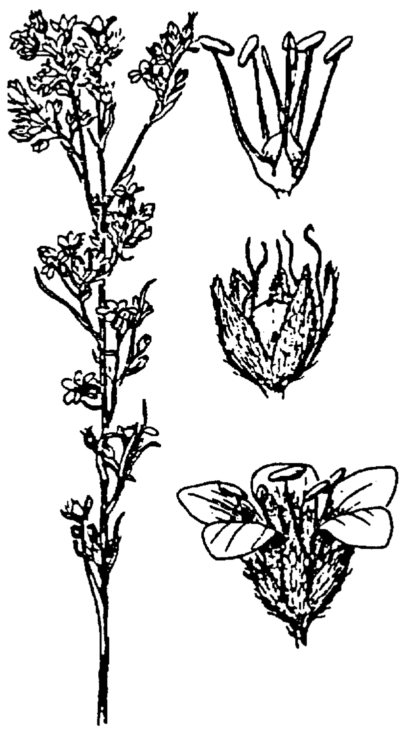

**Figure II-19.** Illustration of Marin dwarf-flax (*Hesperolinon congestum*) (from Abrams 1951, with permission).

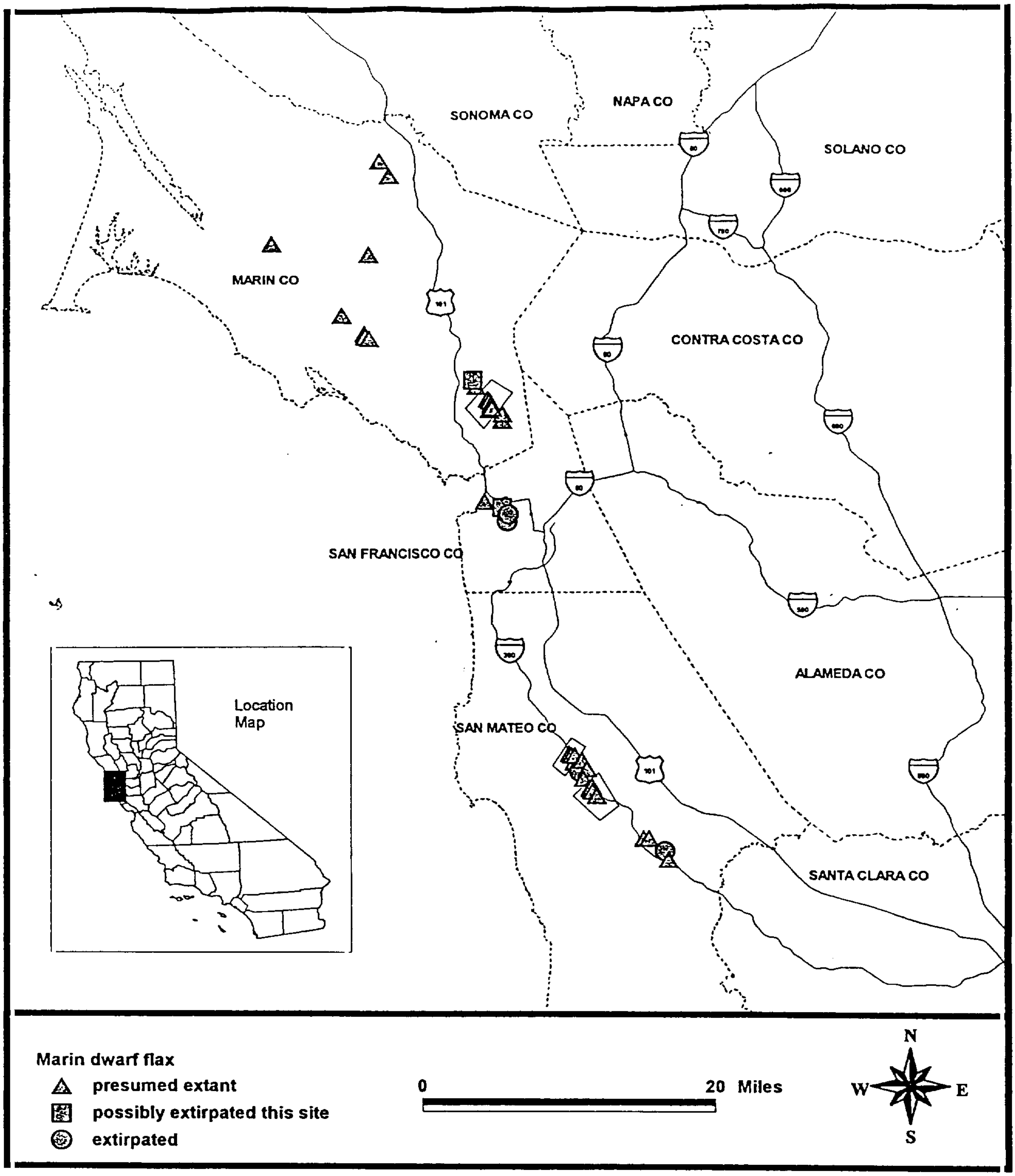


**Figure II-20.** Distribution of Marin dwarf flax (*Hesperolinon congestum*). Each symbol represents one occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

### 3. Life History and Habitat

***Reproduction and Demography.*** - *Hesperolinon congestum* is an annual herb flowering from May to June or July (Munz and Keck 1959, Skinner and Pavlik 1994). The species is pollinated by native insects including bee flies and pollen beetles (Robison and Morey 1992*a*). Populations range in size from one plant to thousands of plants (California Natural Diversity Data Base 1996). Population sizes can fluctuate greatly from year to year (D. Smith, *in litt.*, 1998). No further data on the reproductive biology or demography of the species are available.

***Habitat and Community Associations.*** - *Hesperolinon congestum* is endemic to serpentine soils. Populations are found in serpentine chaparral or serpentine bunchgrass habitat (Robison and Morey 1992*a*). Known populations occur between approximately 30 and 370 meters (100 to 1,200 feet) (California Natural Diversity Data Base 1996). *Hesperolinon congestum* grows with or in the vicinity of other federally listed plants: Tiburon jewelflower (*Streptanthus niger*), Tiburon mariposa lily (*Calochortus tiburonensis*), and Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) in Marin County, Presidio clarkia (*Clarkia franciscana*) and Presidio manzanita (*Arctostaphlyos hookeri* ssp. *ravenii*) in San Francisco County, and fountain thistle (*Cirsium fontinale* var. *fontinale*), San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii*), and white-rayed pentachaeta (*Pentachaeta bellidiflora*) in San Mateo County. The federally listed bay checkerspot butterfly (*Euphydryas editha bayensis*) also occurs in the vicinity of *Hesperolinon congestum*. Other associated plant species include common yarrow (*Achillea millefolium*), purple needlegrass (*Nassella pulchra*), royal larkspur (*Delphinium variegatum*), ruby chalice clarkia (*Clarkia rubicunda*), wavyleaf soapplant (*Chlorogalum pomeridianum*), wicker buckwheat (*Eriogonum viminium*), and yellow mariposa lily (*Calochortus luteus*) (Robison and Morey 1992*a*).

### 4. Reasons for Decline and Threats to Survival

*Hesperolinon congestum* is threatened by residential and recreational development, foot traffic, and competition with non-native species. There are 11 documented populations which exist in Marin County. On the Tiburon Peninsula, one population is on Ring Mountain Preserve (California Natural Diversity Data Base 1996), formerly managed by The Nature Conservancy and currently managed by Marin County (L. Serpa, pers. comm., 1996). The preserve is fenced to reduce the incidence of four-wheel drive vehicle and motorcycle use, but is still accessible to bicycles, equestrians, and hikers (C. Bramham, pers. comm., 1997). Soil slumping may also threaten *Hesperolinon congestum* populations on the preserve (California Natural Diversity Data Base 1996). Another population on the Tiburon Peninsula occurs partially on a small preserve at St. Hilary's Church (Robison and Morey 1992*a*, D. Smith, pers. comm., 1997) and partially on private land which has been proposed for development (Easton Point) (Robison and Morey 1992*a*, U.S. Fish and Wildlife Service, *in litt.*, 1996, D. Watrous, pers. comm., 1997). Some botanists report that the portion of the occurrence near St. Hilary's may be threatened by invasive non-natives (California Department of Fish and Game 1997*b*); others disagree (E. Buxton, *in litt.*, 1998). The occurrence may also be threatened by trampling when people and dogs walk off of established trails (E. Buxton, *in litt.*, 1998). A second proposed development in the same area was denied by the Town of Tiburon (Marinero Estates) (B. Olson, pers. comm., 1996). The area that would have been involved in this second development (Harroman/Marinero Estates) is proposed to be set aside as open space. A ballot measure to secure the funding for the purchase of the property passed in June, 1997; the purchase took place in the fall of 1997 (D. Watrous, pers. comm., 1997). A few scattered groups of plants occur in the Middle Ridge area of the Tiburon Peninsula. Some of these plants grow on land designated as open space by the Town of Tiburon. The remainder of the plants in the Middle Ridge area occur on private land and are threatened by ongoing or proposed residential development (California Natural Diversity Data Base 1993).

Off of the Tiburon Peninsula, the Carson Ridge populations of Marin County are on Marin Municipal Water District land. These populations may be threatened by trampling from hikers (California Natural Diversity Data Base 1996). Marin Municipal Water District is attempting to restrict recreational impacts to *Hesperolinon congestum* along Pine Mountain and Azalea Hill roads. Rare plants along these roads will also be avoided during grading for road maintenance. A new threat to *Hesperolinon congestum* on Marin Municipal Water District land is invasion of non-native barbed goatgrass (*Aegilops triuncialis*) in the Azalea Hill area. While some have suggested that spraying may threaten *Hesperolinon congestum* in this area, lack of spraying may also be a threat because eradication of barbed goatgrass is difficult without the use of herbicides (D. Odion, *in litt.*, 1998).

Like the Ring Mountain population, the Mt. Burdell Open Space populations are on lands managed by Marin County. Threats to these populations have not been identified (California Natural Diversity Data Base 1996). The Big Rock population is on private land; adjacent lands have been proposed for development (D. Smith, *in litt.*, 1996, notes of D. Elam from California Department of Fish and Game Recovery Workshop 1997). The Golden Gate National Recreation Area population is on land managed by the National Park Service (Norris 1995). At the Golden Gate National Recreation Area, *Hesperolinon congestum* occurs on land that is being grazed; the impact of grazing on the species is unknown (L. Nelson, *in litt.*, 1996).

*Hesperolinon congestum* known from San Francisco County is on the Presidio (California Natural Diversity Data Base 1996). The Presidio is currently managed by the National Park Service; however, plans are being made to transfer responsibility for the property from National Park Service to a Federal trust (T. Thomas, pers. comm., 1996). Footpaths threaten the plants with trampling (Robison and Morey 1992*a*, U.S. Fish and Wildlife Service, *in litt.*, 1995*a*, P. Holloran, *in litt.*, 1996). Other threats are invasion of non-native species, road expansion, and mowing (California Natural Diversity Data Base 1996). In 1995, one population was fenced and several Monterey cypress trees (*Cupressus macrocarpa*) adjacent to the habitat were removed in 1995 and 1996. Few natives have established in the area; cypress duff and fill material from an adjacent road may prevent *Hesperolinon congestum* from moving into the restored area. The other documented population at the Presidio, on Inspiration Point, has apparently not been seen in recent years (S. Farrell, *in litt.*, 1996).

In San Mateo County, populations of *Hesperolinon congestum* are known to occur on private property. These plants are threatened by proposed development and by the consequences of completed development, such as trampling, trash dumping, and changes in hydrology caused by irrigation runoff (Robison and Morey 1992*a*). Three occurrences in the vicinity of Crystal Springs Reservoir (including Puglas Ridge) are on land managed by the San Francisco Water Department. Their habitat is threatened by the trails in the watershed as well as by invasion of non-native plants and road construction (California Natural Diversity Data Base 1996). The construction of future trails and accompanying fences may damage *Hesperolinon congestum* habitat in this area as well (San Mateo County 1989, 1991, U.S. Fish and Wildlife Service 1995). A portion of the *Hesperolinon congestum* population located in Edgewood Park is suffering from foot traffic and inadequate trail maintenance (S. Sommers, *in litt.*, 1993). The occurrence at Woodside Glens is in an area set aside as mitigation, but water runoff from upslope homes threatens the population (California Department of Fish and Game 1997*a*).

### 5. Conservation Efforts

*Hesperolinon congestum* was listed as threatened by the State of California in 1992 (California Department of Fish and Game 1992). The species was federally listed as threatened in 1995 (U.S. Fish and Wildlife Service 1995). Two populations of the species occur in Edgewood Park which San Mateo County currently intends to manage as a natural preserve. The County has recently adopted a master plan to guide future activities in the park (San Mateo County 1997). The National Park Service has fenced one population of *Hesperolinon congestum* and removed some non-natives (see above) at the Presidio in an attempt to restore serpentine habitat (S. Farrell, *in litt.*, 1996).

Between 1982 and 1995, Ring Mountain was protected from development because the land on which it occurs was owned and managed by The Nature Conservancy, a group whose management goals are the maintenance of biodiversity and the protection of rare and endangered species. The Ring Mountain property was transferred to Marin County Parks and Open Space in 1995. The Nature Conservancy retained a conservation easement on the property and expects that Marin County will continue monitoring the rare species on the preserve (L. Serpa, pers. comm., 1996). At this point, the County has not developed a monitoring plan and is depending on volunteers from The Nature

Conservancy and the California Native Plant Society for rare plant monitoring (C. Bramham, pers. comm., 1996). Marin Open Space District has developed a management plan for Mt. Burdell Open Space that includes rotational grazing but no rare plant monitoring (C. Bramham, pers. comm., 1997).

## 6. Recovery Strategy

Recovery of *Hesperolinon congestum* must first focus on protecting and managing extant populations. Populations on private land should be protected by land acquisition, conservation easements or other means. Protection of populations on public land will involve working with Marin County Open Space District, the Town of Tiburon, Marin Municipal Water District, National Park Service (for Golden Gate National Recreation Area and the Presidio), and San Mateo County Parks and Recreation Department to ensure the long-term survival of the species on their lands. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected.

Management plans emphasizing *Hesperolinon congestum* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized annual monitoring of *Hesperolinon congestum* populations to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. Threats that need to be eliminated at various sites include invasion of non-natives, recreational activities (e.g. trampling), and trail construction. Where pampas grass (*Cortaderia* spp.) removal is required, caution must be taken to avoid adverse impacts to federally listed animal species that may occur in the area (e.g. San Francisco garter snake [*Thamnophis sirtalis tetrataenia*]). If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Where *Hesperolinon congestum* occurs on public lands (e.g. Marin County Open Space, Edgewood Natural Preserve), educational outreach programs should be developed. Priority areas for protection will include areas throughout the species range, including populations in the center of the range, populations on the periphery of the range, and populations in locations targeted for San Mateo County in the bay checkerspot butterfly recovery strategies (e.g. Edgewood Park).

Also of value in recovery efforts for *Hesperolinon congestum* is collection and banking of seed in Center for Plant Conservation certified botanic gardens. Seed banking is prudent to guard against decline or extinction of populations from chance catastrophic events and to provide potential material for enhancement efforts in the existing population and/or introductions to new sites. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection of known populations and seed collection, historic locations should be surveyed to determine whether suitable habitat remains, the species persists at the sites, and/or the sites may be suitable for repatriation. Suitability of historic locations for repatriation would depend upon (1) whether potential habitat exists, (2) the presence and magnitude of threats, and (3) whether the sites can be secured and managed for the long-term protection of the species. Several historic sites are unlikely to contain suitable habitat because of local urbanization (California Natural Diversity Data Base 1996, California Department of Fish and Game 1997*a*, *b*). Others, such as Inspiration Point at the Presidio, have good potential as repatriation sites (California Department of Fish and Game 1997*b*). Surveys should also include other potential serpentine habitat (e.g. Fifield Ridge west of San Andreas Lake and Crystal Springs Reservoir in San Mateo County) to determine whether undiscovered populations may exist. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Habitat management research important in recovery activities for *Hesperolinon congestum* includes seed germination and propagation techniques, the effect of grazing and burning on the species, and its susceptibility to herbicide, fertilizer, and water runoff (California Department of Fish and Game 1997*a*, *b*). Basic research needs include detailed studies of demography (to identify limiting life history stages and to investigate the soil seed bank) and reproduction (including mating system and pollination). In addition, population genetics studies would be valuable to determine whether and to what extent populations throughout the range of the species are genetically different from one another.

If 21 or more populations of *Hesperolinon congestum* within and representing its entire range are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity and (2) shown to be stable or increasing over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring), the species should be evaluated for delisting. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). The protected populations should be distributed throughout the range of the species. Seven populations should be protected in each of the north, central, and southern portions of the range. For the purpose of recovery, the Service considers the north portion of the range to be Carson Ridge and northward, the central portion to be the Tiburon Peninsula and San Francisco County, and the southern portion to be San Mateo County. If additional surveys indicated that the actual distribution of populations is different (e.g. a greater proportion of populations is found in Marin County), targets for protection should be changed so that they are consistent with the new information. Conserving the target 21 populations may involve a combination of protection of known locations and newly discovered populations. Because repatriation and introduction of populations is expensive and experimental (Falk *et al.* 1996), surveying potential habitat within the species' range to locate currently unknown populations is the preferred strategy.

## K. White-rayed pentachaeta (*Pentachaeta bellidiflora*)

### 1. Description and Taxonomy

***Taxonomy.*** - *Pentachaeta bellidiflora* (white-rayed pentachaeta) was first collected in 1853 to 1854 near Corte Madera by John Milton Bigelow, surgeon and botanist for a railway route exploration (Van Horn 1973). The plant was described as *Pentachaeta bellidiflora* (Greene 1884). Keck (1958) transferred the entire genus to *Chaetopappa*. Van Horn (1973) studied *Chaetopappa* and *Pentachaeta* and concluded that the two genera are not closely related. Based on differences in floral and vegetative morphology and chromosome number, Van Horn (1973) reinstated the genus *Pentachaeta*.

***Description.*** - *Pentachaeta bellidiflora* (Figure II-21) is a small annual plant of the aster family (Asteraceae) with one or a few branches that bear narrow, linear leaves. Each flower head has numerous yellow disk flowers (flowers in the center portion of the head of a member of the aster family) and 5 to 16 white to purplish ray flowers. The fruits are tawny, coarse-haired achenes (dry one-seeded fruits) (Munz and Keck 1959). Related species in the San Francisco Bay Area (*Pentachaeta exilis* ssp. *exilis* [meager pentachaeta] and *Pentachaeta alsinoides* [tiny pentachaeta]) differ from *Pentachaeta bellidiflora* in that they have no ray flowers (Hickman 1993).

### 2. Historical and Current Distribution

***Historical and Current Distribution.*** - Historically, *Pentachaeta bellidiflora* was known from at least nine sites in Marin, San Mateo, and Santa Cruz Counties (Figure II-22). Most populations have been destroyed by urbanization, off-road vehicles, or highway construction over the past 50 years (Robison and Morey 1992*b*). Suitable habitat remains in two San Mateo County locations, but the species has not been seen at either site in many years (R. Morgan, pers. comm. as cited in Robison and Morey 1992*b*). *Pentachaeta bellidiflora* is now known from only one confirmed location in San Mateo County, in the "Triangle" area and adjacent Edgewood County Park (California Natural Diversity Data Base 1996). A second population may have been found on the west side of Crystal Springs Reservoir on San Francisco Water Department land, but the sighting needs to be confirmed (California Department of Fish and Game 1997*a*).

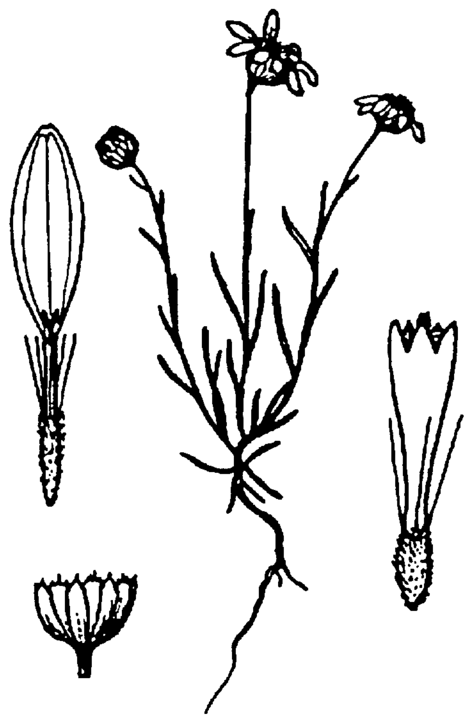

**Figure II-21.** Illustration of white-rayed pentachaeta (*Pentachaeta bellidiflora*) (from Abrams and Ferris 1960, with permission).

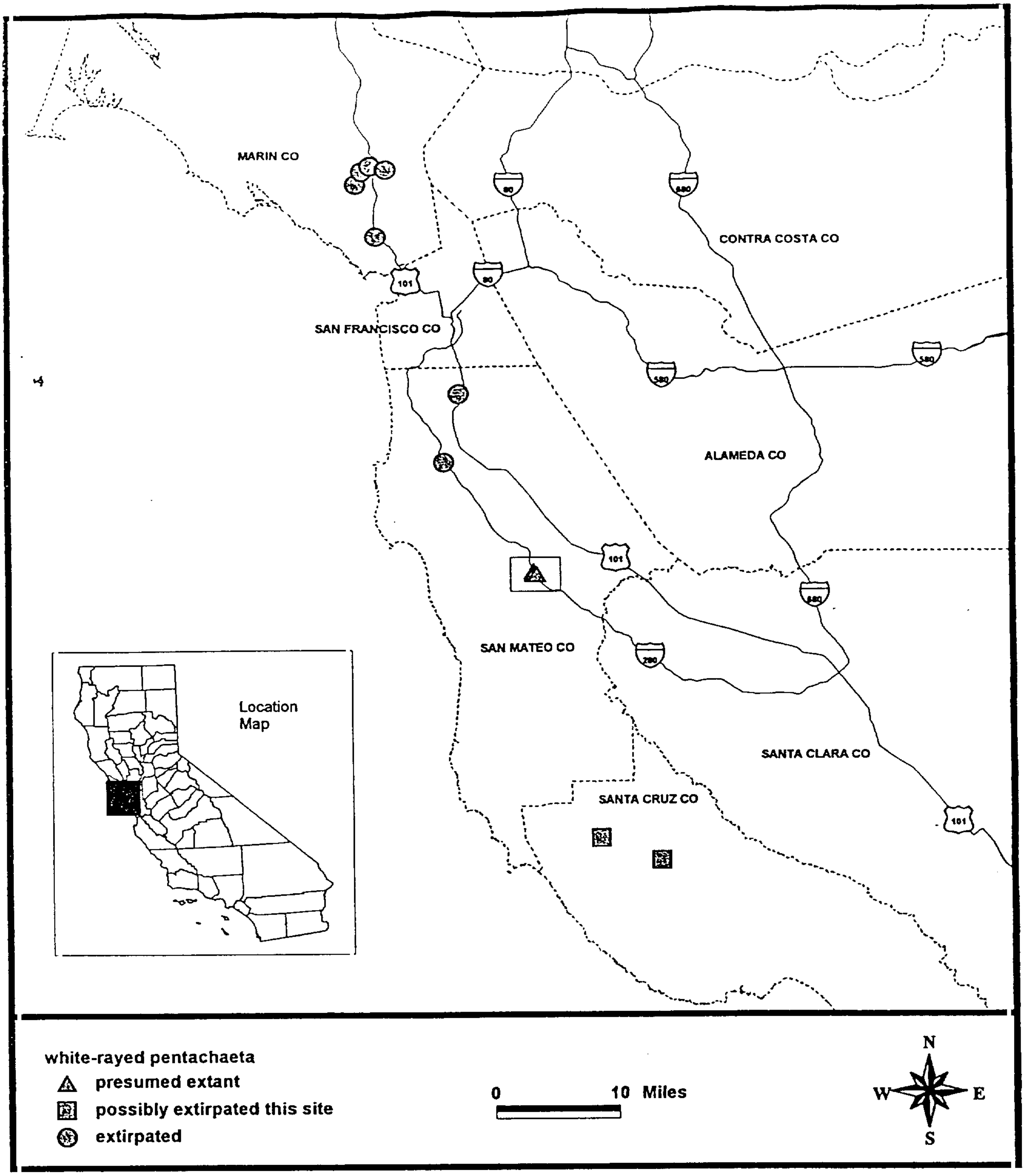


**Figure II-22.** Distribution of white-rayed pentachaeta (*Pentachaeta bellidiflora*). Each symbol represents one occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

### 3. Life History and Habitat

***Reproduction and Demography.*** - *Pentachaeta bellidiflora* flowers from March to May (Van Horn 1973) and may be visited by the federally threatened bay checkerspot butterfly (*Euphydryas editha bayensis*). The butterfly may incidentally pollinate the plant, but the primary pollinators of *Pentachaeta bellidiflora* are unknown (Robison and Morey 1992*b*). Given that the seeds apparently do not over-winter well, the species may have a limited soil seed bank (Van Horn 1973). Detailed data on the reproductive biology of *Pentachaeta bellidiflora* are not available.

As is common among annual plants, *Pentachaeta bellidiflora* population size fluctuates dramatically from year to year. Numbers have ranged from 10,000 to just under 100 million in the last 10 years, with about 1.5 million plants growing in 1991 and 1992 (Z. Chandik, pers. comm., 1992).

***Habitat and Community Associations.*** - *Pentachaeta bellidiflora* grew in serpentine grassland between 36 and 610 meters (120 to 2,000 feet) (California Natural Diversity Data Base 1996). The one remaining location is found at approximately 160 meters (520 feet) with dwarf plantain (*Plantago erecta*), purple needlegrass (*Nassella pulchra*), and tidy-tips (*Layia platyglossa*). Rare species in the area include the federally threatened bay checkerspot butterfly (*Euphydryas editha bayensis*) and Marin dwarf-flax (*Hesperolinon congestum*) and the federally endangered fountain thistle (*Cirsium fontinale* var. *fontinale*) and San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii*) (California Natural Diversity Data Base 1996). Although in the vicinity, Marin dwarf-flax is not directly associated with *Pentachaeta bellidiflora* (Robison and Morey 1992*b*). Other grassland species associated with *Pentachaeta bellidiflora* include bird's-eye gilia (*Gilia tricolor*), blue dicks (*Dichelostemma capitatum*), blue-eyed grass (*Sisyrichium bellum*), California buttercup (*Ranunculus californicus*), California poppy (*Eschscholzia californica*), earth brodiaea (*Brodiaea terrestris*), purple owl's clover (*Castilleja densiflora*), royal larkspur (*Delphinium variegatum*), and yellowray goldfields (*Lasthenia glabrata*) (Robison and Morey 1992*b*).

### 4. Reasons for Decline and Threats to Survival

*Pentachaeta bellidiflora* historically ranged from Marin County to Santa Cruz County. Three populations in Marin County and two in San Mateo County were destroyed by urbanization. One Marin County occurrence was destroyed by off-road vehicles. Two sites in Santa Cruz County no longer support *Pentachaeta bellidiflora* (Robison and Morey 1992*b*).

The single remaining population of *Pentachaeta bellidiflora* was bisected by the construction of California Interstate 280 in the late 1960's. The largest portion of the population occurs in the Triangle, on land administered by the San Francisco Water Department. A small remnant of this population is located to the east of Interstate 280, on Edgewood County Park. In the Triangle/Edgewood location the species is threatened by recreational development (California Department of Fish and Game 1992, M. Skinner, *in litt.*, 1992). Although public access was restricted in the past, the Triangle portion of the population is now part of a recreational easement (California Department of Fish and Game 1992). The proposed construction of trails on San Francisco Water Department land in the Triangle threaten *Pentachaeta bellidiflora* habitat (California Department of Fish and Game 1992, Robinson and Morey 1992*b*). The Edgewood Park portion of the population is on land owned by San Mateo County. The park has been designated a natural preserve. San Mateo County is currently working on a Master Plan for Edgewood (San Mateo County 1997). It is possible that some disturbance could result from changes implemented as a result of the plan, but no decisions about specific actions have been made at this time, and San Mateo County personnel are aware of the population.

*Pentachaeta bellidiflora* potentially is also threatened by competition from non-native plant species; competition becomes a problem when the soils are disturbed (Robison and Morey 1992*b*). If proposed trail construction occurs on the site, the soil disturbance could result in encroachment and competition from non-native species (U.S. Fish and Wildlife Service 1995). In addition, the existence of the species in only one location makes it vulnerable to extinction due to catastrophic events (Menges 1991, Primack 1993, Meffe and Carroll 1994).

## 5. Conservation Efforts

*Pentachaeta bellidiflora* was listed as endangered by the State of California in 1992 (California Department of Fish and Game 1992). The species was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995). The only remaining population occurs in the Triangle and Edgewood Park. San Mateo County intends to manage Edgewood as a natural preserve and has recently adopted a master plan to guide future activities in the park. San Mateo County personnel are aware of the special status plant species at Edgewood, but details of whether and how the County will manage the species are not yet available (San Mateo County 1997). San Francisco Water Department, the owner of the Triangle, has no specific management goals for rare plants at this time (California Department of Fish and Game 1997*a*).

## 6. Recovery Strategy

Recovery of *Pentachaeta bellidiflora* must first focus on protecting and managing the single remaining population by working with San Mateo County and the San Francisco Water Department to ensure the long-term survival of the species on their lands. This should involve protection of the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Pentachaeta bellidiflora* and other special status species in the single known location must be developed and implemented. The plans should include provisions for standardized annual monitoring of the *Pentachaeta bellidiflora* population to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from recreational activities and invasion of non-natives should be addressed. Where pampas grass (*Cortaderia* spp.) removal is required, cautions must be taken to avoid adverse impacts to federally listed animal species that may occur in the area (e.g. San Francisco garter snake [*Thamnophis sirtalis tetrataenia*]). If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Because part of the single remaining population of *Pentachaeta bellidiflora* occurs at Edgewood Natural Preserve, a public park adjacent to a housing development, any management plan developed for Edgewood should include an educational outreach program. Other species that may benefit from protection of serpentine habitat at the Triangle and Edgewood include fountain thistle (*Cirsium fontinale* ssp. *fontinale*), fragrant fritillary (*Fritillaria liliacea*), Marin dwarf-flax (*Hesperolinon congestum*), and San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii*).

Another high priority in recovery efforts for *Pentachaeta bellidiflora* is collection and banking of seed in Center for Plant Conservation certified botanic gardens. Seed banking is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations, and/or introductions to new sites. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection of and seed collection from the remaining population of *Pentachaeta bellidiflora*, the newly discovered potential population on the west side of Crystal Springs Reservoir needs to be confirmed. If this location contains the second known extant population of *Pentachaeta bellidiflora*, then protection and management of the site should proceed as above as should seed collection for banking. In addition, historic locations (particularly in Marin and Santa Cruz Counties) should be surveyed to determine whether suitable habitat remains, the species persists at the sites, and/or the sites may be suitable for repatriation. Suitability of historic locations for repatriation would depend upon (1) whether potential habitat exists, (2) the presence and magnitude of threats, and (3) whether the sites can be secured and managed for the long-term protection of the species. Some historic sites are unlikely to contain suitable habitat because of local urbanization (California Natural Diversity Data Base 1996, California Department of Fish and Game 1997*a*). Surveys should also include other potential habitat in the area of former and present habitat to determine whether other undiscovered populations may exist. Because it is unclear that *Pentachaeta bellidiflora* is a serpentine endemic, surveys should include both serpentine and non-serpentine soils (California Department of Fish and Game 1997*a*). Some of these surveys would require the cooperation of the San Francisco Water Department because suitable habitat occurs on their land. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Other important, but lower priority, recovery activities for *Pentachaeta bellidiflora* are experimental reseeding of the Edgewood portion of the population as well as removal of non-natives (e.g. eucalyptus [*Eucalyptus* spp.]) in the vicinity of the existing population at Edgewood. The latter experiments are of interest because it has been suggested that non-natives at Edgewood are damaging the *Pentachaeta bellidiflora* population (California Department of Fish and Game 1997*a*). Other research needs for *Pentachaeta bellidiflora* include investigations of soil affinity, seed germination and greenhouse propagation techniques, demography (soil seed bank, limiting life history stages), and reproductive biology (mating system, dispersal, pollination).

If five populations of *Pentachaeta bellidiflora* (including the Triangle population and the recently discovered population if its identity is confirmed) are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity, (2) shown to be stable or increasing over a minimum of 20 years that contain the normal precipitation cycle (or longer if suggested by the results of demographic monitoring), (3) seed from both populations is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Meeting this goal would require locating, restoring, and/or successfully introducing three (and possibly four if the new location cannot be confirmed) new populations. To represent the species' entire historic range will require at least one population in each county where the species currently occurs or formerly occurred: Marin, San Mateo, and Santa Cruz Counties. Repatriation of historic sites is preferred over introduction to new sites. However, surveying historic sites and potential habitat within the historic range to locate currently unknown populations is the preferred strategy because repatriation and introduction of populations is expensive and experimental (Falk *et al.* 1996). Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993).

*Pentachaeta bellidiflora* should not be considered for delisting unless 10 populations within its historic range and representing its entire historic range are shown to meet the criteria above. Meeting this goal would require locating, restoring and/or successfully introducing five new populations in addition to the five required for downlisting. The populations should represent the species' entire historic range with at least three populations in each of Marin, San Mateo, and Santa Cruz counties.

## L. Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*)

### 1. Description and Taxonomy

***Taxonomy.*** - *Streptanthus albidus* ssp. *albidus* (Metcalf Canyon jewelflower) was first collected in 1887 by Volney Rattan, a botany teacher and author, from hillsides a few miles south of San Jose (Greene 1887) . Edward Greene described *Streptanthus albidus* ssp. *albidus* in 1887 (Greene 1887); later he redefined the limits of *Euclisia*, formerly a subgenus of *Streptanthus*, treating it as a genus in its own right (Greene 1904). *Streptanthus albidus* ssp. *albidus*, as a member of the *Euclisia* group, was included in this change. Jepson (1925) returned *Euclisia* to subsection status, and later authors followed his treatment. Jepson (1925) also treated *Streptanthus albidus* ssp. *albidus* as a subspecies of *Streptanthus glandulosus*. Kruckeberg published a revision of the *Streptanthus glandulosus* complex in which he recognized the close relationships among *Streptanthus glandulosus*, *Streptanthus albidus*, and *Streptanthus niger* (Kruckeberg 1958). In this paper, he notes that the "sharp genetic discontinuity between *Streptanthus albidus* and all other populations, coupled with the morphological distinctness and regional restriction of *Streptanthus albidus* warrant the restoration of this Greeneian species." He recognized two subspecies: *Streptanthus albidus* ssp. *albidus* and *Streptanthus albidus* ssp. *peramoenus* (Kruckeberg 1958). Recent research affirms the distinctiveness of *Streptanthus albidus* ssp. *albidus*, *Streptanthus albidus* ssp. *peramoenus*, and *Streptanthus niger* (M. Mayer, *in litt*., 1998).

***Description.*** - *Streptanthus albidus* ssp. *albidus* (Figure II-23) is an annual herb of the mustard family (Brassicaceae) that reaches up to 1 meter (3 feet) in height. It has bristly hairs at the base and pale green, strongly glaucous stems and leaves. The flowers are borne in leafless terminal racemes (unbranched clusters or inflorescences of stalked flowers that open from bottom to top). The upper three of the white to yellow to whitish-green sepals are fused (united), with the lower (fourth) sepal free and spreading. The four petals, 8 to 11 millimeters (0.3 to 0.4 inch) long, are whitish with light purple veins. The erect flattened pods (dry fruits that open upon ripening to release the seeds) are 3 to 8 centimeters (1 to 3 inches) long (Kruckeberg 1977). The only *Streptanthus* species likely to co-occur with *Streptanthus albidus* ssp. *albidus* is its close relative *Streptanthus albidus* ssp. *peramoenus* (most beautiful jewelflower) (McCarten 1992*b*). *Streptanthus albidus* ssp. *peramoenus* is distinguished by its lilac-lavender sepals (Kruckeberg 1958). Chloroplast DNA studies suggest that *Streptanthus albidus* ssp. *albidus* may be recently derived (neoendemic) (Mayer and Soltis 1994).

## 2. Historical and Current Distribution

***Historical and Current Distribution.*** - *Streptanthus albidus* ssp. *albidus* always has been rare. It can be locally abundant, but its range is limited, extending less than 30 kilometers (20 miles) from San Jose south to Anderson Lake, which lies northeast of Morgan Hill in Santa Clara County (Figure II-24). Furthermore, the serpentine outcrops on which *Streptanthus albidus* ssp. *albidus* occurs are patchily distributed and comprise only a small percentage of the area within its range (McCarten 1992*b*).

Of 14 occurrences in the California Natural Diversity Data Base, one is extirpated, one is possibly extirpated, and three are historic records with *Streptanthus albidus* ssp. *albidus* not being observed since 1895, 1938 and 1957.

**Figure II-23.** Illustration of jewelflower (*Streptanthus albidus*) (from Abrams 1944, with permission).

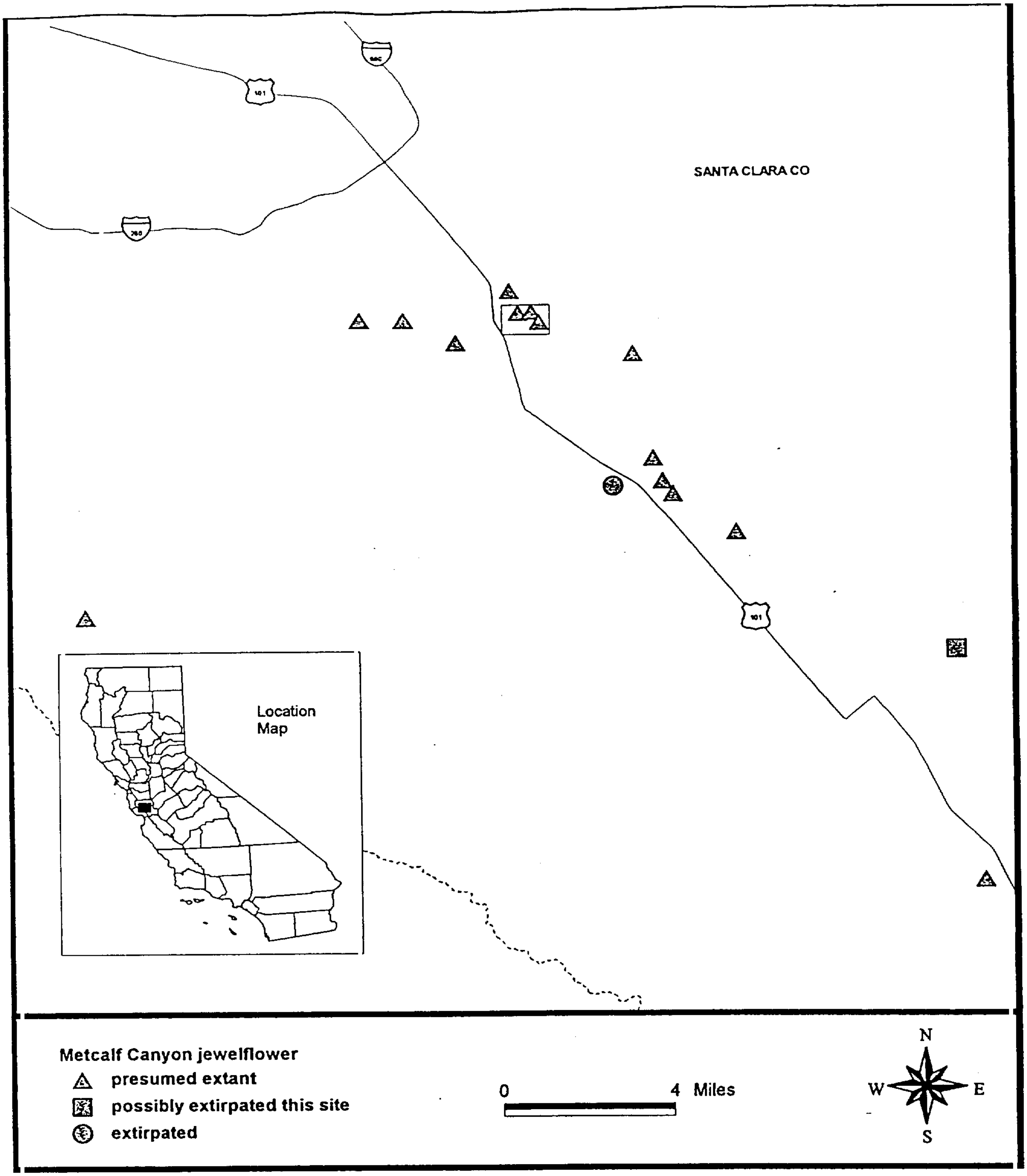


**Figure II-24.** Distribution of Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*). Each symbol represents one occurrence in CNDDB records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

The 1895 Lower Soda Spring Canyon historic occurrence is the westernmost ever recorded and the 1957 Llagas Avenue occurrence south of Morgan Hill is the southernmost (California Natural Diversity Data Base 1996), but both occurrences may be erroneous (California Department of Fish and Game 1997*a*). Nine occurrences have been more recently documented and are known to be extant (California Natural Diversity Data Base 1996).

### 3. Life History and Habitat

***Reproduction and Demography.*** - *Streptanthus albidus* ssp. *albidus* flowers April to June (Kruckeberg 1977). No detailed data on its reproductive biology or demography are available. Nine populations totaling approximately 20,000 to 25,000 plants have been recorded (McCarten 1992*b*).

***Habitat and Community Associations.*** - *Streptanthus albidus* ssp. *albidus* is endemic to serpentine outcrops with little soil development within a matrix of mostly native serpentine grassland. The species has also been seen on roadcuts through serpentine substrate. It grows between 60 and 365 meters (200 to 1,200 feet) in elevation (McCarten 1992*b*). *Streptanthus albidus* ssp. *albidus* grows in areas with other rare species including bay checkerspot butterfly (*Euphydryas editha bayensis*), most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*), Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*), and Santa Clara Valley dudleya (*Dudleya setchellii*). Other plant species associated with *Streptanthus albidus* ssp. *albidus* include annual yellow sweetclover (*Melilotus indica*), blue dicks (*Dichelostemma capitatum*), California poppy (*Eschscholzia californica*), California sagebrush (*Artemisia californica*), dwarf plantain (*Plantago erecta*), foothill deervetch (*Lotus humistratus*), foxtail chess (*Bromus madritensis* ssp. *rubens*), Mariposa lily (*Calochortus venustus*), phacelia (*Phacelia imbricata*), ruby chalice clarkia (*Clarkia rubicunda*), soft brome (*Bromus hordeaceus*), Tiburon buckwheat (*Eriogonum luteolum* var. *caninum*), wavyleaf soapplant (*Chlorogalum pomeridianum*), western larkspur (*Delphinium hesperium*), and wild oat (*Avena fatua*) (California Natural Diversity Data Base 1996). Annual yellow sweetclover, foxtail chess, soft brome, and wild oat are introduced species (Hickman 1993).

## 4. Reasons for Decline and Threats to Survival

The known historical distribution of *Streptanthus albidus* ssp. *albidus* is as restricted as its current distribution. It is found only in the Coyote Valley area of Santa Clara Valley, primarily on the east side of the valley. *Streptanthus albidus* ssp. *albidus* is known to remain at 9 of the 14 documented sites; all of the 9 are wholly or partially privately-owned. One population is known to have been extirpated by being covered with fill from a housing development, and one was probably extirpated by the construction of Anderson Dam. Three occurrences known are from historic records. *Streptanthus albidus* ssp. *albidus* was last observed at these historical sites in 1895, 1938 and 1957 (California Natural Diversity Data Base 1996).

*Streptanthus albidus* ssp. *albidus* is threatened by urbanization. Many of the extant populations are in areas being rapidly urbanized (California Natural Diversity Data Base 1996). One population consisting of approximately 9,000 plants, approximately 45 percent of all known plants, occurs on the proposed site of the Cerro Plata residential and golf course project (City of San Jose 1993, D. Mayall, *in litt.*, 1996). Although no direct destruction of any plants is planned, construction activities, human disturbance, and habitat fragmentation would result in significant impacts to the population (U.S. Fish and Wildlife Service 1995). The original plans to construct Valley Christian School and South Valley Christian Church would have destroyed 1,650 of the 2,700 plants (61 percent) occurring at a second site (City of San Jose 1992). However, the revised construction plans avoid impacts to *Streptanthus albidus* ssp. *albidus* (Jones and Stokes Associates, Inc. 1998).

Cattle grazing has contributed to reduced population sizes of *Streptanthus albidus* ssp. *albidus* and could potentially result in local extinction of the species within its range. Cattle eat or trample individual plants before they mature and set seed (K. Freas, *in litt.*, 1993). Grazing threatens one population in southeast San Jose and populations in the Metcalf Canyon area (California Natural Diversity Data Base 1996).

*Streptanthus albidus* ssp. *albidus* is also threatened by dumping and off-road motorcycle use. Road maintenance or construction threaten populations that occur on roadcuts (McCarten 1992*b*, U.S. Fish and Wildlife Service, *in litt.*, 1995*b*, D. Mayall, *in litt.*, 1996). One population is adjacent to an active quarry and could be threatened by activities associated with its operations (California Natural Diversity Data Base 1996).

**5. Conservation Efforts**

*Streptanthus albidus* ssp. *albidus* was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995).

**6. Recovery Strategy**

Population genetic research completed to date indicates that, because of genetic differences among populations, all populations of *Streptanthus albidus* ssp. *albidus* are valuable genetic resources (Mayer *et al.* 1994, M. Mayer, *in litt.*, 1998). Recovery of *Streptanthus albidus* ssp. *albidus* must first focus on protecting and managing the remaining populations by working with Santa Clara County Parks and private landowners to ensure the long-term survival of the species on their lands. Populations on private land should be protected through land acquisition, conservation easements or other means. Protection of *Streptanthus albidus* ssp. *albidus* should involve the largest possible block of serpentine habitat at each site and securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Streptanthus albidus* ssp. *albidus* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized annual monitoring of *Streptanthus albidus* ssp. *albidus* populations to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from road maintenance and construction, off-road vehicle use, dumping, and grazing must be eliminated. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Priority areas for protection will include those areas targeted in the bay checkerspot butterfly (*Euphydryas editha bayensis*) recovery strategies (e.g. Coyote Ridge). Other species that may benefit from protection of serpentine habitat for *Streptanthus albidus* ssp. *albidus* include Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*), Santa Clara Valley dudleya (*Dudleya setchellii*), Opler's longhorn moth (*Adela oplerella*), and Jung's microblind harvestman (*Microcina jungi*).

Another high priority in recovery efforts for *Streptanthus albidus* ssp. *albidus* is collection and banking of seed in Center for Plant Conservation certified botanic gardens. Seed banking is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations, and/or introductions to new sites. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection and seed collection, historic locations should be surveyed to determine whether suitable habitat remains, the species persists at the sites, and/or the sites may be suitable for repatriation. Suitability of historic locations for repatriation would depend upon (1) whether potential habitat exists, (2) the presence and magnitude of threats, and (3) whether the sites can be secured and managed for the long-term protection of the species. One potential repatriation location might be Tulare Hill if the site could be secured. Surveys should also encompass other potential serpentine habitat including any areas that have been set aside as open space for bay checkerspot butterfly (*Euphydryas editha bayensis*) conservation to determine whether undiscovered populations may exist. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Certain types of research are also high priority recovery activities for *Streptanthus albidus* ssp. *albidus*. In particular, because *Streptanthus albidus* ssp. *albidus* co-occurs with bay checkerspot butterfly and because bay checkerspot butterfly habitat benefits from vegetation management, the effect of various vegetation management techniques (e.g. grazing, mowing, and burning) on

*Streptanthus albidus* ssp. *albidus* needs to be evaluated. Evaluation of these techniques will aid managers in selecting management strategies that maintain bay checkerspot butterfly habitat while not adversely affecting *Streptanthus albidus* ssp. *albidus*. Other research areas that are important, but of lower priority, for *Streptanthus albidus* ssp. *albidus* include habitat preference, seed germination and propagation techniques, demographic studies to identify limiting life history stages and to evaluate the soil seed bank, and reproductive biology (mating system, dispersal and colonization, pollination). In addition, results of genetic and taxonomic research would be useful in future management of the species. Population genetics studies would be valuable to determine if, and to what extent, populations throughout the range of the species are genetically different from one another.

If nine natural populations of *Streptanthus albidus* ssp. *albidus* are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity, (2) shown to be stable or increasing over a minimum of 20 years that contain the normal precipitation cycle (or longer if suggested by the results of demographic monitoring), (3) seed collected from the remaining natural populations is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). The protected populations should be distributed throughout the range of the species including at least 25 percent west of Highway 101 and 75 percent in the Metcalf Canyon area east of Highway 101. If additional surveys indicate that the actual distribution of populations is different (e.g. a greater proportion of populations is found west of Highway 101), targets for protection should be changed so that they are consistent with the new information. *Streptanthus albidus* ssp. *albidus* should not be considered for delisting unless 18 populations within its historic range and representing its entire historic range are shown to meet the criteria above.

Meeting this goal would require locating, restoring, and/or successfully introducing nine new populations. Because repatriation and introduction of populations is expensive and experimental (Falk *et al.* 1996), surveying historic sites and potential habitat within the historic range to locate currently unknown populations is the preferred strategy.

### M. Tiburon jewelflower (*Streptanthus niger*)

#### 1. Description and Taxonomy

***Taxonomy.*** - *Streptanthus niger* (Tiburon jewelflower) was described by Edward L. Greene, from a type specimen he had collected at St. Hilary's Church in the town of Tiburon in Marin County (Greene 1886*b*). Greene later redefined the limits of *Euclisia*, formerly a subgenus of *Streptanthus*, treating it as a genus in its own right (Greene 1904). *Streptanthus niger*, as a member of the *Euclisia* group, was thus referred to as *E. niger*. Jepson (1925) returned *Euclisia* to subsection status, and later authors followed his treatment. Munz and Keck treated *Streptanthus niger* as a subspecies of *Streptanthus glandulosus* in A California Flora (1959), and then Munz returned it to *Streptanthus niger* in his supplement (1968), following Kruckeberg (1958). Recent research affirms the distinctiveness of *Streptanthus niger*, *Streptanthus albidus* ssp. *peramoenus*, and *Streptanthus albidus* ssp. *albidus* (M. Mayer, *in litt.*, 1998).

***Description.*** - *Streptanthus niger* (Figure II-25) is an annual herb of the mustard family (Brassicaceae) that reaches 30 to 60 centimeters (1 to 2 feet) in height. The lower leaves are toothed, the upper leaves less toothed or not at all. The sepals are a very dark purple; the petals have a purple claw and a white blade with a purple midvein. The pods are erect, almost straight and 4 to 7 centimeters (1.5 to 2.75 inches) long (Kruckeberg and Etienne 1977). The zig-zag inflorescence pattern (Kruckeberg and Etienne 1977) and the lack of hairs (Greene 1886*b*) distinguish *Streptanthus niger* from its near relative *Streptanthus glandulosus* (bristly jewelflower).

**Figure II-25.** Illustration of Tiburon jewelflower (*Streptanthus niger*) (from Abrams and Ferris 1960, with permission).

## 2. Historical and Current Distribution

***Historical and Current Distribution.*** - *Streptanthus niger* is found on the Tiburon Peninsula of Marin County (Figure II-26). Two populations are known from the southern end of the peninsula where they occur within 3 kilometers (2 miles) of one another (California Natural Diversity Data Base 1996). One is at the tip of the peninsula near St. Hilary's Church, and the other is along the Middle Ridge of the peninsula (Morey and Hunter 1990). The species probably never occurred outside of the Tiburon Peninsula (California Native Plant Society no date, Morey and Hunter 1990), and no historic occurrences are known (Morey and Hunter 1990).

## 3. Life History and Habitat

***Reproduction and Demography.*** - Seedlings of *Streptanthus niger* appear in March and April (Hunter 1989*b*), and the plants flower from May to June (Kruckeberg and Etienne 1977). The species is self-pollinated (Kruckeberg 1957). The seed capsules open in late June (Hunter 1989*b*). Populations have fluctuated from 50 to 2,000 plants (Hunter 1989*b*, A. Allen, *in litt.*, 1991). A 1990 survey found a total of approximately 800 plants in the two occurrences together (E. Buxton, pers. comm. as cited in Morey and Hunter 1990). The known occurrences combined comprise approximately 5 hectares (12 acres) of habitat (Morey and Hunter 1990). No detailed data are available on the reproductive biology or demography of the species.

***Habitat and Community Associations.*** - *Streptanthus niger* is found on shallow rocky serpentine soils on slopes of the southern Tiburon Peninsula (Kruckeberg and Etienne 1977) at elevations of approximately 100 meters (350 feet) (California Natural Diversity Data Base 1996). Associated federally listed species are Marin dwarf-flax (*Hesperolinon congestum*) and Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) (California Natural Diversity Data Base 1996). Other associated plants include foothill needlegrass (*Nassella lepida*) (Hunter 1989*b*), golden yarrow (*Eriophyllum confertiflorum*), hayfield tarweed (*Hemizonia congesta* ssp. *congesta*), purple needlegrass (*Nassella pulchra*) (California Native Plant Society no date), serpentine reedgrass (*Calamagrostis*

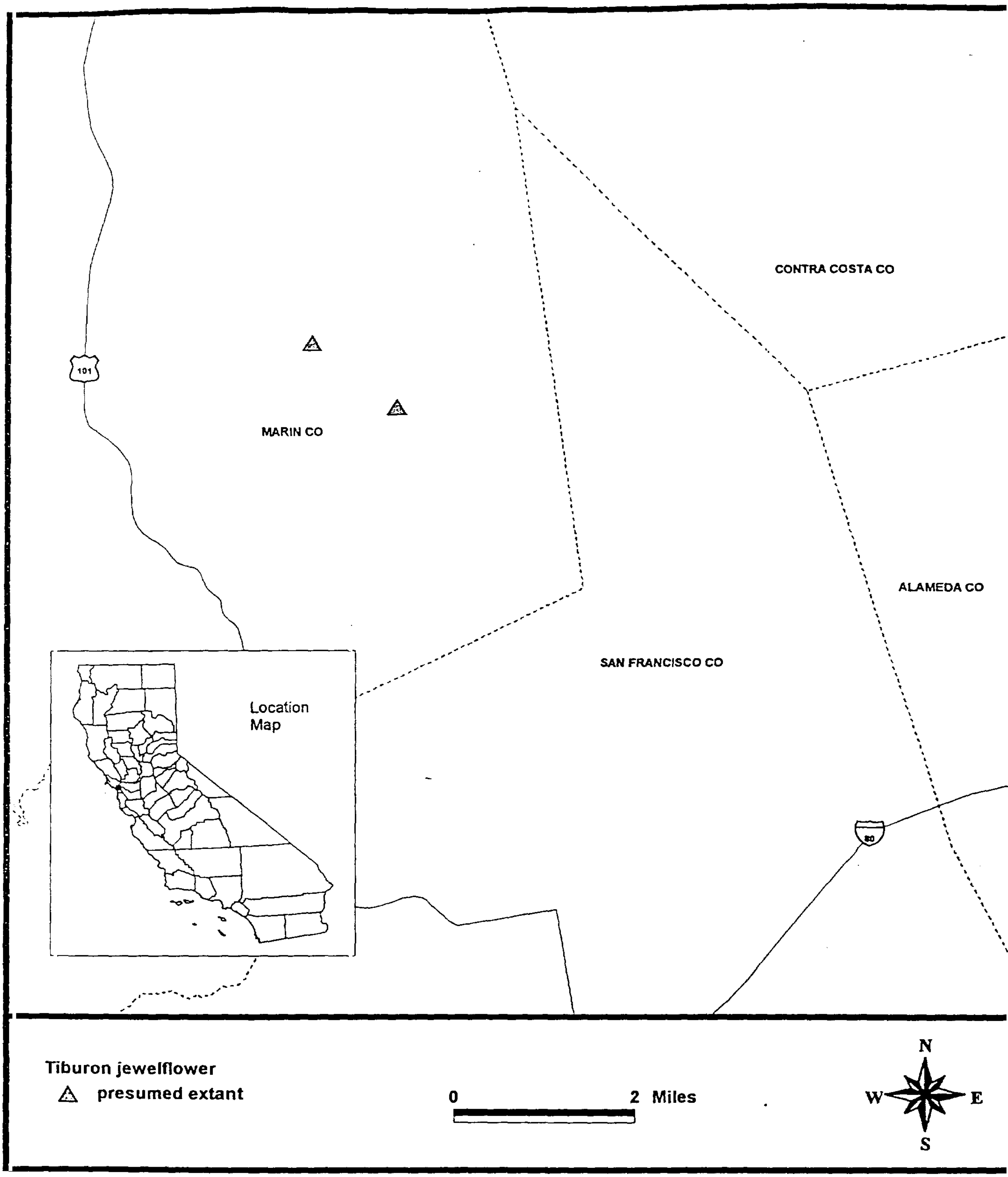


**Figure II-26.** Distribution of Tiburon jewelflower (*Streptanthus niger*).

*ophitidis*) (Hunter 1989*b*), sticky calycadenia (*Calycadenia multiglandulosa*) (California Native Plant Society no date), and Tiburon buckwheat (*Eriogonum luteolum* var. *caninum*) (California Natural Diversity Data Base 1996). Introduced species in the area include Italian ryegrass (*Lolium multiflorum*), slender wild oat (*Avena barbata*) and soft brome (*Bromus hordeaceus*) (Hunter 1989*b*).

### 4. Reasons for Decline and Threats to Survival

*Streptanthus niger* is an extremely narrowly-distributed species; its entire range amounts to less than one-third of a square mile. Urban development has destroyed over 40 percent of potential *Streptanthus niger* habitat (Hunter 1989*b*).

*Streptanthus niger* is threatened by residential development (California Native Plant Society no date, Ordano 1988, California Natural Diversity Data Base 1996, D. Smith, *in litt.*, 1998). Both of the two known occurrences have multiple landowners. The town of Tiburon owns portions of the occurrence on the Middle Ridge of the peninsula (Morey and Hunter 1990). Part of the occurrence at St. Hilary's Church in Tiburon is managed by the Tiburon Landmark Society (C. Bramham, pers. comm., 1997) and part by Marin County Open Space District (California Department of Fish and Game 1997*b*). The remainder of each of the two occurrences is privately-owned and parts are proposed for development (Morey and Hunter 1990; U.S. Fish and Wildlife Service 1995).

One parcel, containing approximately 65 percent of all plants of this species, was the proposed site for 30 homes (Marinero Estates) (LSA Associates, Inc., 1993). Although this project did not propose to directly eliminate the plants, impacts from potentially harmful runoff from upslope construction and landscaping, accelerated erosion, introduction of weedy species during construction, alteration of hydrology, and uncontrolled foot traffic would have threatened the plants (B. Hunter, *in litt.*, 1994). The proposed development was denied by the Town of Tiburon (B. Olson, pers. comm., 1996). The area that would have been involved in this development (Harroman/Marinero Estates) is proposed to be set aside as open space by the Town of Tiburon. A ballot measure to secure the funding for the purchase of the property passed in June, 1997; the purchase took place in the fall of 1997 (D. Watrous, pers. comm., 1997). An area containing 20 plants adjacent to this parcel was bulldozed for construction of condominiums (A. Allen, pers. comm., 1993). Another area adjacent to the Harroman property is also proposed for development (Easton Point Estates), but while *Hesperolinon congestum* (see above) was found in the project area, *Streptanthus niger* was not (D. Watrous, pers. comm., 1997). Residential development is ongoing at several parcels of the Middle Ridge occurrence (E. Buxton, pers. comm., 1993, A. Allen, pers. comm., 1993).

In addition to urbanization, pedestrian traffic, dog walking, invasion of non-natives and road construction threaten the *Streptanthus niger* populations (California Native Plant Society no date, Ordano 1988, Morey and Hunter 1990, California Department of Fish and Game 1997*b*). Invasive non-natives, such as french broom (*Genista [=Cytisus] monspessulana*), that have been removed by volunteers in the past, have reinvaded (D. Smith, *in litt.*, 1998). Further, because there are only two populations of *Streptanthus niger* which occur in close proximity to each other, the species may be at risk of extinction from random events or from natural catastrophes (Morey and Hunter 1990, Menges 1991, Primack 1993, Meffe and Carroll 1994).

## 5. Conservation Efforts

*Streptanthus niger* was listed as endangered by the State of California in 1990 (California Department of Fish and Game 1992). The species was federally listed as endangered in 1995 (U.S. Fish and Wildlife Service 1995). The California Department of Fish and Game granted a research permit for *Streptanthus niger* to Michele Mills, a graduate student at University of California, Davis; Mills intends to study the demography and reproduction of the species (California Department of Fish and Game 1997*c*).

## 6. Recovery Strategy

Recovery of *Streptanthus niger* must first focus on protecting and managing the two natural populations by working with the Town of Tiburon, Marin Open Space District, Tiburon Landmark Society and other landowners to ensure the long-term survival of the species on their lands. The portions of populations that occur on private land should be protected by land acquisition, conservation easements, or other means. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Streptanthus niger* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized annual monitoring of *Streptanthus niger* populations to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from invasion of non-natives and trampling must be eliminated. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Because the remaining natural populations of *Streptanthus niger* occur in a highly urbanized area, any management plans developed should include an educational outreach program. Other species that may benefit from protection of serpentine habitat on the Tiburon Peninsula include Marin dwarf-flax (*Hesperolinon congestum*) and Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*).

Another high priority in recovery efforts for *Streptanthus niger* is collection and banking of seed in Center for Plant Conservation certified botanic gardens. Seed banking is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations and/or introductions to new sites. Seed collection efforts should include both populations. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection and seed collection, surveys of other potential serpentine habitat on the Tiburon Peninsula should be conducted to determine whether undiscovered populations may exist. Although discovery of new populations is unlikely (E. Buxton, *in litt.*, 1998), any new populations should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Other important, but lower priority, recovery activities for *Streptanthus niger* include experimental burning and weeding in plots adjacent to existing populations (California Department of Fish and Game 1997*b*). These experiments would address the question of whether the populations might expand into suitable habitat that has been made available by burning or weeding. If *Streptanthus niger* moves into and persists in treated areas, burning or weeding might be appropriate strategies to encourage expansion of existing populations. Any experimental burning or weeding ought to initially be limited to a very small area (e.g. 1 square meter [10.8 square feet]). Other research needs for *Streptanthus niger* include demography (limiting life history stages, soil seed bank) and reproductive biology (mating system, dispersal, pollination).

If the two natural populations of *Streptanthus niger* are (1) fully protected and managed with the primary intention of preserving the populations in perpetuity, (2) shown to be stable or increasing over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring), (3) seed from both remaining natural populations is stored at a minimum of two Center for Plant Conservation certified botanic gardens, and (4) reliable seed germination and propagation techniques for the species are understood, the species should be evaluated for downlisting to threatened. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993).

The above downlisting criteria constitute a significant improvement in protection and management of *Streptanthus niger*. Completing these actions would substantially increase the security of the species. However, available data suggest that *Streptanthus niger* should not be considered for delisting. The species is known from only two locations in an extensively urbanized area. No historic sites are known for repatriation, and the possible success of introduction of the species is not known. In the unlikely event that (1) a significant number of new populations are discovered and/or (2) research shows habitat within the species range is available and introductions are likely to be successful, development of delisting criteria could be considered.

## N. Plant Species of Concern

### 1. Baker's manzanita (*Arctostaphylos bakeri* ssp. *bakeri*)

***Taxonomy.*** - *Arctostaphylos bakeri* (Baker's manzanita) was described by Alice Eastwood in 1934. The type specimen was collected in 1933 on a serpentine ridge in a grove of cypress 3.2 kilometers (2 miles) east of Occidental in Sonoma County (Eastwood 1934). The taxon was renamed *Arctostaphylos stanfordiana* ssp. *bakeri* by Joseph Edison Adams in 1940 (Adams 1940). This was the treatment accepted by Munz and Keck (1959). Subsequently, Philip Wells (1968) revised the genus and placed *Arctostaphylos bakeri* in *Arctostaphylos manzanita* ssp. *bakeri*. The taxon was moved again in 1976 by James Roof who considered it *Arctostaphylos pungens* ssp. *bakeri* (Roof 1976). Wells revisited the Sonoma complex of *Arctostaphylos* in 1988. In this treatment, he described a closely related subspecies, *Arctostaphylos bakeri* ssp. *sublaevis* (Wells 1988). According to the rules for botanical nomenclature, when a new variety is described in a species not previously divided into infraspecific taxa, a "type" variety is automatically created (Lawrence 1951). In this case, the type variety is *Arctostaphylos bakeri* ssp. *bakeri*.

***Description.*** - *Arctostaphylos bakeri* ssp. *bakeri* (Figure II-27) is an evergreen shrub of the heath family (Ericaceae). The plants are 1 to 3 meters (3 to 10 feet) tall, lack a basal burl (a hard woody growth that is often flattened and hemispherical) (Hickman 1993), and have smooth, reddish-brown bark (Munz and Keck 1959). The twigs are finely glandular-hairy. The dark green leaves are 1 to 3 centimeters (0.4 to 1.2 inches) long and generally elliptic (shaped like a flattened circle) in shape with smooth (entire) margins. The leaf surface, which is

**Figure II-27.** Illustration of Baker's manzanita (*Arctostaphylos bakeri* ssp. *bakeri*) (from Abrams 1951, with permission).

rough to the touch, is finely glandular-bristly with small round or conical protuberances (papillae) (Hickman 1993). The 5 to 6 millimeters (0.2 to 0.24 inch) long pinkish flowers produce bright red fruits (Munz and Keck 1959).

The closely-related Cedar's manzanita, *Arctostaphylos bakeri* ssp. *sublaevis*, differs from *Arctostaphylos bakeri* ssp. *bakeri* in that the latter is more intensely glandular and rough with stiff or bristly hairs. The lack of these features in *Arctostaphylos bakeri* ssp. *sublaevis* is most pronounced on the leaves which lack glands and are minutely hairy. The leaves of *Arctostaphylos bakeri* ssp. *bakeri* are rough with small rounded or conical protuberances (papillae) and glandular hairs. Both subspecies may have been derived by hybridization of *Arctostaphylos hispidula* (Howell's manzanita) and *Arctostaphylos manzanita* (common manzanita) (Wells 1988). *Arctostaphylos manzanita* has been observed growing in association with *Arctostaphylos bakeri* ssp. *bakeri*, but *Arctostaphylos manzanita* is generally taller (2 to 8 meters [6.5 to 26.0 feet]) with larger, hairless leaves and longer leaf stalks (petioles) (Hickman 1993). Roger Raiche of the University of California Botanical Garden at Berkeley has observed some introgression (hybridization followed by backcrossing) between *Arctostaphylos bakeri* ssp. *bakeri* and *Arctostaphylos manzanita* at one site (California Natural Diversity Data Base 1996).

***Historical and Current Distribution.*** - *Arctostaphylos bakeri* ssp. *bakeri* is restricted to Sonoma County (Figure II-28). The species is known from less than 10 occurrences, most located north and east of Occidental. One occurrence, discovered in 1988, is northwest of Healdsburg (California Native Plant Society 1988*e*). The species has also been reported at California Native Plant Society's Vine Hill Preserve (California Department of Fish and Game 1992), but the location contains only a single plant and not a viable population (R. Raiche, pers. comm., 1997). Another single plant has been observed on River Road in Forestville (R. Raiche, *in litt.*, 1998). Historic populations may have been reduced by residential and agricultural development before surveys were conducted (California Native Plant Society 1988*e*).

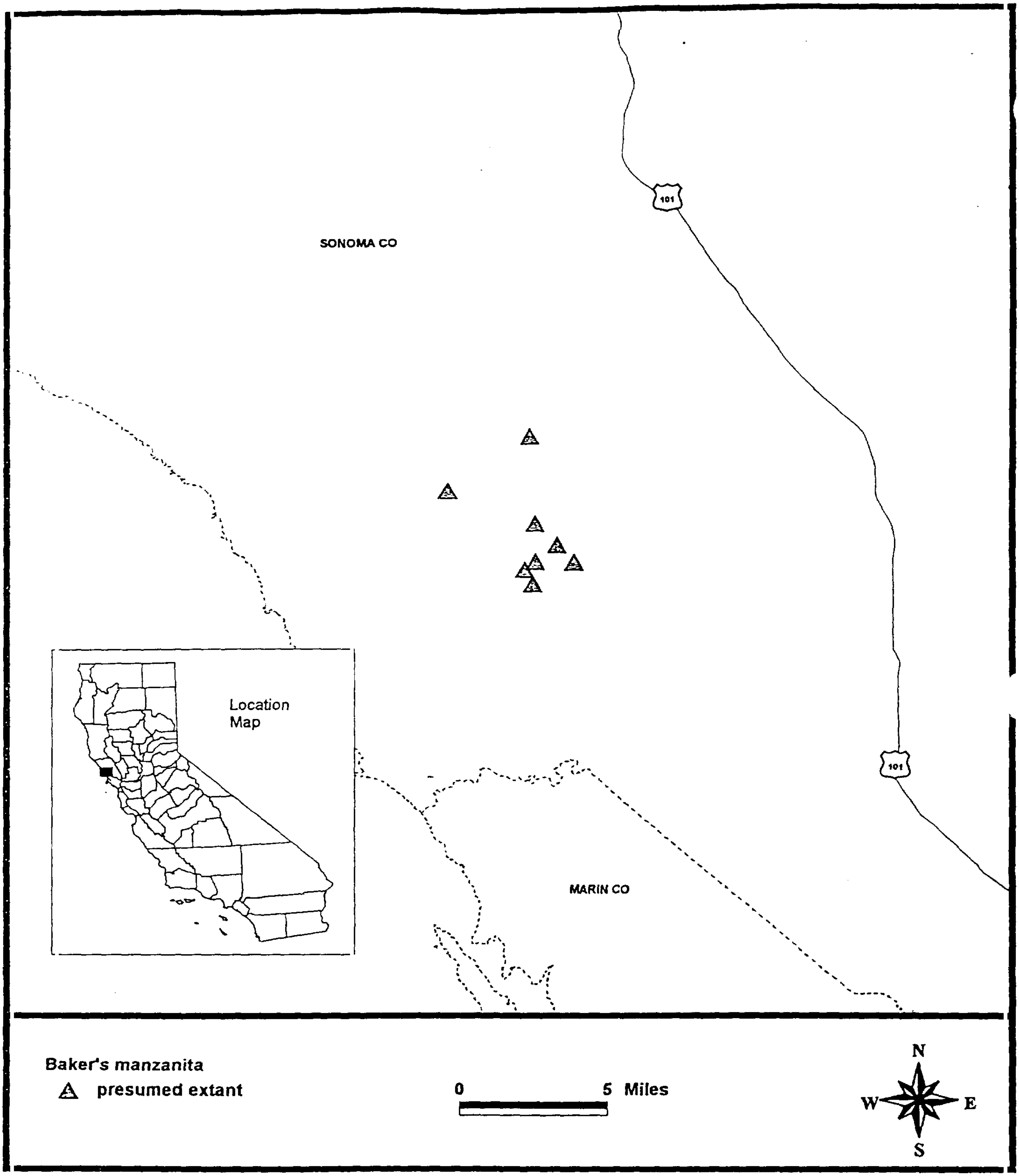


**Figure II-28.** Distribution of Baker's manzanita (*Arctostaphylos bakeri* ssp. *bakeri*).

***Reproduction and Demography.*** - *Arctostaphylos bakeri* ssp. *bakeri* is an evergreen shrub flowering from February to April (Munz and Keck 1959, Skinner and Pavlik 1994). Populations range from around 10 plants to more than 10,000 plants. Most populations appear to number between 100 and 1,000 (California Natural Diversity Data Base 1996). In addition, apparently small isolated stands with fewer than 10 plants each are scattered through the area (California Native Plant Society 1988*e*). Details of the reproductive biology and demography of the species are not available.

***Habitat and Community Associations.*** - *Arctostaphylos bakeri* ssp. *bakeri* grows on serpentine ridges or outcrops (Munz and Keck 1959, Hickman 1993) in broadleafed upland forest and chaparral (Skinner and Pavlik 1994). The species reportedly occupies sites at elevations between 73 and 300 meters (240 to 980 feet) (Hickman 1993, California Natural Diversity Data Base 1996, R. Raiche, *in litt.*, 1998). *Arctostaphylos bakeri* ssp. *bakeri* can grow along with the federally listed endangered Pennell's bird's-beak (*Cordylanthus tenuis* ssp. *capillaris*). Other associated species include coast live oak (*Quercus agrifolia*), madrone (*Arbutus menziesii*), musk brush (*Ceanothus jepsonii*), Sargent cypress (*Cupressus sargentii*), tanoak (*Lithocarpus densiflorus*), and common manzanita (*Arctostaphylos manzanita*) (California Natural Diversity Data Base 1996).

***Reasons for Decline and Threats to Survival.*** - With the exception of a portion of the Harrison Grade population that is on the California Department of Fish and Game's Harrison Grade Ecological Preserve, all known populations of *Arctostaphylos bakeri* ssp. *bakeri* occur on privately-owned land (California Natural Diversity Data Base 1996). Populations on private land are variously threatened by development, grazing, bulldozing, invasion of non-natives (e.g. broom, *Genista [=Cytisus]* spp.) and overgrowth by late successional species (see below) (California Natural Diversity Data Base 1996). Development may threaten the site along the Bohemian Highway where *Arctostaphylos bakeri* ssp. *bakeri* occurs with *Cordylanthus tenuis* ssp. *capillaris* (Pennell's bird's-beak) (S. Swedenborg, pers. comm., 1997). The Healdsburg site was also slated for development, but most of the *Arctostaphylos bakeri* ssp. *bakeri* may be in open space for that project (R. Raiche, pers. comm., 1991). Grazing and bulldozing has degraded one small site. Except for fire roads, one large site north of Camp Meeker is largely undisturbed (California Native Plant Society 1988*e*).

Harrison Grade Ecological Preserve, established in 1985 (California Native Plant Society 1988*e*) and owned by the California Department of Fish and Game, is within the center of a large, nearly contiguous population of *Arctostaphylos bakeri* ssp. *bakeri*. The site contains the second largest known population of the species (McCarten 1987*b*). Light grazing, occasional stone hauling, illegal dumping, as well as some vehicle use associated with these activities may disturb some plants on the unprotected land at the site (California Native Plant Society 1988*e*).

*Arctostaphylos bakeri* ssp. *bakeri* also may be threatened by overgrowth of late successional species due to fire suppression activities. According to Roger Raiche in 1991, populations were in need of fire or clearing to open up habitat for manzanitas, especially at two sites. Most shading was apparently caused by *Pseudotsuga menziesii* (Douglas-fir) and bay trees (*Umbellaria californica*); dead manzanitas (*Arctostaphylos* sp.) were observed in some locations where the trees are large. The smaller sites are being shaded most rapidly, and they may be lost already (R. Raiche, pers. comm., 1991). *Arctostaphylos bakeri* ssp. *bakeri* is also threatened by its very limited distribution which makes it vulnerable to chance catastrophic events (Menges 1991, Primack 1993, Meffe and Carroll 1994).

***Conservation Efforts.*** - *Arctostaphylos bakeri* ssp. *bakeri* was listed as rare by the State of California in 1979 (California Department of Fish and Game 1992). The species was designated a Category 2 candidate by the U.S. Fish and Wildlife Service in 1993. Category 2 included species for which sufficient information was unavailable to make a final listing determination (U.S. Fish and Wildlife Service 1993). In 1996, the U.S. Fish and Wildlife Service discontinued the Category 2 designation. Therefore, *Arctostaphylos bakeri* ssp. *bakeri* is now considered a species of concern, rather than a Category 2 candidate (U.S. Fish and Wildlife Service 1996*a*, *b*). The California Department of Fish and Game developed a management plan for the Harrison Grade Preserve in 1987 (McCarten 1987*b*), and implementation is in progress. In 1995, a fence was built along the eastern edge of the preserve (T. LaBlanc, pers. comm., 1997). The site may be the lowest quality large population because *Cupressus sargentii* (Sargent cypress) and *Pseudotsuga menziesii* (Douglas-fir) have reportedly invaded the manzanita. The site is in need of active management (C. Rogers, *in litt.*, 1996).

*Arctostaphylos bakeri* ssp. *bakeri* is in the nursery trade (Showers and Wiese 1995) as the pink flowered "Lewis Edmonds" variety (R. Raiche, pers. comm., 1991).

***Conservation Strategy.*** - Ensuring long-term survival of *Arctostaphylos bakeri* ssp. *bakeri* must first focus on protecting and managing populations at the known locations by working with the California Department of Fish and Game and private landowners. Populations on private land should be protected by land acquisition, conservation easements, or other means. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Arctostaphylos bakeri* ssp. *bakeri* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized monitoring of *Arctostaphylos bakeri* ssp. *bakeri* populations every 5 years to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from succession, invasion of non-natives and grazing must be eliminated. Controlled burning is a management strategy that should be considered to control succession and non-natives. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Because the California Department of Fish and Game preserve is too small to provide long-term protection for the species as a whole (California Department of Fish and Game 1997*b*), high priority should be given to protection and management of the populations on private land, especially those at the Bohemian Highway site. In addition, protection of the Bohemian Highway site would benefit two other special status plants, Pennell's bird's-beak (*Cordylanthus tenuis* ssp. *capillaris*) and Crystal Springs lessingia (*Lessingia arachnoidea*).

Collection and banking of seed in Center for Plant Conservation certified botanic gardens is also an important conservation strategy for *Arctostaphylos bakeri* ssp. *bakeri*. Seed banking is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations, and/or introductions to new sites. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection and seed collection, other suitable serpentine habitat should be surveyed to determine whether undiscovered populations exist. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Other important conservation activities for *Arctostaphylos bakeri* ssp. *bakeri* include research on the benefits of burning and hand clearing to limit succession and aid regeneration of the species, seed germination and propagation techniques, and basic research on demography and reproduction (including mating system and pollination). Demographic research would be valuable in helping to identify limiting life history stages.

To ensure the long-term conservation of *Arctostaphylos bakeri* ssp. *bakeri,* 10 populations must be fully protected and managed with the primary intention of preserving the populations in perpetuity. The populations must also be stable or increasing with evidence of natural recruitment over a minimum of 30 years that include the normal precipitation cycle (or longer depending on results of research on the role of fire in reproduction). Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). In addition, seed must be stored at a minimum of two Center for Plant

Conservation certified botanic gardens and reliable seed germination and propagation techniques for the species must be understood. The status of *Arctostaphylos bakeri* ssp. *bakeri* should be reevaluated within 5 years of recovery plan approval or when surveys are completed, whichever is less. The need to list *Arctostaphylos bakeri* ssp. *bakeri* should be considered if the criteria for long-term conservation outlined above are not met within 10 years after publication of the recovery plan.

### 2. Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*)

***Taxonomy.*** - The type specimen of *Cirsium fontinale* var. *campylon* (Mt. Hamilton thistle) was collected in 1936 by Helen Sharsmith from a colony along the margins of Del Puerto Creek near its junction with Adobe Creek in the Mt. Hamilton Range of western Stanislaus County. She described the species as *Cirsium campylon* in 1939 (Sharsmith 1939). In 1967, Pilz proposed reducing the species to a subspecies of *Cirsium fontinale* but never published his treatment. Keil and Turner (1992), concurring with Pilz, formally proposed the taxon be treated as *Cirsium fontinale* var. *campylon.*

***Description.*** - *Cirsium fontinale* var. *campylon* (Figure II-29) is an herbaceous perennial of the aster family (Asteraceae) (Hickman 1993, Skinner and Pavlik 1994). The plants are erect, between 6 and 20 decimeters (2 to 6.5 feet) in height usually with a single stem. The stem is leafy throughout and covered with slender entangled hairs as the plant ages. The woolly, spine-tipped leaves are 2 to 4 decimeters (7 to 16 inches) long on the upper part of the stem and up to 7 decimeters (2.25 feet) long at the base. The flower heads are strongly nodding with strongly recurved bracts beneath them. The white flowers produce brown one-seeded fruits (achenes) approximately 4 millimeters (0.16 inch) long (Sharsmith 1939).

*Cirsium fontinale* var. *campylon* is distinguished from the related *Cirsium fontinale* var. *fontinale* by its curved involucral bracts, to which the specific epithet *campylon* refers (Sharsmith 1939). Involucral bracts, or phyllaries, are the group of bracts beneath a flower, fruit or inflorescence (Hickman 1993). In

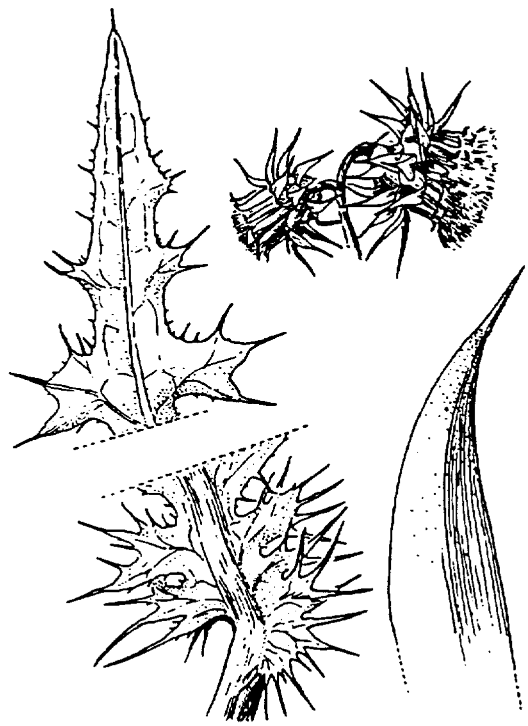

**Figure II-29.** Illustration of Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*) (from Abrams and Ferris 1960, with permission).

addition, the bracts of *Cirsium fontinale* var. *campylon* are green and have a strong spiny tip as compared to the bracts of *Cirsium fontinale* var. *fontinale* which are reddish with a short spiny tip (Sharsmith 1939, McClintock and Danielson 1975). The two species also differ in that the flower heads of *Cirsium fontinale* var. *campylon* are conspicuously drooping and those of *Cirsium fontinale* var. *fontinale* are only slightly nodding and usually erect at maturity (Sharsmith 1939).

***Historical and Current Distribution.*** - *Cirsium fontinale* var. *campylon* is restricted to the Mount Hamilton Range (Sharsmith 1982) (Figure II-30). The species is known from approximately 23 occurrences in Santa Clara, Stanislaus and Alameda Counties. Four occurrences are in Stanislaus County, two in southeastern Alameda County and the remainder in Santa Clara County. The Stanislaus County occurrences are in the vicinity of Del Puerto Canyon in northwestern Stanislaus County near the Stanislaus-Santa Clara County line. The Alameda County occurrences are in the vicinity of Cedar Mountain (California Natural Diversity Data Base 1996). More populations may exist in Alameda County because virtually all the habitat in Alameda County is on private lands that have not been surveyed (B. Olson, *in litt.*, 1998). The Santa Clara County occurrences are distributed (1) from Anderson Lake north to Evergreen on the east side of Highway 101, (2) in the Santa Teresa Hills area west of Highway 101, and (3) in northeastern Santa Clara County from Bolinger Canyon north to Blackbird Valley (California Natural Diversity Data Base 1996).

***Reproduction and Demography.*** - *Cirsium fontinale* var. *campylon* is a perennial herb which flowers from April to September or October (Sharsmith 1939, Skinner and Pavlik 1994). Most locations apparently support 100 to 5,000 plants although more than 18,000 plants were observed in one location in Santa Clara County in 1992 (California Natural Diversity Data Base 1996). Details of reproductive biology and demography for the species are not available.

***Habitat and Community Associations.*** - *Cirsium fontinale* var. *campylon* occurs in serpentine seeps of chaparral, cismontane woodland, valley and foothill grassland (Skinner and Pavlik 1994). Sharsmith (1939) suggested the species

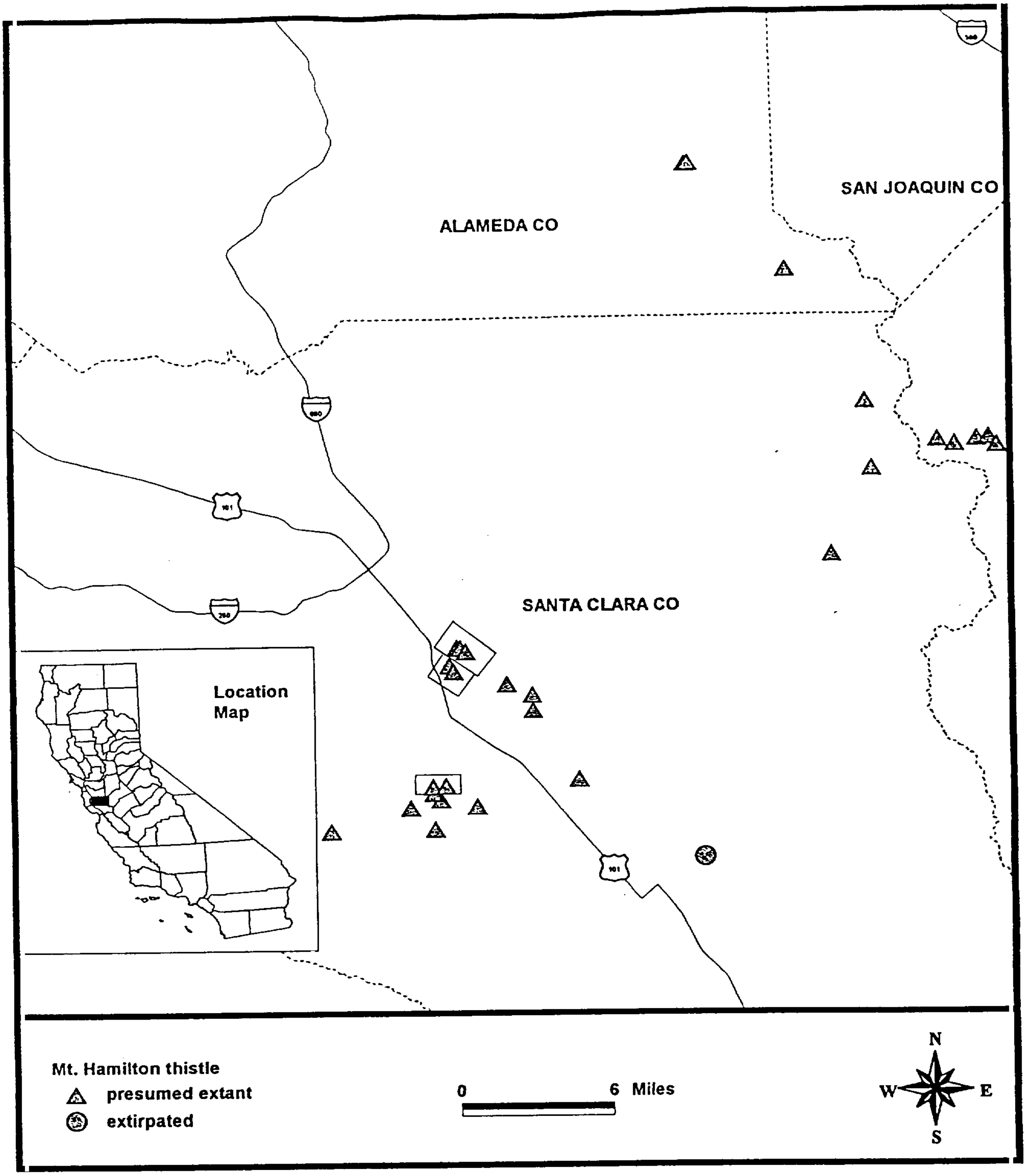


**Figure II-30.** Distribution of Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*). Each symbol represents one occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

occurs at elevations from 300 to 750 meters (1,000 to 2,500 feet); however, there is apparently one occurrence as low as 97 meters (320 feet) and one as high as 885 meters (2,900 feet) (California Natural Diversity Data Base 1996). *Cirsium fontinale* var. *campylon* forms dense but isolated colonies (Sharsmith 1982). The population at the type locality reportedly is bordered by Brewer's willow (*Salix breweri*) and associated with California poppy (*Eschscholzia californica*), columbine (*Aquilegia eximia*), common yarrow (*Achillea millefolium*), and seep monkeyflower (*Mimulus guttatus*) (Pilz 1967). Other species found with *Cirsium fontinale* var. *fontinale* include long-rayed tritelia (*Tritelia peduncularis*) and ryegrass (*Elymus triticoides*) (B. Olson, *in litt.*, 1998). *Cirsium fontinale* var. *campylon* may occur near or with other relatively rare species including bay checkerspot butterfly (*Euphydryas editha bayensis*), fragrant fritillary (*Fritillaria liliacea*), Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*), most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*), Mt. Hamilton coreopsis (*Coreopsis hamiltonii*), Mt. Hamilton jewelflower (*Streptanthus callistus*), Santa Clara Valley dudleya (*Dudleya setchellii*), smooth lessingia (*Lessingia micradenia* var. *glabrata*), and talus fritillary (*Fritillaria falcata*) (California Natural Diversity Data Base 1996).

***Reasons for Decline and Threats to Survival.*** - The vast majority of locations of *Cirsium fontinale* var. *campylon* occur on private land. Two occurrences may be partially within county parks in Santa Clara County. Some populations may be protected by the landowners (S. Edwards, pers. comm., 1996).

*Cirsium fontinale* var. *campylon* is threatened by urbanization, grazing and other activities such as road construction. Development is pending at a number of locations, particularly in Santa Clara County (Z. Chandik, *in litt.*, 1994, California Natural Diversity Data Base 1996, California Department of Fish and Game 1997*a*). Within Santa Clara County, development especially threatens many of the *Cirsium fontinale* var. *campylon* occurrences east of Highway 101 (California Natural Diversity Data Base 1996, California Department of Fish and Game 1997*a*). For example, the proposed Cerro Plata project, mentioned above under *Dudleya setchellii* and *Streptanthus albidus* ssp. *albidus,* could potentially adversely affect *Cirsium fontinale* var. *campylon* (D. Mayall, *in litt.*, 1998).

Populations in the vicinity of Coyote Valley south of San Jose were in a relatively undeveloped area until recently; the area is now under significant development pressure which threatens *Cirsium fontinale* var. *campylon.* Populations in relatively undeveloped areas of the mountains may be less threatened by development, but may be threatened by grazing (D. Kelch, pers. comm., 1996). Grazing has been considered a threat at a number of locations (California Natural Diversity Data Base 1996). One occurrence occupies part of an area proposed for a solid waste landfill. *Cirsium fontinale* var. *campylon* growing in county parks may be threatened by recreational activities, such as horseback riding (California Natural Diversity Data Base 1996). Horse grazing appears to be a threat in at least one population (B. Olson, *in litt.*, 1998). Some populations may also be threatened by mining, road maintenance and flooding (S. Edwards, pers. comm., 1996). Roadway construction involving installation of culverts or fill of riparian or other wetland habitat may be a threat in some locations as well (B. Olson, *in litt.*, 1998).

***Conservation Efforts.*** - *Cirsium fontinale* var. *campylon* was designated a Category 2 candidate by the U.S. Fish and Wildlife Service in 1993 (U.S. Fish and Wildlife Service 1993). Because the U.S. Fish and Wildlife Service discontinued the Category 2 designation in 1996, *Cirsium fontinale* var. *campylon* is now considered a species of concern (U.S. Fish and Wildlife Service 1996*a*, *b*). Disturbance may be beneficial to *Cirsium fontinale* var. *campylon.* In some cases, healthy colonies are growing where newer roads cross streams within areas where it grew (D. Kelch, pers. comm., 1996). However, displacement of *Cirsium fontinale* var. *campylon* by pampas grass (*Cortaderia* spp.) in disturbed areas such as road cuts and road crossings is also possible (B. Olson, *in litt.*, 1996).

***Conservation Strategy.*** - Ensuring long-term survival of *Cirsium fontinale* var. *campylon* must first focus on protecting and managing populations at the known locations by working with Santa Clara County Parks Department and private landowners. Populations on private land should be protected by land acquisition, conservation easements, or other means. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Cirsium fontinale* var. *campylon* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized monitoring of *Cirsium fontinale* var. *campylon* populations every 3 years to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from recreational activities must be eliminated. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Conservation of *Cirsium fontinale* var. *campylon* will involve protection in some areas targeted as high priority for bay checkerspot butterfly (*Euphydryas editha bayensis*) recovery (e.g. Kirby Canyon). Other species that may benefit from conservation efforts for *Cirsium fontinale* var. *campylon* include fragrant fritillary (*Fritillaria liliacea*), Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*), most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*), Santa Clara Valley dudleya (*Dudleya setchellii*), and smooth lessingia (*Lessingia micradenia* var. *glabrata*).

In addition to protecting known sites, other suitable serpentine habitat should be surveyed to determine whether undiscovered populations exist. For example, in Alameda County, the drainages from Man Ridge and Cedar Mountain and along the upper reaches of Arroyo Valle, west of the Cedar Mountain and Man Ridge area, should be surveyed (B. Olson, *in litt.*, 1998). If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Certain types of research are also high priority recovery activities for *Cirsium fontinale* var. *campylon*. In particular, because *Cirsium fontinale* var. *campylon* co-occurs in a number of locations with bay checkerspot butterfly (*Euphydryas editha bayensis*) and because bay checkerspot butterfly habitat benefits from vegetation management, the effect of various vegetation management techniques (e.g. grazing, mowing, and burning) on *Cirsium fontinale* var. *campylon* needs to be evaluated. It has been suggested that grazing is a threat to *Cirsium fontinale* var. *campylon* (California Natural Diversity Data Base 1996). Evaluation of vegetation management techniques will aid managers in selecting management strategies that maintain bay checkerspot butterfly habitat while not adversely affecting *Cirsium fontinale* var. *campylon*. Other research areas that are important, but of lower priority, for *Cirsium fontinale* var. *campylon* include seed germination and propagation techniques, demographic studies to identify limiting life history stages, the influence of disturbance on seedling establishment, reproductive biology (mating system, dispersal and colonization, pollination), and population genetics. Population genetics studies would be valuable to determine whether and to what extent populations throughout the range of the species are genetically different from one another.

To ensure the long-term conservation of *Cirsium fontinale* var. *campylon,* 23 populations must be fully protected and managed with the primary intention of preserving populations in perpetuity. Populations must also be stable or increasing with evidence of natural recruitment over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring). Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). Because the populations should represent the range of the species, populations need to be protected and managed in three areas: (1) the San Jose area, (2) northeastern Santa Clara and northwestern Stanislaus Counties, and (3) southeastern Alameda County. To be consistent with the known distribution, 55 percent of the protected populations should be in the San Jose area, 35 percent should be in northeastern Santa Clara and northwestern Stanislaus Counties and 10 percent should be in Alameda County. The populations in the San Jose area should be distributed approximately half to the east and half to the west of Highway 101. If additional surveys indicate that the actual distribution of populations is different (e.g. a greater proportion of populations is found in Alameda County), targets for protection should be changed so that they are consistent with the new information. The status of *Cirsium fontinale* var. *campylon* should be reevaluated within 5 years of recovery plan approval or when surveys are completed, whichever is less. The need to list *Cirsium fontinale* var. *campylon* should be considered if the criteria for long-term conservation outlined above are not met within 10 years after publication of the recovery plan.

### 3. Crystal Springs lessingia (*Lessingia arachnoidea)*

***Taxonomy.*** - *Lessingia arachnoidea* (Crystal Springs lessingia) was described by Greene as *Lessingia arachnoidea* in 1910 from a specimen collected at Crystal Springs Lake in San Mateo County (Greene 1910). It was treated as *Lessingia hololeuca* var. *arachnoidea* by Howell (1929), as *Lessingia leptoclada* var. *arachnoidea* by Blake (1929), and as *Lessingia micradenia* var. *arachnoidea* by Ferris (1958). Abrams and Ferris (1960) accepted Ferris' 1958 treatment, *Lessingia micradenia* var. *arachnoidea.* Munz and Keck (1959) used Howell's (1929), *Lessingia hololeuca* var. *arachnoidea.* In The Jepson Manual (Hickman 1993), Meredith Lane adopted Greene's original 1910 taxonomy, placing the taxon in *Lessingia arachnoidea.*

***Description.*** - *Lessingia arachnoidea* (Figure II-31) is an erect annual herb of the aster family (Asteraceae). The leaves and stems are hairy and without glands. The 3 to 8 decimeters (approximately 1.0 to 2.5 feet) stems support narrowly elongate leaves less than 11 centimeters (4.3 inches) long. Solitary flower heads have hairy involucral bracts (phyllaries) below and bear pale to deep lavender flowers (8 to 18 per head) (Hickman 1993). The leaves at the base fall off before flowering (Munz and Keck 1959).

Smooth lessingia (*Lessingia micradenia* var. *glabrata*) and Tamalpais lessingia (*Lessingia micradenia* var. *micradenia*) occur in Santa Clara and Marin Counties, respectively. The flower heads of both have slightly fewer flowers and less hairy bracts (phyllaries) than *Lessingia arachnoidea* (Hickman 1993).

**Figure II-31.** Illustration of lessingia (*Lessingia* spp.) (from Abrams and Ferris 1960, with permission).

***Historical and Current Distribution.*** - *Lessingia arachnoidea* is known from the Crystal Springs Reservoir area of San Mateo County (Hickman 1993) and possibly from a few occurrences in Sonoma County (Corelli and Chandik 1995) (Figure II-32). Eight confirmed occurrences are known, seven in San Mateo County and one in Sonoma County, 105 kilometers (65 miles) to the north. A specimen from the Sonoma County occurrence was confirmed by the genus expert, Meredith Lane. Three of the San Mateo County occurrences have not been observed for 35 years or more (California Natural Diversity Data Base 1996), and one may be erroneous (T. Corelli, pers. comm., 1997). The remaining three San Mateo County occurrences are on Buri Buri Ridge (one occurrence) and Pulgas Ridge (two occurrences) (California Natural Diversity Data Base 1996).

***Reproduction and Demography.*** - *Lessingia arachnoidea* is an annual herb flowering in July through September or October (Munz and Keck 1959, Skinner and Pavlik 1994). Germination of *Lessingia* seeds in the laboratory is apparently quite easy (S. Markos, *in litt.*, 1998). However, factors such as local climate, soil, and herbivory may profoundly influence germination rate, seedling establishment, and survivorship in nature (N. McCarten, *in litt.*, 1998). Populations of *Lessingia arachnoidea* range from one plant to tens of thousands of plants (California Natural Diversity Data Base 1996). No detailed data on reproductive biology and demography are available.

***Habitat and Community Associations.*** - *Lessingia arachnoidea* occurs on open serpentine barrens (Hickman 1993) in cismontane woodland, coastal scrub and valley foothill grassland at elevations of approximately 90 to 600 meters (300 to 2,000 feet). All known occurrences are at elevations below 200 meters (650 feet). The species also occurs along roadsides (Skinner and Pavlik 1994). *Lessingia arachnoidea* occurs with other relatively rare species including Baker's manzanita (*Arctostaphylos bakeri*), Marin dwarf-flax (*Hesperolinon congestum*) and Pennell's bird's-beak (*Cordylanthus tenuis* ssp. *capillaris*) (California Natural Diversity Data Base 1996). Other associates include centaury (*Centaurium muehlenbergii*), common madia (*Madia elegans*) (California Natural Diversity Data Base 1996), common yarrow (*Achillea millefolium*), creeping aster (*Aster chilensis*) (Corelli and Chandik 1995), giant reed (*Arundo donax*),

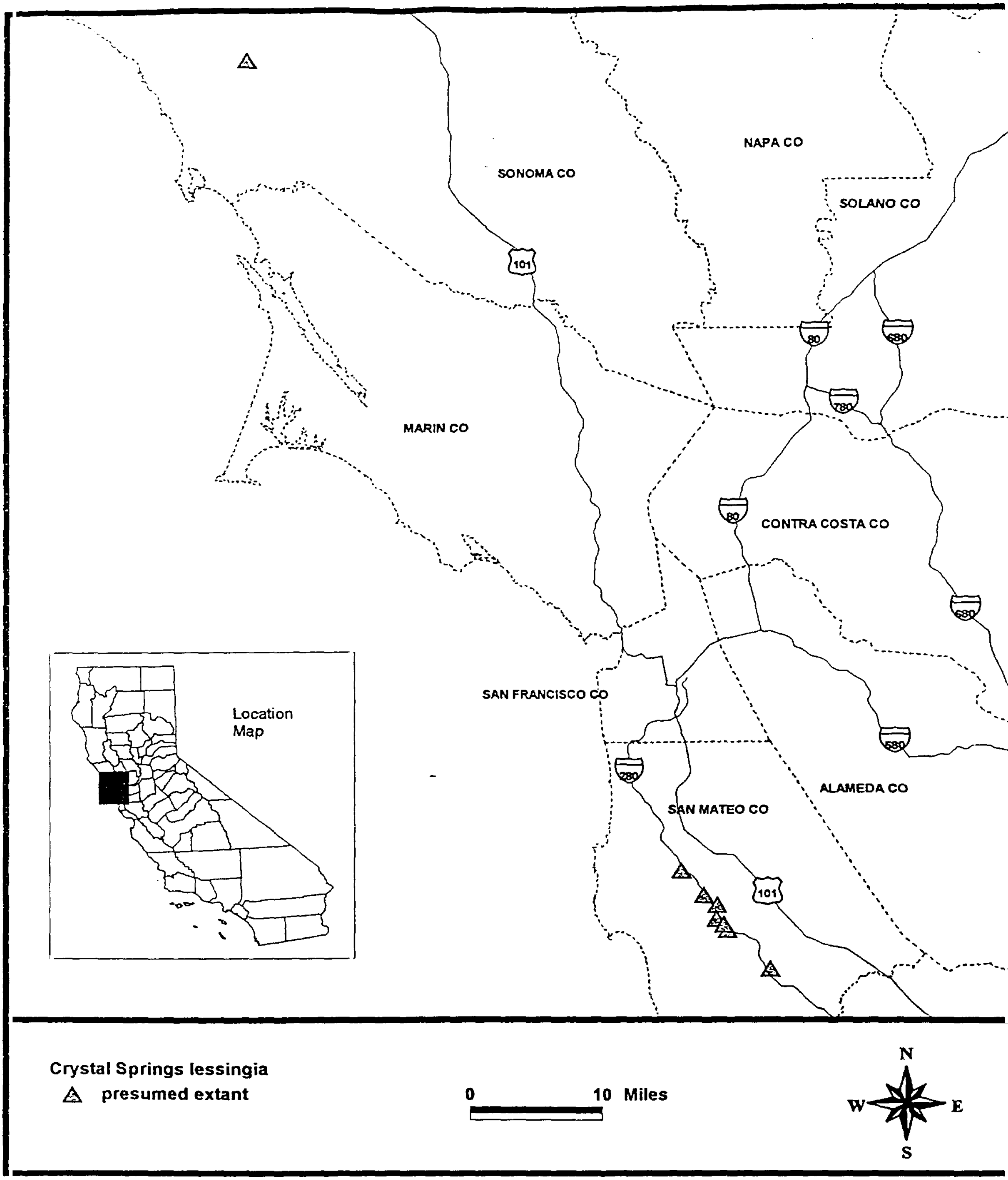


**Figure II-32.** Distribution of Crystal Springs lessingia (*Lessingia arachnoidea*).

Hillsborough chocolate lily (*Fritillaria biflora* var. *ineziana*), naked buckwheat (*Eriogonum nudum*), naked lady lily (*Amaryllis belladonna*), purple needlegrass (*Nassella pulchra*), pampas grass (*Cortaderia* spp.), sticky western rosinweed (*Calycadenia multiglandulosa*), yampa (*Perideridia kelloggii*) (California Natural Diversity Data Base 1996), and yellow star thistle (*Centauria solstitialis*) (Corelli and Chandik 1995). Giant reed, naked lady lily, pampas grass, and yellow star thistle are non-native species (Hortus 1976, Hickman 1993).

***Reasons for Decline and Threats to Survival.*** - The three confirmed San Mateo County occurrences of *Lessingia arachnoidea* (one on Buri Buri Ridge and two on Pulgas Ridge) are on land owned by the City and County of San Francisco and managed by the San Francisco Water Department (California Natural Diversity Data Base 1996). The possibly erroneous occurrence is located in Edgewood County Park which is managed by San Mateo County (T. Corelli, pers. comm., 1997). The remaining three San Mateo County occurrences, which have not been observed for 35 years or more, are on lands for which ownership information is currently not available. The one confirmed Sonoma County population is on private land (California Natural Diversity Data Base 1996).

The populations of *Lessingia arachnoidea* on land managed by the San Francisco Water Department are threatened by invasion of non-native species (J. Sigg, *in litt.*, 1994, S. Smith, *in litt.*, 1994, M. Wood, *in litt.*, 1996, California Natural Diversity Data Base 1996). Non-native species invading the area include fennel (*Foeniculum*), pampas grass (*Cortaderia* spp.), teasel (*Dipsacus* spp.), and yellow star thistle (*Centauria solstitialis*) (California Natural Diversity Data Base 1996). Yellow star thistle is a particularly serious threat (S. Smith, *in litt.*, 1994, California Natural Diversity Data Base 1996). Trails and roads may also threaten these populations (California Natural Diversity Data Base 1996) as may increased public access (M. Wood, *in litt.*, 1996).

The Edgewood County Park population reportedly contained only one plant in 1994 (California Natural Diversity Data Base 1996) and may be erroneous (T. Corelli, pers. comm., 1997). If the species grows in Edgewood County Park, it could be impacted by recreational activities within the park. The park has been designated a natural preserve and San Mateo County is currently working on a Master Plan for Edgewood (San Mateo County, 1996). It is possible that some disturbance could result from changes implemented as a result of the plan, but no decisions about specific actions have been made.

The Sonoma County population is on private land near Bohemian Highway where *Arctostaphylos bakeri* ssp. *bakeri* (Baker's manzanita) and *Cordylanthus tenuis* ssp. *capillaris* (Pennell's bird's-beak) also grow. The site was proposed for a county park (California Natural Diversity Data Base 1996). However, the development project with which the park was associated was abandoned. The site is under new ownership and is again threatened by development (see also above, *Cordylanthus tenuis* ssp. *capillaris*) (S. Swedenborg, pers. comm., 1997) and off-road vehicle use (S. Markos, *in litt.*, 1996).

***Conservation Efforts.*** - *Lessingia arachnoidea* was designated a Category 2 candidate by the U.S. Fish and Wildlife Service in 1993 (U.S. Fish and Wildlife Service 1993). Because the U.S. Fish and Wildlife Service discontinued the Category 2 designation in 1996, *Lessingia arachnoidea* is now considered a species of concern (U.S. Fish and Wildlife Service 1996*a*, *b*).

***Conservation Strategy.*** - Ensuring long-term survival of *Lessingia arachnoidea* must first focus on protecting and managing populations at the known locations by working with San Francisco Water Department and private landowners. Populations should be protected by land acquisition, conservation easements, or other means. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Lessingia arachnoidea* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized annual monitoring of *Lessingia arachnoidea* populations to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from invasion of non-natives and trails must be eliminated. Where pampas grass (*Cortaderia* spp.) removal is required, cautions must be taken to avoid adverse impacts to federally listed animal species that may occur in the area (e.g. San Francisco garter snake [*Thamnophis sirtalis tetrataenia*]). If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. High priority should be given to protection and management of the known populations on Buri Buri and Pulgas Ridges and to the population at the Bohemian Highway site. If the identity of the *Lessingia* in Sonoma County is confirmed to be *Lessingia arachnoidea*, then protection of the Bohemian Highway site is of particular interest because it is the only known site in Sonoma County, 105 kilometers (65 miles) to the north of the San Mateo County sites. Protection at this site would benefit two other special status plants, Pennell's bird's-beak (*Cordylanthus tenuis* ssp. *capillaris*) and Baker's manzanita (*Arctostaphylos bakeri* ssp. *bakeri*). Protection at other sites may benefit Marin dwarf-flax (*Hesperolinon congestum*).

Collection and banking of seed in Center for Plant Conservation certified botanic gardens is also an important conservation strategy for *Lessingia arachnoidea*. Seed banking is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations, and/or introductions to new sites. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection and seed collection, historic locations should be surveyed to determine whether suitable habitat remains, the species persists at the sites, and/or the sites may be suitable for repatriation. Suitability of historic locations for repatriation would depend upon (1) whether potential habitat exists, (2) the presence and magnitude of threats, and (3) whether the sites can be secured and managed for the long-term protection of the species. These surveys should include Edgewood Natural Preserve to determine whether that occurrence is actually erroneous. Surveys should also include other potential serpentine habitat such as in the Crystal Springs area to determine whether undiscovered populations may exist. At least some of these surveys would require the cooperation of the San Francisco Water Department because suitable habitat occurs on their land. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Other important conservation activities for *Lessingia arachnoidea* include research on systematics (to confirm the identity of the Sonoma County material), seed germination and propagation techniques, demography, and reproduction (including mating system and pollination). Demographic research would be valuable in helping to identify limiting life history stages and in evaluating the soil seed bank of *Lessingia arachnoidea*.

To ensure the long-term conservation of *Lessingia arachnoidea,* eight populations must be fully protected and managed with the primary intention of preserving the populations in perpetuity. The populations must also be stable or increasing with evidence of natural recruitment over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring). Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). If the Sonoma County occurrence is confirmed to be *Lessingia arachnoidea*, then at least two of the eight populations should be located in Sonoma County to represent the range of the species. Meeting the goal of eight populations will require locating, restoring and/or successfully introducing four new populations. Because repatriation and introduction of populations is expensive and experimental (Falk *et al.* 1996), surveying historic sites and potential habitat within the historic range to locate currently unknown populations is the preferred strategy. In addition, seed must be stored at a minimum of two Center for Plant Conservation certified botanic gardens and reliable seed germination and propagation techniques for the species must be understood. The need to list *Lessingia arachnoidea* should be considered within 5 years of recovery plan approval if surveys confirm the rarity of the species and the threats to the species place it at risk or if the criteria for long-term conservation outlined above are not met within 10 years after publication of the recovery plan.

### 4. Smooth lessingia (*Lessingia micradenia* var. *glabrata)*

***Taxonomy.*** - *Lessingia micradenia* var. *glabrata* (smooth lessingia) was originally described as *Lessingia ramulosa* var. *glabrata* by Keck in 1958 from a specimen collected between Los Gatos and Almaden in Santa Clara County. The taxon was renamed *Lessingia micradenia* var. *glabrata* by Ferris (1958).

***Description.*** - *Lessingia micradenia* var. *glabrata* (Figure II-31) is an erect annual herb of the aster family (Asteraceae). The stems are 0.5 to 6 decimeters (2 to 24 inches) with spreading branches. The linear or narrowly elongate cauline leaves (leaves on the stem) are 0.2 to 2.0 centimeters (0.1 to 0.8 inch) long, thinly hairy on the upper surface and tipped with a point. There are no glands on the margins of the cauline leaves. The deciduous leaves at the base are less than 6 centimeters (2.4 inches) long. Each flower head has hairless involucral bracts (phyllaries) below and bears three to five white to lavender flowers (Hickman 1993).

*Lessingia micradenia* var. *glabrata* appears to be geographically separated from other varieties which it resembles. Crystal Springs lessingia (*Lessingia arachnoidea*) occurs in San Mateo County and possibly in Sonoma County; Tamalpais lessingia (*Lessingia micradenia* var. *micradenia*) occurs only in Marin County. *Lessingia micradenia* var. *glabrata* is like *Lessingia micradenia* var. *micradenia* except that the involucral bracts (phyllaries) are hairless. *Lessingia arachnoidea* also has hairy involucral bracts (Keck 1958).

***Historical and Current Distribution.*** - *Lessingia micradenia* var. *glabrata* is endemic to the east side of the Santa Cruz Mountains in Santa Clara County (Munz and Keck 1959, Thomas 1961) (Figure II-33). It reportedly occurs near

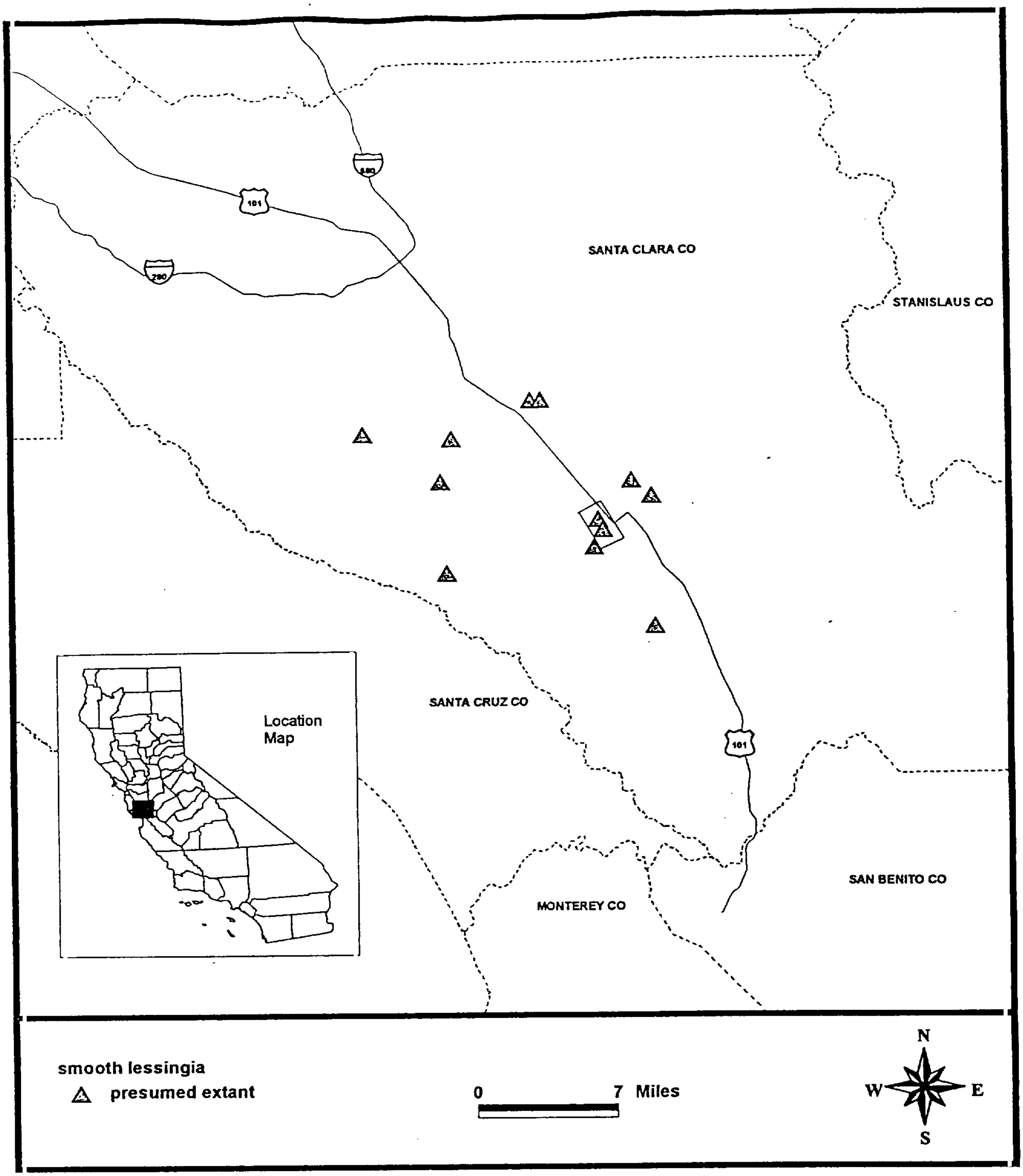


**Figure II-33.** Distribution of smooth lessingia (*Lessingia micradenia* var. *glabrata*). Each symbol represents one occurrence in CNDDB records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

Los Gatos, New Almaden and Madrone (Thomas 1961). Eleven populations are known. According to California Natural Diversity Data Base, only three of these have been found recently; the remaining eight have not been observed for 35 years or more. One was last visited in 1893. The three occurrences more recently observed are in the Madrone area, in the area of Stile Ranch and in Almaden Quicksilver County Park (California Natural Diversity Data Base 1996). Additionally, three populations were found by Staci Markos (University of California, Berkeley), one at the north end of the dam at Anderson Reservoir (this is probably one of the historic occurrences), one near Gilroy (S. Markos, *in litt.*, 1996), and one on the east side of Uvas Road south of Oak Glen Road (S. Markos, *in litt.*, 1998).

***Reproduction and Demography.*** - *Lessingia micradenia* var. *glabrata* is an annual which flowers from July or August into September (Munz and Keck 1959, Thomas 1961). Germination of *Lessingia* seeds in the laboratory is apparently quite easy (S. Markos, *in litt.*, 1998). However, factors such as local climate, soil, and herbivory may profoundly influence germination rate, seedling establishment, and survivorship in nature (N. McCarten, *in litt.*, 1998). No information on reproductive biology, population sizes or demography are available for the species.

***Habitat and Community Associations.*** - *Lessingia micradenia* var. *glabrata* grows on serpentine soils or outcrops (Hickman 1993, Skinner and Pavlik 1994) in dry, open areas of oak woodland (Thomas 1961) or chaparral (Skinner and Pavlik 1994) at elevations below about 300 meters (1,000 feet) (Munz and Keck 1959). The species may often occur on roadsides (Skinner and Pavlik 1994). Rare species observed in association with *Lessingia micradenia* var. *glabrata* include bay checkerspot butterfly (*Euphydryas editha bayensis*), coyote ceanothus (*Ceanothus ferrisiae*), most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*), Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*), and Santa Clara Valley dudleya (*Dudleya setchellii*). Other associated plants include bigberry manzanita (*Arctostaphylos glauca*), common yarrow (*Achillea millefolium*), dwarf plantain (*Plantago erecta*), golden yarrow (*Eriophyllum confertiflorum*), gypsum springbeauty (*Claytonia gysophiloides*), hayfield tarweed

(*Hemizonia congesta*), junegrass (*Koeleria macrantha*), miner's lettuce (*Claytonia perfoliata*), purple needlegrass (*Nassella pulchra*), serpentine linanthus (*Linanthus ambiguus*), serpentine sunflower (*Helianthus bolanderi*), streambank springbeauty (*Claytonia parviflora*), and yellow star thistle (*Centaurea solstitialis*) (California Natural Diversity Data Base 1996). Yellow star thistle is a non-native species (Hickman 1993).

***Reasons for Decline and Threats to Survival.*** - Two populations of *Lessingia micradenia* var. *glabrata* are entirely on private land. One of these sites is an IBM research facility. A third population occurs partially in Almaden Quicksilver County Park on Santa Clara County land. Eight populations of *Lessingia micradenia* var. *glabrata* are on lands for which ownership is unknown; none of these populations has been observed for 35 years or more (California Natural Diversity Data Base 1996). The Gilroy population observed by Staci Markos is on private land (S. Markos, *in litt.*, 1996), and the Anderson Reservoir dam population is probably within Anderson County Park (Markos 1996).

The area adjacent to one of the populations on private land has been approved for residential development. IBM intends to preserve the population on their land. The area encompassed by Almaden Quicksilver County Park, owned by Santa Clara County was formerly mined (California Natural Diversity Data Base 1996). This site could be disturbed by recreational activities. Grazing may be a threat at the privately-owned site near Gilroy, depending on the timing of the grazing (S. Markos, *in litt.*, 1996).

***Conservation Efforts.*** - *Lessingia micradenia* var. *glabrata* was designated a Category 2 candidate by the U.S. Fish and Wildlife Service in 1993 (U.S. Fish and Wildlife Service 1993). Because the U.S. Fish and Wildlife Service discontinued the Category 2 designation in 1996, Lessingia *micradenia* var. *glabrata* is now considered a species of concern (U.S. Fish and Wildlife Service 1996*a*, *b*).

***Conservation Strategy.*** - Ensuring long-term survival of *Lessingia micradenia* var. *glabrata* must first focus on protecting and managing populations at the known locations by working with Santa Clara County Parks and private landowners. Populations on private land should be protected by land acquisition, conservation easements, or other means. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Lessingia micradenia* var. *glabrata* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized annual monitoring of *Lessingia micradenia* var. *glabrata* populations to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from recreational activities and grazing must be eliminated. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. High priority should be given to protection and management of the five known populations as well as to surveys of historic sites (see below). Other species that may benefit from conservation efforts for *Lessingia micradenia* var. *glabrata* include bay checkerspot butterfly (*Euphydryas editha bayensis*), coyote ceanothus (*Ceanothus ferrisiae*), most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*), Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*), and Santa Clara Valley dudleya (*Dudleya setchellii*).

Collection and banking of seed in Center for Plant Conservation certified botanic gardens is also an important conservation strategy for *Lessingia micradenia* var. *glabrata*. Seed banking is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations and/or introductions to new sites. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection and seed collection, surveys of historic and potential habitat are a high priority conservation activity. Historic locations should be surveyed to determine whether suitable habitat remains, the species persists at the sites and/or the sites may be suitable for repatriation. Suitability of historic locations for repatriation would depend upon (1) whether potential habitat exists, (2) the presence and magnitude of threats and (3) whether the sites can be secured and managed for the long-term protection of the species. Other potential serpentine habitat should also be surveyed to determine whether undiscovered populations may exist. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Other important conservation activities for *Lessingia micradenia* var. *glabrata* include research on seed germination and propagation techniques, demography and reproduction (including mating system and pollination). Demographic research would be valuable in helping to identify limiting life history stages and in evaluating the soil seed bank of *Lessingia micradenia* var. *glabrata*.

To ensure the long-term conservation of *Lessingia micradenia* var. *glabrata,* 10 populations must be fully protected and managed with the primary intention of preserving the populations in perpetuity. The populations must also be stable or increasing with evidence of natural recruitment over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring). Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). The 10 populations must represent the entire historic range of the species. Meeting the goal of 10 populations will require locating, restoring and/or successfully introducing five new populations. Because repatriation and introduction of populations is expensive and experimental (Falk *et al.* 1996), surveying historic sites and potential habitat within the historic range to locate currently unknown populations is the preferred strategy. In addition, to prevent the need for listing, seed must be stored at a minimum of two Center for Plant Conservation certified botanic gardens and reliable seed germination and propagation techniques for the species must be understood. The need to list *Lessingia micradenia* var. *glabrata* should be considered within 5 years of recovery plan approval if surveys confirm the rarity of the species and the threats to the species place it at risk or if the criteria for long-term conservation outlined above are not met within 10 years after publication of the recovery plan.

### 5. Tamalpais lessingia (*Lessingia micradenia* var. *micradenia*)

***Taxonomy.*** - Greene described *Lessingia micradenia* var. *micradenia* (Mt. Tamalpais lessingia) as *Lessingia micradenia* (Greene 1910). The species was treated as *Lessingia ramulosa* var. *micradenia* by Howell (1929). Munz and Keck (1959) accepted Howell's 1929 treatment, but Abrams and Ferris (1960) referred to the taxon as part of *Lessingia micradenia*. Most recently, it was treated as *Lessingia micradenia* var. *micradenia* by Meredith Lane in The Jepson Manual (Hickman 1993).

***Description.*** - *Lessingia micradenia* var. *micradenia* (Figure II-31) is an erect annual herb of the aster family (Asteraceae). The stems are 0.5 to 6.0 decimeters (2 to 24 inches) with spreading branches. The linear or narrowly elongate cauline leaves are 0.2 to 2.0 centimeters (0.1 to 0.8 inch) long, thinly hairy on the upper surface and tipped with a point. The cauline leaves have tack-shaped glands on their edges (marginal glands). The deciduous leaves at the base are less than 6 centimeters (2.4 inches) long. Each flower head has hairy involucral bracts (phyllaries) with tack-shaped glands and bears 5 to 10 white to lavender flowers (Hickman 1993).

*Lessingia micradenia* var. *micradenia* is geographically separated from two other varieties which it resembles: Crystal Springs lessingia (*Lessingia arachnoidea*) in San Mateo and Sonoma counties and smooth lessingia (*Lessingia micradenia* var. *glabrata*) in Santa Clara County. *Lessingia micradenia* var. *glabrata* is like *Lessingia micradenia* var. *micradenia* except that the involucral bracts (phyllaries) are hairless (Keck 1958). *Lessingia arachnoidea* has hairy involucral bracts too, but they are more hairy than those of *Lessingia micradenia* var. *micradenia*. In addition, *Lessingia arachnoidea* has slightly larger flower heads than *Lessingia micradenia* var. *micradenia* (Hickman 1993).

***Historical and Current Distribution.*** - *Lessingia micradenia* var. *micradenia* is found only on Mt. Tamalpais and elsewhere among the hills of Marin County (Greene 1910) (Figure II-34). The species occurs along roads in serpentine of the Carson Ridge area, extending from Azalea Hill and Liberty Gulch northeast to just west of Woodacre (D. Odion, *in litt.*, 1998, D. Smith, *in litt.*, 1998). Odion (*in litt.*, 1998) suggests *Lessingia micradenia* var. *micradenia* may also extend onto serpentine of the east-facing slope of San Geronimo Ridge. The California Natural Diversity Data Base contains four specific locations: Alpine Lake, Phoenix Lake, San Anselmo Canyon, and Liberty Gulch. The Phoenix Lake occurrence has not been observed since 1960 and the San Anselmo Canyon occurrence since 1938 (California Natural Diversity Data Base 1996).

***Reproduction and Demography.*** - *Lessingia micradenia* var. *micradenia* is an annual flowering from August to October (Munz and Keck 1959). Germination of *Lessingia* seeds in the laboratory is apparently quite easy (S. Markos, *in litt.*, 1998). However, factors such as local climate, soil, and herbivory may profoundly influence germination rate, seedling establishment, and survivorship in nature (N. McCarten, *in litt.*, 1998). In 1994, the Alpine Lake occurrence of *Lessingia micradenia* var. *micradenia* had thousands of plants, and the Liberty Gulch occurrence had 50 plants (California Natural Diversity Data Base 1996). Detailed data on reproductive biology and demography of the species are lacking.

***Habitat and Community Associations.*** - *Lessingia micradenia* var. *micradenia* grows at elevations of 100 to 500 meters (approximately 300 to 1,600 feet) on thin, gravelly soils of serpentine outcrops and roadcuts (Hickman 1993) in chaparral and valley foothill grassland (Skinner and Pavlik 1994). The species may be more common along roads than in undisturbed serpentine chaparral where it may be widely scattered but difficult to survey (D. Odion, *in litt.*, 1998). Rare plants which have been observed within or adjacent to populations of *Lessingia micradenia* var. *micradenia* are Marin County navarretia (*Navarretia rosulata*) (D. Smith, *in litt.*, 1996), Mason's ceanothus (*Ceanothus masonii*), Mt. Tamalpais thistle (*Cirsium hydrophilum* var. *vaseyi*), and Tamalpais manzanita

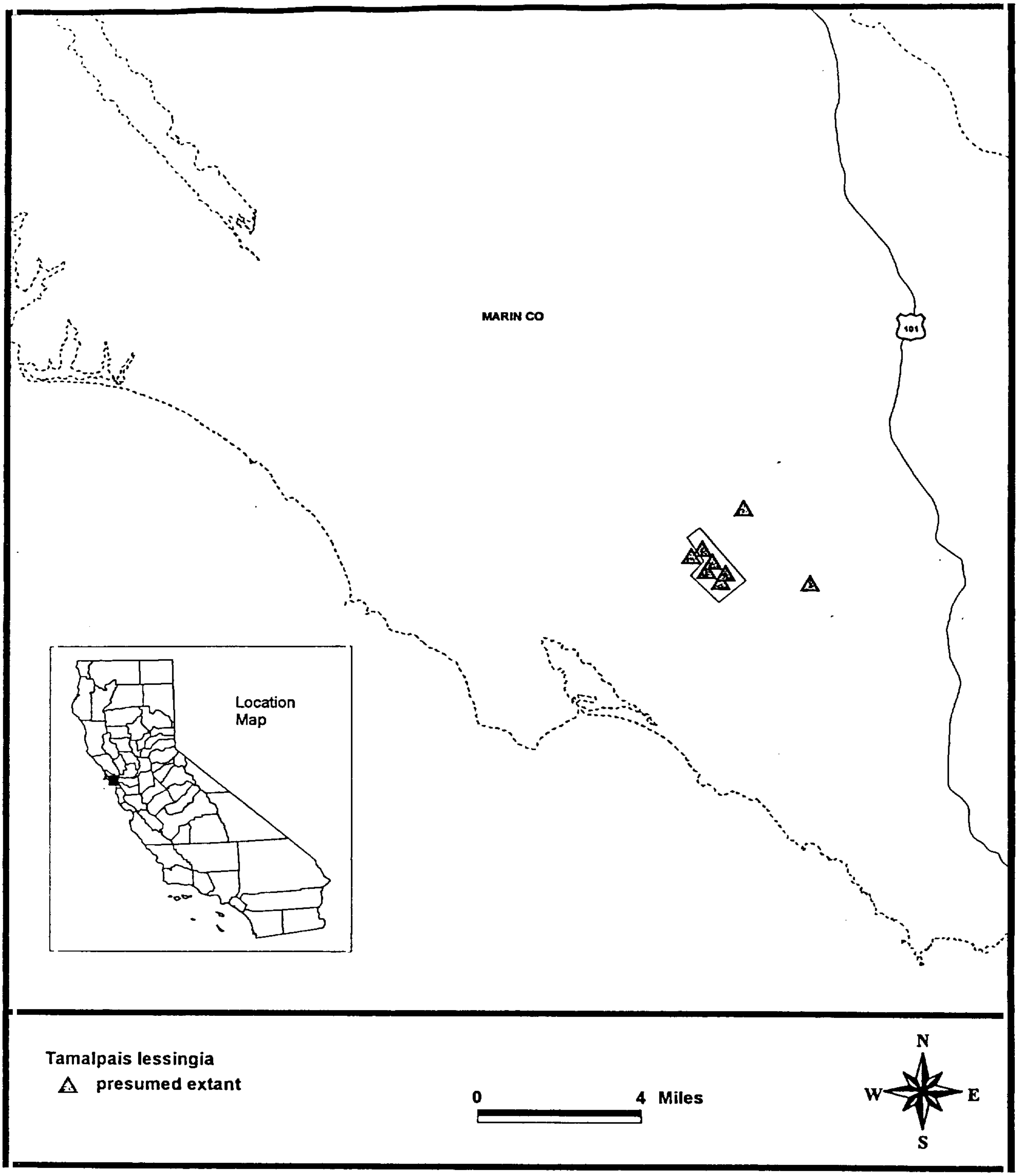


**Figure II-34.** Distribution of Tamalpais lessingia (*Lessingia micradenia* var. *micradenia*). Each symbol represents once occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

(*Arctostaphylos hookeri* ssp. *montana*). Other associates include chamise (*Adenostema fasciculatum*) (Follette 1994), coast live oak (*Quercus agrifolia*), Douglas-fir (*Pseudotsuga menziesii*), hayfield tarweed (*Hemizonia congesta* ssp. *congesta*), leather oak (*Quercus durata*), musk brush (*Ceanothus jepsonii*), serpentine reedgrass (*Calamagrostis ophiditis*), silver European hairgrass (*Aira caryophylla*), slender wild oat (*Avena barbata*) (California Natural Diversity Data Base 1996), sticky western rosinweed (*Calycadenia multiglandulosa*) (Follette 1994), yampa (*Perideridia kelloggii*) (California Natural Diversity Data Base 1996), and yerba santa (*Eriodictyon californicum*) (Follette 1994). Slender wild oat is a non-native species (Hickman 1993).

***Reasons for Decline and Threats to Survival.*** - Two locations of *Lessingia micradenia* var. *micradenia* occur on Marin Municipal Water District land; ownership information is not available for the other two locations (those not observed since 1938 and 1960). Plants on Marin Municipal Water District land may be threatened by roadside clearing, spraying (California Natural Diversity Data Base 1996) and watershed use for hiking (trampling) and biking. The plants could also be impacted by the Marin Municipal Water District fuel reduction plan that involves cutting and thinning as well as prescribed burning activities in the vicinity of *Lessingia micradenia* var. *micradenia* (Follette 1994). A new threat to *Lessingia micradenia* var. *micradenia* as well as to other sensitive species in the Azalea Hill area is the invasion of non-native barbed goatgrass (*Aegilops triuncialis*). While some have suggested that spraying may threaten *Lessingia micradenia* var. *micradenia*, lack of spraying may also be a threat because eradication of barbed goatgrass is difficult without the use of herbicides (D. Odion, *in litt.*, 1998).

The recent hiring of a vegetation ecologist by the Marin Municipal Water District, as directed in the Mt. Tamalpais Vegetation Management Plan, has resulted in some modification of the fuel reduction program and roadside mowing activities in the vicinity of *Lessingia micradenia* var. *micradenia* and other rare plants. A modified, research-oriented, prescribed burning program has the potential to open up habitat for the species and to provide information on whether fire may be a useful management tool for *Lessingia micradenia* var. *micradenia*, a species that may be threatened by long-term fire suppression. Additionally, Marin Municipal Water District is attempting to restrict recreational impacts to *Lessingia micradenia* var. *micradenia* and *Hesperolinon congestum* along Pine Mountain and Azalea Hill roads. Rare plants along these roads will also be avoided during grading for road maintenance (D. Odion, *in litt.*, 1998).

***Conservation Efforts.*** - *Lessingia micradenia* var. *micradenia* was designated a Category 2 candidate by the U.S. Fish and Wildlife Service in 1993 (U.S. Fish and Wildlife Service 1993). Because the U.S. Fish and Wildlife Service discontinued the Category 2 designation in 1996, *Lessingia micradenia* var. *micradenia* is now considered a species of concern (U.S. Fish and Wildlife Service 1996*a*, *b*).

***Conservation Strategy***. - Ensuring long-term conservation of *Lessingia micradenia* var. *micradenia* must first focus on protecting and managing populations at the known locations by working with Marin Municipal Water District. Populations should be protected by land acquisition, conservation easements, or other means. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Lessingia micradenia* var. *micradenia* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized annual monitoring of *Lessingia micradenia* var. *micradenia* populations to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, Marin Municipal Water District should be encouraged to continue its efforts to reduce threats from recreational activities, roadside maintenance, fuel management, and invasive non-native species. Although broadcast spraying of herbicides in roadside maintenance programs may pose a threat to *L. micradenia* var. *micradenia*, spraying to eradicate barbed goatgrass may be an important management tool. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. High priority should be given to protection and management of the two known populations as well as to surveys of historic sites (see below).

Collection and banking of seed in Center for Plant Conservation certified botanic gardens is also an important conservation strategy for *Lessingia micradenia* var. *micradenia*. Seed banking is prudent to guard against extinction of the species from chance catastrophic events and to provide potential material for enhancement efforts in existing populations, repatriations, and/or introductions to new sites. Care should be taken to ensure that seed collection does not adversely affect the donor populations.

In addition to protection and seed collection, surveys of historic and potential habitat are a high priority conservation strategy. Historic locations should be surveyed to determine whether suitable habitat remains, the species persists at the sites, and/or the sites may be suitable for repatriation. Suitability of historic locations for repatriation would depend upon (1) whether potential habitat exists, (2) the presence and magnitude of threats, and (3) whether the sites can be secured and managed for the long-term protection of the species. Other potential serpentine habitat, such as on San Geronimo Ridge (D. Odion, *in litt.*, 1998), should also be surveyed to determine whether undiscovered populations may exist. If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Other important conservation activities for *Lessingia micradenia* var. *micradenia* include research on seed germination and propagation techniques, demography, and reproduction (including mating system and pollination). Demographic research would be valuable in helping to identify limiting life history stages and in evaluating the soil seed bank of *Lessingia micradenia* var. *micradenia*. Research on the fire ecology of the species may also be important if management programs that allow long-term maintenance and regeneration of *Lessingia micradenia* var. *micradenia* are to be developed (D. Odion, *in litt.*, 1998).

To ensure the long-term conservation of *Lessingia micradenia* var. *micradenia,* six populations must be fully protected and managed with the primary intention of preserving the populations in perpetuity. The populations must also be stable or increasing with evidence of natural recruitment over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring). Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). The six populations must represent the entire historic range of the species. Meeting the goal of six populations will require locating, restoring and/or successfully introducing four new populations. Because repatriation and introduction of populations is expensive and experimental (Falk *et al.* 1996), surveying historic sites and potential habitat within the historic range to locate currently unknown populations is the preferred strategy. In addition, seed must be stored at a minimum of two Center for Plant Conservation certified botanic gardens and reliable seed germination and propagation techniques for the species must be understood. The need to list *Lessingia micradenia* var. *micradenia* should be considered within 5 years of recovery plan approval if surveys confirm the rarity of the species and the threats to the species place it at risk or if the criteria for long-term conservation outlined above are not met within 10 years after publication of the recovery plan.

### 6. Most beautiful (uncommon) jewelflower (*Streptanthus albidus* ssp. *peramoenus*)

***Taxonomy.*** - *Streptanthus albidus* ssp. *peramoenus* (most beautiful jewelflower) was described by Greene (1886*b*) as *Streptanthus peramoenus*. In 1904, Greene redefined the limits of *Euclisia*, formerly a subgenus of *Streptanthus*, treating it as a genus in its own right. *Streptanthus peramoenus* was included in the change and was called *Euclisia glandulosa* (Greene 1904). Jepson (1925, 1936) returned *Euclisia* to subsection status, placing the former

*Streptanthus peramoenus* in *Streptanthus glandulosus*. Kruckeberg published a revision of the *Streptanthus glandulosus* complex in which he recognized the close relationships among *Streptanthus glandulosus* (bristly jewelflower), *Streptanthus albidus* (Metcalf Canyon jewelflower) and *Streptanthus niger* (Tiburon jewelflower). Kruckeberg (1958) placed the taxon in *Streptanthus albidus* ssp. *peramoenus*. Munz and Keck considered the taxon part of *Streptanthus glandulosus* in 1959, but Munz (1968) treated it as *Streptanthus albidus* ssp. *peramoenus* as does Hickman (1993). Recent research affirms the distinctiveness of *Streptanthus albidus* ssp. *peramoenus*, *Streptanthus albidus* ssp. *albidus*, and *Streptanthus niger* (M. Mayer, *in litt.*, 1998).

***Description.*** - *Streptanthus albidus* ssp. *peramoenus* (Figure II-23) is a 2 to 8 decimeters (8 to 32 inches) tall annual herb of the mustard family (Brassicaceae). It tends to be fleshy and glaucous throughout (Kruckeberg 1958) with bristly hairs at the base and narrowly elongate leaves (Hickman 1993). The flowers have 5 to 10 millimeters (0.2 to 0.4 inch) long, lilac-lavender sepals and 8 to 14 millimeters (0.3 to 0.5 inch) long, purplish petals (Hickman 1993). The petals are strongly recurved (Kruckeberg 1958). The pods are straight and 3 to 6 centimeters (1.2 to 2.4 inches) long (Kruckeberg 1958).

*Streptanthus albidus* ssp. *peramoenus* is distinguished from the closely related Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*) by its lilac-lavender sepals. *Streptanthus albidus* ssp. *albidus* has greenish white sepals which are purple-tinged at the base. *Streptanthus albidus* ssp. *peramoenus* also tends to be less robust than subspecies *albidus* (Kruckeberg 1958). *Streptanthus albidus* ssp. *peramoenus* can also be difficult to differentiate from *Streptanthus glandulosus* ssp. *glandulosus* (bristly jewelflower). *Streptanthus albidus* ssp. *peramoenus* plants are generally more robust, less hairy and have larger, pinker (instead of dark purple) flowers. However, depauperate sites may produce *Streptanthus albidus* ssp. *peramoenus* plants which look more like *Streptanthus glandulosus* ssp. *glandulosus*, and *Streptanthus glandulosus* ssp. *glandulosus* varies in size and degree of hairiness (R. Raiche, pers. comm., 1992).

***Historical and Current Distribution.*** - According to Kruckeberg (1958), *Streptanthus albidus* ssp. *peramoenus* is found in the Oakland-Berkeley Hills, on Mount Diablo, in the hills above Sunol, and on the ridges of Santa Clara County (Figure II-35). Recent records of the California Natural Diversity Data Base (1996) indicate the species is known from six occurrences in Alameda County, three occurrences in Contra Costa County, and 13 occurrences in Santa Clara County. In Alameda County, the species has been found in three locations: one occurrence in the Oakland Hills, one near Niles, and four in Sunol Regional Park (California Natural Diversity Data Base 1996). The Sunol Regional Park occurrences apparently have characteristics of both *Streptanthus albidus* and *Streptanthus glandulosus* (Mayer *et al.* 1994). Because they could be *Streptanthus albidus* ssp. *peramoenus* or *Streptanthus glandulosus* ssp. *glandulosus*, clarification of the identity of these plants is needed (B. Olson, *in litt.*, 1998). The three Contra Costa County occurrences, including one that has not been seen since 1938, are in Mt. Diablo State Park. Although not shown in Figure I-1, Mt. Diablo State Park contains a serpentine formation (B. Olson, *in litt.*, 1998). In Santa Clara County, three occurrences are located in the area of Anderson Lake east of Highway 101, and nine are distributed from the Carlyle Hills (south of Gilroy) north to the area of the Santa Teresa Hills (California Natural Diversity Data Base 1996).

***Reproduction and Demography.*** - *Streptanthus albidus* ssp. *peramoenus* is an annual herb flowering from April to June (Skinner and Pavlik 1994). *Streptanthus albidus* ssp. *peramoenus* populations are often spectacular with many large profusely blooming plants (R. Raiche, pers. comm., 1992). Population sizes range from less than fifty to tens of thousands (California Natural Diversity Data Base 1996). Details of reproduction and demography of the species are unknown.

***Habitat and Community Associations.*** - *Streptanthus albidus* ssp. *peramoenus* grows between 140 and 700 meters (450 to 2,300 feet) in elevation on serpentine outcrops on ridges and slopes (California Natural Diversity Data Base 1996) in chaparral and valley and foothill grassland (Skinner and Pavlik 1994). Rare species which may occur with *Streptanthus albidus* ssp. *peramoenus* include bay checkerspot butterfly (*Euphydryas editha bayensis*), coyote thistle

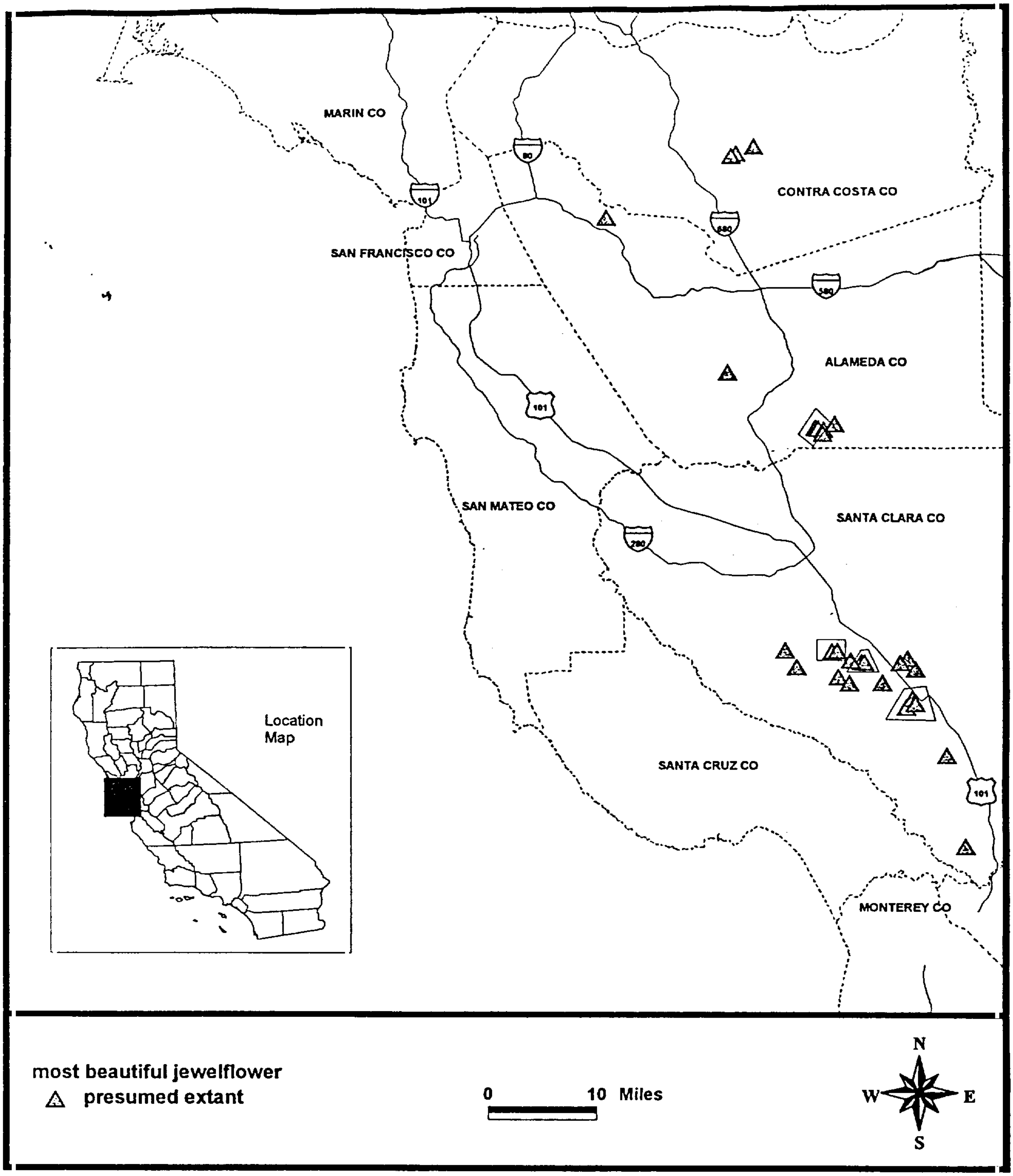


**Figure II-35.** Distribution of most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*). Each symbol represents one occurrence in California Natural Diversity Data Base records except where more than one symbol is enclosed in a polygon; in this case, all the symbols in the polygon together represent a single occurrence.

(*Ceanothus ferrisiae*), Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*), Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*), Presidio clarkia (*Clarkia franciscana*), and Santa Clara Valley dudleya (*Dudleya setchellii*). Associated species include bigberry manzanita (*Arctostaphylos glauca*), buck brush (*Ceanothus cuneatus*), California poppy (*Eschscholzia californica*), dwarf plantain (*Plantago erecta*), and purple needlegrass (*Nassella pulchra*) among others. Non-native species associated with *Streptanthus albidus* ssp. *peramoenus* include foxtail chess (*Bromus madritensis* ssp. *rubens*), pampas grass (*Cortaderia jubata*), slender wild oat (*Avena barbata*), soft brome (*Bromus hordeaceus*), and wild oat (*Avena fatua*) (California Natural Diversity Data Base 1996).

***Reasons for Decline and Threats to Survival.*** - *Streptanthus albidus* ssp. *peramoenus* is found in 22 occurrences on both public and private lands. Four populations are in Sunol Regional Park managed by the East Bay Regional Park District. Three populations are in Mt. Diablo State Park, including a 1938 historic occurrence. Santa Clara County lands contain three populations, two in Almaden Quicksilver County Park and one in Calero County Park. Nine populations are on private land, eight in Santa Clara County and one in Alameda County. Of these privately owned parcels, two are on IBM land (California Natural Diversity Data Base 1996), one is on land leased by Waste Management Inc. from Oceanic (California Natural Diversity Data Base 1996, California Department of Fish and Game 1997*a*), and six have other private landowners. Ownership information is unavailable for the remaining three known populations (California Natural Diversity Data Base 1996).

In general, *Streptanthus albidus* ssp. *peramoenus* is threatened by grazing, development (Z. Chandik, *in litt.*, 1994, Skinner and Pavlik 1994, California Natural Diversity Data Base 1996), road construction (California Natural Diversity Data Base 1996), and invasion of non-natives (California Natural Diversity Data Base 1996, B. Olson, *in litt.*, 1996). Grazing is a threat to one population in Mt. Diablo State Park and to some populations in Santa Clara County west of Highway 101 (California Natural Diversity Data Base 1996). Development is particularly a threat to the Oakland Hills population which occurs in about a 0.5 hectare (1 acre) lot in the City of Oakland (B. Olson, *in litt.*, 1994, California Natural Diversity Data Base 1996) and to some of the Santa Clara County populations west of Highway 101 (Z. Chandik, *in litt.*, 1994, California Natural Diversity Data Base 1996). Populations in Mt. Diablo State Park may also be threatened by off-trail travel, collection and invasion of non-native grasses. Populations east of Highway 101 in Santa Clara County may be threatened by landfill activities (the population on Waste Management land) and road construction. Almaden Quicksilver State Park was formerly an active mercury mine. IBM intends to preserve their site (California Natural Diversity Data Base 1996).

***Conservation Efforts.*** - *Streptanthus albidus* var. *peramoenus* was designated a Category 1 candidate by the U.S. Fish and Wildlife Service in 1990 (U.S. Fish and Wildlife Service 1990). Category 1 included species for which sufficient information was available to support a proposed listing as threatened or endangered, but which were awaiting publication of a formal listing proposal. The Category 1 designation was discontinued in 1996, and many former Category 1 species are now candidate species. However, *Streptanthus albidus* ssp. *peramoenus* is currently considered a species of concern (U.S. Fish and Wildlife Service 1996*a*, *b*).

***Conservation Strategy.*** - Population genetic research completed to date indicates that, because of genetic differences among populations, all populations of *Streptanthus albidus* ssp. *peramoenus* are valuable genetic resources (Mayer *et al.* 1994, M. Mayer, *in litt.*, 1998). Ensuring long-term survival of *Streptanthus albidus* ssp. *peramoenus* must first focus on protecting and managing populations at the known locations by working with East Bay Regional Park District, California Department of Parks and Recreation, Santa Clara County Parks Department and private landowners. Populations on private land should be protected by land acquisition, conservation easements, or other means. In general, the largest possible block of serpentine habitat should be protected at each site. Protection should, at least, involve securing the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations. In addition, other unoccupied habitat at the sites that might provide space for expansion of the populations and habitat for pollinators and seed dispersers must be protected. Management plans emphasizing *Streptanthus albidus* ssp. *peramoenus* and other special status species in these locations must be developed and implemented. The plans should include provisions for standardized annual monitoring of *Streptanthus albidus* ssp. *peramoenus* populations to determine demographic trends. The plans should also include strategies to minimize known threats at the sites as well as to identify new threats as they may appear. In particular, threats from recreational activities, invasion of non-natives and grazing must be eliminated. If new threats are identified or other new information becomes available, management plans need to be reevaluated and revised. Conservation of *Streptanthus albidus* ssp. *peramoenus* will involve protection in some areas targeted as high priority for bay checkerspot butterfly (*Euphydryas editha bayensis*) recovery (e.g. Kirby Canyon). Other species that may benefit from conservation efforts for *Streptanthus albidus* ssp. *peramoenus* include coyote ceanothus (*Ceanothus ferrisiae*), Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*), Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*), Presidio clarkia (*Clarkia franciscana*), and Santa Clara Valley dudleya (*Dudleya setcellii*).

In addition to protecting known sites, historic locations and other suitable serpentine habitat should be surveyed to determine whether undiscovered populations exist. Surveys should include Sunol Regional Park to determine the identity of plants found there (see Historical and Current Distribution above) (B. Olson, *in litt.*, 1998). If new populations are discovered, they should be protected and managed as discussed above. During these surveys, potential introduction sites might also be identified.

Certain types of research are also high priority recovery activities for *Streptanthus albidus* ssp. *peramoenus*. In particular, because *Streptanthus albidus* ssp. *peramoenus* co-occurs in a number of locations in Santa Clara County with bay checkerspot butterfly (*Euphydryas editha bayensis*) and because bay checkerspot butterfly habitat benefits from vegetation management, the effect of various vegetation management techniques (e.g. grazing, mowing, and burning) on *Streptanthus albidus* ssp. *peramoenus* needs to be evaluated. It has been suggested that grazing is a threat to *Streptanthus albidus* ssp. *peramoenus* (California Natural Diversity Data Base 1996). Evaluation of vegetation management techniques will aid managers in selecting management strategies that maintain bay checkerspot butterfly habitat while not adversely affecting *Streptanthus albidus* ssp. *peramoenus*. Other research areas that are important for *Streptanthus albidus* ssp. *peramoenus* include taxonomy and genetics, seed germination and propagation techniques, demography (to identify limiting life history stages and investigate the soil seed bank), and reproductive biology (mating system, dispersal and colonization, pollination). Population genetics studies would be valuable to determine whether and to what extent populations throughout the range of the species are genetically different from one another.

To ensure the long-term conservation of *Streptanthus albidus* ssp. *peramoenus*, 22 populations must be fully protected and managed with the primary intention of preserving the populations in perpetuity. The populations must also be stable or increasing with evidence of natural recruitment over a minimum of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring). Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). Because the populations should represent the range of the species, populations need to be protected and managed in six areas: (1) the Oakland Hills of Alameda County, (2) the Niles area of Alameda County, (3) Sunol Regional Wilderness in Alameda County, (4) Mt. Diablo State Park in Contra Costa County (if the plants are *Streptanthus albidus* ssp. *peramoenus*), (5) the Morgan Hill area northward in Santa Clara County, and (6) south of Morgan Hill in Santa Clara County. To be consistent with the known distribution, 50 percent of the protected populations should be in Santa Clara County in the Morgan Hill area northward. The populations in the San Jose area should be distributed approximately one-third to the east and two-thirds to the west of Highway 101. In Santa Clara County, areas to focus on include the Santa Teresa Hills, Calero County Park and Almaden Quicksilver County Park west of Highway 101 and the Kirby Canyon area east of

Highway 101. Some of these areas will be targeted in the bay checkerspot butterfly (*Euphydryas editha bayensis*) recovery strategies. If additional surveys indicated that the actual distribution of populations is different (e.g. a greater proportion of populations is found in Alameda County), targets for protection should be changed so that they are consistent with the new information. The status of *Streptanthus albidus* ssp. *peramoenus* should be reevaluated within 5 years of recovery plan approval or when surveys are completed, whichever is less. The need to list *Streptanthus albidus* ssp. *peramoenus* should be considered if the criteria for long-term conservation outlined above are not met within 10 years after publication of the recovery plan.

## O. Bay checkerspot butterfly (*Euphydryas editha bayensis*)

### 1. Description and Taxonomy

***Taxonomy.*** - The bay checkerspot was described by Sternitsky (1937) as a race on the basis of its physical characteristics. Dos Passos (1964) and nearly all subsequent published treatments recognize the bay checkerspot as a distinct subspecies. The bay checkerspot is a member of the family Nymphalidae, the brush-footed butterflies, subfamily Nymphalinae, tribe Melitaeini: the checkerspots and crescents.

An anticipated book on the butterflies of California, by Emmel and Mattoon (in press), is expected to apply a different subspecific name to the bay checkerspot, for reasons of historical precedence. This terminological revision is not expected to affect the scope or validity of the biological subspecies.

***Description***. - The bay checkerspot is a medium-sized butterfly with a wing span of about 5 centimeters (2 inches). The forewings have black bands along all the veins on the upper wing surface, contrasting sharply with bright red, yellow and white spots (Figure II-36).

***Identification***. - The bay checkerspot differs from LuEsther's checkerspot (*Euphydryas editha luestherae*) (a later-flying, *Pedicularis*-feeding subspecies of

**Figure II-36.** Bay checkerspot butterfly (*Euphydryas editha bayensis*). Photo by Richard A. Arnold, used with permission.

Inner Coast Range chaparral in central California) by being darker, and by lacking a relatively uninterrupted red band demarcating the outer wing third (Murphy and Ehrlich 1980). The bay checkerspot is not as dark and has brighter red and yellow colors than the island checkerspot (*Euphydryas editha insularis*) (of the Channel Islands off southern California and nearby mainland) (Emmel and Emmel 1975). The black banding on the forewings of the bay checkerspot gives a more checkered appearance than in other subspecies, such as the smaller Quino checkerspot (*Euphydryas editha quino*) of southern California, or the montane subspecies (e.g., the Mono checkerspot, *Euphydryas editha monoensis*).

## 2. Historical and Current Distribution

The bay checkerspot's habitat has been described as consisting of three general types: 1) primary habitat occurs on native grasslands on very large serpentine outcrops, 2) secondary or "satellite" habitat islands of smaller serpentine outcrops with native grassland, typically capable of developing robust bay checkerspot populations in years of favorable weather when the habitat is in good condition, and 3) "tertiary" habitat areas, where both larval food plants occur on soils not derived from serpentine, but which have similarities to serpentine-derived soils (U.S. Fish and Wildlife Service 1987). All known tertiary areas have been located in areas mapped geologically as Franciscan formation, and tertiary habitat has not historically supported dense or persistent populations. Over the entire historic range of the bay checkerspot, the total area of suitable serpentine habitats does not exceed 5,000 hectares (12,000 acres). All areas now or recently inhabited by the bay checkerspot are island-like patches of suitable habitat isolated by intervening unsuitable habitat and urban development.

***Historical Distribution.*** - The bay checkerspot formerly occurred around San Francisco Bay, from Twin Peaks and San Bruno Mountain (west of the Bay) and Contra Costa County (east of the Bay) south through Santa Clara County (Figure II-37) (Murphy and Ehrlich 1980; Opler *et al.* 1985, California Natural Diversity Data Base 1996). Before the introduction of invasive Eurasian grasses and other weeds in the 1700's, its distribution may have been even wider. Areas from which bay checkerspot populations have gone extinct include Contra Costa County

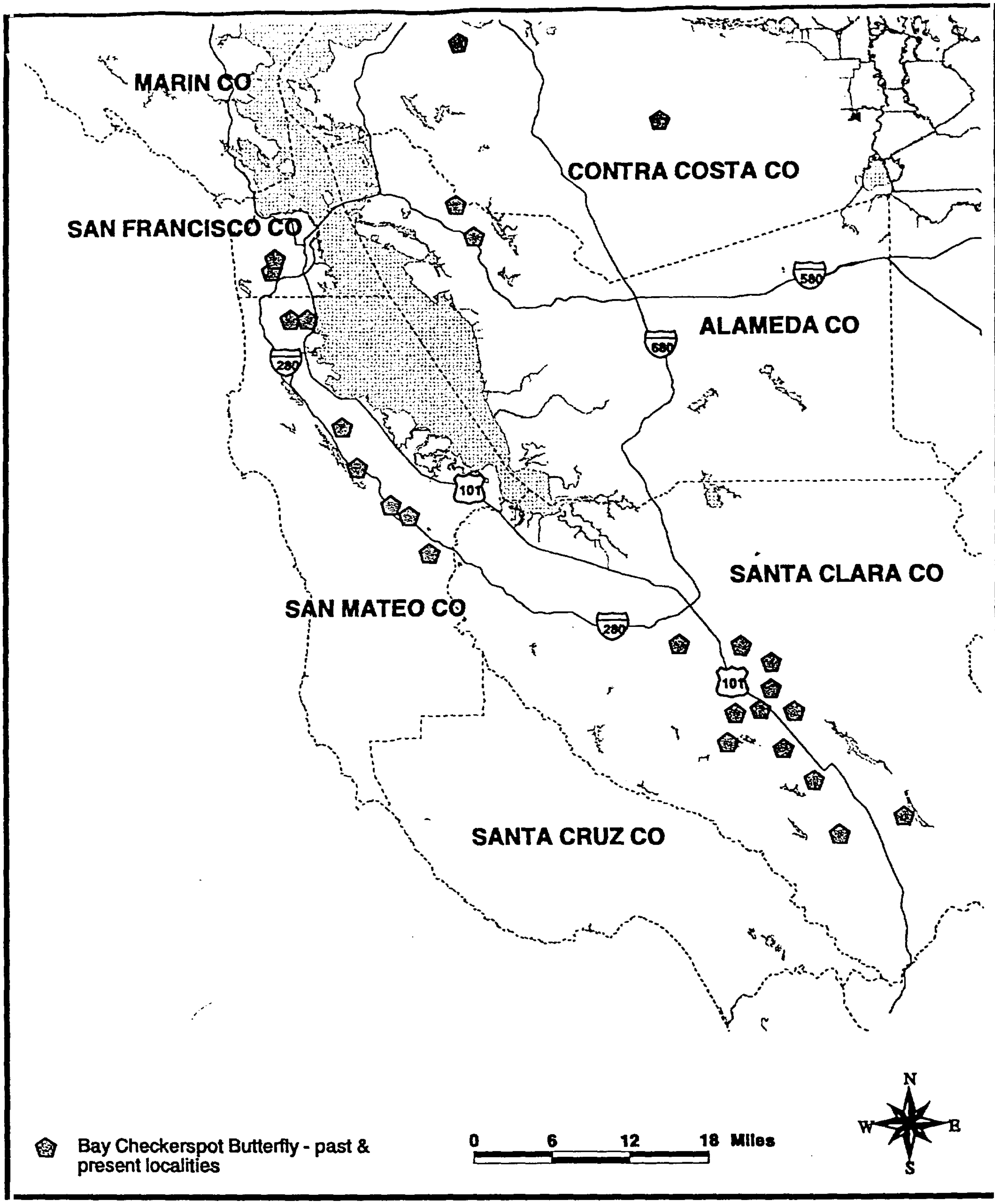


**Figure II-37.** Distribution of the bay checkerspot butterfly (*Euphydryas editha bayensis*). Many northern and some southern populations are currently extirpated. See text for information on the status of populations.

(Franklin Canyon and Morgan Territory areas), Alameda County (Oakland Hills), San Francisco County (Twin Peaks and Mount Davidson), and San Bruno Mountain, Buri Buri Ridge (Hillsborough), Pulgas Ridge (sometimes referred to as "San Mateo"), and Redwood City (part of the site historically referred to as Woodside) in San Mateo County (Murphy and Weiss 1988*a*, California Natural Diversity Data Base 1996). Habitat at the location from which the butterfly was originally described (Hillsborough) was destroyed by freeway construction and suburban development in the 1950's (Murphy and Weiss 1988*a*).

***Current Distribution***. - Studies of the bay checkerspot have described its distribution as an example of a metapopulation and, in fact, population studies of the butterfly were influential in the formulation of the metapopulation concept (Ehrlich *et al.* 1975, 1980, Harrison 1994). A metapopulation is a group of spatially distinct populations that can occasionally exchange dispersing individuals. The populations in a metapopulation are usually thought of as having interdependent extinction and colonization processes, where individual populations may "wink out" (go extinct) and later "wink on" again (be recolonized from another population that is still extant). The frequency of local extinction, and time until recolonization, vary widely from population to population, depending on numerous demographic and environmental factors, such as the size and quality of the habitat, distance from other populations, size of other populations, mobility of the species, and weather.

The current bay checkerspot range is much reduced, and the butterfly is patchily distributed. Because it occurs as a metapopulation, the exact distribution of the butterfly varies through time: sites that are unoccupied one year may be occupied the next, and vice versa (Wilcox and Murphy 1985, Harrison *et al.* 1988). Therefore, any site with appropriate habitat in the vicinity of the historic range of the bay checkerspot should be considered potentially occupied by the butterfly. Figure I-1 shows approximate areas of serpentine geology within the historic range, in San Francisco, San Mateo, Contra Costa, Alameda, and Santa Clara Counties, where potential habitat is likely to exist. Figure I-2 provides greater detail on serpentine geology and soils in central Santa Clara County, and Figure II-37 shows current and historic locations where the butterfly is known or was known to occur. Several scattered populations of a *Plantago*-feeding ecotype (or ecotypes) of *Euphydryas editha* are known to occur to the south and east of the range of the bay checkerspot, as far as Santa Barbara County (U. S. Fish and Wildlife Service 1987, Thomas Reid Associates and Murphy 1997). The subspecific status of these populations is unresolved at this time.

Researchers have identified two bay checkerspot metapopulations, one each in Santa Clara and San Mateo Counties (Murphy 1988). Although the bay checkerspot distribution in these metapopulations is changeable, it is possible to identify core areas: moderate to large areas of suitable habitat that support persistent bay checkerspot populations. Core areas roughly correspond to primary habitat. The pattern of site occupancy by the bay checkerspot suggests that core populations provide migrants that colonize unoccupied habitat. Extirpation in secondary and tertiary areas is common: colonization and extirpation in these areas may occur more than once over a period of several drought cycles (Harrison *et al.* 1988).

There are currently five known core areas for the bay checkerspot: one on the San Francisco peninsula, in San Mateo County (Edgewood County Park), and four in Santa Clara County. The Santa Clara core areas are arrayed along an unnamed ridge immediately east of the Santa Clara Valley, between San Jose and Morgan Hill, which has extensive areas of serpentine soils and excellent habitat for the butterfly. This ridge, or one or more bay checkerspot populations associated with it, has been referred to in a variety of ways in the past: "Morgan Hill", "Kirby Canyon", "East Hills", "East Coyote Foothills", and "Coyote Ridge". This plan refers to the ridge as a whole as Coyote Ridge. The ridge is mostly in private ownership, and is largely used as grazing land. The four core areas along Coyote Ridge, here termed Kirby, Metcalf, San Felipe, and Silver Creek Hills (Figure I-7), are separated by discontinuities in the serpentine soils and by unsuitable vegetation, such as the riparian vegetation along Metcalf Creek (sometimes spelled Metcalfe). Still, these four areas are all within butterfly flight distance of one another, and dispersal of bay checkerspots among them is doubtless frequent.

The four core areas on Coyote Ridge provide a reservoir critical to the survival of the Santa Clara County metapopulation of bay checkerspots. Of the two metapopulations, the Santa Clara County metapopulation has been considered to have the greatest chance of long-term persistence (Murphy 1988, Murphy and Weiss 1988a). The second metapopulation has a reservoir population at the Edgewood Natural Preserve in Santa Mateo County. The habitat area for the Edgewood population is much smaller than at Coyote Ridge, and it has fewer, smaller, and poorer quality secondary sites around it. The two metapopulations are presently separated by about 40 kilometers (25 miles), a very long distance for a bay checkerspot, and so natural immigration between them is likely to be quite rare.

Undiscovered core areas might yet exist in areas that have not been surveyed, but this is not likely because most of the large mapped serpentine intrusions supporting appropriate habitat near the butterfly's historic range have been surveyed adequately to detect a core population. Habitat restoration could convert a small population into a core population, for example in the Santa Teresa Hills, where considerable serpentine area exists but beneficial management of bay checkerspot habitat is lacking.

Satellite or secondary habitat areas are generally smaller and contain less high-quality habitat than core areas, and may occur at some distance from core areas (Harrison *et al.* 1988). Some, perhaps many, satellite populations would not be sustained in the absence of the larger reservoir habitats along Coyote Ridge and at Edgewood Natural Preserve (Figures I-7 and I- 6, respectively). Most satellite habitat areas are privately owned, with the exception of lands owned by the Santa Clara County Parks and Recreation Department--notably portions of Santa Teresa County Park, Calero County Park, and a new park east of San Martin.

Despite the weaker persistence of satellite populations, there are several reasons to conserve secondary habitat and satellite populations of the bay checkerspot. First, the metapopulation distribution among core and satellite populations is part of the natural population dynamics of the butterfly in its current environment. Second, the core-satellite population dynamics of the bay checkerspot have important implications for population and conservation biology, and deserve further scientific study. Third, some satellite populations are likely to be valuable to the bay checkerspot as stepping-stones for dispersal. For example, Tulare Hill appears to provide an excellent stepping-stone for dispersal of the butterfly across the Santa Clara Valley. Fourth, satellite populations may provide a hedge against unusual or unforeseen events that would otherwise drive the bay checkerspot to extinction. Disease, catastrophic fire, prolonged extreme weather, air pollution, or climate change could threaten one or more core populations--events that a satellite population or two might survive, due to isolation, differences in local serpentine soils, airflow or local climate patterns, or for unforeseeable reasons.

***Population Status***. - The most informative numbers reflecting population status of the bay checkerspot butterfly are the total area that it occupies, at present considerably less than 5,000 hectares (12,000 acres), and the number of significant populations, currently only four (Edgewood, Kirby, Metcalf, and San Felipe). The number of individual adults of the species, on the other hand, varies greatly from year to year, and while the total population may appear large, it is in fact disturbingly low for a short-lived insect that relies on high reproductive output to overcome high and variable mortality. The numbers of both total individuals and populations of bay checkerspot undergo large fluctuations, and are reduced by drought, heavy rains, habitat invasion by non-native plants, fire, pesticides, and other natural and human-caused factors.

The best-studied bay checkerspot populations are on the Jasper Ridge Biological Preserve of Stanford University and the Kirby Canyon Butterfly Reserve, both in Santa Clara County. The satellite bay checkerspot population at the Jasper Ridge Biological Preserve of Stanford University in northwestern Santa Clara County is at or near extinction (20 adults in 1994, 80 in 1995, no adults observed in 1996, 5 males and 1 female in 1997: McGarrahan 1997, McCabe 1997). The Kirby Canyon Butterfly Reserve, a temporarily protected, 107-hectare (267-acre) area within the Kirby core habitat area, supports thousands of adult bay checkerspots in most years. The Kirby population has historically been the largest bay checkerspot population, but following the heavy rains of 1998, the Kirby population was unusually low. The Metcalf and San Felipe populations are not accurately known, but are thought to be large, and in 1998 were larger than Kirby.

A 46-hectare (115-acre) butterfly preserve established as part of a development agreement in a portion of the Silver Creek Hills has been monitored yearly since 1990. The bay checkerspot population in the Silver Creek butterfly habitat conservation area initially increased substantially, but then crashed from an estimated 40,000 post-diapause larvae in 1994 to 900 in 1995 and near zero in 1996. No larvae were detected in 1997, but three adults were seen (Launer *et al.* 1997). In part because of recent attention to management and in part because of its proximity to other bay checkerspot populations, the outlook is hopeful for this preserve despite the recent discouraging events. The Silver Creek Hills serpentine area as a whole has the potential to support a core population of bay checkerspots, but currently has a less substantial population.

Of the present core areas, Edgewood Natural Preserve probably has the least capacity to support a substantial population of the bay checkerspot. However, the population there in 1997 was reassuring, roughly estimated to number 10,000 post-diapause larvae (S. Weiss, pers. comm., 1997).

### 3. Habitat and Life History

***Habitat***. - All habitat of the bay checkerspot exists on shallow, serpentine-derived or similar soils, which support the butterfly's larval food plants, as well as nectar sources for adults. The primary larval host plant of the bay checkerspot is dwarf plantain (*Plantago erecta*), an annual, native plantain. The butterfly is usually found associated with populations of *Plantago erecta* in grasslands on serpentine soils, notably soils in the Montara series. In Santa Clara County, the Inks and Climara soil series are related soils and often have inclusions of Montara (Soil Conservation Service 1974). A few Henneke soils, which are also serpentine, occur within the range of the butterfly.

In many years, bay checkerspot larvae require a secondary host plant species, when the plantain dries up while larvae are still feeding. Under these conditions, the larvae move onto purple owl's-clover (*Castilleja [Orthocarpus] densiflora*) or exserted paintbrush (*Castilleja exserta [Orthocarpus purpurascens]*), which remain edible later in the season than dwarf plantain (*Plantago erecta*). Optimal habitat contains substantial densities of *Plantago erecta,* plus at least one of the secondary larval host plant species, and nectar plants for adults. Plant species commonly visited for nectar include desertparsley (*Lomatium* spp.), California goldfields (*Lasthenia californica [=chrysostoma]*), and tidy-tips (*Layia platyglossa*).

Currently, the only areas in the San Francisco Bay Area that support this habitat, and the bay checkerspot, are serpentine soils, which are very limited in area and patchy in distribution. The present association of the bay checkerspot with serpentine soils may be the result of historical factors which have limited the essential habitat to these soils. Murphy and Weiss (1988*a*) hypothesized that the species once occurred widely on many grassland areas around San Francisco Bay, before native grassland communities--except those on serpentine soils--were largely replaced by a mix of alien grasses and forbs. Under this hypothesis, the current association of bay checkerspot with serpentine soils would be a result of the persistence of native grasslands on those soils. The lack of information about native California grassland ecosystems prior to the introduction of invasive Eurasian weeds prevents testing of this hypothesis. The reasons for the relative resistance of native grasslands on serpentine to invasion by non-native grasses and other plants are not completely known, but evidence points to infertility, poor water-holding capacity, challenging chemical composition, or a combination of these factors on serpentine soils as responsible for holding the invaders back (Huenneke *et al.* 1990).

***Topographic Diversity.*** - The topography of a serpentine grassland strongly influences its ability to support bay checkerspot (Weiss *et al.* 1988, 1993, Murphy and Weiss 1988*a*). South-facing slopes are warmer, and thus drier, than north-facing slopes, because south-facing slopes receive more solar radiation on clear spring days than does flat ground or north-facing slopes. This variation in thermal microclimate affects the timing of both butterfly and host plant development on different slopes. Larvae on warm, south-facing slopes develop faster and emerge as adults a month or more earlier than do larvae on cool north-facing slopes (Weiss *et al.* 1988). Host plant senescence also depends on solar exposure: host plants on south-facing slopes flower and senesce three to four weeks before those on cooler slopes.

Weiss (1996) has termed the race between butterfly and plant development the "phenological window": bay checkerspots must complete their development and lay their eggs about 3 or more weeks before the *Plantago erecta* senesces, so that their pre-diapause larvae can grow to sufficient size to survive the summer. Evidence to date suggests that cool slopes are especially valuable to the butterfly for surviving drought conditions, since *Plantago erecta* senesces later there. However, larval and pupal development are faster on warm slopes, an advantage in the race if the larvae can find green host plants. The relationship between slope and habitat quality is complex, and the spatial pattern of pre-diapause survival across slopes changes from year to year. Both warm and cool slopes are needed in different years, and through years of extreme weather, the availability of diverse microclimates at a site can be crucial to bay checkerspot survival. Because the phenological window shifts depending upon thermal microclimate at the ground surface as well as on gross weather patterns, having a range of slopes and exposures within a serpentine habitat area provides a hedge against population-wide reproductive failure in years with extreme weather. Even the hottest slopes, where the chances of pre-diapause survival are small, contribute in some years by providing early season nectar.

***Reproduction.*** - The bay checkerspot's life cycle is closely tied to host plant biology. Host plants germinate anytime from early October to late December, and senesce from early April to mid May. Most of the active parts of the bay checkerspot life cycle also occur during this time.

The bay checkerspot is univoltine and essentially annual (reproducing once and dying in a single year). Adults emerge from pupae in early spring, and feed on nectar, mate and lay eggs during a flight season that typically lasts for 4 to 6 weeks in the period between late February to early May. Male bay checkerspots typically emerge from their pupae 4 to 8 days before females, and find and mate with most females soon after they emerge (Baughman 1991). Males can mate multiple times, while most females are believed to mate only once, although they are capable of re-mating 4 to 7 days after the first copulation, and some females have been found to carry more than one spermatophore (Labine 1964, 1966). The average life span for adults of both sexes is about 10 days, but individuals have lived for over 3 weeks (Ehrlich, unpublished data, cited in Baughman 1991, R. White, *in litt.*, 1998). Eggs are typically laid in March and April. Females lay up to five egg masses of 5 to 250 eggs each, which they deposit near the base of *Plantago erecta*, or, less often, *Castilleja densiflora* and *Castilleja exserta* (Murphy *et al.* 1983, Weiss *et al.* 1988, R. White, unpublished manuscript). In the laboratory, Murphy *et al.* (1983) observed lifetime production of about 250 to 1,000 eggs by female bay checkerspots on various diets, including about 250 to 600 lifetime eggs without food.

In other subspecies of *Euphydryas editha*, adults sometimes congregate on ridge tops to mate, notably when population numbers are small (Ehrlich and Wheye 1988). This "hilltopping" behavior is hypothesized to aid in mate location and to increase mating success. Bay checkerspots show slight hilltopping tendencies (Baughman *et al.* 1990, A. Launer, pers. comm., 1997).

***Larval Development, Mortality, and Dispersal.*** - Larvae hatch from the eggs in about 10 days and grow to the fourth instar (molt) in 2 weeks or more. *Plantago erecta* is the primary food plant, and most larvae feed on it initially. Larvae that successfully reach the fourth instar enter a period of dormancy (diapause) that lasts through the summer, which they pass under rocks or in cracks in the soil (White 1987, Weiss 1996). Larvae that have not reached the fourth instar before the host plant senesces or is defoliated must disperse to find another plant, or die of starvation. Mortality is extremely high among pre-diapause larvae, usually in excess of 90 percent, and can reach 99 percent (Murphy 1988). Figures in Cushman *et al.* (1994, their Table 2) suggest that combined mortality of egg and pre-diapause larval stages was about 97 to 99 percent at Kirby Canyon in 1992--and 1992 was a *good* year (above-average rainfall and increasing numbers of bay checkerspot at Kirby Canyon; Weiss 1996).

Some pre-diapause larvae can successfully reach diapause by switching to the secondary host plant, purple owl's-clover (*Castilleja*, either *densiflora* or *exserta*; e.g., Singer 1972 [as *Orthocarpus densiflorus*]). Since they senesce slightly later, the presence of these plants can extend the feeding season of pre-diapause larvae by several days, which is often all that is needed. The mobility of pre-diapause larvae is limited, however, so the secondary host must be growing near the *Plantago erecta* host plant. Singer (1972) also observed that pre-diapause larvae can survive to a later diapause on *Plantago erecta* growing on soil disturbed by Botta's pocket gophers (*Thomomys bottae*). Host plants on gopher mounds stay green longer, possibly due to greater water capacity and longer roots in the loosened soil. The relative importance of this gopher effect on bay checkerspot populations is not known.

The summer diapause ends with the onset of the next rainy season and the germination of *Plantago erecta*; the larvae then resume activity, feed and complete their development (Singer 1972, Murphy and Weiss 1988*a*). These larger, "post-diapause" larvae are quite mobile, and may crawl tens of meters (yards) in search of food plants or warm microclimates in which to bask or pupate. They pupate after reaching a weight of 300 to 500 milligrams (0.01 to 0.02 ounce) (Singer 1972; Weiss *et al.* 1988). The pupae are suspended from vegetation a few millimeters above the ground (White 1986). This low position may gain the thermal benefits of a warm ground surface. The time from pupation to emergence as an adult varies from about 15 to 30 days, and is strongly affected by thermal conditions (White 1986, Weiss *et al.* 1988). There is some evidence that, in very dry years, a few larvae may enter a second diapause and complete their development the second spring after hatching (White and Levin 1981, Harrison 1989, p. 1242, Weiss 1996).

Sun exposure has a strong effect on temperature and so on development rates of all kinds, including larval feeding and growth and pupal development. The black larvae of the bay checkerspot bask in direct sun to raise their body temperatures, and crawl in active search of warm microclimates or host plants (Weiss *et al.* 1993). In sites that have a variety of slope exposures, adult oviposition (egg-laying) in a variety of microclimates combined with larval dispersal allows bay checkerspot populations to take advantage of warm and cool slopes and hedge against climatic variability (Weiss *et al.* 1988). The ability of larvae to undergo diapause for more than one year is also a powerful mechanism for the bay checkerspot to weather climatic extremes.

Mortality of post-diapause larvae is lower than for pre-diapause larvae. Ehrlich *et al.* (1984) estimated post-diapause larval plus pupal mortality at roughly 75 percent. Mortality of pupae was estimated by White (1986) at 53 to 89 percent at Edgewood and Kirby over 3 years. The latter estimates may be high if the experimentally-placed pupae used by White were more exposed to predators, parasites, or weather than naturally-placed pupae. Sources of mortality for eggs, larvae or pupae identified by White (1986) include predation (unspecified, but probably including small mammals, birds, and predatory invertebrates), inclement weather, disease, parasitism (notably by a tachinid fly, *Siphosturmia melitaeae* Coquillet, and an unidentified large ichneumonid wasp), and crushing, commonly by cattle. White (1986) suggested that a substantial fraction of eggs, larvae and pupae could be lost to trampling in areas that are heavily grazed. Adults and diapausing larvae probably are not as vulnerable to trampling.

In general, persistence of bay checkerspot populations appears to require a balancing act, between high fecundity and high and variable mortality due to climatic fluctuations. An approximate calculation shows the precariousness of this balance: given an average of 400 lifetime eggs per female and a 1:1 sex ratio, total mortality from egg to adult must be less than 99.5 percent for bay checkerspot populations to remain stable or increase. Even this extreme level of mortality is often equaled or exceeded for the bay checkerspot in nature.

***Adult Food Habits***. - Adult bay checkerspots feed on the nectar of a number of plants found in association with serpentine grasslands, including California goldfields (*Lasthenia californica [=chrysostoma]*), tidy-tips (*Layia platyglossa*), desertparsley (*Lomatium* spp.), scytheleaf onion (*Allium falcifolium*), sea muilla (*Muilla maritima*), false babystars (*Linanthus androsaceus*), intermediate fiddleneck (*Amsinckia intermedia*), and other species. The fecundity of the female butterflies is significantly affected by the availability of nectar (Murphy *et al.* 1983). The effects of nectar availability on male longevity and reproduction need to be investigated.

***Adult Dispersal.*** - Adult bay checkerspots are considered to be fairly sedentary (Ehrlich 1961, Ehrlich *et al.* 1975, Harrison 1989), yet long-distance dispersal of the species is well documented. At Jasper Ridge, only 1.7 percent of nearly 3,000 marked males and 4.8 percent of 473 marked females were found to move between subpopulation areas "C", "G", and "H", which are all within 500 meters (1,600 feet) of one another, narrowly separated by chaparral and oak woodland (McKechnie *et al.* 1975). Within serpentine habitat at Kirby Canyon, adult movements between locations decline approximately exponentially with distance: 10 to 15 percent of recaptured butterflies are found about 100 meters (330 feet) from where they were marked, 2 to 4 percent at 500 meters (1,600 feet), and roughly 0.5 percent at distances of 1 kilometer (3,300 feet) (Figure IV-1 in Weiss 1996). However, Harrison (1989) documented recolonizations of habitat areas up to 4.5 kilometers (2.8 miles) from Coyote Ridge, the source population, possibly implying greater dispersal capabilities. Bay checkerspot researchers have tentatively identified a distinct flight behavior of butterflies outside of appropriate habitat, or of occasional individuals within habitat: they fly higher above the ground and make a beeline out of sight (S. Weiss, pers. comm., 1997, A. Launer, pers. comm., 1997). When released outside of appropriate habitat, Harrison (1989) observed bay checkerspot movements of 5.6 kilometers (3.5 miles) (1 male), 3 kilometers (2 miles) (1 female), and 18 movements of 0.5 to 1 kilometer (0.3 to 0.6 mile). One marked bay checkerspot individual is known to have flown between Edgewood Natural Preserve and Jasper Ridge, a straight line distance of 7.6 kilometers (4.7 miles) (R. White, pers. comm., 1997). In all dispersal observations or experiments, long-distance movements are hard to detect, and thus their frequency and importance are underestimated.

Harrison (1989) speculated that colonization of distant serpentine habitat requires a large source of bay checkerspot butterflies, a small number of which disperse randomly over considerable distances. Dispersal distances of *Euphydryas editha*, including bay checkerspot, can vary from population to population and from year to year, depending on environmental conditions (White and Levin 1981). Dispersal of even small numbers of individuals is significant, because just a few gravid females (carrying fertilized eggs), perhaps even one under favorable conditions, can establish or renew a population.

***Relationship Between Weather, Habitat and Population Fluctuations***. - Bay checkerspot populations are very susceptible to weather-induced population fluctuations. Population reductions by a factor of 40 have been observed in a single year (Weiss 1996). Weather can influence the bay checkerspot in several ways, including timing of the adult flight period, timing of host plant senescence, and larval survival. The number of butterflies may increase markedly (e.g., 10 times) following favorable years (Weiss 1996). Populations can crash following poor conditions, as occurred during the 1975 to 1977 drought. Larval host plants senesced extremely early during this period, and many satellite populations were extirpated (Harrison 1989; Ehrlich *et al.* 1980), including, it is believed, all but the largest population(s) in Santa Clara County (the Coyote Ridge populations; Murphy and Weiss 1988*a*). Heavy rains can also cause population crashes (Dobkin *et al.* 1987). Changes in bay checkerspot population sizes are largely regulated by survival of pre-diapause larvae (Singer 1972, Weiss *et al.* 1988, Murphy and Weiss 1992), which in turn is controlled largely by the timing of adult butterfly emergence and egg laying relative to the timing of host plant senescence ("phase relationship," "phenological window"; Dobkin et al 1987, Murphy *et al.* 1990, Weiss *et al.* 1988, Weiss 1996).

While weather patterns (density-independent) usually exert a stronger influence on population changes than do density-dependent factors, weak density-dependence may occasionally occur if post-diapause larval feeding in December through March causes heavy defoliation of larval food plants (Harrison *et al.* 1991, Weiss 1996).

***Population and Metapopulation Viability***. - Two published studies have considered the future viability of bay checkerspot populations: Foley (1994) modeled the extinction probability of two Jasper Ridge subpopulations ("C" and "H") and concluded that, using conservative estimates of population parameters, the expected time to extinction was between 50 and 70 years for the two subpopulations. Using more optimistic assumptions, the expected times to extinction still remained under 300 years. Subpopulation C has since gone extinct, and H is near extinction as of 1997 (McCabe 1997).

The second study outlined the structure for a population viability analysis (a detailed model attempting to assess the probability of future survival of a population or a species, useful in identifying key factors influencing the likelihood of survival) for the bay checkerspot (Murphy *et al.* 1990). The model framework incorporated environmental factors and metapopulation structure, and identified key information needs for completing a population viability analysis for the species. Initial results of modeling for their study included the observation that weather, particularly the timing and duration of rainfall during the growing season, strongly influence butterfly phenology. The authors concluded that habitat heterogeneity is an important element of habitat quality for the bay checkerspot. An accurate predictive population viability analysis would require the following information, which is currently unavailable (Murphy *et al.* 1990): 1) quantification of key life history parameters, and of the variances associated with parameter estimates (which is complicated by a highly variable environment); 2) how factors other than topography influence resource availability and other components of habitat quality; and 3) an understanding of dispersal behavior and the colonization process.

## 4. Reasons for Decline and Threats to Survival

***Reasons for Decline.*** - Primary reasons for the decline of the bay checkerspot are habitat degradation and loss, caused by non-native plants displacing or reducing native food plants, and by urban and suburban development. The extirpation of several populations has been well documented (Murphy and Weiss 1988*a*). At the time of listing in 1987, sufficient habitat to support persistent populations of the bay checkerspot (on a scale of decades) existed on as few as 2 of 16 historic localities of the bay checkerspot. At the present, only Edgewood Natural Preserve in San Mateo County and Coyote Ridge in Santa Clara County support large populations of bay checkerspots.

Habitat loss has reduced the number and the size of extant bay checkerspot populations. Smaller populations are more vulnerable to extinction due to naturally occurring events such as drought. Further, habitat reduction lowers overall habitat quality by reducing the diversity of microclimates and food plants available to larvae and adults. Destroying serpentine habitats or reducing them to non-viable sizes has also eliminated stepping-stone habitats and increased the average distance between populations and habitat patches, making recolonization more difficult.

Prior to the listing of the species, two primary habitat areas believed large enough to support persistent, "core" populations, near Hillsborough and San Mateo in San Mateo County, were converted to roads or housing, with even greater losses of secondary and tertiary habitat areas (extirpation from 29 of 32 probable secondary areas, and 5 of 8 known secondary areas; probably recent extirpation from at least 5 of 6 known areas of marginal habitat, and from more than 9 likely such areas; U.S. Fish and Wildlife Service 1987). Several areas of serpentine soils in San Francisco have been covered by the city for decades (e.g., Hunters Point); their past potential for supporting the bay checkerspot is unknown. Since listing, the destruction of serpentine habitats within the range of the butterfly has slowed considerably, but continues at a low rate, primarily in suboptimal habitat.

Habitat fragmentation has been a factor in the degradation of bay checkerspot habitat, as illustrated in Figure 2 of Murphy and Weiss (1988*a*). In San Mateo County, what were once four patches of serpentine habitat have been carved over the years into 11 pieces. Given the fact that bay checkerspots tend to avoid leaving habitat (Ehrlich 1961, 1965), and that some of the 11 fragments are separated by a six to eight lane high-speed freeway, I-280, the potential for a declining patch to be supplemented or recolonized naturally from an extant population in a different patch is small. Thus, what were once four sizeable populations were split into several smaller ones forced to function independently. For example, the bay checkerspot population on San Francisco Water Department land (the "Triangle") that was separated from the Edgewood Natural Preserve population by the construction of I-280 declined after the road was constructed and is currently extirpated, despite occasional immigrants from the park (A. Launer, pers. comm., 1997). Only Edgewood Natural Preserve, containing the largest of the 11 remaining habitat fragments, still supports a significant population. In addition to the loss of habitat area that accompanies it, habitat fragmentation increases external threats by bringing sources of disturbance closer and increasing the amount of habitat near edges. Managing the conservation of many small, disjunct habitat fragments also presents considerable biological and operational difficulties (Ehrlich and Murphy 1987).

Drought and other extremes of weather have been implicated in more than one period of decline of bay checkerspot populations, although population responses are not always clearcut (Ehrlich *et al.* 1980, Weiss 1996). Certainly weather affects their populations, but bay checkerspots have been in the Bay Area for a long time, despite evidence for droughts in northern California within the last millennium that were far more severe and long-lasting than any recorded in historic times (Stine 1994). This, plus the high reproductive potential of the bay checkerspot suggest that the species is well-adapted to survive and recover from drought and other extremes of climate, and that its failure to recover from recent weather extremes may be due to other, probably human-caused, factors.

The final rule listing the bay checkerspot as a threatened species discussed the role of livestock overgrazing plus drought in the extinction of several populations. While overstocking may adversely affect the species, sustainable grazing practices normally seem to be compatible with the maintenance of bay checkerspot populations. In some parts of its range, grazing is used as a habitat management tool (Thomas Reid Associates and Murphy 1987, Murphy 1988, Weiss 1996).

***Threats to Survival.*** - Urban and suburban growth in the species' range continues to threaten bay checkerspot habitat. Since the species' listing in 1987, numerous projects have involved the U.S. Fish and Wildlife Service under the auspices of the Endangered Species Act , because of potential impacts to the bay checkerspot. In 1995 and 1996, eight projects required technical assistance and five projects required informal consultation with the U.S. Fish and Wildlife Service, regarding potential project impacts to the bay checkerspot.

Habitat Loss and Fragmentation. Several currently proposed or contemplated projects would affect serpentine grassland habitat in the range of the bay checkerspot, including Cerro Plata, Metcalf Road widening, Richmond/Young Ranches, and Calero Lake Estates, in Santa Clara County.

The proposed Cerro Plata project in eastern San Jose would construct housing and a golf course on a large amount of serpentine grassland in the Silver Creek Hills bay checkerspot population area. Total project area is approximately 232 hectares (575 acres), most of which is on serpentine. As noted above, the Silver Creek Hills could support a core population for the bay checkerspot, although the population is currently substantially smaller. The U.S. Fish and Wildlife Service believes that the Environmental Impact Report for the Cerro Plata project underestimated the amount of bay checkerspot habitat on the site and consequently the potential project impacts. The site owner and consultants are currently preparing a Habitat Conservation Plan (HCP) (a conservation plan developed by non-Federal parties applying under section 10 of the Endangered Species Act for a permit for incidental taking of listed species) as part of a revised development proposal for the site.

A proposed project to widen and straighten a portion of Metcalf Road in the City of San Jose would impact adjacent serpentine habitats, increase road kills of bay checkerspots, and improve human access to Coyote Ridge and highly significant bay checkerspot habitat: the Kirby, Metcalf, and San Felipe core populations. This project would also impact the federally threatened California red-legged frog (*Rana aurora draytonii*) as well as several serpentine-associated plants that are listed or rare. The U.S. Fish and Wildlife Service has recommended that the U.S. Army Corps of Engineers consult under section 7 of the Endangered Species Act regarding this project.

YCS Investments of San Francisco and the owners of the Richmond Ranch are pursuing a 735-hectare (1,817-acre) extension of the City of San Jose Urban Growth Boundary to include portions of Young Ranch, Richmond Ranch, and smaller adjacent properties. The proposed extension would include large areas of serpentine habitat in the Metcalf bay checkerspot population area. The applicants have proposed the creation of a planned residential community of up to 2,450 dwelling units, a golf course, and commercial, resort, and miscellaneous uses in this area (City of San Jose 1997).

Calero Lake Estates is an incomplete housing subdivision in the southern Santa Teresa Hills, abutting Santa Teresa County Park. Serpentine grasslands and bay checkerspots occur within the subdivision and on adjacent lands.

Ongoing human population growth and expanding development in the greater San Francisco Bay Area will continue to place pressures on the serpentine grassland habitat of bay checkerspots for the foreseeable future. For example, sizeable and vitally important areas of bay checkerspot habitat lie within the limits of the rapidly growing City of San Jose. The California Court of Appeal recently ruled, in response to a citizens' suit regarding the proposed Cerro Plata project site, that the City of San Jose's zoning need not be consistent with its General Plan (San Jose Mercury News, May 10, 1997, p. 2B). The U.S. Fish and Wildlife Service is concerned that the City of San Jose therefore may be limited in its ability to guide growth and development away from environmentally sensitive areas.

Invasive Plants. Invasion of native grasslands by non-native species is widely seen as one of the major causes of decline of the bay checkerspot. Serpentine habitats are not completely immune to invasion by non-natives, so non-native invasive plants present a continuing threat to the butterfly. For example, non-native grass growth in the Silver Creek Hills has been observed to choke out the host plants of the bay checkerspot (R. White, pers. comm., 1997, A. Launer, pers. comm., 1997, S. Weiss, pers. comm., 1997, D. Murphy, pers. comm., 1997), and yellow star thistle (*Centaurea solstitialis*) has invaded some serpentine areas of Edgewood Natural Preserve. Certain eucalyptus species (*Eucalyptus* spp.) can grow in serpentine, and destroy butterfly habitat with their litter and shading. New invasive plants continue to be introduced to northern California through gardens, landscaping, and accidental means.

The negative impact of invasive plants on serpentine habitats is increased by fertilization (possibly including nitrogen deposition from air pollution), watering or irrigation, and frequency of introduction of seeds or other propagules (Huenneke *et al.* 1990, Thomas Reid Associates and Murphy 1992, 1995).

Grazing and Fire. The relationship between grazing, fire and bay checkerspot habitat quality is not well known, although bay checkerspot populations have persisted in areas grazed by cattle for many decades (Weiss *et al.* 1988). Bay checkerspots persisted on Jasper Ridge for over 30 years after livestock grazing was stopped, but the species is now nearly extinct at this site (McGarrahan 1997, A. Launer, pers. comm., 1997, S. Weiss, pers. comm., 1997). Grasslands which are grazed at moderate levels (particularly in winter and spring) may favor the bay checkerspot by favoring their native food plants and reducing non-native plants. Grazing has been used to manage grasslands for the bay checkerspot (Huenneke *et al.* 1990). Grazing, however, may adversely affect some plant species of serpentine grasslands, and can damage wetlands (Launer and Murphy 1994).

Fire was implicated in the mid-1980's extirpation of the bay checkerspot from tertiary habitat on San Bruno Mountain. However, fire is widely recognized as a useful management tool for reducing non-native invasive plants, which are a major threat to the bay checkerspot. Experiments need to be conducted to determine whether controlled burning of limited areas of habitat at particular times of year would benefit native species, including the bay checkerspot.

Discing to create firebreaks in bay checkerspot habitat areas is likely to kill larvae diapausing in the soil. Mowing to create firebreaks, so long as it is done after the vegetation (notably purple owl's-clover and exserted paintbrush) is mostly dry, should have minimal impacts on the bay checkerspot.

Illegal collecting. Incidents of illegal collecting of bay checkerspots have been documented and prosecuted by the U.S. Fish and Wildlife Service. Illegal collecting is most likely to have a significant negative impact on bay checkerspot populations that are small or have been reduced by natural or artificial factors, and that are easily accessible.

Air Pollution, Nutrients, and Water. Experimental evidence from serpentine grasslands in San Mateo County indicates that increased levels of nitrogen and other nutrients allow invasion and dominance of non-native annual grasses, causing suppression of native forbs including *Plantago erecta*, the bay checkerspot's main larval food plant (Huenneke *et al.* 1990). Weiss (1996, S. Weiss, pers. comm., 1997) has suggested that some bay checkerspot habitats are more prone to non-native grass invasion due to nitrogen deposition from air pollution from sources upwind. Approximately 5 kilograms of nitrogen per hectare per year (4.5 pounds of nitrogen per acre per year) is deposited at a nearby air quality monitoring station in Fremont, Alameda County, California (Blanchard *et al.* 1996).

By threatening to promote the invasion of non-native plants into serpentine soils, where they would compete with bay checkerspot host plants, nutrient deposition from air pollution may have the potential to seriously reduce the quality of many bay checkerspot habitats. Nitrogen tends to be tightly recycled in infertile soils like those derived from serpentines, so fertilization impacts could persist for years, and may be accumulating now. Air pollution does not respect property boundaries, so this threat, if real, is a serious one that could compromise our ability to meaningfully protect lands that support the bay checkerspot. Although nutrient deposition from polluted air in general is not speculative (Riggan *et al.* 1985, Russell *et al.* 1990, Fenn *et al.* 1996), little is known about the actual deposition to or impacts on bay checkerspot habitats, if any, and research in this area must be a priority.

Pesticide use. Use of pesticides, including herbicides, in or near bay checkerspot habitat may affect certain populations. Populations adjacent to development or downwind of areas of heavy pesticide use are most likely to be at risk from pesticide drift; however, at least one case of direct pesticide spraying on bay checkerspot populations has occurred. In 1981, the California Department of Food and Agriculture, in the course of a concentrated program to eradicate a Mediterranean fruit fly invasion, sprayed Edgewood Park with malathion. However, this spraying occurred in the fall, when bay checkerspot larvae were in diapause (S. Weiss, pers. comm., 1997, A. Launer, pers. comm., 1997, N.

Chiariello, pers. comm., 1997). Homeowners, businesses, and public agencies make widespread use of carbaryl (an organophosphate) or *Bacillus thuringiensis* var. *kurstaki* (a disease-causing bacterial strain specific to Lepidoptera [butterflies and moths]) ("Bt") to control California oakworm (*Phryganidia californica*: Dioptidae) and other moth larvae that sometimes defoliate oak trees (M.L. Flint, pers. comm., 1997). Drift or direct application of herbicides may damage bay checkerspot host plants.

Road Kill. Direct strikes and turbulence due to vehicles driving on public roads cause an unknown amount of mortality and injury to bay checkerspots annually.

Impacts of Research. Bay checkerspot research has been carried out on the Jasper Ridge Biological Reserve since 1960. Harrison *et al.* (1991) estimated the effects of collection of bay checkerspot individuals for this research on two Jasper Ridge subpopulations. From 1960 to 1983, between 0 to 385 (mean 57.3) bay checkerspot adult females were removed annually from one or both of these subpopulations, for electrophoresis and other purposes. During this time, the estimated number of female butterflies in the two subpopulations (combined) ranged from 112 to 8,228, and the number removed averaged 6.1 percent of each population (range: 0 to 27.5 percent; Harrison *et al.* 1991). Using population simulation models, the authors concluded that bay checkerspot numbers were extremely variable because of environmental variability; and that the population reductions due to removal for study were small compared to natural variability and were not statistically detectable. The models did indicate, however, that collections may have increased the chances of extinction for the two populations, with an effect ranging from negligible to a 15 percent increase in extinction probability over 30 years depending on model assumptions.

Ehrlich and Murphy (1987) reported that foot-traffic associated with intensive study of one Jasper Ridge population had a significant impact on the area's vegetation, and suggested that butterfly eggs, larvae, and pupae also may have been destroyed by the trampling. Orive and Baughman (1989) studied the effects of a mark-and-recapture study on the bay checkerspot on Jasper Ridge, and found that handling by experienced researchers did not significantly increase observable wing-wear.

Effects of Climate Change. The bay checkerspot would likely be very sensitive to climate change, because its development and mortality are critically dependent on temperature and the development of its host plants, which in turn are controlled by climate (Murphy and Weiss 1992). Climate models do not yet agree on exactly how global climate change is expected to change Bay Area climate, but both temperature and rainfall are likely to be affected. Murphy and Weiss (1992) argue that the Kirby bay checkerspot population, the largest and sometimes considered the most viable population, is not well-buffered against climatic change. This area receives the least rainfall in the species' range, and many small populations in the area disappeared during the 1975 to 1977 drought, whereas small populations in wetter San Mateo County survived. Simulation modeling suggested that three out of four climate-change scenarios (colder and wetter, colder and drier, warmer and drier) would adversely affect the bay checkerspot, as would a change in the timing of rainfall (Murphy and Weiss 1992). Climate change might also affect the relative dominance of native vs. non-native vegetation in serpentine habitats. Because there can be little local control over global climate changes, preservation of bay checkerspot habitats and populations in as broad a range of local climate conditions as possible is prudent.

Gopher Control. Although speculative, it is conceivable that gopher control could adversely affect the bay checkerspot. Singer (1972) noted that bay checkerspot larvae can survive later in the spring on *Plantago erecta* growing in earth disturbed by gophers. Presumably the loosened earth allows deeper root penetration and holds more water. On the other hand, disturbance by gophers may also encourage weed growth.

## 5. Conservation Efforts

The bay checkerspot was federally listed as threatened in 1987 (U.S. Fish and Wildlife Service 1987). Critical habitat has not been designated for the bay checkerspot. On September 11, 1984 (U.S. Fish and Wildlife Service 1984), five areas totaling about 3,300 hectares (8,300 acres) were proposed as critical habitat:

1. Approximately 80 hectares (200 acres) on San Bruno Mountain;
2. Approximately 240 hectares (600 acres) in Edgewood County Park and adjacent San Francisco watershed lands;
3. Approximately 24 hectares (60 acres) in Redwood City along the city boundary between Redwood City and Woodside;
4. Approximately 300 hectares (760 acres) in the Jasper Ridge Biological Preserve of Stanford University; and
5. Approximately 2,700 hectares (6,678 acres) on Coyote Ridge ("Morgan Hill zone").

Each of these areas contains appropriate soils that support larval food plants and adult nectar plants of the bay checkerspot. Not all of the vegetation within each proposed area was suitable habitat for the bay checkerspot, since the purpose of critical habitat designation is to highlight easily identifiable boundaries that encompass one or more areas of habitat that meets the needs of the species. The Service found that critical habitat was not determinable at the time of listing of the species as threatened (U.S. Fish and Wildlife Service 1987).

***Research and Monitoring.*** - Bay checkerspots have been the ongoing subject of a long-term research program initiated by Paul Ehrlich of Stanford University in 1960, and which has been carried out by Ehrlich, colleagues and their students (Ehrlich *et al.* 1975, Ehrlich and Murphy 1987). Their research has covered many aspects of bay checkerspot biology, but particularly their population biology, and has included field studies carried out at Jasper Ridge, Kirby Canyon (see below), Edgewood Natural Preserve, and other locations. The understanding of bay checkerspot biology that has resulted from this work has greatly enhanced this recovery plan, and should continue to contribute to the conservation of the butterfly and other serpentine-associated species. Much of the research is now carried out under the auspices of the Center for Conservation Biology in the Department of Biological Sciences at Stanford University. Scientists at the Center are also actively involved in monitoring bay checkerspot populations throughout its range.

***Jasper Ridge Biological Preserve***. - This 500-hectare (1,200-acre) area is owned by Stanford University and operated as a biological preserve. The serpentine grassland areas of the preserve, totaling less than 10 hectares (25 acres) contain the Jasper Ridge bay checkerspot population. Numerous field research projects are carried out at the preserve by Stanford faculty, students, and associates. There is no conservation easement or other formal deed restriction on use of the land.

***Kirby Canyon Landfill***. - Shortly before listing the bay checkerspot, the U.S. Fish and Wildlife Service entered into a conservation agreement with Waste Management of California, Inc., and the City of San Jose. This agreement was made under provisions of section 7(a)(4) of the Endangered Species Act, and provides mitigation and compensation for the take of bay checkerspots due to the construction and operation of a landfill at Kirby Canyon, located in and adjacent to the large Kirby bay checkerspot population. Principal provisions of the agreement include 1) limited impacts to the total area of bay checkerspot habitat, with impacts concentrated in lower quality habitat, 2) phased landfill use, with restoration of filled areas with appropriate vegetation, 3) a 15-year lease of 107 hectares (267 acres) of high quality habitat for purposes of bay checkerspot conservation from Castle and Cooke California, Inc., 4) restoration and management of bay checkerspot habitat, 5) monitoring bay checkerspot populations and habitat, 6) possible acquisition (for protection) of bay checkerspot habitat, and 7) establishment of a trust fund to finance the measures of the agreement (Murphy 1988).

Currently, revegetation efforts at Kirby Canyon are behind the original schedule, in large part due to lower than expected rates of landfill filling and cell closure. Waste Management has voluntarily committed to 50 percent funding of the agreement for an additional 3 years beyond the required 10 year period, now ended.

Waste Management has shown cooperative interest and the 1986 conservation agreement has helped mitigate the effects of the landfill. The agreement has made a few concrete advances in the conservation of the bay checkerspot, however, permanent protection of bay checkerspot habitat has not been achieved yet. The 15-year lease of some of the most densely populated habitat in the world for bay checkerspot ends in less than 5 years. Approximately $300,000 is currently in the trust fund, which could be applied toward protection of habitat for the Kirby core population.

***Silver Creek Butterfly Conservation Area***. - A housing and golf course project, associated with the Silver Creek Valley Country Club and Shea Homes in the Silver Creek area, led to another agreement to protect bay checkerspot habitat. Construction of about 1,500 homes and a golf course on more than 600 hectares (1,500 acres) in the Silver Creek Valley, east of San Jose, resulted in loss of approximately 7.5 hectares (18.5 acres) of serpentine habitat for the bay checkerspot. As compensation, in 1991, Shea Homes established a permanent, 46.69 hectares (115.4 acres) butterfly habitat conservation area in the Silver Creek Hills, and provided for management and 10 years of monitoring of the reserve. Shea Homes also deposited $100,000 to an account dedicated to regional conservation of the bay checkerspot; this money is available for use at the direction of the U.S. Fish and Wildlife Service. After the Silver Creek Valley Country Club project is complete, Shea Homes will turn over responsibility for the butterfly habitat conservation area to the Silver Creek Valley Country Club Homeowners Association.

After the establishment of the Silver Creek Hills butterfly habitat conservation area, the population of bay checkerspot within the habitat reserve increased markedly, to low tens of thousands of adults in 1993 and 1994. Subsequent delays in implementing necessary management actions are thought to have caused the dramatic crash of this population in 1995 and 1996. In 1997, no post-diapause larvae were found and only three adults were observed in the annual monitoring. Nevertheless, with proper management, this population has good potential to recover from its current low level. Substantial populations of bay checkerspot are located on nearby property in the Silver Creek Hills and in the nearby San Felipe habitat area.

***Edgewood Natural Preserve***. - The Edgewood population in San Mateo

County was formerly threatened by proposed golf course development in Edgewood County Park, however, its position is now more secure. In 1993, the San Mateo County Board of Supervisors closed the golf course issue and adopted a resolution designating Edgewood County Park a natural preserve--"a scenic and natural area where outstanding features as well as significant wildlife habitats are preserved in their present state for the enjoyment, education and well-being of the public" (San Mateo County 1996). The County also modified its agreement and easement with the Midpeninsula Regional Open Space District to prohibit golf course development and to emphasize natural resource preservation and low intensity recreation in the park. A draft master plan for the park has been published, which outlines measures to protect serpentine grasslands and their sensitive species, including the bay checkerspot (San Mateo County 1996).

***Introductions***. - Establishment of new bay checkerspot populations was investigated by Harrison (1989). She experimentally translocated 100 post-diapause larvae to each of 38 serpentine grassland areas, from 0.1 to 120 hectares (0.25 to 300 acres) in size. Success in establishing new populations was relatively low--24 percent survived 3 years--possibly because rainfall was low in the wet season following establishment.

***San Bruno Mountain Habitat Conservation Plan***. - Only one Habitat Conservation Plan potentially addressing the bay checkerspot has been prepared: the San Bruno Mountain Area Habitat Conservation Plan. Adopted in 1983, this was the first Habitat Conservation Plan, covering some 1,400 hectares (3,400 acres) in northern San Mateo County and identifying 7 animal species (including the bay checkerspot, which was not listed at the time) and 44 plant species to be conserved. However, the focus of the plan is the two butterfly species listed at the time (mission blue and San Bruno elfin), the callippe silverspot butterfly, and their host plants. The permit issued by the U.S. Fish and Wildlife Service for the San Bruno Habitat Conservation Plan (PRT 2-9818, expires March 31, 2013) currently has no provision for incidental take of bay checkerspots. The species was extirpated from the Habitat Conservation Plan area around 1986 by fires, non-native plant invasion, and natural fluctuations. Reintroduction of the bay checkerspot on San Bruno Mountain is an objective of this plan.

## 6. Recovery Strategy

The recovery strategy for the bay checkerspot is discussed below with tasks listed in approximate order of importance. This strategy includes the conservation measures recommended by Murphy and Weiss (1988*a*) to ensure long-term survival of the bay checkerspot.

Habitat protection will be essential to bay checkerspot recovery. Factors to consider in deciding which habitat areas to protect should include: 1) habitat size and quality, including habitat diversity; 2) location in relation to other habitat patches, and to core populations; 3) presence, current or historic, of bay checkerspots; and 4) ease and cost of protection. Habitat protection should include buffer zones as necessary.

Because sustainable grazing practices appear to be consistent with conservation of the bay checkerspot, protective measures short of full fee-title land acquisition should be possible. For example, ranchers wishing to preserve their way of life might contribute to this end and to bay checkerspot conservation by selling certain forms of development rights on their lands in perpetuity. Grazing may be less compatible with certain rare plants, however, so such arrangements will have to be approached on a case by case basis.

With recent San Mateo County resolutions, agreements, and plans to preserve its natural character, Edgewood Natural Preserve seems at present to require little further legal protection. Santa Clara County Department of Parks and Recreation lands are partially protected, but the U.S. Fish and Wildlife Service will need to work with the County to identify appropriate limits on recreational development in sensitive areas. Habitat management may be needed on many or all of these county park lands.

Other than the already fully or partially protected park lands, bay checkerspot habitat areas can be ranked in approximate order of priority for the butterfly, based on current understanding (numbers in parentheses indicate approximate areas of serpentine habitat):

1) Core habitat areas--
   a) Kirby (1,600 hectares [3,900 acres]),
   b) Metcalf (460 hectares [1,100 acres]),
   c) San Felipe (320 hectares [780 acres]),
   d) Silver Creek Hills (410 hectares [1,000 acres])
2) Potential core areas--Santa Teresa Hills (440 hectares [1,100 acres])
3) Larger, good quality habitat areas near core populations--
   Tulare Hill (120 hectares [300 acres]),
   north of Llagas Avenue (170 hectares [420 acres]),
   west hills of Santa Clara Valley (30 hectares [74 acres])
4) Stepping stones--Tulare Hill, Santa Teresa Hills, Redwood City
5) Other current or historic localities or suitable habitat areas, generally larger than 1 hectare (2.5 acres), within the historic range of the butterfly, identified for their habitat value, function as dispersal corridors, proximity to other habitat, or other biological value.

All of these areas are considered essential to the recovery of the bay checkerspot.

Habitat restoration and management will be needed on many bay checkerspot habitat areas. Appropriate grazing management should ensure that habitats are neither overgrazed nor overgrown. Weeding, biological control, mowing, herbicides, and fire also should be considered as possible tools to control non-native plant species. Research will have to be conducted and adaptive management techniques incorporated, since no optimal management prescription is now known, and different areas are likely to need different management. For example, eastern Santa Clara County habitats are thought to require more vegetation management than San Francisco Peninsula habitats (Murphy and Weiss 1988*a*).

Monitoring of populations will serve to identify, on an ongoing basis, populations that are in trouble and in need of recovery efforts, as well as populations that are healthy and suitable as sources of individuals for reintroduction efforts. Monitoring methods are well known for both adults and post-diapause larvae (Murphy and Weiss 1988*b*). Monitoring of larvae has several advantages over capture-mark-recapture studies of adults, including: 1) it has fewer impacts--individuals do not need to be handled; 2) it is low-cost and requires less effort than mark-recapture; and 3) it measures small-scale spatial variation in the population, which can provide a better understanding of important demographic processes. Larval population estimates can be extended to estimates of adult population sizes by applying estimated mortality rates for late-instar larvae and pupae (Murphy and Weiss 1988*b*).

Establishment/reestablishment of populations is likely to be a useful tool to increase the number of bay checkerspot individuals and populations, and thus reduce extinction risk. Even in cases where extirpated populations would probably be reestablished eventually by natural immigration, proactive, assisted reintroduction should increase the total bay checkerspot population and reduce the risk of metapopulation-wide extinction due to unforeseen events. Establishing or reestablishing bay checkerspot populations should only be done on protected public lands and private lands with the full permission and cooperation of the landowners.

Apparently suitable but unoccupied habitats adequate to support large bay checkerspot populations are obvious candidates for reintroduction; as are areas important to the metapopulation dynamics of the species, and areas where the bay checkerspot has recently been extirpated but its reestablishment seems feasible. If bay checkerspots were to be extirpated from a core habitat area, such as Edgewood Natural Preserve, reestablishment there would be a high priority. Jasper Ridge Biological Preserve and the Silver Creek Hills Butterfly Habitat Conservation Area may be immediate candidates for reintroduction efforts if the bay checkerspot populations there go extinct.

The feasibility of establishing bay checkerspot populations on non-serpentine soils where a suitable plant community has been restored should be pursued. While the bay checkerspot may have occurred in non-serpentine grasslands in the past, reestablishing bay checkerspots on non-serpentine habitats will be hampered by the difficulty of restoring native California grassland communities. One such tertiary habitat area where reestablishment is appropriate is San Bruno Mountain.

Reintroduction of the bay checkerspot at San Bruno Mountain will have to be preceded by vegetation restoration.

Public outreach on the status and needs of the bay checkerspot will assist the recovery of this species. Public outreach should address the rarity, biological value, and fragility of San Francisco Bay Area serpentine grassland ecosystems, as well as particular steps citizens can take to protect them. Outreach may take many forms, such as appropriate signage at Edgewood Natural Preserve and Santa Teresa County Park or other locations, coordination and informational exchanges with county park personnel, informational handouts available to interested parties, an Internet web page, and public talks. Outreach to particular agencies, landowners, or businesses may be needed; for example, to address appropriate precautions for pesticide use on California oakworm or other pests near bay checkerspot localities.

Artificial rearing could augment reintroduction efforts, by allowing a few captured butterflies to produce hundreds or thousands of offspring for reintroduction. Techniques for rearing post-diapause larvae of the bay checkerspot to adulthood, mating, and egg-laying are known. Unfortunately, techniques to reduce high mortality of pre-diapause larvae in captivity have not yet been demonstrated. If artificial rearing through the pre-diapause stage appears desirable, further research on appropriate rearing techniques may be needed.

The following bay checkerspot research needs have been identified, in approximate order of priority:

1. *Vegetation management.* Develop vegetation management techniques that enhance bay checkerspot survival and reproduction. This research could start with quantifying the grazing management methods currently used at Kirby Canyon. Eventually, a variety of techniques should be tested experimentally, over a variety of years and sites, and adapted as appropriate. The development and use of practical biological control methods should be supported.
2. *Air pollution.* Determine the amount of nitrogen deposition at different

sites across the bay checkerspot's range. Assess the impact of nitrogen deposition and other air pollutants on the butterfly's populations, including the variation in air pollution impacts at different sites. What is the most plausible scenario of cumulative long-term impacts? Set confidence limits on this scenario if possible. Identify possible actions that would reduce or eliminate adverse effects.

3. *Habitat restoration.* Determine the feasibility of restoring bay checkerspot habitat on serpentine and non-serpentine soils. Assess whether previously undetermined factors have been limiting bay checkerspot recovery on apparently favorable habitat, such as Jasper Ridge. Develop restoration methods if appropriate.
4. *Artificial rearing.* Develop techniques for rearing large numbers of bay checkerspots through all life stages.
5. *Role of nectar resources.* Investigate the relative importance of various nectar plant species to survival and reproductive success of both male and female bay checkerspots in the wild. Does the role of nectar or of particular nectar sources vary from year to year?

## P. Animal Species of Concern

### 1. Opler's Longhorn Moth (*Adela oplerella* Powell)

***Taxonomy.*** - Adelid moths, a genus of small, day-flying moths including Opler's longhorn moth, belong to the Family Incurvariidae, along with the yucca moths and other small moths that share certain ancient characteristics as well as a piercing ovipositor (egg-laying appendage) for laying eggs in plant tissue (Forbes 1923, Davis 1967, Powell 1969; some recent workers identify them as a separate family, Adelidae). The adelids are also known as fairy moths. *Adela oplerella* Powell (Opler's longhorn moth) was first described by J.A. Powell in his synopsis of Nearctic adelid moths (Powell 1969), with the genus sometimes subsequently being misspelled as "*Adella*" in the literature and in government documents. The moth is named for Paul A. Opler, who collected many of the specimens used to describe this species, including the type specimen collected with W. J. Turner in

1967, near Nicasio, Marin County.

***Description.*** - Opler's longhorn moth is a small, dark brown, hairy moth with a wingspan ranging from approximately 9 to 14 millimeters (0.35 to 0.55 inch) (Figure II-38). The adults have shorter antennae than most longhorn moths--only slightly longer than the forewing in the male and shorter than the forewing in the female. The forewings are a dark olive-bronze, metallic-looking when fresh, without markings or with two faint whitish spots. The hindwings are dark brown with a purplish reflectance when fresh (Powell 1969).

***Identification.*** - From related moths, the adelids are most easily distinguished by the long antennae, which are often two to three times the length of the forewing in the males. Adelid moths are often brightly colored moths, and color features alone will readily separate nearly all the North American species (Borror *et al.* 1981, Powell 1969). Opler's longhorn moth is most similar to *Adela thorpella* (Thorp's longhorn moth), with the two occurring together in central coastal California. In addition to its shorter antennae, Opler's longhorn moth is smaller, darker, and has smaller eyes in the male than Thorp's longhorn moth (Powell 1969).

***Historical and Current Distribution*** - The historic range of Opler's longhorn moth is believed to have included serpentine and possibly some non-serpentine grassland from most of the greater San Francisco Bay Area counties, possibly extending to adjacent counties such as Lake County to the north and Santa Cruz County to the south (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997) (Figure II-39). However, because studies on this moth are made difficult by the short time mature adults are active and flying (often as little as 2 weeks), it is possible that Opler's longhorn moth could have been overlooked at other serpentine soil sites within its possible historic range, e.g., Lake County and other counties in relatively close proximity with suitable serpentine soil habitats (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). At least 13 areas with serpentine soils within the current range of Opler's longhorn moth cover more than 17 hectares (40 acres) each (McCarten 1986, 1987), but have never been completely surveyed for this species. Most of these unsurveyed areas are private

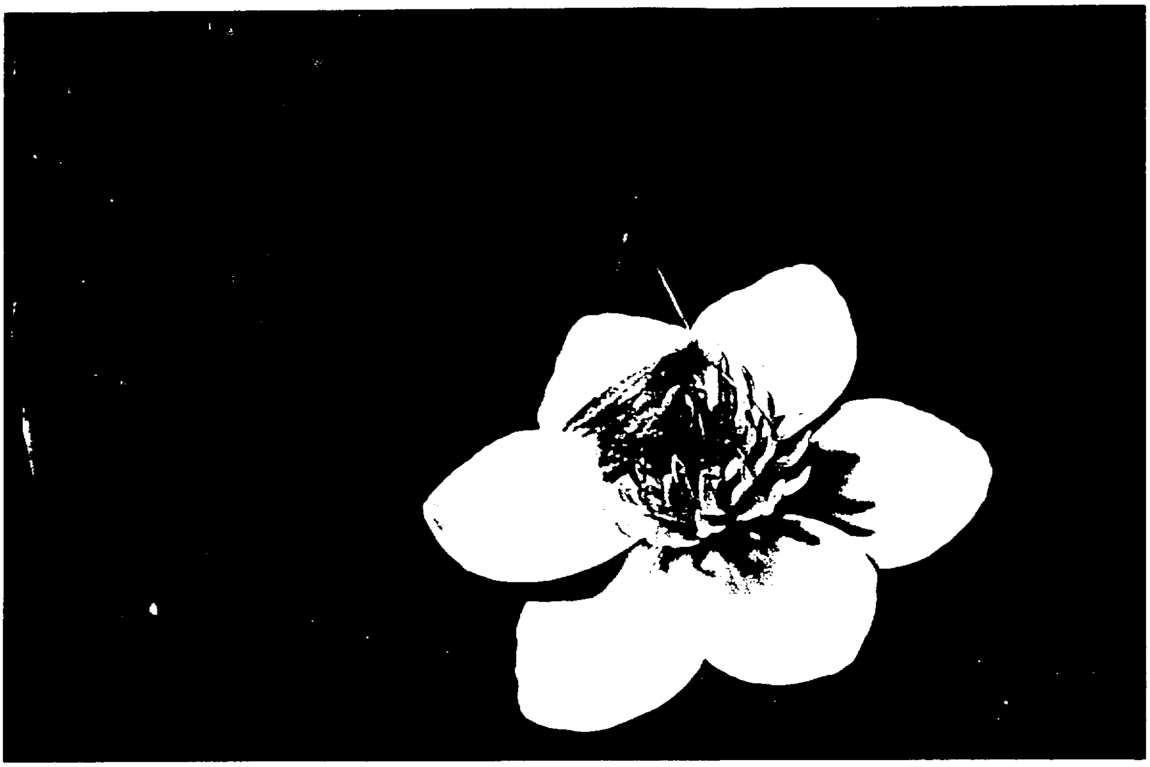

**Figure II-38.** Opler's longhorn moth (*Adela oplerella*) on flower of its host plant, California cream cups (*Platystemon californicus*). The flower is roughly 3 centimeters (1 inch) across. Photo by Paul A. Opler, used with permission.

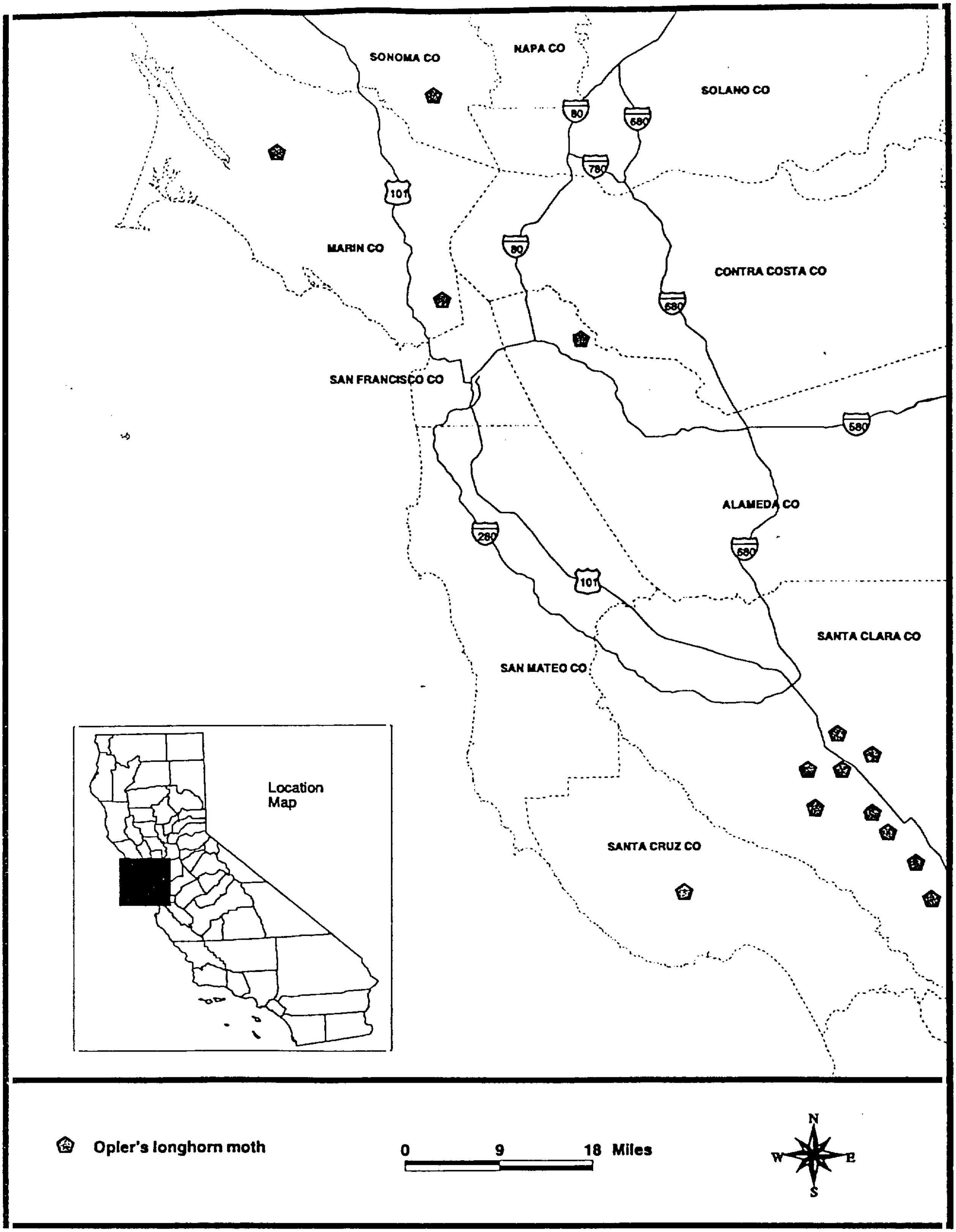


**Figure II-39.** Distribution of Opler's longhorn moth (*Adela oplerella*).

land, and therefore, the historic range, distribution, and number of Opler's longhorn moth populations are unclear (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

Historical records from the turn of the century indicate that Opler's longhorn moth occurred in San Francisco County (Powell 1969). Lake Merced, near the Pacific Ocean in San Francisco County, is listed as the locality for one male and three female specimens collected in 1908 and 1909 (Powell 1969). However, no specimens have been collected since 1909, indicating its likely extirpation from this county (J. Powell, pers. comm., 1997). Small, scattered patches of serpentine habitat still remain in pockets throughout the county, however usually in highly urbanized areas (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). Several areas of serpentine soils in the San Francisco Bay Area have been covered by development for decades (e.g., Hunters Point in San Francisco); hence, their past potential for supporting Opler's longhorn moth is unknown (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). Although the host plant, *Platystemon californicus* (California cream cups), has been found on San Bruno Mountain, numerous surveys there have proven negative for the presence of Opler's longhorn moth (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). Extensive surveys since the 1960's have failed to recover any Opler's longhorn moths from anywhere on the San Francisco Peninsula (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

In 1965, Opler's longhorn moth was collected in the New Almaden area, west of Calero Reservoir in southern Santa Clara County (Powell 1969, A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). These serpentine areas were patchy but extensive, and 35 specimens of the moth were collected in three locations referred to as, "1 mi north," "1.5 miles north," and "3.5 miles northeast" of New Almaden (Powell 1969, A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). Specimens from these three historic New Almaden locations were used by Powell (1969) in describing Opler's longhorn moth. Presence of the moth in this area was reconfirmed in 1998 (A. Launer, pers. comm., 1998).

In recent years, Opler's longhorn moth has been recorded from 14 sites, extending along the west side of San Francisco Bay from 8 kilometers (5 miles) southeast of Nicasio in Marin County south to the Scott's Valley area of Santa Cruz County, and also from the Oakland Hills area on the inner Coast Ranges (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). With the exception of the one disjunct population in Santa Cruz County, this species has not been collected outside of the San Francisco Bay Area (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

The distribution for Opler's longhorn moth is far more restricted than its exclusive host plant, California cream cups, (*Platystemon californicus*), which occurs fairly widely throughout California (Hickman 1993), often on "poor" soils (Murphy *et al.* 1991). The closely related sister taxon, Thorp's longhorn moth, which also uses *Platystemon californicus* as its exclusive host plant, often occurs in close association with Opler's longhorn moth in central coastal California locations (Powell 1969, J. Powell, pers. comm., 1997). Extensive surveys for both moths have revealed that Thorp's longhorn moth is found essentially throughout the range of *Platystemon californicus* in California, whereas Opler's longhorn moth is found exclusively on *Platystemon californicus* in habitat comprised of serpentine soil outcrops in central coastal California (J. Powell, pers. comm., 1997). Other than the localities listed below, repeated surveys of accessible, presumably suitable serpentine habitat within the known range of the species over many years have failed to detect any additional Opler's longhorn moth populations (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

There are two populations of Opler's longhorn moth known from Marin County. The Ring Mountain Preserve, located on the Tiburon Peninsula, contains the largest and most stable population of Opler's longhorn moth (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). The Preserve was owned and managed by The Nature Conservancy from 1982 to 1995, when it was transferred to the Marin County Parks and Open Space District (C. Bramham, pers. comm., 1997). The other Marin County population, where the type locality for Opler's longhorn moth was collected, is located approximately 8 kilometers (5 miles) east-southeast of Nicasio (Powell 1969, A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

One population is known from Sonoma County, approximately 3 kilometers (2 miles) north of the junction of Highway 37 and Lakeville Road, and to the northwest of Sears Point Raceway (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

The one locality in Alameda County, in Redwood Regional Park in the Oakland Hills, near the East Bay Regional Parks headquarters, is a population in a small, disturbed patch of remnant serpentine habitat (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). The status of this population has not been studied since 1990.

There are nine populations of Opler's longhorn moth in Santa Clara County. The large population at Kirby Canyon Butterfly Reserve is situated on one of the largest remaining intact blocks of habitat, located in part on Waste Management's leases from Castle and Cooke California, Inc. (Thomas Reid Associates and Murphy 1992, A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). The reserve is a 107-hectare (267-acre) area set aside until the year 2000 as mitigation for the development of the Kirby Canyon Landfill, and is located on Coyote Ridge, north of Anderson Lake. The Silver Creek butterfly habitat conservation area contains a population of Opler's longhorn moth which has been preserved as a result of bay checkerspot butterfly mitigation for the construction of Silver Creek Valley Country Club Estates in southeastern San Jose (A. Launer, pers. comm., 1997). Tulare Hill, located in north central Santa Clara Valley, supports a large population of the moth (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). A small population is known from the "Kalana Hills," in the western foothills of central Santa Clara Valley (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). Opler's longhorn moth has been observed at Santa Teresa County Park (R. Arnold, *in litt.*, 1992) and west of Calero Reservoir (A. Launer, pers. comm., 1997, 1998, J. Powell, pers. comm., 1997). The moth is also known from the privately-owned Hale property, also in the southwest Santa Clara Valley, but no recent surveys have confirmed its continued presence (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). East of the Hayes Valley, near San Martin in southern Santa Clara Valley, there is a population of Opler's longhorn moth which occurs on serpentine soils located primarily within the dedicated open space of a subdivision of private homes (A. Launer, pers.

comm., 1997, J. Powell, pers. comm., 1997). The southernmost portion of Santa Clara County, just north of Gavilan College, to the west of Santa Teresa Boulevard and south of Gilroy, also contains a remnant patch of intact serpentine grasslands which supports a small population of Opler's longhorn moth (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

The only known population of Opler's longhorn moth not found on serpentine soils occurs in central Santa Cruz County (A. Launer, pers. comm., 1997). This isolated population is found in the mountains near Scott's Valley, north of Vine Hill School, in relatively dry, infertile grasslands on soils derived from marine sandstone deposits (A. Launer and D. Murphy, *in litt.*, 1991). No surveys for Opler's longhorn moth have been conducted at this site since 1990 (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). This population may prove to be significant in the long-term conservation of the species by providing data on suitable habitat characteristics of non-serpentine soils, that could guide reintroduction efforts into non-serpentine soils habitat.

Although apparently suitable serpentine habitat exists in San Mateo County in a number of locations, numerous surveys since the 1960's have failed to recover any Opler's longhorn moth (A. Launer, pers. comm., 1997, J. Powell pers. comm., 1997). Powell conducted up to four or five surveys per year during the period of 1985 to 1990 in appropriate habitat without finding Opler's longhorn moth (J. Powell pers. comm., 1997). Surveys on two populations of the moth's host plant, *Platystemon californicus*, during appropriately timed biweekly periods in 1991 in Edgewood Natural Preserve revealed the presence of Thorp's longhorn moth, but failed to recover any Opler's longhorn moths (J. Powell pers. comm., 1997).

***Reproduction and Demography.*** - North American adelid moths are believed to undergo a single annual generation (Powell 1969, J. Powell, pers. comm., 1997). Opler's longhorn moth completes the active portions of its life cycle in a single season, the winter-spring wet season (Powell 1969, J. Powell, pers. comm., 1997). Adults fly, mate, and females lay their eggs over approximately the same period as bay checkerspots: generally from mid-March to late April, though the exact timing varies from year to year depending on the weather (Murphy *et al.*

1991). At any one population location, the flight season may only last two or three weeks. Survival through the dry season is accomplished by prepupal larvae or pupae in larval cases (Powell 1969, J. Powell, pers. comm., 1997). A related European species can live 2 years in the larval stage (Ford 1949).

Adult Opler's longhorn moths are almost always found within a few meters (yards) of *Platystemon californicus*, and within that constraint are fairly commonly found on potential nectar plants including goldfields (*Lasthenia* sp.), tidy tips (*Layia* sp.) and linanthus (*Linanthus* sp.). The adults appear to have functional mouthparts, but it has not yet been proved that they take nectar (A. Launer, pers. comm., 1998). The importance of nectaring , if any, for survival and reproduction has not been investigated.

Opler's longhorn moth possesses a well-developed piercing ovipositor, which the female uses to insert her eggs directly into the unopened flowers of the host plant, California cream cups (*Platystemon californicus*) (Powell 1969, J. Powell, pers. comm., 1997). Incurvariids are commonly seed parasites, with the larvae hatching and beginning their development inside the host plant fruits by consuming the developing seeds (Powell 1969, J. Powell pers. comm., 1997). In most adelids, after the larvae have fed upon the host plant for a period of a few weeks, usually at the second or third instar stage, the larvae then drop to the ground where they feed on lower parts or fallen, perhaps even dead leaves of the same or other plants (Powell 1969, J. Powell pers. comm., 1997). After dropping from the flower, members of both *Adela* and *Nemophora* (a closely related genus) feed as larger larvae within flat, usually pear- or figure eight-shaped cases that they construct on the food leaves (Powell 1969), but such feeding cases have not yet been described for Opler's longhorn moth. The larvae may enter diapause during the hot dry summer and re-emerge during the rainy winter, when they resume feeding on *Platystemon californicus*. Pupation is thought to occur within the feeding case (J. Powell pers. comm., 1997).

Contrary to successful efforts with related adelid species in Europe (Powell 1969), efforts to rear Nearctic adelid species (including Opler's longhorn moth) in the laboratory have not proven successful (Powell 1969, J. Powell, pers. comm., 1997).

Field observations as well as available data and anecdotal information indicate that Opler's longhorn moths are not strong fliers (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997, S. Weiss, pers. comm., 1997). They typically flutter slowly just a few inches above ground level. A study was conducted in 1995 at the Kirby Canyon site in Santa Clara County by researchers from Center for Conservation Biology of Stanford University, to assess the distance and directionality of Opler's longhorn moth dispersal. The results showed that 95 percent of marked and recaptured moths were recovered within 50 meters (164 feet) of their initial release point (A. Launer, pers. comm., 1997, S. Weiss, pers. comm., 1997). The moths flew significantly shorter distances before recapture in habitat with higher densities of their host plant, *Platystemon californicus;* conversely, they were recovered farther away from the point of release when they encountered habitat with lower densities of *Platystemon californicus*. If there were no host plants apparent, Opler's longhorn moths appeared to search more intensively for their host plant in the initial release area rather than investigate or cross areas supporting little or no suitable habitat (A. Launer, pers. comm., 1997, S. Weiss, pers. comm., 1997).

In some locations in which Opler's longhorn moth is found, surveys have shown that the populations may persist over the short term in relatively small patches of habitat (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). Areas as small as several square meters (20 to 50 square feet) of suitable habitat have apparently maintained populations of the moth over several years (J. Powell, pers. comm., 1997). The future of populations as small as these is highly uncertain, and they are unlikely to persist over the very long term necessary to maintain the survival of the species.

It is presumed that the lack of strong flying ability results in very little annual or intermittent recolonization by this moth of suitable but unoccupied habitat at flight distances more than 1 kilometer (0.6 mile) (A. Launer pers. comm., 1997). No genetic or ecological studies have been done to date to test this assumption. Although Opler's longhorn moth fits criteria for a species exhibiting metapopulation characteristics, its dispersal scale appears to be on the order of hundreds of meters (yards), instead of thousands as in the case of the bay checkerspot butterfly.

***Habitat and Community Associations.*** - The larval host plant of Opler's longhorn moth is *Platystemon californicus*, a native annual plant in the poppy family (Papaveraceae). The moth is usually found associated with populations of *Platystemon californicus* in grasslands on serpentine soils, and often co-occurs with one or more sympatric adelid species (Powell 1969). Much of the data obtained for Opler's longhorn moth habitat and community associations were gathered during research on the federally listed bay checkerspot butterfly, since they often co-occur in the greater San Francisco Bay Area.

Habitat for Opler's longhorn moth exists in the San Francisco Bay Area on shallow, serpentine-derived or similar soils, which support the moth's larval food plants, as well as potential nectar sources for adults. Remaining serpentine soils in the San Francisco Bay Area are very limited in area, with Opler's longhorn moth inhabiting island-like patches of suitable habitat isolated by intervening unsuitable habitat and urban development. As with the bay checkerspot butterfly, it is unclear whether Opler's longhorn moth is an obligate (limited; bound to a restricted environment) serpentine soil species, or if, due to habitat degradation, fragmentation, and reduction, it has become more restricted to serpentine habitats (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). The presence of a population on non-serpentine soils in Santa Cruz County suggests that this moth is not a serpentine obligate. However, further research on the habitat characteristics of the outlying Santa Cruz County population is needed to clarify this relationship.

***Reasons for Decline.***- Primary reasons for the decline of Opler's longhorn moth are urban and suburban development, and habitat degradation and loss caused by nonnative plants displacing or reducing native food plants. Since the Federal listing of the bay checkerspot butterfly in 1985, destruction of serpentine habitats within the range of the moth has slowed considerably, but continues at a low rate, primarily in suboptimal habitat (H. Graham, pers. comm., 1997, A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). At present, only Ring Mountain in Marin County, and Tulare Hill, Silver Creek Hills, and the Kirby Canyon Butterfly Preserve in Santa Clara County support large populations of Opler's longhorn moth (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

Habitat loss, primarily due to residential and commercial development, has reduced the number and the size of extant Opler's longhorn moth populations (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). Although Opler's longhorn moth was collected near Lake Merced in 1908 and 1909 (Powell 1969), no specimens have been collected since then. Extensive urban development has left only very small, scattered patches of serpentine habitat in pockets throughout San Francisco County. Even though the Kirby Canyon Landfill operation in Santa Clara County formulated a conservation agreement to temporarily protect habitat (107 hectares [267 acres] in the Kirby Canyon Butterfly Reserve for 15 years) as mitigation for bay checkerspot butterfly impacts, the co-occurring Opler's longhorn moth suffered a net reduction of approximately 325 hectares (800 acres) of habitat (A. Launer, pers. comm., 1997). No Opler's longhorn moth habitat remains today at the former New Almaden locality. Housing development has virtually eliminated serpentine soil grasslands at the location where the moth was previously collected (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). The construction of Silver Creek Valley Country Club Estates in central Santa Clara County resulted in the loss of approximately 7.5 hectares (18.5 acres) of serpentine habitat (A. Launer, pers. comm., 1997), where the bay checkerspot butterfly and Opler's longhorn moth co-occurred (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

Destroying serpentine habitats or reducing them to non-viable sizes has also eliminated stepping-stone habitats and increased the average distance between populations and habitat patches, making recolonization more difficult. Since Opler's longhorn moths seem to avoid leaving the vicinity of their host plants and are not strong flyers, habitat fragmentation has been a significant factor in the degradation of its habitat (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). The potential for a declining population to be rescued or recolonized from an extant population in a different habitat patch is small. In addition to the loss of habitat area, habitat fragmentation increases external threats by bringing sources of disturbance closer and increasing the amount of habitat near edges (Ehrlich and

Murphy 1987).

While livestock overgrazing, as well as the prolonged absence of grazing, may adversely affect the species, sustainable grazing practices may be compatible with the maintenance of Opler's longhorn moth populations (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997, S. Weiss, pers. comm., 1997). In some parts of the bay checkerspot range where Opler's longhorn moth co-occurs, grazing is used as a habitat management tool (Thomas Reid and Associates and Murphy 1987, Murphy 1988, Weiss 1996). In the absence of some form of vegetation management, aggressive, nonnative plants sometimes displace native plants, competing with *Platystemon californicus* and degrading the habitat for both the bay checkerspot butterfly and Opler's longhorn moth (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997, S. Weiss, pers. comm., 1997).

***Threats to Survival.*** - Many of the same factors that threaten the survival of the bay checkerspot butterfly may also threaten Opler's longhorn moth where they co-occur. Of these factors, urban and suburban growth in the species' range constitutes the largest threat to Opler's longhorn moth habitat. Several currently proposed or contemplated projects would affect serpentine grassland habitat in the current range of Opler's longhorn moth, including Cerro Plata, Calero Lake Estates, Metcalf Road widening, and development of the Richmond/Young Ranches. Other factors that may threaten this species include invasions of native grasslands by nonnative species, climate change, nutrient deposition from air pollution, pesticides, and discing to create firebreaks.

***Conservation Efforts.*** - Opler's longhorn moth was formerly a Category 2 candidate for Federal listing, but is now considered a species of concern (U.S. Fish and Wildlife Service 1996*a*).

Bay checkerspot butterfly research conducted by Paul Ehrlich and other researchers at Stanford University (i.e., Center for Conservation Biology staff) has contributed to conservation of the butterfly, as well as other serpentine-associated species, including Opler's longhorn moth (Ehrlich et al. 1975, Ehrlich and Murphy 1987). Center for Conservation Biology staff, along with Jerry Powell of the University of California at Berkeley, comprise virtually all the researchers who currently study Nearctic Adelids, including Opler's longhorn moth (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). Although no formal efforts have been undertaken to date specifically to ensure the long-term conservation of Opler's longhorn moth, habitat protected for the bay checkerspot butterfly has sometimes contributed to preservation of Opler's longhorn moth. Preserves where Opler's longhorn moth occurs include Ring Mountain in Marin County, and the Kirby Canyon Butterfly Reserve, Silver Creek Butterfly Conservation Area, and open space dedicated as part of the Lions Gate (Hayes Valley) development in Santa Clara County. The moth also occurs and receives a degree of protection though relatively little attention at several county or local parks, including Santa Teresa County Park in Santa Clara County, and Redwood Regional Park in Alameda County.

***Conservation Strategy***. - In locations where the two species co-occur, Opler's longhorn moth currently benefits to some extent from the "umbrella" of protections afforded to the federally listed bay checkerspot butterfly. In addition to these current protections, the seven components below compose the long-term conservation strategy for Opler's longhorn moth.

1) Protect all existing populations. The relatively large distances between disjunct populations, in conjunction with the moth's weak flying/re-colonization ability, necessitates the protection of all existing populations, including the few remaining serpentine habitat "stepping stones" for the dispersal and possible re-colonization of Opler's longhorn moth populations (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). Habitat protection should include a minimum buffer zone of 150 meters (500 feet). Landowners with existing populations of Opler's longhorn moth on their property could establish conservation easements or agreements to protect this species in perpetuity as well as any other co-occurring sensitive species.

Other than the already fully or partially protected park lands, Opler's longhorn moth habitat areas can be ranked in approximate order of priority for protection, based on current understanding:

a) Large populations -- i) Ring Mountain, ii) Kirby Canyon, iii) Silver Creek Hills, and iv) Tulare Hill.

b) Stepping stones -- i) Hale property, ii)"Kalana" Hills (western foothills of central Santa Clara Valley), and iii) Santa Teresa County Park.

c) Outlying, disjunct populations -- I) Joaquin Miller Park, ii) Nicasio, iii) San Martin, iv) State Route 37, and v) Redwood Regional Park.

d) Other current localities.

2) Appropriately manage and/or restore habitat. Appropriate management of all existing populations, and any newly-discovered populations, will be essential to Opler's longhorn moth long-term conservation. Because no optimal management prescription is now known, adaptive management techniques will have to be employed, including appropriate grazing management that ensures habitats are neither overgrazed nor overgrown (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). However, since grazing may adversely impact certain rare plants, habitat management will have to be approached on a case-by-case basis. Other possible management tools include weeding, mowing, herbicides, and fire in varying combinations to control nonnative plant species, since different areas are likely to need different management (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

3) Conduct appropriately timed surveys in all appropriate habitat. Many historic and potential locations should be surveyed during the appropriate time period to assess the moth's continued presence or to identify new populations (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

4) Annually monitor all existing populations, newly discovered populations, and any reintroduced populations. Monitoring is needed to identify any populations in decline and to reverse the decline, as well as to identify populations that are healthy and suitable as sources of individuals for reintroduction efforts.

5) Reintroduce Opler's longhorn moth to appropriate habitat, where feasible.

Opler's longhorn moth is not expected to be able to recolonize all potentially suitable habitats within their historic range because of their weak flying ability. Reintroduction efforts, therefore, are needed to increase the number of populations, thus reducing the risk of extinction from catastrophic events. Augmenting existing populations or reestablishing Opler's longhorn moth populations in suitable habitat within their historic range should only be done on protected public and private lands with the full permission and cooperation of the landowners. Large populations may provide sufficient numbers of adults to capture and reintroduce elsewhere (A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997). However, such reintroduction efforts would likely be dependent upon successful laboratory rearing of larvae or collection of pupae, neither of which has been accomplished to date (Powell 1969, A. Launer, pers. comm., 1997, J. Powell, pers. comm., 1997).

6) Conduct public outreach. Public outreach should address the rarity, biological value, and fragility of San Francisco Bay Area serpentine grassland ecosystems, as well as particular steps citizens can take to protect them. Information should be coordinated and exchanged with county and local parks agencies, county and municipal planning agencies, and environmental organizations regarding conservation of the Opler's longhorn moth

7) Conduct necessary research in the following areas:

a) *Vegetation management.* Develop vegetation management techniques that enhance Opler's longhorn moth and bay checkerspot butterfly survival and reproduction. This research could start with quantifying the grazing management methods currently used at Kirby Canyon. Eventually, a variety of techniques should be tested experimentally, over a variety of years and sites, and adapted as appropriate.

b) *Air pollution.* Determine the amount of nitrogen deposition at different sites across the Opler's longhorn moth's range. Assess the impact of nitrogen deposition and other air pollutants on the moth's populations, including the variation in air pollution impacts at different sites. Identify possible actions that would reduce or eliminate adverse effects.

c) *Habitat restoration.* Determine the feasibility of restoring Opler's longhorn moth habitat on serpentine and, if deemed appropriate, on non-serpentine soils. Assess whether previously undetermined factors have been limiting Opler's longhorn moth recovery on apparently favorable habitat, and develop restoration methods, if appropriate.

d) *Demographic research.* Investigate phenological correlation of the moth with host plant, egg/ larval/ adult mortality rates, sex ratios, vulnerable life stages, and percentages and counts of individuals overwintering as larvae or pupae.

e) *Genetic research.* Investigate dispersal distances, immigration rates and population genetics in small/ isolated habitat patches, genetic relationship among distant populations, and the genetic relationship of the outlying Santa Cruz population on non-serpentine soils to other populations.

f) *Artificial propagation.* Investigate feasibility and methods for artificially rearing Opler's longhorn moth. Determine optimal methods for field collections of different life stages, and assess relative differences in rearing collected eggs, larvae, and pupae to maturity in the laboratory.

## 2. Blind and Microblind Harvestmen

***Species Covered:*** Two species of blind harvestman, the Marin blind harvestman (*Calicina diminua*) and the Edgewood blind harvestman (*Calicina minor*), and five species of microblind harvestman are endemic to serpentine habitats in the San Francisco Bay Area and highly restricted in their ranges. The five microblind harvestman species are: Edgewood microblind harvestman *(Microcina edgewoodensis),* Hom's microblind harvestman *(Microcina homi),* Jung's microblind harvestman *(Microcina jungi),* Fairmont microblind harvestman *(Microcina lumi),* and Tiburon microblind harvestman *(Microcina tiburona)*. Blind harvestman and microblind harvestman are related to spiders but are in the Order Opiliones, generally known as harvestmen or "daddy-longlegs."

***Taxonomy.*** - The harvestman Order Opiliones contains around 3,200 species worldwide, with the majority of species occurring in tropical regions (Jones

1983). Members of the genera *Calicina* [Sitalcina] and *Microcina* (the blind harvestmen) belong to the Family Phalangodidae, arachnids which are characterized by simple paired claws on the posterior tarsi (terminal segments on insect and spider legs). The phalangodid genus *Sitalcina*, established by Banks (1911) for the California harvestman (*Sitalces californicus* Banks), was revised by Briggs (1968). Ubick and Briggs (1989) showed that the genus *Sitalcina* was polyphyletic (derived from more than one ancestral line) and transferred many of the species to new genera, *Calicina* and *Microcina* (Briggs and Ubick 1989). Identifications of these blind and microblind harvestmen species are typically made using male genital characteristics; no characters have been found to reliably distinguish the females (Briggs and Ubick 1989).

***Description***. - Harvestmen typically have unusually long and thin legs in relation to their small, oval-shaped body. In addition to the familiar daddy-longlegs, there are also tiny, mite-sized harvestmen, such as the roughly 1 millimeter long (0.06 inch) harvestmen species covered in this recovery plan (Figure II-40).

***Identification.*** - The most evident distinguishing characteristic between the two genera is the presence of an eyespot or eye in the genus *Calicina*, whereas the *Microcina* all lack eyespots (T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). These animals are nearly microscopic, but are easily detected when their yellow, orange or reddish-brown body coloration contrasts with the undersides of displaced wet stones, and by their motionless stance or slow movements (Briggs 1968).

***Historical and Current Distribution.*** (Figure II-41) - Blind and microblind harvestmen are endemic to California.

The Edgewood blind harvestman (*Calicina minor*) co-occurs with two other federally listed species in the Edgewood Natural Preserve: the threatened bay checkerspot butterfly (*Euphydryas editha bayensis*), and the endangered San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii*), and with another species of concern, the Edgewood microblind harvestman (*Microcina edgewoodensis*). The Edgewood blind harvestman was formerly known from two populations in

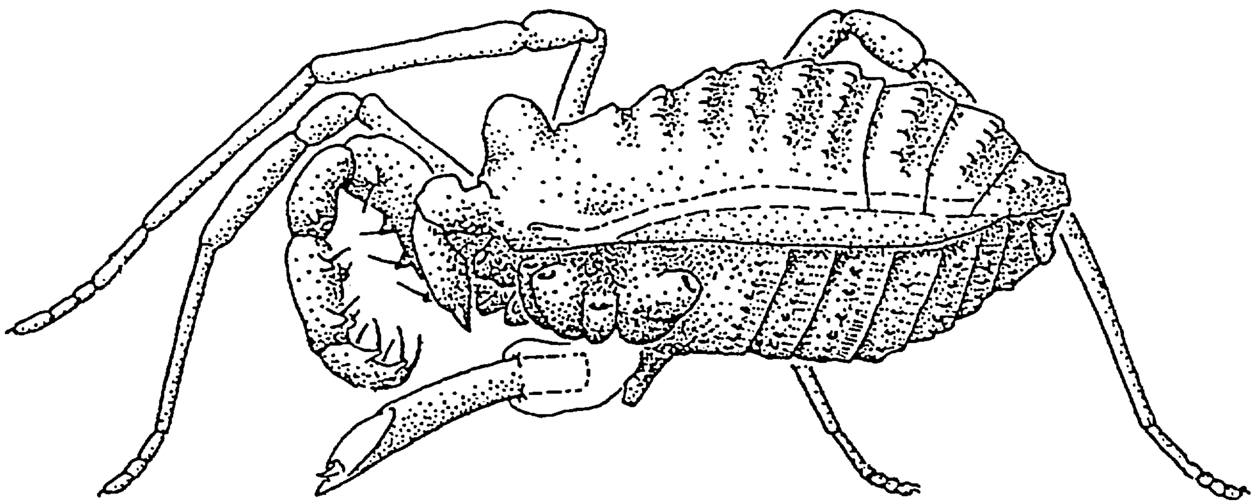

**Figure II-40.** Illustration of *Microcina* sp. (Legs on near side of body are not shown.) Species in the genus *Calicina* are very similar in appearance to *Microcina* but have a characteristic eyespot or eye on the anterior hump. Illustration by Darrell Ubick, used with permission.

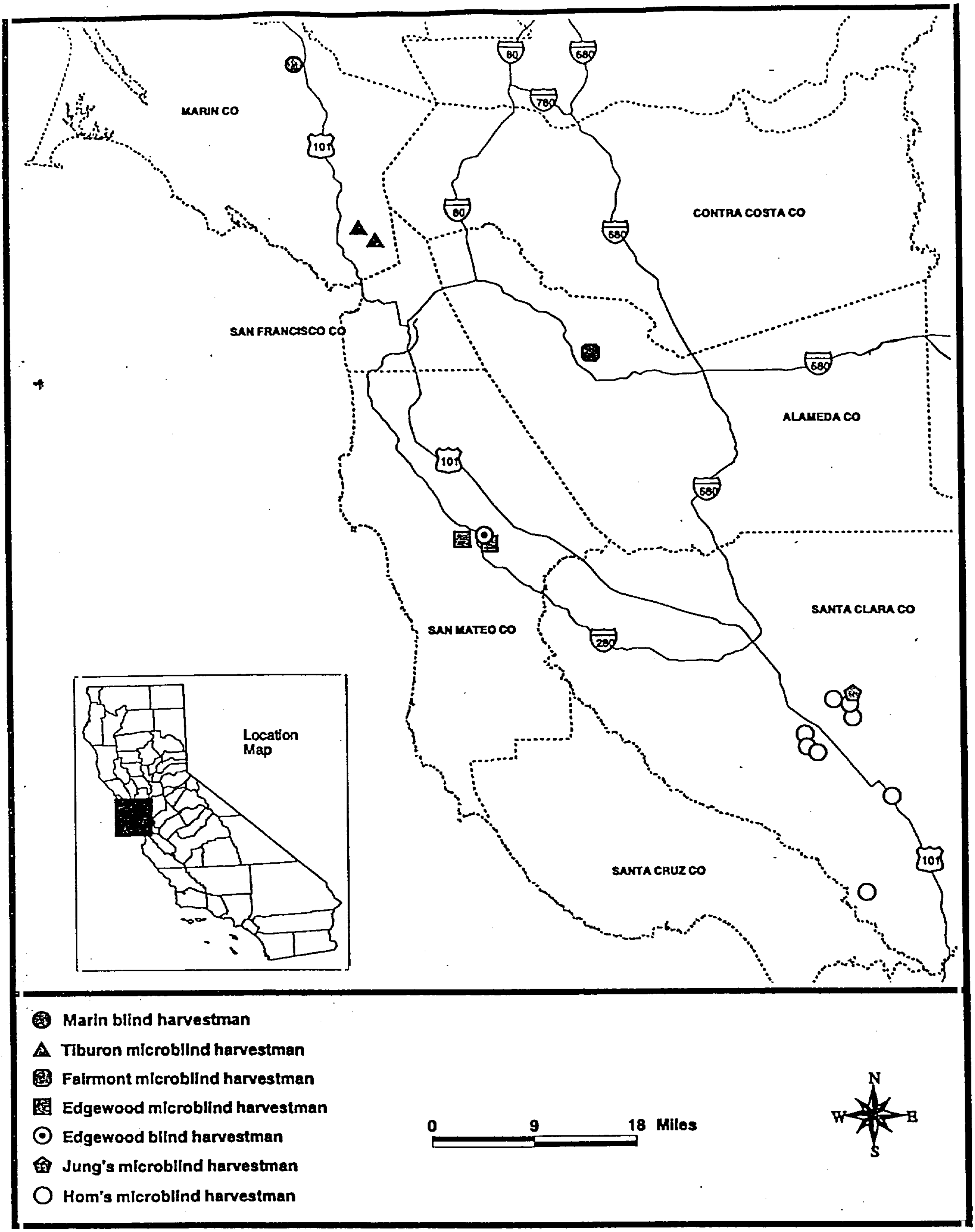


**Figure II-41.** Distribution of blind and microblind harvestmen (*Calicina* sp. and *Microcina* sp.).

San Mateo County: one population where the type specimen was collected from under serpentine at a spring 2 kilometers (0.75 mile) north of Crystal Springs Dam along County Road 14, on 23 January, 1966; and the other population consisting of five locations in relatively close proximity to each other in the central northern portion of the Edgewood Natural Preserve (T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

The Edgewood microblind harvestman (*Microcina edgewoodensis*) is known from only two locations, comprising two populations in the Edgewood Natural Preserve, and a single population west of Interstate 280 in San Mateo County, known as the "Triangle," land administered by the San Francisco Water Department. This species was described from three male specimens collected beneath rocks in serpentine grasslands adjacent to scrub oaks at these two locations (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

The known populations of Edgewood blind harvestman and Edgewood microblind harvestman were bisected by the construction of Interstate 280 in the late 1960's. Subsequent surveys have confirmed the continued presence of the Edgewood microblind harvestman in both its historic localities, but no Edgewood blind harvestmen have been observed or collected subsequently at the type locality north of Crystal Springs dam, and may be extirpated from this locality (T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

The two known populations of the Fairmont microblind harvestman *(Microcina lumi)* occur exclusively in Alameda County on Fairmont Ridge (T. Briggs, *in litt.* 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). One locality is on or to the immediate west of the Fairmont Hills development site just south of Fairmont Drive, and the other is across Fairmont Drive to the southwest of this development site on a private horse pasture, not far from a proposed telecommunications tower (D. Ubick, *in litt.*, 1990, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). Except for the Nike missile site on the adjacent ridge top, all other suitable habitat in this immediate area was surveyed for Fairmont microblind harvestman in 1989 (D. Ubick, *in litt.*, 1990). In some cases, a single sympatric species, Lee's microblind harvestman

(*Microcina leei*) was found (T. Briggs, *in litt.*, 1989), but no Fairmont microblind harvestmen were observed (T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

Hom's microblind harvestmen (*Microcina homi)* has been observed or collected during fall and winter rains at eight sites in Santa Clara County (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).. With one exception collected in Santa Teresa Park under Franciscan sandstone, this species has been found underneath rocks with moist surfaces on deep serpentine soil with fairly gentle slopes, and frequently with adjacent running water (Briggs and Hom 1966; Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). This species is known to be sympatric with Jung's microblind harvestman (*Microcina jungi*) at its only known locality (see below), as well as with the more widespread serpentine harvestman *(Calicina serpentinea* Briggs and Hom) (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

Jung's microblind harvestman (*Microcina jungi*) is known only from one rocky serpentine grassland location, where it co-occurs with Hom's microblind harvestman (*Microcina homi*): 1.5 kilometers (0.9 miles) south of the junction of Silver Creek and San Felipe roads, near San Jose in Santa Clara County (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). Currently only one population is known, but other populations may yet be discovered on unsurveyed serpentine habitat in this area (T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

The Marin blind harvestman (*Calicina diminua*) is known only from two serpentine outcroppings at the eastern base of Burdell Mountain in the Novato area of Marin County; one on private lands, and one occurring on the Buck Center for Research on Aging site (T. Briggs, *in litt.*, 1989, EIP Associates 1992, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). Other potential habitats are fairly widely distributed within the general vicinity of Burdell Mountain, but the species has not been found there despite intensive surveys (T. Briggs, *in litt.*, 1998). No recent surveys have been done to determine if one of the populations may have been eliminated by road construction, or whether the outlying population persists on private land or in the proposed conservation area to mitigate for the Buck Center's construction (EIP Associates 1992, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

The Tiburon microblind harvestman (*Microcina tiburona*) is known only from two occurrences in serpentine grasslands on the Tiburon Peninsula in southern Marin County, (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). One location is within the Ring Mountain Preserve, managed by the Marin County Open Space District, where it co-occurs with a federally listed plant species, the Tiburon mariposa lily *(Calochortus tiburonensis)*. The other locality for the Tiburon microblind harvestman, now private land, is near El Campo, about 0.8 kilometer (0.5 mile) northeast of the Bel Aire School. No recent surveys have been done to confirm whether these two populations persist (T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

***Reproduction and Demography.*** - Almost all the individuals that have been encountered in the field are adults (T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). The appearance of the adults coincides with the onset of the winter rainy season in California. The absence of young suggests that development takes place beneath the soil (T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). Harvestmen typically oviposit directly into the soil, where the eggs are presumed to develop. Normally, only one or a few adults are present under each rock, where they feed upon springtails (very small, primitive insects in the Order Collembola). However, in several harvestmen species, aggregations of 10 or more have been observed (T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). The drying of the ground beneath rocks seems to result in their disappearance until the next year's first major rain (Briggs 1969). Other aspects of blind and microblind harvestmen reproduction and demography remain to be discovered.

***Habitat and Community Association.*** - Blind harvestmen occupy a wide variety of California biomes (a major biotic community) in mesic (with a moderate amount of moisture) habitats, from dense forest to open grassland, but are largely restricted to microhabitats offering high humidity, conditions of total darkness, and warmth (Briggs 1969, T. Briggs, pers. comm., 1997, D. Ubick, pers.

comm., 1997). Low elevation forests and moist grasslands provide favorable habitats while only a few species are found in desert, chaparral, or above 1,200 meters (4,000 feet) (Briggs 1969).

Microblind harvestmen are exclusively known from serpentine grasslands and outcroppings in the greater San Francisco Bay Area. Individual species are often known from only one or two locations (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997), where they often co-occur with a species of *Calicina* (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

Blind and microblind harvestmen from serpentine soil areas are found primarily beneath medium to large rocks, approximately 10 centimeters by 10 centimeters to 45 centimeters by 45 centimeters (4 by 4 inches to 18 by 18 inches), in contact with the soil, having remained undisturbed for a prolonged period (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). Individuals are not found on rocks in standing or running water, and are seldom found along hilltops and other windswept areas (Briggs 1968, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). Although the habitat requirements for these species have not yet been completely characterized, it is presumed that rocks of medium to large size act most effectively to retain ideal humidity and thermal conditions (Briggs 1968, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997).

***Threats to Survival.*** - Threats to serpentine grassland ecosystems typically occur in the form of road and housing development, invasion by aggressive nonnative plants, recreational activities, use of herbicides/ pesticides/ rodenticides, off-road vehicle use, overgrazing by livestock, and garbage dumping.

Populations of both the Edgewood blind harvestman and Edgewood microblind harvestman were formerly threatened by a proposed golf course development in Edgewood Natural Preserve (Thomas Reid Associates 1993). However, in 1993, the San Mateo County Board of Supervisors adopted a resolution designating Edgewood Natural Preserve a natural area (San Mateo County Board of Supervisors 1993). The existence of the Edgewood blind harvestman in only one location, however, makes it vulnerable to extinction from catastrophic events.

Although public access was restricted in the past, the "Triangle" portion (land west of Edgewood Natural Preserve and Interstate 280 in San Mateo County, administered by the San Francisco Water Department) of the Edgewood microblind harvestman population is now part of a recreational easement (California Department of Fish and Game 1992). This species is presently threatened by proposed construction of a golf course or trails in the Triangle which threaten the species' habitat (C. Curtis, in litt., 1998, California Department of Fish and Game 1992). An invasion of Argentine ants (an aggressive, non-native ant species) was noted in this area in 1998 (T. Briggs, in litt., 1998). Threats from Argentine ants may exist at other locations as well. The existence of the Edgewood microblind harvestman in only two locations makes it vulnerable to extinction from catastrophic events.

Both populations of the Fairmont microblind harvestman are threatened by the use of herbicides applied by Alameda County personnel for fire control purposes (Ubick and Briggs, *in litt.*, 1990, Zimmerman, *in litt.*, 1990*a, b, c*), the proposed construction of an emergency access road into the Fairmont Ridge housing development (Ubick and Briggs, *in litt.*, 1990), and access and use by off-road vehicles (Ubick and Briggs, *in litt.*, 1990, Zimmerman, *in litt.*, 1990*a, b, c*). The existence of Fairmont microblind harvestman in only two locations makes it vulnerable to extinction from catastrophic events.

Jung's microblind harvestman is threatened by urban development and its associated infrastructure. On or before 1990, a pipeline was laid through this species' habitat. Currently there are several proposals in various stages of progress to develop the remaining lands as single-family housing (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). The existence of Jung's microblind harvestman in only one location makes it vulnerable to extinction from catastrophic events.

One of the two Marin blind harvestman populations are threatened by urban development (Briggs and Ubick 1989, T. Briggs, pers. comm., 1997, D. Ubick, pers. comm., 1997). The Buck Center for Research on Aging has completed several of the planned buildings, but there is still the possibility that further building or road construction might impact the remaining serpentine soils. The adjacent conservation area is not yet fully delineated or protected from impacts such as foot traffic, domestic animals, vandalism, storm water runoff, or future construction. The existence of the Marin blind harvestman in only two locations makes it vulnerable to extinction from catastrophic events.

One of the two populations of Tiburon microblind harvestman is threatened by urban development. The population on private land is threatened by planned housing developments, though no permits have been issued at present to start construction. The existence of the Tiburon microblind harvestman in only two locations makes it vulnerable to extinction from catastrophic events.

***Conservation Efforts***. - With the exceptions of Hom's microblind harvestman *(Microcina homi)* and the Tiburon microblind harvestman *(Microcina tiburona)*, all the blind and microblind harvestmen covered in this recovery plan were formerly Category 2 candidates for Federal listing. All harvestman species covered in this recovery plan are now considered species of concern (U.S. Fish and Wildlife Service 1996*a*).

The Edgewood blind harvestman and Edgewood microblind harvestman are partially protected in Edgewood Natural Preserve. A draft master plan for Edgewood Natural Preserve has been published (San Mateo County 1996).

The Buck Center for Research on Aging has proposed a 122-hectare (300-acre) conservation area for onsite impacts to the sensitive species on the adjacent 76-hectare (188-acre) development area. This conservation area is thought to include the Marin blind harvestman, but it is not yet fully delineated or protected from impacts such as foot traffic, domestic animals, vandalism, storm water runoff, or future development (EIP Associates 1992, Western Ecological Services Company 1990).

Between 1982 and 1995, the Ring Mountain population of the Tiburon microblind harvestman was protected from development because the land on which it occurs was owned and managed by The Nature Conservancy, a group whose management goals are the maintenance of biodiversity and the protection of rare and endangered species (L. Serpa, pers. comm., 1992). The Ring Mountain property was transferred from The Nature Conservancy to Marin County Parks and Open Space District in 1995; The Nature Conservancy retained a conservation easement on the property and it is expected that Marin County will continue monitoring rare species on the preserve (L. Serpa, pers. comm., 1996). The Nature Conservancy provided Marin County Open Space District with detailed management principles and guidelines (California Department of Fish and Game 1997*a*). At this point, the County has not developed a monitoring plan and is depending on volunteers from The Nature Conservancy and California Native Plant Society for monitoring (C. Bramham, pers. comm., 1996). The preserve is fenced to reduce the incidence of four-wheel drive vehicle and motorcycle use, but is still accessible to bicycles, equestrians, and hikers (C. Bramham, pers. comm., 1997).

***Conservation Strategy***. - The conservation strategy for these species of concern is based on the assumptions that if: (1) populations remain throughout remnants of the historical ranges, (2) populations occur in protected habitat, (3) populations are secure from threats, (4) and populations are not declining, then the long-term conservation of *Calicina* and *Microcina* species addressed in this recovery plan can be ensured. Long-term conservation of these blind and microblind harvestmen species must first focus on protecting existing habitat of the remaining populations by working with private landowners and agencies to ensure the long-term conservation and survival of these species of concern on their lands. Since these species' populations and habitats are often limited to only one or two localities, it is extremely important to protect, and ideally, expand by restoration efforts, the remaining suitable habitat for these species. Given the very limited amount of suitable habitat, the very limited dispersal ability of these harvestmen, and number of impending or adjacent threats to these species, habitat protection must be given top priority in conservation efforts. This habitat protection could take the form of buffers, conservation easements, conservation agreements, or fee title acquisitions, and should involve protection of the populations themselves as well as a 150-meter (500-foot) buffer around each population, where possible, to reduce external influences and allow expansion of populations into potentially suitable habitat. In addition, other unoccupied habitat at the sites that might be restored or provide space for expansion of the populations must be protected.

Presently, there is little information whether populations of these harvestmen are stable or declining, and therefore, additional surveying and monitoring are needed to assess their distribution and status. Population monitoring and surveying are needed to develop a complete conservation strategy and establish quantitative criteria for long-term conservation, with surveys conducted in all historic locations during the appropriate time period of activity for the species. All potential habitats in reasonable proximity to these historic locations should also be surveyed and evaluated, including an assessment of populations capable of supplying individuals for reintroduction efforts. In particular, threats from development, recreational activities, and invasion of exotics should be addressed. Management plans emphasizing special status species in the one or few known locations must be developed and implemented, and should include provisions for standardized annual monitoring of all populations of harvestman covered in this plan to determine demographic trends. The proximity of these species to a large human population increases the likelihood that human-caused disasters or acts of vandalism will affect these blind and microblind harvestmen or their habitat.

Virtually all blind and microblind harvestmen populations in this recovery plan occur adjacent to urban or suburban development; accordingly, any management plan developed for these species should include an educational outreach program which will assist the U.S. Fish and Wildlife Service's efforts to conserve these species. Public outreach should address the rarity, biological value, and fragility of San Francisco Bay Area serpentine grassland ecosystems, as well as particular steps citizens can take to protect them. Outreach may take many forms, such as appropriate signage at Edgewood Natural Preserve and Ring Mountain Preserve or other locations, informational handouts available to interested parties, an Internet web page, and public talks.

Since little is still known about a wide range of ecological and life history aspects of these blind and microblind harvestmen, research needs to be conducted to provide the data with which to effectively conserve and manage these species. In many cases, research needs could be efficiently achieved by incorporating harvestmen observations into parallel studies conducted for bay checkerspot or plant species covered in this plan.

A primary research need is to characterize the habitat used by the harvestmen species and determine the characteristics and individual species requirements for harvestmen habitat, and co-occurring associated species. Further studies need to be conducted on the reproduction, population demographics, and dispersal of these species, including studies on life histories, overwintering stages, feeding requirements, and juvenile/adult mortality. Methods and time of dispersal, impediments to dispersal, and typical dispersal distances need to be determined to formulate proper management actions for these species. Research is also needed to determine whether previously undetermined factors have been limiting harvestmen viability on apparently favorable habitats. Habitat restoration methods should be developed if appropriate. Vegetation management techniques may need to be developed that enhance blind and microblind harvestmen survival and reproduction. Current grazing management methods could be quantified for establishing a variety of grazing regimens. Eventually, a variety of techniques should be tested experimentally, over a variety of years and sites, and adapted as appropriate. Research should also be conducted on the feasibility of reintroducing blind and microblind harvestmen into historic habitats where populations have been recently extirpated but re-establishment seems feasible. Reintroduction methods should be developed if appropriate.

# III. RECOVERY

## A. Objectives

The overall objective of this recovery plan is to delist federally listed species and ensure the long-term conservation of species of concern covered in the plan. Interim goals include (1) stabilizing and protecting populations, (2) conducting research necessary to refine reclassification and recovery criteria, and (3) reclassifying to threatened (downlisting) species currently federally listed as endangered. Reclassification is appropriate when a taxon is no longer in danger of extinction throughout a significant portion of its range. Because data upon which to base decisions about reclassification and recovery are mostly lacking, downlisting and recovery criteria in this plan are necessarily preliminary.

### 1. Multispecies strategy

Recovery and long-term conservation tasks emphasized in this plan are (1) habitat protection, (2) habitat management and restoration, including removal of invasive non-native species, (3) surveying and monitoring, (4) ex-situ conservation measures such as artificial rearing and seed banking, (5) research, and (6) public participation, outreach, and education. Specifics of each strategy are given in this chapter and in the Stepdown Narrative (Chapter IV). Because this recovery plan focuses on a large number of species, whenever possible, emphasis is placed on specific strategies that would benefit several species covered in the plan. Where species do not co-occur, recovery and long-term conservation strategies focus on single species.

All species covered in the plan are threatened by loss of serpentine habitat and by fragmentation of the few remaining larger blocks of serpentine habitat in the San Francisco Bay Area. Therefore, areas currently, historically, or potentially occupied by the species are recommended for habitat protection. High priority protection areas are of two general types: (1) areas currently occupied by, or providing potential habitat for, several species covered in the plan, and (2) areas that are currently occupied by, or providing potential habitat for, only a single species covered in the plan. Areas to be protected for single species include those occupied by populations considered important within the species range (e.g., populations at the edge of the range and populations that may provide stepping stones among populations). Factors influencing choice of sites for protection also include habitat size and quality, ease of protection, and cost. Wherever possible, protection should first focus on larger blocks of land and on publicly-owned lands. However, because serpentine habitat is naturally and artificially limited in area and patchy in distribution, some smaller parcels and cooperation from private individuals and entities may be necessary to ensure recovery and long-term conservation of the species covered in the plan. Cooperation may involve selling of land, selling or granting of easements, or voluntary cooperation in programs to maintain and/or enhance habitat values for serpentine species while continuing certain types of land use (e.g., grazing if it does not threaten species covered in the plan).

Management plans need to be developed for protected serpentine lands. In many cases, effective habitat management and restoration techniques are undeveloped for species covered in the plan. Therefore, management must be "adaptive" or flexible based on new data, research, or observed outcomes of ongoing management. Control of invasive non-native plants is a high priority management strategy in a number of areas. Other potential management strategies include various forms of vegetation management (e.g., grazing and fire). Studies of the impact of various strategies on individual species need to be conducted. In some cases, management techniques for one species may conflict with techniques for other species--research may contribute to resolution of these conflicts.

## B. Recovery Strategies and Criteria

Recovery strategies for species covered in the plan are in individual species accounts (Chapter 2). Recovery criteria for federally listed plant and animal species are given in Table III-1. Criteria for long-term conservation of species of concern are given in Table III-2.

"The recovery of endangered species and the restoration of damaged ecosystems may be the greatest technical challenge in biological conservation" (Pavlik 1996, p.150). "Recovered" species are expected to be restored to a point

Recovery strategies for the plant species covered in this plan focus first on protection and management of known occupied sites. Second priority is given to repatriation of historic sites and third priority to introduction of new sites within the historic range of the species. The lower priority of repatriation and introduction is based on the uncertainty and difficulty associated with these strategies (Falk *et al.* 1996). Falk *et al.*'s (1996) review of existing policies of agencies, national and international conservation organizations, native plant societies, and professional organizations shows that many conservation groups recommend conservation of existing populations and communities over attempting the "difficult and imperfect" task (p. 456) of creating new ones. The American Society of Plant Taxonomists (attachment to D. Crawford, *in litt.*, 1989) and the Canadian Botanical Society (1987, reprinted in Fahselt 1988) have both adopted policy statements opposing transplantation as a means of rare plant preservation. The California Botanical Society has also recently drafted a similar resolution (R. Bittman, pers. comm., 1998).

Repatriations and introductions should be considered experimental because "the reintroduction of any species is inherently complex" and because "the science of reintroduction is in its infancy" (Falk *et al.* 1996, p. 454). Any attempted reintroduction should be for specific, defensible reasons and should be conducted with the recognition that (1) determining the outcome takes time (certainly years and perhaps decades) and (2) planning and long-term commitment are essential (Falk *et al.* 1996).

Despite the uncertainty associated with repatriation and reintroduction, long-term survival in nature of some plant species is unlikely in the absence of establishment of new populations. Repatriated and introduced populations should not be counted toward recovery goals until they have persisted without intervention through the natural range of climatic variation; this will likely require a decade or more. Until there is evidence that such actions are likely to be successful, some plant species covered in the plan should not be considered for delisting (see below). Guidelines for planning rare plant reinroductions are given in Falk *et al.* (1996).

Because many listed plant species in the plan are known from less than five sites, seed collection and banking is considered a high priority, along with preservation of known sites, to guard against extinction or irreversible decline of the species (i.e., a priority 1 task). Specifically, seed collection and banking safeguards against loss or decline of the species due to catastrophic events, an important measure until existing populations are adequately secured and managed and until plants at additional sites are found, repatriated, or introduced. The importance of this strategy is exemplified by the extirpation of the only known population of Malheur wirelettuce (*Stephanomeria malheurensis*). Had no stored seed been available, the species would have been extinct (Guerrant 1996). Seed banking also provides material that may be used in future enhancement, repatriation, or introduction of populations. Since its extirpation in the wild, Malheur wirelettuce has been repatriated (Guerrant 1996). Seed collection should be conducted with caution to ensure that donor populations are not adversely affected by the collection.

***Listed plant species.*** - In general, downlisting criteria for federally listed endangered plant species are based on (1) protection and adaptive management in perpetuity of current (and in some cases historic) occurrences, (2) evidence that populations at these sites are stable or increasing over a number of years (how many years depends on the life history of the individual species, see individual species accounts, Chapter II), (3) storage of seed in Center for Plant Conservation certified facilities, and (4) development of reliable seed germination and propagation techniques. Protection of sites should target the largest possible blocks of land and should include a buffer of 150 meters (500 feet), or as large as is feasible. Protection should involve populations throughout the known range of the species. Populations should be monitored at appropriate time intervals (see individual species accounts, Chapter II). Demographic research should be conducted to identify limiting life history stages. Until research shows otherwise, recovery should target securing populations containing a minimum of 2,000 plants each (but preferably more). The probability of population persistence over the long-term is expected to be higher for larger populations because large population size decreases the likelihood of reduced viability or population extirpations due to random demographic or genetic events (Barrett and Kohn 1991, Ellstrand and Elam 1993). Once downlisting criteria have been attained, a status review must be conducted to determine whether reclassification is appropriate. The review should include an analysis of the likelihood that delisting will be possible. Review of the success of any attempted repatriations or introductions should be included in the analysis of the potential for delisting, because delisting may depend upon the success of such actions. Evidence of unsuccessful or marginally successful repatriations or introductions may indicate that future delisting will not be reasonable.

Delisting generally involves meeting the above criteria as well as finding, repatriating or introducing several additional populations of the species. However, because repatriation and introduction of populations are expensive and experimental (Falk *et al.* 1996), surveying historic sites and potential habitat within the historic range to locate currently unknown populations is also recommended. Although it is not expected that numerous unknown sites will be found, any newly discovered populations may decrease the likelihood that a species will be extirpated (R. Raiche, *in litt.* 1998). Once delisting criteria have been attained, a status review must be conducted to determine whether reclassification is appropriate. Based on currently available information, *Acanthomintha obovata* ssp. *duttonii*, *Calochortus tiburonensis*, *Cirsium fontinale* var. *fontinale*, *Clarkia franciscana*, *Cordylanthus tenuis* ssp. *capillaris*, *Eriophyllum latilobum*, and *Streptanthus niger* should not be considered for delisting. Each of these species is limited to three or fewer locations in areas that are extensively developed, highly fragmented, and/or otherwise subject to threats that are not easily eliminated (see also individual species accounts). In the unlikely event that (1) a significant number of new populations are discovered and/or (2) research shows habitat within the species' range is available and introductions are likely to be successful, development of delisting criteria could be considered for these species.

***Plant Species of Concern.*** - Because existing information on species of concern is limited, high priority should be given to research identifying species range and distribution (i.e., surveys), status of populations, threats to the species, and details of demography, reproduction, and (in some cases) genetics. Ensuring long-term conservation of species of concern involves meeting criteria similar to those given above for reclassifying listed plant species: protection and management of known sites, evidence of stable or increasing populations over a number of years, and seed banking at Center for Plant Conservation certified facilities. These criteria assume that long-term conservation has been achieved if populations remaining throughout the historical range are not declining, and are secure from threats.

## 2. Animal Species

***Listed Animal Species.*** - One federally listed animal species is included in this plan: the bay checkerspot butterfly. Because of the limited amount of serpentine habitat remaining in the San Francisco Bay Area, the bay checkerspot butterfly will be difficult to recover to the point where delisting is possible. Once delisting criteria have been attained, a status review must be conducted to determine whether reclassification is appropriate. The following criteria must be achieved to recover the bay checkerspot butterfly:

1. Core populations - Adult populations of at least 8,000 butterflies, or populations of at least 20,000 post-diapause larvae, in 12 of 15 consecutive years, at each of the following areas: Kirby, Metcalf, San Felipe, Silver Creek Hills, Santa Teresa Hills, and Edgewood Park. Total population across all core areas should be at least 100,000 adults or 300,000 post-diapause larvae in each of the 12 years, with no recent severe decline.

2. Satellite populations - Adult populations of at least 1,000 butterflies, or populations of at least 3,000 post-diapause larvae, in 10 of 15 consecutive years, at each of at least nine distinct areas: three in San Mateo County, five in Santa Clara County, and one in Contra Costa County. Adult populations of at least 300 butterflies, or populations of at least 1,000 post-diapause larvae, in 8 of 15 consecutive years, at each of at least 18 additional distinct areas: 5 in San Mateo County, 10 in Santa Clara County, 1 in Alameda County, and 2 in Contra Costa County. To be "distinct," populations should be separated by at least 1 kilometer (3,000 feet) of unsuitable, unrestorable habitat.

3. Protection and management of habitat - Permanent protection of adequate

primary (core population), secondary (moderate-sized satellite), and tertiary habitat (small-sized satellite) to support long-term persistence of the metapopulations detailed under criteria 1 and 2 above. For satellite populations, because of their natural tendency to wink in and out of existence at various sites, this will mean protecting more habitat areas than the minimum 9 moderate-sized and 18 small-sized populations. It is estimated that nearly all known suitable habitats in San Mateo, central and western Santa Clara, western Alameda, and Contra Costa Counties will be needed to support an adequate constellation of bay checkerspot butterfly satellite populations. Appropriate adaptive management in perpetuity of the bay checkerspot butterfly's native ecosystem should be guaranteed in all protected habitat, including secure funding for ongoing management.

4. Investigation and removal of existing or reasonably foreseeable threats to bay checkerspot butterfly populations and habitat.

***Animal Species of Concern.*** - Recovery and long-term conservation of the eight animal species of concern may be accomplished by using listed species to serve as "umbrella" protection for the non-listed species, which often co-occur with one or more of the listed species targeted in this recovery plan. Evaluation of threats, additional surveys in suitable habitat, and further information on distribution are needed to develop a complete conservation and protection strategy and establish quantitative criteria for long-term conservation for these species of concern. The protection strategies for most species of concern are based on the assumption that if populations remain throughout remnants of the historical range, occur in protected habitat, are secure from threats, and are not declining, then long-term conservation has been achieved.

## C. Recovery Priorities

### 1. General Ranking Categories

Actions necessary to recover (or delist) a listed species or ensure the long-term conservation of a species of concern are ranked in three categories:

**Priority 1-** an action that must be taken to prevent extinction or to prevent a species from declining irreversibly in the foreseeable future.

**Priority 2 -** an action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

**Priority 3 -** all other actions necessary to meet recovery or conservation objectives.

Although recovery or conservation actions are ranked for each species individually, wherever possible the plan focuses on multispecies actions. Where an action involves several species, the recovery/conservation priority reflects both the needs of individual species and the broad benefit to the group of species. Because situations change as time passes, recovery/conservation priorities must be considered in the context of what has already happened and is likely to happen at all sites. Therefore, the priorities assigned are intended to guide, not to constrain, the allocation of limited conservation resources.

**Table III-1. Generalized recovery criteria for federally-listed plants and animals.** Though not explicitly stated, delisting criteria include meeting all the downlisting criteria.

| Species | Recovery Step | Secure and protect specified recovery areas from incompatible uses | Management plan approved and implemented for recovery areas, including survival of the species as an objective | Population monitoring in specified recovery areas shows: | Other actions |
|---|---|---|---|---|---|
| San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii*) | Downlist (Should not be delisted ) | Occupied habitat at Edgewood, the Triangle, and Pulgas Ridge with adjacent unoccupied habitat and a 150-meter (500-foot) buffer; two additional populations (five total) | For all five populations and any adjacent areas identified as essential to continued survival | Stable or increasing over 20 years (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| Tiburon mariposa lily (*Calochortus tiburonensis*) | Should not be delisted (actions shown are to aid survival of the species) | Occupied habitat at Ring Mountain along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For the Ring Mountain Preserve and any adjacent occupied or unoccupied habitat identified as essential to continued survival | Stable or increasing over 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seed stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |

| Species | Recovery Step | Secure and protect specified recovery areas from incompatible uses | Management plan approved and implemented for recovery areas, including survival of the species as an objective | Population monitoring in specified recovery areas shows: | Other actions |
|---|---|---|---|---|---|
| Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) | Downlist | Occupied habitat along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer at six known sites | For all sites and any adjacent occupied or unoccupied habitat identified as essential to continued survival | Stable or increasing over 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta*) | Delist | 10 populations including 2 in Santa Clara County | For all populations and any adjacent areas identified as essential to continued survival | No decline after downlisting; if declining, determine cause and reverse trend | |
| Coyote ceanothus (*Ceanothus ferrisiae*) | Downlist | Occupied habitat along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer at known sites | For all populations and any occupied or unoccupied habitat identified as essential to survival | Stable or increasing with evidence of natural recruitment for a period of 30 years that include the normal precipitation cycle (or longer depending on results of research on the role of fire in reproduction) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |

| **Species** | **Recovery Step** | **Secure and protect specified recovery areas from incompatible uses** | **Management plan approved and implemented for recovery areas, including survival of the species as an objective** | **Population monitoring in specified recovery areas shows:** | **Other actions** |
|---|---|---|---|---|---|
| | Delist | Eight populations representing the range of the species | For all populations and any adjacent areas identified as essential to continued survival | No decline after downlisting; if declining, determine cause and reverse trend | |
| Fountain thistle (*Cirsium fontinale* var. *fontinale*) | Downlist (Should not be delisted ) | Occupied habitat and known former habitat along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer at three known sites (Crystal Springs Reservoir, Triangle, and Edgewood) | For all populations and any occupied or unoccupied habitat identified as essential to survival | Stable or increasing with evidence of natural recruitment for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| Presidio clarkia (*Clarkia franciscana*) | Downlist (Should not be delisted ) | Occupied habitat and known former habitat along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer at the two known locations | For all populations and any occupied or unoccupied habitat identified as essential to survival | Stable or increasing over 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |

| Species | Recovery Step | Secure and protect specified recovery areas from incompatible uses | Management plan approved and implemented for recovery areas, including survival of the species as an objective | Population monitoring in specified recovery areas shows: | Other actions |
|---|---|---|---|---|---|
| Pennell's bird's-beak (*Cordylanthus tenuis* ssp. *capillaris*) | Downlist (Should not be delisted ) | Occupied habitat and known former habitat along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer at the two known sites | For all populations and any occupied or unoccupied habitat identified as essential to survival | Stable or increasing over 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| Santa Clara Valley dudleya (*Dudleya setchellii*) | Downlist | Occupied habitat or 20 populations representing the range of the species along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer (see Chapter II for specifics) | For all populations and any occupied or unoccupied habitat identified as essential to survival | Stable or increasing for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | |
| | Delist | 30 populations representing the range of the species | For all populations and any adjacent areas identified as essential to continued survival | No decline after downlisting; if declining, determine cause and reverse trend | |

| **Species** | **Recovery Step** | **Secure and protect specified recovery areas from incompatible uses** | **Management plan approved and implemented for recovery areas, including survival of the species as an objective** | **Population monitoring in specified recovery areas shows:** | **Other actions** |
|---|---|---|---|---|---|
| San Mateo woolly sunflower (*Eriophyllum latilobum*) | Downlist (Should not be delisted ) | Occupied habitat along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer at the known site | For all populations and any occupied or unoccupied habitat identified as essential to survival | Stable or increasing for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| Marin dwarf-flax (*Hesperolinon congestum*) | Delist | Occupied habitat or 21 populations representing the range of the species along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer (see Chapter II for specifics) | For all populations and any occupied or unoccupied habitat identified as essential to survival | Stable or increasing for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | |

| Species | Recovery Step | Secure and protect specified recovery areas from incompatible uses | Management plan approved and implemented for recovery areas, including survival of the species as an objective | Population monitoring in specified recovery areas shows: | Other actions |
|---|---|---|---|---|---|
| White-rayed pentachaeta (*Pentachaeta bellidiflora*) | Downlist | Total of five populations: occupied and former habitat at the Triangle and Edgewood and at the new potential occurrence if it is confirmed to be *P. bellidiflora* along with additional populations; adjacent unoccupied habitat and a 150-meter (500-foot) buffer at each site | For all populations and any occupied or unoccupied habitat identified as essential to survival | Stable or increasing for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| | Delist | 10 populations; at least 3 in each of Marin, San Mateo, and Santa Cruz Counties | For all populations and any adjacent areas identified as essential to continued survival | No decline after downlisting; if declining, determine cause and reverse trend | |

| Species | Recovery Step | Secure and protect specified recovery areas from incompatible uses | Management plan approved and implemented for recovery areas, including survival of the species as an objective | Population monitoring in specified recovery areas shows: | Other actions |
|---|---|---|---|---|---|
| Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*) | Downlist | Occupied habitat along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer at nine known sites | For all populations and any occupied or unoccupied habitat identified as essential to survival | Stable or increasing for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| | Delist | 18 populations representing entire historic range of the species | For all populations and any adjacent areas identified as essential to continued survival | No decline after downlisting; if declining, determine cause and reverse trend | |
| Tiburon jewelflower (*Streptanthus niger*) | Downlist (Should not be delisted) | Occupied habitat at the St. Hilary's and Middle Ridge sites along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For both populations and any adjacent areas identified as essential to continued survival | Stable or increasing over 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |

| Species | Recovery Step | Secure and protect specified recovery areas from incompatible uses | Management plan approved and implemented for recovery areas, including survival of the species as an objective | Population monitoring in specified recovery areas shows: | Other actions |
|---|---|---|---|---|---|
| Bay checkerspot butterfly (*Euphydryas editha bayensis*) | Delist | Core areas:<br><br>Kirby, Metcalf, San Felipe, Silver Creek Hills, Santa Teresa Hills, Edgewood Preserve | For all core areas | Core area populations of at least 8,000 butterflies, or at least 20,000 post-diapause larvae, in 12 of 15 consecutive years at each core area. Total population across all core areas should be at least 100,000 adults or 300,000 post-diapause larvae in each of the 12 years, with no recent severe decline | |

| Species | Recovery Step | Secure and protect specified recovery areas from incompatible uses | Management plan approved and implemented for recovery areas, including survival of the species as an objective | Population monitoring in specified recovery areas shows: | Other actions |
|---|---|---|---|---|---|
| (Continued next page) | | Satellite areas: sufficient to support metapopulation dynamics of nine moderate-sized populations throughout most of the historic range of the species; see species account in Chapter II for specifics | For all protected habitat areas | Moderate-sized satellite populations of at least 1,000 butterflies or at least 3,000 post-diapause larvae, in 10 of 15 consecutive years, at each of at least nine distinct areas: three in San Mateo, five in Santa Clara, and one in Contra Costa Counties; see species account in Chapter II for specifics | |

| Species | Recovery Step | Secure and protect specified recovery areas from incompatible uses | Management plan approved and implemented for recovery areas, including survival of the species as an objective | Population monitoring in specified recovery areas shows: | Other actions |
|---|---|---|---|---|---|
| Bay checkerspot butterfly (*Euphydryas editha bayensis*) (continued) | Delist | <u>Satellite areas</u>: sufficient to support metapopulation dynamics of 18 small-sized populations throughout most of the historic range of the species; see species account in Chapter II for specifics | For all protected habitat areas | Small-sized satellite populations of at least 300 butterflies or at least 1,000 post-diapause larvae, in 8 of 15 consecutive years, at each of at least 18 additional distinct areas: 5 in San Mateo, 10 in Santa Clara, 1 in Alameda, and 2 in Contra Costa Counties; see species account in Chapter II for specifics | |

**Table III-2. Generalized criteria for long-term conservation of California-listed and other species of concern.**

| Species | Secure and protect specified conservation areas from incompatible uses | Management plan approved and implemented for conservation areas, including survival of the species as the objective | Population monitoring in specified conservation areas shows: | Other actions |
|---|---|---|---|---|
| **Plant Species** | | | | |
| Baker's manzanita (*Arctostaphylos bakeri* ssp. *bakeri*) | 10 populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing with evidence of natural recruitment for a period of 30 years that include the normal precipitation cycle (or longer depending on results of research on the role of fire in reproduction) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*) | 23 populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer (see Chapter II for distribution of populations) | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing with evidence of natural recruitment for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | |

| Species | Secure and protect specified conservation areas from incompatible uses | Management plan approved and implemented for conservation areas, including survival of the species as the objective | Population monitoring in specified conservation areas shows: | Other actions |
|---|---|---|---|---|
| Crystal Springs lessingia (*Lessingia arachnoidea*) | Eight populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer; two of the populations in Sonoma County if known site is confirmed to be *L. arachnoidea* | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing with evidence of natural recruitment for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| Smooth lessingia (*Lessingia micradenia* var. *glabrata*) | 10 populations representing the range of the species along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing with evidence of natural recruitment for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |

| Species | Secure and protect specified conservation areas from incompatible uses | Management plan approved and implemented for conservation areas, including survival of the species as the objective | Population monitoring in specified conservation areas shows: | Other actions |
|---|---|---|---|---|
| Tamalpais lessingia (*Lessingia micradenia* var. *micradenia*) | Six populations representing the range of the species along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing with evidence of natural recruitment for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | Seeds stored in at least two Center for Plant Conservation certified facilities; Seed germination and propagation techniques understood |
| Most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*) | 22 populations representing the range of the species along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer (see Chapter II for specifics) | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing with evidence of natural recruitment for a period of 20 years that include the normal precipitation cycle (or longer if suggested by the results of demographic monitoring) | |

| Species | Secure and protect specified conservation areas from incompatible uses | Management plan approved and implemented for conservation areas, including survival of the species as the objective | Population monitoring in specified conservation areas shows: | Other actions |
|---|---|---|---|---|
| **Animal Species** | | | | |
| Edgewood blind harvestman *(Calicina minor)* | Six populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing for a period of 15 years that includes the normal precipitation cycle | |
| Edgewood microblind harvestman (*Microcina edgewoodensis*) | Three populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing for a period of 15 years that includes the normal precipitation cycle | |
| Fairmont microblind harvestman (*Microcina lumi*) | Two populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing for a period of 15 years that includes the normal precipitation cycle | |
| Hom's microblind harvestman *(Microcina homi)* | Eight populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing for a period of 15 years that includes the normal precipitation cycle | |
| Jung's microblind harvestman (*Microcina jungi)* | One population along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing for a period of 15 years that includes the normal precipitation cycle | |

| Species | Secure and protect specified conservation areas from incompatible uses | Management plan approved and implemented for conservation areas, including survival of the species as the objective | Population monitoring in specified conservation areas shows: | Other actions |
|---|---|---|---|---|
| Marin blind harvestman *(Calicina diminua)* | Three populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing for a period of 15 years that includes the normal precipitation cycle | |
| Opler's longhorn moth *(Adela oplerella* | 13 populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing for a period of 15 years that includes the normal precipitation cycle | |
| Tiburon microblind harvestman (*Microcina tiburona*) | Two populations along with adjacent unoccupied habitat and a 150-meter (500-foot) buffer | For all populations and any adjacent areas identified as essential to continued survival | Stable or increasing for a period of 15 years that includes the normal precipitation cycle | |

# IV. STEPDOWN NARRATIVE

1. Develop and implement cooperative programs and participation plans.

   Cooperative programs are needed to coordinate local public and private land use planning with State and Federal land use and recovery planning for serpentine species. At least two cooperative programs need to be developed, one focusing on the North Bay and one on the South Bay (i.e. San Mateo and Santa Clara Counties). The participation plans produced from these programs will increase the chances of recovery for listed species and ensure the long-term conservation of the species of concern covered in this plan.

   1.1 Establish cooperative programs with participants from the public and private sector (Priority 2).

   Interested parties in local, State, and Federal government and in the private sector should be identified; their willingness to participate in cooperative programs determined. Programs should be initiated.

   1.2 Develop and implement participation plans.

   Participation plans should include: (1) outreach to enhance public understanding of rare species in general and of serpentine endemic species in particular, (2) economic incentives for conservation of rare species, and (3) guidance on establishment of Habitat Conservation Plans.

   1.2.1 Develop and implement outreach plans (Priority 2).

   Plans should focus on providing information to interested and affected landowners, government agencies, and the general public about: (1) species covered in the plan, (2) what is meant by recovery, and (3) how recovery can be achieved. Private landowners should become familiar with rare serpentine plant and animal species that occur on their land, with the significance of the populations, and with available conservation measures including conservation easements and incentive programs (see Task 1.3). For private lands with potential occurrences of species covered in the plan (with historic occurrences or otherwise within the range of the species), permission should be sought to conduct surveys. If populations of species covered in the plan are identified, landowners should be informed of their significance and should be encouraged to continue land uses that support the species' habitat.

1.2.2 Develop and implement economic or other incentives for conservation and recovery on private lands through the cooperative programs and other groups (Priority 2).

Support and assistance of private landowners in conserving and recovering species covered in this plan may be gained by developing economic and other incentive programs (relief from taxes, tax credits, tax deductible habitat management expenses) (Keystone Center 1995).

1.2.3 Encourage and assist counties and owners of large amounts of natural lands to develop and implement Habitat Conservation Plans (Priority 2).

City and county governments, as the primary agencies making land use decisions, need to be involved in recovery planning. Cooperative programs should encourage and promote the development of Habitat Conservation Plans for cities and counties in the area covered by this recovery plan. Similarly, owners of large amounts of natural land should be encouraged to participate in conservation planning.

2. Protect and secure existing populations.

Natural lands that are known to contain species covered in this plan should be protected in perpetuity. Protection of these lands includes identification and minimization of threats in perpetuity and application of appropriate and adaptive management (see Task 3) to ensure species survival and recovery. Serpentine habitat on lands already in public ownership needs to be protected, and private lands need to be secured through land acquisition, conservation easements, or other means. Natural lands that need to be protected or secured can be categorized into 2 types: (1) blocks of land that contain occupied or potential habitat for *two or more* species covered in the plan (Table IV-1) and (2) blocks of land that contain occupied or potential habitat for *one* species covered in the plan (Table IV-2).

2.1 Protect and secure areas important for recovery/conservation of two or more species covered in the plan.

Table IV-1 lists blocks of land that contain occupied or potential habitat for two or more species covered in the plan. Public and conservation lands should be managed to support listed and other sensitive species. Private lands should be protected through conservation management agreements, easements, or other mechanisms and managed to support listed and other sensitive species.

**Table IV-1. Geographic Areas Targeted for Protection of Two or More Species Covered in the Plan.** See Figures I-3 through I-8 for locations of geographic areas.

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| | ALAMEDA COUNTY | | | |
| 2.1.1 | Oakland Hills | Bay checkerspot butterfly*<br>*Clarkia franciscana*<br>----<br>*Streptanthus albidus* ssp. *peramoenus*<br>Opler's longhorn moth | - private, East Bay Regional Parks District<br>- one of only two known locations of *Clarkia franciscana*<br>- control of invasive non-native species needed | 1 |
| | MARIN COUNTY | | | |
| 2.1.2 | Alpine Lake / Carson Ridge | *Hesperolinon congestum*<br>----<br>*Lessingia micradenia* var. *micradenia* | - Marin Municipal Water District<br>- represents northern region of *Hesperolinon congestum* range<br>- control of invasive non-native species needed | 2 |
| 2.1.3 | Golden Gate National Recreation Area | *Castilleja affinis* ssp. *neglecta*<br>*Hesperolinon congestum* | - National Park Service<br>- represents northern region of *Castilleja affinis* ssp. *neglecta* and *Hesperolinon congestum* ranges | 1 |

| Task # | Location | **Listed Taxa and Taxa of Concern** (Listed taxa and taxa of concern are separated by a dashed line.) | **Landowner / Comments** | **Priority** |
|---|---|---|---|---|
| 2.1.4 | Mt. Burdell | *Hesperolinon congestum*<br>----<br>Marin blind harvestman | - Marin County<br>- public ownership<br>- northernmost known location of *Hesperolinon congestum*<br>- only known locations for Marin blind harvestman | 1 |
| | Tiburon Peninsula: | | | |
| 2.1.5 | Middle Ridge | *Castilleja affinis* ssp. *neglecta*<br>*Hesperolinon congestum*<br>*Streptanthus niger*<br>----<br>Tiburon microblind harvestman | - Marin County, private<br>- one of only two known locations of *Streptanthus niger* and Tiburon microblind harvestman<br>- control of invasive non-native species needed | 1 |
| 2.1.6 | Ring Mountain | *Calochortus tiburonensis*<br>*Castilleja affinis* ssp. *neglecta*<br>*Hesperolinon congestum*<br>----<br>Opler's longhorn moth<br>Tiburon microblind harvestman | - Marin County<br>- only known location of *Calochortus tiburonensis*<br>- important location for Opler's longhorn moth<br>- one of only two known locations of Tiburon microblind harvestman | 1 |
| 2.1.7 | St. Hilary's area (including Harroman Property) | *Castilleja affinis* ssp. *neglecta*<br>*Hesperolinon congestum*<br>*Streptanthus niger* | - Tiburon Landmark Society, Marin County, private<br>- one of only two known locations of *Streptanthus niger*<br>- control of invasive non-native species needed | 1 |

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| | SAN FRANCISCO COUNTY | | | |
| 2.1.8 | Presidio | *Clarkia franciscana*<br>*Hesperolinon congestum* | - National Park Service<br>- one of only two known locations of *Clarkia franciscana*<br>- control of invasive non-natives needed | 1 |
| | SAN MATEO COUNTY | | | |
| 2.1.9 | Buri Buri Ridge | Bay checkerspot butterfly*<br>*Hesperolinon congestum*<br>----<br>*Lessingia arachnoidea* | - San Francisco Water Department, private | 2 |
| 2.1.10 | Edgewood Natural Preserve | Bay checkerspot butterfly<br>*Acanthomintha obovata* ssp. *duttonii*<br>*Cirsium fontinale* var. *fontinale*<br>*Hesperolinon congestum*<br>*Pentachaeta bellidiflora*<br>----<br>*Lessingia arachnoidea*<br>Edgewood blind harvestman<br>Edgewood microblind harvestman | - San Mateo County<br>- contains two of only three populations of Edgewood microblind harvestman<br>- only known location for Edgewood blind harvestman<br>- only known location of a large population of *Acanthomintha obovata* ssp. *duttonii*<br>- potential enhancement or repatriation site for *Acanthomintha obovata* ssp. *duttonii* and *Pentachaeta bellidiflora*<br>- work with San Mateo County and volunteers to protect and manage habitat for rare species | 1 |

| Task # | Location | **Listed Taxa and Taxa of Concern** (Listed taxa and taxa of concern are separated by a dashed line.) | **Landowner / Comments** | **Priority** |
|---|---|---|---|---|
| 2.1.11 | Pulgas Ridge | Bay checkerspot butterfly*<br>*Acanthomintha obovata* ssp. *duttonii*<br>*Cirsium fontinale* var. *fontinale*<br>*Hesperolinon congestum*<br>----<br>*Lessingia arachnoidea* | - San Francisco Water Department<br>- includes the ridge itself down to Crystal Springs Reservoir<br>- contains the majority of known locations of *Cirsium fontinale* var. *fontinale* as well as the introduced population of *Acanthomintha duttonii*<br>- control of invasive non-natives needed | 1 |
| 2.1.12 | San Mateo Creek area (Crystal Springs Road area) | *Eriophyllum latilobum*<br>*Hesperolinon congestum*<br>----<br>*Lessingia arachnoidea* | - San Francisco Water Department, Hillsborough, San Mateo County, private<br>- contains the only known population of *Eriophyllum latilobum* | 1 |
| 2.1.13 | Triangle | Bay checkerspot butterfly*<br>*Acanthomintha obovata* ssp. *duttonii*<br>*Cirsium fontinale* var. *fontinale*<br>*Pentachaeta bellidiflora*<br>----<br>Edgewood microblind harvestman | - San Francisco Water Department<br>- contains one of only three populations of Edgewood microblind harvestman, confirmed population of *Pentachaeta bellidiflora* and the smaller natural population of *Acanthomintha duttonii* | 1 |
| 2.1.14 | Woodside Glens / Canada College / Redwood City (Woodside area) | Bay checkerspot butterfly*<br>*Hesperolinon congestum* | - private<br>- includes 11-hectare (26-acre) nature preserve | 1 |

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| | SANTA CLARA COUNTY | | | |
| 2.1.15 | Almaden Quicksilver County Park area | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>----<br>*Lessingia micradenia* var. *glabrata*<br>*Streptanthus albidus* ssp. *peramoenus* | - Santa Clara County, Mid Peninsula Regional Open Space District<br>- most westerly location of *Dudleya setchellii* | 2 |
| 2.1.16 | Anderson Reservoir / County Park area | *Ceanothus ferrisiae*<br>*Streptanthus albidus* ssp. *albidus**<br>----<br>*Cirsium fontinale* var. *campylon**<br>*Lessingia micradenia* var. *glabrata* | - Santa Clara County, private<br>- important location for *Ceanothus ferrisiae*, *Lessingia micradenia* var. *glabrata* rediscovered in 1996 | 1 |
| 2.1.17 | Calero Reservoir area (general area around Calero County Park) | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>----<br>*Cirsium fontinale* var. *campylon*<br>*Streptanthus albidus* ssp. *peramoenus* | - Santa Clara County, private<br>- includes Calero County Park below | 1 |
| 2.1.18 | Calero County Park | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>----<br>*Streptanthus albidus* ssp. *peramoenus* | - Santa Clara County | 1 |
| 2.1.19 | Communications Hill area | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus* | - private<br>- an area representing the northern portion of the range of *Dudleya setchellii* | 2 |
| | Coyote Ridge: | | | |
| 2.1.20 | Kirby (South of Metcalf Canyon Road.) | Bay checkerspot butterfly<br>*Castilleja affinis* ssp. *neglecta*<br>*Ceanothus ferrisiae*<br>*Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus*<br>---- | - private, possibly minor county ownership<br>- core area for bay checkerspot butterfly.<br>- southernmost and only Santa Clara County | 1 |

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| 2.1.21 | Metcalf (North of Metcalf Canyon Road.) | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus*<br>----<br>*Cirsium fontinale* var. *campylon*<br>*Lessingia micradenia* var. *glabrata* | - private<br>-core area for bay checkerspot butterfly.<br>- a critical area for *Streptanthus albidus* ssp. *albidus*<br>- protect area from development | 1 |
| 2.1.22 | San Felipe | Bay checkerspot butterfly<br>*Streptanthus albidus* ssp. *albidus*<br>----<br>*Cirsium fontinale* var. *campylon*<br>Jung's microblind harvestman<br>Hom's microblind harvestman | - private<br>- core area for bay checkerspot butterfly.<br>- protect area from development<br>- only known population of Jung's microblind harvestman | 1 |
| 2.1.23 | Silver Creek Hills | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus*<br>--- -<br>*Cirsium fontinale* var. *campylon*<br>Opler's longhorn moth | - private<br>- core area for bay checkerspot butterfly.<br>- an important area representing the northern portion of the *Dudleya setchellii* and *Streptanthus albidus* ssp. *albidus* ranges<br>- important area for Opler's longhorn moth<br>- protect area from development | 1 |
| 2.1.24 | North of Llagas Avenue | Bay checkerspot butterfly<br>*Ceanothus ferrisiae*<br>*Dudleya setchellii*<br>----<br>Opler's longhorn moth<br>*Lessingia micradenia* var. *glabrata*<br>*Streptanthus albidus* spp. *peramoenus* | - private<br>- may be an important site for *Lessingia micradenia* var. *glabrata*<br>- protect area from development | 2 |

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| 2.1.25 | Palm Avenue / Kalana Hills | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>----<br>*Streptanthus albidus* ssp. *peramoenus*<br>Opler's longhorn moth | - private<br>- protect area from development | 2 |
| 2.1.26 | West of San Martin area (including Hayes Valley / Lions Peak) | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus*<br>----<br>*Lessingia micradenia* var. *glabrata*<br>*Streptanthus albidus* ssp. *peramoenus*<br>Opler's longhorn moth | - private<br>- most southerly location of *Dudleya setchellii*<br>- protect area from development | 1 |
| 2.1.27 | Santa Teresa Hills | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>----<br>*Cirsium fontinale* var. *campylon*<br>*Streptanthus albidus* ssp. *peramoenus*<br>*Lessingia micradenia* var. *glabrata*<br>Opler's longhorn moth<br>Hom's microblind harvestman | - Santa Clara County (Santa Teresa County Park), private<br>- high priority for bay checkerspot butterfly<br>- protect area from development | 1 |
| 2.1.28 | Tulare Hill | Bay checkerspot butterfly<br>*Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus**<br>----<br>Opler's longhorn moth | - private<br>- high priority for bay checkerspot butterfly<br>- important area for Opler's longhorn moth<br>- protect area from development | 1 |
| 2.1.29 | Valley Christian (west of Silver Creek Hills) | *Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus* | - private | 3 |

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| | SONOMA COUNTY | | | |
| 2.1.30 | Bohemian Highway site | *Cordylanthus tenuis* ssp. *capillaris*<br>----<br>*Arctostaphylos bakeri* ssp. *bakeri*<br>*Lessingia arachnoidea* | - private<br>- one of the two locations of *Cordylanthus tenuis* ssp. *capillaris,* the northernmost location of *Lessingia arachnoidea* and an important site for *Arctostaphylos bakeri* ssp. *bakeri* | 1 |
| 2.1.31 | Harrison Grade Preserve and adjacent area | *Cordylanthus tenuis* ssp. *capillaris*<br>----<br>*Arctostaphylos bakeri* ssp. *bakeri* | - California Department of Fish and Game, private<br>- one of the two locations of *Cordylanthus tenuis* ssp. *capillaris* | 1 |

* extirpated

2.2 Protect and secure areas important for recovery/conservation of single species covered in the plan.

Table IV-2 lists areas that contain occupied or potential habitat for single species covered in the plan. Public and conservation lands should be managed to support listed and other sensitive species. Private lands should be protected through conservation management agreements, easements, or other mechanisms and then managed to support listed and other sensitive species.

**Table IV-2. Geographic Areas Targeted for Protection of Single Species Covered in the Plan.** See Figures I-3 through I-8 for locations of geographic areas.

| Task # | Location | Listed Taxon or Species of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| | ALAMEDA COUNTY | | | |
| 2.2.1 | Cedar Mountain area | no listed species known<br>----<br>*Cirsium fontinale* var. *campylon* | - private<br>- one of two known locations of *Cirsium fontinale* var. *fontinale* in Alameda County, at least one of the two should be protected | 1 |
| 2.2.2 | Fairmont Ridge area (south of Lake Chabot) | no listed species known<br>----<br>Fairmont microblind harvestman | - Alameda County, East Bay Regional Parks District<br>- only known locations of Fairmont microblind harvestman | 1 |
| 2.2.3 | Man Ridge area (southeast of Cedar Mountain) | no listed species known<br>----<br>*Cirsium fontinale* var. *campylon* | - private<br>- one of two known locations of *C. fontinale* var. *fontinale* in Alameda County, at least one of the two should be protected | 1 |
| 2.2.4 | San Leandro Hills | Bay checkerspot butterfly | -ownership unknown<br>-historic bay checkerspot locality | 2 |
| 2.2.5 | Sunol Regional Wilderness | no listed species known<br>----<br>*Streptanthus albidus* ssp. *peramoenus* | - East Bay Regional Parks District<br>- only location of *Streptanthus albidus* ssp. *peramoenus* in Alameda County on public land | 1 |
| | CONTRA COSTA COUNTY | | | |
| 2.2.6 | Franklin Canyon area | Bay checkerspot butterfly | - ownership unknown<br>- historic bay checkerspot locality | 3 |

| Task # | Location | Listed Taxon or Species of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| 2.2.7 | Mt. Diablo State Park | no listed species known<br>----<br>*Streptanthus albidus* ssp. *peramoenus* | - California Department of Parks and Recreation<br>- only known location of *Streptanthus albidus* ssp. *peramoenus* in Contra Costa County | 1 |
| 2.2.8 | Morgan Territory area | Bay checkerspot butterfly | - ownership unknown<br>- historic bay checkerspot locality | 3 |
| | MARIN COUNTY | | | |
| 2.2.9 | Big Rock area | *Hesperolinon congestum* | - private<br>- represents the northern region of *Hesperolinon congestum* range | 2 |
| 2.2.10 | Buck Center for Research on Aging | no listed species known<br>----<br>Marin blind harvestman | - private ownership<br>- one of only two known locations for Marin blind harvestman | 1 |
| 2.2.11 | El Campo | no listed species known<br>----<br>Tiburon microblind harvestman | - private ownership<br>- one of only two known locations of Tiburon microblind harvestman | 1 |
| 2.2.12 | Nicasio area | no listed species known<br>----<br>Opler's longhorn moth | - private<br>- one of northernmost known populations | 2 |
| 2.2.13 | Pine Mountain (Carson Ridge area) | *Hesperolinon congestum* | - Marin Municipal Water District<br>- represents the northern region of the range of *Hesperolinon congestum* | 2 |

| Task # | Location | Listed Taxon or Species of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| | NAPA COUNTY | | | |
| 2.2.14 | American Canyon | *Castilleja affinis* ssp. *neglecta* | - private<br>- westernmost location of *Castilleja affinis* ssp. *neglecta* | 1 |
| | SAN MATEO COUNTY | | | |
| 2.2.15 | Jasper Ridge | Bay checkerspot butterfly | - Stanford University | 2 |
| 2.2.16 | San Bruno Mountain | Bay checkerspot butterfly | - San Mateo County, California Department of Fish and Game, private<br>- restore habitat, reintroduce | 2 |
| | SANTA CLARA COUNTY | | | |
| 2.2.17 | Between Anderson and Coyote Reservoirs | *Dudleya setchellii* (potential bay checkerspot habitat) | - unknown, probably private<br>- most easterly location of *Dudleya setchellii* | 2 |
| 2.2.18 | Carlyle Hills (south of Gilroy in southern tip of Santa Clara County) | (potential bay checkerspot habitat)<br>-----<br>*Streptanthus albidus* ssp. *peramoenus* | - unknown<br>- southernmost location of *Streptanthus albidus* ssp. *peramoenus* | 2 |
| 2.2.19 | Chesbro Reservoir area (west of town of Morgan Hill) | *Dudleya setchellii* (potential bay checkerspot habitat) | - private<br>- entire area should be surveyed for *Dudleya setchellii* including along Uvas Road | 2 |
| 2.2.20 | East of San Martin | Bay checkerspot butterfly | - Santa Clara County | 2 |
| 2.2.21 | South of San Martin | no listed species known<br>----<br>Opler's longhorn moth | - private<br>- northernmost known location of Opler's longhorn moth | 2 |

| Task # | Location | Listed Taxon or Species of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| 2.2.22 | Guadalupe Reservoir in Almaden Quicksilver County Park (south of the reservoir outside of the park) | (potential bay checkerspot habitat)<br>----<br>*Cirsium fontinale* var. *campylon* | - private<br>- westernmost location for *Cirsium fontinale* var. *campylon*<br>- work to maintain current land use (grazing) if it is shown not to negatively impact the species | 1 |
| 2.2.23 | Hacienda School (south of Stile Ranch) | no listed species known<br>----<br>*Cirsium fontinale* var. *campylon* | - private<br>- protect from development | 2 |
| 2.2.24 | Northeast Santa Clara County (includes Blackbird Valley, Bolinger Canyon and San Antonio Valley) | no listed species known<br>----<br>*Cirsium fontinale* var. *campylon* | - private<br>- easternmost locations of *Cirsium fontinale* var. *campylon* in Santa Clara County<br>- work to maintain current land use (grazing) if it is shown not to negatively impact the species | 1 |
| 2.2.25 | Uvas Reservoir area (west of San Martin) | Bay checkerspot butterfly | - unknown | 2 |
| | SONOMA COUNTY | | | |
| 2.2.26 | Camp Meeker area (South to Occidental, East to Atascadero Creek) | no listed species known<br>----<br>*Arctostaphylos bakeri* ssp. *bakeri* | - private<br>- area contains the majority of known locations of *Arctostaphylos bakeri* ssp. *bakeri* | 1 |
| 2.2.27 | West of Forestville | no listed species known<br>----<br>*Arctostaphylos bakeri* ssp. *bakeri* | - private<br>- a more northerly and slightly disjunct location of *Arctostaphylos bakeri* ssp. *bakeri* | 1 |

| Task # | Location | Listed Taxon or Species of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Landowner / Comments | Priority |
|---|---|---|---|---|
| 2.2.28 | Northwest of Healdsburg | no listed species known<br>----<br>*Arctostaphylos bakeri* ssp. *bakeri* | - unknown<br>- most northerly location of *Arctostaphylos bakeri* ssp. *bakeri*<br>- more information needed on the site | 2 |
| 2.2.29 | Sears Point | no listed species known<br>----<br>Opler's longhorn moth | - private<br>- one of northernmost known populations | 2 |
| | STANISLAUS COUNTY | | | |
| 2.2.30 | Del Puerto Canyon area (northwestern Stanislaus County) | no listed species known<br>----<br>*Cirsium fontinale* var. *campylon* | - private<br>- easternmost locations of *Cirsium fontinale* var. *campylon* | 1 |

3. Manage habitat.

Managing habitat is essential to the recovery of listed species and the long-term conservation of species of concern included in this plan. Habitat management includes preparation of management plans for all areas inhabited by special status species, and periodic monitoring of populations in each of these areas.

3.1 Implement appropriate management in areas inhabited by special status species (Priority 1).

Management plans should be developed and implemented to the extent possible for areas identified in Tables IV-1 and IV-2 that are inhabited by special status species. The U.S. Fish and Wildlife

Service should review management plans as they are being developed. Management plans should include strategies to minimize threats to special status species, as well as to identify new threats should they appear. If new threats are identified or other new information becomes available, management plans need to be re-evaluated and revised. Management activities should be evaluated periodically, and adjusted as indicated to maximize the potential for survival, conservation, and recovery of listed species and other species of concern. This process of evaluating and adjusting management as needed is termed "adaptive management". Results of new biological research (see Task 5) should also be considered in adaptive management schemes.

3.2 Develop and implement monitoring plans for special status species populations in all areas they inhabit (Priority 2).

Monitoring plans should be developed for all areas inhabited by populations of listed species and species of concern. These populations should then be monitored at time intervals appropriate for each species (see Recovery Strategies for individual species, Chapter II). Monitoring efforts for co-occurring species (e.g. at Ring Mountain) should be coordinated to increase efficiency and reduce costs. Population monitoring should continue where currently underway and should begin, wherever possible, for all other populations regardless of whether management plans have been developed or formal protection has been secured.

4. Survey historic locations and other potential habitat where species covered in the plan may occur. Incorporate any new or rediscovered populations into all aspects of recovery planning.

Recovery of listed species and long-term conservation of species of concern covered in this plan will often require relocating historic populations or locating new populations of these species. Historic locations should be surveyed to determine whether suitable habitat

remains, the species persists at the sites, and/or the sites may be suitable for repatriation. Suitability of historic locations for repatriation would depend upon: (1) whether potential habitat exists, (2) the presence and magnitude of threats, and (3) whether the sites can be secured and managed for the long-term protection of the species. Surveys should also include other potential serpentine habitat to determine whether undiscovered populations may exist. If new populations are discovered, they should be protected and managed as discussed above. During the surveys, potential introduction sites should also be identified.
Specific locations that need to be surveyed for one or more species covered in the plan are given in Table IV-3. To increase efficiency and reduce costs, integrated programs involving several species in the same geographic area should be implemented where possible. Such integration may be especially effective for plant species surveys and censuses.

4.1 Establish a survey program and protocol for species covered in the plan (Priority 2).

Botanical surveys need to follow a standard protocol.

4.2 Conduct general and directed surveys.

General surveys of potential serpentine habitat in each geographic area are needed as well as directed surveys of historic locations and other areas that are especially likely to contain species covered in the plan. Needs for directed surveys (i.e. for specific species in specific areas) are given in Table IV-3.

**Table IV-3. Directed Survey Needs of Historic and Potential Habitat by Geographic Area.** Does not include need for general surveys of potential serpentine habitat throughout the area covered in the plan. See Figures I-3 through I-8 for locations of specific geographic areas.

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Comments | Priority |
|---|---|---|---|---|
| | ALAMEDA COUNTY | | | |
| 4.2.1 | Cedar Mountain and Man Ridge drainages, Arroyo Valle to their west | no listed species known<br>----<br>*Cirsium fontinale* var. *campylon* | - additional populations of *Cirsium fontinale* var. *campylon* likely (B. Olson, *in litt.*, 1998) | 3 |
| 4.2.2 | Fairmont Ridge (south of Lake Chabot) | no listed species known<br>----<br>Fairmont microblind harvestman | - historic location for Fairmont microblind harvestman | 1 |
| 4.2.3 | Joaquin Miller Park | no listed species known<br>----<br>Opler's longhorn moth | - evaluate habitat<br>- more populations of Opler's longhorn moth may exist | 1 |
| 4.2.4 | Niles | no listed species known<br>----<br>*Streptanthus albidus* ssp. *peramoenus* | - unknown ownership<br>- historic location for *Streptanthus albidus* ssp. *peramoenus* | 3 |
| 4.2.5 | Oakland Hills | Bay checkerspot butterfly*<br>*Clarkia franciscana*<br>----<br>*Streptanthus albidus* ssp. *peramoenus*<br>Opler's longhorn moth | - survey needed for *Clarkia franciscana* at the "Tennis Club site"<br>- more populations of Opler's longhorn moth may exist at Redwood Regional Park | 2 |
| | CONTRA COSTA COUNTY | | | |
| 4.2.6 | Franklin Canyon | Bay checkerspot butterfly* | - historic location<br>- evaluate habitat | 3 |
| 4.2.7 | Morgan Territory | Bay checkerspot butterfly* | - historic location<br>- evaluate habitat | 3 |

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Comments | Priority |
|---|---|---|---|---|
| 4.2.8 | Mt. Diablo State Park | Bay checkerspot butterfly<br>----<br>*Streptanthus albidus* ssp. *peramoenus* | - one historic location of *Streptanthus albidus* ssp. *peramoenus* based on 1938 collection, two extant locations | 3 |
| | MARIN COUNTY | | | |
| 4.2.9 | Alpine Lake / Carson Ridge (including San Geronimo Ridge) | *Hesperolinon congestum*<br>----<br>*Lessingia micradenia* var. *micradenia* | - more populations of *Hesperolinon congestum* may exist (California Department of Fish and Game 1997*a*)<br>- *Lessingia micradenia* var. *micradenia* may extend onto San Geronimo Ridge (D. Odion, *in litt.*, 1998) | 2 |
| 4.2.10 | El Campo | No listed species known<br>----<br>Tiburon microblind harvestman | - historic location of Tiburon microblind harvestman<br>- evaluate habitat | 2 |
| 4.2.11 | Golden Gate National Recreation Area | *Castilleja affinis* ssp. *neglecta*<br>*Hesperolinon congestum* | | 2 |
| 4.2.12 | Larkspur (northwest of Tiburon Peninsula) | *Pentachaeta bellidiflora** | - private<br>- check for habitat remnants at this historic *Pentachaeta bellidiflora* site (California Department of Fish and Game 1997*a*) | 3 |
| 4.2.13 | Marin City (on Marin Peninsula west of Tiburon Peninsula) | *Pentachaeta bellidiflora** | - unknown ownership<br>- if potential habitat remains, surveys for *Pentachaeta bellidiflora* should be conducted<br>- most likely historic site at which habitat may remain in the northern Bay Area (California Department of Fish and Game 1997*a*) | 2 |

| Task # | Location | Listed Taxa and Taxa of Concern<br>(Listed taxa and taxa of concern are separated by a dashed line.) | Comments | Priority |
|---|---|---|---|---|
| 4.2.14 | Nicasio (approximately 8 kilometers (5 miles) north, southeast corner of Nicasio Reservoir) | no species listed<br>-----<br>Opler's longhorn moth | - private<br>- check for other habitat remnants for Opler's longhorn moth | 2 |
| 4.2.15 | Phoenix Lake | no listed species known<br>----<br>*Lessingia micradenia* var. *micradenia* | - unknown ownership<br>- historic location based on 1960 collection | 2 |
| 4.2.16 | Ross Valley area (northwest of Tiburon Peninsula) | *Pentachaeta bellidiflora** | - private, unknown ownership<br>- check for remnant habitat at the historic *Pentachaeta bellidiflora* sites in this area (California Department of Fish and Game 1997*a*) | 3 |
| 4.2.17 | San Anselmo Canyon | no listed species known<br>----<br>*Lessingia micradenia* var. *micradenia* | - unknown ownership<br>- historic location based on 1938 collection | 2 |
| 4.2.18 | Tiburon Peninsula | *Calochortus tiburonensis*<br>*Castilleja affinis* ssp. *neglecta*<br>*Hesperolinon congestum*<br>*Streptanthus niger*<br>----<br>Opler's longhorn moth<br>Tiburon microblind harvestman | - possibly extirpated *Hesperolinon congestum* site near Marin County Day School needs to be surveyed<br>- private, unknown ownership<br>- check for remnant habitat | 2 |
| | SAN FRANCISCO COUNTY | | | |
| 4.2.19 | Presidio | *Clarkia franciscana*<br>*Hesperolinon congestum* | - survey for the possibly extirpated population of *Clarkia franciscana* on McDowell Avenue and for potential introduction sites (see species account for *Clarkia franciscana*)<br>- potential introduction sites for *Hesperolinon congestum* might be | 2 |

| Task # | Location | Listed Taxa and Taxa of Concern<br>(Listed taxa and taxa of concern are separated by a dashed line.) | Comments | Priority |
|---|---|---|---|---|
| 4.2.20 | San Francisco Peninsula (South of Presidio) | *Hesperolinon congestum** | - private<br>- check for serpentine habitat remnants at *Hesperolinon congestum* sites south of the Presidio | 3 |
| | SAN MATEO COUNTY | | | |
| 4.2.21 | Area between San Andreas Lake and Crystal Springs Reservoir and to the west | *Hesperolinon congestum*<br>----<br>*Lessingia arachnoidea*<br>Opler's longhorn moth | - Fifield Ridge for *Hesperolinon congestum* (California Department of Fish and Game 1997*b*)<br>- historic location of *Lessingia arachnoidea*; if potential habitat remains, surveys should be conducted | 2 |
| 4.2.22 | Crystal Springs Reservoir area | Bay checkerspot butterfly*<br>*Acanthomintha obovata* ssp. *duttonii*<br>*Cirsium fontinale* var. *fontinale*<br>*Eriophyllum latilobum*<br>*Hesperolinon congestum*<br>*Pentachaeta bellidiflora*<br>----<br>*Lessingia arachnoidea*<br>Edgewood blind harvestman<br>Edgewood microblind harvestman<br>Opler's longhorn moth | - including, but not limited to, Buri Buri and Pulgas ridges and the San Mateo Creek area<br>- one historic *Acanthomintha obovata* ssp. *duttonii* occurrence, two historic locations of *Lessingia arachnoidea*<br>- newly discovered *Pentachaeta bellidiflora* location should be confirmed<br>- surveys should include San Francisco Water Department lands | 1 |
| 4.2.23 | Edgewood Natural Preserve | *Cirsium fontinale* var. *fontinale*<br>*Pentachaeta bellidiflora*<br>----<br>*Lessingia arachnoidea*<br>Edgewood blind harvestman<br>Edgewood microblind harvestman<br>Opler's longhorn moth | -surveys needed to confirm the status of *Cirsium fontinale* var. *fontinale* and *Pentachaeta bellidiflora* and their potential habitats in the preserve and to confirm the absence of *Lessingia arachnoidea* from the preserve | 2 |

| Task # | Location | Listed Taxa and Taxa of Concern<br>(Listed taxa and taxa of concern are separated by a dashed line.) | Comments | Priority |
|---|---|---|---|---|
| 4.2.24 | Loma Mar area southwest of La Honda (south of Woodside) | *Eriophyllum latilobum** | - unknown ownership<br>- possibly extirpated or erroneous (see *Eriophyllum latilobum* species account) | 3 |
| 4.2.25 | Menlo Park area (east of Woodside) | *Acanthomintha obovata* ssp. *duttonii** | - private<br>- check for habitat remnants at this historic *Acanthomintha obovata* ssp. *duttonii* site (California Department of Fish and Game 1997*b*) | 3 |
| 4.2.26 | Redwood City area (east of Woodside) | Bay checkerspot butterfly*<br>*Acanthomintha obovata* ssp. *duttonii** | - private<br>- historic locality for both species<br>-evaluate remaining habitat | 3 |
| 4.2.27 | San Andreas Lake (north of Crystal Springs Reservoir) | *Pentachaeta bellidiflora**<br>----<br>Opler's longhorn moth | - San Francisco Water Department<br>- historic *Pentachaeta bellidiflora* site (California Department of Fish and Game 1997*b*), check for remnant habitat | 3 |
| 4.2.28 | San Bruno Mountain | Bay checkerspot butterfly*<br>*Pentachaeta bellidiflora**<br>-----<br>Opler's longhorn moth | - San Mateo County, State, and private owners<br>- if potential habitat remains, surveys for *Pentachaeta bellidiflora* should be conducted<br>- larval food plant for Opler's longhorn moth has been found here | 3 |
| 4.2.29 | Woodside Glens / Canada College (generally in the Woodside area) | *Hesperolinon congestum* | - one extirpated population and one extant population of *Hesperolinon congestum* known from the area | 2 |

| Task # | Location | **Listed Taxa and Taxa of Concern**<br>(Listed taxa and taxa of concern are separated by a dashed line.) | **Comments** | **Priority** |
|---|---|---|---|---|
| | SANTA CLARA COUNTY | | | |
| 4.2.30 | Anderson Reservoir / Coyote Reservoir area | bay checkerspot butterfly (Anderson Reservoir only)<br>*Ceanothus ferrisiae*<br>*Streptanthus albidus* ssp. *albidus*<br>----<br>*Cirsium fontinale* var. *campylon**<br>*Lessingia micradenia* var. *glabrata*<br>Opler's longhorn moth | - Surveys for *Ceanothus ferrisiae* should include areas east of Anderson Reservoir<br>- historic *Streptanthus albidus* ssp. *albidus* location; may be erroneous (California Department of Fish and Game 1997*b*) | 1 |
| 4.2.31 | Calero Reservoir area (general area around Calero County Park) | *Dudleya setchellii*<br>----<br>*Cirsium fontinale* var. *campylon*<br>*Streptanthus albidus* ssp. *peramoenus*<br>Opler's longhorn moth | - prime area for undiscovered populations of Opler's longhorn moth | 2 |
| 4.2.32 | Communications Hill area | *Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus*<br>----<br>Opler's longhorn moth | - historic location for *Streptanthus albidus* ssp. *albidus* at Canoas Creek, last visited 1938<br>- larval food plant for Opler's longhorn moth has been found here | 2 |
| 4.2.33 | Coyote Ridge | *Castilleja affinis* ssp. *neglecta*<br>*Ceanothus ferrisiae*<br>*Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus*<br>----<br>*Cirsium fontinale* var. *campylon*<br>*Lessingia micradenia* var. *glabrata*<br>*Streptanthus albidus* ssp. *peramoenus*<br>Opler's longhorn moth | - including, but not limited to, areas defined as Kirby, Metcalf, San Felipe, and Silver Creek Hills<br>- *Dudleya setchellii* surveys should include area north of Metcalf Canyon Road and Motorcycle Park<br>- two historic locations of *Lessingia micradenia* var. *glabrata* in Metcalf Canyon and one south of Pigeon Point | 1 |

| Task # | Location | Listed Taxa and Taxa of Concern<br>(Listed taxa and taxa of concern are separated by a dashed line.) | Comments | Priority |
|---|---|---|---|---|
| 4.2.34 | Croy Canyon | *Ceanothus ferrisiae* | - historic occurrence last seen in 1929; possibly erroneous | 2 |
| 4.2.35 | Henry W. Coe State Park | *Castilleja affinis* ssp. *neglecta*<br>----<br>Hom's microblind harvestman<br>Opler's longhorn moth | - at least one other microblind harvestman species occurs here | 2 |
| 4.2.36 | Lexington Reservoir area (west of Almaden Quicksilver County Park) | *Streptanthus albidus* ssp. *albidus* | - private<br>- record may be erroneous, needs to be investigated (California Department of Fish and Game 1997*b*) | 3 |
| 4.2.37 | Loma Prieta | Bay checkerspot butterfly<br>----<br>*Lessingia micradenia* var. *glabrata* | - unknown ownership<br>- historic location for *Lessingia micradenia* var. *glabrata* based on 1893 collection | 2 |
| 4.2.38 | North of Llagas Avenue | *Castilleja affinis* ssp. *neglecta*<br>*Ceanothus ferrisiae*<br>*Dudleya setchellii*<br>----<br>*Lessingia micradenia* var. *glabrata*<br>*Streptanthus albidus* spp. *peramoenus* | - historic location of *Lessingia micradenia* var. *glabrata* | 2 |
| 4.2.39 | New Almaden area (east of Almaden Quicksilver County Park) | Bay checkerspot butterfly<br>----<br>*Lessingia micradenia* var. *glabrata*<br>Opler's longhorn moth | - unknown ownership<br>- historic location for *Lessingia micradenia* var. *glabrata* based on 1941 collection<br>- prime area for undiscovered populations of Opler's longhorn moth | 2 |
| 4.2.40 | Palm Avenue / Kalana Hills | *Castilleja affinis* ssp. *neglecta*<br>*Dudleya setchellii*<br>----<br>*Streptanthus albidus* ssp. *peramoenus*<br>Opler's longhorn moth | - private, unknown ownership<br>- prime area for undiscovered populations of Opler's longhorn moth | 2 |

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Comments | Priority |
|---|---|---|---|---|
| 4.2.41 | San Martin area (including Hayes Valley / Lions Peak) | *Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus*<br>----<br>*Lessingia micradenia* var. *glabrata* *Streptanthus albidus* ssp. *peramoenus*<br>Opler's longhorn moth | - historic location of *Streptanthus albidus* ssp. *albidus* and Opler's longhorn moth; possibly erroneous (California Department of Fish and Game 1997*b*)<br>- historic location of *Lessingia micradenia* var. *glabrata* based on 1936 collection | 1 |
| 4.2.42 | Santa Teresa Hills | *Dudleya setchellii*<br>----<br>*Cirsium fontinale* var. *campylon*<br>*Streptanthus albidus* ssp. *peramoenus*<br>*Lessingia micradenia* var. *glabrata* | - private, unknown ownership | 1 |
| 4.2.43 | Tulare Hill area | *Dudleya setchellii*<br>*Streptanthus albidus* ssp. *albidus**<br>----<br>Opler's longhorn moth | - check for other potential habitat for Opler's longhorn moth | 2 |
| 4.2.44 | Uvas Road | *Dudleya setchellii*<br>----<br>Opler's longhorn moth | - private, unknown ownership<br>- no surveys to date in this area for Opler's longhorn moth | 2 |
| | SANTA CRUZ COUNTY | | | |
| 4.2.45 | Ben Lomond Mountain | *Pentachaeta bellidiflora** | - Big Basin State Park, private<br>- one of two historic locations of *Pentachaeta bellidiflora* in Santa Cruz County<br>- if potential habitat remains, surveys for *Pentachaeta bellidiflora* should be conducted | 2 |

| Task # | Location | Listed Taxa and Taxa of Concern (Listed taxa and taxa of concern are separated by a dashed line.) | Comments | Priority |
|---|---|---|---|---|
| 4.2.46 | San Lorenzo Creek area | *Pentachaeta bellidiflora** | - Big Basin State Park, private<br>- one of two historic locations of *Pentachaeta bellidiflora* in Santa Cruz County<br>- if potential habitat remains, surveys for *Pentachaeta bellidiflora* should be conducted | 2 |
| 4.2.47 | Scott's Valley area | no listed species known<br>----<br>Opler's longhorn moth | -private<br>-only population of Opler's longhorn moth not occurring on serpentine soils | 2 |
| | SONOMA COUNTY | | | |
| 4.2.48 | Bohemian Highway site | *Cordylanthus tenuis* ssp. *capillaris*<br>----<br>*Arctostaphylos bakeri* ssp. *bakeri*<br>*Lessingia arachnoidea* | - identity of *Lessingia* needs to be verified | 2 |
| 4.2.49 | Healdsburg area | no listed species known<br>----<br>*Arctostaphylos bakeri* ssp. *bakeri* | | 2 |
| 4.2.50 | Sears Point area | no listed species known<br>----<br>Opler's longhorn moth | - private, unknown ownership<br>-check for other potential habitat for Opler's longhorn moth | 2 |

* extirpated

5. Conduct necessary biological research and use results to guide recovery/conservation efforts.

Table IV-4 compiles research needs by geographic area for species covered in the plan. Research on habitat management and population biology is important as the basis for adaptive management (see Task 3 above) and to guide repatriation or introduction efforts (see Task 6 below). Other research, such as on how soil chemistry specifically influences evolution of serpentine endemic plant species, would also be interesting but would probably provide data less directly useful for assessing appropriate recovery criteria and for guiding management activities. A summary of research needs for each species is given in Appendix D; for fuller accounts see the Recovery Strategies section of the species accounts for individual species (Chapter II).

**Table IV-4. Research Needs by Geographic Area.** Additional information is given in the individual species accounts (Chapter II). See Figures I-3 through I-8 for locations of geographic areas.

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| | ALAMEDA COUNTY | | | |
| 5.1 | Cedar Mountain / Man Ridge area | - demography, reproduction of *Cirsium fontinale* var. *campylon* | - only Alameda County locations of *Cirsium fontinale* var. *campylon* | 2 |
| 5.2 | Fairmont Ridge area (south of Lake Chabot) | - demography, reproduction, genetics, effects of grazing and burning as management strategies (Opler's longhorn moth) | - grazing ceased about 5 years ago<br>- only known location for Fairmont microblind harvestman | 1 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.3 | Oakland Hills | - demography, soil seed bank, reproduction (*Clarkia franciscana* and *Streptanthus albidus* ssp. *peramoenus*)<br>- techniques for opening new habitat and for seeding (*Clarkia franciscana*)<br>- taxonomic and genetics studies (*Streptanthus albidus* ssp. *peramoenus*)<br>- demography, reproduction, genetics (Opler's longhorn moth) | - population genetics studies to clarify the relationship of Alameda County populations of *Streptanthus albidus* ssp. *peramoenus* to populations in other parts of the range | 1 |
| 5.4 | Sunol Regional Wilderness | - demography, soil seed bank, reproduction, genetics of *Streptanthus albidus* ssp. *peramoenus* | - population genetics studies to clarify the relationship of Alameda County populations of *Streptanthus albidus* ssp. *peramoenus* to populations in other parts of the range | 2 |
| | CONTRA COSTA COUNTY | | | |
| 5.5 | Mt. Diablo State Park | - demography, soil seed bank, reproduction, genetics of *Streptanthus albidus* ssp. *peramoenus* | - population genetics studies to clarify the relationship of Contra Costa County populations of *Streptanthus albidus* ssp. *peramoenus* to populations in other parts of the range | 2 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| | MARIN COUNTY | | | |
| 5.6 | Alpine Lake / Carson Ridge | - demography, soil seed bank, reproduction, effects of burning as a management strategy (*Hesperolinon congestum* and *Lessingia micradenia* var. *micradenia*)<br>- genetics, effects of grazing as a management strategy (*Hesperolinon congestum*) | - population genetics studies to clarify the relationship of northern populations of *Hesperolinon congestum* to populations in other parts of the range | 2 |
| 5.7 | El Campo | - demography, reproduction, genetics, effects of grazing and burning as management strategies (Tiburon microblind harvestman) | | 1 |
| 5.8 | Golden Gate National Recreation Area | - demography, soil seed bank, genetics, reproduction (*Castilleja affinis* ssp. *neglecta* and *Hesperolinon congestum*)<br>- effects of grazing (*Castilleja affinis* ssp. *neglecta* and *Hesperolinon congestum*)<br>- effects of fire, taxonomy and genetics, hemiparasitism (*Castilleja affinis* ssp. *neglecta*) | - demographic studies should include frequency of *Castilleja affinis* ssp. *neglecta* seed germination in the field<br>- population genetics studies to clarify the relationship of *Castilleja affinis* ssp. *neglecta* and *Hesperolinon congestum* populations to populations in other parts of their respective ranges | 2 |
| 5.9 | Mt. Burdell | - demography, soil seed bank, genetics, reproduction, effects of grazing (*Hesperolinon congestum*)<br>- demography, genetics, reproduction, effects of grazing (Marin blind harvestman) | - population genetics studies to clarify the relationship of northern populations of *Hesperolinon congestum* to populations in other parts of the range | 2 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.10 | Nicasio (approximately 8 kilometers (5 miles) north, southeast corner of Nicasio Reservoir) | - demography, reproduction, genetics, effects of grazing and burning as management strategies (Opler's longhorn moth) | - population genetics studies to clarify the relationship of northern populations of Opler's longhorn moth to populations in other parts of the range | 2 |
| | Tiburon Peninsula: | | | |
| 5.11 | Middle Ridge | - demography, soil seed bank, reproduction (*Castilleja affinis* ssp. *neglecta*, *Hesperolinon congestum*, and *Streptanthus niger*)<br>- genetics (*Castilleja affinis* ssp. *neglecta* and *Hesperolinon congestum*)<br>- effects of fire, taxonomy, and hemiparasitism (*Castilleja affinis* ssp. *neglecta*) | - demographic studies should include the frequency of *Castilleja affinis* ssp. *neglecta* seed germination in the field.<br>- population genetics studies to clarify the relationship of *Castilleja. affinis* ssp. *neglecta* and *Hesperolinon congestum* populations to populations in other parts of their respective ranges | 2 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.12 | Ring Mountain | - demography, soil seed bank of annuals, reproduction (*Calochortus tiburonensis*, *Castilleja affinis* ssp. *neglecta*, and *Hesperolinon congestum*)<br>- effects of grazing, burning, mowing on recruitment of *Calochortus tiburonensis*<br>- genetics, effects of burning (*Castilleja affinis* ssp. *neglecta* and *Hesperolinon congestum*)<br>- taxonomy, hemiparasitism (*Castilleja affinis* ssp. *neglecta*)<br>- demography, reproduction, genetics, effects of grazing and burning as management strategies (Tiburon microblind harvestman and Opler's longhorn moth) | - demographic studies should include the frequency of *Castilleja affinis* ssp. *neglecta* seed germination in the field.<br>- population genetics studies to clarify the relationship of *Castilleja affinis* ssp. *neglecta* and *Hesperolinon congestum* populations to populations in other parts of their respective ranges<br>- some research on the demography and reproduction of *Calochortus tiburonensis* has been done by Fiedler (1987) and Sloop (1996). | 1 |
| 5.13 | St. Hilary's area (includes Harroman Property) | - demography, soil seed bank, reproduction (*C. affinis* ssp. *neglecta*, *Hesperolinon congestum*, and *Streptanthus niger*)<br>- genetics, effects of burning (*Castilleja affinis* ssp. *neglecta* and *Hesperolinon congestum*)<br>- taxonomy, hemiparasitism (*Castilleja affinis* ssp. *neglecta*) | - demographic studies should include the frequency of *Castilleja affinis* ssp. *neglecta* seed germination in the field.<br>- population genetics studies to clarify the relationship of *Castilleja affinis* ssp. *neglecta* and *Hesperolinon congestum* populations to populations in other parts of their respective ranges | 2 |
| | NAPA COUNTY | | | |
| 5.14 | American Canyon | - demography, reproduction of *Castilleja affinis* ssp. *neglecta* | | 3 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| | SAN FRANCISCO COUNTY | | | |
| 5.15 | Presidio | - demography, soil seed bank, reproduction (*Clarkia franciscana* and *Hesperolinon congestum*)<br>- techniques for opening new habitat and for seeding (*Clarkia franciscana*)<br>- genetics, effects of burning on *Hesperolinon congestum* | - population genetics studies to clarify the relationship of central populations of *Hesperolinon congestum* to populations in other parts of the range | 1 |
| | SAN MATEO COUNTY | | | |
| 5.16 | County-wide: selected habitat areas | - develop vegetation management methods (bay checkerspot butterfly and other plan species). Methods to be considered should include, e.g., schedules of grazing, mowing, fire. | - quantify existing methods; test a variety of methods experimentally across sites and years. | 1 |
| 5.17 | County-wide: selected habitat areas | - assess air pollution inputs and effects on serpentine habitats (all species) | - study should cover a broad range of conditions | 1 |
| 5.18 | County-wide: selected areas | - determine the feasibility of restoring habitat on serpentine and non-serpentine soils (bay checkerspot butterfly) | - success of restoration for other plan species should also be evaluated | 2 |
| 5.19 | Crystal Springs area (includes Buri Buri and Pulgas Ridges and San Mateo Creek/Crystal Springs Road area) | - demography, soil seed bank for annuals, reproduction (*Acanthomintha obovata* ssp. *duttonii*, *Cirsium fontinale* var. *fontinale*, *Eriophyllum latilobum*, *Hesperolinon congestum*, and *Lessingia arachnoidea*)<br>- genetics (*Eriophyllum latilobum*, *H. congestum*)<br>- seed predation by weevil, hybridization with *Cirsium quercetorum*, influence of | - population genetics studies to clarify the relationship of southern populations of *Hesperolinon congestum* to populations in other parts of the range | 1 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.20 | Edgewood Natural Preserve | - demography, soil seed bank, reproduction (*Acanthomintha obovata* ssp. *duttonii*, *Hesperolinon congestum*, and *Pentachaeta bellidiflora*)<br>- genetics (*Acanthomintha obovata* ssp. *duttonii* and *Hesperolinon congestum*)<br>- reseeding, burning, weeding to enhance habitat for *Acanthomintha obovata* ssp. *duttonii* upslope of current population<br>- relocate and/or reintroduce *Cirsium fontinale* var. *fontinale*<br>-experimental reseeding of *Pentachaeta bellidiflora*<br>- demography, reproduction, genetics, effects of vegetation management strategies (Edgewood blind harvestman and Edgewood microblind harvestman) | - research on demography and reproduction of *Acanthomintha obovata* ssp. *duttonii* has been conducted by Pavlik and Espeland (1991, 1993, 1994), Pavlik *et al.* (1992), and Steeck (1995).<br>- population genetics studies to clarify the relationship of southern populations of *Hesperolinon congestum* to populations in other parts of the range | 1 |
| 5.21 | Jasper Ridge | - investigate reasons for limited reproductive success of bay checkerspot butterfly | | 2 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.22 | Triangle | - demography, soil seed bank for annuals, reproduction (*Acanthomintha obovata* ssp. *duttonii, Cirsium fontinale* var. *fontinale, Pentachaeta bellidiflora*)<br>- habitat requirements (*Acanthomintha obovata* ssp. *duttonii*)<br>- demography, reproduction, genetics, effects of vegetation management strategies (Edgewood microblind harvestman) | - habitat research for *Acanthomintha obovata* ssp. *duttonii* should focus on clarifying why the species is restricted to such a small part of the Triangle | 2 |
| 5.23 | Woodside Glens / Canada College (generally in the Woodside area) | - demography, soil seed bank, reproduction, susceptibility to herbicide, fertilizer and water runoff (*Hesperolinon congestum*) | | 3 |
| | SANTA CLARA COUNTY | | | |
| 5.24 | County-wide: selected habitat areas | - develop vegetation management methods (bay checkerspot butterfly; Opler's longhorn moth, and other plan species). Methods to be considered should include, e.g., schedules of grazing, mowing, fire | - quantify existing methods; test a variety of methods experimentally across sites and years. | 1 |
| 5.25 | County-wide: selected habitat areas | - assess air pollution inputs and effects on serpentine habitats (all species) | - study should cover a broad range of conditions | 1 |
| 5.26 | County-wide: selected areas | - determine the feasibility of restoring habitat on serpentine and non-serpentine soils (bay checkerspot butterfly) | - success of restoration for other plan species should also be evaluated | 2 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.27 | Almaden Quicksilver County Park | - demography, soil seed bank for annuals, reproduction (*Dudleya setchellii, Lessingia micradenia* var. *glabrata, Streptanthus albidus* ssp. *peramoenus*)<br>- dispersal and connectivity among rock outcrops (*Dudleya setchellii*)<br>- taxonomy and genetics of *Streptanthus albidus* ssp. *peramoenus* | - population genetics studies to clarify the relationship of Santa Clara County populations of *Streptanthus albidus* ssp. *peramoenus* to populations in other parts of the range | 2 |
| 5.28 | Anderson Reservoir / County Park area | - demography, reproduction (*Ceanothus ferrisiae*, Lessingia *micradenia* var. *glabrata*)<br>- role of fire in reproduction, impact of grazing, and lack of recruitment for *Ceanothus ferrisiae*<br>- soil seed bank of *Lessingia micradenia* var. *glabrata* | | 2 |
| 5.29 | Calero Reservoir area (general area around and including Calero County Park) | - demography, soil seed bank of annuals, reproduction (*Dudleya setchellii, Cirsium fontinale* var. *campylon, Streptanthus albidus* ssp. *peramoenus*)<br>- influence of disturbance on seedling establishment (*Cirsium fontinale* var. *campylon*)<br>- dispersal and connectivity among rock outcrops (*Dudleya setchellii*)<br>- genetics of *Cirsium fontinale* var. *campylon*<br>- taxonomy and genetics of *Streptanthus albidus* ssp. *peramoenus* | - population genetics studies to clarify the relationship of *Cirsium fontinale* var. *campylon* and *Streptanthus albidus* ssp. *peramoenus* populations to populations in other parts of the range | 2 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.30 | Coyote Ridge | - demography, soil seed bank of annuals, reproduction (*Castilleja affinis* ssp. *neglecta, Ceanothus ferrisiae, Cirsium fontinale* var. *campylon, Dudleya setchellii, Lessingia micradenia* var. *glabrata, Streptanthus albidus* ssp. *albidus*, *Streptanthus albidus* ssp. *peramoenus*)<br>- effects of vegetation management techniques such as grazing, mowing, burning on *Castilleja affinis* ssp. *neglecta, Cirsium fontinale* var. *campylon, Dudleya setchellii, Cirsium fontinale* var. *campylon, Streptanthus albidus* ssp. *albidus*, *Streptanthus albidus* ssp. *peramoenus*<br>- taxonomy and genetics (*Castilleja affinis* ssp. *neglecta, Cirsium fontinale* var. *campylon, Streptanthus albidus* ssp. *albidus* and *Streptanthus albidus* ssp. *peramoenus*)<br>- role of fire in reproduction, impact of grazing, and lack of recruitment for *Ceanothus ferrisiae*<br>- influence of disturbance on seedling establishment (*Cirsium fontinale* var. *campylon*)<br>- dispersal and connectivity among rock outcrops (*Dudleya setchellii*)<br>- demography, reproduction, genetics, effects of vegetation management strategies (Opler's longhorn moth) | - vegetation management research is of high priority to clarify whether management of bay checkerspot butterfly might conflict with management of co-occurring plant species<br>- population genetics studies to clarify the relationship of *Castilleja affinis* ssp. *neglecta, Cirsium fontinale* var. *campylon* and *Streptanthus albidus* ssp. *peramoenus* populations to populations in other parts of their respective ranges | 1 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.31 | North of Llagas Avenue | - demography, soil seed bank of annuals, reproduction (*Ceanothus ferrisiae, Dudleya setchellii, Lessingia micradenia* var. *glabrata, Streptanthus albidus* ssp. *peramoenus*)<br>- role of fire in reproduction, impact of grazing, and lack of recruitment for *Ceanothus ferrisiae*<br>- dispersal and connectivity among rock outcrops (*Dudleya setchellii*)<br>- taxonomy and genetics of *Streptanthus albidus* ssp. *peramoenus* | - population genetics studies to clarify the relationship of Santa Clara County populations of *Streptanthus albidus* ssp. *peramoenus* to populations in other parts of the range | 3 |
| 5.32 | Northeast Santa Clara County (includes Blackbird Valley, Bolinger Canyon and San Antonio Valley) | - demography, reproduction, genetics of *Cirsium fontinale* var. *campylon* | - population genetics studies to clarify the relationship among populations of *Cirsium fontinale* var. *campylon* | 2 |
| 5.33 | Palm Avenue / Kalana Hills | - demography, reproduction (*Dudleya setchellii, Streptanthus albidus* ssp. *peramoenus*)<br>- dispersal and connectivity among rock outcrops (*Dudleya setchellii*)<br>- soil seed bank, taxonomy and genetics of *Streptanthus albidus* ssp. *peramoenus*<br>- demography, reproduction, genetics, effects of vegetation management strategies (Opler's longhorn moth) | - population genetics studies to clarify the relationship of Santa Clara County populations of *Streptanthus albidus* ssp. *peramoenus* to populations in other parts of the range | 3 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.34 | San Martin area (including Hayes Valley / Lions Peak) | - demography, soil seed bank of annuals, reproduction (*Dudleya setchellii, Lessingia micradenia* var. *glabrata, Streptanthus albidus* ssp. *albidus, Streptanthus albidus* ssp. *peramoenus*)<br>- dispersal and connectivity among rock outcrops (*Dudleya setchellii*)<br>- taxonomy and genetics of *Streptanthus albidus* ssp. *albidus* and *Streptanthus albidus* ssp. *peramoenus*<br>- demography, reproduction, genetics, effects of vegetation management strategies (Opler's longhorn moth) | - population genetics studies to clarify the relationship of Santa Clara County populations of *Streptanthus albidus* ssp. *peramoenus* to populations in other parts of the range | 2 |
| 5.35 | Santa Teresa Hills | - demography, soil seed bank of annuals, reproduction (*Cirsium fontinale* var. *campylon, Dudleya setchellii, Lessingia micradenia* var. *glabrata, Streptanthus albidus* ssp. *peramoenus*)<br>- influence of disturbance on seedling establishment (*Cirsium fontinale* var. *campylon*)<br>- dispersal and connectivity among rock outcrops (*Dudleya setchellii*)<br>- genetics of *Cirsium fontinale* var. *campylon*<br>- taxonomy and genetics of *Streptanthus albidus* ssp. *peramoenus*<br>- demography, reproduction, genetics, effects of vegetation management strategies (Opler's longhorn moth) | - population genetics studies to clarify the relationship of *Cirsium fontinale* var. *campylon* and *Streptanthus albidus* ssp. *peramoenus* populations to populations in other parts of the range of the range | 2 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| | SANTA CRUZ COUNTY | | | |
| 5.36 | Scott's Valley | - demography, reproduction, genetics, effects of vegetation management strategies (Opler's longhorn moth) | - population genetics studies to clarify the relationship of Scott's Valley Opler's longhorn moth population to populations in other parts of the range, and use of non-serpentine soils | 2 |
| | SONOMA COUNTY | | | |
| 5.37 | Bohemian Highway site | - demography, soil seed bank of annuals, reproduction of *Cordylanthus tenuis* ssp. *capillaris*, *Arctostaphylos bakeri* ssp. *bakeri*, and *Lessingia arachnoidea*<br>- use of burning as a management strategy for *Cordylanthus tenuis* ssp. *capillaris* and *Arctostaphylos bakeri* ssp. *bakeri*<br>- effects of hand clearing (*Arctostaphylos bakeri* ssp. *bakeri*)<br>- parasitic nature of *Cordylanthus tenuis* ssp. *capillaris*<br>- taxonomy of *Lessingia arachnoidea* | - burning and/or hand clearing may limit succession and aid regeneration of *Arctostaphylos bakeri* ssp. *bakeri*<br>- taxonomy to determine identity of the *Lessingia* at the site | 1 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.38 | Camp Meeker area (including Harrison Grade Preserve) | - demography, reproduction of *Cordylanthus tenuis* ssp. *capillaris* and *Arctostaphylos bakeri* ssp. *bakeri*<br>- use of burning as a management strategy for *Cordylanthus tenuis* ssp. *capillaris* and *Arctostaphylos bakeri* ssp. *bakeri*<br>- effects of hand clearing (*Arctostaphylos bakeri* ssp. *bakeri*)<br>- parasitic nature of *Cordylanthus tenuis* ssp. *capillaris*<br>- soil seed bank of *Cordylanthus tenuis* ssp. *capillaris* | - burning and/or hand clearing may limit succession and aid regeneration of *Arctostaphylos bakeri* ssp. *bakeri* | 2 |
| 5.39 | Sears Point area | - demography, reproduction, genetics, effects of vegetation management strategies, characterize habitat (Opler's longhorn moth) | | 2 |
| | STANISLAUS COUNTY | | | |
| 5.40 | Del Puerto Canyon area (in northwestern Stanislaus County) | - demography, reproduction, genetics of *Cirsium fontinale* var. *campylon* | - population genetics studies to clarify the relationship among populations of *Cirsium fontinale* var. *campylon* | 2 |
| | OTHER RESEARCH NEEDS | | | |
| 5.41 | (not applicable) | - develop artificial rearing techniques (bay checkerspot butterfly) | | 3 |
| 5.42 | (not applicable) | - develop artificial rearing techniques (Opler's longhorn moth) | | 3 |
| 5.43 | (not applicable) | - develop propagation techniques for all listed plant species and plant species of concern | | 2 |

| Task # | Location | Tasks and Target Species | Comments | Priority |
|---|---|---|---|---|
| 5.44 | (not applicable) | Investigate the importance of nectar plant species to both male and female bay checkerspots in the wild. | Study should cover a range of sites, nectar species, and years | 3 |

6. Undertake artificial enhancement, repatriation or introduction efforts, where necessary.

Where it is deemed necessary, artificial enhancement, repatriation or introduction efforts for sensitive plants and animals, should be undertaken. Prior to repatriation or introduction of sensitive plants, genetics studies are needed (see Task 5) to ensure that new populations will not disrupt unique local gene complexes. Plant repatriation or introduction efforts should be undertaken using collected seeds or plant propagules.

6.1 Collect and store seed for plant taxa covered in the plan.

Fifteen of the 19 plant taxa covered in this plan are known from 10 or fewer locations. Twelve of the 15 are known from 5 or fewer recently confirmed locations. Six of the 12 are known from only 1 or 2 locations. Because they occur in very few locations, collection and banking of seed in Center for Plant Conservation certified botanic gardens is prudent to guard against extinction of plant populations or taxa from chance catastrophic events. Seed collections for plant taxa should be representative of both population and species level genetic diversity. Seed collection guidelines have been published by the Center for Plant Conservation (1991). Plant taxa for which seed banking is recommended are given in Table IV-5. These include all listed plant species covered in the plan and plant species of concern known from fewer than 10 locations. Priority 1 is given to taxa known from one or two locations. Priority 2 is given to taxa known from more than two, but fewer than six locations. Priority 3 is given to taxa known from more than 5 locations.

**Table IV-5. Plant Taxa for Which Seeds Need to be Stored.**

| Task # | Taxa | Priority |
|---|---|---|
| 6.1.1 | *Acanthomintha obovata ssp. duttonii*<br>*Calochortus tiburonensis*<br>*Clarkia franciscana*<br>*Cordylanthus tenuis* ssp. *capillaris*<br>*Eriophyllum latilobum*<br>*Pentachaeta bellidiflora*<br>*Streptanthus niger* | 1 |
| 6.1.2 | *Ceanothus ferrisiae*<br>*Cirsium fontinale* var. *fontinale*<br>*Lessingia arachnoidea*<br>*Lessingia micradenia* var. *glabrata*<br>*Lessingia micradenia* var. *micradenia* | 2 |
| 6.1.3 | *Arctostaphylos bakeri* ssp. *bakeri*<br>*Castilleja affinis* ssp. *neglecta*<br>*Dudleya setchellii*<br>*Hesperolinon congestum*<br>*Streptanthus albidus* ssp. *albidus* | 3 |

6.2 Initiate enhancement, repatriation, or introductions where appropriate (Priority 2).

For plants, artificially propagated plants, or collected seeds can provide potential material for enhancement efforts in existing populations, repatriation of former sites and/or introductions to new sites. For the bay checkerspot butterfly and Opler's longhorn moth, if suitable techniques for rearing bay checkerspot become available (see Task 5), artificially propagated larvae or butterflies/moths can be used to augment introduction/reintroduction efforts or to enhance existing depleted populations. Surveys of appropriate serpentine habitat (see Task 4) should identify suitable sites for repatriations or introductions.

7. Periodically review the status of species of concern.

Listing of species of concern covered in this recovery plan may be necessary if tasks specific to the needs of these species are not undertaken within a reasonable amount of time. Species requiring status review and time frames for review are given in Table IV-6.

**Table IV-6. Status Review Requirements for Species of Concern.**

| Recovery Task # | Species | Needed Review | Priority |
|---|---|---|---|
| **Plant Species** | | | |
| 7.1 | Baker's manzanita (*Arctostaphylos bakeri* ssp. *bakeri*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.2 | Mt. Hamilton thistle (*Cirsium fontinale* var. *fontinale*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.3 | Crystal Springs lessingia (*Lessingia arachnoidea*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.4 | smooth lessingia (*Lessingia micradenia* var. *glabrata*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.5 | Tamalpais lessingia (*Lessingia micradenia* var. *micradenia*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.6 | most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| **Animal Species** | | | |
| 7.7 | Edgewood blind harvestman (*Calicina minor*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.8 | Edgewood microblind harvestman (*Microcina edgewoodensis*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.9 | Fairmont microblind harvestman (*Microcina lumi*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.10 | Hom's microblind harvestman (*Microcina homi*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |

| | | | |
|---|---|---|---|
| 7.11 | Jung's microblind harvestman (*Microcina jungi*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.12 | Marin blind harvestman (*Calicina diminua*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.13 | Opler's longhorn moth (*Adela oplerella*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |
| 7.14 | Tiburon microblind harvestman (*Microcina tiburona*) | reevaluate status within 5 years of recovery plan approval or when surveys are completed, whichever is less | 3 |

# V. IMPLEMENTATION SCHEDULE

The implementation schedule that follows outlines actions and estimated costs for this recovery plan. It is a guide for meeting the objectives discussed in Chapter III of this recovery plan. This schedule describes and prioritizes tasks, provides an estimated time table for performance of tasks, indicates the responsible agencies, and estimates costs of performing tasks. These actions, when accomplished, should further the recovery and conservation of the covered species.

Key to Acronyms used in the Implementation Schedule

Definition of task priorities:

**Priority 1 -** An action that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

**Priority 2 -** An action that must be taken to prevent a significant decline in species population or habitat quality, or some other significant negative impact short of extinction.

**Priority 3 -** All other actions necessary to meet recovery or conservation objectives.

Definition of task durations:

**Continual -** A task that will be implemented on a routine basis once begun.

**Ongoing -** A task that is currently being implemented and will continue until action is no longer necessary.

**Unknown -** Either task duration or associated costs are not known at this time.

Total costs:

| | |
|---|---|
| **TBD -** | To be determined |

Responsible parties:

| | |
|---|---|
| **CDFG -** | California Department of Fish and Game |
| **CDPR -** | California Department of Parks and Recreation |
| **Caltrans -** | California Department of Transportation |
| **COUN -** | County |
| **CSJ -** | City of San Jose |
| **EBRPD -** | East Bay Regional Park District |
| **FAA -** | Federal Aviation Administration |
| **MCOSD -** | Marin County Open Space District |
| **MMWD -** | Marin Municipal Water District |
| **MROSD -** | Midpeninsula Regional Open Space District |
| **NPS -** | National Park Service |
| **OWN -** | Private landowners or parties |
| **RSABG -** | Rancho Santa Ana Botanic Garden |
| **SFWD -** | San Francisco Water Department |
| **Tiburon -** | City of Tiburon |
| **TLS -** | Tiburon Landmark Society |
| **UCB -** | University of California Berkeley |
| **USFWS -** | U.S. Fish and Wildlife Service |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.1.1 | Secure and protect serpentine habitat in the Oakland Hills for multiple species | 8 years | USFWS<br>CDFG<br>EBRPD | 60 | 7.5 | 7.5 | 7.5 | 7.5 | |
| 1 | 2.1.3 | Secure and protect serpentine habitat in Golden Gate National Recreational Area for multiple species | ongoing | USFWS<br>NPS | 20 | 5 | 5 | 5 | 5 | |
| 1 | 2.1.4 | Secure and protect serpentine habitat at Mt. Burdell (Marin County) for multiple species | 5 years | USFWS<br>CDFG<br>MCOSD | 20 | 4 | 4 | 4 | 4 | |
| 1 | 2.1.5 | Secure and protect serpentine habitat on Tiburon Peninsula Middle Ridge (Marin County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN<br>Tiburon | 450 | 45 | 45 | 45 | 45 | |
| 1 | 2.1.6 | Secure and protect serpentine habitat on Ring Mountain (Marin County) for multiple species | 7 years | USFWS<br>CDFG<br>COUN | 600 | 100 | 90 | 80 | 70 | |
| 1 | 2.1.7 | Secure and protect serpentine habitat in St. Hilary's area (including Harroman Property) for multiple species | 10 years | USFWS<br>CDFG<br>COUN<br>TLS | 180 | 18 | 18 | 18 | 18 | |
| 1 | 2.1.8 | Secure and protect serpentine habitat on the Presidio (San Francisco County) for multiple species | 4 years | NPS<br>USFWS | 20 | 5 | 5 | 5 | 5 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| | | | | | Cost Estimate (in $10,000 units) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Task Priority | Task Number | Task Description[1] | Task Duration | Responsible Parties | Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
| 1 | 2.1.10 | Secure and protect serpentine habitat in Edgewood Natural Preserve (San Mateo County) for multiple species | 4 years | USFWS<br>CDFG<br>COUN | 16 | 4 | 4 | 4 | 4 | |
| 1 | 2.1.11 | Secure and protect serpentine habitat on Pulgas Ridge (San Mateo County) for multiple species | 15 years | USFWS<br>CDFG<br>SFWD<br>Caltrans | 1,500 | 100 | 100 | 100 | 100 | |
| 1 | 2.1.12 | Secure and protect serpentine habitat in San Mateo Creek area (San Mateo County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN<br>SFWD<br>Caltrans | 600 | 60 | 60 | 60 | 60 | |
| 1 | 2.1.13 | Secure and protect serpentine habitat in Triangle area (San Mateo County) for multiple species | 10 years | USFWS<br>CDFG<br>SFWD<br>Caltrans | 270 | 27 | 27 | 27 | 27 | |
| 1 | 2.1.14 | Secure and protect serpentine habitat in Woodside Glens / Canada College / Redwood City (San Mateo County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN<br>OWN | 300 | 30 | 30 | 30 | 30 | |
| 1 | 2.1.16 | Secure and protect serpentine habitat in Anderson Reservoir area/county park area (Santa Clara County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN, CSJ | TBD | | | | | Precise extent and location need clarification |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.1.17 | Secure and protect serpentine habitat in Calero Reservoir area (Santa Clara County) for multiple species | 8 years | USFWS<br>CDFG<br>COUN, CSJ<br>OWN | 400 | 50 | 50 | 50 | 50 | |
| 1 | 2. 1.18 | Secure and protect serpentine habitat in Calero County Park (Santa Clara County) for multiple species | 8 years | USFWS<br>COUN | TBD | | | | | Nature and extent of actions needed not yet known |
| 1 | 2.1.20 | Secure and protect serpentine habitat in Kirby area (S of Metcalf Road.) (Santa Clara County) for multiple species | 5 years | USFWS<br>CDFG<br>COUN, CSJ<br>OWN | 1,600 | 320 | 320 | 320 | 320 | |
| 1 | 2.1.21 | Secure and protect serpentine habitat in Metcalf area (N of Metcalf Road) (Santa Clara County) for multiple species | 8 years | USFWS<br>CDFG<br>COUN, CSJ<br>OWN | 400 | 50 | 50 | 50 | 50 | |
| 1 | 2.1.22 | Secure and protect serpentine habitat in San Felipe area (Santa Clara County) for multiple species | 8 years | USFWS<br>CDFG<br>COUN, CSJ<br>OWN | 280 | 35 | 35 | 35 | 35 | |
| 1 | 2.1.23 | Secure and protect serpentine habitat in Silver Creek Hills (Santa Clara County) for multiple species | 8 years | USFWS<br>CDFG<br>COUN, CSJ<br>OWN | 400 | 50 | 50 | 50 | 50 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.1.26 | Secure and protect serpentine habitat West of San Martin area (including Hayes Valley / Lions Peak) (Santa Clara County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN<br>OWN | 300 | 30 | 30 | 30 | 30 | |
| 1 | 2.1.27 | Secure and protect serpentine habitat in Santa Teresa Hills (Santa Clara County) for multiple species | 8 years | USFWS<br>CDFG<br>COUN, CSJ<br>OWN | 320 | 40 | 40 | 40 | 40 | |
| 1 | 2.1.28 | Secure and protect serpentine habitat on Tulare Hill (Santa Clara County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN, CSJ<br>OWN | 440 | 44 | 44 | 44 | 44 | |
| 1 | 2.1.30 | Secure and protect serpentine habitat on Bohemian Highway site (Sonoma County) for multiple species | 10 years | USFWS<br>CDFG | 3,000 | 300 | 300 | 300 | 300 | |
| 1 | 2.1.31 | Secure and protect serpentine habitat in Harrison Grade Preserve and adjacent area (Sonoma County) for multiple species | 10 years | USFWS<br>CDFG | 660 | 66 | 66 | 66 | 66 | |
| 1 | 2.2.1 | Secure and protect serpentine habitat in Cedar Mountain area (Alameda County) for *Cirsium fontinale* var. *campylon* | 5 years | USFWS<br>CDFG | 30 | 6 | 6 | 6 | 6 | |
| 1 | 2.2.2 | Secure and protect serpentine habitat in Fairmont Ridge area (south of Lake Chabot) (Alameda County) for Fairmont microblind harvestman | 5 years | USFWS<br>COUN<br>OWN | 30 | 6 | 6 | 6 | 6 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description[1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.2.3 | Secure and protect serpentine habitat in Man Ridge area (southeast of Cedar Mountain) (Alameda County) for *Cirsium fontinale* var. *campylon* | unknown | USFWS<br>CDFG | TBD | | | | | Precise extent and location need clarification |
| 1 | 2.2.5 | Secure and protect serpentine habitat in Sunol Regional Wilderness (Alameda County) for *Streptanthus albidus* ssp. *peramoenus* | 10 years | USFWS<br>EBRPD | 300 | 30 | 30 | 30 | 30 | |
| 1 | 2.2.7 | Secure and protect serpentine habitat in Mt. Diablo State Park (Alameda County) for *Streptanthus albidus* ssp. *peramoenus* | 5 years | USFWS<br>CDPR | 10 | 2 | 2 | 2 | 2 | |
| 1 | 2 2.10 | Secure and protect serpentine habitat on Buck Center for Research on Aging (Marin County) for Marin blind harvestman | 5 years | USFWS<br>COUN<br>OWN | 500 | 100 | 100 | 100 | 100 | |
| 1 | 2.2.11 | Secure and protect serpentine habitat in El Campo (Marin County) for Tiburon microblind harvestman | 5 years | USFWS<br>COUN<br>OWN | 100 | 20 | 20 | 20 | 20 | |
| 1 | 2.2.14 | Secure and protect serpentine habitat in American Canyon (Napa County) for *Castilleja affinis* ssp. *neglecta* | 5 years | USFWS<br>CDFG | 90 | 18 | 18 | 18 | 18 | |
| 1 | 2.2.22 | Secure and protect serpentine habitat near Guadalupe Reservoir (south of) (Santa Clara County) for multiple species | unknown | USFWS<br>CDFG<br>COUN<br>MROSD | TBD | | | | | Precise extent and locations need clarification |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) | | | | | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | |
| 1 | 2.2.24 | Secure and protect serpentine habitat in northeast Santa Clara County (including Blackbird Valley, Bolinger Canyon and San Antonio Valley) for *Cirsium fontinale* var. *campylon* | unknown | USFWS | TBD | | | | | Precise extent and locations need clarification |
| 1 | 2.2.26 | Secure and protect serpentine habitat in Camp Meeker area (South to Occidental, East to Atascadero Creek) (Sonoma County) for *Arctostaphylos bakeri* ssp. *bakeri* | unknown | USFWS | TBD | | | | | Precise extent and locations need clarification |
| 1 | 2.2. 27 | Secure and protect serpentine habitat in Forestville (west of) (Sonoma County) for *Arctostaphylos bakeri* ssp. *bakeri* | unknown | USFWS | TBD | | | | | Precise extent and locations need clarification |
| 1 | 2.2.30 | Secure and protect serpentine habitat in Del Puerto Canyon area (northwestern Stanislaus County) for *Cirsium fontinale* var. *camplyon* | unknown | USFWS | TBD | | | | | Precise extent and locations need clarification |
| 1 | 3.1 | Develop and implement appropriate management actions at multiple sites for multiple species | ongoing | various | TBD | | | | | |
| 1 | 4.2.2 | Survey historic and potential habitat on Fairmont Ridge (Alameda County) for Fairmont microblind harvestman | 3 years | USFWS | 3 | 1 | 1 | 1 | | |
| 1 | 4.2.3 | Survey historic and potential habitat in Joaquin Miller Park (Alameda County) for Opler's longhorn moth | 2 years | USFWS EBRPD | 2 | 1 | 1 | | | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| | | | | | Cost Estimate (in $10,000 units) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
| 1 | 4.2.22 | Survey historic and potential habitat at Crystal Springs Reservoir area (San Mateo County) for multiple species | 6 years | USFWS<br>CDFG<br>SFWD<br>Caltrans | 18 | 3 | 3 | 3 | 3 | |
| 1 | 4.2.30 | Survey historic and potential habitat at Anderson Reservoir / Coyote Reservoir area (Santa Clara County) for multiple species | 4 years | USFWS<br>CDFG<br>COUN | 8 | 2 | 2 | 2 | 2 | |
| 1 | 4.2.33 | Survey historic and potential habitat at Coyote Ridge area (Santa Clara County) for multiple species | 8 years | USFWS<br>CDFG<br>COUN<br>OWN | 16 | 2 | 2 | 2 | 2 | |
| 1 | 4.2.41 | Survey historic and potential habitat in the San Martin area (Santa Clara County) for multiple species | 4 years | USFWS<br>CDFG<br>COUN | 8 | 2 | 2 | 2 | 2 | |
| 1 | 4.2.42 | Survey historic and potential habitat at Santa Teresa Hills (Santa Clara County) for multiple species | 5 years | USFWS<br>CDFG<br>COUN | 10 | 2 | 2 | 2 | 2 | |
| 1 | 5.2 | Conduct necessary research at Fairmont Ridge area (south of Lake Chabot) (Alameda County) for Fairmont microblind harvestman | 5 years | USFWS | 25 | 5 | 5 | 5 | 5 | |
| 1 | 5..3 | Conduct necessary research at Oakland Hills (Alameda County) for multiple species | 6 years | USFWS<br>CDFG | 30 | 5 | 5 | 5 | 5 | |
| 1 | 5.7 | Conduct necessary research at El Campo (Marin County) for Tiburon microblind harvestman | 5 years | USFWS | 25 | 5 | 5 | 5 | 5 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.12 | Conduct necessary research at Ring Mountain (Marin County) for multiple species | 5 years | USFWS<br>CDFG<br>COUN | 25 | 5 | 5 | 5 | 5 | |
| 1 | 5.15 | Conduct necessary research at the Presidio (San Francisco County) for multiple species | 5 years | USFWS<br>NPS | 10 | 2 | 2 | 2 | 2 | |
| 1 | 5.16 | Conduct research on vegetation management methods in selected areas county-wide(San Mateo County) for multiple species | 8 years | USFWS<br>CDFG | 160 | 20 | 20 | 20 | 20 | |
| 1 | 5.17 | Assess county-wide air pollution inputs and effects on serpentine habitats (all species) (San Mateo County) | 4 years | USFWS | 160 | 55 | 35 | 35 | 35 | |
| 1 | 5.19 | Conduct necessary research at Crystal Springs area (includes Buri Buri and Pulgas Ridges and San Mateo Creek area) (San Mateo County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN<br>SFWD<br>Caltrans | 50 | 5 | 5 | 5 | 5 | |
| 1 | 5.20 | Conduct necessary research at Edgewood Natural Preserve) (San Mateo County) for multiple species | 15 years | USFWS<br>CDFG<br>COUN | 52.5 | 3.5 | 3.5 | 3.5 | 3.5 | |
| 1 | 5.24 | Conduct research on vegetation management methods in selected areas county-wide (Santa Clara County) for multiple species | 8 years | USFWS<br>CDFG<br>COUN | 160 | 20 | 20 | 20 | 20 | |
| 1 | 5.25 | Assess county-wide air pollution inputs and effects on serpentine habitats (Santa Clara County) for all species covered in the plan | 4 years | USFWS | 250 | 100 | 50 | 50 | 50 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.30 | Conduct necessary research at Coyote Ridge (Santa Clara County) for multiple species | 15 years | USFWS<br>CDFG<br>COUN<br>OWN | 52.5 | 3.5 | 3.5 | 3.5 | 3.5 | |
| 1 | 5..37 | Conduct necessary research at Bohemian Highway site (Sonoma County) for multiple species | 6 years | USFWS<br>CDFG | 30 | 5 | 5 | 5 | 5 | |
| 1 | 6.1.1 | Store seeds of plant taxa from the following:<br>*Acanthomintha obovata* ssp.*duttonii*<br>*Calochortus tiburonensis*<br>*Clarkia franciscana*<br>*Cordylanthus tenuis* ssp. *capillaris*<br>*Eriophyllum latilobum*<br>*Pentachaeta bellidiflora*<br>*Streptanthus niger* | 10 years | USFWS<br>CDFG<br>UCB<br>RSABG<br>EBRPD<br>COUN (San Mateo and Marin)<br>SFWD | 15 | 1.5 | 1.5 | 1.5 | 1.5 | |
| 2 | 1.1 | Establish cooperative programs with participants from the public and private sector | ongoing | USFWS<br>CDFG | TBD | | | | | |
| 2 | 1.2.1 | Develop and implement outreach plans | ongoing | USFWS | TBD | | | | | |
| 2 | 1.2.2 | Develop and implement economic and other incentives | ongoing | USFWS<br>CDFG<br>OWN | TBD | | | | | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1.2.3 | Encourage and assist counties and landowners to develop and implement Habitat Conservation Plans | ongoing | USFWS CDFG COUN, OWN | TBD | | | | | |
| 2 | 2.1.2 | Secure and protect serpentine habitat at Alpine Lake / Carson Ridge (Marin County) for mulitple species | 10 years | USFWS MMWD | 450 | 45 | 45 | 45 | 45 | |
| 2 | 2.1.9 | Secure and protect serpentine habitat at Buri Buri Ridge (Santa Clara County) for multiple species | 8 years | USFWS CDFG SFWD | 240 | 30 | 30 | 30 | 30 | |
| 2 | 2.1.15 | Secure and protect serpentine habitat at Almaden Quicksilver County Park area (Santa Clara County) for multiple species | 6 years | USFWS CDFG COUN MROSD | 120 | 20 | 20 | 20 | 20 | |
| 2 | 2.1.19 | Secure and protect serpentine habitat at Communications Hill area (Santa Clara County) for multiple species | 6 years | USFWS CDFG COUN | 120 | 20 | 20 | 20 | 20 | |
| 2 | 2.1.24 | Secure and protect serpentine habitat North of Llagas Avenue (Santa Clara County) for multiple species | 10 years | USFWS CDFG COUN, OWN | 150 | 15 | 15 | 15 | 15 | |
| 2 | 2.1.25 | Secure and protect serpentine habitat at Palm Avenue / Kalana Hills (Santa Clara County) for multiple species | 10 years | USFWS CDFG COUN, OWN | 250 | 25 | 25 | 25 | 25 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2.2.4 | Secure and protect serpentine habitat in San Leandro Hills (Alameda County) for Bay checkerspot butterfly | 20 years | USFWS<br>CDFG<br>COUN, OWN | TBD | | | | | Precise extent and location need clarification actions needed may vary |
| 2 | 2.2.9 | Secure and protect serpentine habitat at Big Rock area (Marin County) for *Hesperolinon congestum* | unknown | USFWS<br>CDFG<br>COUN | TBD | | | | | |
| 2 | 2.2.12 | Secure and protect serpentine habitat in the Nicasio area (Marin County) for Opler's longhorn moth | 5 years | USFWS<br>COUN<br>OWN | 20 | 4 | 4 | 4 | 4 | |
| 2 | 2.2.13 | Secure and protect serpentine habitat at Pine Mountain (Carson Ridge area) (Marin County) for *Hesperolinon congestum* | 4 years | USFWS<br>CDFG<br>MMWD | 20 | 5 | 5 | 5 | 5 | |
| 2 | 2.2.15 | Secure and protect serpentine habitat at Jasper Ridge area (San Mateo County) for bay checkerspot butterfly | 5 years | USFWS<br>OWN | 5 | 1 | 1 | 1 | 1 | |
| 2 | 2.2.16 | Restore and protect historic habitat on San Bruno Mountain (San Mateo County) for bay checkerspot butterfly; reintroduce the species | 8 years | COUN<br>USFWS<br>CDFG | 160 | 20 | 20 | 20 | 20 | Cost estimates of restoration tentative. |
| 2 | 2.2.17 | Secure and protect serpentine habitat between Anderson and Coyote Lakes (Santa Clara County) for multiple species | 4 years | USFWS<br>CDFG<br>COUN | 21 | 5.25 | 5.25 | 5.25 | 5.25 | |
| 2 | 2.2.18 | Secure and protect serpentine habitat in Carlyle Hills (south of Gilroy in southern tip of Santa Clara County) for multiple species | 4 years | USFWS<br>CDFG | 15 | 3.75 | 3.75 | 3.75 | 3.75 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| | | | | | Cost Estimate (in $10,000 units) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
| 2 | 2.2.18 | Secure and protect serpentine habitat in Carlyle Hills (south of Gilroy in southern tip of Santa Clara County) for multiple species | 4 years | USFWS<br>CDFG | 15 | 3.75 | 3.75 | 3.75 | 3.75 | |
| 2 | 2.2.19 | Secure and protect serpentine habitat in Chesbro Reservoir area (west of Morgan Hill) (Santa Clara County) for multiple species | 6 years | USFWS<br>CDFG | 90 | 15 | 15 | 15 | 15 | |
| 2 | 2.2.20 | Secure and protect serpentine habitat East of San Martin (Santa Clara County) for bay checkerspot butterfly | 10 years | USFWS<br>CDFG<br>COUN, OWN | TBD | | | | | Nature and extent of actions needed not yet known |
| 2 | 2.2.21 | Secure and protect serpentine habitat south of San Martin (Santa Clara County) for Opler's longhorn moth | 5 years | USFWS<br>COUN<br>OWN | 300 | 60 | 60 | 60 | 60 | |
| 2 | 2.2.23 | Secure and protect serpentine habitat near Hacienda School (south of Stile Ranch) (Santa Clara County) for *Cirsium fontinale* var. *campylon* | unknown | USFWS<br>CDFG<br>COUN | TBD | | | | | |
| 2 | 2.2.25 | Secure and protect serpentine habitat in Uvas Reservoir area (west of San Martin) (Santa Clara County) for bay checkerspot butterfly | 15 years | USFWS<br>CDFG<br>COUN, OWN | TBD | | | | | Precise extent and location need clarification |
| 2 | 2.2.28 | Secure and protect serpentine habitat Northwest of Healdsburg (Sonoma County) for *Arctostaphylos bakeri* ssp. *bakeri* | unknown | USFWS<br>CDFG<br>COUN | TBD | | | | | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 2.2.29 | Secure and protect serpentine habitat in the Sears Point area (Sonoma County) for Opler's longhorn moth | 5 years | USFWS<br>COUN<br>OWN | 30 | 6 | 6 | 6 | 6 | |
| 2 | 3.2 | Develop and implement monitoring plans for all populations | continual | various | TBD | | | | | |
| 2 | 4.1 | Establish a survey program and protocol for all species covered in the plan | 4 years | various | TBD | | | | | |
| 2 | 4.2.5 | Conduct surveys in historic and potential habitat in the Oakland Hills (Alameda County) for multiple species | 4 years | USFWS<br>CDFG<br>EBRPD | 8 | 2 | 2 | 2 | 2 | |
| 2 | 4.2.9 | Conduct surveys in historic and potential habitat at Alpine Lake / Carson Ridge (Marin County) for multiple species | 4 years | USFWS<br>CDFG<br>MMWD | 8 | 2 | 2 | 2 | 2 | |
| 2 | 4.2.10 | Conduct surveys in historic and potential habitat at El Campo (Marin County) for Tiburon microblind harvestman | 3 years | USFWS | 3 | 1 | 1 | 1 | | |
| 2 | 4.2.11 | Conduct surveys in historic and potential habitat at Golden Gate National Recreation Area (Marin County) for multiple species | 4 years | NPS<br>USFWS<br>CDFG | 8 | 2 | 2 | 2 | 2 | |
| 2 | 4.2.13 | Conduct surveys in historic and potential habitat at Marin City (on Marin Peninsula west of Tiburon Peninsula) (Marin County) for *Pentachaeta bellidiflora* | 2 years | USFWS<br>CDFG | 2 | 1 | 1 | | | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 4.2.14 | Conduct surveys in historic and potential habitat in the Nicasio area (Marin County) for Opler's longhorn moth | 2 years | USFWS | 2 | 1 | 1 | | | |
| 2 | 4.2.15 | Conduct surveys in historic and potential habitat at Phoenix Lake (Marin County) for *Lessingia micradenia* var. *micradenia* | 4 years | USFWS<br>CDFG<br>MMWD | 4 | 1 | 1 | 1 | 1 | |
| 2 | 4.2.17 | Conduct surveys in historic and potential habitat at San Anselmo Canyon (Marin County) for *Lessingia micradenia* var. *micradenia* | 4 years | USFWS<br>CDFG<br>MMWD | 4 | 1 | 1 | 1 | 1 | |
| 2 | 4.2.18 | Conduct surveys in historic and potential habitat on Tiburon Peninsula (Marin County) for multiple species | 6 years | USFWS<br>CDFG<br>COUN<br>Tiburon | 12 | 2 | 2 | 2 | 2 | |
| 2 | 4.2.19 | Conduct surveys in historic and potential habitat on the Presidio (San Francisco County) for multiple species | 4 years | USFWS<br>CDFG<br>NPS | 4 | 1 | 1 | 1 | 1 | |
| 2 | 4.2.21 | Conduct surveys in historic and potential habitat in area between San Andreas Lake and Crystal Springs Reservoir and to the west (San Mateo County) for multiple species | 6 years | USFWS<br>CDFG<br>COUN | 12 | 2 | 2 | 2 | 2 | |
| 2 | 4.2.23 | Conduct surveys in historic and potential habitat in Edgewood Natural Preserve (San Mateo County) for multiple species | 5 years | USFWS<br>CDFG<br>COUN | 5 | 1 | 1 | 1 | 1 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 4.2.29 | Conduct surveys in historic and potential habitat in Woodside Glens / Canada College (generally in the Woodside area) (San Mateo County) for *Hesperolinon congestum* | 4 years | USFWS<br>CDFG | 4 | 1 | 1 | 1 | 1 | |
| 2 | 4.2.31 | Conduct surveys in historic and potential habitat in Calero Reservoir area (Santa Clara County) for multiple species | 8 years | USFWS<br>CDFG<br>COUN | 16 | 2 | 2 | 2 | 2 | |
| 2 | 4.2.32 | Conduct surveys in historic and potential habitat in Communications Hill area (Santa Clara County) for multiple species | 4 years | USFWS<br>CDFG<br>FAA | 8 | 2 | 2 | 2 | 2 | Mostly private lands |
| 2 | 4.2.34 | Conduct surveys in historic and potential habitat in Croy Canyon area (Santa Clara County) for *Ceanothus ferrisiae* | 2 years | USFWS<br>CDFG | 2 | 1 | 1 | | | |
| 2 | 4.2.35 | Conduct surveys in historic and potential habitat in Henry Coe State Park (Santa Clara County) for multiple species | 2 years | USFWS<br>CDFG<br>CDPR | 2 | 1 | 1 | | | Finite area of serpentine to be searched |
| 2 | 4.2.37 | Conduct surveys in historic and potential habitat Loma Prieta area (Santa Clara County) for multiple species | 2 years | USFWS<br>CDFG<br>COUN | 2 | 1 | 1 | | | |
| 2 | 4.2.38 | Conduct surveys in historic and potential habitat North of Llagas Avenue (Santa Clara County) for multiple species | 6 years | USFWS<br>CDFG<br>COUN | 12 | 2 | 2 | 2 | 2 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 5.8 | Conduct necessary research at Golden Gate National Recreation Area (Marin County) for multiple species | 6 years | USFWS<br>CDFG<br>NPS | 24 | 4 | 4 | 4 | 4 | |
| 2 | 5.9 | Conduct necessary research at Mt. Burdell (Marin County) for multiple species | 4 years | USFWS<br>CDFG<br>COUN | 12 | 3 | 3 | 3 | 3 | |
| 2 | 5.10 | Conduct necessary research in the Nicasio area (Marin County) for Opler's longhorn moth | 4 years | USFWS<br>CDFG | 8 | 2 | 2 | 2 | 2 | |
| 2 | 5.11 | Conduct necessary research at Middle Ridge, Tiburon Peninsula (Marin County) for multiple species | 6 years | USFWS<br>CDFG<br>COUN<br>Tiburon | 24 | 4 | 4 | 4 | 4 | |
| 2 | 5.13 | Conduct necessary research at St. Hilary's area (includes Harroman Property), Tiburon Peninsula (Marin County) for multiple species | 6 years | USFWS<br>CDFG<br>COUN<br>Tiburon | 24 | 4 | 4 | 4 | 4 | |
| 2 | 5.18 | Conduct necessary research at selected areas county-wide in San Mateo County on restoring native habitats on serpentine and non-serpentine soils (multiple species) | 8 years | USFWS<br>CDFG<br>COUN | 64 | 8 | 8 | 8 | 8 | |
| 2 | 5.21 | Conduct necessary research at Jasper Ridge (Santa Clara County) for bay checkerspot butterfly | 5 years | USFWS<br>Stanford Univ. | 20 | 4 | 4 | 4 | 4 | |

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| Task Priority | Task Number | Task Description[1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) | | | | | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | |
| 2 | 5.22 | Conduct necessary research at Triangle (San Mateo County) for multiple species | 6 years | USFWS<br>CDFG<br>SFWD<br>Caltrans | 24 | 4 | 4 | 4 | 4 | |
| 2 | 5.26 | Conduct necessary research at selected areas county-wide in Santa Clara County on restoring native habitats on serpentine and non-serpentine soils (multiple species) | 8 years | USFWS<br>CDFG<br>COUN | 80 | 10 | 10 | 10 | 10 | |
| 2 | 5.27 | Conduct necessary research at Almaden Quicksilver Park (Santa Clara County) for multiple species | 6 years | USFWS<br>CDFG<br>COUN | 24 | 4 | 4 | 4 | 4 | |
| 2 | 5.28 | Conduct necessary research at Anderson Reservoir / County Park area (Santa Clara County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN | 22 | 2 | 4 | 2 | 2 | Research includes fire ecology of *Ceanothus ferrisiae* |
| 2 | 5.29 | Conduct necessary research at Calero Reservoir area (includes Calero County Park) (Santa Clara County) for multiple species | 6 years | USFWS<br>CDFG<br>COUN | 24 | 4 | 4 | 4 | 4 | |
| 2 | 5.32 | Conduct necessary research in Northeast Santa Clara County (includes Blackbird Valley, Bolinger Canyon and San Antonio Valley) for *Cirsium fontinale* var. *campylon* | 6 years | USFWS<br>CDFG<br>COUN | 24 | 4 | 4 | 4 | 4 | |
| 2 | 5.34 | Conduct necessary research at San Martin area (including Hayes Valley / Lions Peak) (Santa Clara County) for multiple species | 4 years | USFWS<br>CDFG<br>COUN | 8 | 2 | 2 | 2 | 2 | |

Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 5.35 | Conduct necessary research at Santa Teresa Hills (Santa Clara County) for multiple species | 6 years | USFWS<br>CDFG<br>COUN | 18 | 3 | 3 | 3 | 3 | |
| 2 | 5.36 | Conduct necessary research at Scott's Valley (central Santa Cruz County) for Opler's longhorn moth | 4 years | USFWS<br>CDFG | 8 | 2 | 2 | 2 | | |
| 2 | 5.38 | Conduct necessary research at Camp Meeker area (including Harrison Grade Preserve) (Sonoma County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN | 22 | 2 | 4 | 2 | 2 | Research includes fire ecology of *Arctostaphylos bakeri* ssp. *bakeri* |
| 2 | 5.39 | Conduct necessary research in the Sears Point area (Sonoma County) for Opler's longhorn moth | 4 years | USFWS<br>CDFG<br>COUN | 8 | 2 | 2 | 2 | 2 | |
| 2 | 5.40 | Conduct necessary research at Del Puerto Canyon area (northwestern Stanislaus County) for *Cirsium fontinale* var. *campylon* | 4 years | USFWS<br>CDFG<br>COUN | 16 | 4 | 4 | 4 | 4 | |
| 2 | 5.43 | Throughout species' ranges: Develop plant propagation techniques for all listed species and species of concern | 10 years | USFWS<br>CDFG<br>UCB<br>COUN<br>RSABG | 114 | 11.4 | 11.4 | 11.4 | 11.4 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description[1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 4.2.4 | Conduct surveys in historic and potential habitat near Niles (Alameda County) for *Streptanthus albidus* ssp. *peramoenus* | unknown | USFWS<br>CDFG | TBD | | | | | Precise extent and locations need clarification |
| 3 | 4.2.6 | Conduct surveys in historic and potential habitat in Franklin Canyon (Contra Costa County) for bay checkerspot butterfly | 4 years | USFWS<br>CDPR<br>EBRPD | 4 | 1 | 1 | 1 | 1 | |
| 3 | 4.2.7 | Conduct surveys in historic and potential habitat in Morgan Territory (Contra Costa County) for bay checkerspot butterfly | 4 years | USFWS<br>CDPR<br>EBRPD | 4 | 1 | 1 | 1 | 1 | |
| 3 | 4.2.8 | Conduct surveys in historic and potential habitat in Mt. Diablo State Park (Contra Costa County) for multiple species | 4 years | USFWS<br>CDFG<br>CDPR | 8 | 2 | 2 | 2 | 2 | |
| 3 | 4.2.12 | Conduct surveys in historic and potential habitat in Larkspur (northwest of Tiburon Peninsula) (Marin County) for *Pentachaeta bellidiflora* | 2 years | USFWS<br>CDFG | 2 | 1 | 1 | | | |
| 3 | 4.2.16 | Conduct surveys in historic and potential habitat in Ross Valley area (northwest of Tiburon Peninsula) (Marin County) for *Pentachaeta bellidiflora* | 2 years | USFWS<br>CDFG | 2 | 1 | 1 | | | |
| 3 | 4.2.20 | Conduct surveys in historic and potential habitat on San Francisco Peninsula (South of Presidio) (San Francisco County) for *Hesperolinon congestum* | 2 years | USFWS<br>CDFG<br>NPS | 2 | 1 | 1 | | | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| | | | | | Cost Estimate (in $10,000 units) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
| 3 | 4.2.24 | Conduct surveys in historic and potential habitat in Loma Mar area southwest of La Honda (south of Woodside) (San Mateo County) for *Eriophyllum latilobum* | 2 years | USFWS<br>CDFG | 2 | 1 | 1 | | | |
| 3 | 4.2.25 | Conduct surveys in historic and potential habitat in Menlo Park area (east of Woodside) (San Mateo County) for *Acanthomintha obovata* ssp. *duttonii* | 2 years | USFWS<br>CDFG | 2 | 1 | 1 | | | |
| 3 | 4.2.26 | Conduct surveys in historic and potential habitat in Redwood City area (east of Woodside) (San Mateo County) for multiple species | 2 years | USFWS<br>CDFG | 2 | 1 | 1 | | | |
| 3 | 4.2.27 | Conduct surveys in historic and potential habitat at San Andreas Lake (north of Crystal Springs Reservoir) (San Mateo County) for multiple species | 2 years | USFWS<br>CDFG<br>SFWD | 2 | 1 | 1 | | | |
| 3 | 4.2.28 | Conduct surveys in historic and potential habitat at San Bruno Mountain (San Mateo County) for multiple species | 2 years | USFWS<br>CDFG | 2 | 1 | 1 | | | |
| 3 | 4.2.36 | Conduct surveys in historic and potential habitat at Lexington Reservoir area for *Streptanthus albidus* ssp. *albidus* | 2 years | USFWS<br>CDFG | 2 | 1 | 1 | | | |
| 3 | 5.14 | Conduct necessary research at American Canyon (Napa County) for *Castilleja affinis* ssp. *neglecta* | 4 years | USFWS<br>CDFG | 16 | 4 | 4 | 4 | 4 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 5.23 | Conduct necessary research at Woodside Glens / Canada College (generally in the Woodside area) (San Mateo County) for *Hesperolinon congestum* | 4 years | USFWS<br>CDFG | 16 | 4 | 4 | 4 | 4 | |
| 3 | 5.31 | Conduct necessary research North of Llagas Avenue (Santa Clara County) for multiple species | 10 years | USFWS<br>CDFG<br>COUN | 22 | 2 | 4 | 2 | 2 | Research includes fire ecology of *Ceanothus ferrisiae* |
| 3 | 5.33 | Conduct necessary research around Palm Avenue / Kalana Hills (Santa Clara County) for multiple species | 6 years | USFWS<br>CDFG<br>COUN | 18 | 3 | 3 | 3 | 3 | |
| 3 | 5.41 | Develop artificial rearing techniques for bay checkerspot butterfly | 8 years | various | 16 | 2 | 2 | 2 | 2 | |
| 3 | 5.42 | Develop artificial rearing techniques for Opler's longhorn moth | unknown | USFWS | TBD | | | | | |
| 3 | 5.44 | Conduct research on importance of nectar plants to male and female bay checkerspots in the wild | 6 years | USFWS | 30 | 5 | 5 | 5 | 5 | |
| 3 | 6.1.3 | Store viable seeds for the following plant taxa:<br>*Arctostaphylos bakeri* ssp. *bakeri*<br>*Castilleja affinis* ssp. *neglecta*<br>*Dudleya setchellii*<br>*Hesperolinon congestum*<br>*Streptanthus albidus* ssp. *albidus* | 6 years | USFWS<br>CDFG<br>UCB<br>RSABG<br>COUN<br>NPS | 9 | 1.5 | 1.5 | 1.5 | 1.5 | |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| | | | | | Cost Estimate (in $10,000 units) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
| 3 | 7.1 | Review species listing status for species of concern *Arctostaphylos bakeri* ssp. *bakeri* | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.2 | Review species listing status for species of concern *Cirsium fontinale* var. *fontinale* | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.3 | Review species listing status for species of concern *Lessingia arachnoidea* | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.4 | Review species listing status for species of concern *Lessingia micradenia* var. *glabrata* | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.5 | Review species listing status for species of concern *Lessingia micradenia* var. *micradenia* | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.6 | Review species listing status for species of concern *Streptanthus albidus* ssp. *peramoenus* | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.7 | Review species listing status for species of concern Edgewood blind harvestman | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.8 | Review species listing status for species of concern Edgewood microblind harvestman | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.9 | Review species listing status for species of concern Fairmont microblind harvestman | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.10 | Review species listing status for species of concern Hom's microblind harvestman | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.11 | Review species listing status for species of concern Jung's microblind harvestman | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |

## Implementation Schedule for San Francisco Bay Area Serpentine Habitat Multi-Species Recovery Plan

| Task Priority | Task Number | Task Description [1] | Task Duration | Responsible Parties | Cost Estimate (in $10,000 units) Total Costs | FY 1 | FY 2 | FY 3 | FY 4 | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 7.12 | Review species listing status for species of concern Marin blind harvestman | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.13 | Review species listing status for species of concern Opler's longhorn moth | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |
| 3 | 7.14 | Review species listing status for species of concern Tiburon microblind harvestman | 1 year | USFWS | 1 | | | | | Review conducted in year 5 |

[1] Task Description : Please see Stepdown Narrative (Chapter IV) for a full list of species included in each task.

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# VII. APPENDICES

## A. List of Scientific and Common Names of Plants and Animals

| Common Name | Scientific Name |
|---|---|
| **PLANTS** | |
| annual agoseris | *Agoseris heterophylla* |
| annual yellow sweetclover | *Melilotus indica* |
| Baker's manzanita | *Arctostaphylos bakeri* ssp. *bakeri* |
| barbed goatgrass | *Aegilops triuncialis* |
| bigberry manzanita | *Arctostaphylos glauca* |
| big squirreltail | *Elymus multisetus* |
| bird's-eye gilia | *Gilia tricolor* |
| blackberries | *Rubus* spp. |
| blue dicks | *Dichelostemma capitatum* |
| blue-eyed grass | *Sisyrinchium bellum* |
| blue wildrye | *Elymus glaucus* |
| bottlebrush squirreltail | *Elymus elmoides* |
| Brewer's willow | *Salix breweri* |
| bristly jewelflower | *Streptanthus glandulosus* and *S. g.* ssp. *glandulosus* |
| brownie thistle | *Cirsium quercetorum* |
| buck brush | *Ceanothus cuneatus* |
| bugle hedgenettle | *Stachys ajugoides* |
| bull clover | *Trifolium fucatum* |
| burclover | *Medicago polymorpha* |
| California bay | *Umbellaria californica* |

| Common Name | Scientific Name |
|---|---|
| California brome | *Bromus carinatus* |
| California broom | *Lotus scoparius* |
| California buckeye | *Aesculus californica* |
| California buttercup | *Ranunculus californicus* |
| California coffeeberry | *Rhamnus californica* |
| California creamcups | *Platystemon californicus* |
| California dwarf-flax | *Hesperolinon californicum* |
| California gilia | *Gilia achilleifolia* ssp. *multicaulis* |
| California goldfields | *Lasthenia californica* = *L. chrysostoma* |
| California melic | *Melica californica* |
| California oatgrass | *Danthonia californica* |
| California poppy | *Eschscholzia californica* |
| California sagebrush | *Artemisia californica* |
| canyon liveforever | *Dudleya cymosa* ssp. *cymosa*, ssp. *paniculata* |
| Cedar's manzanita | *Arctostaphylos bakeri* ssp. *sublaevis* |
| centaury | *Centaurium muehlenbergii* |
| chamise | *Adenostemma* sp., *A. fasciculatum* |
| checker mallow | *Sidalcea malvaeflora* |
| Chorro Creek bog thistle | *Cirsium fontinale* var. *obispoense* |
| coast buckwheat | *Eriogonum latifolium* |
| coast live oak | *Quercus agrifolia* |
| coastal onion | *Allium dichlamydeum* |
| columbine | *Aquilegia eximia* |
| common madia | *Madia elegans* |

| Common Name | Scientific Name |
|---|---|
| common manzanita | *Arctostaphylos manzanita* |
| common woolly sunflower | *Eriophyllum lanatum* var. *arachnoideum* |
| common yarrow | *Achillea millefolium* |
| coyote brush | *Baccharis pilularis* |
| coyote ceanothus | *Ceanothus ferrisiae* |
| cream sacs | *Castilleja rubicunda* ssp. *lithospermoides* |
| creeping aster | *Aster chilensis* |
| Crystal Springs lessingia | *Lessingia arachnoidea* |
| deerweed | *Lotus purshianus* |
| desertparsley | *Lomatium* spp. |
| Douglas-fir | *Pseudotsuga menziesii* |
| Douglas' thistle | *Cirsium breweri* |
| dwarf plantain | *Plantago erecta* |
| earth brodiaea | *Brodiaea terrestris* |
| English plantain | *Plantago lanceolata* |
| eucalyptus | *Eucalyptus* spp. |
| exserted paintbrush | *Castilleja exserta [=Orthocarpus purpurascens]* |
| false babystars | *Linanthus androsaceus* |
| fennel | *Foeniculum vulgare* |
| filaree | *Erodium* sp. |
| foothill deervetch | *Lotus humistratus* |
| foothill needlegrass | *Nassella lepida* |
| foothill pine | *Pinus sabiniana* |
| fountain thistle | *Cirsium fontinale* var. *fontinale* |

| Common Name | Scientific Name |
|---|---|
| foxtail chess | *Bromus madritensis* ssp. *rubens* |
| fragrant fritillary | *Fritillaria liliacea* |
| Fremont's death camas | *Zigadenus fremontii* |
| french broom | *Genista [=Cytisus] monspessulana* |
| German ivy | *Senecio mikanioides* |
| giant reed | *Arundo donax* |
| golden yarrow | *Eriophyllum confertiflorum* |
| gypsum springbeauty | *Claytonia gypsophiloides* |
| hairy bird's-beak | *Cordylanthus pilosus* |
| Harding grass | *Phalaris aquatica* |
| hayfield tarweed | *Hemizonia congesta, H. c.* ssp. *congesta* |
| Hillsborough chocolate lily | *Fritillaria biflora* var. *ineziana* |
| Howell's manzanita | *Arctostaphylos hispidula* |
| iceplant | *Carpobrotus* spp. |
| incense cedar | *Calocedrus decurrens* |
| intermediate fiddleneck | *Amsinckia intermedia* |
| Italian ryegrass | *Lolium multiflorum* |
| Ithuriel's spear | *Triteleia laxa* |
| Jeffrey pine | *Pinus jeffreyi* |
| junegrass | *Koeleria macrantha* |
| leather oak | *Quercus durata* |
| longhorn plectritis | *Plectritis macrocera* |
| long-rayed tritelia | *Tritelia peduncularis* |
| madrone | *Arbutus menziesii* |
| Marin County navarretia | *Navarretia rosulata* |

| Common Name | Scientific Name |
|---|---|
| Marin dwarf-flax | *Hesperolinon congestum* |
| Mariposa lily | *Calochortus venustus* |
| Mason's ceanothus | *Ceanothus masonii* |
| meager pentachaeta | *Pentachaeta exilis* ssp. *exilis* |
| Metcalf Canyon jewelflower | *Streptanthus albidus* ssp. *albidus* |
| milkwort jewelflower | *Streptanthus polygaloides* |
| miner's lettuce | *Claytonia perfoliata* |
| Monterey cypress | *Cupressus macrocarpa* |
| Monterey Coast paintbrush | *Castilleja latifolia* ssp. *rubra* |
| Monterey pine | *Pinus radiata* |
| most beautiful jewelflower | *Streptanthus albidus* ssp. *peramoenus* |
| Mt. Hamilton coreopsis | *Coreopsis hamiltonii* |
| Mt. Hamilton jewelflower | *Streptanthus callistus* |
| Mt. Hamilton thistle | *Cirsium fontinale* var. *camplyon* |
| Mt. Tamalpais jewelflower | *Streptanthus glandulosus* ssp. *pulchellus* |
| Mt. Tamalpais thistle | *Cirsium hydrophilum* var. *vaseyi* |
| musk brush | *Ceanothus jepsonii* |
| mustard | *Brassica* sp. |
| naked buckwheat | *Eriogonum nudum* |
| naked lady lily | *Amaryllis belladonna* |
| Oakland star-tulip | *Calochortus umbellatus* |
| ocean-bluff bluegrass | *Poa unilateralis* |
| pampas grass | *Cortaderia jubata, Cortaderia selloana* |
| Pennell's bird's-beak | *Cordylanthus tenuis* ssp. *capillaris* |
| perennial ryegrass | *Lolium perenne* ssp. *perenne* |

| Common Name | Scientific Name |
|---|---|
| phacelia | *Phacelia imbricata* |
| plumeless thistle | *Carduus* sp. |
| Presidio clarkia | *Clarkia franciscana* |
| Presidio manzanita | *Arctostaphylos hookeri* var. *ravenii* |
| purple needlegrass | *Nassella pulchra* |
| purple owl's- clover | *Castilleja densiflora [ = Orthocarpus densiflorus]* |
| purple sanicle | *Sanicula bipinnatifida* |
| royal larkspur | *Delphinium variegatum, D. v.* ssp. *variegatum* |
| ruby chalice clarkia | *Clarkia rubicunda* |
| ryegrass | *Elymus triticoides* |
| Sandberg's bluegrass | *Poa secunda = Poa scabrella* |
| San Benito thornmint | *Acanthomintha obovata* |
| San Diego thornmint | *Acanthomintha ilicifolia* |
| San Francisco wallflower | *Erysimum franciscanum* |
| San Mateo thornmint | *Acanthomintha obovata* ssp. *duttonii = A. duttonii* |
| San Mateo woolly sunflower | *Eriophyllum latilobum* |
| Santa Clara thornmint | *Acanthomintha lanceolata* |
| Santa Clara Valley dudleya | *Dudleya setchellii* |
| Sargent cypress | *Cupressus sargentii* |
| scytheleaf onion | *Allium falcifolium* |
| sea muilla | *Muilla maritima* |
| seashore bentgrass | *Agrostis pallens* |
| seep monkeyflower | *Mimulus guttatus* |

| Common Name | Scientific Name |
|---|---|
| serpentine bird's-beak | *Cordylanthus tenuis* ssp. *brunneus* |
| serpentine linanthus | *Linanthus ambiguus* |
| serpentine reedgrass | *Calamagrostis ophitidus* |
| serpentine sunflower | *Helianthus bolanderi* |
| silver European hairgrass | *Aira caryophylla* |
| slender dwarf-flax | *Hesperolinon spergulinum* |
| slender fairyfan | *Clarkia gracilis* |
| slender wheatgrass | *Elymus trachycaulus* |
| slender wild oat | *Avena barbata* |
| smallflower dwarf-flax | *Hesperolinon micranthum* |
| smooth lessingia | *Lessingia micradenia* var. *glabrata* |
| soft brome | *Bromus hordeaceus* |
| spring deathcamas | *Zigadenas fontanus* |
| sticky calycadenia | *Calycadenia multiglandulosa* |
| sticky western rosinweed | *Calycadenia multiglandulosa* |
| stickywilly | *Galium aparine* |
| streambank springbeauty | *Claytonia parviflora* |
| sulphurflower buckwheat | *Eriogonum umbellatum* ssp. *bahiaforme* |
| talus fritillary | *Fritillaria falcata* |
| Tamalpais lessingia | *Lessingia micradenia* var. *micradenia* |
| Tamalpais manzanita | *Arctostaphylos hookeri* ssp. *montana* |
| tanoak | *Lithocarpus densiflorus* |
| teasel | *Dipsacus* spp. |
| Texas paintbrush | *Castilleja foliolosa* |

| Common Name | Scientific Name |
|---|---|
| Tiburon buckwheat | *Eriogonum caninum* = *E. luteolum* var. *caninum* |
| Tiburon jewelflower | *Streptanthus niger* |
| Tiburon Mariposa lily | *Calochortus tiburonensis* |
| Tiburon paintbrush | *Castilleja affinis* ssp. *neglecta* |
| tidy-tips | *Layia platyglossa* |
| tiny pentachaeta | *Pentachaeta alsinoides* |
| Torrey's melicgrass | *Melica torreyana* |
| toyon | *Heteromeles arbutifolia* |
| trefoils | *Lotus micranthus*, *Lotus wrangelianus* |
| wavyleaf soapplant | *Chlorogalum pomeridianum*, *C. p.* var. *divaricatum* |
| western larkspur | *Delphinium hesperium* |
| white globe lily | *Calochortus albus* |
| white-rayed pentachaeta | *Pentachaeta bellidiflora* |
| wicker buckwheat | *Eriogonum viminium* |
| wild oat | *Avena fatua* |
| yampa | *Perideridia kelloggii* |
| yellowflower tarweed | *Holocarpha virgata* |
| yellow mariposa lily | *Calochortus luteus* |
| yellow star thistle | *Centaurea solstitialis* |
| yellowray goldfields | *Lasthenia glabrata* |
| yerba santa | *Eriodictyon californicum* |
| **BACTERIA** | |
| "Bt" | *Bacillus thuringiensis*, *B. t.* var. *kurstaki* |

| Common Name | Scientific Name |
|---|---|
| **ANIMALS** | |
| bay checkerspot butterfly | *Euphydryas editha bayensis* |
| Botta's pocket gopher | *Thomomys bottae* |
| bumble bee | *Bombus vosnesenskii*, *B. californicus*, *Bombus* spp. |
| California harvestman | *Sitalces californicus* |
| California oakworm | *Phryganidia californica* |
| California red-legged frog | *Rana aurora draytonii* |
| California tiger salamander | *Ambystoma californiense* |
| Edgewood blind harvestman | *Calicina* [*Sitalcina*] *minor* |
| Edgewood microblind harvestman | *Microcina edgewoodensis* |
| Fairmont microblind harvestman | *Microcina lumi* |
| Hom's microblind harvestman | *Microcina homi* |
| horned lark | *Eremophila alpestris* |
| island checkerspot butterfly | *Euphydryas editha insularis* |
| Jung's microblind harvestman | *Microcina jungi* |
| leafcutting bee | *Osmia* spp. |
| Lee's microblind harvestman | *Microcina leei* |
| Luesther's checkerspot butterfly | *Euphydryas editha luestherae* |
| Marin blind harvestman | *Calicina diminua* |
| Mono checkerspot butterfly | *Euphydryas editha monoensis* |
| Muir's hairstreak | *Mitoura nelsoni muiri* |
| Myer's blind harvestman | *Sitalcina cockerelli* |

| Common Name | Scientific Name |
|---|---|
| no common name | *Andrena* spp.<br>*Calicina polina*<br>*Synalonia* spp. |
| Opler's longhorn moth | *Adela oplerella* |
| Quino checkerspot butterfly | *Euphydryas editha quino* |
| San Francisco garter snake | *Thamnophis sirtalis tetrataenia* |
| serpentine blind harvestman | *Calicina serpentinea* |
| tachinid fly | *Siphosturmia melitaeae* |
| Thorp's longhorn moth | *Adela thorpella* |
| Tiburon microblind harvestman | *Microcina tiburona* |

## B. Glossary of Technical Terms

| Term | Definition |
| --- | --- |
| *adult* | life stage capable of reproduction--in butterflies and moths, this is the winged form that emerges from the pupa |
| *adelids* | small, day-flying moths sometimes called fairy moths, including Opler's longhorn moth |
| *annual* | living less than one year and completing the entire life cycle from seed germination to seed production in a single growing season |
| *anther* | male reproductive flower part |
| *anthesis* | opening |
| *apical* | situated at the tip |
| *autogamy* | self-pollination in the absence of pollinators |
| *biomass* | the amount of living matter in the form of one or more kinds of organisms present in a particular habitat |
| *biome* | a major biotic community or life zone |
| *bodenvag species* | plants not restricted to a specific type of substrate |
| *bract* | small leaf- or scale-like structures associated with an inflorescence |
| *burl* | a hard woody growth that is often flattened and hemispherical |
| *calyx* | collective term for the sepals or outermost whorl of flower parts |
| *capsule* | a dry fruit, generally with many seeds |

| *Term* | **Definition** |
|---|---|
| *Category 1 candidate* | species for which sufficient information is available to support a proposed listing as threatened or endangered by the U.S. Fish and Wildlife Service, but which is awaiting publication of a formal listing proposal; The Category 1 designation was discontinued in 1996, and most former Category 1 species are now simply considered candidate species (U.S. Fish and Wildlife Service 1996*b*, *c*) |
| *Category 2 candidate* | species for which listing may be appropriate but for which sufficient information is unavailable for U.S. Fish and Wildlife Service to make a final listing determination; Category 2 was discontinued in 1996 (U.S. Fish and Wildlife Service 1996*b*, *c*) |
| *cation exchange* | ion exchange in which one cation (positively charged ion) is substituted for one or more other cations |
| *cation exchange capacity* | a measure of the total exchangeable cations (some of which are important plant nutrients) that are available in a soil |
| *cauline leaves* | leaves on the stem |
| *cephalothorax* | the anterior portion of various arthropods and crustaceans, consisting of the fused head and thorax |
| *Collembola* | insect Order, known as "springtails" |
| *colony* | population |
| *congested* | crowded together |
| *corolla* | collective term for all the petals |

| *Term* | **Definition** |
|---|---|
| *costa* | longitudinal wing vein in certain insects, usually forming the front margin of the wing |
| *cuticle* | connective tissue or fibers arranged in a web or mesh |
| *demography* | the study of populations, such as of growth rates and number or percentage of individuals in each age group |
| *diapause* | a dormant phase |
| *disjunct* | removed from; distinctly separated |
| *disk flower* | flower in the center portion of the head of a member of the aster family |
| *dormancy* | with suspended growth, development or other biological activity; inactive or resting |
| *elliptic* | shaped like a flattened circle |
| *endemic* | prevalent in or peculiar to a particular locality |
| *entire* | with smooth edges, as in entire leaves |
| *enzyme* | any of a very large class of complex proteinaceous substances that are produced by living cells |
| *estivate* | to go into "hibernation" during dry periods |
| *extant* | currently existing, not extirpated or destroyed |
| *extirpated* | locally extinct |
| *fecundity* | production of offspring |
| *field capacity* | the amount of water that a soil will hold under conditions of free drainage (= field moisture capacity) |
| *fused* | united, e.g. petals united into a tube |

| Term | Definition |
|---|---|
| *genotypically* | of or related to the totality of genes possessed by an individual or group |
| *genus (plural: genera)* | next taxonomic classification above species |
| *germinate* | begin to grow |
| *glabrous* | lacking hairs, hairless |
| *glaucous* | with a white or bluish waxy or powdery film |
| *glomerule* | compact flower cluster |
| *gravid* | carrying fertilized eggs |
| *hyperaccumulate* | to accumulate far greater than normally |
| *igneous rocks* | rock formed by solidification of a molten magma |
| *inbreeding* | mating of related individuals |
| *inbreeding depression* | loss of viability and/or fecundity associated with mating among relatives |
| *incurvariids* | small moths of the family Incurvariidae |
| *inflorescence* | entire cluster of flowers and associated structures |
| *instar* | stage in the development of insect larvae between molts, in which the larva grows until it must shed its old skin (exoskeleton). The first instar precedes the first molt, and so on |
| *intrusive igneous rocks* | molten magma forced into cavities or cracks or between layers of other rock |
| *involucral bracts* | groups of bracts beneath a flower, fruit or inflorescence |

| *Term* | **Definition** |
|---|---|
| *larva (plural: larvae)* | early stage in the life of an invertebrate; in butterflies and moths, the stages between egg and pupa. Butterfly and moth larvae are also called caterpillars. |
| *Lepidoptera* | insect Order composed of butterflies and moths |
| *margin* | edge |
| *mesic* | with a moderate amount of moisture |
| *metapopulation* | a group of distinct but interdependent populations, capable of exchanging dispersing individuals |
| *microclimate* | climate close to the ground or other surface; also varies greatly over short horizontal distances, for example, due to differences in solar exposure |
| *microenvironment* | environment viewed at a very small scale, as around a single plant |
| *microlepidoptera* | very small moths in the Suborder Frenatae |
| *morphological* | of or related to form or structure |
| *Nearctic* | biogeographical realm which includes Greenland and all of North America |
| *Nemophora* | moths in genus closely related to *Adela* |
| *nutlet* | small, dry nut or nut-like fruit |
| *oblanceolate* | narrowly elongate and widest at the tip |
| *obligate* | limited; bound to a restricted environment |
| *occurrence* | defined by California Natural Diversity Data Base as a location separated from other locations of the species by at least one-fourth mile; may contain one or more populations |

| Term | Definition |
|---|---|
| *ocherous* | containing or resembling the color ocher yellow |
| *outcrossing* | mating not involving inbreeding |
| *ovipositing* | egg-laying |
| *ovipositor* | egg-laying appendage of female insect |
| *paedomorphs* | adults which retain juvenile characteristics |
| *pedicel* | stalk of an individual flower or fruit |
| *perennial* | persisting or living for several years with a period of growth each year |
| *permanent wilting point* | the soil water level at which permanent wilting of the plant occurs |
| *phenology* | the timing of developmental stages of plants or animals |
| *phenotypic plasticity* | the capacity for marked variation in observable structural and functional properties of an organism as a result of environmental influences during development |
| *pod* | dry fruit that opens upon ripening to release the seeds |
| *polyphyletic* | (a species) having more than one ancestral line |
| *polyploid* | having more than two sets of chromosomes |
| *prepupal larvae* | larvae in stage(s) before pupation (see "*pupa*") |
| *prosoma* | the cephalothorax of an arthropod |
| *protandry* | with male reproductive parts maturing before female parts |
| *pubescence* | a covering of short, soft hairs |

| *Term* | **Definition** |
|---|---|
| *pupa (plural: pupae)* | a non-feeding and usually inactive stage in the life of certain insects, during which the transition from larva to adult is made; hence pupate; pupation |
| *raceme* | unbranched cluster or inflorescence of stalked (pedicled) flowers that open from bottom to top |
| *ray flower* | the flowers usually located on the edge of the head of members of the aster family |
| *repatriation* | return to a location formerly occupied |
| *sedentary* | tending to remain in one place |
| *seed bank* | viable dormant seeds that accumulate in or on the soil |
| *self-compatible* | capable of self-fertilization |
| *senesce* | to die back and dry out, usually in reference to plants |
| *sepal* | individual member of the outermost whorl or set of flower parts |
| *serpentine* | soils formed from weathered ultramafic rocks such as serpentinite, dunite, and peridotite; generally having (1) low calcium/magnesium ratio, (2) a lack of essential nutrients such as nitrogen, potassium, and phosphorous, and (3) high concentrations of heavy metals |
| *Sitalces* | harvestman genus in the Order Opiliones |
| *soil inclusions* | a small area of soil with different properties than the mapped soil series |

| *Term* | **Definition** |
|---|---|
| *spermatophore* | a capsule containing sperm, produced by males of some insects and other organisms, and transferred to the female during copulation |
| *springtails* | very small insects in the Order Collembola |
| *stigma* | female reproductive flower part |
| *stochastic* | involving random or chance processes |
| *survivorship* | the probability that a representative newly born individual will survive to various ages |
| *tarsus (plural: tarsi)* | terminal portion of an arthropod leg, often ending in claws or hooks |
| *taxon (plural: taxa)* | a group that is sufficiently distinct to be considered a separate unit; e.g. family, species, subspecies, variety |
| *thorax* | the portion of the body in insects between head and abdomen, bearing legs and wings |
| *toxicity* | the quality, state, or relative degree of being toxic or poisonous |
| *tubercle* | a small, rounded prominence or knob |
| *type locality* | the exact geographic location from which the specimen(s) used to describe a taxon was (were) collected |
| *type specimen* | a specimen or series of specimens chosen when the taxon is described and considered representative of the species, subspecies or variety |
| *ultramafic* | extremely basic, very low in silica and rich in ferromagnesian minerals |
| *univoltine* | having one brood per year |

| *Term* | **Definition** |
|---|---|
| *viable* | living (as in viable seeds); capable of persistence (as in viable population) |
| *whorl* | group of flowers |
| *xeric* | dry or arid |
| *xeromorphic* | concerning plants whose morphology has adapted to dry conditions |

## C. Priorities for Recovery of Threatened and Endangered Species.

| Degree of Threat | Recovery Potential | Taxonomy | Priority | Conflict |
|---|---|---|---|---|
| High | High | Monotypic Genus | 1 | 1C<br>1 |
| | High | Species | 2 | 2C<br>2 |
| | High | Subspecies | 3 | 3C<br>3 |
| | Low | Monotypic Genus | 4 | 4C<br>4 |
| | Low | Species | 5 | 5C<br>5 |
| | Low | Subspecies | 6 | 6C<br>6 |
| Moderate | High | Monotypic Genus | 7 | 7C<br>7 |
| | High | Species | 8 | 8C<br>8 |
| | High | Subspecies | 9 | 9C<br>9 |
| | Low | Monotypic Genus | 10 | 10C<br>10 |
| | Low | Species | 11 | 11C<br>11 |
| | Low | Subspecies | 12 | 12C<br>12 |
| Low | High | Monotypic Genus | 13 | 13C<br>13 |
| | High | Species | 14 | 14C<br>14 |
| | High | Subspecies | 15 | 15C<br>15 |
| | Low | Monotypic Genus | 16 | 16C<br>16 |
| | Low | Species | 17 | 17C<br>17 |
| | Low | Subspecies | 18 | 18C<br>18 |

## D. Major Research and Management Needs for Species Covered in the Plan.

| Species | Research | | | | | |
|---|---|---|---|---|---|---|
| | Habitat Surveys | Management | Population Monitoring | Reprod. and Demography | Systematics and Genetics | Others |
| **Listed plant species** | | | | | | |
| San Mateo thornmint (*Acanthomintha obovata* ssp. *duttonii*) | historic sites and other potential habitat within historic range | burning, weeding | all | yes | genetics | soil seed bank dynamics, characterization of habitat |
| Tiburon mariposa lily (*Calochortus tiburonensis*) | | grazing, burning, mowing | all | yes | | germination and propagation techniques |
| Tiburon paintbrush (*Castilleja affinis* ssp. *neglecta)* | potential habitat, especially in Santa Clara County | grazing, burning, mowing | all | yes | yes | hemiparasitism |
| coyote ceanothus (*Ceanothus ferrisiae*) | potential habitat, (e.g. east of Anderson Reservoir) | grazing, burning | all | yes, (e.g. recruitment) | | role of fire |

| Species | Research | | | | | |
|---|---|---|---|---|---|---|
| | **Habitat Surveys** | **Management** | **Population Monitoring** | **Reprod. and Demography** | **Systematics and Genetics** | **Others** |
| fountain thistle (*Cirsium fontinale* var. *fontinale*) | formerly occupied habitat at Edgewood Natural Preserve and the Triangle; potential habitat elsewhere | disturbance | all | yes | | seed predation by weevil, seed germination and propagation techniques, hybridization with *C. quercetorum*, |
| Presidio clarkia (*Clarkia franciscana*) | all formerly occupied and potential habitat | soil scraping, duff removal, burning | all | yes | | soil seed bank |
| Pennell's bird's-beak (*Cordylanthus tenuis* ssp. *capillaris*) | potential habitat within the species' range | burning | all | yes | | seed germination and propagation techniques, root parasitism, soil seed bank |

| Species | Research | | | | | |
|---|---|---|---|---|---|---|
| | Habitat Surveys | Management | Population Monitoring | Reprod. and Demography | Systematics and Genetics | Others |
| Santa Clara Valley dudleya (*Dudleya setchellii*) | potential habitat (e.g. north of Metcalf road, East Hill Ridge, Uvas road, Motorcycle Park, and areas set aside for bay checkerspot butterfly) | grazing, mowing, burning | all | yes | | seed germination and propagation techniques, dispersal |
| San Mateo woolly sunflower (*Eriophyllum latilobum*) | potential serpentine and non-serpentine habitat (e.g. south side of San Mateo Creek, land in the vicinity of Hillsborough, and SFWD land) | mowing | all | yes | yes | seed germination and propagation techniques, soil affinity, beetle predation, plasticity |

| Species | Research | | | | | |
|---|---|---|---|---|---|---|
| | **Habitat Surveys** | **Management** | **Population Monitoring** | **Reprod. and Demography** | **Systematics and Genetics** | **Others** |
| Marin dwarf-flax (*Hesperolinon congestum*) | potential habitat throughout the species' range | grazing, burning | all | yes | yes | seed germination and propagation techniques, soil seed bank |
| white-rayed pentachaeta (*Pentachaeta bellidiflora*) | all historic sites and other potential habitat within historic range | | all | yes | | seed germination and propagation techniques, soil seed bank |
| Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*) | all historic sites and other potential habitat within historic range | grazing, mowing, burning | all | yes | yes | seed germination and propagation techniques, soil seed bank, dispersal |
| Tiburon jewelflower (*Streptanthus niger*) | other potential habitat on Tiburon Peninsula | burning, weeding | all | yes | | seed germination and propagation techniques, soil seed bank, dispersal |

| Species | Research | | | | | |
|---|---|---|---|---|---|---|
| | **Habitat Surveys** | **Management** | **Population Monitoring** | **Reprod. and Demography** | **Systematics and Genetics** | **Others** |
| **Plant species of concern** | | | | | | |
| Baker's manzanita (*Arctostaphylos bakeri* ssp. *bakeri*) | potential habitat within species' range | burning, hand clearing | all | yes | | seed germination and propagation techniques |
| Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*) | potential habitat within species' range | grazing, mowing, burning | all | yes | yes | seed germination and propagation techniques, disturbance |
| Crystal Springs lessingia (*Lessingia arachnoidea*) | all historic sites and potential habitat within species' range | | all | yes | yes (identity of Sonoma County material) | seed germination and propagation techniques, soil seed bank |
| smooth lessingia (*Lessingia micradenia* var. *glabrata*) | all historic sites and potential habitat within species' range | grazing | all | yes | | seed germination and propagation techniques, soil seed bank |
| Tamalpais lessingia (*Lessingia micradenia* var. *micradenia*) | all historic sites and potential habitat within species' range | | all | yes | | seed germination and propagation techniques, soil seed bank |

| Species | Research | | | | | |
|---|---|---|---|---|---|---|
| | Habitat Surveys | Management | Population Monitoring | Reprod. and Demography | Systematics and Genetics | Others |
| most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*) | all historic sites and potential habitat within species' range | grazing, mowing, burning | all | yes | yes | seed germination and propagation techniques, soil seed bank |
| **Listed animal species** | | | | | | |
| Bay checkerspot butterfly (*Euphydryas editha bayensis*) | historic sites and potential habitat | grazing, mowing, burning, weeding, herbicides, biocontrol of non-natives | all | yes | | air pollution impacts, habitat restoration |
| **Animal species of concern** | | | | | | |
| Edgewood blind harvestman *(Calicina minor)* | historic sites and other potential habitat within historic range | disturbance | all | yes | systematics | dispersal effects of vegetation management |

| Species | Research | | | | | |
|---|---|---|---|---|---|---|
| | Habitat Surveys | Management | Population Monitoring | Reprod. and Demography | Systematics and Genetics | Others |
| Edgewood microblind harvestman (*Microcina edgewoodensis*) | historic sites and other potential habitat within historic range | disturbance | all | yes | systematics | dispersal, effects of vegetation management |
| Fairmont microblind harvestman (*Microcina lumi*) | historic sites and other potential habitat within historic range | mowing, weeding, disturbance | all | yes | systematics | dispersal, effects of vegetation management |
| Hom's microblind harvestman (*Microcina homi*) | historic sites and other potential habitat within historic range | grazing, mowing, burning, weeding, disturbance | all | yes | systematics | dispersal, effects of vegetation management |
| Jung's microblind harvestman (*Microcina jungi*) | historic sites and other potential habitat within historic range | disturbance | all | yes | systematics | dispersal, effects of vegetation management |
| Marin blind harvestman (*Calicina diminua*) | historic sites and other potential habitat within historic range | mowing, weeding, disturbance | all | yes | systematics | dispersal, effects of vegetation management |

| Species | Research | | | | | |
|---|---|---|---|---|---|---|
| | **Habitat Surveys** | **Management** | **Population Monitoring** | **Reprod. and Demography** | **Systematics and Genetics** | **Others** |
| Opler's longhorn moth *(Adela oplerella)* | historic sites and other potential habitat within historic range | grazing, mowing, burning, weeding, disturbance | all | yes | | dispersal, effects of vegetation management, air pollution |
| Tiburon microblind harvestman (*Microcina tiburona*) | historic sites and other potential habitat within historic range | grazing, mowing, weeding, disturbance | all | yes | systematics | dispersal, effects of vegetation management |

## E. Agency and Public Comment on the Draft Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area

### I. Summary of Agency and Public Comment on the Draft Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area

In March, 1998, the U.S. Fish and Wildlife Service (Service) released the Draft Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area (Draft Plan) for a 90-day comment period for Federal agencies, state and local governments, and members of the public (Federal Register 63: 14129). The comment period ended on June 22, 1998. Thomas S. Briggs, Dennis D. Murphy, Susan P. Harrison, Alan E. Launer, Niall McCarten, Jerry A. Powell, and Roger Raiche, were asked to provide peer review of the Draft Plan. Comments were received from five peer reviewers.

This section provides a summary of general information about the comments the Service received, including the number of letters from various sources. A complete index of commenters, by affiliation, is available from the U.S. Fish and Wildlife Service, Ecological Services, Sacramento Fish and Wildlife Office, 3310 El Camino Avenue, Suite 130, Sacramento, California 95821. All comment letters are kept on file in the Sacramento Fish and Wildlife Office.

The following is a breakdown of the number of comment letters received from various sources:

state agencies--2
local governments--3
academia/professional--10
business/industry--3
environmental/conservation organizations--9
individual citizens--2

Twenty-nine letters were received. Each contained one or more comments. Some letters raised similar issues. Most letters provided new

Service expects to provide assistance to agencies and individuals who wish to conduct surveys on their lands. The Service can help with design of surveys protocols and with conducting the surveys. Private landowners are encouraged to work with the Service to survey their lands, but the Service has no authority to require surveys on private land.

**Comment:** Two commenters suggested that the Service should work with a variety of other agencies, such as Bay Area Resource Conservation Districts, U.S. Department of Agriculture-Natural Resource Conservation Service, Caltrans, California Department of Food and Agriculture, and cities and counties. Various issues that need to be addressed include flood and erosion control, vegetation management, adequate monitoring at project sites, management of roadside rights-of-way, use of pesticide sprays in and near serpentine areas, buffering from developed areas and golf courses, and control of invasive non-native plants. The Service should (1) coordinate with Bureau of Land Management to trade federal lands for biologically valuable serpentine on private land and (2) enter into a Memorandum of Understanding with resource conservation districts and the U.S. Department of Agriculture-Natural Resource Conservation Service to optimize vegetation-altering practices.

**Response:** The commenters point out several valuable avenues to pursue in recovery efforts. Recovery of endangered and threatened species requires the cooperation of many agencies, organizations, and individuals, as mentioned in task 1 of the Stepdown Narrative. To the extent that staffing and funding allow, the Service expects to work with numerous agencies responsible for managing lands with serpentine habitat to address the issues raised by the commenters.

**Comment:** With the exception of Golden Gate National Recreation Area, land management agencies are not protecting or preserving species. Instead, recovery work is being done by volunteers.

**Response:** Due to limited staffing and funding of many public agencies, the work of volunteers ensures that conservation tasks are accomplished on public lands. The contributions of these volunteers are extremely valuable. Nevertheless, the Service encourages land management agencies to participate in protection and preservation of rare species and is eager to provide technical assistance to help them accomplish this goal.

**Comment:** Educational programs should be included in the plan. Various land management and local agencies would benefit from an education program to provide information on serpentine species and train managers how to best protect and manage serpentine habitats. Education and outreach could extend to the community as well. The Service should make information on serpentine species and associated conservation actions (such as easements and habitat conservation plans) available to the public, perhaps via the Internet.

**Response:** Education and outreach are fundamental to success of conservation efforts and are briefly addressed in task 1 of the Stepdown Narrative. Brief clarifications of educational efforts needed have been added in several other places in the plan. The Service is willing to provide educational programs about serpentine species and their habitat for local agencies, environmental organizations, and the general public. Currently, information on serpentine species and associated conservation actions is available to interested individuals from the Service's files. The Service is working toward making information accessible via the Internet on a wide variety of listed species and other species of concern.

**Comment:** The Implementation Schedule estimated the task duration for "securing and protecting...Edgewood Natural Preserve" at four years. The commenter suggested that "securing and protecting" habitat at Edgewood will be a continual process because Edgewood is in an urban area.

**Response:** The Service agrees that protecting and managing preserves in urban areas is challenging and labor intensive. On-going management of Edgewood Natural Preserve and other protected locations is identified as task 3.1 and given a priority 1. The task duration is ongoing.

**Comment:** The scientific basis for the recovery standards in the plan is not clear. More detail should be provided on how recovery criteria, population size standards, buffer requirements, and monitoring standards were chosen.

**Response:** Discussion of recovery criteria is given in Chapter III and below in the first comment in the plant section. Recovery strategies and other recommendations are based upon the best scientific information available. Most recommendations are preliminary because (1) available data on the covered species are limited and (2) conservation biology has yet to resolve the details of how endangered species recovery is best achieved for any species. Current conservation biology and/or population genetic theory were used to develop certain standards. For example, suggested census population size targets were chosen based on evidence on how effective population size may be related to census population size, and some local population size targets were based on information about the genetic consequences and extinction risks of small populations. Numbers and distributions of populations were based on considerations of extinction frequency of individual populations and spreading of risk across the landscape. Recovery strategies and other recommendations may need to be altered as more data become available and as conservation science develops. Such information will be reviewed periodically by the Service.

**Comment:** Steps should be taken to alleviate population fragmentation and genetic isolation because small, isolated populations are subject to genetic drift and bottlenecks. The commenter suggested that long-term population stability can not be achieved unless gene flow is reestablished by creation or expansion of migration corridors. Five guidelines were recommended: (1) maintain large population size and maximize the proportion of adults contributing to reproduction, (2) minimize incidence of bottlenecks in population size, (3) minimize duration of bottlenecks, (4) maintain movement of individuals and hence gene flow between local populations, and (5) maintain environmental heterogeneity within and between biotopes.

**Response:** The Service agrees that (1) population fragmentation and genetic isolation may have a variety of potential negative consequences and (2) recommended guidelines 1, 2, 3, and 5 are generally appropriate. However, caution should be exercised in use of guideline 4. As discussed in Ellstrand and Elam (1993), gene flow among plant populations within a species may be beneficial, preventing inbreeding depression and depletion of genetic variation in small populations. However, gene flow among plant populations is not *necessarily* beneficial and may be detrimental. Potential detrimental effects include reduction of local variation, prevention of local adaptive differentiation, and reduction of fitness through outbreeding depression. The same may be true for harvestman species that have limited dispersal. Whether gene flow is beneficial or detrimental depends largely on the role it has played in a species' recent evolutionary history. The management goal for populations that are considered healthy should be to maintain gene flow at approximately natural levels. Transferring individuals merely to augment local populations should not be contemplated in such cases. Because serpentine outcrops are naturally distributed in patches and are isolated from each other (Stebbins 1942, Kruckeberg 1992), dispersal "corridors" may not exist, and it is conceivable that gene flow among populations always has been low (Mayer *et al.* 1994). In this case, promoting gene flow among populations has the potential to be detrimental. Population genetic analysis can give an idea of historic levels of gene flow. Recent population genetic analysis of *Streptanthus* species covered in this plan suggests that gene flow among populations is low (Mayer *et al.* 1994). Such analysis would be valuable for other plant and animal species covered in the plan, both to estimate historic gene flow and to quantify levels and distribution of genetic variation in the species.

**Comment:** Protection from cattle grazing is critical for long-term persistence of serpentine plant and invertebrate populations. However, seasonal management of grazing is necessary, rather than complete exclusion of cattle. Elimination of grazing can result in displacement of native plant species by non-native annual grasses. Non-native grasses may also increase fuel loads. The commenter suggested grazing needs to be managed to prevent destruction of serpentine species by both grazing and invasion of non-native annuals.

**Response:** Grazing and its potential importance in controlling invasion of non-native annual grasses in serpentine habitats covered in this plan is discussed in the Bay checkerspot butterfly species account (Chapter II, section O.4). The Service agrees vegetation management techniques that prevent further invasion of non-native species and still protect rare serpentine plant species need to be developed. Research to develop these techniques is a high priority in the plan.

**Comment:** One commenter stated that the City of San Francisco would like to build a golf course on lands managed by its Water Department near Edgewood Natural Preserve around the intersection of Edgewood and Cañada Roads (the "Triangle").

**Response:** Any such proposal would be required to undergo extensive public review and authorization, including review of likely effects on threatened and endangered species and wetlands by the U.S. Fish and Wildlife Service. The U.S. Fish and Wildlife Service is not presently aware of any active proposal for a golf course at the site.

**Comment:** Other than purchasing land outright, what measures are recommended to protect non-public serpentine habitat from various kinds of development? Are there any standard conditions of approval that county or local planning agencies should place on developments in serpentine habitats?

**Response:** Conservation easements and other conservation agreements with private landowners have great potential to contribute to the recovery of species covered by the plan. Zoning and land use designations such as urban growth boundaries can guide development into less environmentally damaging avenues. Tax incentives to maintain habitat values on environmentally sensitive land deserve consideration by state and local government. A simple standard condition of approval for projects that may affect serpentine habitats would be to make such projects available for review by the U.S. Fish and Wildlife Service and the California Department of Fish and Game. Projects that would result in any "take" of federally listed fish or wildlife species must be referred to the U.S. Fish and Wildlife Service for Endangered Species Act compliance. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any listed wildlife species. "Harm" in this definition includes significant habitat modification or degradation where it actually kills or injures wildlife, by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR § 17.3).

**Comment:** Broad priorities for habitat protection are presented in the stepdown narrative (section IV), but more specific priorities are presented under the recovery strategy for the bay checkerspot butterfly. Do the priorities spelled out for the butterfly reflect the most important serpentine areas to protect?

**Response:** Not necessarily. The priorities identified in the bay checkerspot account are focused on that one species' needs. Identifying a strict ranking of priorities across sites for a multispecies recovery plan is extremely problematic and probably of limited utility. Careful reading of the species accounts, recovery criteria, and Tables IV-1 and IV-2 can help guide the identification of high priority sites for a given objective. For example, in Santa Clara County, the Kirby habitat area (task 2.1.20), identified as highest priority for bay checkerspot, is a large, diverse, well buffered site that also supports the largest number of other listed species and species of concern. However, other important areas exist in the county and elsewhere in the plan area, and other considerations such as focal species, regional need for open space, or degree of immediate threat could conceivably cause other sites to receive priority.

**Comment:** Don Rocha, Natural Resource Coordinator for the County of Santa Clara, Parks and Recreation Department, explained that the Parks Department's mission includes providing a place for recreation as well as preservation and education, and stated that the Parks Department's full mission must be taken into consideration.

**Response:** The U.S. Fish and Wildlife Service acknowledges that local agencies have diverse missions that are sometimes difficult to reconcile with competing needs. We believe that many recreational activities in demand among Bay Area residents are compatible with habitat protection and management for listed species, and that ecosystem preservation and endangered species conservation must be accorded a place in the landscape. The U.S. Fish and Wildlife Service intends to coordinate with local parks to develop recovery actions that fit with park goals.

**Comment:** Susan Cochrane, Chief of the Natural Heritage Division of the California Department of Fish and Game, cautioned against excessive reliance on "umbrella" species in efforts to conserve non-listed species.

**Response:** We agree that the umbrella-species concept has limitations and have revised relevant sections of the plan.

**Plant Species**

**Comment:** Some commenters (1) disagreed with any attempt to downlist or delist the listed plant species covered in the plan, (2) felt that downlisting and delisting criteria were too low or were arbitrary, or (3) suggested that the Service should proceed cautiously with any listing changes. Some questioned whether having only one or a few natural populations of a species in protected status was sufficient justification for downlisting or delisting and suggested that federal listing is a useful protection tool for species with few occurrences, even after sites are protected.

**Response:** The Endangered Species Act requires that recovery criteria be objective and measurable. However, as discussed in Chapter III of the plan, recovery criteria are difficult to determine in the best of circumstances and are particularly problematic when adequate biological data are not available. To the extent possible, Cypher's (1998) guidelines were used to develop recovery criteria for plant species covered in the plan. However, a lack of available data for the covered species made application of the guidelines difficult. Based on the comments received, the Service reevaluated and raised some of the proposed downlisting and delisting criteria. Nevertheless, criteria given in the plan are preliminary and should be reevaluated as more data become available.

**Comment:** Evaluation of the trend of a species should occur over decades. The plan is relatively progressive to suggest evaluation over 15 to 20 years that include the normal precipitation cycle, but 30 years would be more appropriate because of California's changeable climate.

**Response:** The Service agrees that California's climate dictates that monitoring should take place over many years. Based on the comment, the Service reevaluated and, in some cases, increased monitoring times.

**Comment:** Created populations should not count toward the recovery goal, or created populations should only be counted after they have withstood the natural range of climatic variation.

**Response:** Repatriated or introduced populations would only contribute toward the recovery goal if they are considered stable through the normal precipitation cycle. Discussion of the role of repatriated and introduced populations has been expanded and clarified, particularly in Chapter III.

**Comment:** One commenter noted that the plan calls for studies of atmospheric deposition of nitrogen from air pollution and suggested using lichen species as air pollution monitors.

**Response:** The Service will consider this suggestion when preparing or reviewing any proposal to conduct this research study.

**Comment:** Using *Dudleya setchellii* as an example, one commenter stated that the threats to existing populations in the plan are overstated and outdated. New information on the potential impacts of certain projects, such as Cerro Plata, was not considered.

**Response:** The best information available was used to evaluate threats to species covered in the plan. In many cases, as with

*Dudleya setchellii*, populations on private land cannot be surveyed to verify or update population sizes, threats, or other information. Any additional, relevant data provided by interested parties will be considered by the Service. With respect to the proposed Cerro Plata project, the Service is working with the applicant to minimize impacts to *Dudleya setchellii*, but a habitat conservation plan ensuring protection of *Dudleya setchellii* at the site has yet to be finalized.

**Comment:** Many rare serpentine endemics at Mt. Diablo State Park were not discussed in the plan.

**Response:** A number of other serpentine endemic plant species of concern could have been considered in the plan. The California Native Plant Society's Electronic Inventory (1997) indicates 111 rare plant species grow on serpentine substrates in the eight counties occupied by the listed species covered in the plan. Species of concern were only included if evidence suggested that they co-occur with one or more of the listed species covered in the plan.

**Comment:** Populations of *Streptanthus albidus* ssp. *peramoenus* in Sunol Regional Wilderness and serpentine habitats on Mt. Diablo are already "secured" by virtue of their occurrence on public lands.

**Response:** The task referred to refers not just to public ownership of land, but also to protection of serpentine habitat on those public lands from incompatible uses.

**Comment:** The threat from invasion of non-native species to listed plant species is serious. Control of these invasive species is the single most important recovery action for the listed species covered in the plan. The Service should stress the removal of non-native invasive species is necessary to ensure recovery of the listed species and should provide technical assistance and funding to land managers for removal of invasive species.

**Response:** Invasion of non-native plant species is a serious threat to some species covered in the plan. As such, control of non-natives is a high priority for recovery of certain species in certain locations. However, it is almost never the only action required to ensure long-term survival of populations in nature. The Service urges land management agencies to manage non-native species on their lands and is willing and eager to provide technical assistance to land managers who want to control invasive species. In the last year, the Service has worked with the San Francisco Water Department and Caltrans to remove pampas grass on their lands (see *Cirsium fontinale* var. *fontinale* species account). The Service will consider for funding any proposal regarding removal of non-native species that threaten plant species covered in this plan.

**Comment:** The Service overemphasizes repatriation of historic locations. Introduction of new populations in any suitable habitat within a species' historic range should not be ruled out. The commenter suggested that the Service provide more opportunities and incentives for introductions.

**Response:** The Service does not rule out introduction of plant populations in suitable habitat within their historic ranges. While the plan states that repatriations of appropriate historic sites are preferred over introductions to new sites, nothing in the plan precludes attempts to introduce populations (see Chapter III). The Service agrees that, in some cases, ensuring long-term survival of species in the wild will require successful introduction of new populations. The Service will provide assistance to agencies, conservation organizations, and others who wish to pursue such activities.

**Comment:** One commenter wondered how seed collection and banking was to be handled, asking specifically whether collection is to be annual or based on seed viability, how guidelines for collection would be established, and who would do the collecting.

**Response:** The Service expects to work with the Plant Conservation Program of the California Department of Fish and Game and with landowners and managers to coordinate seed collection and banking activities. To avoid damage to donor populations, annual collections are unlikely. General guidelines for seed collection have been published by Center for Plant Conservation (1991). The Service and the Plant Conservation Program have not determined who will do the collecting. That decision will likely be made when funding becomes available and when an opportunity to collect arises. Anyone collecting seed must possess appropriate Federal and State permits.

**Comment:** A 150-meter (500-foot) buffer should be required, not just around each population, but also around each sub-population.

**Response:** Whether the group of plants in question is considered a population or a sub-population, the purpose of a buffer is to reduce external influences and allow increases in the number of plants at a site. A 150-meter (500-foot) buffer is suggested as a minimum guideline. Because individual site conditions will influence the necessary buffer size, the Service will evaluate particular sites and situations on an individual basis and determine whether each is adequately buffered. To protect the integrity of the site and avoid fragmentation, the Service would probably prefer to ensure a site with several groups of plants (subpopulations) had an adequate buffer around the entire site.

**Comment:** One peer reviewer suggested that the Service convene a group of scientists and local experts to evaluate the needs of *Acanthomintha obovata* ssp. *duttonii* prior to initiating further work, particularly translocation studies.

**Response:** Forming such a group would be very valuable. The Service will take the suggestion into consideration when recovery implementation begins.

**Comment:** Research on the systematic relationship of *Streptanthus albidus* ssp. *albidus* to other related species of *Streptanthus* would be helpful.

**Response:** Systematic work on *Streptanthus albidus* ssp. *albidus* and related species is being conducted by Michael Mayer at the University of San Diego. Recent results of Mayer *et al.* (1994) have been published in the American Journal of Botany (81: 1288-1299).

**Animal Species**

**Comment:** A peer reviewer for the bay checkerspot account commented that the account reflects a solid understanding of general issues in population biology, presents a valuable synthesis of the *Euphydryas editha* literature, and provides an excellent basis for undertaking the recovery of the butterfly. The reviewer stated that habitat restoration at Tulare Hill, in the Santa Teresa Hills, and in the "Kalana" Hills (western foothills of the central Santa Clara Valley) seems feasible and valuable. The reviewer also suggested that reintroduction efforts might be delayed to gain valuable information about the bay checkerspot's natural capacity for recolonization.

**Response:** Comments noted. A controlled experiment to look for natural recolonization might be acceptable at a subset of sites, but the Service believes that some reintroductions can proceed concurrently at other sites without sacrificing scientific knowledge, to minimize risk to the species.

**Comment:** One commenter asked whether butterflies would be taken from Edgewood Natural Preserve to repopulate Jasper Ridge, and expressed concern that this might weaken the Edgewood population.

**Response:** Edgewood Natural Preserve would be a logical source of individuals for reintroduction to Jasper Ridge, if necessary; however, removal of individuals from Edgewood Natural Preserve would only be pursued if there was minimal risk to the crucial Edgewood population.

**Comment:** Reintroduction of the bay checkerspot to San Bruno Mountain should be a goal of the plan.

**Response:** This goal has been clarified in the plan. Present habitat conditions on San Bruno Mountain may not allow survival of bay checkerspots, therefore some prior reconnaissance and restoration work is included.

**Comment:** The area on Jasper Ridge that supported the bay checkerspot was never greater than about 25 acres, not 760 acres, as in the discussion about proposed critical habitat at the beginning of section O.5.

**Response:** Not all of the vegetation in a proposed critical habitat area need be suitable habitat for the species. The purpose of critical habitat designation is to highlight easily identifiable boundaries that encompass one or more areas of suitable habitat. The subsequent discussion of the Jasper Ridge Biological Preserve in the same section correctly identifies the area of serpentine grassland habitat as less than 10 hectares (25 acres).

**Comment:** One commenter stated that, in the past, he has reared bay checkerspot butterflies with low pre-diapause larval mortality. If he could do more experimental work, he might be able to provide a protocol for successful rearing.

**Response:** This report is encouraging because it suggests that difficulties in rearing large numbers of butterflies for reintroduction efforts are surmountable. To our knowledge this work has not yet been published or duplicated, so no substantive changes have been made to the portions of the recovery plan that call for additional research in this area.