

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 Boggs 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).

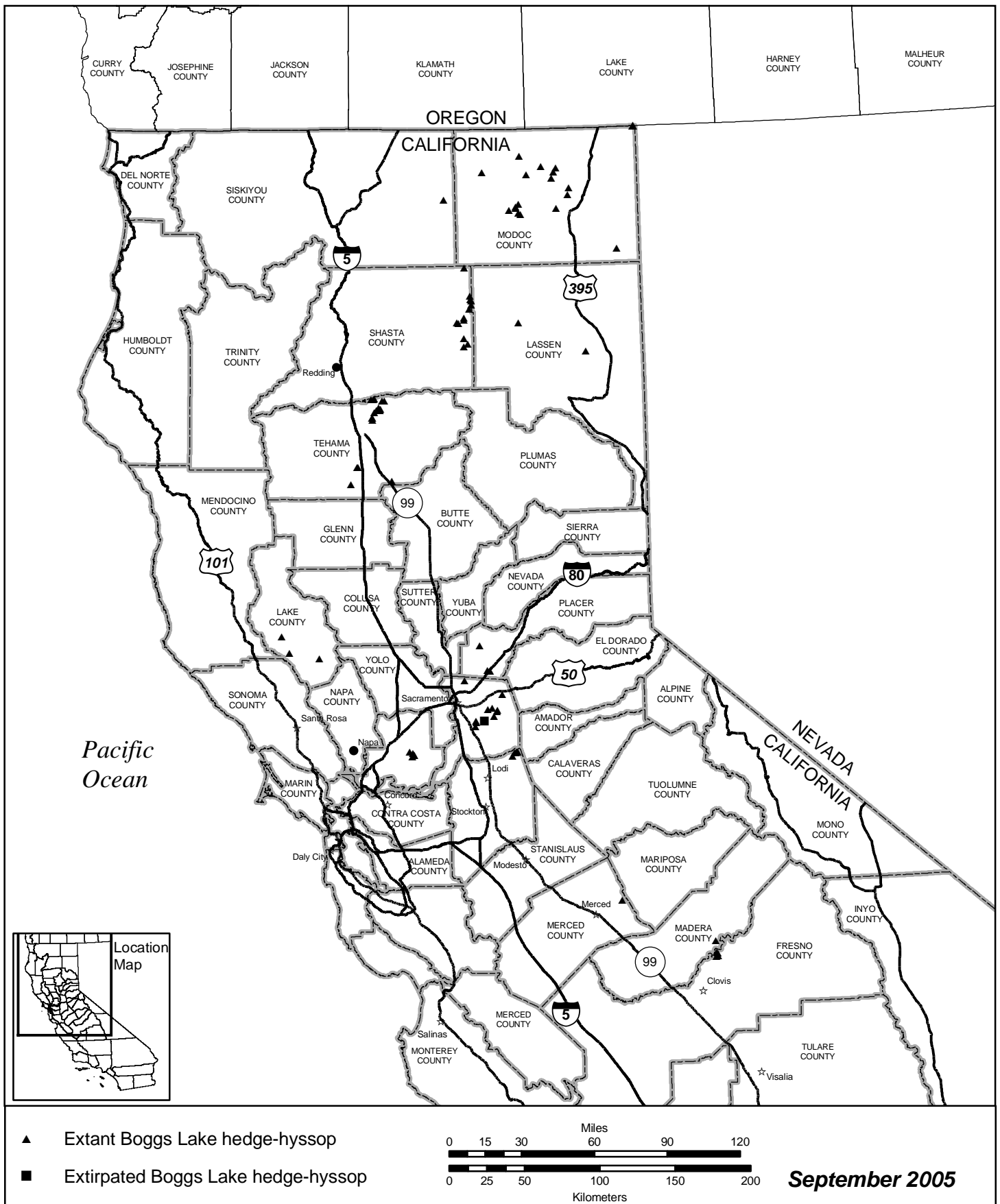


Figure II-27. Distribution of *Gratiola heterosepala* (Boggs Lake hedge-hyssop)

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 1987*d*, 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).