

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 1990b). However, Ferris had collected the type specimen in 1926, "3 miles west of Colusa," in Colusa County (Liston 1990b: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 1990b). According to Liston (1990b), 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

crescent-shaped, papery pods with narrow, stalk-like bases. The pods are 2.7 to 5 centimeters (1.1 to 2.0 inches) long, about 2 millimeters (0.08 inch) wide, and have a groove running the length of the underside. The stalk-like base is at least 3 millimeters (0.12 inch) long. At maturity, the fruit stalks are deflexed at an angle of about 45 degrees. Each pod contains between 10 and 16 smooth seeds divided between two chambers (Liston 1990*b*, A. Liston *in litt.* 1993, Spellenberg 1993). The diploid chromosome number of *A. tener* var. *ferrisiae* is not known.

The other varieties of *Astragalus tener* have shorter, straighter fruits than *A. tener* var. *ferrisiae*, and their fruits do not have long, stalk-like bases (Liston 1990*b*, A. Liston *in litt.* 1993, Spellenberg 1993). All other *Astragalus* species that overlap in range have erect fruit stalks and rough seeds (Liston 1992). *Astragalus rattanii* var. *jepsonianus* is further distinguished from *A. tener* var. *ferrisiae* by its fruit shape and flower color (purple keel, white wings, and a white banner tipped with purple). Although *A. clarianus* has a pod similar in shape to that of *A. tener* var. *ferrisiae*, the former is shorter. Moreover, the flowers of *A. clarianus* differ in that the keel is longer than the wings and the banner is whitish with a purple tip (Liston 1990*b*, Liston 1992, Spellenberg 1993).

b. Historical and Current Distribution

Historical Distribution.—A total of 18 historical occurrences of *Astragalus tener* var. *ferrisiae* are reported by the California Natural Diversity Data Base (2005) (**Figure II-21**). Seven historical localities in the Solano-Colusa Vernal Pool Region included College City, Colusa, and Mountain House in Colusa County; Dunnigan and Saxon in Yolo County; Olcott Lake in Solano County; and the Sacramento National Wildlife Refuge in Glenn County. Four occurrences have been discovered in the Northeastern Sacramento Valley Vernal Pool Region (T. Keeler-Wolf *in litt.* 2000, J. Silveira *in litt.* 2000) since 1989. Three were on the Llano Seco Unit of the Sacramento River National Wildlife Refuge and one was in the Gray Lodge Waterfowl Management Area, all in Butte County (California Natural Diversity Data Base 2005). Seven other historical localities were outside of the vernal pool regions designated by Keeler-Wolf *et al.* (1998) or were not described in sufficient detail to determine the region. These sites include Biggs, Nord, Oroville Road, Sacramento River, and Upper Butte Basin Wildlife Management Area in Butte County; Yuba City in Sutter County; and an unidentified “causeway” location.

Current Distribution.— Although the California Natural Diversity Data Base (2005) lists nine occurrences as “presumed extant,” despite repeated visits only two have been confirmed extant since 1996. The extant occurrences are at Saxon Station in Yolo County, in the Solano-Colusa Vernal Pool Region, and at the Gray Lodge Waterfowl Management Area in Butte County, managed by the

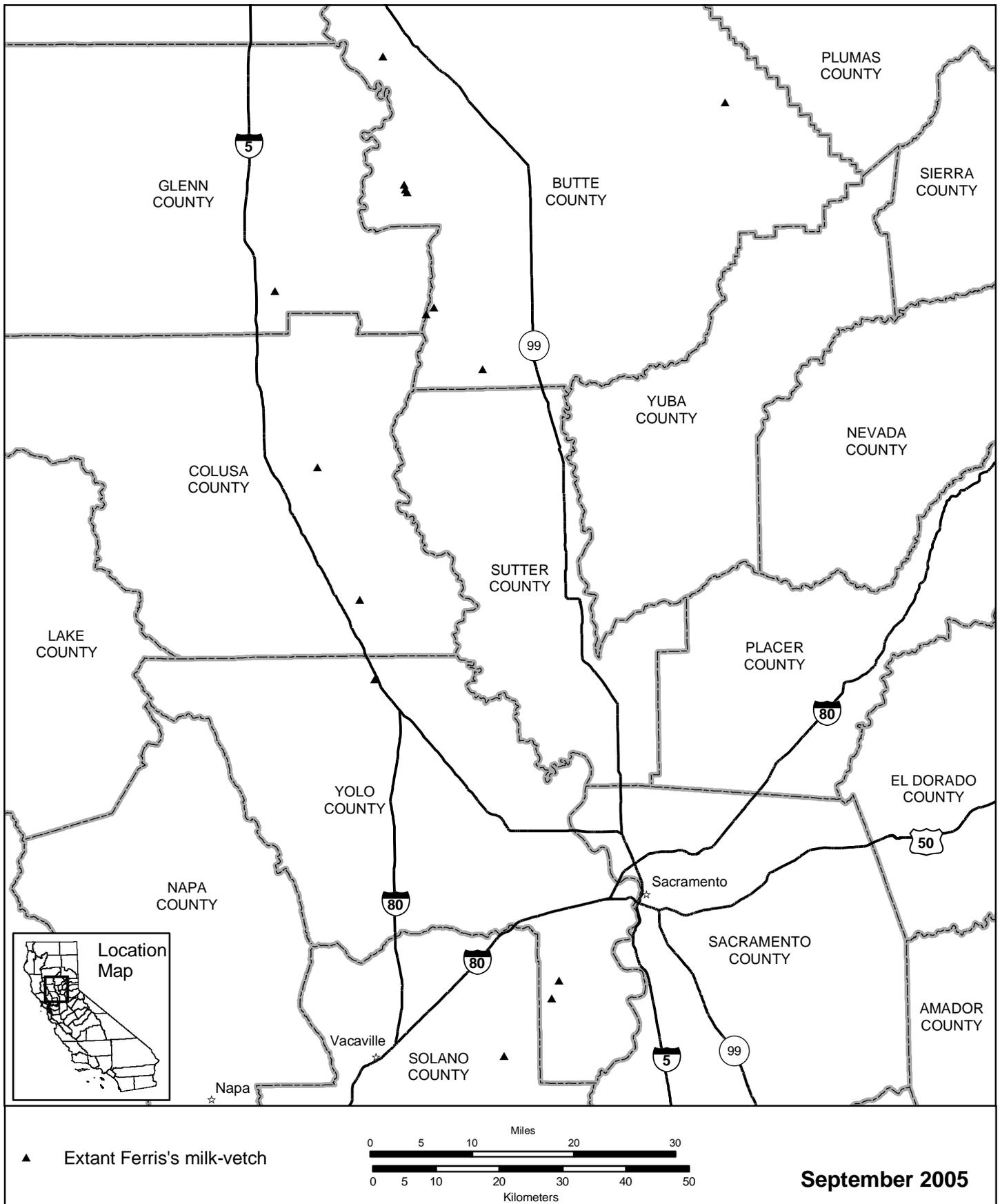


Figure II-21. Distribution of *Astragalus tener* var. *ferrisiae* (Ferris's milk-vetch).

California Department of Fish and Game. Morphology of the plants seems to vary depending on associated vegetation, casting doubt on the validity of this taxon (C. Witham pers. comm. 2003).

c. Life History and Habitat

Reproduction and Demography.—The life history of *Astragalus tener* var. *ferrisiae* has not been studied. Most of the information on reproductive biology and genetics in the species was gathered from *A. tener* var. *tener* and another variety of the same species, *A. tener* var. *titi* (coastal dunes milk-vetch) because the researcher (Liston 1992) was unaware of any extant populations of *A. tener* var. *ferrisiae*. Many of his observations apply to the species *A. tener* as a whole, and other information provided in the *A. tener* var. *tener* species account may also apply to *A. tener* var. *ferrisiae*.

Astragalus tener var. *ferrisiae* is an annual, but the conditions necessary for seed germination are unknown. It flowers in April and May (Skinner and Pavlik 1994). The pollinators are not known for certain. Liston (1992) predicted that butterflies would pollinate all varieties of *A. tener*, even though most other species of *Astragalus* are pollinated by bees. His rationale was that the flower structure, in which the wings are pressed tightly together with the keel shorter than the wings, would not allow bees to reach the nectar glands with their mouthparts. Butterflies are known to visit other *Astragalus* species with similar flower morphology (Liston 1990a cited in Liston 1992). Little is known about seed dispersal in *A. tener*, except that the pod does not split until it drops from the plant (Liston 1992). Liston (1992) speculated that this species would form a soil seed bank because seeds of related species undergo dormancy (Liston 1990a cited in Liston 1992).

The demography of *Astragalus tener* var. *ferrisiae* has not been monitored. Among occurrences for which the population size has been estimated, 2 numbered 200 and 400 plants when they were discovered, and 2 others numbered 10 or fewer. If the populations of *A. tener* var. *ferrisiae* follow a pattern similar to that of *A. tener* var. *tener*, plants may reappear in future years at sites where they have been absent for a number of years.

Habitat and Community Associations.—Since it was first discovered, *Astragalus tener* var. *ferrisiae* has been found in a variety of habitats including vernal meadows, “tule land” (presumably a marsh), borders of drainages, and fallow rice fields. The factors common to collection sites were that they were alkaline, moist in the springtime, and level (Liston 1992, Skinner and Pavlik 1994, California Natural Diversity Data Base 2001). This taxon does not occur in vernal pools *per se* and therefore is not referenced by vernal pool type in

A Manual of California Vegetation (Sawyer and Keeler-Wolf 1995). *Astragalus tener* var. *ferrisiae* grows on clay soils (California Natural Diversity Data Base 2001 and unprocessed data, J. Silveira *in litt.* 2000). Collection localities were at elevations ranging from 6 to 46 meters (20 to 150 feet). Plant species associated with *A. tener* var. *ferrisiae* have rarely been reported. It was growing with *Sidalcea hirsuta* (hairy checker-mallow), *Scirpus mucronatus* (bog bulrush), *Eleocharis obtusa* (blunt spikerush), and *Phalaris lemmonii* (Lemmon's canary grass) near Biggs and among "weedy grasses and forbs" at Upper Butte Basin Wildlife Management Area (California Natural Diversity Data Base 2001).

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 *Astragalus tener* var. *ferrisiae* are described below.

Much of the suitable habitat in the historical range of *Astragalus tener* var. *ferrisiae* has been converted to agriculture (Skinner and Pavlik 1994). The reasons why this variety no longer occurs at Olcott Lake, which is in a nature preserve, are unknown.

Permanent flooding is a potential threat to *Astragalus tener* var. *ferrisiae* at wildlife management areas if waterfowl production is given priority (California Natural Diversity Data Base 2001). Competition from unspecified upland plants is a problem at the Upper Butte Basin Wildlife Management Area (C. Rocco *in litt.* 1993) and probably at all sites in the Sacramento Valley (J. Silveira *in litt.* 2000). Small population size is a concern for all of the extant occurrences, which ranged in size from 10 to 400 individuals during the 1990s; growing plants have been absent from all but 1 population over the past several years (C. Witham pers. comm. 2003). An additional threat is a decline in pollinators. Pollinating insects may breed in areas outside of *A. tener* var. *ferrisiae* habitat and thus may be subject to different threats than the plants. However, until the specific pollinators of *A. tener* var. *ferrisiae* have been identified, the robustness of their populations cannot be assessed.

e. Conservation Efforts

Astragalus tener var. *ferrisiae* has no Federal or State protection. The California Native Plant Society includes this variety on List 1B, giving it the highest endangerment rating possible (Skinner and Pavlik 1994). Dr. Vernon Oswald discovered several populations during the past decade while exploring Butte and

Glenn Counties (California Natural Diversity Data Base 2001 and unprocessed data). Five occurrences are afforded some protection by virtue of their location on public land, but no particular conservation efforts have been undertaken in those areas.

2. *ASTRAGALUS TENER* VAR. *TENER* (ALKALI MILK-VETCH)

a. Description and Taxonomy

Taxonomy.—Alkali milk-vetch is in the pea family Fabaceae. Gray (1864) named *Astragalus tener*, commonly known as alkali milk-vetch. He gave the type locality only as “California ... from near Monterey or San Francisco” (Gray 1864:206). No varieties were named until Barneby (1950) reduced *Astragalus titi*, commonly known as coastal dunes milk-vetch, from a full species to the variety *Astragalus tener* var. *titi*. In so doing, the combination *Astragalus tener* var. *tener* was created automatically to represent Gray’s original material (*i.e.*, alkali milk-vetch), according to accepted rules of botanical nomenclature. Another common name by which this variety is known is slender rattle-weed (Abrams 1944).

Description and Identification.—*Astragalus tener* var. *tener* (Figure II-22) is similar in most respects to *A. tener* var. *ferrisiae*. However, the two taxa differ in leaflet shape and fruit morphology. *Astragalus tener* var. *tener* leaflets vary, even on the same plant, from narrow and pointed to wedge-shaped with blunt or notched tips. In *A. tener* var. *tener*, the pod is only 1 to 2.5 centimeters (0.4 to 1.0 inch) long and straight or only slightly curved. The base of the pod is typically rounded; if stalk-like, the base is much less than 3 millimeters (0.12 inch) long. Also, the fruits are deflexed all the way to the stem of the inflorescence. *Astragalus tener* var. *tener* pods contain between 8 and 14 seeds (Gray 1864, Liston 1990*b*, A. Liston *in litt.* 1993, Spellenberg 1993). The plants have a diploid chromosome number of 22 (Liston 1992).

The variable leaflets and shorter, straighter pods, which are more strongly deflexed, distinguish *Astragalus tener* var. *tener* from *A. tener* var. *ferrisiae* (Liston 1990*b*, A. Liston *in litt.* 1993, Spellenberg 1993). *Astragalus tener* var. *titi* has a shorter banner (5.2 to 6 millimeters [0.20 to 0.24 inch] long) and only 5 to 11 seeds per pod (Spellenberg 1993). This species can be distinguished from all other species of *Astragalus* that occur in the same areas by its deflexed fruit stalks and smooth seeds (Liston 1992). Additional identifying features were given in the *A. tener* var. *ferrisiae* account presented earlier in this document.

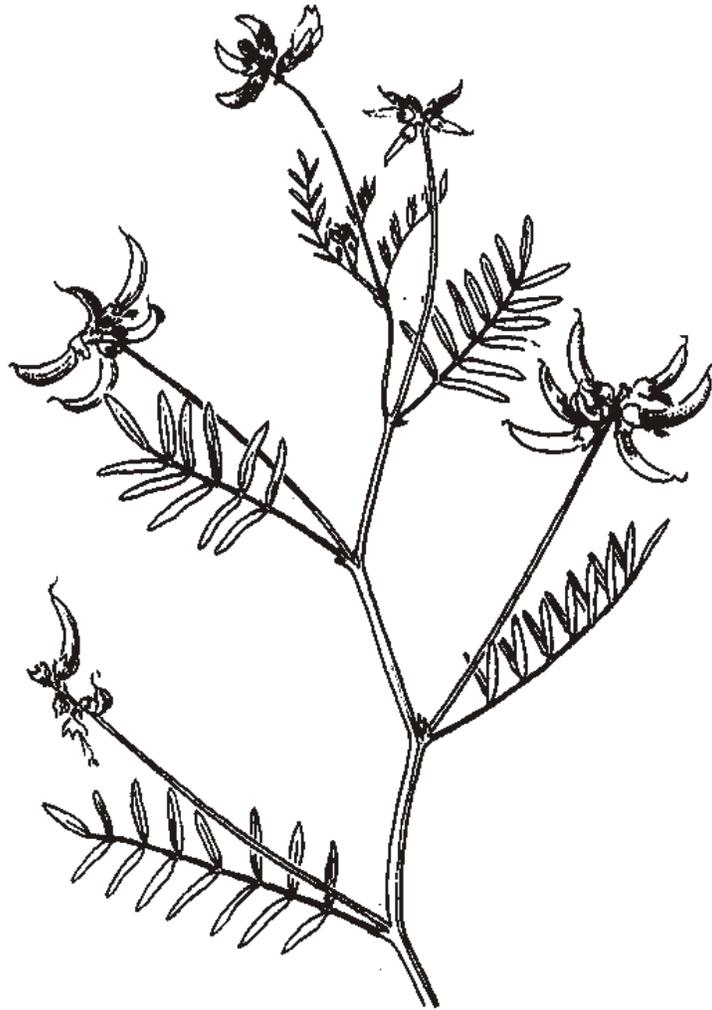


Figure II-22. Illustration of *Astragalus tener* var. *tener* (alkali milk-vetch). Reprinted with permission from Abrams (1944), *Illustrated Flora of the Pacific States: Washington, Oregon, and California*, Vol. II. © Stanford University Press.

b. Historical and Current Distribution

Historical Distribution.—*Astragalus tener* var. *tener* formerly occurred in the Central Coast, Lake-Napa, Livermore, San Joaquin Valley, Solano-Colusa, and Santa Rosa Vernal Pool Regions (Keeler-Wolf *et al.* 1998), as well as in several locations outside of the named regions (**Figure II-23**). Between 1864 and the early 1980s, collections were made in more than 40 separate sites within 13 counties, ranging from the Salinas Valley and the San Francisco Bay area to the Central Valley (Barneby 1950, Liston 1989). Populations in the San Francisco Bay and Sacramento-San Joaquin Delta areas were being extirpated by the mid-1960s, but additional sites were discovered in the Central Valley after that time (Liston 1989, Skinner and Pavlik 1994, California Natural Diversity Data Base 2001). Alameda and Solano Counties had the largest number of historical collection sites, with 10 each, followed by Yolo County with 9 sites. Specimens were collected from two sites each in Contra Costa, Santa Clara, and San Joaquin Counties. *Astragalus tener* var. *tener* was known from one site each in Merced, Monterey, Napa, San Benito, San Francisco, Sonoma, and Stanislaus Counties prior to 1988 (A. Liston *in litt.* 1988, California Natural Diversity Data Base 2001).

Current Distribution.—Of the 66 occurrences of *Astragalus tener* var. *tener* that have been reported, 36 are presumed to be extant (A. Liston *in litt.* 1988, California Natural Diversity Data Base 2005). Twenty-three of those were discovered within the past decade. The majority of the extant occurrences are in the Solano-Colusa Vernal Pool Region (Keeler-Wolf *et al.* 1998); most are in the Dozier-Fairfield area of Solano County, but three are southeast of Woodland in Yolo County (C. Witham *in litt.* 1990, California Natural Diversity Data Base 2001). Eight other occurrences of *A. tener* var. *tener* are clustered between Merced, Newman, and Los Banos in north-central Merced County (Silveira 1996, California Natural Diversity Data Base 2005), which is in the San Joaquin Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998). The single occurrence of *A. tener* var. *tener* that remains in the Lake-Napa Vernal Pool Region is located in Napa County (Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2005). The other extant occurrence, at Albrae in the Central Coast Vernal Pool Region, was considered to be “possibly extirpated” until about 40 plants were rediscovered in a created pool there in 1999 (California Natural Diversity Data Base 2001).

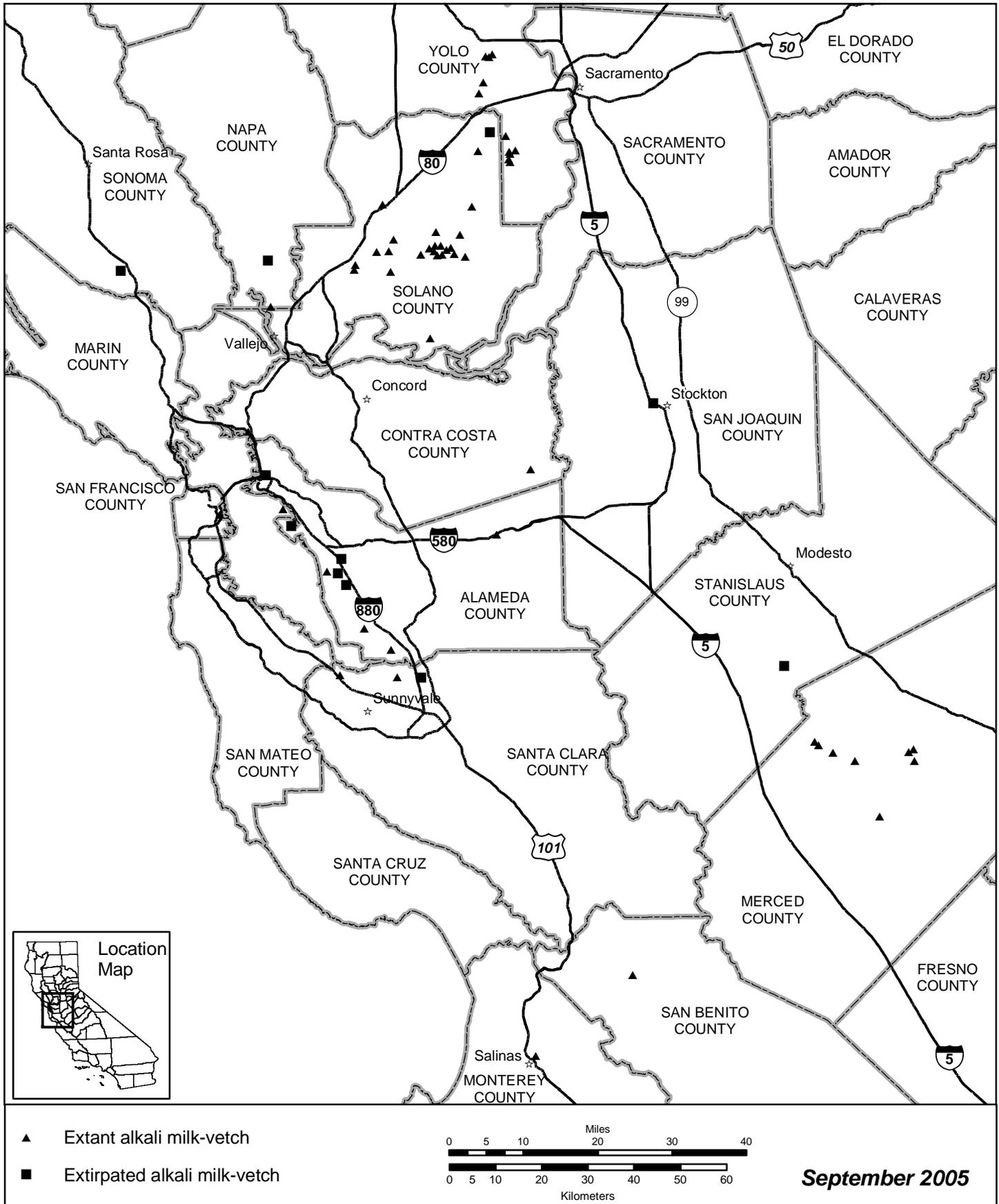


Figure II-23. Distribution of *Astragalus tener* var. *tener* (alkali milk-vetch).

c. Life History and Habitat

Reproduction and Demography.—The dates and conditions under which seeds of *Astragalus tener* var. *tener* germinate are not known. *Astragalus tener* var. *tener* flowers from March through June (Skinner and Pavlik 1994). The plants become inconspicuous within a few weeks of flowering (C. Witham *in litt.* 1993, A. Liston *in litt.* 2000). As described under the *A. tener* var. *ferrisiae* account, the probable pollinators are butterflies. However, C. Witham (*in litt.* 2000a) noted that butterflies are not common in the grassland habitats of *A. tener* var. *tener*. Liston's (1992) genetic studies indicated that plants within a population crossed randomly and did not suffer from excessive inbreeding, even though individual pistils can be fertilized by pollen from the same plant. *Astragalus tener* var. *tener* did not produce seeds when crossed experimentally with *A. tener* var. *titi* or with other closely-related species (Liston 1992). Seed dormancy and dispersal in *A. tener* were discussed in the *A. tener* var. *ferrisiae* account.

Based on analysis of proteins, Liston (1992) determined that *Astragalus tener* var. *tener* had more genetic variation within populations than the other six taxa in his study, although genetic diversity was low in the entire group. Genetic diversity among populations of *A. tener* var. *tener* was minimal. He also determined that *A. tener* var. *tener* and *A. tener* var. *titi* were very similar genetically. Unfortunately, *A. tener* var. *ferrisiae* was not available for inclusion in Liston's study because no populations were known to be extant at that time. Collectively, the two varieties of *A. tener* that Liston studied had two gene forms that were not found in the other five taxa (Liston 1992).

The demography of this taxon has not been investigated in detail. However, monitoring results indicated that populations could change by two orders of magnitude from one year to the next, as in one Solano County population that increased from 4 plants in 1993 to 350 in 1994 (California Natural Diversity Data Base 2001). Of the populations whose sizes have been estimated, 6 had fewer than 100 plants at maximum, 6 others numbered between 100 and 500 plants, and 1 had more than 500 (California Natural Diversity Data Base 2001).

Habitat and Community Associations.—The range of plant communities in which *Astragalus tener* var. *tener* has been found is indicative of its broad geographic range. This taxon has been reported from vernal pools and playas, edges of salt marshes, alkali meadows, and moist grassy flats (California Natural Diversity Data Base 2001). The vernal pool types in which it grows are Northern Basalt Flow, Northern Claypan, Northern Hardpan, and Northern Volcanic

Ashflow (Sawyer and Keeler-Wolf 1995). Optimum pool depth, duration, and area are unknown.

Soil types have been reported for only a few *Astragalus tener* var. *tener* occurrences in the Solano-Colusa Vernal Pool Region; those in Solano County are Solano-Pescadero and Pescadero clay, whereas one in Yolo County is Capay silty loam. The sites where this taxon grows typically are alkaline. Current and historical *A. tener* var. *tener* sites range in elevation from 1.5 to 88 meters (5 to 290 feet); one vaguely described site may have been 168 meters (550 feet) in elevation (California Natural Diversity Data Base 2001).

The species associated with *Astragalus tener* var. *tener* vary throughout its range. Plants that have been reported to occur with *Astragalus tener* var. *tener* in two or more of the vernal pool regions are *Bromus* spp. (bromes), *Castilleja densiflora* (dense-flowered owl's-clover), *Downingia pusilla* (dwarf downingia), *Lasthenia* spp. (goldfields), *Layia chrysanthemoides* (vernal pool layia), *Myosurus minimus*, and *Psilocarphus oregonus* (Oregon woolly-heads). In the Solano-Colusa Vernal Pool Region, from which multiple reports were available, the most frequent associates of *Astragalus tener* var. *tener* are *Lepidium latipes* var. *latipes* (dwarf peppergrass), *Lasthenia fremontii*, and *Distichlis spicata*, in order of frequency. Among the other plants featured in this recovery plan, those occurring in the same pools with *Astragalus tener* var. *tener* throughout its range include *Lasthenia conjugens*, *Neostapfia colusana*, *Atriplex persistens*, and *Legenere limosa*. In addition, *Chamaesyce hooveri*, *Tuctoria mucronata*, and *Gratiola heterosepala* grow in some of the same vernal pool complexes as *Astragalus tener* var. *tener*, but in different pools. The endangered *Cordylanthus palmatus* (palmate-bracted bird's-beak) occurs with *Astragalus tener* var. *tener* near Woodland (California Natural Diversity Data Base 2001), but this species is included in a different recovery plan (U.S. Fish and Wildlife Service 1998a).

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 *Astragalus tener* var. *tener* are described below.

Agricultural conversion remains a threat to *Astragalus tener* var. *tener* (Skinner and Pavlik 1994). However, anecdotal evidence suggests that *A. tener* var. *tener* may benefit from some types of temporary surface disturbance. It was observed growing above a recently buried pipeline at two different sites, probably because the disturbance temporarily reduced the cover of competing plants (C. Witham *in*

litt. 1998). *Astragalus tener* var. *tener* also appeared in a created vernal pool near Albrae, where it had not been observed since 1923 (California Natural Diversity Data Base 2001).

Grazing by cattle, sheep, or horses has been mentioned as a possible threat at 10 occurrences. However, all of the grazed populations were rated as being in “good” to “excellent” condition, including two used as permanent cattle pastures (California Natural Diversity Data Base 2001). Moreover, grazing may be necessary to reduce competition, for example from invasives such as filaree (*Erodium* species) at the Arena Plains Unit of the Merced National Wildlife Refuge in Merced County (J. Silveira *in litt.* 2000). Competitors that threaten *A. tener* var. *tener* include *Lepidium latifolium* and *Salsola* spp. (Russian thistle) in Yolo County, and *Melilotus indica* (sweet clover) and *Lolium multiflorum* in Alameda County (California Natural Diversity Data Base 2001). Extirpation from random processes is also a threat to virtually all of the populations due to their small numbers of plants, which make them vulnerable to chance events. Loss of pollinators due to destruction or degradation of their habitat also is a threat to *A. tener* var. *tener* because it would not be able to set seed if pollinators were absent. Threats specific to the Yolo County site where *A. tener* var. *tener* grows near *Tuctoria mucronata* were described under the description of the latter species. A fire burned through one of these occurrences in 2003 and construction of large stormwater retention basins for the Springlake development project impacted another. Soil that supported *A. tener* var. *tener* was salvaged from the basin footprint and translocated to a nearby site. *Astragalus tener* var. *tener* was not observed at the burn site in 2003 or 2004. The status of the seedbank at the translocation site is not known (M. Showers *in litt.* 2005).

e. Conservation Efforts

Astragalus tener var. *tener* currently is neither federally- nor State-listed. The California Native Plant Society did not consider it to be a rare taxon until 1994; it is now on List 1B and is regarded as endangered in a portion of its range (Skinner and Pavlik 1994). Dr. Aaron Liston visited historical sites and conducted research on the breeding systems and genetics of *A. tener* var. *tener* and related taxa (A. Liston *in litt.* 1988, Liston 1989, Liston 1990a, Liston 1992). Carol Witham undertook surveys for *A. tener* var. *tener* in Solano and Yolo Counties beginning in 1990 and discovered many of the populations now known (C. Witham *in litt.* 1990, C. Witham *in litt.* 1993, California Natural Diversity Data Base 2001). Additional populations were found during surveys for other vernal pool plants (California Natural Diversity Data Base 2001) and during pre-construction surveys for a gas pipeline (BioSystems Analysis 1994).

Twelve occurrences of *Astragalus tener* var. *tener* occur on sites protected by conservation organizations or on public land. Three are within the Jepson Prairie Preserve in Solano County (C. Witham *in litt.* 1990, California Natural Diversity Data Base 2001). Two occurrences are on the Wilcox Ranch in Solano County, part of which is owned and managed by The Nature Conservancy and the other part of which is owned and managed by Solano County (J. Marty, pers. comm. 2004). Four occurrences are on Federal or State wildlife areas in Merced County: the Arena Plains Unit of the Merced National Wildlife Refuge, Kesterson National Wildlife Refuge, the Los Banos Wildlife Management Area, and the North Grasslands Wildlife Management Area (Silveira 1996, California Natural Diversity Data Base 2001). *Astragalus tener* var. *tener* grows on land administered by the U.S. Department of Defense at Travis Air Force Base in Solano County and the U.S. Air Force Communications Facility in Yolo County (California Natural Diversity Data Base 2001). Also, one Yolo County occurrence is on property protected by a conservation easement with the City of Woodland (C. Witham *in litt.* 1990, California Natural Diversity Data Base 2001). However, this taxon is not necessarily protected simply by virtue of existing on public lands. No particular management activities have been undertaken for *A. tener* var. *tener*, and monitoring is sporadic.

3. *ATRIPLEX PERSISTENS* (VERNAL POOL SMALLSCALE)

a. Description and Taxonomy

Taxonomy.—This species is in the goosefoot family (Chenopodiaceae). Vernal pool smallscale was recognized as a unique species only recently. Stutz and Chu (1993) gave it the scientific name *Atriplex persistens*. Specimens of vernal pool smallscale collected prior to publication of the name had been incorrectly assigned to Parish's brittle scale (*Atriplex parishii*), a southern California species. The type locality of vernal pool smallscale is "Glenn Co., 5 miles S of Willows, 1/4 mi SW of Sacramento Wildlife Refuge Headquarters" (Stutz and Chu 1993:211). Other common names by which it is known are vernal pool saltbush (Silveira 1996, Keeler-Wolf *et al.* 1998) and persistent-fruited saltscale (California Department of Fish and Game 1999, California Natural Diversity Data Base 2001).

Description and Identification.—*Atriplex persistens* (**Figure II-24**) is an annual. The plants appear silvery-green (Silveira 1996) because the leaves and branches are covered with whitish, mealy scales. The 10- to 20-centimeter (4- to 8-inch) long stems may be upright or curved outward, and the branches originate from the base. *Atriplex persistens* has alternate, stalkless leaves 2 to 4 millimeters (0.08 to 0.16 inch) long. The leaves are basically egg-shaped with smooth margins, although their bases range from heart-shaped to triangular. Male and

female reproductive parts are borne in separate, inconspicuous flowers. The male flowers occur in clusters in the upper leaf axils or at the branch tips, whereas the female flowers occur singly in the lower leaf axils. Each fruit consists of a single, reddish-brown seed enclosed by two bracts. The bracts are 3 to 4 millimeters (0.12 to 0.16 inch) long, wider at the tip than at the base, coarsely toothed on the upper margins, and have a few tubercles on their surfaces. At maturity, the center and base of each bract become hardened. The fruits remain on the branches even after the plants have died, a characteristic reflected in the scientific name of the species. The diploid chromosome number of *A. persistens* is 18 (Stutz and Chu 1993).

The annual species most easily confused with *Atriplex persistens* is *A. parishii*. However, *A. parishii* is restricted to southern California; male and female flowers occur together in axillary clusters; the fruiting scales remain soft, are not toothed, and are widest below the middle; and the fruits detach easily from the stem. *Atriplex fruticulosa* (ball saltbush) has hardened fruiting bracts, but they are widest at the middle, the fruits are not persistent, the leaves are longer than in *A. persistens*, and the plants are perennial (Stutz and Chu 1993, Taylor and Wilken 1993).

b. Historical and Current Distribution

Historical Distribution.—*Atriplex persistens* was collected from only five localities prior to 1990, all in the San Joaquin Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998) (**Figure II-25**). The earliest record is from 1926, when Howell collected the species southwest of Merced, Merced County. Another site was discovered southwest of Merced during the late 1980s (Stone *et al.* 1988, California Natural Diversity Data Base 2001). In the 1960s, *A. persistens* was collected south of Modesto in Stanislaus County and west of Pixley in Tulare County (Stutz and Chu 1993, California Natural Diversity Data Base 2001). Another occurrence was discovered near Pixley in 1985 (California Natural Diversity Data Base 2001).

Current Distribution.—Since 1990, 27 additional populations of *Atriplex persistens* have been found in Glenn, Madera, Merced, and Solano Counties. However, three occurrences apparently have been extirpated, one each in Merced, Stanislaus, and Tulare Counties. Thus, of 32 known occurrences, 29 are believed to remain extant (California Natural Diversity Data Base 2005). Eleven of these are in the Solano-Colusa Vernal Pool Region, and the other 18 are in the San Joaquin Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998). The largest concentration, comprising 11 occurrences, is on the Sacramento National Wildlife Refuge in Glenn County. The second-largest concentration is in central Merced

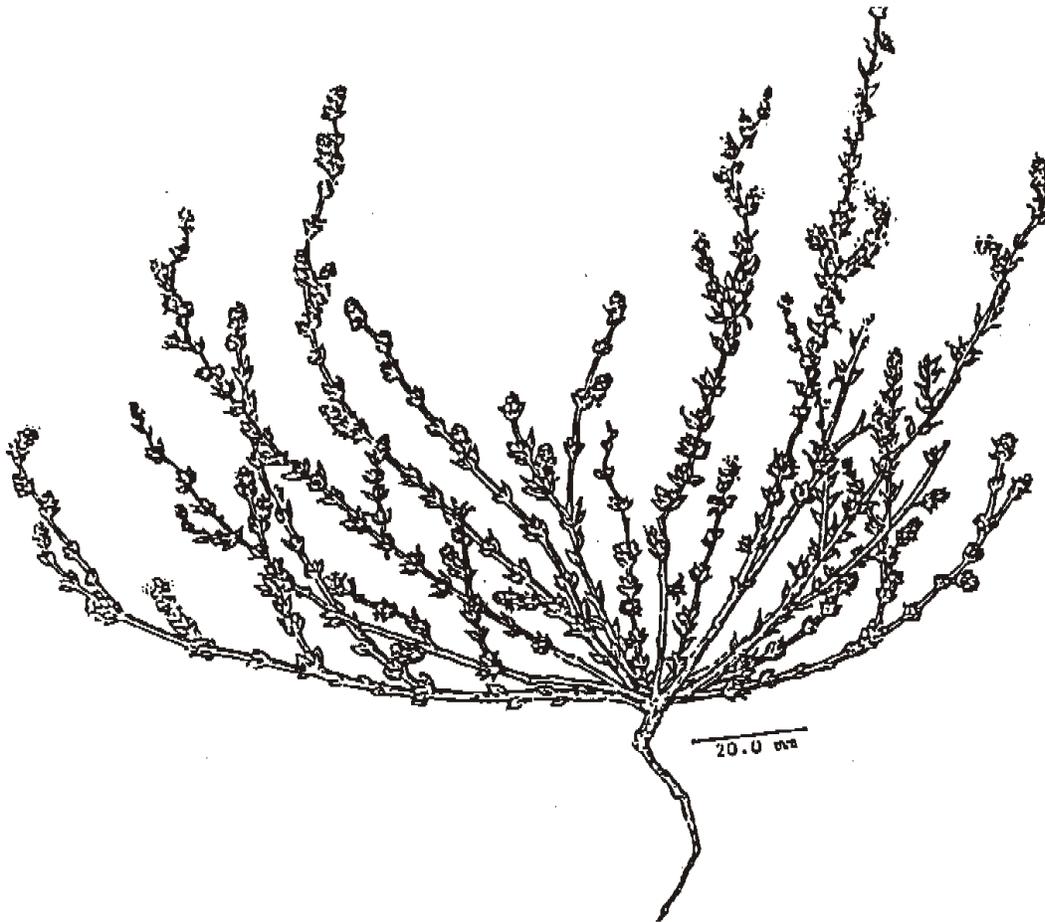


Figure II-24. Illustration of *Atriplex persistens* (vernal pool smallscale). (Reprinted with permission from the California Botanical Society)

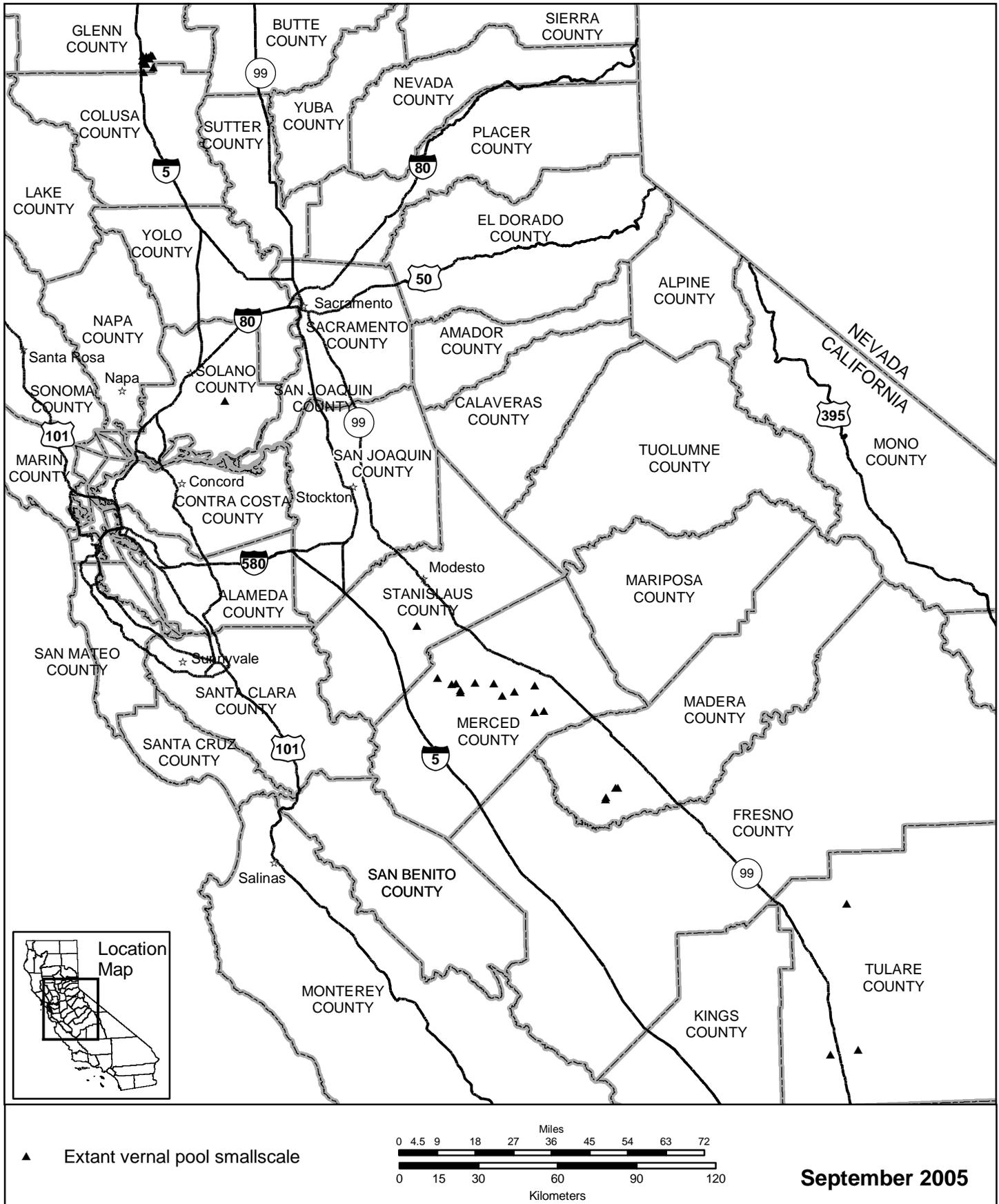


Figure II-25. Distribution of *Atriplex persistens* (vernal pool smallscale).

County between Los Banos and Merced, where 11 occurrences remain extant. The other seven extant occurrences are in Solano, Madera, and Tulare Counties (California Natural Diversity Data Base 2005).

c. Life History and Habitat

Reproduction and Demography.—*Atriplex persistens* was described so recently that little information has been collected on its life history. However, it is a summer annual that flowers from July through September (Stutz and Chu 1993). Germination dates and conditions have not been reported, nor have demographic parameters or pollination agents. Population size has been reported only for the Arena Plains Unit of the Merced National Wildlife Refuge, where about 10,000 plants were observed in 1995 (California Natural Diversity Data Base unprocessed data).

Habitat and Community Associations.—*Atriplex persistens* has been observed only in large, alkaline vernal pools, where it occurs in the bottoms of the basins as opposed to the edges (D. Taylor pers. comm. 1997). These pools are considered the Northern Claypan type (Keeler-Wolf *et al.* 1998). The Glenn County pools contained water about 15 to 30 centimeters (6 to 12 inches) deep in the spring seasons of 1991 and 1993 (Stutz and Chu 1993). In Merced County, this species occurs on sandy, silty clay soils (California Natural Diversity Data Base 2001); soil types have not been noted elsewhere. Reported populations were at elevations ranging from 8 to 105 meters (25 to 345 feet) (California Natural Diversity Data Base 2001).

Atriplex persistens co-occurs with many of the other plant species featured in this recovery plan, including *Chamaesyce hooveri*; *Orcuttia pilosa*, *Neostapfia colusana*, *Astragalus tener* var. *ferrisiae*, *Astragalus tener* var. *tener*; *Tuctoria greenei*, and *Legenere limosa* (Stone *et al.* 1988, Oswald and Silveira 1995, Silveira 1996, J. Silveira *in litt.* 2000, California Natural Diversity Data Base 2001). Other plants with which it is commonly associated are *Cressa truxillensis*, *Bassia hyssopifolia* (hyssop-leaved bassia), *Frankenia salina*, *Grindelia camporum*, *Hemizonia pungens* (common spikeweed), and *Distichlis spicata* (J. Silveira *in litt.* 2000).

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 *Atriplex persistens* are described below.

The comparison of recent versus historical accounts of this species fails to document a decline. Although Stutz and Chu (1993) indicated that they could not find the species at any of the historical sites, it has since been rediscovered in Merced and Tulare Counties. Nevertheless, much suitable habitat of this species throughout the Central Valley has no doubt been lost or degraded, due to the same primary factors that have reduced populations of various other vernal pool-related species addressed earlier in this document.

One specific continuing threat is altered hydrology, which threatens the survival of *Atriplex persistens* in the East Grasslands of Merced County, where vernal pools have been flooded illegally for use as duck ponds (J. Silveira *in litt.* 2000).

e. Conservation Efforts

Atriplex persistens has no official Federal or State status. However, the California Native Plant Society has added it to List 1B of the sixth edition of their *Inventory of Rare and Endangered Vascular Plants of California* (California Native Plant Society 2001), indicating that they view the species as endangered throughout its range.

Although *Atriplex persistens* has not been the subject of focused survey efforts, it has been discovered during general surveys for vernal pool plants (Stutz and Chu 1993, Silveira 1996, D. Taylor *in litt.* 1997). Of the 29 *A. persistens* populations currently known to be extant, 19 (66 percent) are on public land or in nature preserves. However, no specific measures have been undertaken to conserve or manage for this species on these or other sites. The occurrences in public ownership include 11 on the Sacramento National Wildlife Refuge and 4 in Merced County: 2 in San Joaquin Grasslands State Park, and 1 each on the Arena Plains Unit of the Merced National Wildlife Refuge and the North Grasslands Wildlife Management Area. The two nature preserves where *A. persistens* occurs are the Jepson Prairie in Solano County and the Pixley Vernal Pool Preserve in Tulare County (Stutz and Chu 1993, D. Taylor *in litt.* 1997, California Natural Diversity Data Base 2001).

4. ERYNGIUM SPINOSEPALUM (SPINY-SEPALED BUTTON-CELERY)

a. Description and Taxonomy

Taxonomy.—Spiny-sepaled button-celery is a member of the carrot family Apiaceae. The scientific name first used for spiny-sepaled button-celery was *Eryngium globosum* (Jepson 1922). However, the name *Eryngium globosum* had already been used to represent an entirely different species, so Mathias (1936) changed the name of spiny-sepaled button-celery to *Eryngium spinosepalum*.

Hoover (1937) decided that this taxon was more appropriate at the rank of variety than species and thus suggested the name *Eryngium vaseyi* var. *globosum* in his thesis. Hoover's thesis did not meet the requirements for official publication of a scientific name; Mathias and Constance (1941) later properly published Hoover's combination *Eryngium vaseyi* var. *globosum*. That name remained in use until Sheik (1978) decided that spiny-sepaled button-celery deserved the rank of species and returned to the scientific name *Eryngium spinosepalum*, which remains in use (Constance 1993). However, some vernal pool experts (J. Stebbins *in litt.* 2000a) question whether spiny-sepaled button-celery should be considered a species due to the presence of intermediate forms. Other common names for this plant are spiny-sepaled coyote-thistle (Smith *et al.* 1980) and spiny coyote-thistle (EIP Associates 1994). The type locality of spiny-sepaled button-celery is Exeter, in Tulare County (Jepson 1922).

Description and Identification.—*Eryngium spinosepalum* has stout, branching, hairless stems 30 to 75 centimeters (11.8 to 29.5 inches) tall. The terrestrial leaves consist of a short petiole (less than 2 centimeters [0.8 inch] long) and a spiny-toothed or deeply-lobed blade 9 to 35 centimeters (3.5 to 13.8 inches) long. The flower heads of *E. spinosepalum* are spherical or egg-shaped, 0.8 to 2 centimeters (0.3 to 0.8 inch) in diameter, and contain more than 10 flowers each. Each flower head is on a stalk 2 centimeters (0.8 inch) long or less. The narrow bracts are spiny on the margin and on the underside, and typically protrude beyond the flower heads. Conversely, most bractlets are shorter than the flower head; each has a broad, papery margin at the base and only a few spines. The individual flowers of *E. spinosepalum* are tiny, with white petals and distinctive sepals. The sepals are 3.5 to 4.5 millimeters (0.14 to 0.18 inch) long, egg- or lance-shaped, and deeply divided into 3 to 8 spiny lobes or teeth. The fruits of *E. spinosepalum* are oblong to egg-shaped and 2.5 to 3 millimeters (0.10 to 0.12 inch) long (Jepson 1922, Abrams 1951, Mason 1957, Constance 1993). The diploid chromosome number of *E. spinosepalum* is 32 (Constance 1993).

Unlike *Eryngium constancei*, *E. spinosepalum* lacks hairs, has more than 10 flowers per head, the main stems are stout, and the stems supporting the flower heads are short. *Eryngium spinosepalum* is similar to both *E. castrense* and *E. vaseyi*, but both have narrower flower heads (no more than 15 millimeters [0.59 inch] in diameter) than *E. spinosepalum*. *Eryngium castrense* also has more deeply lobed leaves than *E. spinosepalum*, bracts and bractlets that are similar to each other and densely covered with spines, and bractlets that protrude well beyond the flower heads. *Eryngium vaseyi* also has deeply lobed leaves; the bracts and bractlets are similar to those of *E. spinosepalum*, but the sepals of the former are entire and shorter (2 to 3 millimeters [0.08 to 0.12 inch]) than those of *E. spinosepalum*.

Many plants found in nature are intermediate between *Eryngium spinosepalum* and either *E. castrense* or *E. vaseyi* in the size of the heads, length of the bractlets, and shape of the sepal margin. Moreover, individual plants and even single heads of *E. spinosepalum* may have both entire and toothed sepals (Hoover 1937, R. Stone *in litt.* 1992). The intermediate forms are thus difficult to classify, leading to uncertainties about the range of each taxon.

b. Historical and Current Distribution

Historical Distribution.—Typical *Eryngium spinosepalum* was known historically from the Southern Sierra Foothills Vernal Pool Region (Keeler-Wolf *et al.* 1998) in Fresno and Tulare Counties (**Figure II-26**). Hoover and others collected typical *E. spinosepalum* specimens from Orange Cove (Hoover 1937), east of Minkler, Sand Creek Basin, north of Sanger, and Squaw Valley, all in Fresno County (California Natural Diversity Data Base 2001). Specimens were collected from the following Tulare County sites between 1902 and 1954: Exeter, “Kaweah,” Lemon Cove, Redstone Park near Visalia, west of Springville, and Woodlake (Jepson 1922, Hoover 1937, California Natural Diversity Data Base 2001). The exact location of Redstone Park (Hoover 1937) is not certain because it is not shown on maps, but it could possibly be in the San Joaquin Valley Vernal Pool Region rather than the Southern Sierra Foothills Vernal Pool Region. Plants intermediate between *E. spinosepalum* and *E. castrense* or *E. vaseyi* were found in the Central Coast, Livermore, and San Joaquin Valley vernal pool regions. The five westernmost locations were in Contra Costa, Merced, San Joaquin, and Stanislaus Counties (Hoover 1937). Additional sites farther east included at least three in Kern County (Hoover 1937, Twisselmann 1967) and one in Fresno County, where specimens were collected in 1971 (California Natural Diversity Data Base 2001).

Current Distribution.—The California Natural Diversity Data Base (2005) currently includes 59 extant occurrences of *Eryngium spinosepalum* and 4 that are known or presumed extirpated; it does not include intermediate populations. In addition, three of the typical populations reported historically are not included in the California Natural Diversity Data Base (2005), but could still be extant. Thus, 66 typical populations have been reported, of which 62 may remain extant. Thirty-three populations presumed to be extant are in Merced County, 14 are in Tulare County, 6 are in Fresno County, 3 are in Madera County, 2 in Tuolumne County, and 1 in Calaveras County (Jepson 1922, Hoover 1937, California Natural Diversity Data Base 2005). Thirty of the Merced County

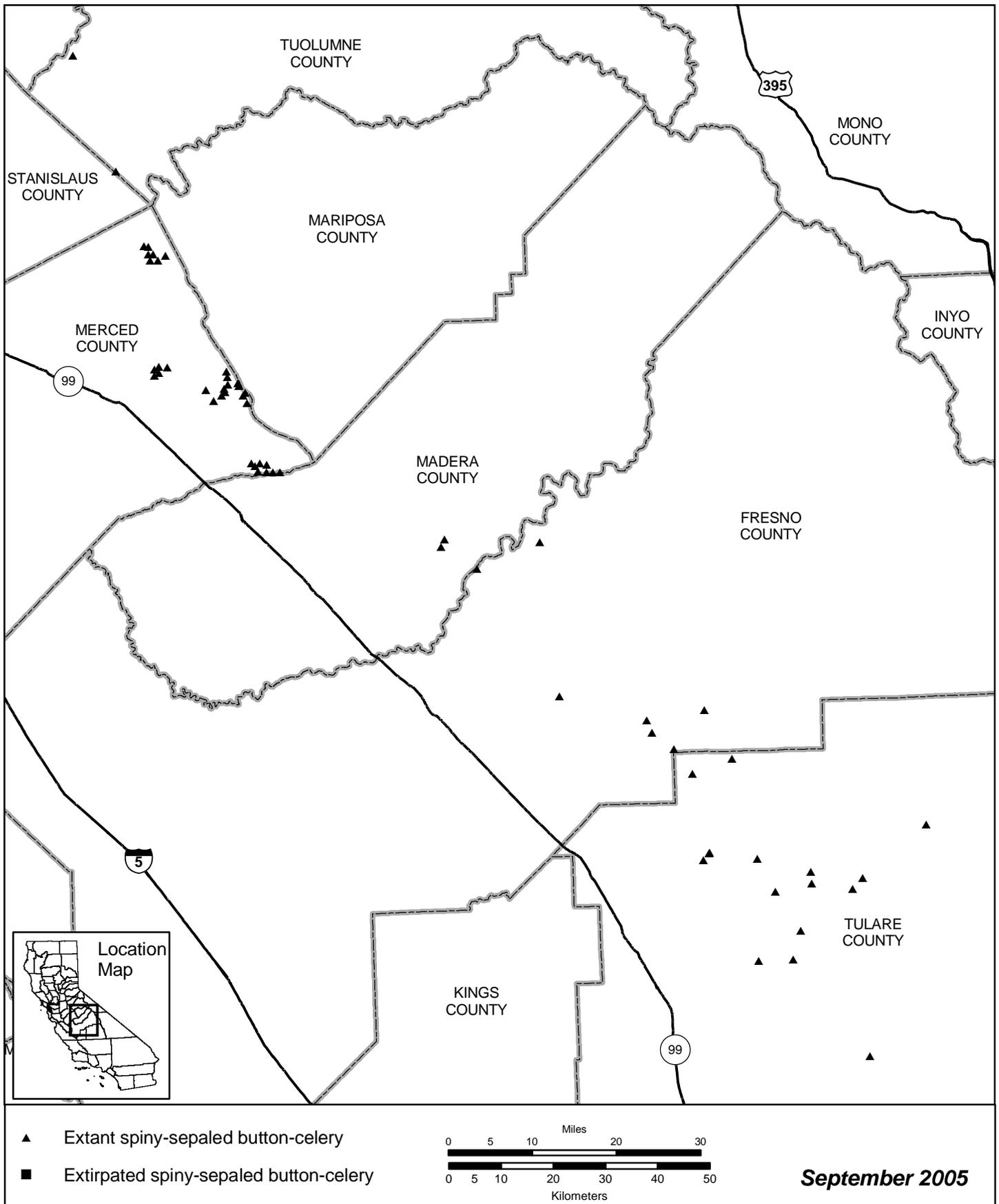


Figure II-26. Distribution of *Eryngium spinosepalum* (spiny-sepaled button-celery).

occurrences were reported in 2001 (Vollmar 2001) from eastern Merced County in the Owens Reservoir/Planada area, south of Le Grand, and in the Snelling area (California Natural Diversity Data Base 2005). Many populations of this species are isolated, but minor areas of concentration are in the vicinity of Lake Kaweah in Tulare County and in the Orange Cove-Kaktus Korner area spanning the Tulare-Fresno County line. Two sites are known near Seville in Tulare County, and two others are in the Four Corners area of Madera County. According to Keeler-Wolf *et al.* (1998), *E. spinosepalum* is restricted to the Southern Sierra Foothills Vernal Pool Region.

Intermediate forms of *Eryngium* and other populations whose identity has not been confirmed have been reported from a total of 15 sites. Seven of these populations are extant: three in Fresno County (S. Snover *in litt.* 1994), three in Madera County (R. Stone *in litt.* 1992), and one in Merced County (Stebbins *et al.* 1993). The eight historical localities of intermediates (Hoover 1937, Twisselmann 1967, California Natural Diversity Data Base 2001) have not been revisited in 30 to 60 years and may or may not be extant.

c. Life History and Habitat

Reproduction and Demography.—Unlike most of the vernal pool plants included in this recovery plan, *Eryngium spinosepalum* is a perennial. *Eryngium spinosepalum* flowers in April and May (Skinner and Pavlik 1994). Its pollinators, seed dispersal agents, and population demographics are unknown. As a perennial, population sizes probably do not fluctuate drastically between years, except in response to major disturbances.

Habitat and Community Associations.—*Eryngium spinosepalum* grows in both Northern Hardpan and Northern Claypan vernal pools (Sawyer and Keeler-Wolf 1995), as well as in roadside ditches (Mason 1957), depressions, and swales in annual grassland and oak woodlands (Twisselmann 1967, California Natural Diversity Data Base 2001). Characteristics of pools supporting *E. spinosepalum* have been described only from the Stone Corral Ecological Reserve in Tulare County. There, the species grew in two “swale-like” Northern Claypan Vernal Pools about 0.5 and 2.4 hectares (1.2 and 6.0 acres) in area, respectively. The smaller pool was about 41 centimeters (16 inches) deep, and the larger was more than 46 centimeters (18 inches) deep. Soil pH ranged from 6.1 to 7.1 at various points below the smaller pool and from 7.0 to 7.5 below the larger pool. Population size was in the thousands in the larger pool and in the hundreds in the smaller one (Stebbins *et al.* 1995). Both pools occur on Lewis clay loam over lime-silica hardpan at the rim of the saline-alkali basin (Stone *et al.* 1988).

Sites from which typical *Eryngium spinosepalum* has been reported range in elevation from 107 meters (350 feet) at Stone Corral Ecological Reserve to about 567 meters (1,860 feet) north of Marshall Hill in Fresno County (California Natural Diversity Data Base 2005). Intermediate forms of *Eryngium* have been reported from elevations of 67 meters (220 feet) in Merced County (Stebbins *et al.* 1993) to about 1,000 meters (3,281 feet) at Lynns Valley in Kern County (Twisselmann 1967).

Species most frequently associated with *Eryngium spinosepalum* include *Psilocarphus brevissimus*; upland grasses such as *Bromus* spp., *Hordeum marinum* ssp. *gussoneanum* (Mediterranean barley), and *Lolium multiflorum*; unidentified species of *Plagiobothrys*; and other species of *Eryngium* (California Natural Diversity Data Base 2001). Listed vernal pool plants with which *E. spinosepalum* grows are *Chamaesyce hooveri* and *Orcuttia inaequalis*, both at the Stone Corral Ecological Reserve complex (Stone *et al.* 1988, California Natural Diversity Data Base 2005). An intermediate form of *Eryngium* also grows with *O. inaequalis* in Madera County (R. Stone *in litt.* 1992, J. Stebbins *in litt.* 2000a). *Brodiaea insignis* (Kaweah brodiaea), a State-listed endangered species that does not occur in vernal pools, grows with typical *E. spinosepalum* at three sites near Lake Kaweah (California Natural Diversity Data Base 2001).

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 spinosepalum* are described below.

One former population of *Eryngium spinosepalum* in Fresno County was extirpated by conversion to an orange grove. Another in Tulare County was in an area that has been developed for urban and agricultural uses (California Natural Diversity Data Base 2001).

Specific continuing threats include proposed construction of a new dam at Lake Kaweah, which would inundate one occurrence of *Eryngium spinosepalum* at the east end of the lake (U.S. Army Corps of Engineers 1996, California Natural Diversity Data Base 2005). Road construction and maintenance threaten one Fresno County occurrence and the two in Madera County. A development has been proposed for the single Tuolumne County site (California Natural Diversity Data Base 2005). In addition, many of the other occurrences representing typical *E. spinosepalum* face potential threats. Fourteen of the extant occurrences are threatened by conversion to intensive agriculture, particularly to citrus groves, or

by development for residential or urban uses. Although the pollinating agents for *E. spinosepalum* have not yet been determined, if insects are the pollinators a decline in their populations due to habitat loss is a potential problem.

e. Conservation Efforts

Eryngium spinosepalum has no formal protection at either the Federal or State level. This species was a Federal Category 2 candidate for listing (U.S. Fish and Wildlife Service 1985c) until we eliminated that classification (U.S. Fish and Wildlife Service 1996a). The California Native Plant Society has considered *E. spinosepalum* to be rare for many years (Smith *et al.* 1980) and currently includes this species on its List 1B, noting that it is endangered in a portion of its range (California Native Plant Society 2001). This species has not been targeted for any particular conservation efforts. The only protected occurrence of *E. spinosepalum* is at the California Department of Fish and Game's Stone Corral Ecological Reserve (Stebbins *et al.* 1995). Three other occurrences are on public land owned by the U.S. Army Corps of Engineers or the California Department of Transportation, but they are not free from threats (California Natural Diversity Data Base 2005).

5. GRATIOLA HETEROSEPALA (BOGGS LAKE HEDGE-HYSSOP)

a. Description and Taxonomy

Taxonomy.—Boggs Lake hedge-hyssop has been known by only one scientific name, *Gratiola heterosepala*, since it was first named by Mason and Bacigalupi (1954). The type locality is Boggs Lake, in Lake County (Mason and Bacigalupi 1954). This species is a member of the figwort family (Scrophulariaceae).

Description and Identification.—*Gratiola heterosepala* is an erect annual with hollow stems 2 to 10 centimeters (0.8 to 3.9 inches) tall. The stems are mostly hairless, except for a few glandular hairs in the inflorescence. The leaves are opposite and have entire margins. Leaves near the base of the stem are 1 to 2 centimeters (0.4 to 0.8 inch) long and lance-shaped, but the leaves become shorter, wider, and blunt-tipped farther up on the stem. The 6 to 8 millimeters (0.23 to 0.31 inch) long flowers are borne singly in the upper leaf axils. Each corolla has two lips; the tube and upper lip are yellow, whereas the lower

lip is white. However, the flowers appear yellow from a distance. The calyx is 4 to 6 millimeters (0.16 to 0.24 inch) long and has five sepals of differing lengths and shapes, giving rise to the specific epithet, *heterosepala* (meaning different sepals). The upper three sepals are united for about one-third of their length; the center sepal is longer than the others. The two lower sepals are separate and have notched tips, in contrast to the blunt tips of the upper sepals. The fruit of *G. heterosepala* is a small, dry, pear-shaped capsule that is about the same length as the calyx. The tiny seeds are oblong and have narrow lengthwise ridges (Mason and Bacigalupi 1954, Mason 1957, Wetherwax 1993). *Gratiola heterosepala* is most similar to *G. ebracteata* (bractless hedge-hyssop). However, in *G. ebracteata* the sepals are longer, pointed, and are separate almost all the way to their bases; all five corolla lobes are white; and the seeds have both lengthwise and crosswise ridges. The other California species, *G. neglecta* (common American hedge-hyssop), has bracts below the calyx, purplish corolla lobes, and a corolla at least twice as long as the calyx (Mason 1957, Wetherwax 1993).

b. Historical and Current Distribution

Historical Distribution.—This species was first collected in Lake County, California, in 1923. The exact collection site is uncertain, but probably was Bogs Lake, where the species also was collected in 1929 and 1953 (Mason and Bacigalupi 1954) (**Figure II-27**). An additional site was found in Madera County in 1961, then another in Sacramento County in 1977 (California Natural Diversity Data Base 2001). During the 1980s, 20 additional occurrences were discovered in California, plus one in Lake County, Oregon (California Department of Fish and Game 1987*d*). These additional California occurrences included nine in Shasta County; three each in Fresno, Placer, and Sacramento Counties; and one each in Lake and Modoc Counties (California Natural Diversity Data Base 2001). Thus, the historical range included the Lake-Napa, Modoc Plateau, Southeastern Sacramento Valley, and Southern Sierra Foothills Vernal Pool Regions (Keeler-Wolf *et al.* 1998).

Current Distribution.—Currently, *Gratiola heterosepala* is known from 85 extant occurrences in California plus 1 in Oregon. Only one of the historical occurrences is believed to have been extirpated, in Sacramento County. In addition to the four vernal pool regions where it was known historically, *G. heterosepala* is now known from the Northeastern and Northwestern Sacramento Valley and the Solano-Colusa vernal pool regions (Keeler-Wolf *et al.* 1998). Additional counties of occurrence are Lassen, Madera, Merced, San Joaquin, Siskiyou, Solano, and Tehama (C. Witham *in litt.* 2000*b*, California Natural Diversity Data Base 2005).

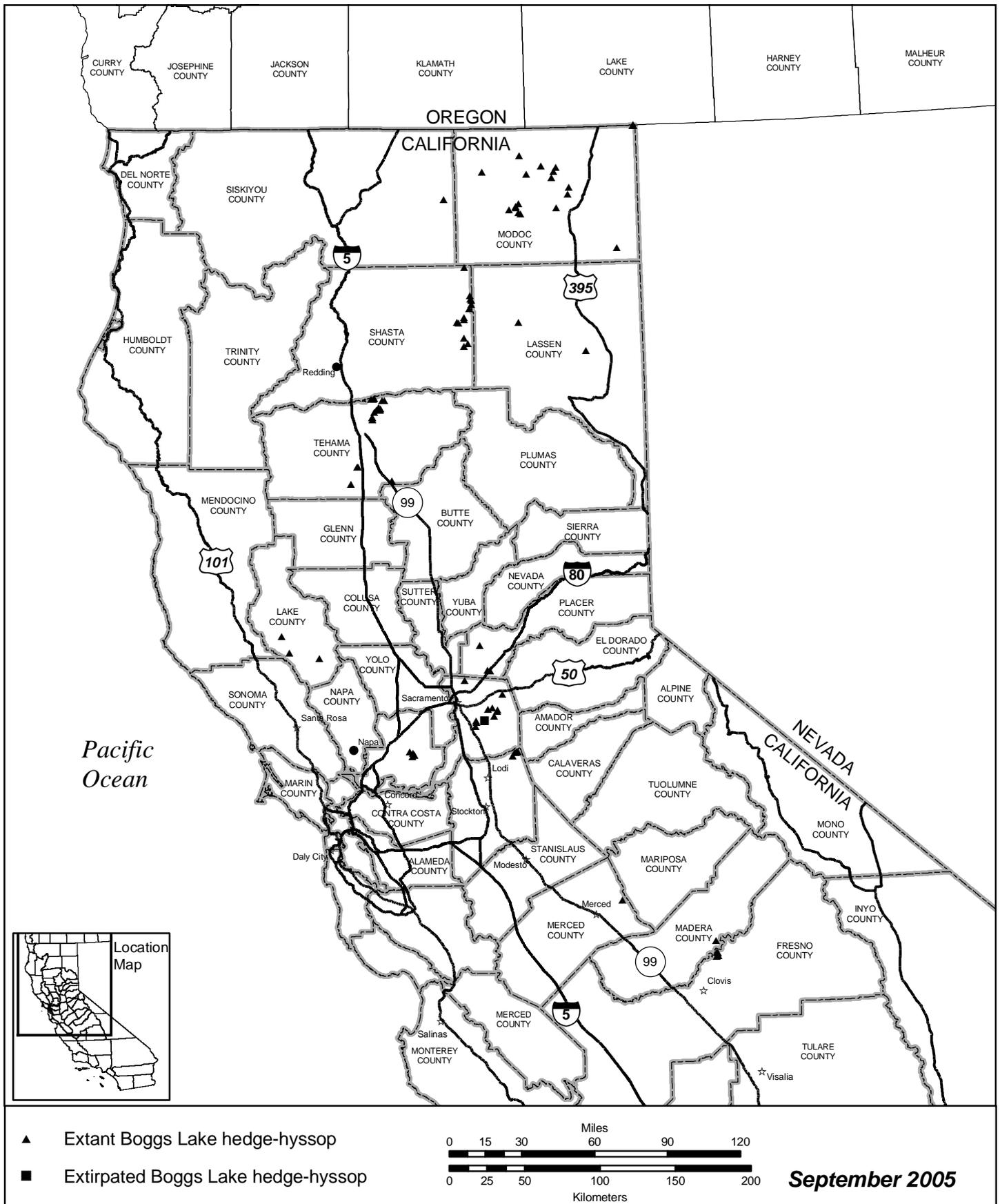


Figure II-27. Distribution of *Gratiola heterosepala* (Boggs Lake hedge-hyssop)

The primary area of concentration for *Gratiola heterosepala*, with 32 occurrences (37 percent), is the Modoc Plateau, where occurrences are known from Lassen, Modoc, and Shasta Counties in California and Lake County in Oregon (Kaye *et al.* 1990, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2005). Two secondary areas of occurrence are the southeastern Sacramento Valley and the northeastern Sacramento Valley, with 17 extant occurrences (20 percent) each. The southeastern Sacramento Valley concentration is in Placer, Sacramento, and San Joaquin Counties, primarily between the cities of Roseville and Elk Grove. The northeastern Sacramento Valley concentration is in the vicinity of Dales, in Tehama County. The Southern Sierra Foothills Vernal Pool Region has six occurrences (7 percent), including four in Fresno County and one each in Madera (California Natural Diversity Data Base 2005) and Merced (C. Witham *in litt.* 2000b) Counties. Five (6 percent) occurrences in Solano County are within the Solano-Colusa Vernal Pool Region. The remaining occurrences include three (4 percent) in Lake County, California, and one in Siskiyou County, representing the Lake-Napa and Northwestern Sacramento Valley Vernal Pool Regions, respectively (California Natural Diversity Data Base 2005).

c. Life History and Habitat

Reproduction and Demography.— Most of the life history information regarding *Gratiola heterosepala* comes from an intensive study of the Oregon population by Kaye *et al.* (1990). California plants are morphologically similar to those in Oregon and grow in similar habitats; therefore, the life history of *G. heterosepala* is presumed to be similar in the two states.

The seeds of *Gratiola heterosepala* most likely germinate in response to autumn or winter rains (Kaye *et al.* 1990, Corbin *et al.* 1994). By the time the water recedes the plants already are in bud or in flower; flowering can begin when as much as 5 centimeters (2.0 inches) of water remains (Kaye *et al.* 1990, Corbin *et al.* 1994). Throughout the range of the species, flowers are open between April and August, with those at the highest elevations flowering later (Corbin *et al.* 1994). Each plant typically produces only one or two flowers (Kaye *et al.* 1990, Corbin *et al.* 1994), which mature into fruits within 1 to 2 weeks after flowering begins. The plants disappear quickly after seed-set (Corbin *et al.* 1994).

Kaye *et al.* (1990) determined that *Gratiola heterosepala* is self-compatible and does not require insects for pollination. During their one-season study in Oregon, plants set equal amounts of seed whether or not insects were excluded. Moreover, insects were not observed visiting the flowers in natural settings (Kaye *et al.* 1990). The Oregon population averaged about 150 seeds per fruit, but the number of fruits per plant was not reported. The fruits showed no insect damage (Kaye *et al.* 1990). Seed dispersal agents are not known, and seed longevity in

the soil has not been tested. However, seeds in one population on the Lassen National Forest (Shasta County) apparently remained dormant for 3 years, which was the interval between observations of growing plants (Corbin *et al.* 1994).

California populations of *G. heterosepala* range in size from only a few individuals to over 1 million (California Natural Diversity Data Base 2001). As observed with other vernal pool annuals, population numbers fluctuate greatly from year to year (Corbin *et al.* 1994). The Boggs Lake population declined from 1,000 individuals in 1981 to 0 in 1989 and remained at 0 until 1997, when 5 plants were found (Serpa 1993, California Natural Diversity Data Base 2001). The plants were widely scattered at Boggs Lake historically, with individuals growing isolated from each other (Mason and Bacigalupi 1954). At the one Vina Plains occurrence, the density of *G. heterosepala* was 67.4 plants per square meter (6.3 plants per square foot) in 1995 (Alexander and Schlising 1997).

Habitat and Community Associations.—*Gratiola heterosepala* occurs in vernal pools and in marshy areas on the margins of reservoirs and lakes, as well as in man-made habitats such as borrow pits and cattle ponds (Kaye *et al.* 1990, Corbin *et al.* 1994, California Natural Diversity Data Base 2001). It has been found in several types of vernal pools, including Northern Basalt Flow, Northern Claypan, Northern Hardpan, Northern Volcanic Ashflow, and Northern Volcanic Mudflow (Sawyer and Keeler-Wolf 1995). Occupied wetlands are amongst annual grassland, *Quercus* (oak) woodland, *Juniperus* (juniper) woodland, or coniferous forest (California Department of Fish and Game 1987d, Kaye *et al.* 1990, Corbin *et al.* 1994, California Natural Diversity Data Base 2001).

Although *Gratiola heterosepala* most often occurs on the margins of lakes and pools where water does not become too deep (Corbin *et al.* 1994), it also has been found in the beds of deeper vernal pools (California Natural Diversity Data Base 2001). Clay is the most frequently encountered soil underlying occupied habitats, although loam and loamy sand have also been noted. Most sites are underlain by an impermeable layer (Corbin *et al.* 1994, California Natural Diversity Data Base 2001). Kaye and others (1990) noted that in juniper woodlands, *G. heterosepala* occurred on acidic soils with a pH of about 5. Some northern California sites are on slightly acidic soils, but soil pH has not been tested in other areas (Corbin *et al.* 1994).

Known *Gratiola heterosepala* sites in California range in elevation from 8 meters (25 feet) in Solano County to at least 1,576 meters (5,170 feet) in Modoc County (B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2001). A reported occurrence of *G. heterosepala* at North Emerson Lake in Modoc County is at 2,400 meters (7,900 feet) in elevation (California Natural Diversity Data Base 2001), but several species experts have revisited the site and found only

G. ebracteata (B. Corbin *in litt.* 2000, G. Schoolcraft *in litt.* 2000). The elevation of the Lake County, Oregon, occurrence is 1,634 meters (5,340 feet) (Kaye *et al.* 1990).

The most frequent associate of *Gratiola heterosepala* is *G. ebracteata* (California Natural Diversity Data Base 2001); the latter may form dense colonies containing only a few individuals of *G. heterosepala* (Mason and Bacigalupi 1954). Other typical associates, in order of frequency, are *Plagiobothrys stipitatus*, *Downingia bicornuta* (two-horned downingia), *Orcuttia tenuis*, and *Eleocharis macrostachya*. Several of the rare, threatened, and endangered plants in this recovery plan co-occur with *G. heterosepala*; these taxa include *O. tenuis* at 20 sites, *Tuctoria greenei* at 2 sites, and *Castilleja campestris* ssp. *succulenta*, *O. pilosa*, *Chamaesyce hooveri*, *Legenere limosa*, *Myosurus minimus* ssp. *apus*, *Navarretia leucocephala* ssp. *pliantha*, *O. viscida*, and *O. inaequalis* at 1 site each (B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2001).

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 *Gratiola heterosepala* are described below.

Habitat conversion for housing was responsible for the extirpation of one *Gratiola heterosepala* population in Sacramento County (California Natural Diversity Data Base 2001). Cattle trampling destroyed many immature plants at the Oregon occurrence (Kaye *et al.* 1990). Four occurrences have been disturbed but not extirpated by hydrological alterations such as excavation and damming, and another three by surface disturbances such as discing and grading (California Natural Diversity Data Base 2001). Urban growth through residential development, shopping center construction, and landfill expansion threatens seven of the populations in Placer and Sacramento Counties (California Natural Diversity Data Base 2001). Competition from *Taeniatherum caput-medusae* potentially threatens *G. heterosepala* at five sites of occurrence on the Modoc Plateau (Corbin *et al.* 1994). Nine of the extant occurrences contain fewer than 100 individuals at their maximum, and several are undergoing rapid declines (California Natural Diversity Data Base 2001). These populations are sufficiently small that they are in danger of extirpation from chance events (Menges 1991).

Livestock grazing may or may not pose a threat to the survival of *Gratiola heterosepala*. Although 48 California occurrences are subject to grazing by cattle, sheep, horses, or feral pigs (Corbin *et al.* 1994, B. Corbin *in litt.* 2000,

California Natural Diversity Data Base 2001), only 6 of those were reported to have heavy grazing or severe trampling (California Natural Diversity Data Base 2001). Trampling and herbivory can be detrimental if they occur before seed set or if use is concentrated in a small area. Moderate grazing is believed to be a compatible use if it occurs after *G. heterosepala* sets seed (Mason and Bacigalupi 1954, California Department of Fish and Game 1987*d*). Directed research is necessary to establish appropriate use levels and seasons. The 47 occurrences administered by the U.S. Forest Service and the U.S. Bureau of Land Management potentially are subject to disturbance or destruction from livestock grazing and trampling, activities associated with logging, assorted recreational uses, hydrological alterations, road construction, fire suppression, weed competition, and herbicide drift (Corbin *et al.* 1994, California Natural Diversity Data Base 2001). However, management guidelines proposed by the agencies (Corbin *et al.* 1994) (see also “Conservation Efforts” below) would mitigate such disturbances.

e. Conservation Efforts

Gratiola heterosepala has no Federal listing status. It was listed as endangered by California in 1978 (California Department of Fish and Game 1991) and is listed as threatened in Oregon (Tibor 2001). It was included in the California Native Plant Society’s first list of rare and endangered plants (Powell 1974). In the most recently published listing by this group (Tibor 2001), *G. heterosepala* was placed on List 1B. The U.S. Forest Service formerly considered *G. heterosepala* to be “sensitive” but has reclassified it as a “special interest plant” because it is more abundant than previously thought (B. Corbin *in litt.* 2000). The U.S. Bureau of Land Management classifies *G. heterosepala* as a “special status” species (Corbin *et al.* 1994).

Twelve (14 percent) of the known occurrences of *Gratiola heterosepala* are in nature reserves. Seven of those are on ecological reserves or preserves operated by the California Department of Fish and Game, including four at Dales Lake in Tehama County, two at Thomes Creek in Tehama County, and one at Big Table Mountain in Fresno County. Nature reserves owned by private conservation organizations support another five occurrences, including two at Big Table Mountain Preserve in Fresno County (one of which is partially on Federal land) and one each at Boggs Lake Preserve in Lake County, Vina Plains Preserve in Tehama County, and Jepson Prairie Preserve in Solano County. When The Nature Conservancy managed the Boggs Lake Preserve, they erected fences around colonies of *G. heterosepala* to exclude horses and deer (Serpa 1993). Volunteers conduct periodic monitoring and searches for *G. heterosepala* and other rare plants at the Boggs Lake, Jepson Prairie, and Vina Plains preserves (Baldwin and Baldwin 1991, California Natural Diversity Data Base 2001).

Forty-seven (57 percent) of *Gratiola heterosepala* occurrences are on Federal land, which does not necessarily mean that they are protected from future disturbance. Among the occurrences on Federal land, 32 are on the Lassen and Modoc National Forests in Lassen, Modoc, and Shasta Counties. Two of these occurrences are in areas with special designations, the Murken Botanical Special Interest Area and the South Warner Wilderness, where many uses are restricted (Corbin *et al.* 1994). Another 15 occurrences are at least partially on lands administered by the U.S. Bureau of Land Management in five different resource areas. These occurrences include six in Tehama County, five in Shasta County, two in Fresno County (one of which is partially on a private nature reserve), and one each in Lassen County, California, and Lake County, Oregon (Kaye *et al.* 1990, Corbin *et al.* 1994, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2001). Four of the occurrences on U.S. Bureau of Land Management property are in wilderness study areas (Corbin *et al.* 1994) and may be afforded additional protection if Congress designates those areas as official wilderness. The U.S. Forest Service and the U.S. Bureau of Land Management developed a formal conservation strategy for *G. heterosepala* (Corbin *et al.* 1994) on lands they administer in northeastern California. Their goal was to protect 90 percent of the plants and sites from direct disturbance and hydrological alterations over a 10-year period. Additional conservation measures identified in the plan were comparisons of grazed and control areas, monitoring, surveys, and acquisition through land exchanges. However, due to funding priorities and the reclassification from “sensitive” status, intensive monitoring has been discontinued (B. Corbin *in litt.* 2000). The agencies have fenced several sites in northeastern California (Corbin *et al.* 1994, B. Corbin *in litt.* 2000) and in Fresno County (California Department of Fish and Game 1991, A. Franklin *in litt.* 1993) to prevent cattle from trampling *G. heterosepala*. *Gratiola heterosepala* also may benefit from a grazing-management experiment being conducted at Big Table Mountain in Fresno County (see discussion under *Castilleja campestris* ssp. *succulenta*).

Numerous groups and individuals, including the U.S. Forest Service, and U.S. Bureau of Land Management, participated in surveys for this species over the past decade, resulting in the identification of many new populations (Kaye *et al.* 1990, Corbin *et al.* 1994, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2001). Some of the surveys were in Oregon, where the Oregon Department of Agriculture and the U.S. Bureau of Land Management also funded studies to determine the breeding system of *Gratiola heterosepala* (Kaye *et al.* 1990).

6. *JUNCUS LEIOSPERMUS* VAR. *AHARTII* (AHART'S DWARF RUSH)

a. Description and Taxonomy

Taxonomy.—This taxon was first described in 1986 as *Juncus leiospermus* var. *ahartii* (Ertter 1986), although it had been recognized as unique more than 10 years earlier (L. Ahart *in litt.* 1986). The type locality is on the Ahart Ranch in Butte County, northeast of Honcut (Ertter 1986). Ahart's dwarf rush is a member of the rush family (Juncaceae) and is also known by the common name Ahart's rush (U.S. Fish and Wildlife Service 1996b).

Description and Identification.—*Juncus leiospermus* var. *ahartii* is a small, reddish, grass-like plant from 2 to 6 centimeters (0.8 to 2.4 inches) tall. Each plant may produce as many as 100 slender stems from its base, but the individual stems do not branch. The grass-like leaves arise from the base and are about half as long as the stems. Each stem produces only a single, tiny flower at its tip. The 6 to 10 petal-like parts per flower are not differentiated into sepals and petals but instead are all similar in appearance. They are lance-shaped, 2.4 to 3.6 millimeters (0.09 to 0.14 inch) long, and are maroon with a green or reddish stripe down the center. The flowers have two to five stamens with anthers greater than 0.7 millimeter (0.03 inch) long and a style 0.9 to 4 millimeters (0.04 to 0.16 inch) long. The fruit is a spherical or egg-shaped capsule 2.5 to 4.5 millimeters (0.10 to 0.18 inch) long, which contains many tiny, smooth seeds. The diploid chromosome number of *J. leiospermus* var. *ahartii* is 32 (Ertter 1986, Swab 1993).

The most closely related species, *Juncus leiospermus* var. *leiospermus* (Red Bluff dwarf rush), has several flowers clustered together. *J. uncialis* (inch-high dwarf rush) is similar to *J. leiospermus* var. *ahartii* in that it has only one flower per stem, but the former is less than 3.5 centimeters (1.4 inches) tall and has a shorter style and anthers. Other annual rushes have one or more of the following characteristics: thread-like stems, flowers in heads, shorter styles and anthers, or conspicuous ridges on the seeds (Ertter 1986, Swab 1993).

b. Historical and Current Distribution

Historical Distribution.—When it was named, *Juncus leiospermus* var. *ahartii* was known from four occurrences in two areas. Three of the four historical occurrences were on the Ahart Ranch in Butte County, where this species occurred in about 10 separate pools (**Figure II-28**). The fourth occurrence was near the town of Jenny Lind in Calaveras County (Ertter 1986). The Ahart Ranch is in the Northeastern Sacramento Valley Vernal Pool Region,

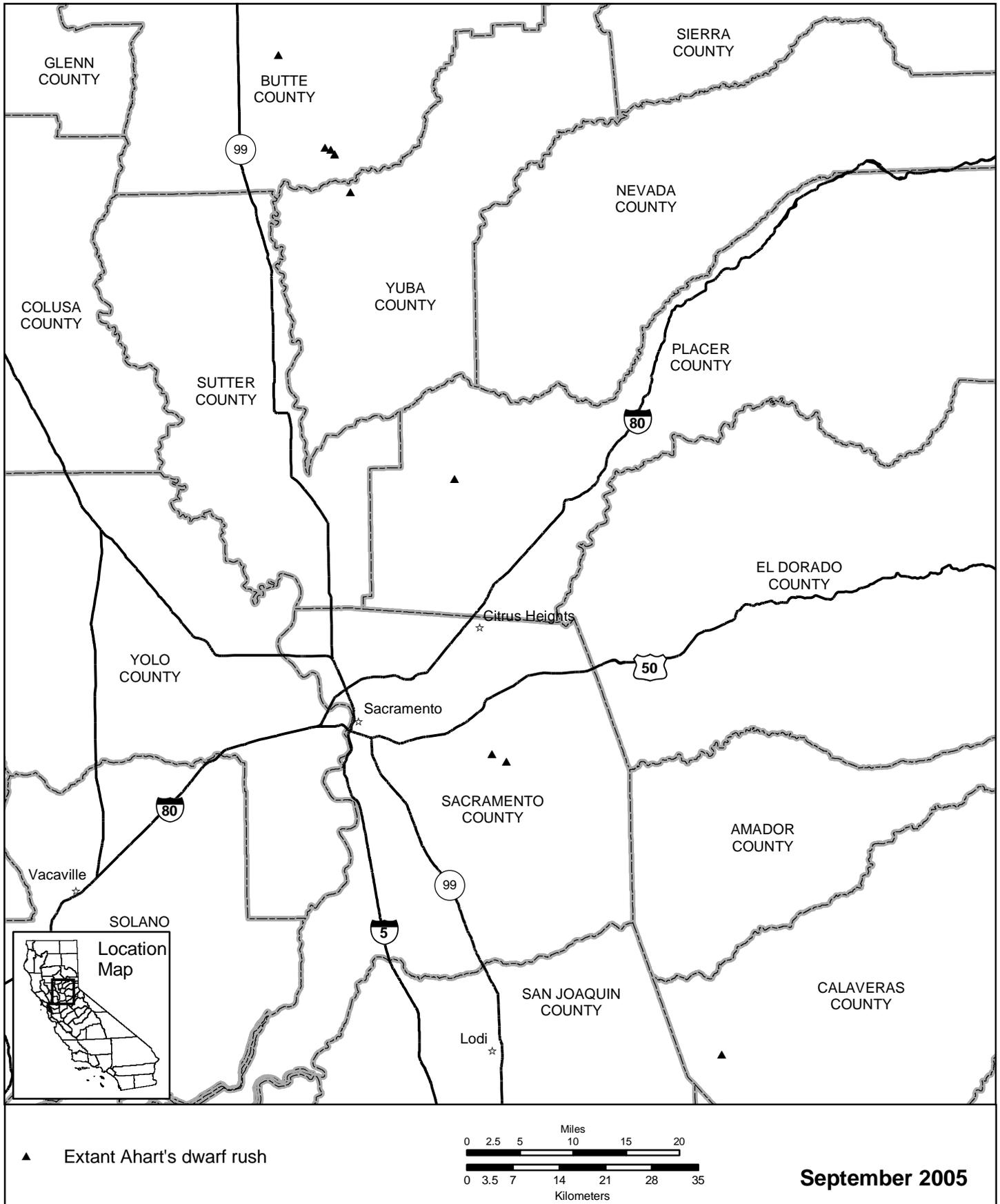


Figure II-28. Distribution of *Juncus leiospermus* var. *ahartii* (Ahart's dwarf rush).

and Jenny Lind is in the Southeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf *et al.* 1998).

Current Distribution.—*Juncus leiospermus* var. *ahartii* is currently known to be extant from nine occurrences in Butte, Calaveras, Placer, Sacramento, Tehama, and Yuba Counties (California Natural Diversity Data Base 2005). This taxon is believed to remain extant on the Ahart Ranch and near Jenny Lind, although these sites have not been revisited since 1991. In addition, *Juncus leiospermus* var. *ahartii* has been found at the Oroville Municipal Airport in Butte County, near the Lincoln Airport in Placer County and in the Buffalo Creek area of Sacramento County (California Natural Diversity Data Base 2005). Thus, a total of nine occurrences are presumed to be extant and one is presumed to be extirpated in Sacramento County. All are in either the Northeastern Sacramento Valley or the Southeastern Sacramento Valley Vernal Pool Regions (Keeler-Wolf *et al.* 1998).

c. Life History and Habitat

Reproduction and Demography.—Very little information concerning *Juncus leiospermus* var. *ahartii* has been reported. It is an annual that flowers in April and May (L. Ahart *in litt.* 1986, California Natural Diversity Data Base 2001). Germination dates and conditions are unknown. *Juncus leiospermus* var. *ahartii* is wind-pollinated (Ertter 1986). In years of low rainfall, each plant typically has only a single stem. Moreover, larger populations have been observed in wet than in dry years (L. Ahart *in litt.* 1986).

Habitat and Community Associations.—*Juncus leiospermus* var. *ahartii* occurs in the Northern Basalt Flow, Northern Claypan, Northern Hardpan, and Northern Volcanic Mudflow vernal pool types (Sawyer and Keeler-Wolf 1995). The surrounding plant communities were not mentioned, except that the vernal pools at the type locality were in a grain field. Microhabitats from which the plants have been reported are the edges of vernal pools, bottoms of intermittent drainages, and on pocket gopher (*Thomomys* species) and ground squirrel (*Spermophilus* species) mounds (L. Ahart *in litt.* 1986, Ertter 1986, California Natural Diversity Data Base 2001). Soils underlying the pools typically are acidic clays (Ertter 1986). Known occurrences are at about 30 to 90 meters (100 to 300 feet) in elevation (California Natural Diversity Data Base 2001). The most frequent associate is *J. uncialis* (L. Ahart *in litt.* 1986, Ertter 1986, 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 *Juncus leiospermus* var. *ahartii* are described below.

Expansion of the runway at Oroville Municipal Airport destroyed part of the *Juncus leiospermus* var. *ahartii* population there (California Natural Diversity Data Base 2001). The type locality for *J. leiospermus* var. *ahartii* was dry-farmed in the 1970s. However, the disturbance created by plowing and the associated reduction in competing species apparently were beneficial to this taxon. Farming has since ceased in the area (L. Ahart *in litt.* 1986, Ertter 1986), but the response of *J. leiospermus* var. *ahartii* has not been determined. The Lincoln site has been degraded by off-road vehicle use, road construction, livestock grazing, and unspecified “disturbance” from adjacent developments (California Natural Diversity Data Base 2001). Other populations may have been destroyed before their discovery because much of the suitable habitat for *J. leiospermus* var. *ahartii* has been converted to agriculture and housing (Ertter 1986).

The Lincoln occurrence is on the site of a proposed housing development, which would destroy all of the occupied pools there (California Natural Diversity Data Base 2001). Random events coupled with small population size (Menges 1991) are a potential threat to 3 of the occurrences, which range in size from 45 to about 120 individuals (L. Ahart *in litt.* 1986, California Natural Diversity Data Base 2001).

e. Conservation Efforts

Juncus leiospermus var. *ahartii* was a Category 1 candidate for Federal listing even before it was officially named (U.S. Fish and Wildlife Service 1983b). However, in 1996 candidate status was withdrawn because insufficient information was available to propose the taxon for listing, and existing data suggested that it was not in danger of extinction throughout a significant portion of its range (U.S. Fish and Wildlife Service 1996b). *Juncus leiospermus* var. *ahartii* has no State status. The California Native Plant Society includes it on List 1B and considers it to be rare and of limited distribution, but not in danger of extinction (California Native Plant Society 2001). The only conservation measure implemented for this taxon to date was the establishment of a preserve near the Oroville Municipal Airport (California Natural Diversity Data Base 2005).

7. *LEGENERE LIMOSA* (LEGENERE)

a. Description and Taxonomy

Taxonomy.—Greene (1890) originally published the scientific name *Howellia limosa* for legenera. He gave the type locality only as “the lower Sacramento” (Greene 1890:81). Based on label information from Greene’s collections, the type locality has been further described as “Fields of the lower Sacramento Valley near Elmira, Solano County, California” (McVaugh 1943:14). McVaugh (1943) determined that this species differed sufficiently from *Howellia* to be transferred to a new genus, *Legenere*. Thus, the currently accepted name for this species is *Legenere limosa*. *Legenere* is the only species in its genus (Morin 1993), which is in the bellflower family (Campanulaceae). Another common name for this species is Greene’s legenera (Morin and Niehaus 1977, Holland 1984).

Description and Identification.—*Legenere limosa* is an inconspicuous annual. The entire plant is hairless. The main stems are 10 to 30 centimeters (3.9 to 11.8 inches) long and decumbent, although any branches are erect. Extra roots often arise from the lower nodes. The leaves, which are produced underwater, are 1 to 3 centimeters (0.4 to 1.2 inches) long and narrowly triangular; they fall off the plant before flowers appear. The egg-shaped or oval bracts are 6 to 12 millimeters (0.24 to 0.47 inch) long and remain throughout the flowering period. A single flower arises above each bract. *Legenere limosa* flowers may or may not have corollas, and a single plant can produce both types of flowers. When present, the corollas are white or yellowish, 3.5 to 4 millimeters (0.14 to 0.16 inch) long, and two-lipped. The upper two corolla lobes are narrower than the lower three, and the corolla tube is slit on the upper side. The stamens are joined to form a tubular structure. The flower stalks are very slender and elongate as the fruit matures, reaching a final length of as much as 3 centimeters (1.2 inches). *Legenere limosa* has a cylindrical capsule 6 to 10 millimeters (0.24 to 0.39 inch) long, which splits open only at the tip. Each capsule contains up to 20 seeds, which are about 1 millimeter (0.04 inch) long, brown, smooth, and shiny (McVaugh 1943, Mason 1957, Abrams and Ferris 1960, Holland 1984, Morin 1993). The chromosome number of *L. limosa* has not been determined.

The genera most likely to be confused with *Legenere limosa* are *Howellia*, *Downingia*, *Lobelia*, and *Porterella*. Both *Howellia* and *Downingia* have capsules that split along the sides, whereas the capsule of *L. limosa* opens at the tip. Moreover, *Downingia* flowers are not stalked. The *Lobelia* species in California have either red or blue flowers and spherical fruits, as opposed to the whitish flowers and cylindrical fruits of *L. limosa*. *Porterella* has showy blue flowers with yellow or white marks at the base of the corolla lobes, and it occurs

at higher elevations than *L. limosa* (Morin and Niehaus 1977, Holland 1984, Morin 1993).

b. Historical and Current Distribution

Historical Distribution.—Between 1890 and 1984, *Legenere limosa* had been reported from 12 sites in 8 counties encompassing 6 vernal pool regions. The historical counties of occurrence were Solano (three sites, including the type locality), Lake and Sacramento (two sites each), and Napa, Placer, San Mateo, Sonoma, and Stanislaus Counties (one site each) (Hoover 1937, Mason 1957, Rubtzoff and Heckard 1975, Holland 1984) (**Figure II-29**). These sites were located in the Central Coast, Lake-Napa, Santa Rosa, Solano-Colusa, Southeastern Sacramento Valley, and Southern Sierra Foothills vernal pool regions (Keeler-Wolf *et al.* 1998). As of 1984 the only three populations believed to remain extant were in Napa, Placer, and Sacramento Counties (Holland 1984).

Current Distribution.—Since 1984, *Legenere limosa* has been rediscovered at several historical sites and has been found at numerous new locations. During that same time period, the type locality and six other occurrences were extirpated. Among the 52 occurrences presumed to be extant, 20 are in Sacramento County, including 9 in the vicinity of Elk Grove and 6 in the vicinity of the former Mather Air Force Base. Another area of concentration, with 11 extant occurrences, is near Dozier in Solano County. Other counties where this species is presumed to remain are Alameda, Santa Clara, Sonoma, Lake, Napa, Placer, San Joaquin, San Mateo, Shasta, Tehama, and Yuba (Skinner and Pavlik 1994, W. Legard *in litt.* 2005, Platenkamp *in litt.* 2005, California Natural Diversity Data Base 2005). The vernal pool regions (Keeler-Wolf *et al.* 1998) where *Legenere limosa* remains extant are Lake-Napa, Northeastern Sacramento Valley, Northwestern Sacramento Valley, Santa Rosa, Solano-Colusa, and Southeastern Sacramento Valley. It has been extirpated from the Southern Sierra Foothills Vernal Pool Region. Please refer to the Draft Santa Rosa Plains Recovery Plan (in development) for information regarding occurrences within the Santa Rosa Vernal Pool Region, as identified by Keeler-Wolf *et al.* (1998). The Central Coast Vernal Pool Region occurrence, in San Mateo County, has not been rediscovered since 1906 but is presumed to be extant because suitable habitat remains in the area (California Natural Diversity Data Base 2001).

c. Life History and Habitat

Reproduction and Demography.—*Legenere limosa* seeds germinate between late February and April. The specific conditions necessary for seed germination are unknown. The plants grow through the standing water; as the

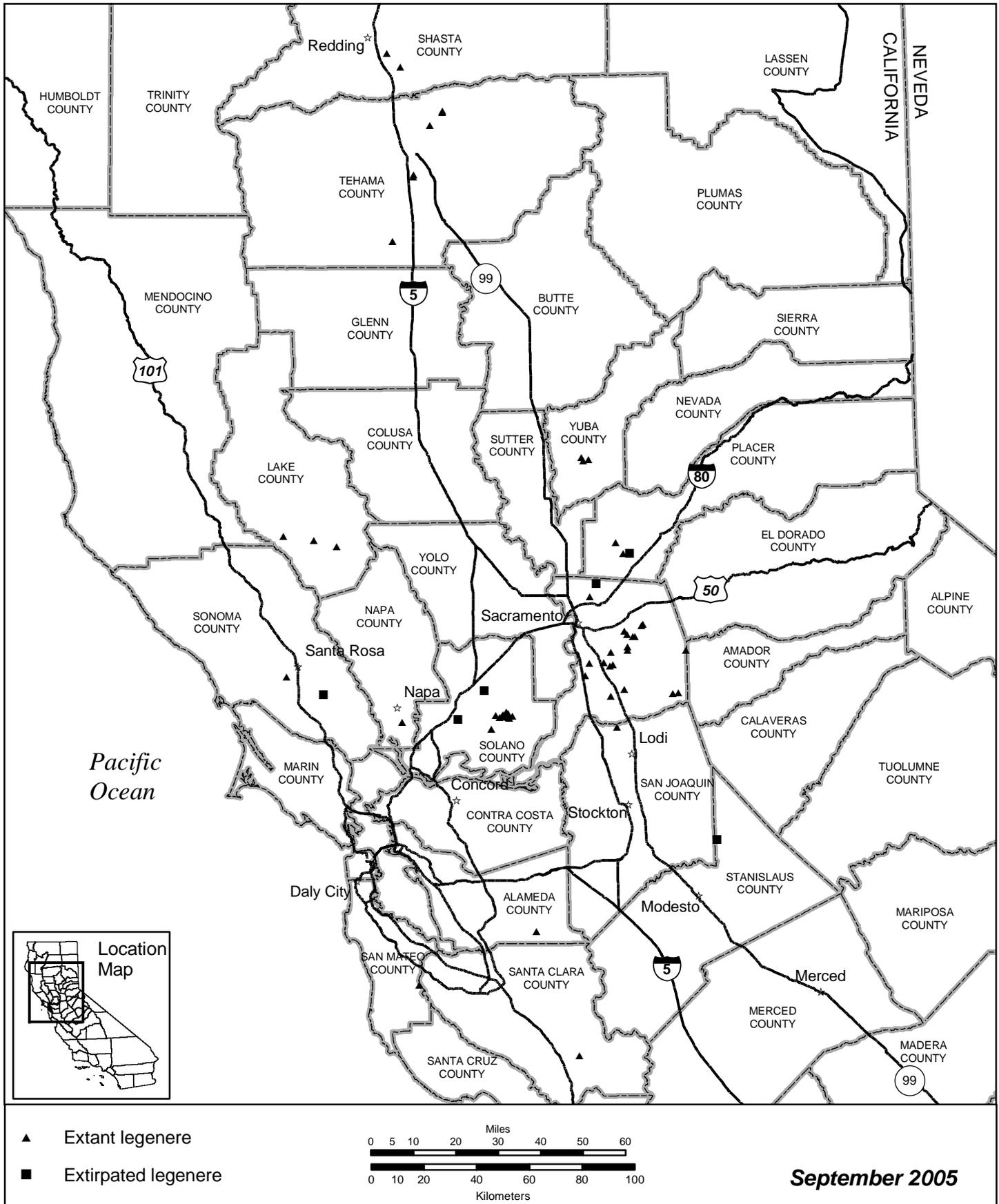


Figure II-29. Distribution of *Legenere limosa* (legenere).

water evaporates or recedes, *L. limosa* stems may collapse onto the lake bottom or become caught on taller, stronger plants (Holland 1984). *L. limosa* flowers during April, May, or June (Morin and Niehaus 1977, Holland 1984, Skinner and Pavlik 1994). Pollination in *L. limosa* has not been studied, but the small, inconspicuous flowers suggest that it may be self-pollinated (Holland 1984). By late June, each plant typically produces 6 to 10 capsules containing several hundred seeds each. Seed dispersal agents are unknown but may include gravity, water, and waterfowl. Most populations contain densities of less than one plant per square meter (10.8 square feet) (Holland 1984). The presence of *Legenere limosa* is even more variable than other vernal pool annuals; entire populations have disappeared for decades, then reappeared (Holland 1984, California Natural Diversity Data Base 2001). Thus, a persistent soil seed bank most likely exists. Survival rates and other aspects of demography have not been investigated.

Habitat and Community Associations.—*Legenere limosa* grows in a variety of habitats including vernal pools, vernal marshes, artificial ponds, and floodplains of intermittent streams. Occupied vernal pool types include Northern Basalt Flow, Northern Claypan, Northern Hardpan, Northern Volcanic Ashflow, and Northern Volcanic Mudflow (Sawyer and Keeler-Wolf 1995). The surrounding plant community may be grassland, open woodland, or hardwood forest containing *Quercus* species (oaks) or *Aesculus californica* (California buckeye). At one site, *L. limosa* grows in both a vernal pool and the adjacent grassland (California Natural Diversity Data Base 2001). The vernal pools and lakes supporting *L. limosa* vary in size from about 4 square meters (43 square feet) to 41 hectares (100 acres) (Holland 1984, California Natural Diversity Data Base 2001). When it occurs in large pools and vernal lakes, *L. limosa* grows only in the shallower areas (less than 20 centimeters [8 inches] deep) (Holland 1984). Substrates in occupied areas may have been deposited by streams or volcanic flows. Soils underlying the pools themselves typically are shallow, acidic clays with few stones (Holland 1984). *Legenere limosa* has been reported from elevations ranging from 3 meters (10 feet) in Solano County to 1,024 meters (3,360 feet) in Alameda County (California Natural Diversity Data Base 2005).

Legenere limosa occurs most often with *Lasthenia glaberrima* and *Eleocharis macrostachya*, and to a lesser extent with *Gratiola heterosepala* and *Downingia pusilla*. In addition to *Gratiola heterosepala*, other plants in this recovery plan that co-occur with *Legenere limosa* are *Navarretia leucocephala* ssp. *plieantha*, and *Orcuttia tenuis* (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 *Legenere limosa* are described below.

Of the six occurrences of *Legenere limosa* known to be extirpated, two were destroyed by conversion to agriculture, one by changes in hydrology, two by urban development, and one by unknown causes (Holland 1984, California Natural Diversity Data Base 2005). Several sites where the species still occurs have been degraded by discing or other agricultural practices, inappropriate livestock grazing, dirt biking, and trash dumping (California Natural Diversity Data Base 2005). The San Mateo County site has been subjected to logging and hydrological changes; *L. limosa* has not been observed there in over 90 years (Holland 1984). *Legenere limosa* occurred at Boggs Lake in the 1950's but has not been seen there since (Rubtzoff and Heckard 1975, Holland 1984, California Natural Diversity Data Base 2005), even though suitable habitat remains.

About one-third of the extant occurrences of *Legenere limosa* are in areas slated for commercial or residential development (Holland 1984, California Natural Diversity Data Base 2005). In fact, some of the populations extant in 1983 already may have been destroyed by development, but they have not been visited since that time. More than one-third of populations are subject to livestock grazing (California Natural Diversity Data Base 2005), but few appear to be declining. Holland (1984) indicated that “light” grazing during the winter and early spring did not seem to be detrimental to *L. limosa*. Competition from *Phyla nodiflora* is a threat at one Solano County site (California Natural Diversity Data Base 2005). If insects are involved in pollinating *L. limosa*, a decline in insect populations poses a potential threat.

e. Conservation Efforts

Legenere limosa has no Federal or State status. It has been included on California Native Plant Society lists of rare and endangered species for 25 years (Powell 1974) and is currently on List 1B because it is “endangered throughout its range” (Tibor 2001).

Holland (1984) conducted a status survey of *Legenere limosa* in 1983 with funding from the County of Sacramento, R.C. Fuller Associates, and The Nature Conservancy. He confirmed that several historical populations no longer persisted. New populations of this species were discovered during pre-project surveys and during searches by Nature Conservancy volunteers (Holland 1984, California Natural Diversity Data Base 2005).

Eighteen occurrences of *Legenere limosa* are (or were) on nature preserves or publicly-owned lands. Five occurrences are known currently from the Jepson Prairie Preserve in Solano County, two from the nearby Calhoun Cut Ecological Reserve, and two from the Dales Lake Ecological Reserve. *Legenere limosa* was known from Boggs Lake before the preserve was established, but it has not been rediscovered in that area for over 40 years (Holland 1984). *Legenere limosa* occurs in abundance in several vernal pools on the Valensin Ranch Property in Sacramento County owned and managed by The Nature Conservancy (J. Marty, unpub.data). A population of *L. limosa* was also discovered in a restored pool on Beale Air Force Base in Yuba County, California (J. Marty, unpub. data.). Two occurrences, at Hog Lake and on the Stillwater Plains, are on property administered by the U.S. Bureau of Land Management. Sacramento County owns land supporting three occurrences of *L. limosa*; one is at a wastewater treatment plant, and the other two are in county parks. Finally, one occurrence is on land owned by the Sacramento Municipal Utility District (California Natural Diversity Data Base 2001). However, mere occurrence on public land is not a guarantee of protection. Only the preserves and the U.S. Bureau of Land Management occurrences are managed to promote the continued existence of *L. limosa* and other rare species. As of 1991, one Sacramento County developer had plans to preserve several pools containing *L. limosa* when he developed the property (California Natural Diversity Data Base 2001).

8. *MYOSURUS MINIMUS* SSP. *APUS* (LITTLE MOUSETAIL)

a. Description and Taxonomy

Taxonomy.—Little mousetail was first named by Greene (1885) as *Myosurus minimus* var. *apus*. The type specimen of little mousetail was collected “from the table-lands back of San Diego” (Greene 1885:277). Campbell (1952) changed the rank of little mousetail from a variety to a subspecies, resulting in the new combination *Myosurus minimus* ssp. *apus*, which is in use today. This subspecies is believed to have originated as a hybrid between *Myosurus minimus* ssp. *filiformis* (thread-like mousetail) and *Myosurus sessilis* (sessile mousetail); *Myosurus minimus* var. *apus* is now self-perpetuating and therefore worthy of recognition as a separate taxon (Mason 1957, Stone 1959). However, *Myosurus minimus* var. *apus* may cross with *Myosurus sessilis* or with other mousetails and the hybrids then may interbreed again, resulting in a series of intermediates that are difficult to identify (Campbell 1952, Stone 1959) and that may not warrant taxonomic recognition (A. Whittemore *in litt.* 1993). Mousetails are members of the buttercup family (Ranunculaceae).

Description and Identification.—*Myosurus minimus* ssp. *apus* (Figure II-30) is a tiny, tufted annual lacking showy flowers. Both the leaves and

the scapes originate from the base of the plant. The very narrow leaves are only 2 to 9 centimeters (0.8 to 3.5 inches) long, and the cylindrical scapes are shorter (at most 7 centimeters [2.8 inches] long). Each scape bears a single, inconspicuous flower consisting of 5 to 10 greenish-white petal-like sepals, 3 to 5 greenish-white petals, about 10 stamens, and 70 or more separate pistils. The sepals have a flattened, erect portion 2.5 to 3.5 millimeters (0.10 to 0.14 inch) long and a shorter spur pointing downward. The petals are shorter than the sepals and do not have spurs. *Myosurus minimus* ssp. *apus* has achenes (single-seeded fruits) that are more or less rectangular, 0.75 to 2 millimeters (0.03 to 0.08 inch) long, and have a beak no more than 0.5 millimeter (0.02 inch) long protruding upward from one side. The pistils cover almost the entire length of the scape or receptacle that elongates as the achenes reach maturity, and the beaks are closely appressed to this elongate receptacle, often referred to as a “spike” in this genus (Campbell 1952, Mason 1957, Wilken 1993). The diploid chromosome number of *M. minimus* ssp. *apus* is 16 (Stone 1957 as cited in Stone 1959).

Myosurus minimus ssp. *minimus* (common mousetail) and *M. minimus* ssp. *filiformis* have scapes taller than their leaves, and the achenes are only in the upper part of the scape. *Myosurus sessilis* has shorter spurs on the sepals than does *M. minimus* ssp. *apus*, only five stamens per flower, and the achene beaks project outward from the scape (Campbell 1952). *Myosurus minimus* ssp. *alopecuroides* (foxtail mousetail) also has outward-projecting beaks (Stone 1959). Other taxa of *Myosurus* are differentiated by their scape length in relation to leaf length, achene shape, outcurved beaks, or tendency to drop their flower parts and achenes when they are mature, which *M. minimus* ssp. *apus* does not (Campbell 1952, Mason 1957, Wilken 1993).

b. Historical and Current Distribution

Historical Distribution.—*Myosurus minimus* ssp. *apus* was first collected in 1882. The typical form was known historically from southern California (Campbell 1952), occurring only in the San Diego and Western Riverside County Vernal Pool Regions (Keeler-Wolf *et al.* 1998) (**Figure II-31**). Campbell (1952) also mentioned collections of plants that differed somewhat from those in southern California but were more similar to *M. minimus* ssp. *apus* than to other taxa. These collections were from Alameda, Fresno, Merced, San Benito, San Luis Obispo, and Stanislaus Counties, plus one site that was along the border of Colusa and Glenn Counties. Stone (1959) collected specimens that he attributed to this taxon in Colusa, Contra Costa, Kern, and Stanislaus Counties. Whittemore (*in litt.* 1993) does not believe that the atypical plants mentioned by Campbell and Stone actually represent *M. minimus* ssp. *apus*. If the questionable populations are truly *M. minimus* ssp. *apus*, it also occurred historically in the Carrizo, Central Coast, Livermore, San Joaquin Valley, and Solano-Colusa Vernal Pool Regions,

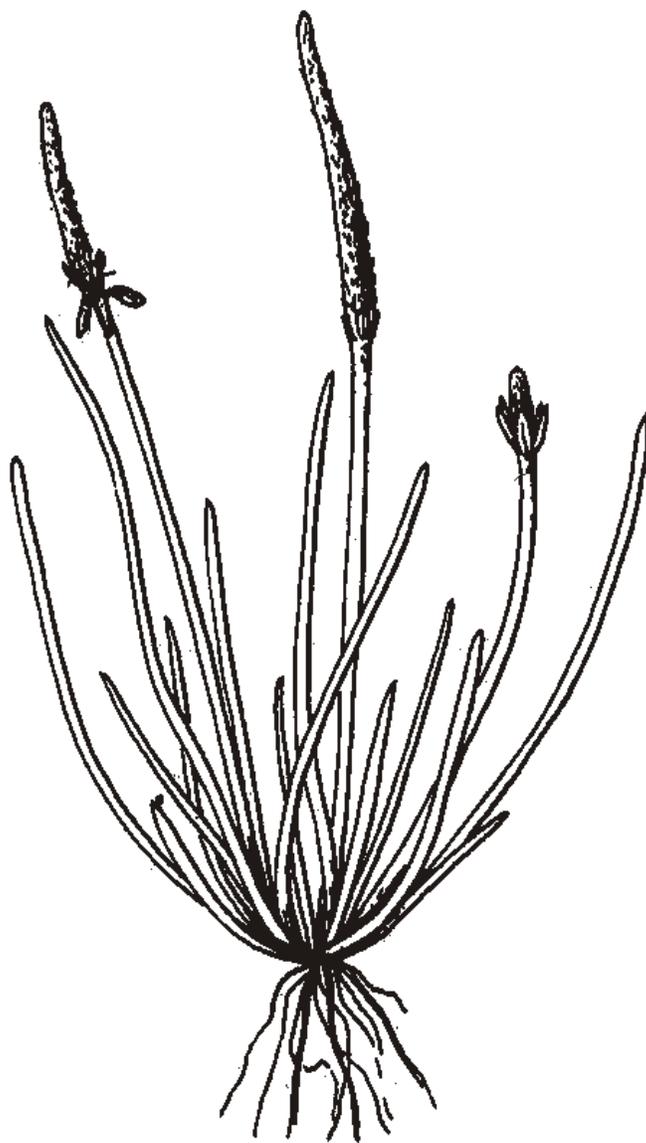


Figure II-30. Illustration of *Myosurus minimus* var. *apus* (little mousetail) Reprinted with permission from Abrams (1944), *Illustrated Flora of the Pacific States: Washington, Oregon, and California*, Vol. II. © Stanford University Press.

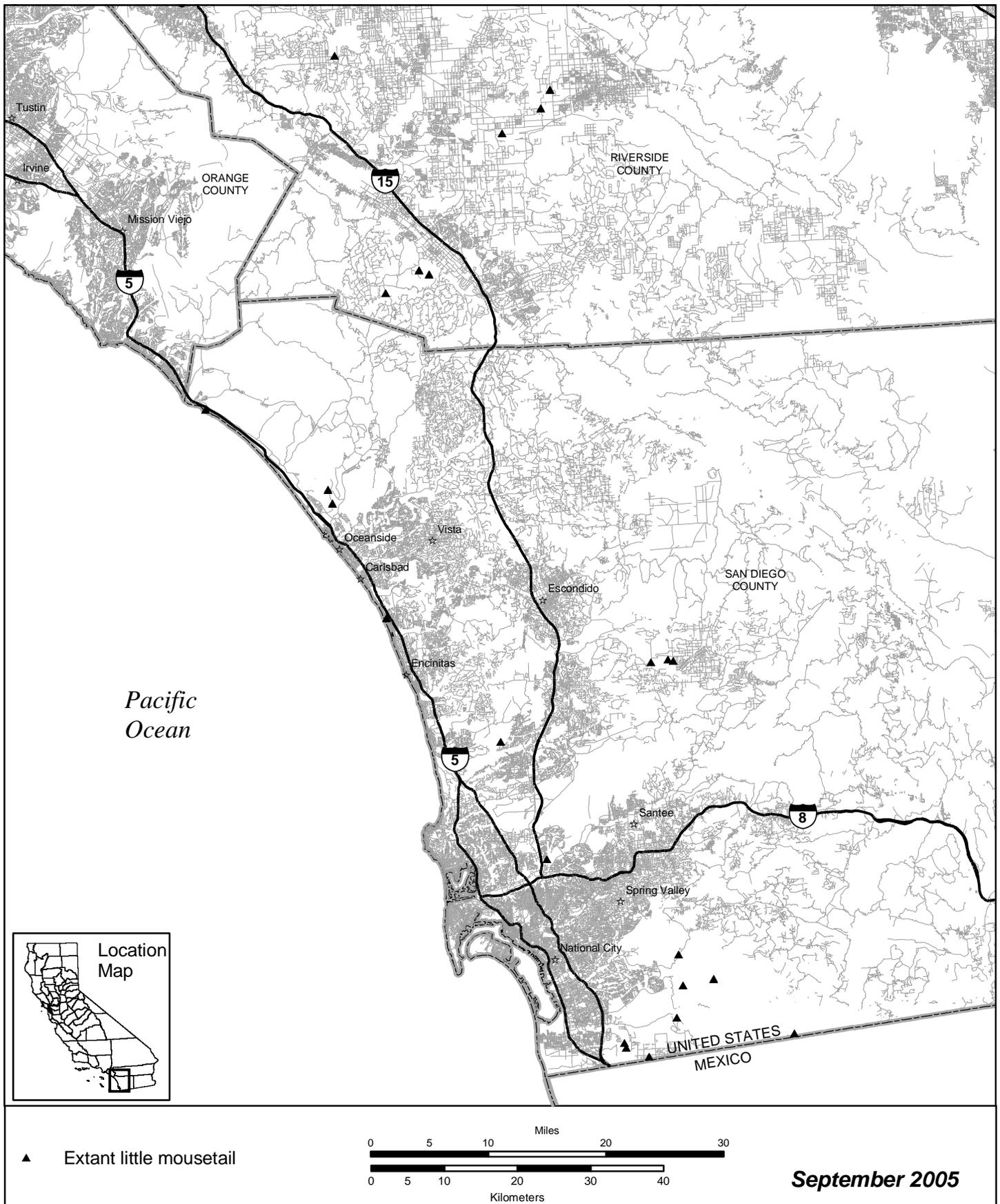


Figure II-31. Distribution of *Myosurus minimus* ssp. *apus* (little mouse-tail).

as well as in areas of Fresno and Kern Counties that are outside of the vernal pool regions designated by Keeler-Wolf *et al.* (1998).

Current Distribution.—The current distribution of *Myosurus minimus* ssp. *apus* is uncertain. Few sites have been revisited since they were first discovered, and contemporary botanists often are reluctant to assign a name to intermediate plants. The California Natural Diversity Data Base tracks only the Riverside and San Diego county occurrences; this taxon is presumed to remain extant at 24 occurrences in those two counties (California Natural Diversity Data Base 2005).

Atypical plants identified as *Myosurus minimus* ssp. *apus* have been reported recently from Alameda, Colusa, Contra Costa, and Kern Counties (Kuenster *et al.* 1994, J. Marr *in litt.* 1996, California Natural Diversity Data Base unprocessed data). An unknown subspecies of *M. minimus* still occurs in Merced County (Silveira 1996). In addition to the counties mentioned above, Tibor (2001) reported that *M. minimus* ssp. *apus* was extant in Butte, San Bernardino, and Stanislaus Counties, as well as Oregon and Baja California, Mexico. If all of the recent reports are correct, *M. minimus* ssp. *apus* is currently known from 10 California counties and from at least 6 vernal pool regions as defined by Keeler-Wolf *et al.* (1998). The vernal pool regions encompassing the recent reports are Livermore, Northeastern Sacramento Valley, San Diego, San Joaquin Valley, Solano-Colusa, and Western Riverside County; depending on the exact location of the Stanislaus County report, it could be in the Southern Sierra Foothills Vernal Pool Region or in the San Joaquin Valley Vernal Pool Region. The San Bernardino County report would be outside of any named vernal pool regions.

c. Life History and Habitat

Reproduction and Demography.—The timing of seed germination in nature has not been reported. However, two greenhouse germination experiments have been conducted with related taxa. Bliss and Zedler (1998) studied an unspecified subspecies of *Myosurus minimus* from San Diego. They compared initial wetting on 30 January, 1 March, and 31 March as well as various durations of inundation. Only the earliest wetting date was effective in triggering germination; out of 178 seeds that germinated during their study, 177 (99.4 percent) germinated following the January wetting. Fifty percent of those seeds germinated by 23 February. Also, Bliss and Zedler (1998) found that moist soil was more conducive to germination and growth of *M. minimus* than was inundated soil. Stone (1959) studied the related taxa *M. minimus* ssp. *filiformis* and *M. sessilis*. Under unspecified “standardized” conditions, both taxa reached median seed germination in 13 days. Flower buds formed about 2 months later,

averaging 69 days for *M. minimus* ssp. *filiformis* and 69 days for *M. sessilis* (Stone 1959).

Myosurus minimus ssp. *apus* flowers between March and June (Tibor 2001). The seeds mature in late March and April in the Central Valley, whereas plants in southern California begin producing seed in May (Campbell 1952). Dispersal mechanisms have not been reported. The soil seed bank of *M. minimus* ssp. *apus* has not been studied, but Campbell (1952) reported that seeds of other *M. minimus* subspecies are viable for only 2 to 3 years following their production.

Although tiny flies (order Diptera) have been observed visiting *Myosurus minimus* ssp. *minimus*, insects apparently are not necessary to transfer pollen (Knuth 1908). Reproduction in *Myosurus* has been studied in depth by Stone (1959). He noted that the reproductive strategy of *Myosurus minimus* ssp. *apus* was similar to that of *M. sessilis*, which he reported in greater detail. Both are predominantly self-pollinating. Pollen is shed before the flower opens, when the pistils and stamens are covered by the sepals; although fertilization does not take place until 3 to 10 days later, this mechanism ensures that pollen will reach all the pistils that have developed. After the pollen is shed, the flower opens. If growing conditions are favorable, the scape will continue to elongate and produce additional pistils at its tip. Only pollen produced by other flowers would be available for fertilization of the newly-formed pistils. In mixed populations, the pollen could even come from different species or subspecies of *Myosurus*. However, Stone found that only 2 percent of plants collected from the field exhibited any evidence of hybridization. He noted that hybridization would be more likely in years with long growing seasons because the plants would have a greater opportunity to develop exposed pistils.

Myosurus species may produce between 10 and 400 pistils per flower, with at most one seed each, and most plants produce only one or two flowers. However, both the number of flowers and the number of pistils may vary depending on the growing conditions (Stone 1959). Other aspects of *M. minimus* ssp. *apus* demography are unknown.

Habitat and Community Associations.—*Myosurus minimus* ssp. *apus* occurs in Northern Claypan, Northern Hardpan, San Diego Mesa, San Jacinto Valley, and Santa Rosa Plateau vernal pool types (Sawyer and Keeler-Wolf 1995). It also grows occasionally in other types of depressions that hold water seasonally (Stone 1959, California Natural Diversity Data Base 2001) and in alkaline marshes (Mason 1957). Most of the occupied vernal pools occur within coastal sage scrub, *Adenostoma fasciculatum* (chamise) chaparral, or annual and perennial grasslands (California Natural Diversity Data Base 2001). In one case this taxon was found in a depression in a fallow field (Stone 1959). In the few

instances where the sizes of occupied pools were reported, they ranged from 25 square meters (269 square feet) to 0.12 hectare (0.3 acre) in area (Stone 1959, California Natural Diversity Data Base 2001). Similarly, the microhabitats for *M. minimus* ssp. *apus* are not well documented; several southern California populations occurred on both the margins and beds of vernal pools (California Natural Diversity Data Base 2001).

Soils at the Central Valley sites studied by Stone (1959) were all alkaline and ranged in texture from clay to sandy loam. Information on characteristics of soils elsewhere in the range are not available. According to the California Natural Diversity Data Base (2001), elevations of occurrences in San Diego and Riverside Counties range from 4 to 640 meters (20 to 2,100 feet), but sites in other parts of the State would likely extend the elevation range.

Myosurus minimus ssp. *apus* is frequently associated with other *Myosurus* taxa, including *M. minimus* ssp. *minimus*, *M. minimus* ssp. *alopecuroides*, *M. minimus* ssp. *filiformis*, and *M. sessilis* (Stone 1959, California Natural Diversity Data Base 2001). Other genera with which it occurs in the Central Valley are *Downingia*, *Plantago* (plantain), and *Lepidium* (Stone 1959). At one site, it co-occurs with *Gratiola heterosepala* (California Natural Diversity Data Base 2005, under *G. heterosepala*). The most frequent associate of *M. minimus* ssp. *apus* in southern California is the federally- and State-listed endangered *Eryngium aristulatum* var. *parishii* (San Diego button-celery). Other federally- and State-listed endangered plants that co-occur with *M. minimus* ssp. *apus* are *Pogogyne nudiuscula* (Otay Mesa mint), *Pogogyne abramsii* (San Diego mesa mint), and *Orcuttia californica*; the federally-listed threatened species *Navarretia fossalis* (spreading navarretia) also co-occurs with *M. minimus* ssp. *apus* (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 *Myosurus minimus* ssp. *apus* are described below.

The lack of site-specific historical information and the lack of recent surveys preclude quantification of habitat loss for this taxon. However, *Myosurus minimus* ssp. *apus* probably has declined because much vernal pool habitat throughout California has been lost through agricultural conversion and development, as described in other species accounts. At one San Diego site where *M. minimus* ssp. *apus* occurs, several vernal pools were destroyed by

conversion to agriculture, but it is not known whether or not this taxon had been present in those pools. Several other southern California sites where *M. minimus* ssp. *apus* occurs were disturbed by off-road vehicle use, road and powerline construction, livestock grazing, brush removal, and trash dumping (California Natural Diversity Data Base 2001).

Urban development is mentioned as a threat to one San Diego occurrence of *Myosurus minimus* ssp. *apus*. The same occurrence also is threatened by agriculture, trash dumping, livestock grazing, construction of a border crossing, and competition from weedy species. In addition, three southern California occurrences are threatened by damage from off-highway vehicles (California Natural Diversity Data Base 2005). However, other occurrences in that region also may be threatened, particularly by urban development, judging by the magnitude of threats to the listed species of southern California vernal pools (U.S. Fish and Wildlife Service 1998b). Threats have not been assessed at northern and central California occurrences of *M. minimus* ssp. *apus*. If insects do play a role in pollination of *M. minimus* ssp. *apus*, habitat loss for the pollinators could contribute to the decline of this plant.

e. Conservation Efforts

Myosurus minimus ssp. *apus* has no official Federal status. It is not protected in California but is listed as endangered in Oregon (Tibor 2001). *Myosurus minimus* ssp. *apus* formerly was considered to be rare and endangered by the California Native Plant Society (Smith *et al.* 1980). Although it is still considered to be “endangered throughout its range,” *M. minimus* ssp. *apus* now is on the California Native Plant Society “Review List” (List 3) of taxa for which insufficient information is available (Tibor 2001).

Ten of the extant occurrences are on public land or in the ownership of a conservation organization. Only three of these occurrences, all on The Nature Conservancy’s Santa Rosa Plateau Preserve in Riverside County, are being managed for the benefit of rare species (California Natural Diversity Data Base 2001). Three occurrences are on Federal land in San Diego County: one is on a Navy base and the other two are on the Camp Pendleton Marine Corps installation. Two other sites are administered by State agencies; one is on California Department of Water Resources property in Contra Costa County (Kuenster *et al.* 1994) and the other, in San Diego County, is partially owned by the California Department of Transportation (California Natural Diversity Data Base 2001). County agencies are responsible for one *Myosurus minimus* ssp. *apus* site each in Kern (J. Marr *in litt.* 1996), Riverside, and San Diego Counties (California Natural Diversity Data Base 2001). No conservation actions are known to have been taken specifically for the benefit of this taxon.

9. NAVARRETIA MYERSII SSP. DEMINUTA (SMALL PINCUSHION NAVARRETIA)

a. Description and Taxonomy

Taxonomy.—Small pincushion navarretia was named only recently. The scientific name, *Navarretia myersii* ssp. *deminuta* (Day 1995), has not undergone any changes. The type locality for this subspecies is about 3 kilometers (2 miles) southeast of Middletown, in Lake County (Day 1995). *Navarretia myersii* ssp. *deminuta* is a member of the phlox family (Polemoniaceae).

Description and Identification.—Basic morphology of the genus was described under *Navarretia leucocephala* ssp. *pauciflora*. The overall appearance of *N. myersii* ssp. *deminuta* is that of a compact head of flowers growing directly out of the ground. *Navarretia myersii* ssp. *deminuta* (**Figure II-32**) has a very short stem that is thickened below ground level and bears one or two closely-spaced pairs of leaves above ground. The narrow, usually entire leaves are 1 to 5 centimeters (0.4 to 2.0 inches) long and extend far beyond the flower head, which is only 0.8 to 2 centimeters (0.3 to 0.8 inch) wide. Typically each plant has only a single flower head, although one or two secondary heads occur occasionally. Individual flowers are stalkless, with a short-hairy calyx 5 to 6 millimeters (0.20 to 0.24 inch) long and a blue corolla 12 to 13 millimeters (0.47 to 0.51 inch) long. The corolla tube is about the same length as the calyx, and the stamens and stigma protrude from the corolla tube. Inner bracts (those closest to the flowers) are about equal to the calyx in length; they have a broad, papery base and a few lobes near the tip. Three to five outer bracts, which are 1 to 2 centimeters (0.4 to 0.8 inch) long, occur on the periphery of the head. The outer bracts are broad and papery at the base, have toothed or forked lobes between the base and the middle, and are unbranched near the tip. The capsules contain four to six seeds each (Day 1995). The chromosome number of *N. myersii* ssp. *deminuta* is not known.

Navarretia myersii ssp. *myersii* (pincushion navarretia) is the closest relative of *N. myersii* ssp. *deminuta*. The former has a white flower, the corolla is longer (17 to 21 millimeters [0.67 to 0.83 inch]) than in *N. myersii* ssp. *deminuta*, the corolla tube is two to four times as long as the calyx, and the outer bracts are lobed only above the middle. Another similar species, *N. prostrata* (prostrate navarretia), has multiple (up to 20) flower heads per plant, shorter corollas (6 to 9 millimeters

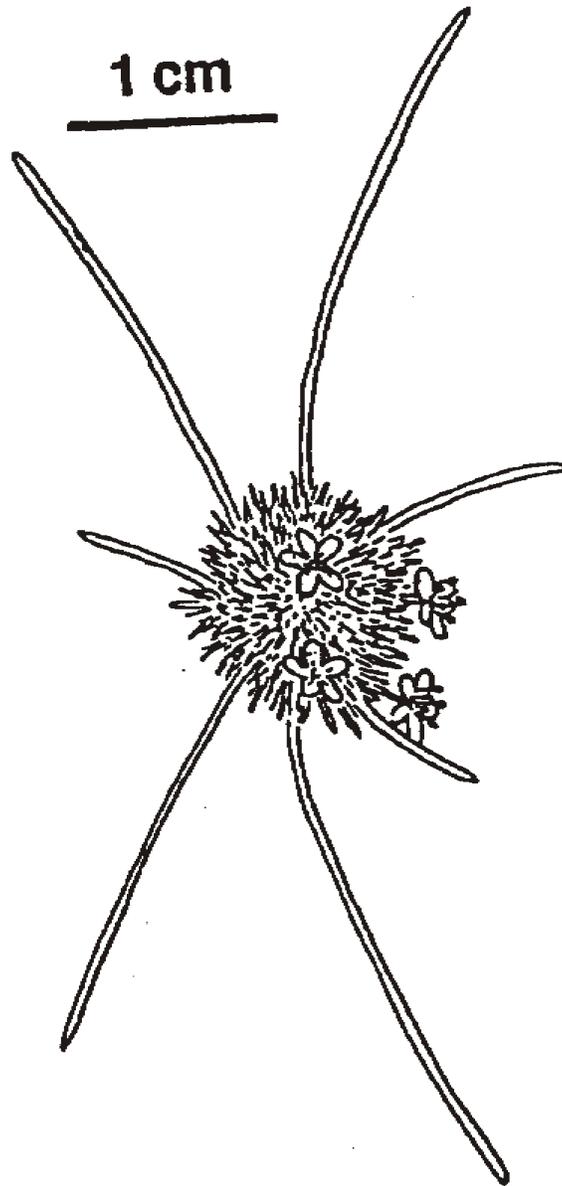


Figure II-32. Illustration of *Navarretia myersii* ssp. *deminuta* (small pincushion navarretia).
(Reprinted with permission from the California Botanical Society)

[0.24 to 0.35 inch]), white or blue flowers, lobed leaves, outer bracts that are lobed throughout their length, and contains between 5 and 25 seeds per capsule (Day 1995). Other vernal pool navarretias, including *N. leucocephala* ssp. *pauciflora* and *N. leucocephala* ssp. *pliantha*, differ from *N. myersii* ssp. *deminuta* in that they have conspicuous branches and their corollas are comparatively short (Day 1993b).

b. Historical and Current Distribution

Historical Distribution.—*Navarretia myersii* ssp. *deminuta* was just discovered in 1992 and no earlier collections are known. Thus, the historical distribution is identical with the current distribution (**Figure II-5**).

Current Distribution.—*Navarretia myersii* ssp. *deminuta* is known only from the type locality in Lake County (Day 1995, A. Day pers. comm. 1997, L. Esposito pers. comm. 1997, California Natural Diversity Data Base 2005). Thus, the taxon is restricted to the Lake-Napa Vernal Pool Region (Keeler-Wolf *et al.* 1998).

c. Life History and Habitat

Reproduction and Demography.—The reproductive biology of *Navarretia myersii* ssp. *deminuta* has not been investigated but probably is similar to that of *N. leucocephala* ssp. *pauciflora* because they are closely-related vernal pool annuals (Day 1993a). *Navarretia myersii* ssp. *deminuta* flowers in April and May (Day 1995). The single population contained about 25,000 plants in 1992 (California Natural Diversity Data Base 2001). In 1993, following a season of above-average rainfall, *N. myersii* ssp. *deminuta* plants had longer leaves and more flowers than in the previous or the following years, which were drier (Day 1995).

Habitat and Community Associations.—At the single known site, *Navarretia myersii* ssp. *deminuta* occurs in vernal pools, at the edges of vernal swales, and in low areas adjacent to a road. The pools and other depressions occur within a matrix of annual grassland on clay loam soil (Day 1995, California Natural Diversity Data Base 2001). Specific types of vernal pools in which it occurs have not been reported. The type locality is at 331 meters (1,087 feet) in elevation (California Natural Diversity Data Base 2001). Plants associated with *N. myersii* ssp. *deminuta* at the site include *Eryngium aristulatum*, *Downingia concolor* (fringed downingia), *Juncus bufonius*, *Isoetes howelli* (Howell's quillwort), and *Psilocarphus brevissimus* (California Natural Diversity Data Base 2001).

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 myersii* ssp. *deminuta* are described below. *Navarretia myersii* ssp. *deminuta* is not known to have declined; the subspecies was unknown prior to 1992.

The single locality for *Navarretia myersii* ssp. *deminuta* was threatened by a subdivision (Day 1995, California Natural Diversity Data Base 2001), which was never developed. However, the parcel is zoned rural residential, and the landowner could build a residence, drain the wetland, or make other alterations without being required to obtain permits or conduct an environmental review (L. Esposito *in litt.* 2000). No imminent threats to the population have been noted but two more remote threats are possible. The single population makes *N. myersii* ssp. *deminuta* extremely susceptible to extinction by random events, including both natural and human-caused catastrophes.

e. Conservation Efforts

Navarretia myersii ssp. *deminuta* does not have any formal protection under Federal or State law. However, the California Native Plant Society (2001) considers *N. myersii* ssp. *deminuta* to be extremely rare and in danger of extinction, and thus has added it to List 1B. No conservation efforts have been reported other than denial of a development permit by Lake County officials (L. Esposito pers. comm. 1997).

10. PLAGIOBOTHRYIS HYSTRICULUS (BEARDED POPCORN FLOWER)

a. Description and Taxonomy

Taxonomy.—Piper (1920) first recognized bearded popcorn flower as a unique entity, assigning the name *Allocarya hystricula*. Jepson had collected the type specimen in 1892 from the Montezuma Hills, Solano County (Piper 1920). In his monograph on *Plagiobothrys*, Johnston (1923) considered *Allocarya hystricula* to be the same as *Plagiobothrys greenei* (Greene's popcorn flower). After several revisions to the name by various individuals, Johnston (1932 as cited in Abrams 1951) assigned the name by which bearded popcorn flower is known today, *Plagiobothrys hystriculus*. This taxon is in the borage family (Boraginaceae). Another common name for bearded popcorn flower is bearded allocarya (Smith *et al.* 1980).

Description and Identification.—*Plagiobothrys hystriculus* is an annual with erect or decumbent branched stems 10 to 45 centimeters (3.9 to 17.7 inches) long. The stem, leaves, and calyx are sparsely to densely covered with short, straight, appressed hairs. The narrow leaves are opposite near the base of the stem but alternate above. The leaves decrease in size up the stem, with the lower leaves 2 to 6 centimeters (0.8 to 2.4 inches) long. The flowers are widely spaced throughout the inflorescence. Each is supported by an individual stalk that is shorter than the flower, and many are subtended by bracts. The calyx consists of five sepals fused only at the base. When the flowers open, the calyx is 3 to 6 millimeters (0.12 to 0.24 inch) long, but the lobes increase in length as the flowers mature. The white corolla is tiny (1 to 2.5 millimeters [0.04 to 0.10 inch] wide) and has a tubular base with five lobes. Each flower produces four egg-shaped nutlets 1.5 to 2.5 millimeters (0.06 to 0.10 inch) long. The nutlets have narrow lengthwise and crosswise ridges that are covered with tubercles; each tubercle is broad at the base, blunt at the tip, and is about one-sixth the length of the nutlet. The tubercles and the nutlet surface in between are densely covered with tiny, barbed bristles (Piper 1920, Jepson 1925, Abrams 1951, Messick 1993). The chromosome number of *P. hystriculus* has not been reported.

Plagiobothrys hystriculus is difficult to distinguish from *P. acanthocarpus* (adobe popcorn flower), *P. greenii*, and *P. trachycarpus* (rough-fruited popcorn flower). Close inspection of the nutlets is necessary to identify the various species. Both *P. acanthocarpus* and *P. greenii* have long, pointed prickles instead of blunt tubercles. Furthermore, *P. acanthocarpus* has few bristles on the prickles or on the nutlet surface. *Plagiobothrys greenii* has longer nutlets than *P. hystriculus* and lacks crosswise ridges. *P. trachycarpus* rarely has tubercles on the nutlets but when present they lack bristles (Piper 1920, Abrams 1951, Messick 1993).

b. Historical and Current Distribution

Historical Distribution.—*Plagiobothrys hystriculus* was known historically from only two Solano County sites: the type locality and Elmira, where it was collected in 1883 (Piper 1920, Hoover 1937) (**Figure II-20**). The two reported occurrences of *P. hystriculus* would fall within the Solano-Colusa Vernal Pool Region, as defined by Keeler-Wolf *et al.* (1998).

Current Distribution.—This species has not been observed since 1892. Although classified as 1A (presumed extinct) by the California Native Plant Society, the California Natural Diversity Data Base (2005) still presumes the type locality to be extant. Various botanists have reported finding populations of *Plagiobothrys hystriculus*, but all recent reports have been determined to represent other species (Skinner and Pavlik 1994, Skinner *et al.* 1995).

c. Life History and Habitat

Reproduction and Demography.—The only information available on reproduction in *Plagiobothrys hystriculus* is that it flowers in April and May (Abrams 1951). Demographic data also are lacking.

Habitat and Community Associations.—The habitat of *Plagiobothrys hystriculus* is not well understood. The original collectors did not give detailed descriptions of the environment, and later botanists presented conflicting habitat descriptions. Jepson (1925:853), one of only two people who collected *P. hystriculus*, described the habitat as “low plains.” Hoover (1937:22) included *P. hystriculus* in his “Hog-wallow Endemism Area.” Abrams (1951:561) noted that the species grew on “grassy hillsides and plains.” More recent descriptions give the habitat as “grassland, probably vernal pools, wet sites” (Messick 1993:389) and as Northern Claypan Vernal Pools (Sawyer and Keeler-Wolf 1995). Microhabitats, soil types, and associated species are not known. Both collection sites are less than 50 meters (164 feet) in elevation (California Natural Diversity Data Base 2001).

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 *Plagiobothrys hystriculus* include the conversion of the area around Elmira to agriculture; no natural land remains (Holland 1984). The type locality for *Plagiobothrys hystriculus* was not specific enough to allow determination of its probable current status, based on known land uses. Threats to the survival of *P. hystriculus* cannot be assessed until any possible extant populations are located.

e. Conservation Efforts

Plagiobothrys hystriculus has no Federal or State status. The California Native Plant Society originally considered it to be rare (Powell 1974) but now includes it on List 1A, among those species presumed to be extinct (Skinner and Pavlik 1994). Various groups have looked for *P. hystriculus* in the course of surveying, but it has not been relocated. Thus, no other protection measures have been possible. *Plagiobothrys hystriculus* is included in this recovery plan to bring attention to the species and to encourage comprehensive surveys so that any potentially extant populations may be located.

Conservation Actions for Rediscovered Plants.—In the event of rediscovery, both immediate and long-term actions will be needed. Outlining these actions in a recovery plan increases the potential for participation by both State and Federal agencies and for funding to carry out needed actions. Three actions—status review, plant stabilization, and protection of plants and habitat—would be needed concurrently. First, a status review should be conducted immediately to assess if there are threats from current or planned activities such as grazing, fire, nonnative plant species, rodents, insects, habitat conversion, inbreeding depression, or others. The status review should include consideration of whether existing mechanisms for protection are adequate. The results of the status review would help determine if the plant warrants listing. Second, stabilizing the plants or populations of plants by alleviating threats to short-term survival would be essential. Such stabilization efforts may include controlling invasive nonnative or native vegetation, erosion, destructive rodents and/or insects, and providing insurance for the population by collecting and storing seed (if such collection would not further imperil the population’s survival). Third, securing and protecting the habitat and the existing plants would be essential. If the plant is rediscovered on public lands, it would be important to work with the land manager to develop a site-specific management plan that would include yearly monitoring measures to minimize any threats. If the plant is rediscovered on private lands, the willingness of the land owner to participate in recovery efforts would need to be assessed and encouraged. If the landowner (and land manager or lessee) were amenable, an agreement should be developed to formalize plant protection. This agreement could be temporary or long-term, depending on the willingness of the landowner and the needs of the species.

After short-term mechanisms for protection are in place, long-term management should begin. Different approaches should be evaluated. An implementation team, consisting of members with the expertise to determine appropriate measures and the means to implement such measures, would be of great benefit. Options include reintroduction to historical sites, propagation in greenhouses and/or botanical gardens, and seed collection and storage. Other necessary actions would include the alleviation of threats, securing sites, maintaining or enhancing abundance, developing and implementing a monitoring plan, conducting essential research (*e.g.*, demography, genetics, reproductive biology, and propagation techniques), reassessing status every 5 years to determine if Federal listing is warranted, and coordinating efforts with conservation and recovery actions for other species covered in this recovery plan or throughout the recovery plan area. Although actions are outlined here, they will not all necessarily be appropriate to the future situation, nor is the list complete.