II. BIOLOGY OF COVERED SPECIES

A. Federally Listed Plant Species

1. *CASTILLEJA CAMPESTRIS* SSP. *SUCCULENTA* (FLESHY OWL'S-CLOVER)

a. Description and Taxonomy

Taxonomy.—Owl's-clovers are members of the figwort or snapdragon family (Scrophulariaceae). Hoover (1936*a*) first named fleshy owl's-clover, giving it the scientific name *Orthocarpus campestris* var. *succulentus.* The type specimen had been collected at Ryer, in Merced County. Hoover (1968) raised fleshy owl's-clover to the rank of species and assigned it the name *Orthocarpus succulentus*. Chuang and Heckard (1991) reconsidered the taxonomy of *Orthocarpus* and related genera. Based on floral morphology, seed morphology, and chromosome number, they transferred many species into the genus *Castilleja*. Furthermore, they determined that the appropriate rank for fleshy owl's-clover was as a subspecies of field owl's-clover (*Castilleja campestris*). Thus, the scientific name currently assigned to fleshy owl's-clover is *Castilleja campestris* ssp. *succulenta*, whereas field owl's-clover is *Castilleja campestris* ssp. *campestris* (Chuang and Heckard 1991). Another common name for fleshy owl's-clover is succulent owl's-clover (Skinner and Pavlik 1994).

Description and Identification.— *Castilleja campestris* ssp. *succulenta* (**Figure II-1**) has rather intricate flowers, with the corolla consisting of two lips. The flower has four sepals that are fused at the base, creating the calyx tube. Together, all the flowers plus the bracts comprise the inflorescence. The plant has erect or decumbent stems up to 30 centimeters (11.8 inches) long. The stems are usually unbranched and without hairs. The leaves at the base of the stem are small and scale-like, whereas those on the upper stem are 1.5 to 4 centimeters (0.6 to 1.6 inches) long, lance-shaped, not lobed, thick, fleshy, and easily broken. The bracts are green, similar to but shorter than the upper leaves, and longer than the flowers. Overall, the inflorescence may occupy as much as half of the plant's height and be 2 to 3 centimeters (0.8 to 1.2 inches) wide. *Castilleja campestris* ssp. *succulenta* has a diploid chromosome number of 24 (Chuang and Heckard 1993).

The brittle leaves are a key characteristic for identification of *Castilleja campestris* ssp. *succulenta*. The most similar taxon is *C. campestris* ssp. *campestris*. *Castilleja campestris* ssp. *campestris* has branched stems; thin, flexible, non-fleshy leaves; larger, lighter yellow flowers; a stigma that protrudes

Figure II-1. Illustration of *Castilleja campestris*. Reprinted with permission from Abrams (1951), Illustrated Flora of the Pacific States: Washington, Oregon, and California, Vol. III. © Stanford University Press.

beyond the upper lip of the flower; a lower anther sac that is no more than one-third the size of the upper; and more rounded seeds. *Castilleja campestris* ssp. *campestris* occurs farther north than *C. campestris* ssp. *succulenta* (Hoover 1937, Hoover 1968, Heckard 1977, California Department of Fish and Game 1986). Other *Castilleja* species have lobed leaves and bracts, and the bracts are often colored.

b. Historical and Current Distribution

Historical Distribution.—Between 1937 and 1986, *Castilleja campestris* ssp. *succulenta* was reported from 33 localities (Hoover 1937, Hoover 1968, California Natural Diversity Data Base 2005), all in the Southern Sierra Foothills Vernal Pool Region (Keeler-Wolf *et al.* 1998). Sixteen of those occurrences, including the type locality, were in eastern Merced County. Six occurrences each were in Fresno and Madera Counties and five others were in Stanislaus County (California Natural Diversity Data Base 2003) (**Figure II-2**).

Current Distribution.—Through August 2005, the California Natural Diversity Data Base (2005) had catalogued 91 occurrences of *Castilleja campestris* ssp. *succulenta* (catalogued as succulent owl's clover). About one-third of these occurrences are records from Merced County, catalogued in association with rare plant and wildlife surveys of eastern Merced County grass and ranch lands conducted during 2001 by a team of consultants to the County and California Department of Fish and Game (Vollmar 2002).

Of the 91 total data base occurrences, 90 are presumed to be extant, lacking any evidence to the contrary. One occurrence in Fresno County is considered to be "possibly extirpated" (California Natural Diversity Data Base 2005) because the site had been disced when it was last visited in 1981. Another unreported (to the data base) site in Fresno County may also be extirpated (J. Stebbins *in litt.* 2000*a*). Currently, among the 91 reported occurrences, 70 percent are in Merced County, 12 percent are in Fresno County, 10 percent are in Madera County, 5 percent are in Stanislaus County, and 1 percent is in San Joaquin County (M. Trask *in litt.* 1993, EIP Associates 1994, C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2003). All but one of these occurrences are in the Southern Sierra Foothills Vernal Pool Region; one San Joaquin County site is in the Southeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al*. 1998).

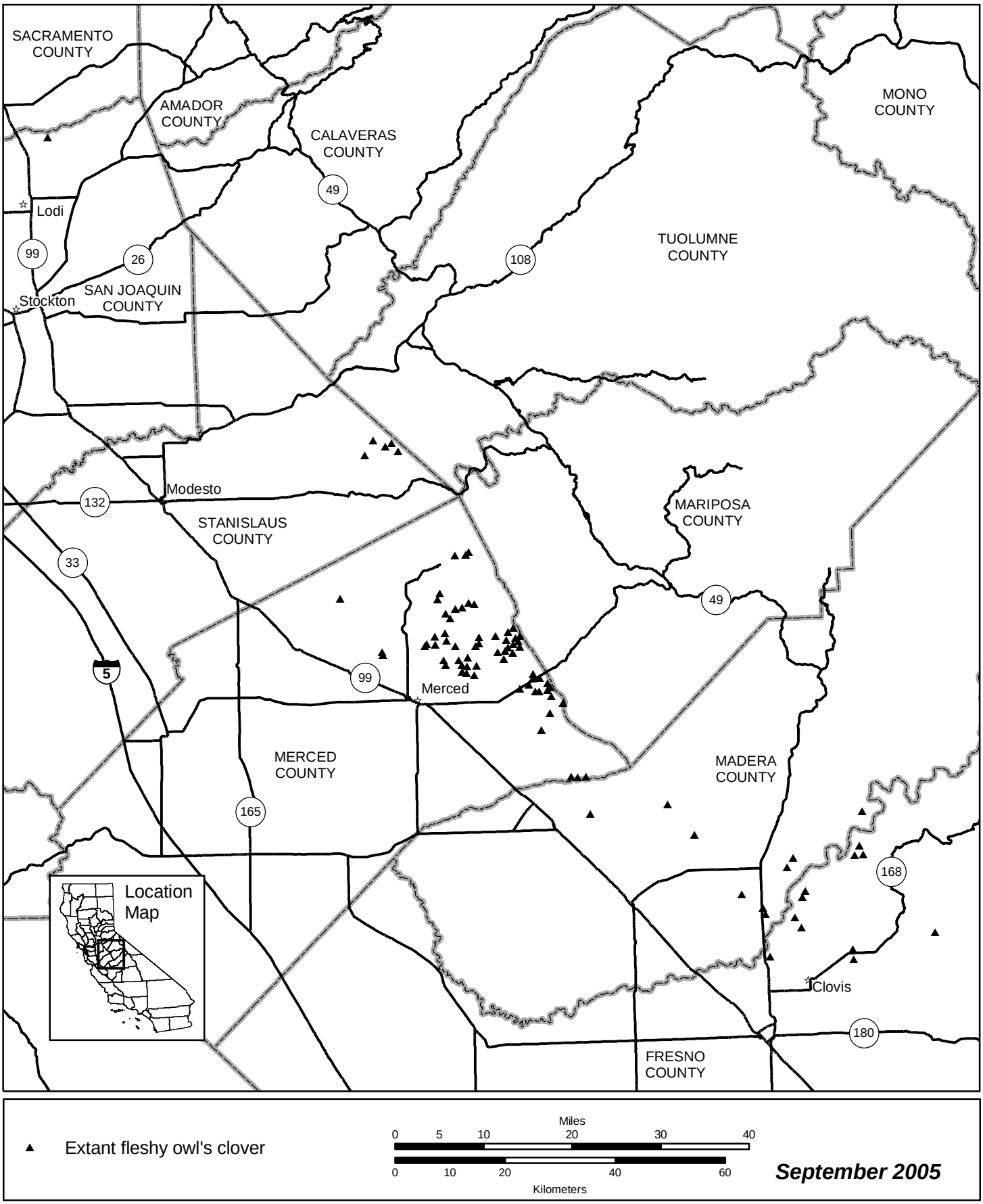

Figure II-2. Distribution of *Castilleja campestris* ssp. *succulenta* (fleshy owl's-clover).

This information, and especially the recent records, confirm that the primary area of concentration for *Castilleja campestris* ssp. *succulenta* is in eastern Merced County, especially just northeast of the City of Merced. In particular, many of the known occurrences are between La Paloma Road and Highway 140, east of Yosemite Lake. In addition to the proposed University of California campus area and related community, this area includes the Flying M Ranch and other ranch land. In addition, *C. campestris* ssp. *succulenta* was found in 296 vernal pools in the proposed campus and community area during recent surveys of 34 percent of that area (EIP Associates 1999). A later study of vernal pool habitat in the campus lands area, using a different reporting format that is not directly comparable, nevertheless also found *C. campestris* ssp. *succulenta* at significant levels (3 to 6 percent of the habitat area) (Jones and Stokes 2003). Moreover, Vollmar (2002) concluded that this listed plant is likely to be found throughout much of the range land portion of the eastern Merced County survey area, wherever there are better-developed, dense, interconnected vernal pools, and that this study area clearly represents a very important geographical region for the conservation of *C. campestris* ssp. *succulenta*.

Other occurrences in Merced County are somewhat farther to the north and south. In addition, a secondary area of concentration is located in southern Madera County and northern Fresno County, from just west of Highway 41 east to Academy and north to Miller's Corner, with 17 occurrences. Also, two smaller areas of concentration, which include five occurrences each but contain large numbers of plants, are near Cooperstown in Stanislaus County and the "tabletop" mountains near Millerton Lake in Fresno and Madera Counties. Other more scattered occurrences include two at Castle Airport northwest of Merced, one near Wildcat Mountain in Fresno County, and one in San Joaquin County. Significant areas of suitable habitat remain unsurveyed, particularly in northern Merced County (EIP Associates 1999) and between the northern Stanislaus County and northern San Joaquin County sites (J. Stebbins *in litt.* 2000*b*). Thus, additional occurrences are likely to be found if further surveys similar to those reported by Vollmar (2002) are conducted.

c. Life History and Habitat

Reproduction and Demography.—*Castilleja campestris* ssp. *succulenta* is an annual plant. As with many related species, it is a hemiparasite, meaning that it obtains water and nutrients by forming root grafts with other host plants but manufactures its own food through photosynthesis (Chuang and Heckard 1991). Research on hemiparasitism has focused on related species of *Castilleja*, but not specifically on *C. campestris* ssp. *succulenta*. Many different plants can serve as hosts for a single species or even a single individual of *Castilleja.* Seeds of *Castilleja* species do not require the presence of a host to germinate, and form

root connections only after reaching the seedling stage. Some seedlings can survive to maturity without attaching to a host's roots, but in general reproduction is enhanced by root connections (Atsatt and Strong 1970).

The conditions necessary for germination of *Castilleja campestris* ssp. *succulenta* seeds have not been studied, nor has the timing of seed germination been documented. Flowering occurs in April and May (Skinner and Pavlik 1994). The importance of pollinating insects is not known for certain. Some aspects of *C. campestris* ssp. *succulenta* biology suggest that it may be self-pollinating (Heckard 1977), but many related taxa of *Castilleja* are pollinated by generalist bees (Superfamily Apoidea) (Chuang and Heckard 1991).

Among close relatives that do not require insect pollinators, flower structure and timing of stigma receptivity maximize the chances for self-fertilization and seed set. Even so, insects may transfer some pollen among individual plants and species occurring in the same area. Self-pollinating species of *Castilleja* typically occur as widely scattered individuals, rather than in dense colonies (Atsatt 1970). *Castilleja campestris* ssp. *succulenta* follows this pattern in part, often occurring in many pools within a complex but with fewer than 100 plants per pool. However, *C. campestris* ssp. *succulenta* also may occur in large populations within a single pool (California Natural Diversity Data Base 2003). Little is known about the demography of *C. campestris* ssp. *succulenta*, although population size can fluctuate greatly from year to year. In the few populations where population size was reported for more than 1 year, fluctuations up to two orders of magnitude were noted (California Natural Diversity Data Base 2003).

Habitat and Community Associations.—*Castilleja campestris* ssp. *succulenta* occurs in Northern Claypan and Northern Hardpan vernal pools (Sawyer and Keeler-Wolf 1995) within annual grassland communities (California Natural Diversity Data Base 2003). The plant is known from both small and large pools (EIP Associates 1999, J. Stebbins *in litt.* 2000*a*). Although not all pools occupied by this taxon have been studied in detail, Stebbins *et al.* (1995) collected data on six occupied pools in Fresno and Madera Counties. Some were typical "bowl-like" pools, whereas others were more similar to swales. Approximate pool area ranged from 0.03 to 0.65 hectare (0.07 to 1.61 acres), depth from 30 to 38 centimeters (11.8 to 15.0 inches), and pH of the soil underlying the pools from 5.00 to 6.24 (Stebbins *et al.* 1995). This subspecies has been reported from pools with both long and short inundation periods (EIP Associates 1999) and from both shallow and "abnormally deep" vernal pools, but approximate depth of these pools was not given (California Natural Diversity Data Base 2003).

The soil types have not been determined for all of the sites where *Castilleja campestris* ssp. *succulenta* occurs. At the one site in the Southeastern Sacramento

Valley Vernal Pool Region, the soil is San Joaquin sandy loam. Soil series supporting *C. campestris* ssp. *succulenta* in the Southern Sierra Foothills Vernal Pool Region include Amador, Anderson, Corning, Fallbrook, Hideaway, Keyes, Pentz, Ramona, Redding, San Joaquin, Vista, and Yokohl, as well as the Pollasky-Montpellier complex. Soil textures at those sites range from extremely stony loam to loamy clay. In the proposed University of California-Merced campus and community area, 81.4 percent of the individual pools where this taxon was found were on Redding gravelly loam, 9.5 percent were on Corning gravelly sandy loam, 6.4 percent were on Corning gravelly loam, 1.7 percent were on Keyes gravelly loam, 0.7 percent were on Keyes gravelly clay loam, and 0.3 percent were on Pentz loam (EIP Associates 1999).

Populations of *Castilleja campestris* ssp. *succulenta* have been reported from elevations of 24 meters (80 feet) at the San Joaquin County site to 700 meters (2,300 feet) at Kennedy Table in Madera County (California Natural Diversity Data Base 2003). Plants most commonly reported as occurring with *C. campestris* ssp. *succulenta* are *Lasthenia fremontii* (Fremont's goldfields) (EIP Associates 1999), *Downingia* spp. (downingia), *Mimulus tricolor* (three-colored monkey-flower), *Plagiobothrys stipitatus* (vernal pool popcorn flower), and *Eryngium* spp. (coyote-thistle) (California Natural Diversity Data Base 2005). Other plants featured in this recovery plan that have been reported growing with *C. campestris* ssp. *succulenta* are: *Neostapfia colusana*, *Orcuttia inaequalis*, *O. pilosa*, *Gratiola heterosepala* (EIP Associates 1999, California Natural Diversity Data Base 2005), and *Eryngium spinosepalum* (EIP Associates 1994).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Castilleja campestris* ssp. *succulenta* are described below.

One significant specific threat is the proposed construction of the new University of California campus in Merced County. This project, plus associated residential development and access roads, are threats to the primary and relatively extensive population in that area. Of the 12 occurrences recorded in the California Natural Diversity Data Base on the proposed campus and associated community, 4 are in the area that is expected to be developed within the next 15 years; these 4 occurrences include 226 of the 296 occupied pools (76 percent) in the University planning area (EIP Associates 1999). Additional urban developments that threaten many other known occurrences include planned housing subdivisions in Fresno, Madera, and San Joaquin Counties; a freeway expansion in Madera

County; and a proposed landfill in Fresno County (U.S. Fish and Wildlife Service 1997*a*, J. Stebbins *in litt.* 2000*b*, California Natural Diversity Data Base 2003).

Exclusion of grazing from sites that have been grazed historically may increase the threat of competition with nonnative plants. About two-thirds of the reported occurrences of the species, including those at the University of California-Merced site, were subject to cattle grazing when first discovered (EIP Associates 1999, California Natural Diversity Data Base 2003). Grazing should be monitored, and adjusted as needed, to maintain and enhance the species. Grazing may not be appropriate for all populations. Consideration of the possible negative effects to *Castilleja campestris* ssp. *succulenta* should be given before grazing is introduced into a population that has not been previously grazed.

Threats due to alterations in natural hydrology include the Merced County Stream Channel Project proposed by the U.S. Army Corps of Engineers (U.S. Fish and Wildlife Service 1997*a*) and proposed enlargement of Burns Reservoir in Merced County (California Natural Diversity Data Base 2003), which collectively threaten seven occurrences of *Castilleja campestris* ssp. *succulenta*. Expansion of agricultural operations threatens three occurrences in Fresno and Madera Counties that are surrounded by orchards, vineyards, or citrus groves (California Natural Diversity Data Base 2003). A proposed gravel mine threatens one occurrence of *C. campestris* ssp. *succulenta* in Fresno County. Two other occurrences, at the former Castle Air Force Base in Merced County, are threatened by excavation to remove soil that was contaminated by lead from skeet shooting (California Natural Diversity Data Base 2003).

Threats posed by small population size may also be a significant continuing factor because small size makes populations more vulnerable to extirpation from chance events. Among the 24 populations of *Castilleja campestris* ssp. *succulenta* for which size estimates have been documented, 10 consisted of fewer than 100 plants each at their peak size (J. Stebbins *in litt.* 2000*b*, California Natural Diversity Data Base 2003).

e. Conservation Efforts

We listed *Castilleja campestris* ssp. *succulenta* as threatened on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). This taxon has been State-listed as endangered since 1979 (California Department of Fish and Game 1991). The California Native Plant Society considered it to be rare and endangered 5 years earlier (Powell 1974) and still includes *C. campestris* ssp. *succulenta* on its List 1B, noting that it is "endangered in a portion of its range" (California Native Plant Society 2003). In 2005, critical habitat was designated for *C. campestris* ssp. *succulenta* and several other vernal pool species in *Final Designation of Critical*

Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule (U.S. Fish and Wildlife Service 2005).

Three populations of *Castilleja campestris* ssp. *succulenta* fall primarily within designated reserves, on two "tabletop" mountains near Millerton Lake in Fresno County. The Sierra Foothill Conservancy's Big Table Mountain Preserve includes all of one population. The second population is shared between the preserve and the adjacent U.S. Bureau of Land Management property. The third population is within the California Department of Fish and Game's Big Table Mountain Preserve. A cooperative group consisting of the California Department of Fish and Game, California Department of Parks and Recreation, Sierra Foothill Conservancy, U.S. Bureau of Land Management, and U.S. Bureau of Reclamation is developing a management and monitoring plan for Big Table Mountain. Initial efforts include a study on grazing as a means to control nonnative grasses while comparing population trends of threatened and endangered species in grazed and ungrazed portions of the tableland (M. Griggs *in litt*. 2000, J. Darren, BLM, *in litt.*, 2005).

A fourth population is found on a nearby tabletop, occurring partly on U.S. Bureau of Land Management land and partly on privately-owned land. Previously the site was seriously overgrazed, leading the U.S. Bureau of Land Management to erect fences to exclude cattle from the tabletop, with variable success (A. Franklin *in litt.* 1993). The management and monitoring plan for the other nearby tabletop vernal pools could be easily modified to include this fourth population.

At least seven occurrences of *Castilleja campestris* ssp. *succulenta* on the Flying M Ranch in Merced County are protected from development by a conservation easement negotiated between the landowner and The Nature Conservancy (U.S. Fish and Wildlife Service 1997*a*). Several other occurrences are in public ownership but are not necessarily protected from development, nor are they managed for the benefit of this or other vernal pool taxa. These occurrences include (1) the extensive populations on the proposed University of California campus in Merced County, (2) a large population on property acquired by the California Department of Transportation for mitigation purposes in Madera County (Stebbins *et al.* 1995, California Natural Diversity Data Base 2003), (3) two small populations on Castle Airport, formerly Castle Air Force Base, in Merced County (California Natural Diversity Data Base 2003), (4) a small population on U.S. Bureau of Reclamation property that is managed by the

Madera Irrigation District (Stebbins *et al.* 1995, California Natural Diversity Data Base 2003), and (5) the small population in San Joaquin County that is on land used for educational purposes by the University of California Cooperative Extension (California Natural Diversity Data Base 2003).

2. *CHAMAESYCE HOOVERI* (HOOVER'S SPURGE)

a. Description and Taxonomy

Taxonomy.—Hoover's spurge is a member of the spurge family (Euphorbiaceae). This plant was originally named *Euphorbia hooveri*, based on a specimen collected by Hoover in Yettem, Tulare County (Wheeler 1940). At that time, the genus *Euphorbia* was viewed as comprising several subgenera, including *Chamaesyce* and *Euphorbia*. Webster (1975) subsequently elevated the subgenus *Chamaesyce* to the rank of genus based on growth patterns and physiology. The currently accepted scientific name, *Chamaesyce hooveri,* was validated when Koutnik (1985) published the new combination.

Several other species of *Chamaesyce* have ranges similar to that of *Chamaesyce hooveri* and may occur in the same habitats. *Chamaesyce ocellata* ssp. *ocellata* (yerba golondrina) is yellowish-green, has untoothed leaves, and lacks appendages on the glands. *Chamaesyce ocellata* ssp. *rattanii* (Stony Creek spurge) has hairy stems and leaves and the gland appendages are entire. *Chamaesyce serpyllifolia* (thyme-leaved spurge) also has entire appendages and further differs from *C. hooveri* in microscopic characters of the female flower (Wheeler 1941, Munz and Keck 1959, Koutnik 1993).

Description and Identification.—*Chamaesyce hooveri* (**Figure II-3**) trails along the ground, forming gray-green mats 5 to 100 centimeters (2.0 to 39.4 inches) in diameter (Broyles 1987, Stone *et al.* 1988). The stems are hairless and contain milky sap. The tiny (2 to 5 millimeter [0.08 to 0.20 inch]) leaves are opposite, rounded to kidney-shaped, with an asymmetric base and a toothed margin. In the genus *Chamaesyce*, the structures that appear to be flowers actually are groups of flowers; each group is referred to as a cyathium. The cyathium in *C. hooveri* consists of a tiny, cup-like structure 2 millimeters (0.08 inch) in diameter containing five clusters of male flowers and a single female flower. None of the flowers have petals, but instead have white appendages on the edge of the cup that resemble petals. Each appendage is divided into from three to five finger-like projections about 1 millimeter (0.04 inch) long. The appendages are attached to four reddish glands situated along the margin of the cup. The tiny, white seeds are contained in a spherical capsule 2 millimeters (0.08 inch) in

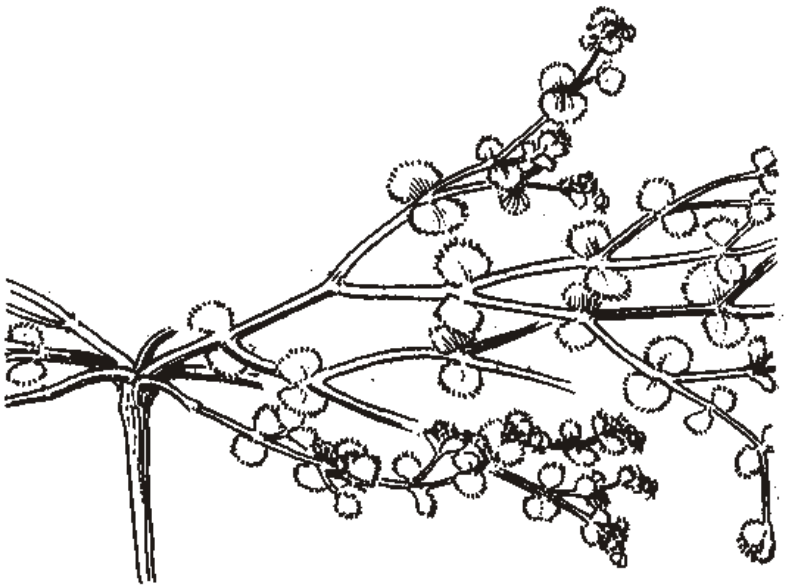

Figure II-3. Illustration of *Chamaesyce hooveri* (Hoover's spurge). Reprinted with permission from Abrams (1951), Illustrated Flora of the Pacific States: Washington, Oregon, and California, Vol. III. © Stanford University Press.

diameter on a stalk that hangs over the edge of the cup. One cyathium is located between each pair of leaves (Wheeler 1941, Munz and Keck 1959, Koutnik 1993). The chromosome number of this taxon has not been determined.

b. Historical and Current Distribution

Historical Distribution.—For decades, *Chamaesyce hooveri* was known from only three localities: near Yettem and Visalia in Tulare County, and near Vina in Tehama County. Collections were made from these three areas in the late 1930s and early 1940s (Wheeler 1941, Munz and Keck 1959, Stone *et al.* 1988). From 1974 through 1987, 21 additional occurrences of *C. hooveri* were reported. The majority of these (15) were in Tehama County. One to three occurrences were discovered during this period in each of Butte, Merced, Stanislaus, and Tulare Counties (Stone *et al.* 1988). The historical localities for this species were in the Northeastern Sacramento Valley, San Joaquin Valley, Solano-Colusa, and Southern Sierra Foothills Vernal Pool Regions (Keeler-Wolf *et al.* 1998) (**Figure II-4**).

Current Distribution.—Through August 2005, the California Natural Diversity Data Base (2005) listed 30 occurrences of *Chamaesyce hooveri*. In addition to these historical records, six occurrences were discovered in 1992 (three each in Glenn and Tulare Counties). Of the 30 California Natural Diversity Data Base (2003) occurrences, one each in Tehama and Tulare Counties are classified as extirpated; two others, in Butte and Tehama Counties, are "possibly extirpated" because this species was not observed for 2 consecutive years (Stone *et al.* 1988, California Natural Diversity Data Base 2003). Of the 26 occurrences presumed to be extant, only 3 have been observed within the past decade (California Natural Diversity Data Base 2003).

The main remaining area of concentration for *Chamaesyce hooveri* is within the Northeastern Sacramento Valley Vernal Pool Region. The Vina Plains of Tehama and Butte Counties contain 14 (53.8 percent) of the 26 known extant occurrences for *C. hooveri* (California Natural Diversity Data Base 2003) in an area of about 91 square kilometers (35 square miles; Stone *et al.* 1988). One other site in the same region is near Chico in Butte County. Seven of the extant occurrences are in the Southern Sierra Foothills Vernal Pool Region, including five in the Visalia-Yettem area of Tulare County and two in the Hickman-La Grange area of Stanislaus County. Three other occurrences are on the Sacramento National Wildlife Refuge in Glenn County, which is in the

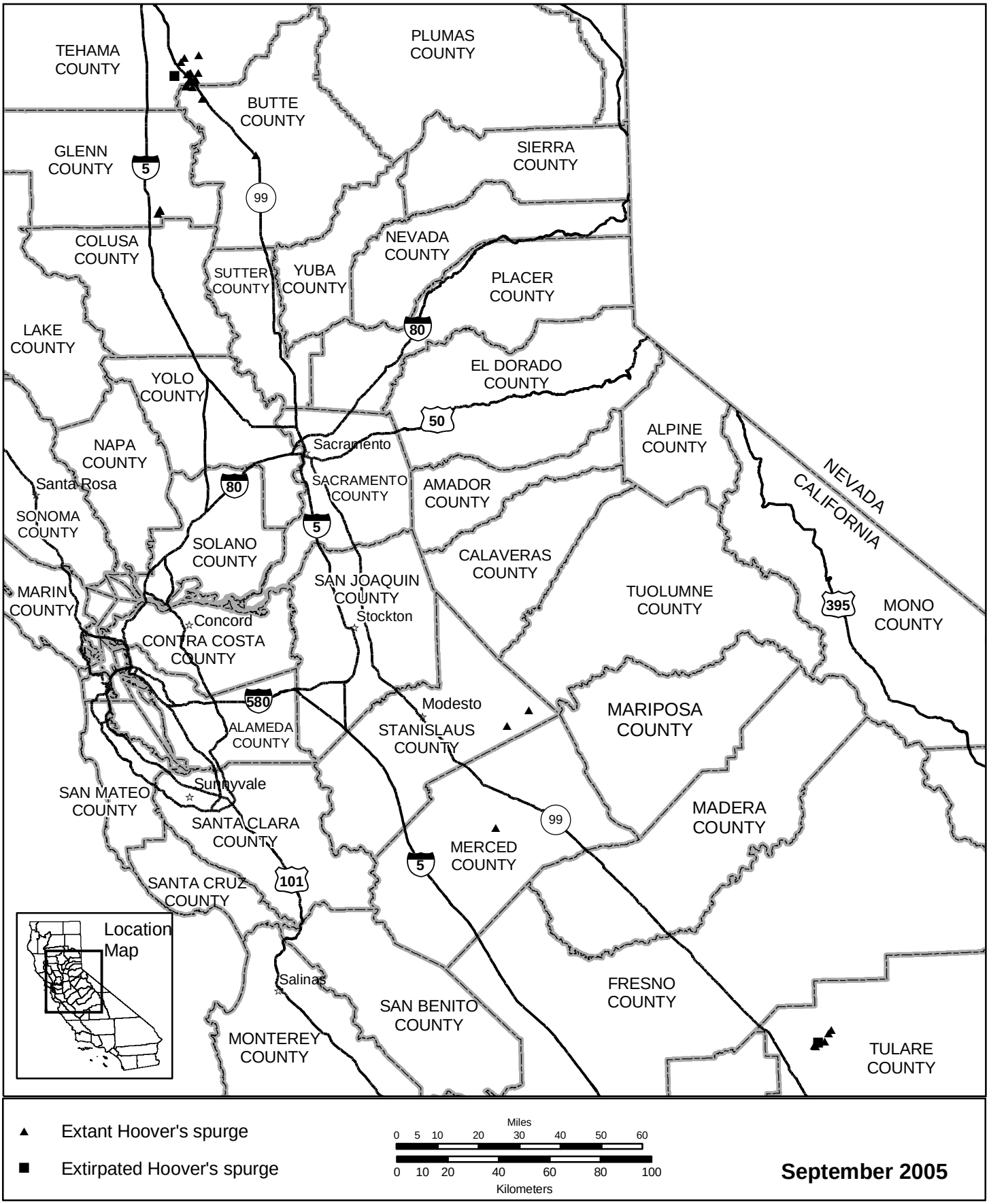

Figure II-4. Distribution of *Chamaesyce hooveri* (Hoover's spurge).

Solano-Colusa Vernal Pool Region. The one other extant occurrence is on the Bert Crane Ranch in Merced County, which is within the San Joaquin Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2003).

c. Life History and Habitat

Reproduction and Demography.—*Chamaesyce hooveri* is a summer annual, but few details of its life history are known. Seeds of *C. hooveri* germinate after water evaporates from the pools; the plants cannot grow in standing water (Alexander and Schlising 1997). The indeterminate growth pattern allows the plants to continue growing as long as sufficient moisture is available. The proportion of seedlings surviving to reproduction has not been documented; in years of below-normal rainfall, seedling survival was characterized as "low" (Stone *et al.* 1988). Phenology varies among years and among sites, even for those populations in close proximity (Stone *et al.* 1988). Populations in Merced and Tulare Counties typically flower from late May through July, whereas those farther north in Stanislaus County and the Sacramento Valley flower from mid-June into October (Alexander and Schlising 1997, J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2003). Seed set apparently begins soon after flowering. Seed production has not been quantified or studied in relation to environmental factors, but Stone *et al.* (1988) reported that large plants may produce several hundred seeds.

Demographic data suggest that seeds of *Chamaesyce hooveri* can remain dormant until the appropriate temperature and moisture conditions occur. This dormancy is evident from the fact that plants can be absent from a given pool for up to 4 years and then reappear in substantial numbers (Stone *et al.* 1988).

Beetles (order Coleoptera), flies (order Diptera), bees and wasps (order Hymenoptera), and butterflies and moths (order Lepidoptera) have been observed visiting the flowers of *Chamaesyce hooveri* and may potentially serve as pollinators (Stone *et al.* 1988, Alexander and Schlising 1997). Related species in the spurge family are pollinated by flies (Heywood 1978). Also, the glands on the cyathium produce nectar (Wheeler 1941), which is attractive to insects. Related species in the genus *Euphorbia* typically are cross-pollinated because the female flowers on each plant mature before the male (Heywood 1978), which may or may not be the case for *C. hooveri*.

Habitat and Community Associations.—*Chamaesyce hooveri* is restricted to vernal pools (Stone *et al.* 1988, Koutnik 1993, Skinner and Pavlik 1994). However, the plant appears to adapted to a wide variety of soils, which range in

texture from clay to sandy loam. Specific soil series from which it has been reported include Anita, Laniger, Lewis, Madera, Meikle, Riz, Tuscan, Whitney, and Willows.

Natural pools in which the plant occurs are primarily classified as Northern Hardpan and Northern Claypan vernal pools (Sawyer and Keeler-Wolf 1995). In the Northeastern Sacramento Valley Vernal Pool Region, occupied pools are generally on acidic soils over iron-silica cemented hardpan. Most pools supporting *Chamaesyce hooveri* in the San Joaquin Valley, Solano-Colusa, and Southern Sierra Foothills vernal pool regions are on neutral to saline-alkaline soils over lime-silica cemented hardpan or claypan (Broyles 1987, Stone *et al.* 1988, Sawyer and Keeler-Wolf 1995, California Natural Diversity Data Base 2003).

Vernal pools supporting *Chamaesyce hooveri* typically occur on alluvial fans or terraces of ancient rivers or streams, with a few on the rim of the Central Valley basin. In addition, *C. hooveri* has been reported from several pools that were formed artificially when small ponds were created in appropriate soil types (California Natural Diversity Data Base 2003).

The pools supporting this species vary in size from 0.19 to 243 hectares (0.47 to 600 acres), with a median area of 0.58 hectare (1.43 acres) (Stone *et al.* 1988). This species may occur along the margins or in the deepest portions of the dried pool-bed (Stone *et al.* 1988, Alexander and Schlising 1997). Deeper pools apparently provide better habitat for this species because the duration of inundation is longer and the deeper portions are nearly devoid of other vegetation, thus limiting competition from other plants (J. Stebbins *in litt.* 2000*a*, Stone *et al.* 1988).

Throughout its range, two of the most frequent associates of *Chamaesyce hooveri* are the rare vernal pool grasses *Tuctoria greenei* and *Orcuttia pilosa*. However, *Chamaesyce hooveri* does tend to grow in different portions of the pools than these grasses (Stone *et al.* 1988, Alexander and Schlising 1997). Other plants addressed in this recovery plan that grow with *Chamaesyce hooveri* are *Atriplex persistens*, *Eryngium spinosepalum*, *Neostapfia colusana*, *Orcuttia inaequalis*, *Astragalus tener* var. *ferrisiae*, and *Gratiola heterosepala* (Oswald and Silveira 1995, Alexander and Schlising 1997, California Natural Diversity Data Base 2005). In the Vina Plains, other common associates of *Chamaesyce hooveri* are *Marsilea vestita* (water shamrock), *Eryngium castrense* (common coyote-thistle), *Convolvulus arvensis* (bindweed), and *Amaranthus albus* (white tumbleweed) (Alexander and Schlising 1997). In Glenn, Merced, and Tulare Counties, *Cressa truxillensis* (alkali weed), *Distichlis spicata* (saltgrass), *Frankenia salina* (frankenia), *Grindelia camporum* (Great Valley gumplant), and other plants

tolerant of saline-alkali soils are typical associates of *Chamaesyce hooveri* (Stone *et al.* 1988, J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2005).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Chamaesyce hooveri* are described below.

Agricultural conversions (*i.e.,* from grasslands or pastures to croplands, or from one crop-type to another) are a continuing specific threat, particularly in Stanislaus County (Stone *et al.* 1988). Competition from invasive native and non-native plant species threatens nine of the extant occurrences, including eight in the Vina Plains and one on the Sacramento National Wildlife Refuge in Glenn County. Native competitors of *Chamaesyce hooveri* include *Eryngium* spp., *Malvella leprosa* (alkali mallow, a noxious weed according to Hill 1993), *Phyla nodiflora* (lippia), *Scirpus acutus* var. *occidentalis* (hard-stemmed tule), *Scirpus maritimus* (alkali bulrush), and *Xanthium strumarium* (cocklebur). Nonnative competitors include *Convolvulus arvensis* (a noxious weed according to Dempster 1993) and *Crypsis schoenoides* (swamp grass) (J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2003). On the Vina Plains Preserve (in 1995), the pools with *Chamaesyce hooveri* also had the highest frequency of *Convolvulus arvensis* (Alexander and Schlising 1997). Increasing dominance by these competitors may be associated with changes in hydrology and livestock grazing practices (Stone *et al.* 1988, Alexander and Schlising 1997, California Natural Diversity Data Base 2003).

Five of the remaining occurrences of *Chamaesyce hooveri* are subject to specific hydrologic threats; four of the five are in the San Joaquin Valley and the fifth is in the Vina Plains. Hydrology has been altered by (1) construction of levees and other water barriers and (2) runoff from adjacent agricultural operations, roads, and culverts. Such impacts result in some pools receiving insufficient water, while others remain flooded for too long to allow growth of *C. hooveri*. Although no occurrences have been completely extirpated due to hydrologic changes, the species has been eliminated from one or more individual pools at several sites and a number of the remaining populations appear to be in decline (Stone *et al.* 1988, Stebbins *et al.* 1995, California Natural Diversity Data Base 2003).

Some specific threats also are continuing due to inappropriate livestock grazing practices. While livestock generally do not forage on *Chamaesyce hooveri*, because it grows very close to the ground and contains a toxic, milky sap

(Wheeler 1941, Stone *et al.* 1988), cattle trampling has nevertheless been identified as seriously reducing *C. hooveri* populations at one site each in Butte and Stanislaus Counties (Stone *et al.* 1988); relatively high livestock stocking rates such as often prevail during summer months could similarly damage this plant's populations at other locations.

The threat posed by small population size may also be a significant continuing factor. At least 5 of the known occurrences of this plant total fewer than 100 individuals in years of most-favorable conditions (California Natural Diversity Data Base 2003). Two other occurrences with populations of only a few hundred individuals also may be similarly threatened. Such small populations are subject to extirpation from random events, including extrinsic factors such as weather and intrinsic factors such as genetic drift (Shaffer 1981, Menges 1991).

Another specific threat is the potential lack of pollinators. However, because the specific insects that pollinate *Chamaesyce hooveri* have not yet been identified, assessment of their status and providing them with protection, if necessary, cannot yet be undertaken. If essential pollinators are declining through habitat loss, *C. hooveri* may be declining in response. Another very localized threat to *C. hooveri* on certain public and private lands is direct trampling, particularly in areas that receive high controlled human usage or vandalism activity (U.S. Fish and Wildlife Service 1997*a*).

e. Conservation Efforts

Chamaesyce hooveri was listed as a threatened species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). *Chamaesyce hooveri* is not listed under the California Endangered Species Act (California Department of Fish and Game 1999). The California Native Plant Society included *C. hooveri* on its first list of rare plants (Powell 1974); currently, *C. hooveri* is on List 1B and is considered to be "endangered in a portion of its range" (California Native Plant Society 2001). In 2005, critical habitat was designated for *C. hooveri* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Ten occurrences of *Chamaesyce hooveri* are in preserves or on public land. The Vina Plains Preserve, managed by The Nature Conservancy, includes four of the extant occurrences and one presumed extirpated occurrence. The California Department of Fish and Game manages two of the extant Tulare County occurrences as part of the Stone Corral Ecological Reserve complex. Three of the extant occurrences are on the Sacramento National Wildlife Refuge (California

Natural Diversity Data Base 2003). The Sacramento National Wildlife Refuge populations have been monitored annually since 1992 (J. Silveira *in litt.* 2000). One additional occurrence of *C. hooveri* in Merced County is on private land (the Bert Crane Ranch) that is protected from development by a conservation easement (J. Silveira *in litt.* 2000).

We funded a status survey for *Chamaesyce hooveri* and other vernal pool plants in 1986 and 1987 (Stone *et al.* 1988), resulting in 10 new occurrences. We and the California Department of Fish and Game jointly funded an ecological study of the Vina Plains Preserve pools, which was conducted by faculty from California State University, Chico (Alexander and Schlising 1997). Independent surveys conducted by Joseph Silveira led to discovery of the Merced and Glenn county occurrences (J. Silveira *in litt.* 2000). Private landowners also have contributed to conservation of this species. One pool in Tehama County was fenced by the property owner in the late 1980s, to exclude livestock (Stone *et al.* 1988).

3. *ERYNGIUM CONSTANCEI* (LOCH LOMOND BUTTON-CELERY)

a. Description and Taxonomy

Taxonomy.—Loch Lomond button-celery, specifically known as *Eryngium constancei* (Sheikh 1983), is a member of the carrot family (Apiaceae). This species was only recently described and therefore has no history of name changes. The common name was derived from the type locality, Loch Lomond, which is in Lake County (Sheikh 1983). Other common names for this species are Loch Lomond coyote-thistle (Skinner and Pavlik 1994) and Constance's coyote-thistle (Smith *et al.* 1980).

Description and Identification.—Certain features are common to species of the genus *Eryngium*. Unlike most vernal pool plants, *Eryngium* species are biennial or perennial, with an overwintering rootstock. The plant parts are often spiny, hence the word "thistle" in the common names. The earliest leaves produced from the rootstock each year are long and tubular with crosswise partitions. Leaves produced later in the growing season typically have a narrow petiole and a broader blade, which is usually lobed. *Eryngium* plants also have leaves at both the base of the plant and on the stem; stem leaves are typically opposite, but the upper leaves may be alternate. The tiny flowers are clustered into spiny heads. Individual fruits are small, dry, often scaly, and composed of two one-seeded, indehiscent units which separate at maturity and function as seeds.

Eryngium constancei has slender, loosely branched stems 20 to 30 centimeters (7.9 to 11.8 inches) tall, which may be decumbent or upright. The entire plant is covered with downy hairs. The mature leaves are 11 to 16 centimeters (4.3 to 6.3 inches) long, with the petiole accounting for most of the length. The leaf blade is lance-shaped and may have a smooth, sharply toothed, or lobed margin. The bracts are narrow, spiny-margined, and shorter than the leaves. In this species, the rounded flower heads are only 3 to 5 millimeters (0.12 to 0.20 inch) in diameter; however, the stems supporting the flower heads may be as much as 8 centimeters (3.1 inches) long. Each flower head contains only five to seven tiny flowers. The petals are approximately 1 millimeter (0.04 inch) long and are white or tinged with purple. Fruits of this species are egg-shaped and approximately 2 millimeters (0.08 inch) long. The diploid chromosome number of *E. constancei* is 32 (Sheikh 1983, Constance 1993).

The downy hairs and sparsely-flowered heads of *Eryngium constancei* distinguish it from other *Eryngium* species. All other species in the genus are hairless and have more than 10 flowers per head (Sheikh 1983, Constance 1993).

b. Historical and Current Distribution

Historical Distribution.—For over 5 decades, this species was known only from Loch Lomond, where it was first collected in 1941 (Sheikh 1983). *Eryngium constancei* has always been restricted to the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-5**).

Current Distribution.—Three additional populations of *Eryngium constancei* were discovered during the late 1990s, bringing the total number of populations to four. Three of the *E. constancei* populations are in Lake County and the other is in Sonoma County; all are in the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998). In Lake County, the species grows at Loch Lomond, Dry Lake (California Natural Diversity Data Base 2003), and in an unnamed pool near Cobb (A. Howald *in litt.* 1995, J. Diaz-Haworth pers. comm. 2001). The Sonoma County occurrence is composed of two pools on Diamond Mountain (California Natural Diversity Data Base 2003).

The Sonoma County plants differ slightly from the description above in that the heads have more flowers and some individuals have stout stems, but their identity was verified by species expert Dr. Lincoln Constance (Hrusa and Buckmann 2000). The site near Cobb is not yet listed as an occurrence in the California Natural Diversity Data Base (2003), but Dr. Constance has confirmed the identity of the specimens (A. Howald *in litt.* 1995). Based on an analysis of soils, slope,

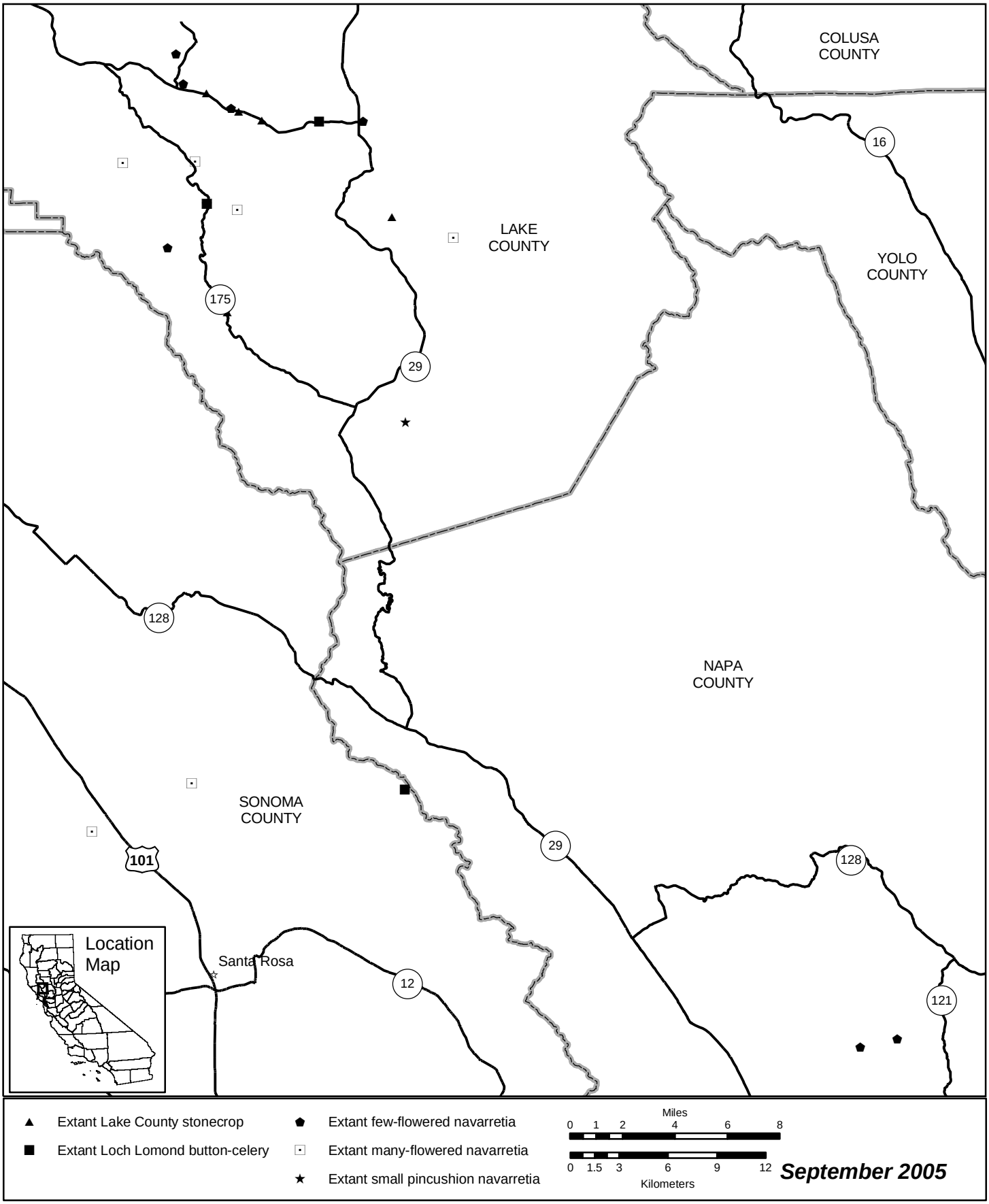

Figure II-5. Distribution of *Parvisedum leiocarpum* (Lake County stonecrop), *Eryngium constancei* (Loch Lomond button-celery, *Navarretia leucocephala* ssp. *pauciflora* (few-flowered navarretia), *Navarretia leucocephala* ssp. *plieantha* (many-flowered navarretia), and *Navarretia myersii* ssp. *deminuta* (pincushion navarretia).

elevation, and climate, only a very limited area in Lake and Napa Counties is considered to be suitable habitat for *Eryngium constancei* (Holland 2003).

c. Life History and Habitat

Reproduction and Demography.—*Eryngium constancei* flowers after the water evaporates from the pools, typically between June and August (California Department of Fish and Game 1985, 1994). Little else is known about the reproductive ecology or demography of this species. However, its life history may be quite similar to that of *E. vaseyi* (Vasey's coyote-thistle): producing a tuft of tubular leaves underwater from the perennial rootstock or from a newly-germinated seed in the late winter or early spring; developing broad terrestrial leaves later in the spring as the water evaporates; flowering in the summer; and developing fruits in July or August (Jepson 1922).

The demography of *Eryngium constancei* has not been studied. However, population size would not be expected to vary substantially among years because it is a perennial. The Dry Lake and Sonoma County populations numbered in the tens of thousands in both 1996 and 1997. However, in 1996, the Loch Lomond population was at least two orders of magnitude larger than in 1997 (California Natural Diversity Data Base 2003). The size of the fourth population has not been reported. Germination dates and conditions for *E. constancei* have not been determined, nor have pollinators or seed dispersal agents been identified.

Habitat and Community Associations.—Habitat information is available only for the three occurrences catalogued by the California Natural Diversity Data Base (2005). Loch Lomond is a small, intermittent lake with a surface area of about 3 hectares (7 acres) at maximum inundation (U.S. Fish and Wildlife Service 1985*b*). This wetland is classified as a Northern Volcanic Ashflow Vernal Pool (Sawyer and Keeler-Wolf 1995, California Natural Diversity Data Base 2003) and is on Collayomi-Aiken-Whispering complex soils. The lake is at an elevation of 853 meters (2,800 feet). The surrounding area is mountainous and supports a mixed forest dominated by *Pinus ponderosa* (ponderosa pine), *Quercus kelloggii* (black oak), *Pseudotsuga menziesii* (Douglas fir), and understory of *Arctostaphylos* spp. (manzanita) and *Ceanothus* spp. (California lilac) (California Department of Fish and Game 1994, K. Aasen *in litt.* 1995, California Natural Diversity Data Base 2003). *Eryngium constancei* occurred throughout the lakebed in 1994, but grew most densely towards the center, where it was one of the most abundant species. Other plants that were abundant in Loch Lomond that year included *Perideridia gairdneri* ssp. *gairdneri* (Gairdner's yampah), *Cuscuta howelliana* (Boggs Lake dodder), *Mentha pulegium* (pennyroyal), *Plagiobothrys stipitatus* (stalked popcornflower), *Plagiobothrys tener* (slender popcorn flower),

and a species of navarretia (California Department of Fish and Game 1994) that has been identified as an intergrade between *Navarretia leucocephala* ssp. *plieantha* and *N. leucocephala* ssp. *pauciflora* (A. Day *in litt.* 1997). *Eryngium aristulatum* (Jepson's button-celery), a close relative of *E. constancei*, also co-occurred in the lakebed (California Department of Fish and Game 1994).

On Diamond Mountain, the pools where *Eryngium constancei* grows are shallow and spring-fed (California Natural Diversity Data Base 2003); they are classified as Northern Basalt Flow Vernal Pools (Sawyer and Keeler-Wolf 1995, California Natural Diversity Data Base 2003). The surface area of the occupied pools and the soil type have not yet been determined. The surrounding plant community consists of *Quercus garryana* (Oregon oak), *Q. lobata* (valley oak), and *Pseudotsuga menziesii* (Hrusa and Buckmann 2000). The elevation of the site has been variously reported as 628 meters (2,060 feet) (California Natural Diversity Data Base 2003) or 685 meters (2,247 feet) (Hrusa and Buckmann 2000). *Eryngium constancei* was dominant in both pools in 1996 (B. Hunter *in litt.* 1996). Associated plant species that year included *Pogogyne douglasii* (Douglas' pogogyne), *Perideridia kelloggii* (Kellogg's yampah), *Perideridia howellii* (Howell's yampah), *Eleocharis* spp. (spikerush), *Madia elegans* ssp. *densifolia* (leafy common madia), and *Clarkia purpurea* (winecup clarkia) (California Natural Diversity Data Base 2003).

Less information is known about the Cobb and Dry Lake occurrences. The surface area of the Cobb pool is approximately 2 hectares (5 acres) (J. Diaz-Haworth pers. comm. 2001), but its elevation and soil type are not known. The endangered plant *Navarretia leucocephala* ssp. *pauciflora* is the only associate that has been reported at the Cobb pool (A. Howald *in litt.* 1995). The Dry Lake pool is at an elevation of 463 meters (1,520 feet) and is surrounded by *Quercus douglasii* (blue oak) woodland. In 1997, *Eryngium constancei* was the dominant species and was associated with unidentified rushes (*Juncus* spp.; California Natural Diversity Data Base 2003). Soils underlying Dry Lake are in the Sobrante-Guenoc-Hambright complex.

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Eryngium constancei* are described below.

Specific threats to two of the four populations are that at least one of the occupied pools at Diamond Mountain may be converted to a vineyard, and the owner of

Dry Lake has proposed excavating the pool for a reservoir (California Natural Diversity Data Base 2003). Changes in hydrology threaten three of the four occurrences. In addition, runoff from adjacent roads and swimming pools creates excess water flow, whereas drainage ditches, culverts, and diversion of a natural spring are reducing the flow of water to *Eryngium constancei* habitat (Hrusa and Buckmann 2000, California Natural Diversity Data Base 2005).

Larger-scale hydrological alterations, including commercial development and timber harvesting, are also occurring in all the watersheds where *Eryngium constancei* grows, thus posing added hydrological threats (U.S. Fish and Wildlife Service 1985*b*, 1986, 1993*b*; California Department of Fish and Game 1994; K. Aasen *in litt.* 1995; B. Hunter *in litt.* 1996; California Natural Diversity Data Base 2005).

The extremely restricted distribution of *Eryngium constancei* is an additional threat to this species. Although the individual populations of *E. constancei* are sufficiently large that intrinsic problems such as genetic drift are not a concern, other random events could cause the species to go extinct. Catastrophic weather events, climate change, or other unforeseen circumstances potentially could eliminate all of the populations, due the very limited distribution of this plant.

A more subtle threat that could cause decline of *Eryngium constancei* populations would be a lack of pollinators, if they are necessary for seed-set. Pollinating insects may require habitat outside of the vernal pools, which could be lost if it is not identified and targeted for protection. However, neither the importance nor status of pollinators have been identified at this time.

e. Conservation Efforts

In 1985, we declared *Eryngium constancei* to be endangered under emergency listing provisions of the Endangered Species Act (U.S. Fish and Wildlife Service 1985*b*). Following this emergency listing, we published a final rule on December 23, 1986 determining *E. constancei* to be an endangered species (U.S. Fish and Wildlife Service 1986). However, due to conservation efforts directed at Loch Lomond (see below), we later proposed to downlist the species to threatened status (U.S. Fish and Wildlife Service 1993); action on this proposal is still pending.

The California Fish and Game Commission listed *Eryngium constancei* as endangered in 1987 (California Department of Fish and Game 1991). The California Native Plant Society has considered the plant rare and endangered since 1980 (Smith *et al.* 1980). *Eryngium constancei* currently is on the

California Native Plant Society's List 1B, with the highest endangerment rating possible (California Native Plant Society 2001).

California's Wildlife Conservation Board and Public Works Board acquired Loch Lomond and a small adjacent buffer in 1988 to prevent its conversion to a recreational lake. The site is now known as the Loch Lomond Vernal Pool Ecological Reserve. In 1989, the California Department of Fish and Game, with financial assistance from us, fenced the perimeter of the lake to exclude off-road vehicles and other detrimental recreational use (U.S. Fish and Wildlife Service 1993, California Department of Fish and Game 1994). In 1994, the California Department of Fish and Game prepared a management plan for the reserve and obtained a baseline population estimate for *Eryngium constancei*. Periodic monitoring of the population and interpretive displays about the species are planned (California Department of Fish and Game 1994).

A local citizen with an interest in conservation bought the Cobb parcel where *Eryngium constancei* grows. She intends to protect the vernal pool and its associated species (J. Diaz-Haworth pers. comm. 2001, B. Flynn pers. comm. 2001). The California Department of Fish and Game has reviewed timber harvest plans and other land uses for areas adjacent to any of the populations and has provided recommendations on how to avoid impacts to *E. constancei* (*e.g.*, K. Aasen *in litt.* 1995, B. Hunter *in litt.* 1996, A. Buckmann *in litt.* 1998). In addition, their biologists conducted surveys for this species (U.S. Fish and Wildlife Service 1985b), and the agency is investigating ways to protect the Diamond Mountain occurrence (Hrusa and Buckmann 2000).

4. *LASTHENIA CONJUGENS* (CONTRA COSTA GOLDFIELDS)

a. Description and Taxonomy

Taxonomy.—Greene (1888) first described Contra Costa goldfields, naming this species *Lasthenia conjugens.* The type locality is Antioch, in Contra Costa County (Greene 1888). Hall (1914) later lumped Contra Costa goldfields with the common species Fremont's goldfields, which at that time was called *Baeria fremontii*. Ferris (1958) proposed the name *Baeria fremontii* var. *conjugens* to recognize the distinctiveness of Contra Costa goldfields. Finally, Ornduff (1966) restored Greene's original name and rank, returning this species to the genus *Lasthenia*. The two closest relatives of *Lasthenia conjugens* are *L. burkei* (Burke's goldfields) and *L. fremontii* (Fremont's goldfields).

Description and Identification.—The stems of *Lasthenia conjugens* (**Figure II-6**) are 10 to 30 centimeters (4 to 12 inches) tall, somewhat fleshy, and usually branched. The leaves are opposite and narrow; the lower leaves are entire, but stem leaves have one or two pairs of narrow lobes. The daisy-like flower heads are solitary. Both the disk and ray flowers are golden-yellow, and the ligules are 5 to 10 millimeters (0.20 to 0.39 inch) long. Each head has numerous disk flowers and 6 to 13 ray flowers. The club-shaped achenes are no more than 1.5 millimeters (0.06 inch) long and are shiny, olive-green, hairless, and lack a pappus (Greene 1888, Ornduff 1993*b*). *Lasthenia conjugens* has a diploid chromosome number of 12 (Ornduff 1966, Ornduff 1993*b*).

Whereas all other species of *Lasthenia* have either completely free phyllaries or phyllaries fused more than two-thirds of their length, *L. conjugens* has phyllaries fused from one-quarter to one-half their length. The free phyllaries and presence of a pappus distinguish both *L. burkei* and *L. fremontii* from *L. conjugens* (Ornduff *1969*, Ornduff 1979, Ornduff 1993*b*). *Blennosperma* species can be differentiated from *L. conjugens* by the alternate leaves, clustered (as opposed to solitary) flower heads, and paler yellow ligules of the former (Ornduff 1993*a,b*).

b. Historical and Current Distribution

Historical Distribution.—*Lasthenia conjugens* occurred historically in seven vernal pool regions: Central Coast, Lake-Napa, Livermore, Mendocino, Santa Barbara, Santa Rosa, and Solano-Colusa (**Figure II-7**) (Keeler-Wolf *et.al*. 1998). In addition, several historical occurrences in Contra Costa County are outside of the defined vernal pool regions (Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2003). Many collection sites from the late 19th and early 20th centuries are difficult to pinpoint because locality information on specimen labels often was vague. Ornduff (1966) reported collections from 13 sites in Alameda, Contra Costa, Mendocino, Napa, Santa Barbara, Santa Clara, and Solano Counties. Although he cited three specimens each from Contra Costa (including the type) and Santa Barbara Counties, Ornduff (1966, 1979) noted that the species was most common in Solano County. One additional site in Alameda County was documented in 1959 by G. Thomas Robbins, who collected a specimen (# 3963, housed at the Jepson Herbarium) on the “shore of San Francisco Bay” south of Russell.

Figure II-6. Photograph of *Lasthenia conjugens* (Contra Costa goldfields). (© John Game 1998; reprinted with permission).

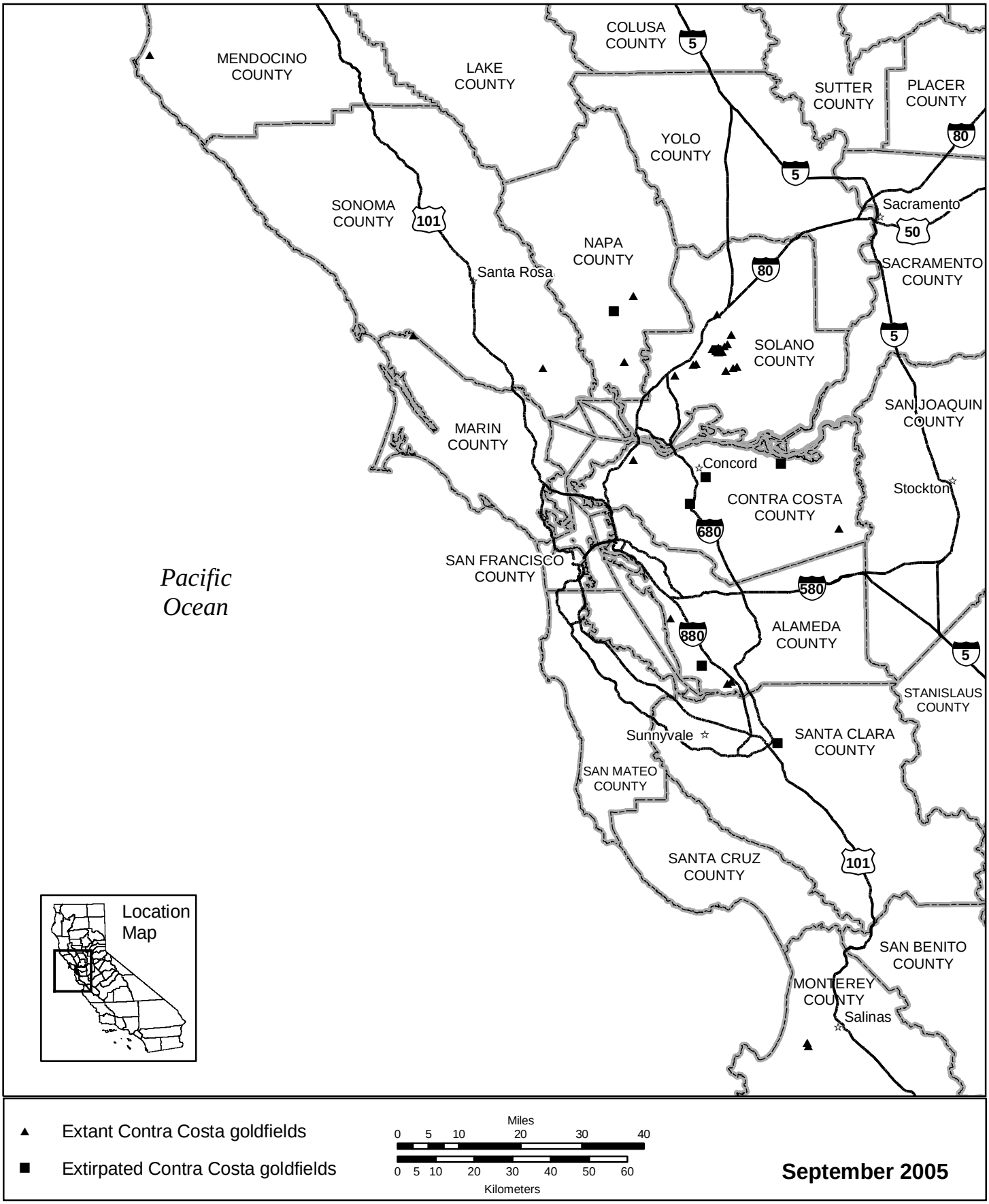

Figure II-7. Distribution of *Lasthenia conjugens* (Contra Costa goldfields).

Current Distribution.—Of the 32 occurrences of *Lasthenia conjugens* recorded between 1884 and 2003 that are currently (through August 2005) catalogued in the California Natural Diversity Data Base (2005), 22 are likely extant. Two additional populations exist at the former Fort Ord site that have not been reported to the California Natural Diversity Database (W. Collins, U.S. Army, pers. comm. 2005). Thus the total number of likely extant populations is 24. However, there is uncertainty due in part to the difficulty of relocating sites based on early vague site descriptions and also because this species may reappear on a site after several years, even if it is absent during a given survey. *Lasthenia conjugens* presumably remains in all of the vernal pool regions where it occurred historically, except for the Santa Barbara Vernal Pool Region. However, by far the greatest concentration of this species is in the Solano-Colusa Vernal Pool Region; the specific area east of Fairfield in Solano County contains 10 occurrences that are presumed extant, plus 1 that may be extirpated. Another extant occurrence is near Rodeo in Contra Costa County (California Natural Diversity Data Base 2005) which was captured within the Solano-Colusa Vernal Pool Region. Six occurrences are extant in the Central Coast Vernal Pool Region, including four at the former Fort Ord in Monterey County, one at San Francisco Bay National Wildlife Refuge, and one near Fremont, both in Alameda County (California Natural Diversity Data Base 2005). One occurrence is presumed to remain extant in the Mendocino Vernal Pool Region near Manchester in Mendocino County. In the Lake-Napa Vernal Pool Region, one occurrence is presumed to remain extant at Suscol Ridge in Napa County. Another Napa County site, Milliken Canyon, also in the Lake-Napa Vernal Pool Region contained only a single plant in 1987 and may or may not be extant (California Natural Diversity Data Base 2005). One recently discovered occurrence extends the range of *Lasthenia conjugens* to the northern part of Marin County near the boundary with Sonoma County (California Natural Diversity Data Base 2005). This location is not within the vernal pool regions covered by this plan.

c. Life History and Habitat

Little is known about this plant. However, germination, growth, reproduction, and demography are likely to be similar to *Lasthenia burkei*, a close relative that has been studied more intensively.

Reproduction and Demography.—As a vernal pool annual plant, seeds of *Lasthenia conjugens* would be expected to germinate in response to autumn rains, with the plants maturing in a single growing season, setting seed, and dying back during the summer. However, detailed research on the life cycle has not been conducted. Laboratory germination tests on the related species *L. burkei* (Rancho Santa Ana Botanical Garden unpublished data), indicated that germination occurs

rapidly in a single flush (peak germination date the same as first germination date), with relatively high germination rates (49 to 100 percent). *Lasthenia burkei* plants that establish in autumn under natural conditions may tolerate prolonged submergence but do not begin rapid stem growth until vernal pools and swales drain down during late winter or early spring (Ornduff 1969, Patterson *et al.* 1994).

Lasthenia conjugens flowers from March through June (Ornduff 1966, Ornduff 1979, Skinner and Pavlik 1994). The flowers are self-incompatible (Crawford and Ornduff 1989). Although *L. conjugens* has not been the subject of pollinator studies, observations suggest that the same insects visit all outcrossed species of *Lasthenia*, rather than concentrating on any particular species (Thorp 1976). Insect visitors to flowers of *Lasthenia* belong to five orders: Coleoptera, Diptera, Hemiptera (true bugs), Hymenoptera, and Lepidoptera (Thorp and Leong 1998). Most of these insects are generalist pollinators. All of the specialist pollinators of *Lasthenia* are solitary bees (family Andrenidae); these pollinators include two species in the subgenus *Diandrena* (*Andrena submoesta* and *A. puthua*) and five or six species in the subgenus *Hesperandrena* (*Andrena baeriae, A. duboisi, A. lativentris*, and two or three undescribed species) (Thorp and Leong 1998). The extent to which pollination of *L. conjugens* depends on host-specific bees or more generalist pollinators is currently unknown.

Seed dispersal mechanisms in *Lasthenia conjugens* are unknown. However, the lack of a pappus or even hairs on the achenes makes wind dispersal unlikely (Ornduff 1976). Seed longevity, survival rates, fecundity, and other demographic parameters have not been investigated. However, as with other vernal pool annuals, population sizes have been observed to vary by up to four orders of magnitude from year to year (California Natural Diversity Data Base 2003). Thus, this species most likely forms a persistent soil seed bank. Seeds of the related species *L. burkei* have been stored artificially for many years with little loss of viability (C. Patterson, pers. comm.). However, the maximum duration of viable seed in the soil is not known.

Habitat and Community Associations.—*Lasthenia conjugens* typically grows in vernal pools, swales, moist flats, and depressions within a grassland matrix (California Natural Diversity Data Base 2003). However, several historical collections were from populations growing in the saline-alkaline transition zone between vernal pools and tidal marshes on the eastern margin of the San Francisco Bay (P. Baye *in litt.* 2000*a*). The herbarium sheet for one of the San Francisco Bay specimens notes that the species also grew in evaporating ponds used to concentrate salt (P. Baye *in litt.* 2000*b*). The vernal pool types from which this species has been reported are Northern Basalt Flow, Northern Claypan, and Northern Volcanic Ashflow (Sawyer and Keeler-Wolf 1995). The

landforms and geologic formations for sites where *L. conjugens* occurs have not yet been determined. Most occurrences of *L. conjugens* are at elevations of 2 to 61 meters (6 to 200 feet), but the recently discovered Monterey County occurrences are at 122 meters (400 feet) and one Napa County occurrence is at 445 meters (1,460 feet) elevation (California Natural Diversity Data Base 2003).

The soil types have not yet been identified for most *Lasthenia conjugens* localities. However, soil series from which it is known are: Aiken, Antioch, Concepcion, Conejo, Crispin, Haire, Linne, Los Robles, Rincon, Solano, and San Ysidro, plus the Arnold-Santa Ynez, Hambright-rock outcrop, and Los Osos complexes. Soil textures, where known, are clays or loams. At least in Solano County and on the shores of San Francisco Bay, *L. conjugens* grows in alkaline or saline-alkaline sites (P. Baye *in litt.* 2000*a*, P. Baye *in litt.* 2000*b*, California Natural Diversity Data Base 2003).

Many plant species grow in association with *Lasthenia conjugens* in various parts of its range, but no comprehensive survey of associates has been undertaken. The two most commonly reported associates are *Lolium multiflorum* (Italian ryegrass) and *Plagiobothrys* spp. (popcorn flower). Other plant species that occur at several *Lasthenia conjugens* sites include *Cotula coronipifolia* (brass buttons), *Downingia pulchella* (valley downingia), *Eryngium aristulatum* (California eryngo), *Lasthenia glaberrima* (smooth goldfields), *Myosurus minimus* (common mousetail), and *Pleuropogon californicus* (California semaphore grass). Among the rare plants addressed in this recovery plan, those that co-occur with *Lasthenia conjugens* include *Astragalus tener* var. *tener* at two sites and *Navarretia leucocephala* ssp. *pauciflora* and *Legenere limosa* at one site each (California Natural Diversity Data Base 2003).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Lasthenia conjugens* are described below.

With the exception of Travis Air Force Base, the entire concentration area in Solano County is within the City of Fairfield's sphere of influence and subject to relatively intense development pressure under the City's general plan. Numerous construction projects, including residential development, landfill expansion, and drainage channels, are proposed and pose specific threats (U.S. Fish and Wildlife Service 1997*b*). Some projects, such as proposed highways, may disturb habitat on Travis Air Force Base as well as in the Fairfield area (U.S. Fish and Wildlife

Service 2002). Threats due to conversions to vineyards are also continuing. The largest Napa County occurrence of this plant, at Suscol Ridge (California Natural Diversity Data Base 2003), is imminently threatened by vineyard conversion; the site is already under a 25-year lease to a winery (P. Baye *in litt.* 2000*a*).

Competition from nonnative plants, particularly *Lolium multiflorum* (Italian ryegrass), threatens at least eight occurrences of *Lasthenia conjugens*, several of which are also targeted for development (California Natural Diversity Data Base 2003). Nonnative grasses such as *Lolium multiflorum* not only shade out short-statured plants like *Lasthenia conjugens*, but can also negatively impact vernal pool hydrology by decreasing inundation periods in pools (Marty 2004). In addition, encroachment by nonnative plants often follows surface-disturbing activities, such as discing, grading, filling, ditch construction, and off-road vehicle use, which can alter hydrology and microhabitat conditions. Such surface disturbances are visually apparent at nine sites occupied by *L. conjugens*, four of which do not yet have reported problems with nonnative species (California Natural Diversity Data Base 2003). Management strategies including grazing, mowing, and burning are vital to controlling these weed species. The California Natural Diversity Data Base (2003) also cites inappropriate livestock grazing practices as a threat to seven occurrences of *Lasthenia conjugens*. However, the removal of livestock grazing from at least one site in Contra Costa County has caused significant population declines in this species (J. Marty, pers. comm. 2004). Therefore, the complete elimination of grazing, as well as overgrazing, may have adverse impacts to the *Lasthenia conjugens* and other species in this plan.

e. Conservation Efforts

We listed *Lasthenia conjugens* as endangered on June 18, 1997 (U.S. Fish and Wildlife Service 1997*b*). This species does not currently have any State listing status. The California Native Plant Society has considered *L. conjugens* rare and endangered since the organization's first list was published (Powell 1974); *L. conjugens* currently is on List 1B, the highest endangerment rating possible (Skinner and Pavlik 1994). In 2005, critical habitat was designated for *L. conjugens* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Six occurrences of *Lasthenia conjugens* are on public lands: four at Fort Ord, and one each at San Francisco Bay National Wildlife Refuge and Travis Air Force Base. These lands are administered by the U.S. Bureau of Land Management, the

U.S. Fish and Wildlife Service, and the U.S. Air Force, respectively. All of the Fort Ord occurrences are on land within the Habitat Management Plan Habitat Reserve lands and will be conserved and managed in perpetuity (W. Collins *in litt*. 2005; U.S. Army Corps of Engineers 1997). The population at Travis Air Force Base, including over 20 acres of adjacent restored vernal pools, is protected as a special ecological preserve, with protective measures and appropriate management for the species provided in the Travis Air Force Base Land Management Plan.

Seasonal managed cattle grazing has been returned to two conservation sites supporting *Lasthenia conjugens*: 1) the Warm Springs Seasonal Wetland Unit of the Don Edwards San Francisco Bay National Wildlife Refuge in Alameda County, and 2) the State Route 4 Preserve managed by the Muir Heritage Land Trust in Contra Costa County. The *L. conjugens* population at the Warm Springs Unit has declined during the last 10 years due to many factors including competition by nonnative plant species. During this time period, grazing, which occurred intermittently at the Warm Springs Unit since the 1800s, has been excluded by the Refuge until a management plan could be developed. The decline in the *L. conjugens* population at the Warm Springs Unit cannot be attributed to a single factor, but most likely results from the complex interaction of several variables including current and historical land uses, the abiotic environment, and annual climatic variation. The increasing dominance of nonnative grasses, however, coincides with the suspension of livestock grazing, suggesting that the lack of a disturbance regime may be a primary factor in the degradation of habitat for *L. conjugens* at this site (U.S. Fish and Wildlife Service 2004). The population of *L. conjugens* at the State Route 4 Preserve, which was protected as part of compensation for the construction of the State Route 4 Gap Closure Project, has also declined in recent years. The decline may be due to a number of causes, including below normal precipitation and competition from nonnative species (Pardieck 2003). The site had been grazed heavily for many years resulting in stream channel erosion. Grazing was suspended in 2000 and the numbers of plants dropped sharply in 2001 and continued to decline the following year. Controlled grazing has been reintroduced to control the amount of seed and thatch produced by nonnative plants.

5. *LIMNANTHES FLOCCOSA* SSP. *CALIFORNICA* (BUTTE COUNTY MEADOWFOAM)

a. Description and Taxonomy

Taxonomy.—Before 1973, Butte County meadowfoam was not differentiated from the more widespread woolly meadowfoam (*Limnanthes floccosa* ssp. *floccosa*). Then, Arroyo (1973) determined that Butte County meadowfoam was a distinct taxon and gave it the scientific name *Limnanthes*

floccosa ssp. *californica*. The type locality is in Butte County between Chico and Oroville, near the intersection of State Highway 99 and Shippee Road (Arroyo 1973). An alternative common name, Shippee meadowfoam, is derived from the type locality (California Department of Fish and Game 1987*a*, Ornduff 1993*c*). *Limnanthes floccosa* ssp. *californica* is a member of the meadowfoam or false mermaid family (Limnanthaceae), which is a small family comprising only 2 genera and 10 species (Ornduff 1993*c*).

Description and Identification.— *Limnanthes floccosa* ssp. *californica* is a small annual with erect stems less than 25 centimeters (9.8 inches) tall. The stem and leaves are densely pubescent. The alternate leaves are pinnately compound, up to 8 centimeters (3.1 inches) long, and consist of 5 to 11 leaflets on a long petiole. The individual leaflets are approximately 1 centimeter (0.4 inch) long and vary from narrow to egg-shaped; their margins may be smooth, toothed, or lobed. A single flower arises in the axil of each upper leaf. The fragrant flowers are cup- or bowl-shaped and consist of 5 petals, 5 sepals, 5 pistils, and 10 stamens on a long flower stalk. The petals are 8 to 10 millimeters (0.31 to 0.39 inch) long, white with yellow veins, and have two rows of hairs at the base. The sepals are about the same length as the petals and are densely pubescent on both their inner and outer surfaces. Although the sepals are not fused, the dense hairs hold them together, preventing the flower from opening fully. The pistils are separate at the base, but the upper parts are fused. Each pistil is capable of producing a nutlet; the nutlets are egg-shaped, 3 to 4.5 millimeters (0.12 to 0.18 inch) long, and covered with cone-shaped tubercles. As the nutlets mature, the petals turn inward, and at maturity the entire flower, including the nutlets, falls off the plant as a unit. The diploid chromosome number for all *Limnanthes* species is 10 (Mason 1952, Arroyo 1973, McNeill and Brown 1979, Ornduff 1993*c*).

Limnanthes floccosa ssp. *californica* has longer sepals, petals, anthers and filaments than *L. floccosa* ssp. *floccosa*. Moreover, *L. floccosa* ssp. *floccosa* lacks rows of hairs at the petal base; the nutlet is covered with narrow, sharp-pointed tubercles; and the flowers do not open as widely as in *L. floccosa* ssp. *californica*. Among the other species that occur in the same region as *L. floccosa* ssp. *californica* are *L. alba* (white meadowfoam) and *L. douglasii* ssp. *rosea* (pink meadowfoam). *Limnanthes alba* has petals that are longer than the sepals at flowering. *Limnanthes douglasii* ssp. *rosea* has longer petals that are veined with pink and notched at the tip, and the petals turn outward as the nutlets mature.

b. Historical and Current Distribution

Historical Distribution.— *Limnanthes floccosa* ssp. *californica* has always been confined to the Northeastern Sacramento Valley Vernal Pool Region,

and in fact defines the extent of the region (Keeler-Wolf *et al.* 1998) (**Figure II-8**). This plant was first collected in 1914 at a site 13 kilometers (8 miles) north of Oroville (BioSystems Analysis, Inc. 1993), although it had not yet been recognized as a separate subspecies at that time. In her original description, Arroyo (1973) mentioned six collections, which ranged from 16 kilometers (10 miles) north of Chico south to the type locality and east to Table Mountain, which is north of Oroville. By 1988, 14 occurrences of *L. floccosa* ssp. *californica* had been reported (Arroyo 1973, McNeill and Brown 1979, Dole 1988, Jokerst 1989). Eight were within the city limits of Chico, four (including the type locality) were from the vicinity of Shippee, one was from Table Mountain, and one was from a site northeast of the town of Nord.

Current Distribution.—At least eight new occurrences of *Limnanthes floccosa* ssp. *californica* have been discovered since 1988, two occurrences have been combined in the California Natural Diversity Data Base, while one occurrence is now considered possibly extirpated, for a current total of 21 known natural occurrences (Jokerst 1989, Dole and Sun 1992, U.S. Fish and Wildlife Service 1992, California Natural Diversity Data Base 2005, C. Sellers *in litt.* 2001). The California Natural Diversity Data Base (2005) presumes that the Nord site maintains the most northerly extant occurrence of *L. floccosa* ssp. *californica*, a conclusion bolstered by the finding of 500 plants in this vicinity in 1999. The other occurrences are also presumed to be extant (California Natural Diversity Data Base 2005), although not all have been visited recently. Among the occurrences that have been revisited, many have been reduced in extent. Conversely, in several cases additional occupied habitat has been identified and expanded the boundaries of other occurrences (California Natural Diversity Data Base 2005, C. Sellers *in litt.* 2001).

Counting a recently recorded population and a formerly questionable population both in the Nord area, *Limnanthes floccosa* ssp. *californica* is thus now found in five natural centers of concentration: the Shippee Road area between Chico and Oroville; near the intersection of Highways 99 and 149, where there are five extant occurrences, five new occurrences on the Dove Ridge Conservation Bank south of Highway 149 not yet recorded in the California Natural Diversity Database, and three other centers of concentration within the City of Chico. The northern center is near the Chico Municipal Airport and consists of four occurrences, the northeastern center has a single occurrence and is known as Rancho Arroyo or Bidwell Ranch, and the southeastern center consists of two extant occurrences. In addition, a new location was found in 2005 on North Table Mountain east of the intersection of Highways 149 and 70.

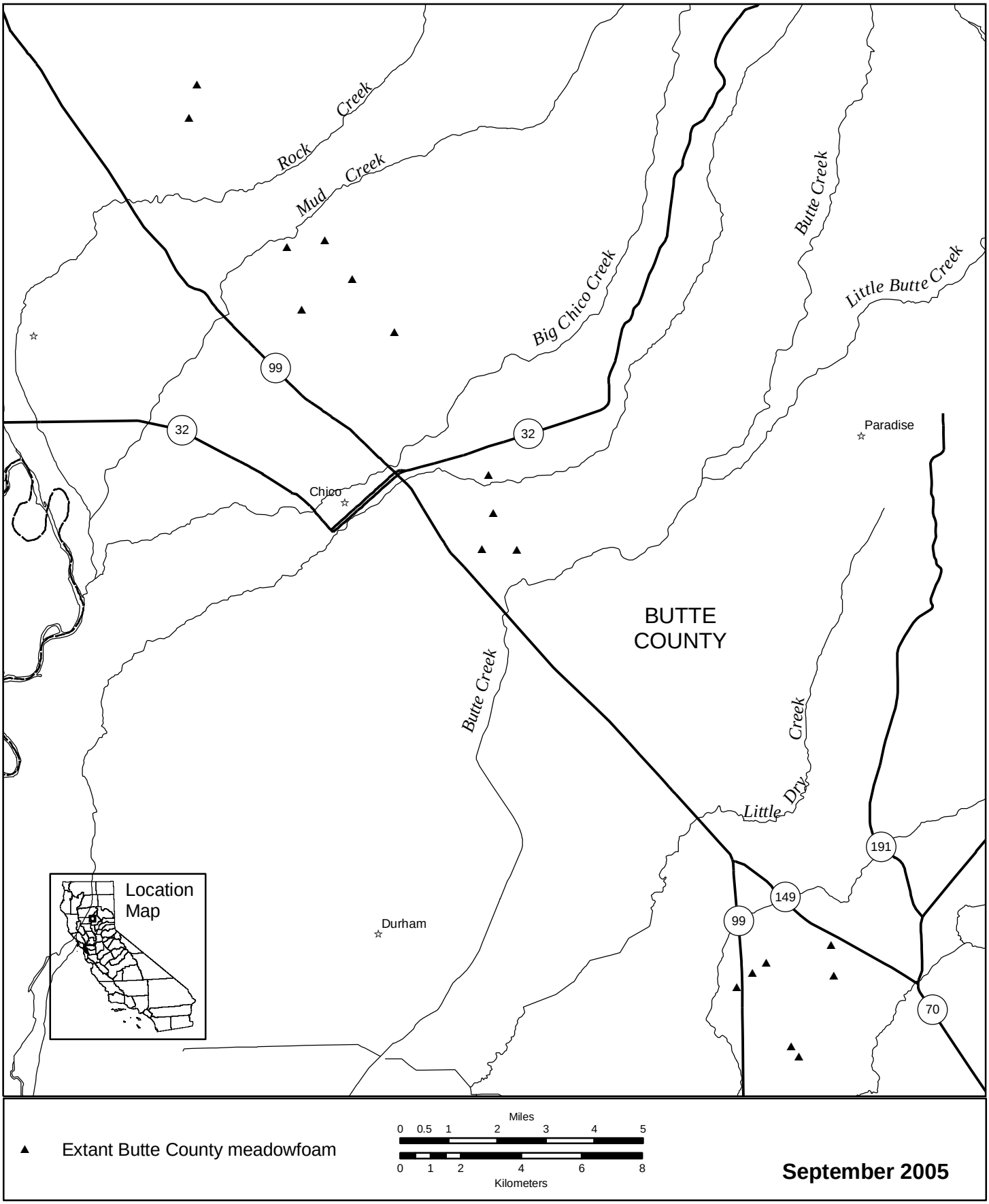

Figure II-8. Distribution of *Limnanthes floccosa* ssp. *californica* (Butte County meadowfoam).

In addition to the 21 naturally occurring populations, an experimental population of *Limnanthes floccosa* ssp. *californica* has been introduced on the Tuscan Preserve in northwestern Butte County (Kelley *et al.* 1994, C. Sellers *in litt.* 2001). The introduction site was just outside of the historical range of the taxon and thus marginally increased its range.

c. Life History and Habitat

Various species in the genus *Limnanthes* have been studied extensively because meadowfoam seeds produce an oil that is potentially valuable for many industrial and pharmaceutical uses. Research has been underway for at least two decades to identify the taxa with the most desirable features for commercial use and to cross-breed them (Pierce and Jain 1977, Brown and Jain 1979, Dole 1988). However, most of the research has been on taxa other than *L. floccosa* ssp. *californica*. Life history traits of related species are presented below when no information is available specifically for *L. floccosa* ssp. *californica*. However, it is recognized that only taxon-specific information should be used in making management decisions (Holland 1987).

Reproduction and Demography.—*Limnanthes floccosa* ssp. *californica* seeds germinate in the late fall after the rainy season begins. The earliest reported observation of seedlings is from November (M. Wacker *in litt*. 2005). Dole and Sun (1992) successfully germinated *L. floccosa* ssp. *californica* seeds under 12 hours of daylight at 15 degrees Celsius (59 degrees Fahrenheit), alternating with 12 hours of darkness at 10 degrees Celsius (50 degrees Fahrenheit). However, the optimum length of daylight and germination temperature under natural conditions have not been investigated.

Seed that does not germinate in the first year following its production may still be viable. In laboratory tests on the more common *Limnanthes floccosa* ssp. *floccosa*, two-thirds of the seed remained dormant even after exposure to favorable conditions, and some ungerminated seed remained in soil samples after 3 years (Ritland and Jain 1984). Seed dormancy also would explain population fluctuations of up to two orders of magnitude between years in *L. floccosa* ssp. *californica* (see below).

Limnanthes floccosa ssp. *californica* seedlings can apparently tolerate short periods of submergence (Jokerst 1989, Dole and Sun 1992). The seedlings develop into rosettes, which do not begin producing flowering stems immediately (McNeill and Brown 1979, Ritland and Jain 1984). *Limnanthes floccosa* ssp. *californica* typically begins flowering in February, reaches peak flowering in March, and may continue into April if conditions are suitable. Nutlets are

produced in March and April, and the plants die back by early May (Jokerst 1989, Dole and Sun 1992).

Limnanthes floccosa ssp. *californica* has floral adaptations that allow for cross-pollination by insects, but self-pollination mechanisms take over to ensure seed set if insect pollination is unsuccessful. Insects are attracted by the large flowers and production of nectar. The stamens begin shedding pollen 1 day before the stigma is receptive. Thus, during this period a given flower could not self-pollinate. If insects visit the flower during this period, they remove the pollen (Arroyo 1975). However, if pollen remains in the anthers when the stigma matures, gravity can carry it to the stigma, which is situated below the anthers (Arroyo 1973). The rate of self-pollination may vary among years or among sites, depending on the size of insect populations (Kalin 1971 *in* Arroyo 1973, Dole and Sun 1992). Arroyo (1975) estimated that approximately 26 percent of *L. floccosa* ssp. *californica* flowers were self-pollinated in the field during her study. However, when she excluded insects in a greenhouse study, overall seed set in *L. floccosa* ssp. *californica* was the same as that observed under natural conditions (Arroyo 1975). Cross-pollination by insects would allow opportunities for genetic recombination, unlike self-pollination.

Although most populations of *Limnanthes floccosa* ssp. *californica* have bisexual flowers, the population at the type locality contains a small percentage of male-sterile plants (Dole and Sun 1992). Pollination of male-sterile flowers can be achieved only by insects. Male sterility also has been observed in populations of two different subspecies of *L. douglasii* (Douglas' meadowfoam). In that species, male-sterile plants produced smaller flowers than were found on bisexual plants (Jain *et al.* 1978, Kesseli and Jain 1984). Moreover, in *L. douglasii* ssp. *rosea* the male-sterile flowers differed in color from the bisexual flowers, and male-sterile plants grew faster, flowered 2 to 3 days later, and produced more flowers per plant than did bisexual individuals. Seeds produced by male-sterile plants survived longer than those produced by bisexual flowers (Kesseli and Jain 1984).

The particular pollinators of *Limnanthes floccosa* ssp. *californica* have not been identified. Other meadowfoam species are pollinated by the native burrowing bees *Andrena limnanthis* and *Panurginus occidentalis* (Thorp and Leong 1998) and by honeybees (Kesseli and Jain 1984), beetles, flies, true bugs (order Hemiptera), butterflies, and moths (Mason 1952, Thorp and Leong 1998). Hybridization between *Limnanthes* taxa is limited in natural settings, due to differences in flower structure, phenology, and microhabitat (Arroyo 1973, Jain 1976*b*, Ritland and Jain 1984, Dole and Sun 1992). However, some hybrids between *L. floccosa* ssp. *californica* and *L. alba* have been produced under laboratory conditions (Dole and Sun 1992).

Nutlets of *Limnanthes floccosa* ssp. *californica* are apparently dispersed by water and can remain afloat for up to 3 days (Hauptli *et al.* 1978). The nutlets of *Limnanthes* taxa that grow in wet sites have larger tubercles than those adapted to dry sites. Hauptli *et al.* (1978) speculated that the tuberculate surface of such nutlets may aid in flotation by trapping air. However, most meadowfoam nutlets are dispersed only short distances. In an experiment where nine meadowfoam taxa were seeded into artificial vernal pools (Jain 1978), only four taxa colonized other parts of the pools where they had been introduced, and only two appeared in pools where they had not been seeded, even after 2 years. *Limnanthes floccosa* ssp. *californica* was not included in the study; however, *L. floccosa* ssp. *floccosa* was not found outside of the areas where it had been seeded. Thus, *L. floccosa* ssp. *californica* nutlets would not be expected to disperse beyond their pool or swale of origin. Birds and livestock are potential sources of long-distance seed dispersal, but specific instances of such dispersal have not been documented (Jain 1978).

Demographic data on *Limnanthes floccosa* ssp. *californica* include population sizes as well as estimates of survival and fecundity. Population highs for *L. floccosa* ssp. *californica* are not necessarily reached in the same year at all sites because the amount and timing of rainfall interacts with soil and topography to determine site-specific population size.

The average number of flowers and nutlets per plant also differ among sites and years. Overall, the largest populations of *Limnanthes floccosa* ssp. *californica* produce the greatest number of nutlets per plant (Dole 1988, Dole and Sun 1992). However, the number of flowers per plant is reduced in dense colonies of *L. floccosa* ssp. *californica* because individuals produce fewer branches and therefore fewer flowers. Competition from other plant species also reduces flower production (Crompton 1993, Kelley and Associates Environmental Sciences 1993*b*). Reproduction of *L. floccosa* ssp. *californica* may be reduced by insufficient moisture (Brown and Jain 1979) or inappropriate livestock grazing practices (Dole 1988, Dole and Sun 1992).

Several races of *Limnanthes floccosa* ssp. *californica* exist. Jokerst (1989) identified "north" and "south" races of *L. floccosa* ssp. *californica* in the Chico "sphere of influence" based on morphology. Later, in studies of enzyme systems, Dole and Sun (1992) confirmed that these races differed genetically. They also identified genetically distinct races that they called "northeast" and "southwest," with the latter referring to the type locality. Although Arroyo (1975) had concluded that *L. floccosa* exhibited considerable genetic diversity within populations, Dole and Sun (1992) evaluated many more enzyme systems and refuted her conclusions. They found that 96 percent of genetic diversity in *L. floccosa* ssp. *californica* existed among populations and that little variability

was evident within populations. Dole and Sun speculated that the low genetic diversity was due to bottlenecks and subsequent inbreeding. In other words, if populations were reduced to only a few plants at certain times in their history, only those few individuals would have passed on their genes. Self-pollination among the remaining plants would have further restricted the gene pool. Dole and Sun (1992) used mathematical formulas to estimate an average generation time of 2 years for *L. floccosa* ssp. *californica* and to predict that a seed would be transferred between populations only once every 100 to 200 years. Although considerable morphological variability has been observed within populations, it apparently is attributable to differences in environmental response by plants of similar genetic makeup (Jain 1976*a*, Jokerst 1989).

Habitat and Community Associations.—*Limnanthes floccosa* ssp. *californica* is found primarily in vernal swales and to a lesser extent on the margins of vernal pools (Arroyo 1973, Dole 1988, Jokerst 1989, BioSystems Analysis, Inc. 1993, California Natural Diversity Data Base 2003). Both the swales and vernal pools where it grows are on alluvial terraces in annual grasslands with a mima mound topography (Kelley and Associates Environmental Sciences 1992*b*, BioSystems Analysis, Inc. 1993). Swales vary in width from narrow channels to broad, pool-like areas (LSA Associates, Inc. 1994). They may connect in branching, tree-like patterns or in net-like patterns around low mounds. Occupied swales are inundated periodically by water from the surrounding uplands, causing the soil to become saturated. However, *L. floccosa* ssp. *californica* does not persist in pools or swales that are inundated for prolonged periods or remain wet during the summer months, nor does it occur in drainages where water flows swiftly (Jokerst 1989, Kelley and Associates Environmental Sciences 1993*a*). One *L. floccosa* ssp. *californica* site near the Chico Municipal Airport is unusual in that it does not contain vernal pools or recognizable swales (Dole 1988, Dole and Sun 1992), which were most likely obliterated by earlier grading (Jokerst 1989).

The swales that support *Limnanthes floccosa* ssp. *californica* are generally less than 10 centimeters (3.9 inches) deep (LSA Associates, Inc. 1994) and pools are typically less than 30 meters (100 feet) long (Jokerst 1989). In vernal pools, *L. floccosa* ssp. *californica* more often grows on the margins than in the bottom, but the pattern is reversed in swales, with the plants more often growing in the center (BioSystems Analysis, Inc. 1993). This plant typically occurs in long, narrow bands in connected swales or on pool margins but can be found in irregular clusters in isolated drainages (Crompton 1993). *Limnanthes floccosa* ssp. *californica* has also been found occasionally in disturbed areas, such as drainage ditches, firebreaks, and graded sites (McNeill and Brown 1979, Jokerst 1989, Kelley and Associates Environmental Sciences 1992*b*, BioSystems Analysis, Inc. 1993, Kelley and Associates Environmental Sciences 1993*a*).

Limnanthes floccosa ssp. *californica* occurs on soils of the Tuscan-Anita and the Redding-Igo complexes, specifically on the Anita and Igo soils, which are confined to the pools and swales. Tuscan and Redding soils are restricted to the mounds. Anita soils can be up to 50 centimeters (19.7 inches) deep, whereas Igo soils are no more than 18 centimeters (7.1 inches) deep; the two soils are underlain by iron-silica cemented and indurated hardpan, respectively (Kelley and Associates Environmental Sciences 1993*a*). Large cobbles are often present throughout pools and swales in such areas (Jokerst 1989). *Limnanthes floccosa* ssp. *californica* has been observed on Anita clay soils annually regardless of rainfall but appears on Igo soils only in years of above average rainfall (Kelley and Associates Environmental Sciences 1992*a*, 1992*b*; Crompton 1993; R. Schonholtz *in litt.* 1995), presumably because the former can hold roughly twice as much moisture (Kelley and Associates Environmental Sciences 1993*a*). Confirmed occurrences have been found at 50 to 90 meters (165 to 300 feet) in elevation (McNeill and Brown 1979, California Natural Diversity Data Base 2003).

Associated species vary somewhat through the range of *Limnanthes floccosa* ssp. *californica*. In most of the occupied habitat within the City of Chico, *Limnanthes floccosa* ssp. *californica* grows with *Layia fremontii* (Fremont's tidy-tips), *Navarretia leucocephala* (whiteflower navarretia), *Blennosperma nanum* (yellow carpet), and *Lasthenia californica* (California goldfields) (Dole 1988, Dole and Sun 1992). In the Shippee area, *Limnanthes floccosa* ssp. *californica* is associated most frequently with *Juncus bufonius* (toad rush), *Erodium botrys* (long-beak heron's bill), and *Eryngium vaseyi* ssp. *vallicola* (Vasey's coyote thistle) (BioSystems Analysis, Inc. 1993). *Limnanthes floccosa* ssp. *californica* also co-occurs with *Limnanthes alba* at two occurrences and with *Limnanthes douglasii* ssp. *rosea* at five occurrences (McNeill and Brown 1979, Dole and Sun 1992, California Natural Diversity Data Base 2003). *Limnanthes floccosa* ssp. *floccosa* was observed not far from a population of *Limnanthes floccosa* ssp. *californica*, but the two subspecies were not growing together (California Natural Diversity Data Base 2003).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Limnanthes floccosa* ssp. *californica* are described below.

At least seven more urbanization actions are being considered within occupied *Limnanthes floccosa* ssp. *californica* habitat in the City of Chico (Kelley and

Associates Environmental Sciences 1992*c*). These projects include various proposals for residential developments and expansion of the Chico Municipal Airport (U.S. Fish and Wildlife Service 1992, C. Sellers *in litt.* 2001, E. Warne pers. comm. 2001, California Natural Diversity Data Base 2003); these projects would affect two occurrences of the southeastern race and one of the northern race of the taxon. Outside of the City, residential developments and agricultural conversions are also continuing threats to some populations.

A proposed project to widen Highway 149 and build interchanges potentially threatens portions of California Natural Diversity Data Base Element Occurrence 1 and 40 of *Limnanthes floccosa* ssp. *californica* (Finn 2000, California Natural Diversity Data Base 2003), which represent the Shippee race. The California Department of Transportation plans to avoid altering the patterns of surface water flow along Gold Run Creek when they widen Highway 149, but individual pools and swales could be filled and the watersheds of others could be reduced (Finn 2000). Additionally, a casino is proposed to be constructed on a 50-acre site containing potential *Limnanthes floccosa* ssp. *californica* habitat approximately 10 miles south of the city of Chico and adjacent to and east of State Route 149, near its intersection with Highway 99.

Another example of ongoing degradation of *Limnanthes floccosa* ssp. *californica* habitat involves illegal trash dumping and off-highway vehicle use (U.S. Fish and Wildlife Service 1992). Also, competition from grasses and other weedy nonnative plants poses a potential problem to four occurrences of *L. floccosa* ssp. *californica* (California Natural Diversity Data Base 2003). For example, at the Doe Mill Preserve, competition from the nonnative grass *Taeniatherum caput-medusae* (medusahead) apparently has reduced population size and seed set in *L. floccosa* ssp. *californica* (Center for Natural Lands Management 1997). In addition, threats are also continuing due to inappropriate grazing practices in certain instances, such as insufficient grazing at the Doe Mill Preserve. Finally, two populations of *L. floccosa* ssp. *californica* are small enough (fewer than 500 plants even in favorable years) that random events could lead to their extirpation (C. Sellers *in litt.* 2001, California Natural Diversity Data Base 2003). Moreover, the narrow geographic range of the taxon increases the likelihood that a single catastrophic event could destroy all or most of the occurrences. A threat to the Doe Mill Preserve and other *L. floccosa* ssp. *californica* preserves in Butte County is their small size (Conservation Efforts below). A concern for these small preserves is that the risk of extirpation in the event of stochastic events increases if low population densities of the plants are coupled with restricted distribution.

Another potential threat is lack of pollinators. Although *Limnanthes floccosa* ssp. *californica* is capable of setting seed in the absence of insect pollinators,

continuing adaptation to environmental changes is not possible without the genetic recombination that occurs during cross-pollination. Considering the widespread habitat destruction and degradation in the area where *L. floccosa* ssp. *californica* is endemic, breeding habitat for pollinators could well be declining. However, the identity of pollinators for this subspecies must be determined before their population and habitat status can be evaluated.

e. Conservation Efforts

We listed *Limnanthes floccosa* ssp. *californica* as an endangered species on June 8, 1992 (U.S. Fish and Wildlife Service 1992). The California Fish and Game Commission had previously listed this taxon as endangered under the California Endangered Species Act in 1982 (California Department of Fish and Game 1991). *Limnanthes floccosa* ssp. *californica* has been included on the California Native Plant Society's list of rare and endangered plants for almost two decades (Smith *et al.* 1980) and is currently on List 1B with the highest endangerment rating (California Native Plant Society 2001). In 2002, critical habitat was proposed for *L. floccosa* ssp. *californica* and several other vernal pool species in *Proposed Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon* (U.S. Fish and Wildlife Service 2002a); however, it was eliminated from the final designation (U.S. Fish and Wildlife Service 2003). In 2005, however, critical habitat was reinstated for L. *floccosa* ssp. *californica* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

In 1988, the City of Chico funded surveys to determine the status of *Limnanthes floccosa* ssp. *californica* (Dole 1988). Money from the California Endangered Species Tax Check-Off Fund was used to prepare a plan for conserving *L. floccosa* ssp. *californica* within the City, while allowing for continued development (Jokerst 1989). The City prepared a supplement to the conservation plan presenting a schedule for acquisition and other details of management (City of Chico 1989) and was developing a Habitat Resources Conservation Plan for *L. floccosa* ssp. *californica* and other listed species, but has abandoned the effort (J. Knight pers. comm. 1997).

Several areas have been set aside for the conservation of *Limnanthes floccosa* ssp. *californica*. These areas include the 6-hectare (15-acre) Doe Mill Preserve, a conservation easement of about 14 hectares (35 acres) on Humboldt Road, and a 2.8-hectare (7-acre) conservation easement on the publicly owned Gillick-Evans Firing Range (U.S. Fish and Wildlife Service 1992, K. Tarp pers. comm. 1997, C.

Sellers *in litt.* 2001). The City of Chico also has a conservation easement on 118 hectares (292 acres) of habitat that appears to be suitable for *L. floccosa* ssp. *californica*, although very few of the plants are present (C. Sellers *in litt.* 2001). The Dove Ridge Conservation Bank, which contains over 200 acres of vernal pool habitat, is operated as conservation bank for this and other vernal pool species. The Center for Natural Lands Management holds a conservation easement and conducts management and monitoring of the site (M. Wacker *in litt.* 2005).

Other conservation efforts for *Limnanthes floccosa* ssp. *californica* have been accomplished through mitigation programs. The Bruce-Stilson population was enhanced by spreading nutlets to unoccupied areas within a proposed preserve (Stern 1992, K. Stern *in litt.* 1994). *Limnanthes floccosa* ssp. *californica* also was introduced onto suitable, unoccupied habitat on the Tuscan Preserve (also known as Lower Wurlitzer Ranch) in 1992 and 1993 (Kelley *et al.* 1994). The population has continued to reproduce and expand, increasing to approximately 200,000 plants by the spring of 2000 (C. Sellers *in litt.* 2001).

6. *NAVARRETIA LEUCOCEPHALA* SSP. *PAUCIFLORA* (FEW-FLOWERED NAVARRETIA)

a. Description and Taxonomy

Taxonomy.—Navarretias are members of the phlox family (Polemoniaceae). Mason (1946) first gave few-flowered navarretia the Latin name *Navarretia pauciflora*. He had collected the type specimen "5 miles north of Lower Lake, Lake County" in 1945 (Mason 1946). Day (1993*a*) subsequently reduced few-flowered navarretia in rank and assigned it the name *Navarretia leucocephala* ssp. *pauciflora*.

Some plants exhibit characteristics intermediate between *Navarretia leucocephala* ssp. *pauciflora* and ssp. *plieantha*. According to Dr. Alva Day (A. Day *in litt.* 1993, *in litt.* 1997, pers. comm. 1997), such plants cannot be assigned definitively to either subspecies. She does not consider these intergrades (intermediate plants) to be hybrids because there is no evidence that they resulted from crosses between the two subspecies. Thus, the characterization of these intermediate plants as "intercrosses" in the final rule (U.S. Fish and Wildlife Service 1997*b*) was misleading. The existence of such intermediate forms was Dr. Day's primary reason for reducing several taxa previously treated as full species to subspecies within *N. leucocephala* (Day 1993*a,* A. Day pers. comm. 1997). The distribution, life history, threats, conservation efforts, and recovery strategy for intergrades are discussed in the species account for *N. leucocephala* ssp. *plieantha*.

Description and Identification.—Navarretias are annual herbs with alternate, usually lobed leaves that also may have secondary lobes. The small, funnel-shaped flowers have four or five corolla lobes and a tubular calyx with four or five sepals joined at the base by a papery membrane. *Navarretia* flowers are clustered into head-like inflorescences that are surrounded by spine-tipped bracts similar to the leaves. The small capsules are egg-shaped and contain one or more tiny seeds (Day 1993*b*). All *Navarretia* species and subspecies that occur in vernal pools apparently evolved from a single ancestor and share a suite of characteristics including short stature, simple stem anatomy, few glands, very short stigmas, a single vein leading to each corolla lobe, stamens attached near or at the top of the corolla tube, a membranous-walled capsule that does not split along predetermined lines, and few seeds (Crampton 1954, Spencer 1993).

Navarretia leucocephala ssp. *pauciflora* (**Figure II-9**) is only 1 to 4 centimeters (0.4 to 1.6 inches) tall but is twice as wide due to branches originating near the base of the stem. The stem is white with purple streaks and has few hairs. Although the majority of the stem is very slender (less than 0.5 millimeter [0.02 inch] thick), the portion at and just below ground level is two to four times as thick. The narrow leaves are 1 to 2.5 centimeters (0.4 to 1.0 inch) long and may have a few narrow lobes. Each flower head is 4 to 10 millimeters (0.16 to 0.39 inch) wide and contains between 2 and 20 pale blue or white flowers. The fruit of *Navarretia leucocephala* ssp. *pauciflora* is a papery capsule that breaks open in an irregular pattern only when it is wet. Each capsule contains one or two reddish-brown seeds that stick together until water washes them apart (Mason 1946, Day 1993*b*). The chromosome number of this taxon has not been determined.

Navarretia leucocephala ssp. *pauciflora* has fewer flowers per head and fewer lobes on the outer bracts than *N. leucocephala* ssp. *plieantha*. Also, the latter has narrower, needle-like tips on the bract lobes (A. Day *in litt.* 1993). Other navarretias that occur in vernal pools differ in growth habit or have more flowers per head, longer corollas with the tube extending beyond the calyx lobes, branching veins in the corollas, or stamens attached farther down the corolla tube. Those growing outside of vernal pools typically are covered with glandular hairs and have many corolla veins, longer stigma branches, and leathery capsules that split apart when dry; they also may differ in flower color or number of corolla and calyx lobes (Mason 1946, Crampton 1954, Day 1993*b*).

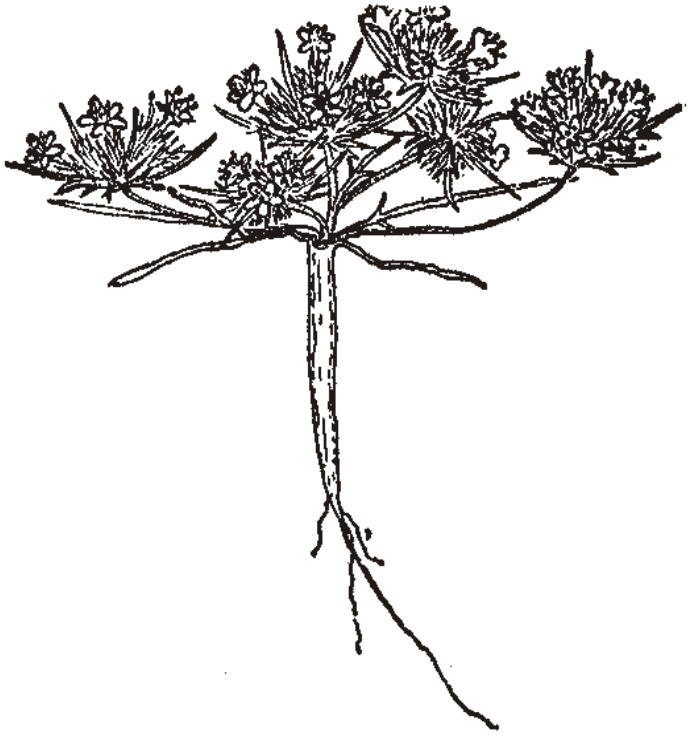

Figure II-9. Illustration of *Navarretia leucocephala* ssp. *pauciflora* (few-flowered navarretia). Reprinted with permission from Abrams (1951), Illustrated Flora of the Pacific States: Washington, Oregon, and California, Vol. III. © Stanford University Press.

b. Historical and Current Distribution

Historical Distribution.—Between 1923 and 1988, typical *Navarretia leucocephala* ssp. *pauciflora* specimens were collected from as many as nine sites in southern Lake County (A. Day *in litt.* 1997). The actual number of collection localities may have been fewer because some vaguely-described sites may in fact be the same as others described in greater detail. Manning Flat is presumed to be the type locality (California Natural Diversity Data Base 2003), even though it is actually west-northwest, rather than north, of Lower Lake. The specimens of typical *N. leucocephala* ssp. *pauciflora* were collected in the area between the towns of Clearlake, Kelseyville, and Middletown (Niehaus and Fruchter 1977, Bittman 1989, A. Day *in litt.* 1997). All of the historical sites were in the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-5**).

Intermediates between *Navarretia leucocephala* ssp. *pauciflora* and ssp. *plieantha* were collected historically from Loch Lomond and from the Siegler Springs Road area of Lake County. Those specimens have been cited as *N. leucocephala* ssp. *pauciflora* in some reports (*e.g.,* Niehaus and Fruchter 1977, Bittman 1989). The California Natural Diversity Data Base (2005) treats Loch Lomond as an occurrence of both *Navarretia leucocephala* ssp. *pauciflora* and ssp. *plieantha*. However, Day (*in litt.* 1993, *in litt.* 1997) does not consider collections from either Loch Lomond or Siegler Springs Road to represent *N. leucocephala* ssp. *pauciflora*.

Current Distribution.—Existing information is insufficient to clearly assess whether or not *Navarretia leucocephala* ssp. *pauciflora* has, in fact, significantly declined. Although two of the historical sites in Lake County are not confirmed to have extant populations, the vague original location information leaves open the possibility that these historical occurrences are actually the same as where the taxon is currently known.

Navarretia leucocephala ssp. *pauciflora* is restricted to the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998). Eight populations of typical *N. leucocephala* ssp. *pauciflora* are known or presumed to be extant (California Natural Diversity Data Base 2005), including three that were discovered during the past two decades (A. Howald *in litt.* 1995, California Natural Diversity Data Base 2005). Six of the eight extant occurrences are in Lake County and the other two are in Napa County. Among the Lake County occurrences, all six are south of Clear Lake within the area where the taxon was reported historically. One site in Lake County is farther south near the town of Cobb and was discovered in 1995 (J. Diaz-Haworth pers. comm. 2001). According to Howald (*in litt.* 1995), Dr. Alva Day verified the identity of the Cobb occurrence. The two Napa County

occurrences were also discovered within the past two decades. Both are in the Foss Valley-Milliken Canyon area east of Yountville (A. Day *in litt.* 1997, California Natural Diversity Data Base 2005).

There is one occurrence that contains both true *Navarretia leucocephala* ssp. *pauciflora* and populations of plants intermediate between *N. leucocephala* ssp. *pauciflora* and ssp. *plieantha*. These populations are in the vicinity of Loch Lomond and near Siegler Springs (A. Day *in litt.* 1993, *in litt.* 1997; California Department of Fish and Game 1994; California Natural Diversity Data Base 2005).

c. Life History and Habitat

Reproduction and Demography.—Little is known about the life history and demography of *Navarretia leucocephala* ssp. *pauciflora*. Like many vernal pool annuals, *N. leucocephala* ssp. *pauciflora* seeds germinate underwater (Crampton 1954) and flower after the pools dry (Day 1993*a*). The plants flower in May and June (California Department of Fish and Game 1994, Skinner and Pavlik 1994). The flowers are probably insect-pollinated. Navarretias with similar flowers that occur outside of vernal pools are pollinated by a variety of bees and bee flies (family Bombyliidae), although other insects may visit to collect nectar (Grant and Grant 1965). The seeds of *N. leucocephala* ssp. *pauciflora* do not disperse far from the parent plant because they have a gelatinous coating and stick together when the fruit ruptures (Crampton 1954, Day 1993*b*). Population sizes fluctuate widely among years (California Natural Diversity Data Base 2005).

Habitat and Community Associations.—*Navarretia leucocephala* ssp. *pauciflora* grows in vernal pools that form on substrates of volcanic origin (Bittman 1989, California Natural Diversity Data Base 2005), specifically in Northern Basalt Flow and Northern Volcanic Ashflow Vernal Pools (Sawyer and Keeler-Wolf 1995). Extant occurrences in Lake County are in "flats" of recent alluvium in mountainous areas; site-specific details are not available for Napa County sites. The vernal pools where *N. leucocephala* ssp. *pauciflora* occurs are interspersed with grassland or marsh and chaparral (Mason 1946, California Natural Diversity Data Base 2005). Pool sizes have not been well characterized, although this taxon has been reported from both small pools and large, shallow, playa-type lakes. Soils underlying the pools typically are shallow and rocky, and obsidian often is present on the surface (Mason 1946, California Natural Diversity Data Base 2003). The Manning Flat site has volcanic ash soil mapped as Oxalis variant silt loam, whereas one Milliken Canyon site has Aiken loam. Soil types are not known for the other occurrences. *Navarretia leucocephala* ssp. *pauciflora*

has been reported from elevations ranging from 445 to 707 meters (1,460 to 2,320 feet).

Associated plants differ among sites. In Lake County, associates include other rare plants: *Gratiola heterosepala, Parvisedum leiocarpum, Lasthenia burkei*, and *Eryngium constancei* (A. Howald *in litt.* 1995, California Natural Diversity Data Base 2003). Napa County associates include *E. aristulatum, L. conjugens*, and several species of *Downingia* (California Natural Diversity Data Base 2003).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Navarretia leucocephala* ssp. *pauciflora* are described below.

Continuing specific threats involving potential loss or fragmentation of habitat include: (1) various disturbances of the volcanic ash soils, which accelerates erosion, at Manning Flat (Bittman 1989, A. Buckmann pers. comm. 2001); (2) off-road vehicle use continuing to degrade certain habitat (Bittman 1989, California Natural Diversity Data Base 2005); (3) erosion problems from attempts to drain habitat (California Natural Diversity Data Base 2005); (4) land-use conversions for residential development or agriculture threatening all but two occurrences (J. Diaz-Haworth pers. comm. 2001, B. Flynn pers. comm. 2001); (5) possible inappropriate grazing practices at certain sites; and (6) possible population reductions of important insect pollinators.

e. Conservation Efforts

Navarretia leucocephala ssp. *pauciflora* was federally-listed as an endangered species on June 18, 1997 (U.S. Fish and Wildlife Service 1997*b*). The California Fish and Game Commission had previously listed *N. leucocephala* ssp. *pauciflora* as threatened in 1990 (California Department of Fish and Game 1991). The California Native Plant Society included this plant in their first listing of rare plants (Powell 1974). Currently, *N. leucocephala* ssp. *pauciflora* is on the California Native Plant Society's List 1B and has the highest endangerment rating possible (California Native Plant Society 2001).

The Mead Ranch population of *Navarretia leucocephala* ssp. *pauciflora* in Napa County is protected from development by a conservation easement (California Natural Diversity Data Base 2003). A private citizen bought the Cobb-area vernal pool that supports *N. leucocephala* ssp. *pauciflora* and *Eryngium*

constancei specifically to protect these species from potential threats (J. Diaz-Haworth pers. comm. 2001, B. Flynn pers. comm. 2001). One of the sites near Loch Lomond is now protected by the California Department of Fish and Game as a Vernal Pool Ecological Reserve and is managed for the benefit of several rare plants (California Department of Fish and Game 1994, California Natural Diversity Data Base 2003). However, the *Navarretia* at that site is an intermediate form (A. Day *in litt.* 1997).

Surveys conducted by California Native Plant Society members and California Department of Fish and Game personnel in the 1990s led to the discovery of several new or historical populations. In 1988, the California Native Plant Society petitioned the California Fish and Game Commission to list *Navarretia leucocephala* ssp. *pauciflora* (Bittman 1989, California Department of Fish and Game 1990*a*).

7. *NAVARRETIA LEUCOCEPHALA* SSP. *PLIEANTHA* (MANY-FLOWERED NAVARRETIA)

a. Description and Taxonomy

Taxonomy.—Many-flowered navarretia is in the phlox family. The name first assigned to many-flowered navarretia was *Navarretia plieantha*. The type locality for the species is Boggs Lake, in Lake County (Mason 1946). Day (1993*a*) later reduced many-flowered navarretia to the rank of subspecies, under the name *Navarretia leucocephala* ssp. *plieantha*.

As explained in the species account for *Navarretia leucocephala* ssp. *pauciflora*, some populations of *Navarretia* consist of individuals intermediate in characteristics between two subspecies. According to Dr. Alva Day (*in litt.* 1997, pers. comm. 1997), these plants are not properly called hybrids nor "intercrosses," as the final listing rule (U.S. Fish and Wildlife Service 1997*b*) described them. Dr. Day (*in litt.* 1997) has distinguished two types of intermediate specimens, which others have identified as *N. leucocephala* ssp. *plieantha*. One group is intermediate between *N. leucocephala* ssp. *pauciflora* and *N. leucocephala* ssp. *plieantha*, and the other is intermediate between *N. leucocephala* ssp. *plieantha* and *N. leucocephala* ssp. *bakeri* (Baker's navarretia). For convenience, we refer to all of these as *N. leucocephala* ssp. *plieantha* throughout this plan, but the population at the type locality is referred to as "typical" *N. leucocephala* ssp. *plieantha*.

Description and Identification.—Characteristics common to all members of this genus were presented in the *Navarretia leucocephala* ssp. *pauciflora*

account. *Navarretia leucocephala* ssp. *plieantha* (**Figure II-10**) forms mats 5 to 20 centimeters (2.0 to 7.9 inches) across and 1 to 3 centimeters (0.4 to 1.2 inches) high. The stems have a peeling, white surface and are highly branched. Stem thickness is 0.8 to 1.4 millimeters (0.03 to 0.06 inch) and is more or less uniform throughout its length. The leaves are 3 to 4 centimeters (1.2 to 1.6 inches) long and are either entire or have a few thread-like lobes. Flower heads are 1.5 to 2 centimeters (0.6 to 0.8 inch) across and contain between 10 and 60 pale blue flowers. Each flower in the head is 5 to 6 millimeters (0.20 to 0.24 inch) long. The capsule and seeds are similar to those of *N. leucocephala* ssp. *pauciflora*; each fruit may contain as many as three seeds (Mason 1946, Day 1993*b*). The chromosome number is unknown.

Navarretia leucocephala ssp. *plieantha* has up to twice as many flowers per head as *N. leucocephala* ssp. *pauciflora*, and the former also has more highly branched outer bracts with needle-like tips on the lobes (A. Day *in litt.* 1993). Moreover, *N. leucocephala* ssp. *plieantha* does not have a thicker stem below ground level and its corolla is about the same length as its calyx. *Navarretia leucocephala* ssp. *bakeri* differs from *N. leucocephala* ssp. *plieantha* in that the former has an erect habit, stems up to 15 centimeters (5.9 inches) tall, and white corollas. Other vernal pool navarretias have corolla lobes with more veins, corolla tubes longer than the calyx, calyx lobes of unequal length, or different stamen attachment (Mason 1946, Crampton 1954, Munz and Keck 1968, Day 1993*b*). Identifying features of upland navarretias were described under *N. leucocephala* ssp. *pauciflora*.

b. Historical and Current Distribution

Historical Distribution.—The California Natural Diversity Data Base (2005) includes seven occurrences of *Navarretia leucocephala* ssp. *plieantha*, (California Natural Diversity Data Base 2005) (**Figure II-5**). The final rule for *N. leucocephala* ssp. *plieantha* (U.S. Fish and Wildlife Service 1997*b*) erroneously reported eight historical locations instead of the nine that were catalogued by the California Natural Diversity Data Base at that time. The historical occurrences are from Lake and Sonoma Counties.

Typical *Navarretia leucocephala* ssp. *plieantha* was known historically only from Boggs Lake (A. Day *in litt.* 1993, 1997). The other reported occurrences include six sites with plants that are intermediate between *N. leucocephala* ssp. *plieantha* and other subspecies, and two sites where Dr. Alva Day does not have access to specimens to confirm the identity of the plants (A. Day *in litt.* 1993, 1997). Three historical occurrences in Lake County (Loch Lomond, Mount Hannah Lodge, and

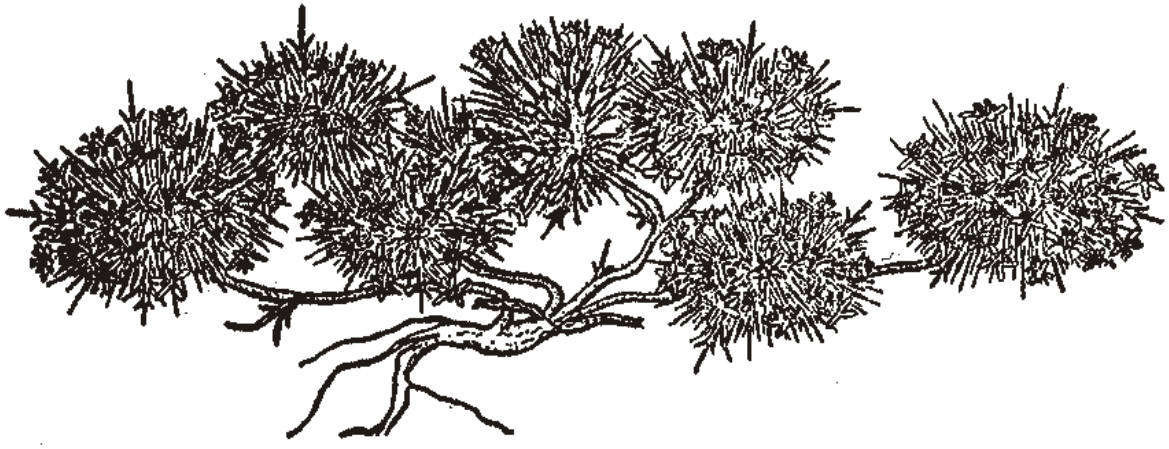

Figure II-10. Illustration of *Navarretia leucocephala* ssp. *plieantha* (many-flowered navarretia). Reprinted with permission from Abrams (1951), Illustrated Flora of the Pacific States: Washington, Oregon, and California, Vol. III. © Stanford University Press.

Siegler Springs Road) have plants intermediate between *N. leucocephala* ssp. *pauciflora* and *N. leucocephala* ssp. *plieantha*. At least three occurrences in the Santa Rosa area, in Sonoma County, consist of plants intermediate between *N. leucocephala* ssp. *plieantha* and *N. leucocephala* ssp. *bakeri* (A. Day *in litt*. 1993, 1997). Dr. Day has not seen specimens from Stienhart Lake in Lake County and thus cannot confirm that *N. leucocephala* ssp. *plieantha* occurs there (A. Day *in litt.* 1997).

Current Distribution.——Of the seven occurrences the California Natural Diversity Data Base (2005) has catalogued as *Navarretia leucocephala* ssp. *plieantha*, all are considered to be extant. Please refer to the Draft Santa Rosa Plains Recovery Plan (in development) for information regarding occurrences within the Santa Rosa vernal pool region identified by Keeler-Wolf *et. al*. (1998).

The five occurrences reported as extant in the final rule (U.S. Fish and Wildlife Service 1997*b*) were Boggs Lake, Loch Lomond, Mount Hannah Lodge, Siegler Springs Road, and Stienhart Lake, which are in the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998). These occurrences are still believed to be extant, although only three populations have been revisited since 1989 (California Natural Diversity Data Base 2005). The typical population of *Navarretia leucocephala* ssp. *plieantha* at Boggs Lake has not declined (Baldwin and Baldwin 1991, California Natural Diversity Data Base 2005).

c. Life History and Habitat

Reproduction and Demography.—The basic life history of *Navarretia leucocephala* ssp. *plieantha* presumably is similar to that of *N. leucocephala* ssp. *pauciflora*, although neither has been studied intensively. Three different measures of abundance collected annually from 1987 through 1991 at Boggs Lake revealed that the *N. leucocephala* ssp. *plieantha* population in the lakebed had increased in abundance while that in the adjoining meadow had decreased. *Navarretia leucocephala* ssp. *plieantha* plants rarely had more than one flower head each during the monitoring period (Baldwin and Baldwin 1991). In certain years, competition from associated plants along the lake margin apparently caused the *N. leucocephala* ssp. *plieantha* plants to develop longer, less robust stems (Baldwin and Baldwin 1990).

Habitat and Community Associations.—Typical *Navarretia leucocephala* ssp. *plieantha* occurs only at Boggs Lake. The lake itself is classified as a Northern Volcanic Ashflow Vernal Pool (Sawyer and Keeler-Wolf 1995), which consists of a clay layer that is impervious to water and is buried under a layer of volcanic ash (California Department of Fish and Game 1987*b*). Mason

(1946:200) noted that he collected the type specimen "In peaty soil of lake margin surrounded by a black oak, madrone [*Arbutus menziesii*], Douglas fir, and yellow pine [*Pinus ponderosa*] forest." More recent reports from Boggs Lake indicated that *N. leucocephala* ssp. *plieantha* also can grow in the center of the lake bed and in wet portions of the surrounding meadow (Baldwin and Baldwin 1989*a*, Baldwin and Baldwin 1991). The soil at Boggs Lake is in the Collayomi-Aiken-Whispering complex. Numerous plant species are associated with *N. leucocephala* ssp. *plieantha* at Boggs Lake, including *Eryngium aristulatum*, *Plagiobothrys stipitatus*, *Downingia* spp., and several other species of *Navarretia*. Rare plants that co-occur with typical *N. leucocephala* ssp. *plieantha* include *Orcuttia tenuis* and *Gratiola heterosepala* (Baldwin and Baldwin 1989*a*, California Natural Diversity Data Base 2003). The elevation of Boggs Lake is approximately 850 meters (2,800 feet) (California Natural Diversity Data Base 2005).

Elsewhere, *Navarretia leucocephala* ssp. *plieantha* occurs in vernal pools, vernal lakes, and swales (California Natural Diversity Data Base 2003). Occupied pools are classified as "Northern Vernal Pools" or Northern Volcanic Ashflow Vernal Pools (Sawyer and Keeler-Wolf 1995, California Natural Diversity Data Base 2003). *Pinus ponderosa* forest or mixed forests of *Quercus kelloggii*, *Pseudotsuga menziesii*, and *Pinus ponderosa* typically occur in the surrounding areas (California Department of Fish and Game 1987*b*, California Natural Diversity Data Base 2003).

Associates of *Navarretia leucocephala* ssp. *plieantha* throughout its range are similar to those at Boggs Lake (California Natural Diversity Data Base 2003). Other plants featured in this recovery plan that co-occur with *N. leucocephala* ssp. *plieantha* include *Eryngium constancei*, *Orcuttia tenuis*, *Gratiola heterosepala*, and *Legenere limosa*. In addition, the endangered plant *Lasthenia burkei* co-occurs with *N. leucocephala* ssp. *plieantha* in Sonoma County (California Natural Diversity Data Base 2005).

At three sites that support *Navarretia leucocephala* ssp. *plieantha*, the soils are mapped in the Collayomi-Aiken-Whispering complex, whereas the Stienhart Lake site has soils in the Konocti-Hambright complex. Soil types are not known for the other occurrences. At Loch Lomond, *N. leucocephala* ssp. *plieantha* is found in the deeper parts of the pool (California Department of Fish and Game 1994). Known sites range in elevation from 33 meters (110 feet) north of Santa Rosa to 853 meters (2,800 feet) at Loch Lomond (California Natural Diversity Data Base 2005).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Navarretia leucocephala* ssp. *plieantha* are described below.

Unique to *Navarretia leucocephala* ssp. *plieantha* are three habitat impacts not generally reported as important factors in the declines of the other vernal pool species: rooting by feral pigs, horseback riding, and foot traffic related to human recreational activity. Hybridization has also been cited as a reason for the decline of *N. leucocephala* ssp. *plieantha* (Bittman 1989, California Department of Fish and Game 1990*a*), but the presence of intermediate forms is not evidence of any threat. The intermediates are not believed to be hybrids (A. Day *in litt.* 1997, pers. comm. 1997), and the fact that similar specimens were collected historically at all sites with intermediate plants indicates that the intergradation is not a recent phenomenon (A. Day *in litt.* 1993).

Other threats are also continuing. In particular, at Boggs Lake, competition from *Typha* spp. (cat-tail), *Centaurea solstitialis* (yellow star-thistle), and a native thistle (*Cirsium remotifolium*) threaten to crowd out *Navarretia leucocephala* ssp. *plieantha* (Baldwin and Baldwin 1991). Competition from nonnative plants such as *Taeniatherum caput-medusae* and *Centaurea solstitialis* threatens *N. leucocephala* ssp. *plieantha* at the site east of Mount Hannah Lodge. Random events pose a threat to two small populations, one east of Mount Hannah Lodge and another in Sonoma County, which number only a few hundred individuals in even the most favorable years (California Natural Diversity Data Base 2003). Please refer to the Draft Santa Rosa Plains Recovery Plan (in development) for information regarding threats facing *Navarretia leucocephala* ssp. *plieantha* in the Santa Rosa vernal pool region, as identified by Keeler-Wolf *et. al*. (1998).

e. Conservation Efforts

A final rule listing *Navarretia leucocephala* ssp. *plieantha* as an endangered species was published on June 18, 1997 (U.S. Fish and Wildlife Service 1997*b*). *Navarretia leucocephala* ssp. *plieantha* had previously been listed as endangered by the California Fish and Game Commission since 1979 (California Department of Fish and Game 1991). The California Native Plant Society has long recognized *N. leucocephala* ssp. *plieantha* as rare and endangered (Powell 1974); it is currently on List 1B and is ranked as “endangered in a portion of its range” (California Native Plant Society 2003).

Two localities for *Navarretia leucocephala* ssp. *plieantha* are protected as reserves. The Trust for Wildland Communities manages the Boggs Lake Preserve and the California Department of Fish and Game manages the Loch Lomond Vernal Pool Ecological Reserve. Management activities at the two reserves include annual monitoring, protective measures such as fencing, and removal of competitors, and interpretive displays (Baldwin and Baldwin 1991; California Department of Fish and Game 1991, 1994).

Additional past conservation efforts included a 1985 survey throughout the range of *Navarretia leucocephala* ssp. *plieantha* (California Department of Fish and Game 1987*b*) and a survey in the Santa Rosa area of Sonoma County in 1988 (Waaland and Vilms 1989). Please refer to the Draft Santa Rosa Plains Recovery Plan (in development) for specific information regarding *Navarretia leucocephala* ssp. *plieantha* conservation efforts.

8. *NEOSTAPFIA COLUSANA* (COLUSA GRASS)

a. Description and Taxonomy

Taxonomy.—Colusa grass is a member of the subfamily Chloridoideae in the grass family (Poaceae) and is in the Orcuttieae tribe, which also includes *Orcuttia* and *Tuctoria* (Reeder 1965, Keeley 1998). Davy (1898) first described Colusa grass, giving it the Latin name *Stapfia colusana.* He had collected the type specimen near the town of Princeton in Colusa County. Davy soon realized that the name *Stapfia* had already been assigned to a genus of green algae and therefore changed the scientific name of Colusa grass to *Neostapfia colusana* (Davy 1899). The name *Anthochloa colusana* was used for decades after Scribner (1899) published the combination in the mistaken belief that Colusa grass was closely related to a South American species of that genus. However, Hoover (1940) evaluated the many differences between *Anthochloa* and *Neostapfia* and concluded that the latter should be considered a distinct genus. Since that time, the accepted name for Colusa grass has been *Neostapfia colusana*. No other species of *Neostapfia* are known (Reeder 1982, Reeder 1993). *Neostapfia* is the most primitive member of the tribe (Keeley 1998).

Description and Identification.—All members of the Orcuttieae share several characteristics that differ from many other grasses. Most grasses have hollow stems, but the Orcuttieae have stems filled with pith. Another difference is that the Orcuttieae produce two or three different types of leaves during their life cycle, whereas most grasses have a single leaf type throughout their life span. The juvenile leaves of the Orcuttieae, which form underwater, are cylindrical and clustered into a basal rosette. After the pool dries, terrestrial leaves form in all

species of the tribe; these leaves have flattened blades and are distributed along the stem (Keeley 1998). *Orcuttia* species have a third type of leaf that is not found in *Neostapfia* or *Tuctoria* (Reeder 1982, Keeley 1998). The terrestrial leaves of the Orcuttieae also differ from other grasses in other respects. Whereas grass leaves typically are differentiated into a narrow, tubular sheath that clasps the stem tightly and a broader blade that projects away from the stem, terrestrial leaves of the Orcuttieae are broad throughout and the lower portion enfolds the stem only loosely. The Orcuttieae also lack a ligule, which is a leaf appendage commonly found in other grasses (Reeder 1965, Reeder 1982, Keeley 1998). Another characteristic common to all Orcuttieae is the production of an aromatic exudate, which changes from clear to brown during the growing season (Reeder 1965, Reeder 1982). The exudate most likely helps to repel herbivores (Crampton 1976, Griggs 1981).

The Orcuttieae are, however, similar to other grasses in their flower structure. Grasses do not have petals and sepals like most other flowering plants, so their flowers are inconspicuous. Grass flowers are reduced to florets, which include several stamens (three in the Orcuttieae) and one pistil enclosed in two scales known as the lemma and palea. A spikelet consists of one or more florets and may have one or two glumes at its base. The grass inflorescence typically includes several to many spikelets, which are attached to a central stem known as the rachis. A grass fruit, which is known as a caryopsis or grain, consists of a single seed fused to the fruit wall. Each floret is capable of producing one grain.

Compared to other members of the Orcuttieae, *Neostapfia colusana* (**Figure II-11**) shows fewer adaptations to existence underwater, indicative of its relatively primitive evolutionary position and the shorter duration of underwater growth (Keeley 1998). The aquatic seedlings of *N. colusana* have only one or two juvenile leaves (Keeley 1998). The terrestrial stage consists of multiple stems arising in clumps from a common root system. The stems are decumbent and have a characteristic zigzag growth form (Crampton 1976). Overall stem length ranges from 10 to 30 centimeters (3.9 to 11.8 inches). The entire plant is pale green when young (Davy 1898), but becomes brownish as the exudate darkens (Reeder 1982, Reeder 1993). Leaf length is 5 to 10 centimeters (2.0 to 3.9 inches) (Hitchcock and Chase 1971). Each stem produces one dense, cylindrical inflorescence that is 2 to 8 centimeters (0.8 to 3.1 inches) long and 8 to 12 millimeters (0.31 to 0.47 inch) broad. Within the inflorescence, the spikelets are densely packed in a spiral arrangement; the tip of the rachis projects beyond the spikelets. *Neostapfia colusana* has a diploid chromosome number of 40 (Reeder 1982, Reeder 1993).

Figure II-11. Illustration of *Neostapfia colusana* (Colusa grass). Reprinted with permission from Abrams (1940), Illustrated Flora of the Pacific States: Washington, Oregon, and California, Vol. I. © Stanford University Press.

Unlike terrestrial grasses, *Neostapfia colusana* has pith-filled stems, lacks distinct leaf sheaths and ligules, and produces exudate. *Neostapfia colusana* differs from other members of the Orcuttieae in that it has zigzag stems, cylindrical inflorescences, and fan-shaped lemmas and lacks glumes, whereas the other genera within the tribe have fairly straight stems and possess glumes. Moreover, *Orcuttia* species have distichous spikelets and narrow, five-toothed lemmas, and *Tuctoria* species have spikelets arranged in a loose spiral, and narrow, more-or-less entire lemmas. *Neostapfia colusana* is not likely to be confused with *Anthochloa*, despite their former taxonomic affiliation. The latter does not occur in North America, is perennial, does not have glands, the inflorescence is not cylindrical, and the spikelets have glumes (Hoover 1940).

b. Historical and Current Distribution

Historical Distribution.—In the 50 years after its initial discovery (Davy 1898), *Neostapfia colusana* was reported from only three sites other than the type locality; these sites were in Merced and Stanislaus Counties. By 1989, 51 occurrences were known, but 11 of those had already been extirpated (Stone *et al.* 1988, California Natural Diversity Data Base 2003). Through November 2003, the California Natural Diversity Data Base (2003) included 60 reported occurrences of *N. colusana* in Colusa, Merced, Solano, Stanislaus. and Yolo Counties. Five each were reported from the San Joaquin Valley and Solano-Colusa Vernal Pool Regions, and the remainder were from the Southern Sierra Foothills Vernal Pool Region (**Figure II-12**).

Current Distribution.—Currently, no more than 42 occurrences of *Neostapfia colusana* remain extant (Hogle 2002, California Natural Diversity Data Base 2005). At least one population remains in each of the vernal pool regions from which *N. colusana* was known historically. The majority of extant occurrences are in the Southern Sierra Foothills Vernal Pool Region, where they are concentrated northeast of the City of Merced in Merced County and east of Hickman in Stanislaus County. One or two occurrences remain in central Merced County, which is part of the San Joaquin Valley Vernal Pool Region. Four occurrences are extant in the Solano-Colusa Vernal Pool Region, with two each in southeastern Yolo and central Solano Counties (Stone *et al*. 1988 , Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2003). This species has apparently been extirpated from Colusa County (California Natural Diversity Data Base 2005).

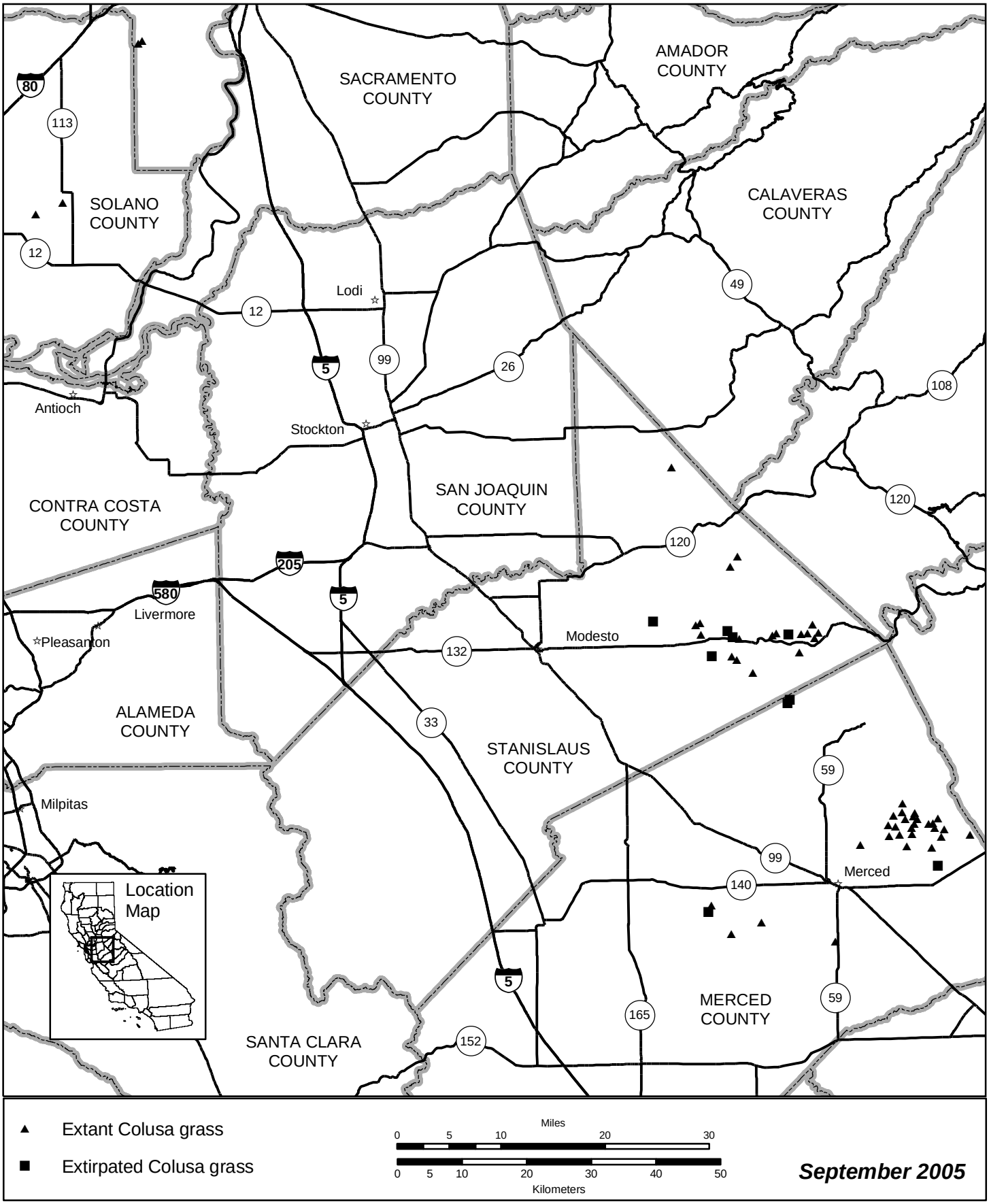

Figure II-12. Distribution of *Neostapfia colusana* (Colusa grass).

c. Life History and Habitat

Many life history characteristics are common to all members of the Orcuttieae. In particular, they are all annuals (Griggs 1981). All are wind-pollinated, but pollen probably is not carried long distances between populations (Griggs 1980, Griggs and Jain 1983). Local seed (*i.e.*, caryopsis) dispersal is by water, which breaks up the inflorescences (Reeder 1965, Crampton 1976, Griggs 1980, Griggs 1981). Long-distance dispersal is unlikely (U.S. Fish and Wildlife Service 1985*a*), but seed may have been carried occasionally by waterfowl (family Anatidae), tule elk (*Cervus elaphus nannoides*), or pronghorn (*Antilocapra americana*) in historical times (Griggs 1980). The seeds can remain dormant for an undetermined length of time (but at least 3 to 4 years) and germinate underwater after they have been immersed for prolonged periods (Crampton 1976, Griggs 1980, Keeley 1998). Unlike typical terrestrial grasses that grow in the uplands surrounding vernal pools, members of the Orcuttieae flower during the summer months (Keeley 1998).

Among all members of the Orcuttieae, the soil seed bank may be 50 times or more larger than the population in any given year. In general, years of above-average rainfall promote larger populations of Orcuttieae, but population responses vary by pool and by species (Griggs 1980, Griggs and Jain 1983). Population sizes have been observed to vary by one to four orders of magnitude among successive years and to return to previous levels even after 3 to 5 consecutive years when no mature plants were present (Griggs 1980, Griggs and Jain 1983, Holland 1987). Thus, many years of observation are necessary to determine whether a population is stable, declining, or extirpated. All members of the Orcuttieae are endemic to vernal pools. Although the various species have been found in pools ranging widely in size, the vast majority occur in pools of 0.01 hectare (0.025 acre) to 10 hectares (24.7 acres) (Stone *et al.* 1988). Large pools such as these retain water until May or June, creating optimal conditions for Orcuttieae (Crampton 1959, 1976; Griggs 1981; Griggs and Jain 1983). Within such pools, Orcuttieae occurs in patches that are essentially devoid of other plant species (Crampton 1959, 1976). Typically, plants near the center of a pool grow larger and produce more spikelets than those near the margins, but patterns vary, depending on individual pool characteristics and seasonal weather conditions (Griggs 1980).

Reproduction and Demography.—In an experiment where *Neostapfia colusana* was grown along with *Tuctoria greenei* and two species of *Orcuttia* (Keeley 1998), seeds of *N. colusana* took about 3 months to germinate following inundation, longer than all other species. Hogle (2002) also provided evidence that long periods of inundation are necessary for germination of *N. colusana* seeds. Unlike *Orcuttia* species, *N. colusana* does not produce flattened, floating,

juvenile leaves (Reeder 1982, Keeley 1998). Germination and seedling development have not been studied in the wild, but are assumed to be similar to those of *Tuctoria* species, which have similar seedlings. Thus, *N. colusana* seed would be expected to germinate in late spring when little standing water remains in the pool, and flowering would begin approximately 3 to 4 weeks later, as observed for *Tuctoria* (Griggs 1980). Flowering individuals of *N. colusana* have been collected as early as May throughout the range of the species (California Natural Diversity Data Base 2005). *Neostapfia colusana* spikelets break between the florets (Reeder 1993), quickly shattering as soon as the inflorescence matures (Crampton 1976).

Reproductive and survival rates have not been reported, but annual monitoring confirms that population sizes of *Neostapfia colusana* vary widely from year to year. Over a 6-year monitoring period, the population at the Bert Crane Ranch in Merced County dropped from 250 plants in 1987 to zero in 1989 and 1990, but rebounded to over 2,000 plants in 1992 (J. Silveira *in litt.* 2000). At Olcott Lake in Solano County, the lowest population of the decade was 1,000 in 1994; but this low point was followed by a high of over 1 million estimated plants the following year (California Natural Diversity Data Base 2003).

Habitat and Community Associations.—*Neostapfia colusana* has the broadest ecological range among the Orcuttieae. It occurs on the rim of alkaline basins in the Sacramento and San Joaquin Valleys, as well as on acidic soils of alluvial fans and stream terraces along the eastern margin of the San Joaquin Valley and into the adjacent foothills (Stone *et al.* 1988). Elevations range from 5 meters (18 feet) to about 105 meters (350 feet) at known sites (California Natural Diversity Data Base 2005). *Neostapfia colusana* has been found in Northern Claypan and Northern Hardpan vernal pool types (Sawyer and Keeler-Wolf 1995) within rolling grasslands (Crampton 1959). It grows in pools ranging from 0.01 to 250 hectares (0.02 to 617.5 acres), with a median size of 0.2 hectare (0.5 acre), and also occurs in the beds of intermittent streams and in artificial ponds (Stone *et al.* 1988, K. Fuller pers. comm. 1997, EIP Associates 1999). This species typically grows in the deepest portion of the pool or stream bed (Crampton 1959, Stone *et al.* 1988), but may also occur on the margins (Hoover 1937, Stone *et al.* 1988). It appears that deeper pools and stock ponds are most likely to provide the long inundation period required for germination (EIP Associates 1999).

Several soil series are represented throughout the range of *Neostapfia colusana*. In the Solano-Colusa Vernal Pool Region, *N. colusana* grows on clay, silty clay, or silty clay loam soils in the Marvin, Pescadero, and Willows series. In the San Joaquin Valley Vernal Pool Region, soils are clay or silty clay loam in the Landlow and Lewis series (J. Silveira *in litt.* 2000). *Neostapfia colusana* habitat in the Southern Sierra Foothills Vernal Pool Region includes many soil series

with textures ranging from clay to gravelly loam. For sites with known soil series, Bear Creek, Corning, Greenfield, Keyes, Meikle, Pentz, Peters, Raynor, Redding, and Whitney are represented (Stone *et al.* 1988, EIP Associates 1999, California Natural Diversity Data Base 2003). The type and composition of impermeable layers underlying occupied vernal pools also varies, ranging from claypan to lime-silica or iron-silica cemented hardpan and tuffaceous alluvium (Stone *et al.* 1988).

Neostapfia colusana usually grows in single-species stands, rather than intermixed with other plants. Thus, associated species in this case are plants that occur in different zones of the same pools, but are generally present in the same season. For example, Crampton (1959) observed that *N. colusana* dominated pool beds, with *Orcuttia pilosa* forming a band around the upper edge of the stand. In saline-alkaline sites, common associates of *N. colusana* are *Frankenia salina* and *Distichlis spicata*, whereas on acidic sites associates include *Eryngium* spp., *Eremocarpus setigerus* (turkey mullein), and *Plagiobothrys stipitatus* (Stone *et al.* 1988, EIP Associates 1999). Many of the other rare plants featured in this recovery plan grow in the same pools as *N. colusana*. Among these species, the most frequent associate is *Orcuttia inaequalis*, followed by *O. pilosa*, *Tuctoria mucronata*, *Chamaesyce hooveri*, *Atriplex persistens*, and *Astragalus tener* var. *tener* (Stone *et al.* 1988, EIP Associates 1999, J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2003). *Tuctoria greenei* formerly grew in one vernal pool with *N. colusana*, but the former no longer occurs there (Stone *et al.* 1988, California Natural Diversity Data Base 2003).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Neostapfia colusana* are described below.

Three additional potential reasons for site-specific declines have been reported relative to this species: inundation by poultry manure and, in Yolo County, damage by herbicide applications (C. Witham *in litt.* 2000*a*) and contamination of groundwater by industrial chemicals (K. Fuller pers. comm. 1997).

The largest continuing threat to this species is agricultural conversion, especially in Stanislaus County. Urbanization is the second greatest threat, especially at the proposed University of California campus and associated community development in eastern Merced County. Four occurrences are in the area expected to be developed within the next 15 years and two others are within the

general “planning area” (EIP Associates 1999, California Natural Diversity Data Base 2003). Proposed construction of a new prison and a landfill also threaten other specific populations (U.S. Fish and Wildlife Service 1997*a*). A proposed flood control project in eastern Merced County threatens four of the occurrences with inundation, and runoff alterations are a threat to the two Yolo County occurrences. Almost all of the extant occurrences of *Neostapfia colusana* are subject to livestock grazing, thus to the extent inappropriate grazing practices are still being followed at certain sites, these sites may be threatened. Competition from invasive native and nonnative plants poses a problem at several sites, especially in combination with adverse hydrology changes and adverse grazing practices (Stone *et al.* 1988, C. Witham *in litt.* 2000*a*). One or two sites have also been reported as threatened by vandalism (*i.e.*, trampling near urban areas [U.S. Fish and Wildlife Service 1997*a*]) and foraging by grasshopper outbreaks (Stone *et al.* 1988). Small population size may be a threat at 9 sites, which have never exceeded 100 plants in number. In addition, several other sites that were formerly larger than 100 plants each now appear to have declined to fewer than that number of individuals (Hogle 2002, California Natural Diversity Data Base 2003).

e. Conservation Efforts

We listed *Neostapfia colusana* as a threatened species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). *Neostapfia colusana* has been State-listed as endangered since 1979 (California Department of Fish and Game 1991) and has been considered to be rare and endangered by the California Native Plant Society since 1974 (Powell 1974). The California Native Plant Society now includes *N. colusana* on List 1B and considers it to be “endangered throughout its range” (California Native Plant Society 2001). In 2005, critical habitat was designated for *N. colusana* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Most of the conservation efforts for *Neostapfia colusana* have been accomplished as part of the broader effort to survey and protect vernal pools in the Central Valley. Surveys conducted by Crampton (1959), Medeiros (1976), and Stone *et al.* (1988) contributed to distributional records and identification of threats. Four occurrences of *N. colusana*, comprising six occupied pools, have been protected by The Nature Conservancy. One is Olcott Lake on the Jepson Prairie Preserve in Solano County, where the *N. colusana* population has been monitored annually since 1989 (C. Witham *in litt.* 1992, California Natural Diversity Data

Base 2003). The other five pools are on the Flying M Ranch conservation easement in eastern Merced County (Stone *et al.* 1988).

Three additional occurrences of *Neostapfia colusana* are on Federal land, which offers more options for conservation, but does not in itself constitute protection. Two are on a U.S. Department of Defense facility in Yolo County (Davis Communications Annex), which is in the process of being transferred to the ownership of Yolo County Parks (K. Fuller *in litt.* 2000). This site is the subject of a nonnative invasive plant management effort, particularly for *Lepidium latifolium* (pepperweed), and vernal pool restoration under a CalFed grant to benefit *N. colusana* and *Tuctoria mucronata*, another federally-listed plant included in this plan (N. McCarten *in litt*. 2004). The third occurrence on Federal land is on the Arena Plains Unit of the Merced National Wildlife Refuge in Merced County. Our National Wildlife Refuge system acquired the Arena Plains in 1992, and refuge personnel have been monitoring the *N. colusana* population annually since 1993. Although the refuge allowed grazing to continue on the Arena Plains after it was purchased, temporary electric fencing was placed around the *N. colusana* pool to exclude cattle in one year when the plant population was deemed to be particularly vulnerable (D. Woolington pers. comm. 1997, J. Silveira *in litt.* 2000).

9. *ORCUTTIA INAEQUALIS* (SAN JOAQUIN VALLEY ORCUTT GRASS)

a. Description and Taxonomy

Taxonomy.—Hoover (1936*b*) first published the scientific name *Orcuttia inaequalis* for San Joaquin Valley Orcutt grass. A 1935 collection from "Montpellier [sic], Stanislaus County" was cited as the type specimen (Hoover 1936*b*). Hoover (1941) subsequently reduced this taxon to a variety of California Orcutt grass (*Orcuttia californica*), using the combination *Orcuttia californica* var. *inaequalis*. Based on differences in morphology, seed size, and chromosome number, Reeder (1980) restored the taxon to species status, and the scientific name *Orcuttia inaequalis* is thus currently in use (Reeder 1993). *Orcuttia inaequalis* is a member of the grass family (Poaceae), subfamily Chloridoideae, and is in the tribe Orcuttieae (Reeder 1965). The genus *Orcuttia* is the most evolutionarily advanced group within the tribe (Keeley 1998, L. Boykin *in litt.* 2000). Alternative common names for this species are San Joaquin Valley orcuttia (Smith *et al.* 1980) and San Joaquin Orcutt grass (U.S. Fish and Wildlife Service 1985*c*).

Description and Identification.—Characteristics common to all members of the Orcuttieae were described earlier in this document in the *Neostapfia*

colusana species account. Species in the genus *Orcuttia* are characterized by an inflorescence consisting of narrow, flattened, distichous spikelets, each of which has two glumes at the base. *Orcuttia* species produce three different types of leaves during their life cycle: a submerged basal rosette of five to eight cylindrical, juvenile leaves; intermediate leaves in which the submerged portion is cylindrical but the upper portion has a flat, floating blade; and terrestrial leaves with a flattened blade and loosely sheathing base, which develop after the pools dry (Keeley 1998).

Mature plants of *Orcuttia inaequalis* grow in tufts of several erect stems, each of which ranges from 5 to 30 centimeters (2.0 to 11.8 inches) in length. The entire plant is grayish-green, due to the long hairs on the stem and leaves, and the plant produces exudate. Terrestrial leaves are 2 to 4 millimeters (0.08 to 0.16 inch) wide. The oval lemmas are 4 to 5 millimeters (0.16 to 0.20 inch) long and their tips are divided into five teeth approximately 2 millimeters (0.08 inch) long; the central tooth is longer than the others, hence the name *inaequalis* ("unequal"). Each spikelet is flattened and contains 4 to 30 florets. Both rows of spikelets grow towards one side. The spikelets are crowded near the top one-third of the stem, producing a head-like inflorescence 2 to 3.5 centimeters (0.8 to 1.4 inches) long. Each caryopsis is 1.3 to 1.5 millimeters (0.05 to 0.06 inch) long (Hoover 1941; Crampton 1976; Reeder 1982, 1993). The seeds averaged 0.28 milligram (1×10^{-5} ounce) in one population, although seed weight likely varies among sites (Griggs 1980). *Orcuttia inaequalis* has a diploid chromosome number of 24 (Reeder 1980, 1982).

The pith-filled stems, lack of both leaf sheaths and ligules, and presence of exudate distinguish *Orcuttia inaequalis* (and all members of the Orcuttieae) from grasses in other tribes. The elongate, distichous spikelets with oval lemmas and glumes differentiate *Orcuttia* species from *Neostapfia*, which has a cylindrical head with the spikelets arranged in a spiral, fan-shaped spikelets and lemmas, and no glumes. The unequal lemma teeth in *O. inaequalis* distinguish it from *O. pilosa* and *O. tenuis*. *Orcuttia californica* is similar to *O. inaequalis* but the former does not have a head-like inflorescence, has few hairs on the plant, and grows only near the California-Mexico border. *Orcuttia inaequalis* has shorter lemmas, shorter bristles, and smaller seeds than *O. viscida*. Furthermore, each species of *Orcuttia* has a unique chromosome number (Reeder 1982).

b. Historical and Current Distribution

Historical Distribution.—*Orcuttia inaequalis* has always been restricted to the Southern Sierra Foothills Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-13**). The earliest collection was made in 1927 from the

Fresno-Madera County border near Lanes Bridge (California Natural Diversity Data Base 2003). Hoover (1941) mentioned collections from eight sites in Fresno, Madera, Merced, Stanislaus, and Tulare Counties. A total of 20 occurrences had been reported by the mid-1970s, all in the same 5 counties (Crampton 1959, California Natural Diversity Data Base 2003), but none remained as of the late 1970s (Griggs 1980, Griggs and Jain 1983). However, 20 new occurrences were discovered within the following decade, including 16 in Merced County, 3 in Madera County, and 1 in Fresno County (Stone *et al.* 1988, California Natural Diversity Data Base 2003).

Current Distribution.—Since 1990, 18 additional occurrences of *Orcuttia inaequalis* have been found, including 1 in Tulare County (EIP Associates 1999, C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2005) and 5 on ranches in Merced County (California Natural Diversity Data Base 2005), with another 1 that was established artificially (Stebbins *et al.* 1995). Of the 52 occurrences of *O. inaequalis* catalogued, 32 are presumed to be extant; 17 are extirpated and 3 others are considered possibly extirpated because the habitat has been modified (California Natural Diversity Data Base 2005). However, only 3 of the occurrences presumed extant have been revisited within the past decade, so even the most recent information is outdated. This species has apparently been extirpated from Stanislaus County but remains in Fresno, Madera, Merced, and Tulare Counties (Stone *et al.* 1988, Skinner and Pavlik 1994, California Natural Diversity Data Base 2003). *Orcuttia inaequalis* does not occur outside of the Southern Sierra Foothills Vernal Pool Region (Keeler-Wolf *et al.* 1998). The primary area of concentration of presumed extant occurrences is northeast of Merced in Merced County, with 19 occurrences (59 percent) on the Flying M Ranch and adjacent lands (EIP Associates 1999, C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2005). Eastern Merced County is considered a critical region for the conservation of this species from the perspective of being located near the historical geographic center of the range, for harboring a large majority of the extant occurrences, and for harboring one of the largest incompletely surveyed blocks of quality habitat within the species' range (Vollmar 2002).

The Lanes Bridge area of Madera and Fresno Counties has the second highest concentration, with seven occurrences (22 percent), including the introduced population. The remaining six occurrences include three in the Le Grand area of Merced County, two on the tabletops near the San Joaquin River in Madera and Fresno Counties, and one in northwestern Tulare County (Stone *et al.* 1988, Stebbins *et al.* 1995, California Natural Diversity Data Base 2003).

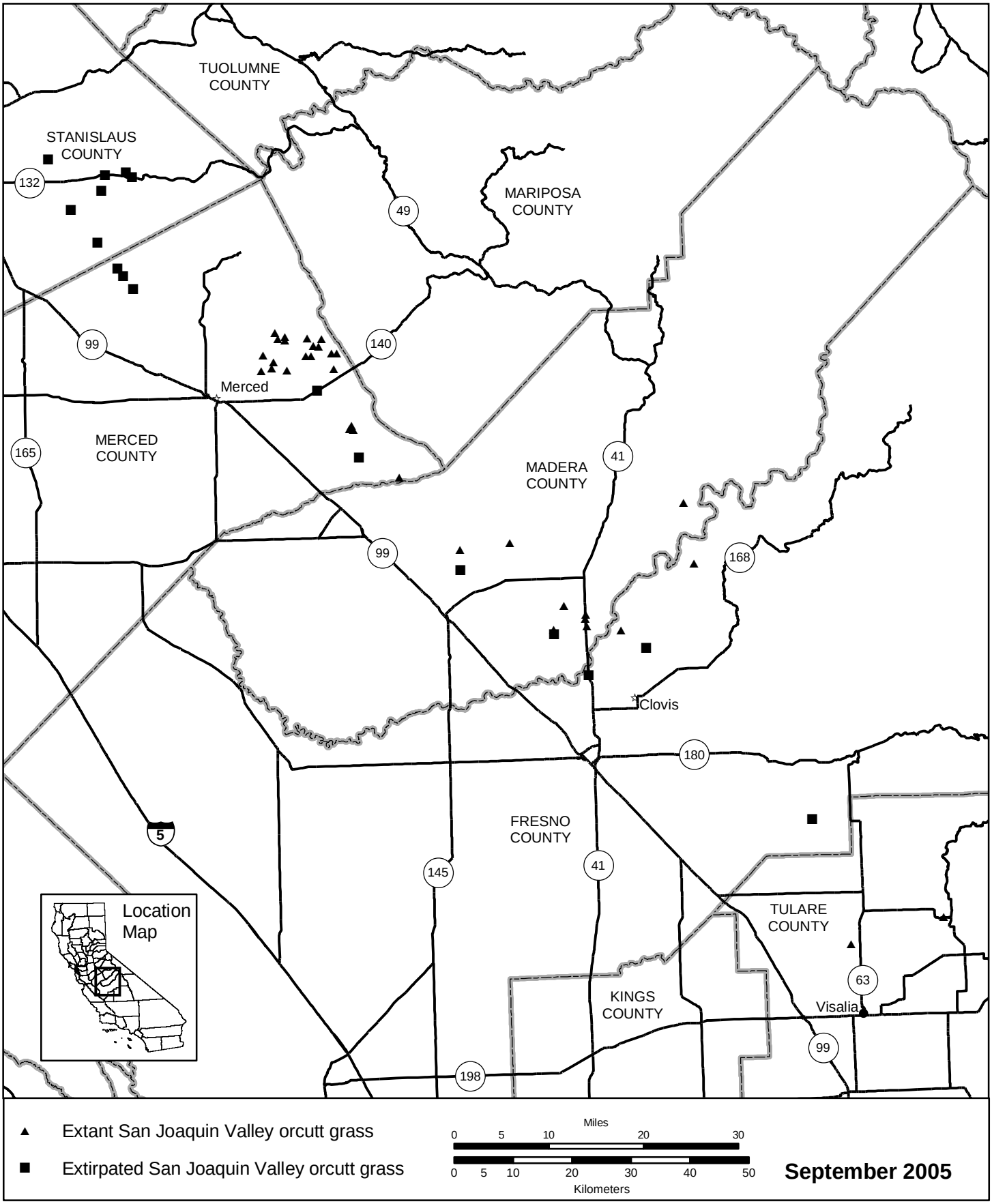

Figure II-13. Distribution of *Orcuttia inaequalis* (San Joaquin Valley Orcutt grass).

c. Life History and Habitat

Many life-history characteristics for *Orcuttia inaequalis* are common to the entire tribe and have been discussed earlier in this document. Certain other aspects of the life history are shared by *Orcuttia* and *Tuctoria* species, but not by *Neostapfia*. One of these aspects is the pattern of flowering. The first two flowers on a given plant open simultaneously and do not produce pollen until the ovaries are no longer receptive. Thus, if they are fertilized it must be with pollen from another plant. Flowers that open subsequently may receive pollen from the same plant or others (Griggs 1980). *Orcuttia* and *Tuctoria* species are believed to be outcrossers based on estimates of genetic diversity (Griggs 1980, Griggs and Jain 1983). Seed production in *Orcuttia* and *Tuctoria* species can vary two- to three-fold among years (Griggs 1980, Griggs and Jain 1983).

Another suite of life history characteristics is shared among all Orcutt grasses (*Orcuttia* species), but not other genera in the Orcuttieae. In particular, seeds of *Orcuttia* species germinate underwater in January and February (Griggs 1980, Griggs and Jain 1983, Keeley 1998), after being colonized by aquatic fungi (Griggs 1980, 1981). This observation was supported by Keeley's (1988) research, which indicated that fungicide inhibited germination of *O. californica* seeds, but did not affect *Tuctoria greenei* seeds. Detailed germination studies have not been conducted on all species, but cold treatment and other forms of stratification promoted germination in *O. californica* (Keeley 1988), *O. pilosa*, and *O. tenuis* (Griggs 1974, as cited in Stone *et al.* 1988) and most likely benefit other *Orcuttia* species as well. In an experimental study of *O. californica*, seeds germinated equally well in the light or the dark and could germinate whether exposed to air or anaerobic conditions; maximum germination was achieved in anaerobic conditions following cold stratification (Keeley 1988).

Orcuttia plants grow underwater for 3 months or more and have evolved specific adaptations for aquatic growth (Keeley 1998). Among these adaptations is the formation of the three different leaf types. The well-developed rosette of juvenile leaves is more specialized than those in *Neostapfia* or *Tuctoria* species, however (Keeley 1998). The floating-leaf stage is unique to *Orcuttia* species; these leaves form as water in the pool warms and remain as long as the standing water lasts (Hoover 1941; Griggs 1980, 1981; Reeder 1982; Keeley 1998). Aquatic leaves of *Orcuttia* species also lack stomates, even though they are present on the juvenile leaves of both *Neostapfia* and *Tuctoria* (Keeley 1998).

As soon as the pools dry, normally in June or July, Orcutt grasses begin producing their typical terrestrial leaves (Hoover 1941; Griggs 1980, 1981; Reeder 1982; Keeley 1998). Inflorescences appear within a few days after the water evaporates. June and July are the peak months of flower production for

most species, although flowering may continue into August and September in years of above-normal precipitation (Griggs 1980, 1981). Late-spring rains may prolong the flowering season (Griggs 1981, Griggs and Jain 1983), but inundation is more likely to kill flowering individuals (J. Silveira *in litt.* 1997). Spikelets break apart and scatter their seeds when autumn rains arrive (Reeder 1965; Crampton 1976; Griggs 1980, 1981).

Reproduction and Demography.—Griggs (1980) conducted demographic and genetic studies of one Fresno County population of *Orcuttia inaequalis* during spring 1976. In that year, each plant in the population produced an average of approximately 8 stems, 1,783 florets, and 254 seeds. The floret-to-seed ratio indicated a relatively good rate of pollination. Survival rates were not determined. Annual population estimates indicated that 1976 and 1978 were favorable years for the Fresno County population. Genetic diversity was high, even among plants grown from seeds collected from the same plant; among-population diversity was not evaluated for this species. The enzyme systems of *O. inaequalis* were most similar to those of *O. tenuis* (Griggs 1980, Griggs and Jain 1983).

Habitat and Community Associations.—Typical habitat requirements for all members of the Orcuttieae were described above under *Neostapfia colusana*. *Orcuttia inaequalis* occurs on alluvial fans, high and low stream terraces (Stone *et al.* 1988), and tabletop lava flows (Stebbins *et al.* 1995, California Natural Diversity Data Base 2003). This species grows in Northern Claypan, Northern Hardpan, and Northern Basalt Flow vernal pools (Sawyer and Keeler-Wolf 1995) within rolling grassland (Crampton 1959). Occupied pools range in surface area from 0.014 to 4.9 hectares (0.05 to 12.1 acres), with a median area of 0.62 hectare (1.54 acres) (Stone *et al.* 1988). *Orcuttia inaequalis* has been reported from elevations of 30 to 755 meters (100 to 2,475 feet); the highest-elevation sites are those on the tabletops of Fresno and Madera Counties (Stebbins *et al.* 1995, California Natural Diversity Data Base 2003).

Soils underlying *Orcuttia inaequalis* pools are acidic and vary in texture from clay to sandy loam. Soil series represented include the Hideaway series on Fresno-Madera County tabletops, and Amador, Cometa, Corning, Greenfield, Los Robles, Madera, Peters, Pollasky-Montpellier complex, Raynor, Redding, and San Joaquin soil series elsewhere in the range. Underlying layers at historical or extant occurrences included iron-silica cemented hardpan, tuffaceous alluvium, and basaltic rock from ancient volcanic flows (Stone *et al.* 1988, Stebbins *et al.* 1995, EIP Associates 1999, California Natural Diversity Data Base 2003).

The plants most commonly associated with *Orcuttia inaequalis* are *Eryngium* spp., *Plagiobothrys stipitatus*, *Neostapfia colusana*, *Psilocarphus brevissimus* (dwarf woolly-heads), and *Eremocarpus setigerus*. Among the rare plants featured in this recovery plan, five currently co-occur or historically co-occurred with *O. inaequalis*. In descending order by number of co-occurrences, these are: *N. colusana* (nine), *Castilleja campestris* ssp. *succulenta* (five), *Gratiola heterosepala* (three), *O. pilosa* (two), and *Chamaesyce hooveri* (one) (EIP Associates 1999, C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2003).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Orcuttia inaequalis* are described below.

A potential reason for some site-specific declines of this species may be foraging during grasshopper outbreaks, which can decimate entire plant populations of *Orcuttia inaequalis* before they set seed (Griggs and Jain 1983, Stone *et al.* 1988).

At least ten of the extant occurrences are threatened with habitat loss due to urbanization. Four of these are in the path of the proposed extension of State Highway 41 in Madera County (R. Stone *in litt.* 1992). Three others are threatened by a proposed residential development in Madera and Fresno Counties (Stone *et al.* 1988, Stebbins *et al.* 1995, California Natural Diversity Data Base 2003), and three more could be destroyed by construction of the proposed University of California campus and associated community in Merced County (EIP Associates 1999, California Natural Diversity Data Base 2003). Most extant populations are still being grazed; thus to the extent inappropriate grazing practices are still being followed, certain sites may be threatened. At least six occurrences are threatened by small population size. Among the *Orcuttia inaequalis* occurrences for which population size has been estimated, 6 numbered fewer than 100 plants each, even in favorable years. Ten others are of unknown size (R. Stone *in litt.* 1992, Stebbins *et al.* 1995, California Natural Diversity Data Base 2003).

e. Conservation Efforts

Orcuttia inaequalis was federally-listed as a threatened species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). The State of California had previously listed this grass as endangered in 1979 (California Department of Fish and Game 1991). The California Native Plant Society has considered this species to be rare and endangered for even longer (Powell 1974). Currently, *O. inaequalis* is on the California Native Plant Society's List 1B and is rated as "endangered throughout its range" (California Native Plant Society 2001). In 2005, critical habitat was designated for *O. inaequalis* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Currently, few occurrences of *Orcuttia inaequalis* are protected permanently. Two occurrences are on the Flying M Ranch in Merced County, which is protected under a conservation easement with The Nature Conservancy. Within those two occurrences, four pools supported *O. inaequalis* populations in excess of 5,000 individuals each in 1986 (Stone *et al.* 1988). The extant Tulare County occurrence of *O. inaequalis* is on a California Department of Fish and Game Ecological Reserve; it contained 250 plants in 1997 (California Natural Diversity Data Base 2003).

Three other occurrences are wholly or partially on public land. One occurrence in Fresno County consists of a pool that is partially on public land administered by the U.S. Bureau of Land Management. The pool supports the second-largest existing population of the species. The U.S. Bureau of Land Management and conservation groups hope to protect the entire pool through the potential acquisition of adjacent lands (California Natural Diversity Data Base 2003). Another occurrence is within an 81-hectare (200-acre) vernal pool complex in Madera County, where one pool contains a small population of *Orcuttia inaequalis* (Stebbins *et al.* 1995); the California Department of Transportation recently acquired this complex. Although the proposed Highway 41 extension would cross this property, alignment to avoid affecting the plant is possible (D. York pers. comm. 1996). The third occurrence on public land is the result of a vernal pool re-creation program coupled with seeding of various plant species. The California Department of Transportation funded the creation of artificial vernal pools in Madera County by staff and students from California State University, Fresno (D. York pers. comm. 1996). *Orcuttia inaequalis* was introduced into six of the created pools; it germinated and flowered in five pools during the 2 years following its introduction (Durgarian 1995, Stebbins *et al.* 1995) and was still present in 2000 (R. Faubion *in litt.* 2000). This site is now

recorded in California Natural Diversity Data Base occurrences (California Natural Diversity Data Base (2003). The Madera Irrigation District manages this property, which is owned by the U.S. Bureau of Reclamation (Stebbins *et al.* 1995).

10. *ORCUTTIA PILOSA* (HAIRY ORCUTT GRASS)

a. Description and Taxonomy

Taxonomy.—Hairy Orcutt grass is in the tribe Orcuttieae of the grass family Poaceae (Reeder 1965). Hoover (1941) published the original scientific name *Orcuttia pilosa* for hairy Orcutt grass, which has remained unchanged since. He collected the type specimen in Stanislaus County, "12 miles east of Waterford" (Hoover 1941) in 1937. Hoover (1937) initially identified that specimen as *Orcuttia tenuis*, but later recognized that it represented a new species (Hoover 1941). This species also has been known by the common names hairy Orcuttia (Smith *et al.* 1980) and pilose Orcutt grass (U.S. Fish and Wildlife Service 1985*c*).

Description and Identification.—Characteristics shared among all members of the tribe or among species in the genus *Orcuttia* are described above in the *Neostapfia colusana* and *O. inaequalis* species accounts. *Orcuttia pilosa* grows in tufts consisting of numerous stems. The stems are decumbent or erect and branch from only the lower nodes. Stems are 5 to 20 centimeters (2.0 to 7.9 inches) long and 1 to 2 millimeters (0.04 to 0.08 inch) in diameter (Stone *et al.* 1988). Almost the entire plant is pilose (bearing long, soft, straight hairs), giving it a grayish appearance. The terrestrial leaves are 3 to 6 millimeters (0.12 to 0.24 inch) wide. The inflorescence is 5 to 10 centimeters (2.0 to 3.9 inches) long and contains between 8 and 18 flattened spikelets. The spikelets near the tip of the inflorescence are crowded together, whereas those near the base are more widely spaced. Each spikelet consists of 10 to 40 florets and two tiny (3 millimeters [0.12 inch]) glumes. The lemmas are 4 to 5 millimeters (0.16 to 0.20 inch) long, with five teeth of equal size. Each caryopsis is 1.75 to 2 millimeters (0.07 to 0.08 inch) long (Hoover 1941; Reeder 1982, 1993) and weighs 0.46 to 0.95 milligram (1.6 to 3.4×10^{-5} ounce) (Griggs 1980). *Orcuttia pilosa* has a diploid chromosome number of 30 (Reeder 1982).

Orcuttia pilosa is most likely to be confused with *O. tenuis*. However, *O. pilosa* has broader stems and leaves, branches originating from the lower nodes, smaller spikelets that are crowded near the rachis tip, smaller grains, a later flowering period, and a different chromosome number (Reeder 1982). Other *Orcuttia* species typically have unequal lemma teeth and differ in seed size and chromosome number from *O. pilosa* and *O. tenuis* (Reeder 1982).

b. Historical and Current Distribution

Historical Distribution.—Prior to the surveys by Stone *et al.* (1988), *Orcuttia pilosa* had been reported from 25 sites, primarily in the Northeastern Sacramento Valley and Southern Sierra Foothills Vernal Pool Regions (Keeler-Wolf *et al.* 1998) (**Figure II-14**). These included eight occurrences each in Tehama and Stanislaus Counties, six in Madera County, and two in Merced County (Hoover 1941, Crampton 1959, Reeder 1982, Stone *et al.* 1988, California Natural Diversity Data Base 2003). *Orcuttia pilosa* also was collected in the Solano-Colusa Vernal Pool Region, Glenn County, in 1937 (California Natural Diversity Data Base 2003); the specimen has since been lost, but may have originally been misidentified as California Orcutt grass (Oswald and Silveira 1995, J. Silveira pers. comm. 1997, J. Silveira *in litt.* 2000). During the late 1980s, Stone *et al.* (1988) determined that 12 historical occurrences had been extirpated, but they and others discovered 3 additional populations in Madera, Stanislaus, and Tehama Counties. One other occurrence from Madera County (California Natural Diversity Data Base Element Occurrence 29) was previously considered to be *O. pilosa* and is still listed as such in the California Natural Diversity Data Base (2003); however, this population has been identified as *O. inaequalis* (R. Stone *in litt.* 1992).

Current Distribution.—Within about the last decade, 10 new natural occurrences of *Orcuttia pilosa* have been discovered: 5 in Madera County, 4 in Tehama County, and 1 in Stanislaus County (California Natural Diversity Data Base 2005). *Orcuttia pilosa* also has been discovered in another pool at the Vina Plains Preserve in Tehama County (Alexander and Schlising 1997); this pool may represent a separate occurrence or it may be an extension of California Natural Diversity Data Base Element Occurrence 25. In addition, this species has been introduced into a re-created pool in Madera County (Durgarian 1995, Stebbins *et al.* 1995, California Natural Diversity Data Base 2005).

Figure II-14. Distribution of *Orcuttia pilosa* (hairy Orcutt grass).

Of the 39 Element Occurrences listed by the California Natural Diversity Data Base (2003), not counting the misidentified population of *Orcuttia inaequalis* previously mentioned, 27 natural occurrences and the introduced population are presumed to be extant (California Natural Diversity Data Base 2005).

Currently, the main area of concentration for *Orcuttia pilosa* (9 extant occurrences and 1 that is possibly extirpated) is the Vina Plains in Tehama County, which is in the Northeastern Sacramento Valley Vernal Pool Region. An isolated occurrence in central Butte County is in the same region. Eleven occurrences are in the Southern Sierra Foothills Vernal Pool Region, including nine in Madera County between the City of Madera and Millerton Lake, and two in eastern Stanislaus County. All six extant occurrences in the Solano-Colusa Vernal Pool Region are on the Sacramento National Wildlife Refuge in Glenn County (Stone *et al.* 1988, Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2005).

c. Life History and Habitat

The life history characteristics common to all members of the Orcuttieae were presented above within the *Neostapfia colusana* discussion, and others shared by all *Orcuttia* species were described under the *O. inaequalis* discussion.

Reproduction and Demography.— Griggs (1974, as cited in Stone *et al.* 1988) found that stratification followed by temperatures of 15 to 32 degrees Celsius (59 to 90 degrees Fahrenheit) was necessary for seed germination in *Orcuttia pilosa*. Flowering individuals have been observed as early as mid-April in Madera County (Durgarian 1995). Populations observed in Glenn County began flowering at the beginning of May 1993. However, heavy rains in late May and early June of that year refilled the five pools that were being monitored, causing 80 percent to 100 percent of the plants to die before they set seed (J. Silveira *in litt.* 1997). Seed production has not been studied extensively in *O. pilosa*, but Griggs and Jain (1983) did note that one individual plant produced more than 10,000 seeds. Although the predominant pollination agent for all Orcutt grasses is wind, native bees (Halictidae) have been observed visiting the inflorescences of *O. pilosa* to gather pollen (Griggs 1974, as cited in Stone *et al.* 1988).

Like other vernal pool annuals, the size of *Orcuttia pilosa* populations fluctuates dramatically from year-to-year. Population sizes have varied by as much as four orders of magnitude over time (Griggs 1980, Griggs and Jain 1983, Alexander and Schlising 1997). In fact, two populations that had no visible plants for 3 years in succession exceeded 10,000 plants in the fourth year (Griggs 1980, Griggs and Jain 1983). However, populations that number fewer than 100 plants

in even the most favorable years are not likely to persist. They probably begin with chance dispersal events which never build up enough of a soil seed bank to become established. This phenomenon was noted at the Sacramento National Wildlife Refuge, the Vina Plains, and an unspecified location where the population consisted of six plants in 1973, dropped to zero the following year, and was considered to be extirpated when no plants reappeared by 1978 (Griggs 1980, Griggs and Jain 1983).

Densities of *Orcuttia pilosa* were determined at the Vina Plains Preserve in 1995. Among four pools where this species grew, densities ranged from 45 to 474 plants per square meter (4.2 to 44.0 plants per square foot) (Alexander and Schlising 1997). The high densities illustrate that although the total population size seems large, the individuals grow in close proximity and may actually occupy a relatively small area.

Habitat and Community Associations.— This species is found on high or low stream terraces and alluvial fans (Stone *et al.* 1988). *Orcuttia pilosa* occurs in Northern Basalt Flow, Northern Claypan, and Northern Hardpan vernal pools (Sawyer and Keeler-Wolf 1995) within annual grasslands (California Natural Diversity Data Base 2003). The median size of occupied pools measured in the late 1980s was 1.7 hectares (4.2 acres), with a range of 0.34 to 250 hectares (0.8 to 617.5 acres) (Stone *et al.* 1988). At the Vina Plains, *O. pilosa* was found growing only in pools that held water until May, June, or July in 1995, and not in those that had dried by April (Alexander and Schlising 1997). This species is known from elevations of 26 meters (85 feet) in Glenn County to 123 meters (405 feet) in Madera County (California Natural Diversity Data Base 2003). *Orcuttia pilosa* is found on both acidic and saline-alkaline soils, in pools with an iron-silica cemented hardpan or claypan. In the Northeastern Sacramento Valley Vernal Pool Region, pools supporting *O. pilosa* occur on the Anita and Tuscan soil series (Stone *et al.* 1988, California Natural Diversity Data Base 2003). At one pool in the Vina Plains that spans both Anita clay and Tuscan loam soils, *O. pilosa* was found growing primarily on the Anita clay type (Alexander and Schlising 1997). In the Solano-Colusa Vernal Pool Region, *O. pilosa* occurs on the Willows and Riz soil series (J. Silveira *in litt.* 2000), whereas in the Southern Sierra Foothills Vernal Pool Region, it occurs on the Cometa, Greenfield, Hanford, Meikle, and Whitney soil series (Stone *et al.* 1988).

Common associates of *Orcuttia pilosa* throughout its range include *Eryngium* spp. and *Plagiobothrys stipitatus*. *Orcuttia pilosa* also co-occurs at numerous sites with other rare plants addressed in this recovery plan, including *Neostapfia colusana* in the San Joaquin Valley and *Chamaesyce hooveri* and *Tuctoria greenei* in the Sacramento Valley (Stone *et al.* 1988, Alexander and Schlising 1997, California Natural Diversity Data Base 2003). Additional associates in the

San Joaquin Valley include *Trichostema lanceolatum* (vinegar weed) and *Anthemis cotula* (mayweed) (Stone *et al.* 1988). *Orcuttia pilosa* formerly occurred in one pool with *O. inaequalis* (Crampton 1959), a habitat that has since been converted to almond orchards (California Natural Diversity Data Base 2003). In the Vina Plains, other common associates of *O. pilosa* are *Marsilea vestita*, *Convolvulus arvensis*, and *Amaranthus albus* (Alexander and Schlising 1997). Both *O. pilosa* and *O. tenuis* grow on the Vina Plains, but do not occur in the same pools (Stone *et al.* 1988, Alexander and Schlising 1997). At least in 1995, the Vina Plains pools where *O. pilosa* grew had few spring-flowering annuals (Alexander and Schlising 1997).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Orcuttia pilosa* are described below.

Some indications of decline (*i.e.,* California Natural Diversity Data Base description as "possibly extirpated") for this species may have, in fact, been only artifacts of random dispersal events in which the "extirpated" populations were never well-established to begin with. In particular, two such occurrences on the Vina Plains Preserve apparently died out because the populations were too small to be viable. These occurrences involved only 2 plants at one site and fewer than 100 at the other site, and thus may have not represented truly established populations.

Nevertheless, the primary threats are continuing. In particular, agricultural and residential developments, and planning for such, are proceeding in the vicinity of the remaining Stanislaus and Madera County occurrences and may lead to the destruction of additional populations in the foreseeable future (Stone *et al.* 1988). Construction of a landfill threatens one occurrence (U.S. Fish and Wildlife Service 1997*a*). Cattle grazing was an ongoing land use at 20 occurrences when they were last visited, including 6 where this species may already be extirpated (California Natural Diversity Data Base 2003). Also, competition from invasive plants is believed to be an increasing problem throughout the range of *Orcuttia pilosa* (Stone *et al.* 1988). Several researchers (Stone *et al.* 1988, Alexander and Schlising 1997) have suggested that cattle may have carried in seeds of nonnative plants, and disturbance from trampling may have then facilitated their establishment. *Convolvulus arvensis* has increased in frequency in the Vina Plains since 1984, and *Xanthium strumarium* is still present. In addition, small population size continues to be a threat to *O. pilosa*. Six of the presumably extant

populations have had fewer than 100 plants at their peak (California Natural Diversity Data Base 2003).

e. Conservation Efforts

We listed *Orcuttia pilosa* as an endangered species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). *Orcuttia pilosa* had previously been State-listed as endangered in 1979 (California Department of Fish and Game 1991) and was identified as rare and endangered by the California Native Plant Society 5 years before that (Powell 1974). The California Native Plant Society still considers this species to be "endangered throughout its range" and includes it on its List 1B (California Native Plant Society 2001). In 2005, critical habitat was designated for *O. pilosa* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Relatively large populations of *Orcuttia pilosa* are protected at The Nature Conservancy's Vina Plains Preserve in Tehama County (Broyles 1987, Alexander and Schlising 1997, California Natural Diversity Data Base 2003) and at our Sacramento National Wildlife Refuge in Glenn County (J. Silveira *in litt.* 1997, J. Silveira *in litt.* 2000). A small population is now protected at a California Department of Transportation mitigation site in Madera County, although that site has, at times, been degraded due to discing by the former landowner (Stebbins *et al.* 1995). The Vina Plains populations have been monitored sporadically since 1983 (Alexander and Schlising 1997) and the Sacramento National Wildlife Refuge populations since 1993 (J. Silveira *in litt.* 2000). *Xanthium strumarium*, an aggressive native plant, has been removed by hand from some of the Vina Plains pools (Alexander and Schlising 1997), an effort that began in 1991 using funds from the California Endangered Species Tax Check-Off Fund (California Department of Fish and Game 1991).

Orcuttia pilosa was one component of an interagency vernal pool re-creation program in Madera County. The experiment was funded by the California Department of Transportation, carried out on U.S. Bureau of Reclamation property, and conducted by personnel from California State University, Fresno, and the University of California, Davis (Stebbins *et al.* 1996). *Orcuttia pilosa* was seeded into nine of the re-created pools in fall 1993. Flowering individuals were found in eight of the pools the following year, six in 1995, and eight in 1996 (Durgarian 1995, Stebbins *et al.* 1996), and the species was also observed in the re-created pools in 2000 (R. Faubion *in litt.* 2000).

11. *ORCUTTIA TENUIS* (SLENDER ORCUTT GRASS)

a. Description and Taxonomy

Taxonomy.—Slender Orcutt grass is a member of the tribe Orcuttieae in the grass family Poaceae (Reeder 1965). Hitchcock (1934) first published the name *Orcuttia tenuis* for slender Orcutt grass, and this name has remained unchanged. Nonetheless, some confusion surrounds the taxonomy of the species. The type specimen of *Orcuttia tenuis* was collected in Goose Valley, Shasta County, in 1912. Before the initial collections had been recognized as a new species, they were mistakenly identified as *Orcuttia californica* and were used as the basis for illustrating the latter species in a 1920 publication (Hitchcock 1934). Another common name is slender orcuttia (Smith *et al.* 1980).

Description and Identification.—The *Neostapfia colusana* account provided above describes characteristics common to all members of the tribe, and the *Orcuttia inaequalis* account describes features shared among *Orcuttia* species. *Orcuttia tenuis* grows as single stems or in small tufts consisting of a few stems. The plants are sparsely hairy and branch only from the upper half of the stem. Although the stems typically are erect, they may become decumbent if many branches form near the stem tip (Reeder 1982). The stems range from 5 to 20 centimeters (2.0 to 7.9 inches) in height (G. Schoolcraft *in litt.* 2000) and are about 0.5 millimeter (0.02 inch) in diameter. The terrestrial leaves are 1.5 to 2 millimeters (0.06 to 0.08 inch) wide. In *O. tenuis*, the inflorescence comprises more than half of the plant's height, and the spikelets are more or less evenly spaced throughout the inflorescence. Each spikelet contains from 5 to 20 florets. The grains are about 3 millimeters (0.12 inch) long (Hitchcock 1934, Reeder 1982, Stone *et al.* 1988, Reeder 1993). In one study, seed weight ranged from 0.32 to 0.81 milligram (1.1 to 2.8×10^{-5} ounce) (Griggs 1980). The diploid chromosome number of *O. tenuis* is 26 (Reeder 1982).

Orcuttia tenuis is most similar to *O. pilosa*, but the former has narrower stems and leaves, branches at the upper nodes, larger spikelets that are not crowded on the rachis, larger seeds, a different chromosome number, and it flowers earlier (Reeder 1982). Other *Orcuttia* species have unequal lemma teeth and also differ in seed size and chromosome number (Reeder 1982).

b. Historical and Current Distribution

Historical Distribution.—As of the mid-1980s, *Orcuttia tenuis* was known from only 18 localities in Lake, Sacramento, Shasta, and Tehama Counties (Reeder 1982, Stone *et al.* 1988) (**Figure II-15**). During the late 1980s, Stone *et al.* (1988) and others (California Natural Diversity Data Base 2003) discovered 34 additional occurrences of *O. tenuis*. Of these 52 occurrences reported prior to 1990, the majority (29 occurrences, 55.8 percent) were in the Northeastern Sacramento Valley Vernal Pool Region of Tehama County, mostly in the vicinity of Dales, except for 4 occurrences on the Vina Plains. Another 14 occurrences (26.9 percent) were in the Northwestern Sacramento Valley Vernal Pool Region, on the Stillwater and Millville Plains of Shasta County. The Modoc Plateau Vernal Pool Region accounted for another six occurrences (11.5 percent), including four in Shasta County and two in Siskiyou County. The remaining three occurrences included two in Lake County, which was in the Lake-Napa Vernal Pool Region, and one in Sacramento County, in the Southeastern Sacramento Valley Vernal Pool Region (Griggs and Jain 1983, Stone *et al.* 1988, California Natural Diversity Data Base 2003).

Current Distribution.—A total of 82 occurrences are known, of which 76 are presumed extant, 2 are possibly extirpated, and 4 are extirpated (K. Fuller *in litt*. 2004, California Natural Diversity Data Base 2005). Occurrences are presumed to be extant until the California Natural Diversity Data Base receives documentation that they have been extirpated. In addition to the counties where it was reported historically, *O. tenuis* is also known from Lassen, Modoc, Butte, and Plumas Counties. The primary area of concentration for *O. tenuis* is still in the vicinity of Dales, Tehama County, where 27 natural occurrences and the three introduced populations apparently remain extant (36 percent of occurrences). Those 30 occurrences and the four in the Vina Plains of Tehama County are all in the Northeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998). A secondary area of concentration is the Modoc Plateau Vernal Pool Region in Lassen, Plumas, Shasta, and Siskiyou Counties, with 25 extant occurrences (33 percent). The portion of Shasta County that is in the Northwestern Sacramento Valley Vernal Pool Region has 12 extant occurrences (16 percent). The Lake-Napa Vernal Pool Region accounts for two extant occurrences, both in Lake County; three occurrences are in Sacramento County, in the Southeastern Sacramento Valley Vernal Pool Region; and the one remaining occurrence, in Shasta County (California Natural Diversity Data Base Element Occurrence 69), is outside of mapped vernal pool regions (Stone *et al.* 1988, Corbin and Schoolcraft 1989, B. Corbin *in litt.* 1999, California Natural Diversity Data Base 2005, K. Fuller *in litt*. 2005).

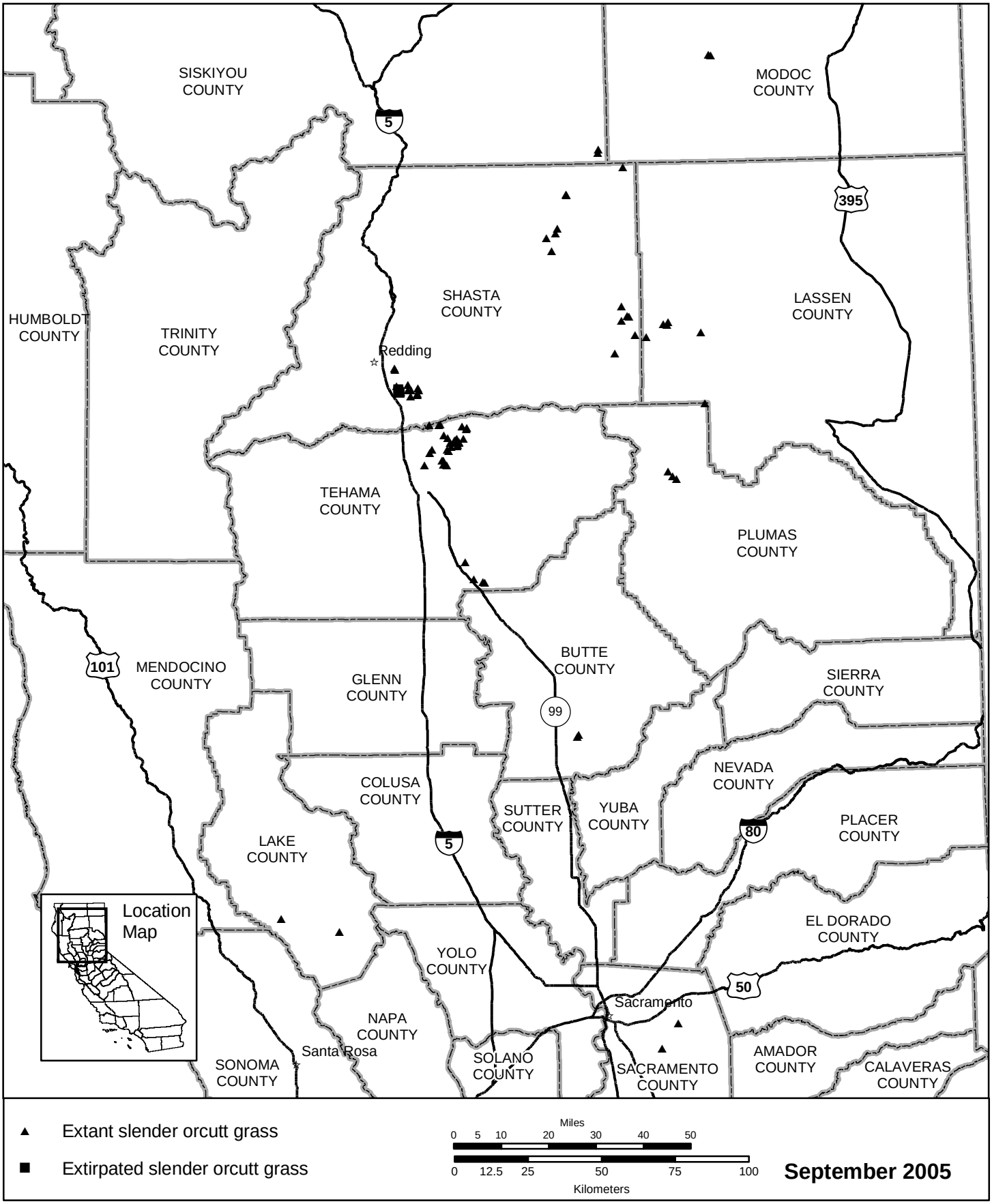

Figure II-15. Distribution of *Orcuttia tenuis* (slender Orcutt grass).

c. Life History and Habitat

The general life history of *Orcuttia tenuis* is similar to that of *O. inaequalis* and *Neostapfia colusana,* as discussed previously in this recovery plan.

Reproduction and Demography.—Optimal germination of *Orcuttia tenuis* is achieved through stratification followed by warm days and mild nights (Griggs 1974 as cited in Stone *et al.* 1988). Peak flowering of this species typically occurs in May in the Central Valley (Griggs 1981, Reeder 1982), but not until June or July on the Modoc Plateau (B. Corbin *in litt.* 2000, G. Schoolcraft *in litt.* 2000). Unlike *O. pilosa* and *Tuctoria greenei*, *O. tenuis* is not likely to die when pools are flooded by late spring or summer rains. At two sites near Dales that were inundated by rains in May 1977, *O. tenuis* plants dropped their existing inflorescences, but resprouted and flowered again within 1 month (Griggs 1980, Griggs and Jain 1983). Moreover, the population at the Vina Plains Preserve in Tehama County experienced a second pulse of germination after summer rains in 1982 (Broyles 1983, cited in Alexander and Schlising 1997). Conversely, drought has been known to cause 100 percent mortality of local populations (Griggs 1980, Griggs and Jain 1983).

Similar to other vernal pool annuals, *Orcuttia tenuis* populations can vary greatly in size from year to year. Fluctuations of up to four orders of magnitude have been documented in Lake and Shasta Counties (Griggs 1980, Griggs and Jain 1983). At the Vina Plains Preserve, the single population ranged in size from 1,000 to 147,700 estimated individuals during the 5 times it was reported over a 13-year period (Stone *et al.* 1988, Alexander and Schlising 1997). However, *O. tenuis* populations do not always fluctuate in size. Among five populations of *O. tenuis* that Griggs tracked from 1973 to 1979, two remained at the same order of magnitude for the entire period; both were in the Dales area. None of the other five species of Orcuttieae included in the study remained stable for the full 7 years (Griggs 1980, Griggs and Jain 1983).

Seeds of *Orcuttia tenuis* germinate even in dry years, but the proportion of plants surviving to maturity varies. In a 1977 demographic study of two *O. tenuis* populations near Dales and a third near Redding (Griggs 1980, Griggs and Jain 1983), survivorship ranged from 0 to 75 percent, averaging 40 percent. At the two sites near Dales, densities of *O. tenuis* were 694 and 1,530 plants per square meter (64.5 and 142.1 plants per square foot, respectively) in 1977 (Griggs 1980, Griggs and Jain 1983). At the Vina Plains Preserve, the single occupied pool had a density of 71 plants per square meter (6.6 plants per square foot) in 1995 (Alexander and Schlising 1997). *Orcuttia tenuis* produced an average of 58 seeds per plant in 1977, ranging from 11.3 to 163.9 among the populations studied. At

one Dales-area site, the soil seed bank was estimated to be more than 14 times greater than the population of growing plants in 1977 (Griggs 1980, Griggs and Jain 1983).

Griggs (1980, Griggs and Jain 1983) reported that most of the genetic diversity in *Orcuttia tenuis* occurred among individuals with the same seed parent. He found nearly as much genetic diversity within a single population, but little difference between populations. However, his study included only two populations from Tehama County, which were in close proximity. One of the Sacramento County populations differs considerably from other occurrences in outward appearance, suggesting that it may differ in genetic makeup (S. Cochrane *in litt.* 1995*a*).

Habitat and Community Associations.—*Orcuttia tenuis* is found primarily on substrates of volcanic origin (Crampton 1959, Corbin and Schoolcraft 1989). Natural pools in which *O. tenuis* grows are classified as Northern Volcanic Ashflow and Northern Volcanic Mudflow vernal pools (Sawyer and Keeler-Wolf 1995). However, this species has also been reported from other natural and artificially-created seasonal wetlands such as creek floodplains, stock ponds, and borrow pits. Impervious layers range from iron-silica hardpan to bedrock (Stone *et al.* 1988, Corbin and Schoolcraft 1989, California Natural Diversity Data Base 2003). Among the populations studied by Stone *et al.* (1988), the median area of pools occupied by *O. tenuis* was 0.65 hectare (1.6 acres) and ranged from 0.08 to 45 hectares (0.2 to 111 acres). On the Modoc Plateau, occupied pools known as of 1989 ranged in size from 2 to 40 hectares (5 to 100 acres) and were typically at least 30 centimeters (11.8 inches) deep; this species was restricted to the deepest areas of these pools (Corbin and Schoolcraft 1989). *Orcuttia tenuis* occurs across a wide range of elevations corresponding to its broad geographical range. The lowest reported elevation is 27 meters (90 feet) in Sacramento County (Stone *et al.* 1988) and the highest is 1,756 meters (5,761 feet) in Plumas County (B. Corbin *in litt.* 1999).

Soil types supporting *Orcuttia tenuis* are similarly diverse, ranging from slightly to strongly acidic (Stone *et al.* 1988) and from clay to sandy, silty, or cobbly loam (Corbin and Schoolcraft 1989, California Natural Diversity Data Base 2003 and unprocessed data). The soil series has not been reported for all *O. tenuis* sites, but includes at least the following, by region: In the Lake-Napa Vernal Pool Region, this species occurs on the Collayomi-Aiken-Whispering complex and the Konocti-Hambright complex; Modoc Plateau populations occur on the Gooval, Lasvar, Lasvar-Pitvar complex, and Nosoni soil series; and those in the Northeastern Sacramento Valley are on the Anita, Guenon, Inks, Inskip, Laniger, Moda, Redding, Toomes, and Tuscan soil series. The Redding soil series also supports *O. tenuis* in the Southeastern Sacramento Valley Vernal Pool Region (Stone *et al.* 1988, California Natural Diversity Data Base 2003).

Vegetation types in which the occupied pools occur are diverse, ranging from grassland and oak woodland to mixed conifer forest, *Artemisia cana* (silver sagebrush) flats, and sedge meadows (Crampton 1959, California Natural Diversity Data Base 2003). Associated species vary throughout the range of *Orcuttia tenuis*. Among the most common associates in the Sacramento Valley are *Plagiobothrys stipitatus*, *Eleocharis macrostachya* (pale spikerush), *Eryngium* spp., *Navarretia leucocephala*, and *Marsilea vestita*. At other locations throughout northern California, *O. tenuis* occurs with a wide variety of plants, including various species of *Downingia*, *Eryngium*, and *Navarretia* (Stone *et al.* 1988, Corbin and Schoolcraft 1989, Alexander and Schlising 1997, California Natural Diversity Data Base 2003). *Orcuttia tenuis* also co-occurs with several of the other species addressed in this recovery plan, including *Navarretia leucocephala* ssp. *plieantha* and *Gratiola heterosepala* at Boggs Lake in Lake County (California Natural Diversity Data Base 2003), *G. heterosepala* and *Legenere limosa* at Dales Lake Ecological Reserve and Hog Lake in Tehama County (C. Witham *in litt.* 2000*a*), *Tuctoria greenei* at Laniger Lakes in Tehama County, and *G. heterosepala* at nine other sites in Tehama County and four sites in Shasta County (Stone *et al.* 1988, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2003). Although *O. tenuis* grows in the same vernal pool complexes as *O. pilosa* in Tehama County (including the Vina Plains Preserve) and *O. viscida* in Sacramento County, it has not been found to share any pools with either of these two species (Stone *et al.* 1988, S. Cochrane *in litt.* 1995*a*, Alexander and Schlising 1997, California Natural Diversity Data Base 2003).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Orcuttia tenuis* are described below.

A number of specific threats are continuing for this species. In particular, urbanization is a continuing threat to *Orcuttia tenuis* populations in the vicinity of Redding and Sacramento. Off-road vehicle use is a particular problem near Redding and in forested areas of the Modoc Plateau. Despite the comparatively wide range of *O. tenuis*, small population size is of concern in the Lake-Napa Vernal Pool Region and the Millville Plains-Stillwater Plains area of the Northeastern and Northwestern Sacramento Valley Vernal Pool Regions.

e. Conservation Efforts

Orcuttia tenuis was federally listed as threatened on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*) and has been State listed as endangered since 1979 (California Department of Fish and Game 1991). This species was recognized as rare and endangered by the California Native Plant Society as early as 1974 (Powell 1974) and is now included on List 1B and is considered to be "endangered throughout its range" (California Native Plant Society 2001). In 2005, critical habitat was designated for *O. tenuis* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Four natural occurrences of *Orcuttia tenuis* are in designated preserves. These include the Trust for Wildland Communities' Boggs Lake Preserve in Lake County, The Nature Conservancy's Vina Plains Preserve in Tehama County, and two occurrences on the California Department of Fish and Game's Dales Lake Ecological Reserve in Tehama County (Broyles 1987, Stone *et al.* 1988, California Natural Diversity Data Base 2003). All four populations are monitored annually (Baldwin and Baldwin 1989*a*, 1989*b*, 1991; D. Alexander pers. comm. 1997; California Natural Diversity Data Base 2003). Also, a conservation area containing a population of *O. tenuis* was recently established in Sacramento County to compensate for impacts to vernal pools (K. Fuller *in litt.* 2000). An unknown number of additional occurrences are protected from development by conservation easements; one is in Shasta County (California Natural Diversity Data Base 2003), and the others are in the Dales Lake area of Tehama County, where a private landowner put more than 16,188 hectares (40,000 acres) of ranch land into a conservation easement in cooperation with The Nature Conservancy (C. Witham *in litt.* 2000*a*).

Introductions of *Orcuttia tenuis* have been attempted at two privately-owned sites. In 1978, *O. tenuis* was seeded into two adjacent "ponds" in Chico, Butte County. Fewer than 100 plants grew in the 2 ponds that year or in 1979 (Griggs 1980), which was the last time the population size was reported. The other introduction was in 1982, when *O. tenuis* was seeded into an artificial pool in Shasta County. As of 1987, the population was thriving (California Natural Diversity Data Base 2003), but its current size is not known. An unintentional introduction may have taken place at the Dales Lake Ecological Reserve. In 1995, *O. tenuis* appeared in 11 of 21 artificially-created vernal pools there, possibly because its seeds were contained in plant litter from nearby natural pools that was spread on the surface of the created pool (C. Witham *in litt.* 2000*a*). The California Natural Diversity Data Base (2003) considers those 11 pools to

comprise 3 Element Occurrences, but the populations may not be viable; very few plants were found in 1995 and only 1 of the pools still supported *O. tenuis* in 1999 (C. Witham *in litt.* 2000*a*).

Twenty-seven of the 76 (36 percent) extant occurrences of *Orcuttia tenuis* are wholly or partially on Federal land. Seventeen of these are managed by the U.S. Forest Service, primarily the Lassen National Forest, although one is on the Shasta-Trinity National Forest. The other 10 are on lands controlled by the U.S. Bureau of Land Management; 9 of these are in the Redding Resource Area and the other is in the Alturas Resource Area. Two of the occurrences on the Lassen National Forest, Adobe North and South Vernal Pools, are within an area that has been proposed as a Research Natural Area (B. Corbin *in litt.* 2000). The Green Place Reservoir occurrence in Shasta County is within a Wilderness Study Area and has been jointly proposed by the U.S. Bureau of Land Management and the Lassen National Forest as a Research Natural Area (G. Schoolcraft *in litt.* 2000).

The Lassen National Forest and Susanville District of the U.S. Bureau of Land Management jointly prepared a management plan for *Orcuttia tenuis* sites under their administration (including those in the Shasta-Trinity National Forest) in order to ensure the long-term survival of the species (Corbin and Schoolcraft 1989). Actions identified in that plan included avoidance of known populations, maintenance of natural hydrology, monitoring selected populations, and surveys in suitable habitats. As a result of the plan, several areas have been fenced to exclude livestock and a considerable number of additional populations have been discovered (B. Corbin *in litt.* 1999, B. Corbin *in litt.* 2000, G. Schoolcraft *in litt.* 2000, California Natural Diversity Data Base 2003).

Substantial information on the demography, ecology, and genetics of *Orcuttia tenuis* was provided by Griggs (1980) through his doctoral research. Also, a status survey funded by us led to the discovery of 18 new *O. tenuis* occurrences (Stone *et al.* 1988). In addition, U.S. Forest Service personnel subsequently discovered 16 additional occurrences on public land (California Natural Diversity Data Base 2003). In 1995, the California Department of Fish and Game sponsored a workshop focusing on recovery strategies for *Orcuttia* species in Sacramento County (S. Cochrane *in litt.* 1995*a*, *in litt.* 1995*b*). A study of vernal pools on the Vina Plains preserve that was conducted in 1995 provided additional ecological information and management recommendations; we supported this research through section 6 funding (Alexander and Schlising 1997).

12. *ORCUTTIA VISCIDA* (SACRAMENTO ORCUTT GRASS)

a. Description and Taxonomy

Taxonomy.—Sacramento Orcutt grass is in the tribe Orcuttieae of the grass family Poaceae (Reeder 1965). Hoover (1941) first published the scientific name *Orcuttia californica* var. *viscida* for Sacramento Orcutt grass. He had collected the type specimen from "7 miles south of Folsom" in Sacramento County (Hoover 1941:155). Although Hoover recognized that Sacramento Orcutt grass differed from California Orcutt grass in several respects, he did not consider the former to represent a distinct species. However, Reeder (1980) determined that the differences in morphology, seed size, and chromosome number were sufficient grounds to elevate Sacramento Orcutt grass to the species level as *Orcuttia viscida*. Reeder's taxonomy has been accepted since that time. Other common names for this species include Sacramento orcuttia (Smith *et al.* 1980) and sticky Orcutt grass (California Department of Fish and Game 1987*c*).

Description and Identification.—In basic form, *Orcuttia viscida* resembles other members of the tribe and genus. Although all members of the Orcuttieae produce exudate, *O. viscida* is particularly viscid even when young, hence the scientific name. The plants are densely tufted, bluish-green, and covered with hairs. The stems are erect or spreading, 3 to 10 centimeters (1.2 to 3.9 inches) long, and do not branch. Leaf width is 2 to 4 millimeters (0.08 to 0.16 inch). The inflorescence occupies the upper one-third to one-half of the stem and consists of between 5 and 15 spikelets. The spikelets are closely spaced, and although distichous, are oriented towards one side of the stem. Each spikelet contains 6 to 20 florets. The lemmas are 6 to 7 millimeters (0.24 to 0.28 inch) long and divided about halfway into teeth; the central tooth is longer than the others. The teeth are tipped with bristles 1 millimeter (0.04 inch) or more in length. The tips of the lemma teeth bend downward slightly, giving the inflorescence a bristly appearance. Seeds of *O. viscida* are about 2.5 millimeters (0.10 inch) long (Hoover 1941; Griggs 1977*a*; Reeder 1982, 1993; Stone *et al.* 1988) and weigh about 0.45 milligram (1.6×10^{-5} ounce) (Griggs 1980, Griggs and Jain 1983). The diploid chromosome number is 28 (Reeder 1980).

Orcuttia viscida has unequal lemma teeth, unlike *O. pilosa* and *O. tenuis*. Both *O. californica* and *O. inaequalis* have unequal lemma teeth but can be distinguished from *O. viscida* by the length of the lemma and its teeth and

bristles, the size and density of the inflorescence, and the size of the seeds. Moreover, the chromosome number of *O. viscida* differs from all other *Orcuttia* species (Reeder 1982).

b. Historical and Current Distribution

Historical Distribution.—*Orcuttia viscida* is endemic to the Southeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998) and always has been restricted to Sacramento County (**Figure II-16**). The earliest collection was from 1936 near Phoenix Field. Three other occurrences documented in 1941 and 1958 extended the range north to Orangevale and south to near Sloughhouse. *Orcuttia viscida* was introduced to Phoenix Park, in Sacramento County, in 1978. Three additional natural occurrences were discovered in the late 1980s, including one in extreme southeastern Sacramento County near Route 104. Thus, by 1990, this species was known from a total of seven natural occurrences and one introduction (Stone *et al.* 1988, California Natural Diversity Data Base 2003).

Current Distribution.—Within the past two decades, *Orcuttia viscida* has been discovered at one new site in Sacramento County, within the previously known range. However, one entire occurrence and a portion of another have been extirpated. Thus, eight of the nine occurrences are extant. Five occurrences, comprising more than 70 percent of the occupied habitat, are concentrated into a single area of about 6 square kilometers (2.3 square miles) in the Rancho Cordova area east of Mather Field. Two other occurrences are adjacent to each other: Phoenix Field Ecological Reserve and the introduced population at Phoenix Park. The eighth extant occurrence is near Rancho Seco Lake (Stone *et al.* 1988, S. Cochrane *in litt.*1995*a*, S. Morey *in litt.* 1996, California Natural Diversity Data Base 2003). All occurrences are in the Southeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998).

c. Life History and Habitat

Basic life history and habitat requirements of this plant are likely similar to those described above in the species accounts for *Orcuttia inaequalis* and *Neostapfia colusana*.

Reproduction and Demography.—*Orcuttia viscida* flowers in May and June (Griggs 1977a, Skinner and Pavlik 1994, S. Cochrane *in litt.* 1995*a*) and sets seed in June and July (Holland 1987). The plants are adapted for wind pollination, but do provide a source of pollen for native bees (Griggs 1974 as

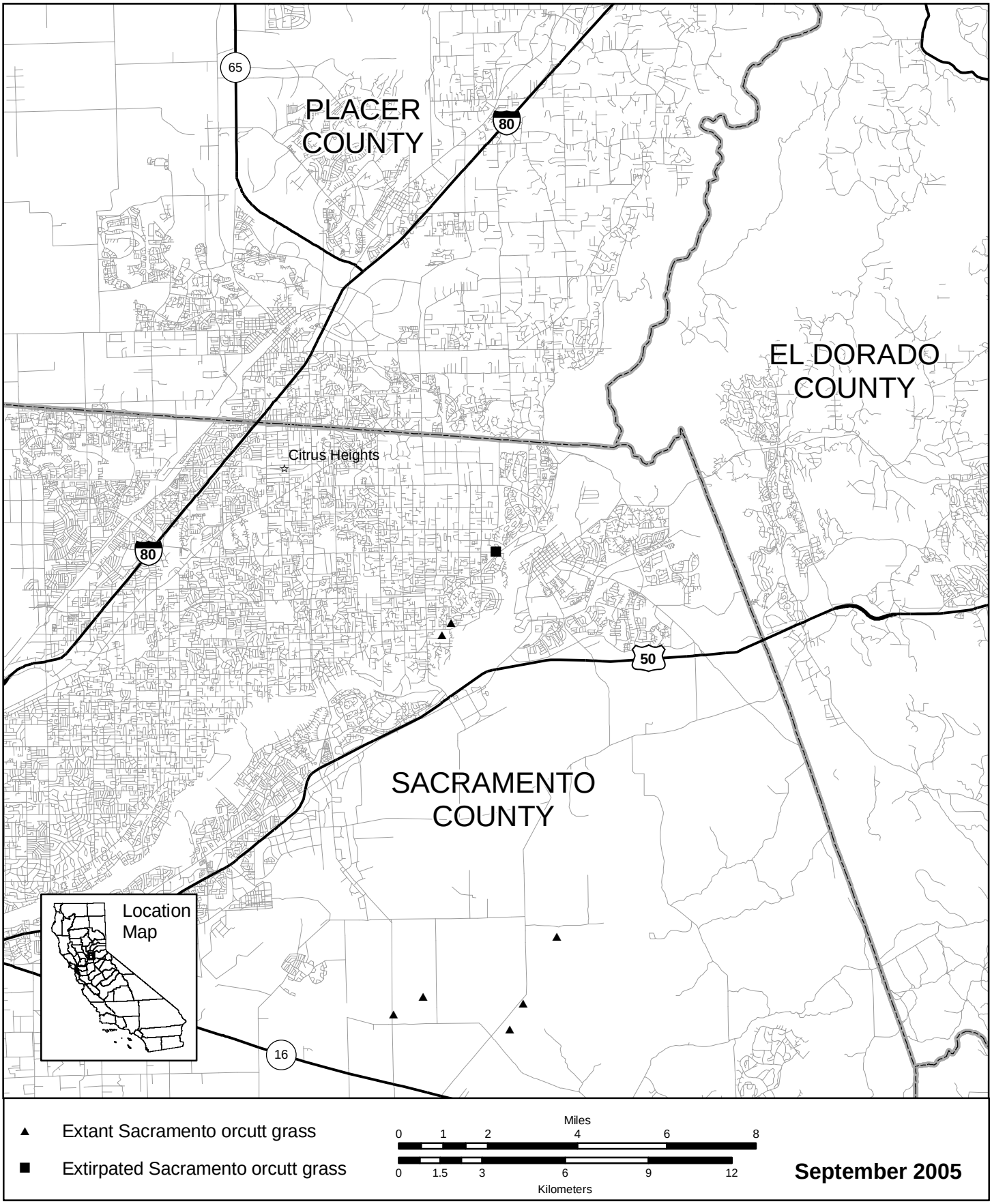

Figure II-16. Distribution of *Orcuttia viscida* (Sacramento Orcutt grass).

cited in Stone *et al.* 1988). Seeds likely do not disperse far under natural conditions. In a 6-year period, an experimental population spread at most 3 meters (10 feet) from the seed source, and 95 percent of plants were within 30 centimeters (11.8 inches) of the source (R. Holland *in litt.* 1986). A demographic study conducted from 1974 to 1978 (Griggs 1980, Griggs and Jain 1983) indicated that *O. viscida* produced an average of 500 seeds per plant. At one site in 1978, 88 percent of plants survived to maturity. The size of the seed bank stored in the soil was about 44 times as great as the population of growing plants (Griggs 1980, Griggs and Jain 1983). The number of plants varies with rainfall. Large numbers of plants grow only in years when seasonal rainfall exceeds 40 centimeters (15.7 inches), particularly when heavy rains begin in November and continue through the end of April (Holland 1987). This species is apparently less likely to germinate in years of below-normal precipitation than are other members of the tribe (Griggs 1980, Griggs and Jain 1983). In studies of enzyme systems, genetic diversity between populations of *O. viscida* was low. However, plants from the primary area of concentration had alleles that did not occur in other areas. The amount of genetic variation occurring among related individuals was about equal to that within populations (Griggs 1980, Griggs and Jain 1983).

Habitat and Community Associations.—*Orcuttia viscida* has been found in Northern Hardpan and Northern Volcanic Mudflow vernal pools (Sawyer and Keeler-Wolf 1995). It occurs on high-terrace sites (Stone *et al.* 1988) at elevations of 46 to 82 meters (150 to 270 feet) (California Natural Diversity Data Base 2005). Occupied pools occur in *Quercus douglasii* woodland and annual grassland (Crampton 1959, Griggs 1977a, California Natural Diversity Data Base 2005). Among occupied pools discovered prior to 1988, the median area was 0.28 hectare (0.69 acre) and ranged from 0.1 hectare (0.25 acre) to 0.82 hectare (2.03 acres). Soils underlying pools where *O. viscida* grows are acidic with an iron-silica hardpan (Stone *et al.* 1988), and the pools contain numerous cobbles (Crampton 1959, Stone *et al.* 1988). Four of the known occurrences are on soils in the Redding series, two are on Red Bluff-Redding complex soils, two are (or were) on Xerarents-urban land-San Joaquin complex, and one is on Corning complex soils. The most common associates of *Orcuttia viscida* are *Plagiobothrys stipitatus*, *Eryngium* spp., *Eleocharis macrostachya*, and *Psilocarphus brevissimus* (Stone *et al.* 1988). *Gratiola heterosepala* co-occurs with *O. viscida* in one pool (Stone *et al.* 1988, California Natural Diversity Data Base 2005). One population of *O. tenuis* grows in the same vicinity as *O. viscida*, but the two species have not been found together (Cochrane *in litt.* 1995*a*).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Orcuttia viscida* are described below.

Urbanization is a continuing threat, particularly in the Rancho Cordova area (S. Cochrane *in litt.* 1995*a*). Expansion of the Kiefer Landfill in Sacramento County may adversely affect the occurrences adjacent to the new landfill footprint (S. Cochrane *in litt.* 1995*a*, U.S. Fish and Wildlife Service 2005). At present, trash from the landfill frequently blows into the pools (S. Cochrane *in litt.* 1995*b*). An industrial park and road widening are other urban-related factors that threaten *Orcuttia viscida* (Stone *et al.* 1988, S. Cochrane *in litt.* 1995*a*). The Phoenix Field Ecological Reserve and Phoenix Park occurrences are in an urban landscape. The Ecological Reserve is completely surrounded by housing and the vernal pools are buffered by as little as 3 feet (1 meter) from adjacent residential backyards (D. Burmester, pers. comm. 2005). They are affected by excess runoff from lawns, ball fields, and roads; by herbicide and fertilizer applied in adjacent areas (Griggs and Jain 1983, R. Holland *in litt.* 1986, Stone *et al.* 1988, S. Cochrane *in litt.* 1995*a*, S. Morey *in litt.* 1996, Clark *et al.* 1998); and by dumping of landscape waste (Clark *et al.* 1998). The California Department of Fish and Game installed a drain to prevent urban and landscape runoff from entering the vernal pools (M. Showers, *in litt*. 2005). Another threat at the Phoenix Field Ecological Reserve is invasion of garden plants (Clark *et al.* 1998, California Natural Diversity Data Base 2003). Recreational activities such as rollerblading (C. Witham *in litt.* 2000*a*), biking, and horseback riding (S. Cochrane *in litt.* 1995*a,b*; Clark *et al.* 1998) also pose continuing threats of damage to the Phoenix Park occurrence of this plant. In addition, competition from other native plants, such as *Eleocharis macrostachya* and nonnative plants such as *Glyceria* spp. (mannagrass) could displace *O. viscida* (Stone *et al.* 1988, S. Cochrane *in litt.* 1995*a,b*; Clark *et al.* 1998). Mining, off-road vehicle use, and vandalism also threaten one or more specific occurrences (U.S. Fish and Wildlife Service 1997*a*). Although the individual populations of *O. viscida* are sufficiently large that they are not subject to random fluctuations such as genetic drift, the very restricted range of the species as a whole puts it in continued danger of extinction from random, catastrophic events.

e. Conservation Efforts

Orcuttia viscida was federally listed as an endangered species on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*) and had been previously State-listed as endangered in 1979 (California Department of Fish and Game 1991). The California Native Plant Society has included it on lists of very rare and endangered plants for over two decades (Powell 1974); *O. viscida* is currently on List 1B, with the highest endangerment rating possible (California Native Plant Society 2001). In 2005, critical habitat was designated for *O. viscida* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Two reserves have been set aside to protect *Orcuttia viscida*. The Phoenix Field Ecological Reserve encompasses 3.2 hectares (8 acres) and is managed by the California Department of Fish and Game. The site has been fenced, and only authorized persons have access. The California Department of Fish and Game plans to install a drain to prevent urban and landscape runoff from entering the pools. Volunteers and agency personnel monitor the *O. viscida* population periodically (S. Morey *in litt.* 1996, Clark *et al.* 1998). The nearby Phoenix Park Vernal Pool Preserve encompasses 5.7 hectares (14 acres) and is managed by the Fair Oaks Recreation and Park District. A low fence excludes motorized vehicles, but allows foot traffic. Interpretive signs and a footbridge also have been installed (Clark *et al.* 1998).

Griggs (1980) studied the ecology, demography, and genetics of several species in the Orcuttieae tribe, including *Orcuttia viscida*. In the course of his research, he introduced local seeds into an unoccupied, natural pool in Phoenix Park. The introduction apparently was successful because the population has persisted and remained stable since 1978 (S. Cochrane *in litt.* 1995*a*, California Natural Diversity Data Base 2003).

We funded a status survey for members of the Orcuttieae in the 1980s, which led to the discovery of several new populations (Stone *et al.* 1988). The California Department of Fish and Game sponsored a native plant recovery workshop in 1995 to develop recovery strategies for *Orcuttia viscida* (S. Cochrane *in litt.* 1995*a*). Workshop participants have since conducted several tasks contributing to the species' recovery, including monitoring populations, assessing threats, and providing public education (S. Cochrane *in litt.* 1995*b*, S. Morey *in litt.* 1996).

13. *PARVISEDUM LEIOCARPUM* (LAKE COUNTY STONECROP)

a. Description and Taxonomy

Taxonomy.—Lake County stonecrop is in the stonecrop family (Crassulaceae) and is one of only three (Moran 1997) or four (Clausen 1946, Denton 1993) species in the genus *Parvisedum*, depending on individual interpretations by taxonomists. The original scientific name for Lake County stonecrop was *Sedella leiocarpa* (Sharsmith 1940). The type locality was cited as "6.5 miles north of Lower Lake, Lake County, California" (Sharsmith 1940:193). Clausen (1946) changed the name of this species to *Parvisedum leiocarpum* because the genus name *Sedella* already had been applied to another group of plants. However, Moran (1997) returned to using the name *Sedella leiocarpa* for Lake County stonecrop, after another taxonomist determined that the genus name *Sedella* had been used improperly for the other group of plants. We originally listed the species as endangered under the name *Parvisedum leiocarpum* (U.S. Fish and Wildlife Service 1997b) and we have not yet formally changed our nomenclature for the species, so in this recovery plan we continue to refer to it by the scientific name *Parvisedum leiocarpum*.

Description and Identification.—*Parvisedum leiocarpum* (**Figure II-17**) is a tiny, fleshy, annual herb. The reddish, hairless stems are at most 5 centimeters (2.0 inches) tall and may or may not be branched. Leaf arrangement is opposite at the base of the plant and alternate on the upper stem. The 2 to 5 millimeter-long (0.08 to 0.20 inch-long) leaves are entire, fleshy, and green with red streaks; the bracts are similar but smaller. The leaves fall off the stem before the flowers open, but the bracts persist. On each branch of the inflorescence, the flowers are crowded together in two rows, which are both on the same side of the branch. The individual flowers are 3 to 4 millimeters (0.12 to 0.16 inch) wide and about the same length. Flowers typically have five petals and other parts (sepals, pistils, and stamens), but occasionally have four of each flower part. The petals range in color from pale yellow to chartreuse, have reddish streaks on the back, and are about 2.6 to 3.8 millimeters (0.10 to 0.15 inch) long with light fusing at the base. Each petal has a flattened, reddish nectar-producing gland at its base; the glands are 0.5 to 0.8 millimeter (0.02 to 0.03 inch) in length. Each pistil develops into a dry, hairless fruit 1.5 to 2.5 millimeters (0.06 to 0.10 inch) long, which contains a single seed. The narrow seeds are light brown and 1 to 1.5 millimeters (0.04 to 0.06 inch) long (Sharsmith 1940, Clausen 1975, Denton 1993, Moran 1997). *Parvisedum leiocarpum* has a diploid chromosome number of 18 (Moran 1997), as do all other species in the genus (Clausen 1975, Denton 1993). The species most likely to be confused with *P. leiocarpum* is *P. pentandrum* (Mt. Hamilton stonecrop), which overlaps in range. However, the

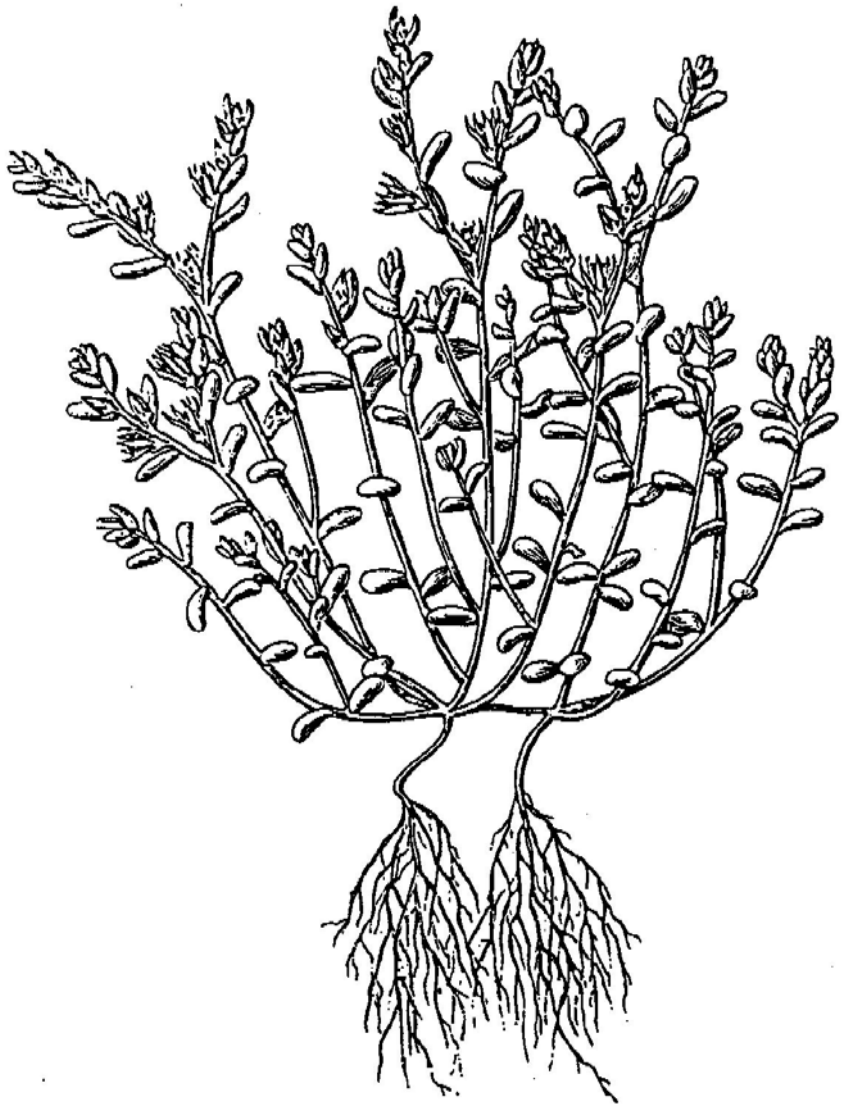

Figure II-17. Illustration of *Parvisedum leiocarpum* (Lake County stonecrop). Drawing by Elfriede Abbe, reprinted from R.T. Clausen, *Sedum of North America North of the Mexican Plateau.* Copyright © 1975 by Cornell University. Used by permission of the publisher, Cornell University Press.

latter is a taller plant with smaller flowers, nectaries, fruits, and seeds; the petals do not have red streaks on the back; and the fruits are glandular-hairy.

Other species of *Parvisedum* have 10 stamens. *Crassula connata* (pygmy stonecrop), another inconspicuous annual species in the same family, has strictly opposite leaves that are fused at the base and very tiny flowers in the leaf axils. Other genera in the family are perennial or have more seeds per pistil (Sharsmith 1940, Clausen 1975, Denton 1993).

b. Historical and Current Distribution

Historical Distribution.—Current evidence indicates that this species always has been restricted to southeastern Lake County, and to the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-5**). *Parvisedum leiocarpum* was known historically from six to eight occurrences west and south of Clear Lake, where it was collected repeatedly between 1936 and 1961. The exact number of sites is uncertain because several vague location descriptions may or may not refer to the same site. All collections were from the area roughly bounded by Kelseyville, Lower Lake, and Middletown (Patterson 1986). Manning Flat, which is along Highway 29 west of Lower Lake, apparently represents the type locality (Moran 1997). Although it is west rather than north of Lower Lake, Clausen (1975:597) noted that the type specimen was collected "on Kelseyville Highway," which apparently refers to Highway 29. *Parvisedum leiocarpum* was not observed between 1963 (Clausen 1975) and the late 1980s, when it was rediscovered at three of the historical localities (Patterson 1986, 1988; California Natural Diversity Data Base 2003). A sixth population was discovered in 1995 near Snows Lake in Lake County (Moran 1997), but is not catalogued by the California Natural Diversity Data Base (2005).

Current Distribution.—The four occurrences of *Parvisedum leiocarpum* last seen in the 1980s and 1990s are assumed to be extant, although they have not been revisited. Two others not seen since the 1940s also are assumed to remain extant because suitable habitat remained in the vicinity of those collections as of 1986. Three of those six occurrences, including Manning Flat, are along Highway 29. The other three occurrences include one farther south near Whispering Pines, one southeast of Lower Lake in Little High Valley (Patterson 1986, 1988; California Natural Diversity Data Base 2005), and one at Snows Lake (Moran 1997). All known occurrences are in the Boggs Lake-Clear Lake Core Area in the Lake-Napa Vernal Pool Region.

c. Life History and Habitat

Reproduction and Demography.—Relatively little is known about the life history and demography of *Parvisedum leiocarpum*. It is an annual that flowers in April and May (Clausen 1975, California Department of Fish and Game 1990*b*, Skinner and Pavlik 1994, Moran 1997). The presence of conspicuous nectaries suggests that the flowers are insect-pollinated. Seed dispersal is likely very limited in extent. The seeds normally remain inside the fruits and the fruits remain on the plants even after the growing season (Moran 1997). Water is one possible dispersal mechanism because the fruits can float if detached (Moran 1997). *Parvisedum leiocarpum* typically occurs in dense patches with few other plants (Clausen 1975), although Patterson (1988) found one colony that was very sparse. The number of individual plants in a population can be high, even when it occupies a very small area due to the high density and the small size of each plant.

Habitat and Community Associations.—*Parvisedum leiocarpum* occurs on more or less level sites in shallow depressions that retain water seasonally. Known microhabitats include Northern Basalt Flow and Northern Volcanic Ashflow vernal pools (Sawyer and Keeler-Wolf 1995), low areas in meadows and gravelly flats, and hollows in exposed rocks. A few plants were found on a man-made berm within a flat that supported a large population. The occupied habitats occur adjacent to oak woodland, chaparral, or grassland. Substrates on which *P. leiocarpum* occur frequently are of volcanic origin and often are gravelly (Patterson 1986). Soil pH at one site ranged from 6.2 to 6.4 (Clausen 1975). Soil types are not known for all historical sites, but this species grows on at least the Glenview-Bottlerock complex, the Konocti-Benridge complex, the Konocti Variant-Konocti-Hambright complex and the Speaker-Sanhedrin-Maymen association.

Extant and historical localities ranged in elevation from 518 to 792 meters (1,700 to 2,600 feet) (Moran 1997, California Natural Diversity Data Base 2003). Plants that frequently grow in the same vernal pools and meadows with *Parvisedum leiocarpum* include *Mimulus tricolor, Lasthenia fremontii*, and *Plagiobothrys stipitatus*. The only immediate associate in the rock pools at the Little High Valley site is an unidentified moss (class Musci). Two other plants featured in this recovery plan co-occur with *Parvisedum leiocarpum*: *Navarretia leucocephala* ssp. *pauciflora* co-occurs at three sites, and *Gratiola heterosepala* is present at one of the three. *Lasthenia burkei*, an endangered plant that is not addressed in this recovery plan, occurs at Manning Flat, but is found across the road from the *Parvisedum leiocarpum* population (Patterson 1986, California Natural Diversity Data Base 2003).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Parvisedum leiocarpum* are described below.

Land conversion for housing and agriculture, highway widening, and road maintenance continue as specific threats to *Parvisedum leiocarpum* habitat at five of the historical localities (Patterson 1986, California Department of Fish and Game 1990*b*). At each of the presumed extant occurrences, *P. leiocarpum* occupies no more than 0.04 hectare (0.1 acre), so even small habitat losses to any of these factors could easily extirpate an entire population (Patterson 1986). Also, the extremely small populations are highly vulnerable to elimination from random fluctuations in environmental conditions, natural catastrophes, and genetic bottlenecks (Menges 1991); the restricted range of the species means that a regional catastrophe could drive the entire species to extinction.

e. Conservation Efforts

Parvisedum leiocarpum was federally listed as an endangered species on June 18, 1997 (U.S. Fish and Wildlife Service 1997*b*). *Parvisedum leiocarpum* was previously State listed as endangered in 1990 (California Department of Fish and Game 1991). The California Native Plant Society has recognized this species as rare and endangered since its first list was published (Powell 1974); it is still on the California Native Plant Society List 1B, assigned the highest endangerment rating possible (California Native Plant Society 2001).

The California Department of Fish and Game funded a status survey of *Parvisedum leiocarpum* in 1986 (Patterson 1986). Patterson conducted additional surveys in 1987, then petitioned the California Fish and Game Commission to list *P. leiocarpum* as an endangered species (Patterson 1988). None of the localities for this species are in public ownership, and no conservation measures have been implemented by any of the landowners.

14. *TUCTORIA GREENEI* (GREENE'S TUCTORIA)

a. Description and Taxonomy

Taxonomy.—The genus *Tuctoria* is in the grass family (Poaceae), subfamily Chloridoideae, and is a member of the Orcuttieae tribe, which also includes *Neostapfia* and *Orcuttia* (Reeder 1965, Keeley 1998). Vasey (1891:146) originally assigned the name *Orcuttia greenei* to this species, from a type specimen collected in 1890 "on moist plains of the upper Sacramento, near Chico, California," presumably in Butte County (Hoover 1941, Crampton 1958). Citing differences in lemma morphology, arrangement of the spikelets, and other differences (see "Description" below), Reeder (1982) segregated the genus *Tuctoria* from *Orcuttia* and created the new scientific name *Tuctoria greenei* for this species. Subsequent research suggests that *Tuctoria* is intermediate in evolutionary position between the primitive genus *Neostapfia* and the advanced genus *Orcuttia* (Keeley 1998, L. Boykin *in litt.* 2000). Several other common names have been used for this species, including Chico grass (Scribner 1899), awnless Orcutt grass (Abrams 1940), Greene's orcuttia (Smith *et al.* 1980), and Greene's Orcutt grass (California Department of Fish and Game 1991, U.S. Fish and Wildlife Service 1985*c).*

Description and Identification.—The basic characteristics pertaining to all members of the Orcuttieae were described above in the *Neostapfia colusana* account. The genus *Tuctoria* is characterized by flattened spikelets similar to those of *Orcuttia* species, except that the spikelets of *Tuctoria* grow in a spiral, as opposed to a distichous, arrangement. *Tuctoria* species have short-toothed, narrow lemmas. The juvenile and terrestrial leaves of *Tuctoria* are similar to those of *Orcuttia*, but *Tuctoria* does not produce the floating type of intermediate leaves (Reeder 1982, Keeley 1998). *Tuctoria* appears to be intermediate between *Neostapfia* and *Orcuttia* in its degree of aquatic specialization (Keeley 1998).

Tuctoria greenei (**Figure II-18**) grows in tufts of several stems, which are erect or decumbent and break easily at the base. The entire plant tends to be pilose, but is only slightly viscid. The stems are usually 5 to 15 centimeters (2.0 to 5.9 inches) tall and are not branched. *Tuctoria greenei* has purplish nodes and leaves no wider than 5 millimeters (0.20 inch). The inflorescence can be as much as 8 centimeters (3.1 inches) long; it may be partly hidden by the leaves when young, but is held above the leaves at maturity. The inflorescence usually consists of 7 to 15 spikelets, but may contain as many as 40. The spikelets are arranged in a spiral, with those in the upper half crowded together and those near the base more widely separated. Each spikelet consists of 5 to 15 florets and 2 glumes. The lemmas are 4 to 5 millimeters (0.16 to 0.20 inch) long and have squarish tips with 5 to 9 very short teeth; the central tooth is tipped by a very small spine. The

roughened seeds are about 2 millimeters (0.08 inch) long (Vasey 1891, Hoover 1941, Griggs 1977*b*, Stone *et al.* 1988, Reeder 1982) and weigh about 0.5 milligram (1.8×10^{-5} ounce) (Griggs 1980). *Tuctoria greenei* has a diploid chromosome number of 24 (Reeder 1982).

Tuctoria greenei is differentiated from Orcutt grasses by the spiral arrangement of spikelets and lack of floating juvenile leaves, from *Neostapfia colusana* by the shape of the spikelets and the inflorescence, and from both by the shape of the lemmas. *Tuctoria greenei* can be distinguished from *T. mucronata* by the squarish lemma tip; smaller, roughened seeds; and inflorescence held above the leaves in the former. Both can be told from the remaining *Tuctoria* species by stem length, seed shape, and range. The chromosome number of *T. greenei* also differs from the other two species in the genus (Reeder 1982).

b. Historical and Current Distribution

Historical Distribution.—After its initial discovery in Butte County in 1890, *Tuctoria greenei* was not reported again for over 40 years. However, during extensive surveys in the late 1930s, Hoover (1937, 1941) found the species at 12 sites in Fresno, Madera, Merced, San Joaquin, Stanislaus, Tehama, and Tulare Counties (**Figure II-19**). In fact, he described it as the most common of all *Orcuttia* species, with which it was classified at the time.

Current Distribution.—*Tuctoria greenei* has been reported from a total of 41 occurrences in the original 8 counties listed above, plus Shasta County (Stone *et al.* 1988, Oswald and Silveira 1995, California Natural Diversity Data Base 2005). About half of the historical occurrences of *Tuctoria greenei* are presumed to be extant; 9 are certainly extirpated, and 10 others are possibly extirpated (Alexander and Schlising 1997, California Natural Diversity Data Base 2005). The majority of the 22 extant occurrences are in the Northeastern Sacramento Valley Vernal Pool Region, particularly in the Vina Plains. The next largest concentration is in the Southern Sierra Foothills Vernal Pool Region, where the only remaining occurrences are in eastern Merced County. The other two extant occurrences are in Glenn (Oswald and Silveira 1995, J. Silveira *in litt.* 2000) and Shasta Counties (California Natural Diversity Data Base 2003); the former is in the Solano-Colusa Vernal Pool Region, and the latter is in the Modoc Plateau Vernal Pool Region (Keeler-Wolf *et al.* 1998). *Tuctoria greenei* is believed extirpated from Fresno, Madera, San Joaquin, Stanislaus, and Tulare Counties (Stone *et al.* 1988, Skinner and Pavlik 1994, California Natural Diversity Data Base 2003).

Figure II-18. Illustration of *Tuctoria greenei* (Greene's tuctoria). Reprinted with permission from Abrams (1940), Illustrated Flora of the Pacific States: Washington, Oregon, and California, Vol. I. © Stanford University Press.

c. Life History and Habitat

The basic life history strategy and habitat requirements of *Tuctoria* species were described earlier in this document, under discussions for *Neostapfia colusana* and *Orcuttia inaequalis*.

Reproduction and Demography.—Optimum germination of *Tuctoria greenei* seed occurs when the seed is exposed to light and anaerobic conditions after stratification (Keeley 1988). Germination occurs about 2 months following inundation (Keeley 1998). *Tuctoria* seedlings do not develop floating juvenile leaves, as does *Orcuttia* (Griggs 1980, Keeley 1998). The plants apparently do not tolerate inundation; all five *T. greenei* plants in a Glenn County pool died when the pool refilled during late spring rains in 1996 (J. Silveira *in litt.* 1997). *Tuctoria greenei* flowers from May to July (Skinner and Pavlik 1994), with peak flowering in June and July (Griggs 1981, Broyles 1987).

As with other vernal pool annuals, population size in *Tuctoria greenei* varies widely from year to year, and populations that have no visible plants one year can reappear in large numbers in later years. Population fluctuations may be due to annual variations in weather, particularly rainfall, to changes in management, or combinations of the two. Such fluctuations were observed at scattered sites in Butte and Tehama Counties during the 1970s (Griggs 1980, Griggs and Jain 1983) and at Sacramento National Wildlife Refuge, where the population in the single occupied pool ranged from 0 to 60 plants between 1994 and 1999 (J. Silveira *in litt.* 2000). Fluctuations of as much as three orders of magnitude were documented on the Vina Plains Preserve during the 1980s and 1990s; the high 1995 population estimates followed a winter of favorable rainfall (Alexander and Schlising 1997) and a long period without livestock grazing. Cattle grazing on the Vina Plains Preserve was discontinued in the growing season of 1987 to 1988 and did not resume until the growing season of 1995 to 1996 (D. Alexander *in litt.* 1998).

Populations that decline to zero may not always be capable of rebounding from the soil seed bank, however, and the population is likely extirpated if the plants do not reappear under favorable conditions. One Stanislaus County population of *Tuctoria greenei* (Element Occurrence 39) numbered fewer than 100 plants in 1973, dropped to 2 the following year, and remained at 0 for the next 3 years (Griggs 1980, Griggs and Jain 1983). The population was not monitored for the following decade. Although the vernal pool was still intact as of 1986, *T. greenei* was not observed during surveys that year; however, the winter had been drier than average. In 1987, following a winter of favorable rainfall, *T. greenei* still was not present, even though *Neostapfia colusana* was found in large numbers.

Figure II-19. Distribution of *Tuctoria greenei* (Greene's tuctoria).

(Stone *et al.* 1988), indicating that *T. greenei* has most likely permanently disappeared from this site. The area had been "rather heavily grazed" in 1987 (Stone *et al.* 1988), but livestock grazing intensity during the 1970s is not known

In a demographic study conducted during 1977 to 1978 on two populations from Butte and Tehama Counties, from 0 to 54 percent of seedlings survived to maturity. Plants that reached the flowering stage achieved a density of 82 to 133 individuals per square meter (7.6 to 12.4 individuals per square foot) and averaged 111 seeds per plant (Griggs 1980, Griggs and Jain 1983). In 1995, the density of *Tuctoria greenei* on the Vina Plains Preserve ranged from 7 to 133 plants per square meter (0.7 to 12.4 plants per square foot) (Alexander and Schlising 1997).

A study of genetic partitioning in five species of *Orcuttia* and *Tuctoria* (Griggs 1980, Griggs and Jain 1983) revealed that *T. greenei* had the lowest genetic diversity (50 percent) of the species studied. As with the other species, plants originating from the same seed parent accounted for about the same degree of genetic diversity (44 percent) as others within the same population (46 percent). Only 10 percent of the total genetic variability observed in the species was due to between-population differences, indicating low levels of gene flow between populations, but high levels of gene flow within populations. However, Griggs' genetic study included only two populations from adjacent counties (Butte and Tehama) and did not consider geographically distant occurrences.

Habitat and Community Associations.—*Tuctoria greenei* has been found in three types of vernal pools: Northern Basalt Flow, Northern Claypan, and Northern Hardpan (Sawyer and Keeler-Wolf 1995) on both low and high terraces (Stone *et al.* 1988). Occupied pools are or were underlain by iron-silica cemented hardpan, tuffaceous alluvium, or claypan (Stone *et al.* 1988). Of pools where the species was known to be extant in 1987, the median size was 0.6 hectare (1.5 acres), with a range of 50 square meters (0.01 acre) to 3.4 hectares (8.4 acres) (Stone *et al.* 1988). Stone *et al.* (1988) noted that *T. greenei* grew in shallower pools than other members of the tribe or on the shallow margins of deeper pools, but they did not quantify pool depth. At the Vina Plains, *T. greenei* grew in pools of "intermediate" size, which dried in April or early May of 1995 (Alexander and Schlising 1997). The Central Valley pools containing *T. greenei* are (or were) in grasslands; the Shasta County occurrence is surrounded by pine forest (California Natural Diversity Data Base 2003). Occupied pools in the Central Valley are (or were) at elevations of 33.5 to 134 meters (110 to 440 feet) (Stone *et al.* 1988), whereas the Shasta County occurrence is at 1,067 meters (3,500 feet) (California Natural Diversity Data Base 2003).

In the Northeastern Sacramento Valley Vernal Pool Region, *Tuctoria greenei* grows mostly on Anita clay and Tuscan loam soils, with one occurrence on Tuscan stony clay loam. Soil types are not certain for several other occurrences in this region; one is on either the Rocklin or the San Joaquin series, and the others are unknown. The single occurrence in the Solano-Colusa Vernal Pool Region is on strongly saline-alkaline Willows clay (J. Silveira *in litt.* 2000). In the Southern Sierra Foothills Vernal Pool Region, *T. greenei* is known to grow on a number of different soil series including Archerdale, Bear Creek, Exeter, Meikle, Ramona, Raynor, Redding, and San Joaquin. Soil types have not been determined for occurrences in the other regions.

At the Vina Plains Preserve, frequent associates of *Tuctoria greenei* are *Eryngium castrense* and *Marsilea vestita* (Alexander and Schlising 1997). Elsewhere in the Sacramento Valley and in the San Joaquin Valley, *T. greenei* often grows in association with *E. vaseyi*, *Plagiobothrys stipitatus*, and *Alopecurus saccatus* (foxtail). The rare *Chamaesyce hooveri* co-occurs with *T. greenei* at eight sites in the Sacramento Valley. Other rare plants that grow in the same vernal pools with *T. greenei* at a few occurrences are: *Orcuttia pilosa*, *O. inaequalis*, *O. tenuis*, *Neostapfia colusana*, and *Gratiola heterosepala* (Broyles 1987, Stone *et al.* 1988, California Natural Diversity Data Base 2005).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Tuctoria greenei* are described below.

One potential factor unique to this and some other vernal pool plant species may be decimation by grasshopper outbreaks. Grasshoppers have been noted consuming entire populations of *Tuctoria greenei* before they set seed (Griggs 1980, Griggs and Jain 1983, Stone *et al.* 1988). At the Vina Plains Preserve in Tehama County, the seed bank permitted some recovery after total destruction of the plants by grasshoppers. Sampling at one Vina Plains Preserve vernal pool in 1997 prior to a grasshopper event in 1998 showed that *Tuctoria greenei* had a frequency of 0.066 and a density of 26.3 plants per square meter (2.4 plants per square foot). In 1998 grasshoppers ate all of the plants and no seeds were produced. In 1999, 1 year after the grasshopper event, the same sampling showed a frequency of 0.025 and a density of 2.9 plants per square meter (0.27 plants per square foot) (R. Schlising *in litt*. 2005).

Primary threats to this species are also continuing. Agricultural conversion and inappropriate livestock grazing practices pose threats to virtually all of the occurrences remaining in the San Joaquin Valley, although one small population is on a site that has been proposed for protection as a mitigation bank (California Natural Diversity Data Base 2003). Fifteen populations of *Tuctoria greenei* throughout its range are subject to adverse effects related to cattle grazing (Stone *et al.* 1988, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2003). Small population size poses a continuing threat to seven occurrences in Butte, Glenn, and Merced Counties. Each of these populations numbered 110 or fewer *T. greenei* plants at its peak (Stone *et al.* 1988, California Natural Diversity Data Base 2005). The Shasta County population also may have declined to the point where it could be extirpated by random causes; although it consisted of 2,500 plants in 1993 and 1994, the population declined to 120 in 1996 and 35 in 1998, despite favorable hydrological conditions (B. Corbin *in litt.* 2000). Urbanization, including construction of a landfill, is a potential threat to the species.

e. Conservation Efforts

We listed *Tuctoria greenei* as endangered on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). The State of California listed *T. greenei* as rare in 1979 (California Department of Fish and Game 1991), and the California Native Plant Society had recognized it as rare and endangered even earlier (Powell 1974). Currently, the California Native Plant Society (2001) includes *T. greenei* on List 1B, ranking it as "endangered throughout its range." In 2005, critical habitat was designated for *T. greenei* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Surveys by Hoover (1937, 1941) documented the historical range of *Tuctoria greenei*. Later surveys by Crampton (1959) and Medeiros (1976) revealed the destruction of various occurrences. The most recent, comprehensive survey (Stone *et al.* 1988) was funded by us to determine the status of *T. greenei* and related species. During the course of their surveys and related projects, Stone and others (1988) discovered four populations that were previously unknown. Research conducted by Griggs (1980) provided insights into the demography, ecology, and genetics of *T. greenei*, among other species. As part of his research, Griggs attempted to introduce *T. greenei* to two pools in Butte County, but the species never became established. Keeley (1988) conducted research on the conditions necessary for germination. We and the California Department of Fish and Game supported an ecological study of *T. greenei* and other rare species on the Vina Plains Preserve in 1995 (Alexander and Schlising 1997).

Six occurrences of *Tuctoria greenei* are on The Nature Conservancy's Vina Plains Preserve. This species has grown in as many as seven pools on the preserve in certain years (Stroud 1990, Alexander and Schlising 1997), including one pool on the Wurlitzer Unit (California Natural Diversity Data Base 2003). The Glenn County population, on the Sacramento National Wildlife Refuge, is the only occurrence known from public land.

15. *TUCTORIA MUCRONATA* (SOLANO GRASS)

a. Description and Taxonomy

Taxonomy.—Solano grass is in the Orcuttieae tribe of the grass family Poaceae (Reeder 1965). Solano grass was originally described under the name *Orcuttia mucronata*, based on specimens collected "12 miles due south of Dixon, Solano County" (Crampton 1959:108). Reeder (1982) transferred this species to a new genus, *Tuctoria*, resulting in the currently accepted name *Tuctoria mucronata*. Other common names are Crampton's Orcutt grass (Griggs 1977*b*), mucronate orcuttia (Smith *et al.* 1980), and Crampton's tuctoria (Skinner and Pavlik 1994).

Description and Identification.—Characteristics of the Orcuttieae were described earlier in this document under the *Neostapfia colusana* account and those common to the genus *Tuctoria* were presented in the *T. greenei* account. *Tuctoria mucronata* is grayish-green, pilose, and viscid. The tufted stems are decumbent, 12 centimeters (4.7 inches) or less long, and do not branch. The leaves are 1 to 4 centimeters (0.4 to 1.6 inches) long, are rolled inward, and have pointed tips. The inflorescence is 1.5 to 6 centimeters (0.6 to 2.4 inches) long, and its base is partially hidden by the uppermost leaves. As for all plants in this genus, the spikelets are arranged in a spiral; the 7 to 19 spikelets in the inflorescence of *T. mucronata* are crowded together. Spikelets range from 7 to 13 millimeters (0.28 to 0.51 inch) in length and consist of 5 to 10 florets, plus two glumes. The lemmas are 5 to 7 millimeters (0.20 to 0.28 inch) long and taper towards the tip, which is curved outward. The lemma teeth are not obvious except for the central one, which has a sharply pointed tip up to 1 millimeter (0.04 inch) long. *Tuctoria mucronata* has smooth seeds about 3 millimeters (0.12 inch) long and a diploid chromosome number of 40 (Crampton 1959; Reeder 1982, 1993).

Unlike *Tuctoria greenei*, the inflorescence of *T. mucronata* remains partly hidden by the leaves, even at maturity. In addition, *T. mucronata* stems are shorter than those of *T. greenei*, and the former has tapered lemmas and larger, smoother seeds. The spiral arrangement of the spikelets and single obvious tooth per lemma distinguish *T. mucronata* from the Orcutt grasses. Finally, the tapered

lemmas of *T. mucronata* differ from the fan-shaped lemmas of *Neostapfia colusana* (Reeder 1982).

b. Historical and Current Distribution

Historical Distribution.—Prior to 1985, *Tuctoria mucronata* was known only from Olcott Lake in Solano County, which is believed to be the type locality (Crampton 1959, California Natural Diversity Data Base 2003) (**Figure II-20**). Another occurrence was discovered in 1985 about 4 kilometers (2.5 miles) southwest of Olcott Lake (California Natural Diversity Data Base 2005). A third occurrence, comprising the largest population now known, was discovered in 1993 on a Department of Defense communications facility in Yolo County (California Natural Diversity Data Base 2005). All three sites are in the Solano-Colusa Vernal Pool Region (Keeler-Wolf *et al.* 1998).

Current Distribution.— *Tuctoria mucronata* may have been extirpated from Olcott Lake; the species has not been found there since 1993, when only four individual plants were observed (California Natural Diversity Data Base 2003). Twenty-six plants were found in 2004 and 3 plants were found in 2005 at the other Solano County site (C. Witham *in. litt*. 2005). The Yolo County population is extant.

c. Life History and Habitat

Typical life history and habitat characteristics for all members of the Orcuttieae and for all *Tuctoria* species were presented earlier in this document, under the *Neostapfia colusana* and *Orcuttia inaequalis* accounts.

Reproduction and Demography.—The germination period for *Tuctoria mucronata* seeds is not known, but is presumed to be in May or June (U.S. Fish and Wildlife Service 1985*a*). *Tuctoria* seedlings do not produce floating juvenile leaves (Griggs 1980). This species typically flowers in June and sets seed during July (Holland 1987). The demography of *Tuctoria mucronata* has not been investigated in detail. Annual estimates or counts at Olcott Lake (Holland 1987, California Natural Diversity Data Base 2005) indicated that population sizes for this species fluctuate dramatically from year to year, as do other members of the Orcuttieae. *Tuctoria mucronata* was not observed at Olcott Lake from 1976 through 1980, then reappeared in 1981 (Holland 1987), indicating that viable seeds can persist in the soil for at least 5 years. Apparently both drought years and years of excessively high rainfall are unfavorable for *T. mucronata*; the largest populations were observed after seasons of 45 to 60 centimeters (17.7 to 23.6 inches) of precipitation (Holland 1987).

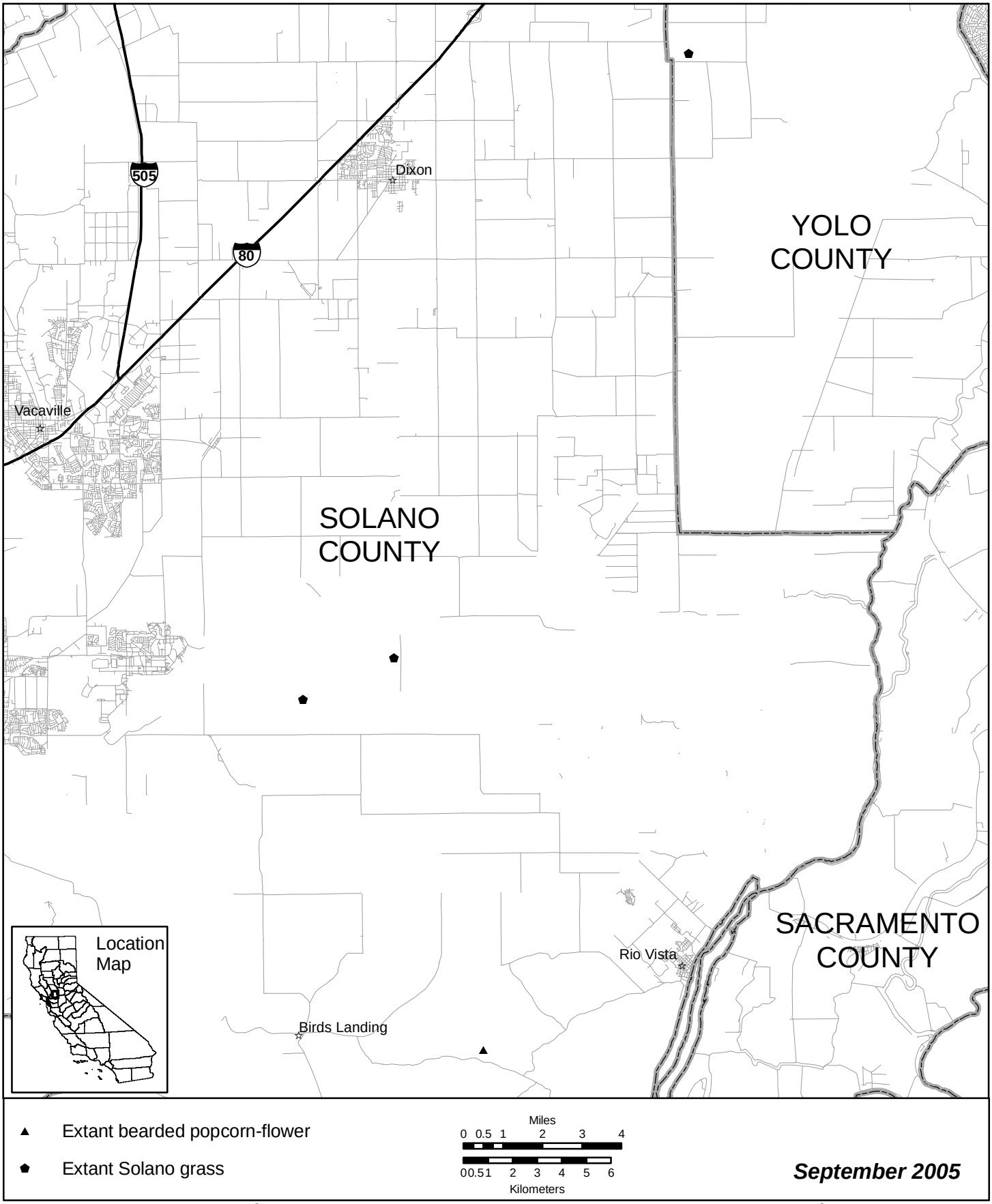

Figure II-20. Distribution of *Tuctoria mucronata* (Solano grass) and historical distribution of *Plagiobothrys hystriculus* (bearded popcorn-flower).

Habitat and Community Associations.—*Tuctoria mucronata* has been found only in the Northern Claypan type of vernal pool (Sawyer and Keeler-Wolf 1995) within annual grassland (California Natural Diversity Data Base 2005). Pools where *T. mucronata* occurs tend to be milky from suspended sediments (Holland 1987). The pools that are occupied in Solano County are more properly described as alkaline playas or intermittent lakes, due to their large surface area (Crampton 1959, U.S. Fish and Wildlife Service 1985*a*), whereas those at the Yolo County site are "relatively small" (C. Witham *in litt.* 2000*a*). Soils underlying known *T. mucronata* sites are saline-alkaline clay or silty clay in the Pescadero series (Crampton 1959, California Natural Diversity Data Base 2003). Known occurrences are at elevations of about 5 to 11 meters (15 to 35 feet) (California Natural Diversity Data Base 2005).

Tuctoria mucronata is most commonly associated with *Frankenia salina*, *Eryngium aristulatum*, and *Neostapfia colusana*; *N. colusana* occurred near *T. mucronata* at all three sites. Additional associates include *Cressa truxillensis*, *Distichlis spicata*, *Phyla nodiflora*, *Crypsis schoenoides*, *Eleocharis macrostachya*, and *Malvella leprosa* (Crampton 1959, California Natural Diversity Data Base 2003). Other than *N. colusana*, the only other rare plant featured in this recovery plan that co-occurs with *T. mucronata* is *Astragalus tener* var. *tener*; the two taxa grow in the same vernal pool complex in Yolo County, but are not found in the same pool (California Natural Diversity Data Base 2005).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Tuctoria mucronata* are described below.

One additional factor potentially involved in the decline of this particular species may be overcollection (T. Griggs *in litt*. 2000, California Natural Diversity Data Base 2005). Other additional factors include the evidence that the Yolo County habitat for *Tuctoria mucronata* has been degraded by discing, excavation, herbicide runoff, application of salt, and industrial contaminants in the groundwater (K. Fuller pers. comm. 1997, C. Witham *in litt.* 2000*a*, California Natural Diversity Data Base 2005).

A number of specific threats to the species are also continuing. These include competition from aggressive plants at all three known sites where the species occurs or formerly occurred. The primary competitors are *Phyla nodiflora* at

Olcott Lake (C. Witham *in litt.* 2000*a*), *Malvella leprosa* and *Crypsis schoenoides* at the other site in Solano County (California Natural Diversity Data Base 2003), and *Lepidium latifolium* (broad-leaved pepper-weed) in Yolo County (K. Fuller *in litt.* 1999). Altered hydrology may threaten the Olcott Lake occurrence, if it is extant (T. Griggs *in litt*. 2000). Effects of inappropriate grazing continue to threaten the other Solano County population, as does trampling by hunters (California Natural Diversity Data Base 2005). Eradication of *Lepidium latifolium* is occurring at the Yolo County site, however, habitat degradation continues to be a threat (California Natural Diversity Data Base 2005, N. McCarten *in litt*. 2005). Small population size is a threat to the occurrence southwest of Olcott Lake, and to the one at Olcott Lake if it is not already extirpated. In 2005, the site southwest of Olcott Lake had declined to 3 plants and the Olcott Lake site has had no plants since 1993 (California Natural Diversity Data Base 2005).

e. Conservation Efforts

Tuctoria mucronata was listed as an endangered species on September 28, 1978 (U.S. Fish and Wildlife Service 1978*a*). A recovery plan was then prepared, which became effective 7 years following the listing (U.S. Fish and Wildlife Service 1985*a*). The California Fish and Game Commission listed *T. mucronata* as endangered in 1979 (California Department of Fish and Game 1991). *Tuctoria mucronata* is also on the California Native Plant Society's List 1B, with the highest endangerment rating possible (Skinner and Pavlik 1994). In fact, the California Native Plant Society has recognized this species as rare and endangered since it first compiled such lists (Powell 1974). In 2005, critical habitat was designated for *T. mucronata* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

The Nature Conservancy acquired Olcott Lake in 1980 as part of the Jepson Prairie Preserve. The preserve was transferred to the Solano County Farmlands and Open Space Foundation in 1997, which manages it jointly with the University of California, Davis (C. Witham *in litt.* 1998). Livestock grazing is now excluded from the areas of the lake formerly occupied by *Tuctoria mucronata* (U.S. Fish and Wildlife Service 1985*a*, California Natural Diversity Data Base 2005). Money from the California Endangered Species Tax Check-Off Fund has been used to repair fences and post signs in the Jepson Prairie Preserve (California Department of Fish and Game 1991). The Nature Conservancy (1991) conducted some research on the control of *Phyla nodiflora* using herbicides and mechanical removal in the early 1990s. Private individuals have partially implemented one

aspect of the recovery plan, which was to survey suitable habitats for *T. mucronata*; their efforts led to the discovery of the two populations that were unknown at the time of listing (California Natural Diversity Data Base 2003).

B. State-Listed Plant Species and Other Plant Species of Concern

1. *ASTRAGALUS TENER* VAR. *FERRISIAE* (FERRIS' MILK-VETCH)

a. Description and Taxonomy

Taxonomy.—Milk-vetches are members of the pea family (Fabaceae). Ferris' milk-vetch was recognized and named as a distinct variety (*Astragalus tener* var. *ferrisiae*) only recently (Liston 1990*b*). However, Ferris had collected the type specimen in 1926, "3 miles west of Colusa," in Colusa County (Liston 1990*b*:100). Specimens now attributed to Ferris' milk-vetch formerly had been included under Jepson's milk-vetch (*Astragalus rattanii* var. *jepsonianus*), a serpentine endemic plant (Barneby 1964 as cited in Liston 1990*b*). According to Liston (1990*b*), further confusion about the taxonomy was generated when Abrams (1944) mistakenly provided a drawing of Ferris' milk-vetch labeled as Clara Hunt's milk-vetch (*Astragalus clarianus*). There is some speculation that Ferris' milk-vetch is an ecomorph of alkali milk vetch, *Astragalus tener* var. *tener*, a somewhat more common species of concern found in vernal pool habitats (C. Witham pers. comm. 2003). An alternative common name for *Astragalus tener* var. *ferrisiae* is Sacramento Valley milk-vetch.

Description and Identification.—The flower structure of *Astragalus* and related genera is complex. Although the calyx is unremarkable, the corolla consists of five petals that differ in size, shape, and sometimes in color. The outermost petal, which is called the banner, often curves upward away from the other petals. Just inside the banner is a pair of petals that are very narrow at the base; these separate but similar petals are known as the wings. The innermost pair of petals is called the keel because the two petals are fused to form a flattened structure resembling a boat. The pistil and stamens are hidden inside the keel. Although each flower has ten stamens, only one is separate; the filaments of the other nine are fused together (Smith 1977).

Astragalus tener var. *ferrisiae* is a delicate annual with one or more stems up to 26 centimeters (10.2 inches) long. The pinnately compound leaves have 7 to 15 wedge-shaped leaflets. The dense inflorescences arise from the leaf axils and contain 3 to 12 pinkish-purple flowers each. In *A. tener* var. *ferrisiae*, the banner ranges from 7.8 to 9.6 millimeters (0.31 to 0.38 inch) in length and has a white spot in the center. The keel is shorter than the wings, which are 5.8 to 7.1 millimeters (0.23 to 0.28 inch) long. Fruits of *A. tener* var. *ferrisiae* are