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RARE AND ENDEMIC PLANTS OF LAKE COUNTY SERPENTINE SOIL HABITATS

by

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for

Endangered Plant Program

California Department of Fish and Game

Sacramento, California

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ABSTRACT

This report describes the results of a study on the rare plants, plant communities and plant species diversity that occur in serpentine soil habitats in Lake County, California. Thirty-five rare plant species were documented to occur on serpentine soil in the county and their population locations mapped. Six plant communities, their subtypes, and three unclassified serpentine habitats are described and discussed with respect to their occurrence on different soil series. A floristic analysis found that at least 574 vascular plant species, subspecies and varieties occur on approximately 64,000 acres of serpentine soil in Lake County, which represents about ten percent of the land area for the county.

Nine of the 35 rare plant species were determined to be considerably rarer than the others. These nine species were studied in detail and soil samples from populations of seven of the nine species were analyzed for a variety of important soil factors. The results of the study found that these seven rare plant species occur on serpentine soils that have extremely low concentrations of calcium, manganese, phosphorus, and nitrogen, but exceedingly high in concentrations of magnesium. Important differences were found in the soil calcium and magnesium cation concentrations between serpentine barrens and other serpentine soils that support more vegetation. The serpentine barrens soils, which are habitat to three rare plants, *Eriogonum nervulosum*, *Streptanthus brachiatus*, and *S. morrisonii*, were found to have the lowest concentrations of most soil factors measured. The other rare plant species were found to occur on serpentine soils that have different levels of profile development, an important factor that can influence the amount of nutrients and moisture availability in the soil. A discussion is given on the types of physiological attributes plants have evolved in their adaptation to serpentine soil.

The high number of rare plants, and overall species diversity are discussed in terms of the need for protecting this high diversity of plants. A set of recommendations are provided that include a procedure for developing serpentine habitat preserves. Five areas of significant serpentine habitat were mapped and discussed as potential areas for developing a serpentine soil habitat preserve system. These five areas include some populations of 75 percent of the rare plants observed in this study. Additional recommendations include a list of important management considerations for actively managing areas that might be preserved.

INTRODUCTION

Serpentine soils have been recognized as habitats that often support a high diversity of plant species (Whitaker, 1960; Proctor and Woodell, 1975; Kruckeberg, 1984; Brooks, 1987). Among those plant species are geographically localized or rare species. Further, many of those rare species are restricted to the serpentine soil and are generally referred to as serpentine soil endemics (Kruckeberg, 1984; Brooks, 1987). Kruckeberg (1984) has determined that at least 10 percent of all plant endemics to the California floristic province are also serpentine soil endemics. The significance of that figure is recognized when one realizes that less than one percent of the California surface area constitutes serpentine soil. This report describes a study of the rare and endemic plants that occur in serpentine soil habitats in Lake County, California.

Lake County is an area having an extremely high level of plant species diversity (Jepson, 1925; Mason, 1945a,b; Stebbins and Major, 1965; Raven and Axelrod, 1977). Jepson (1925) was perhaps the first to recognize the area he referred to as the Napa-Lake area of endemism as a region that is not only diverse, but also one containing numerous rare and endemic species. In addition, the northern part of Lake County was included in Jepson's Tehama area of endemism that similarly has a high degree of plant diversity. Later, Stebbins and Major (1965) included portions of Lake County in their delineation of the Central Coast Range area within the California Floristic Province. They considered it to be an important one with respect to recent plant evolution as well as plant species diversity. Raven and Axelrod (1978) have determined that the Central Coast Range area, in fact, had the highest species diversity and number of California endemics in the state including the Sierra Nevada and North Coast Ranges. Mason (1945a,b), and later Raven and Axelrod (1978), emphasized the significance of serpentine soils as habitats that support a high degree of plant species diversity in Lake County.

METHODS

Location information and a list of rare plants in Lake County were obtained from the Natural Diversity Data Base. Additional rare plant taxa known to occur in Lake County were found in the California Native Plant Society's (CNPS) Inventory on Rare and Endangered Plants (Smith and York, 1984; Smith and Berg, 1988). Locations for rare plants not found in the Natural Diversity Data Base were obtained from herbarium specimens, through personal communication with botanists, and from the literature. Rare plant locations were visited and their population number was counted or estimated. Extensive field surveys also were made of serpentine soil habitats not known to support rare plants. A list of all vascular plant species observed was made for all the serpentine habitats surveyed. All herbarium specimens collected were deposited at the University of California, Berkeley herbarium (UC).

Soil samples were taken from rare plant locations of serpentine endemic species included in list 1B of the CNPS inventory (Smith and Berg, 1988). Each soil sample was taken from the upper 10 cm of soil and weighed approximately 500 grams. Five soil samples were taken one meter apart from representative populations of each of the rarer plant taxa (i.e. those included in the Natural Diversity Data Base). Soil samples were analyzed at the CH2M Hill Environmental Testing Laboratory, Redding, California. Each soil sample was sieved and the 2 mm fraction analyzed for exchangeable calcium, magnesium and manganese cations. In addition, cation exchange capacity (CEC), available phosphorus, total nitrogen, and pH were determined for each soil sample. Details of methods used in the soil analysis are included in Walsh and Beaton (1973).

RESULTS

The results are divided into four sections, rare plants, floristics, plant communities, and soils and geology.

Rare Plants

Sixty seven species, subspecies or varieties of plants found in Lake County are considered to be rare. Thirty-five (54 percent) of those 64 taxa are either restricted to serpentine soil or at least have some of their populations occurring on serpentine soil (Table 1). Thirty (45 percent) of the 67 rare plant taxa are endemic to serpentine soil substrates. Nine of the 35 rare plants are included in list 1B of the CNPS inventory (Smith and Berg, 1988). Those nine species are; *Ceanothus confusus*, *Ceanothus divergens*, *Eriogonum nervulosum*, *Hesperolinon adenophyllum*, *Hesperolinon didymocarpum*, *Hesperolinon drymarioides*, *Madia hallii*, *Streptanthus brachiatus*, and *Streptanthus morrisonii*. One of those species, *Hesperolinon didymocarpum*, is state-listed as Endangered and occurs only in Lake County.

TABLE 1

Status of Rare Serpentine Plants of Lake County, California

Species	Status[1] State	Status[1] Federal	Endemism[2] CNPS	Endemism[2] (+/-)
Allium cratericola	-	-	list 3	+
Allium fimbriatum var. purdyi	-	-	list 4	+
Asclepias solanoana	-	-	*	+
Astragalus breweri	-	-	list 4	+
Astragalus clevelandii	-	-	list 4	+
Astragalus rattanii var. jepsonianus	-	-	list 4	+
Calamagrostis ophitidis	-	-	list 4	+
Calyptridium quadripetalum	-	-	list 4	+
Calystegia collina ssp. oxyphylla	-	C2	list 3	+
Ceanothus confusus	-	C2	list 1B	-
Ceanothus divergens	-	C2	list 1B	+
Collinsia greenei	-	-	*	+
Collomia diversifolia	-	-	list 4	+
Cryptantha hispidula	-	-	list 4	+
Delphinium uliginosum	-	-	list 4	+
Eriogonum nervulosum	-	C2	list 1B	+
Fritillaria pluriflora	-	C2	list 3	-
Fritillaria purdyi	-	-	list 4	-
Helianthus exilis	-	C3	list 3	+

TABLE 1 continued

Species	Status[1] State	Federal	CNPS	Endemism[2] (+/-)
Hesperolinon adenophyllum	-	C3	list 4	+
Hesperolinon bicarpellatum	-	C3	list 4	+
Hesperolinon didymocarpum	CE	C1	list 1B	+
Hesperolinon drymarioides	-	C3	list 1B	+
Hesperolinon spergulinum	-	-	*	+
Lomatium ciliolatum var. hooveri	-	-	list 4	+
Madia hallii	-	C2	list 3	+
Mimulus brachiatus	-	-	list 3	+
Mimulus nudatus	-	-	list 4	+
Navarretia jepsonii	-	-	list 4	+
Nemacladus montanus	-	-	*	+
Orobanche vallida ssp. howellii	-	-	list 4	+
Senecio clevelandii	-	-	list 4	+
Streptanthus brachiatus	-	C2	list 1B	+
Streptanthus morrisonii	-	C2	list 3	+
Thelypodium brachycarpum	-	C3	list 4	-

CODES: CE = California Endangered Species
C1, C2, C3 = Federal Candidate for Listing
CNPS = In California Native Plant Society Inventory (Smith and Berg, 1988):
List 1B = highest priority,
List 3 = Information Needed, List 4 = Watch List,
* = In inventory but not included in a list
Endemism + = serpentine endemic, - = not restricted to serpentine
* = Plant taxa not included in the Natural Diversity Data Base, or in the CNPS inventory, but considered to be rare based on this study.

Table 1 lists the 35 rare plants that occur on serpentine soil in Lake County and their rarity status based on the California Native Plant Society's inventory (Smith and Berg, 1988). Table 1 does, however, include some plant taxa which are not included in particular lists in the 1988 edition of the inventory (i.e. Smith and Berg, 1988). These species include Asclepias solanoana, Collinsia greenei, Hesperolinon spergulinum, and Nemocladus montanus. These species are considered to be rare due to the small size of their populations even though their overall distribution may encompass several counties and due to their restriction to serpentine soil habitats. Table 1 also shows which species are serpentine endemics as opposed to which species only have some populations growing on serpentine soil.

Each of the 35 rare species is discussed individually in Appendix A. The nine rarer species in list 1B of the CNPS inventory are treated at length in Appendix A and include information on species description, related species and taxonomy, distribution including topographic maps of populations, land ownership habitat,and land use and threats.

Floristics

Five hundred and seventy four plant species, subspecies and varieties were identified through this study to grow in serpentine soil habitats in Lake County (Appendix B). Those taxa are included within 69 families and 251 genera. The five families having the largest number of representative taxa are the Asteraceae (94 taxa), Poaceae (51 taxa), Fabaceae (42 taxa), Scrophulariaceae (41 taxa) and the Brassicaceae (21 taxa). The genera having the largest number of species are Trifolium (15 taxa), Allium (10 taxa), Hesperolinon (9 taxa) and Calochortus, Lupinus and Streptanthus each with 8 taxa.

From the total 574 plant taxa occurring on the Lake County serpentine soil habitats 498 or 88 percent are native to California. Appendix B lists the plants occurring on serpentine soil in Lake County, their families and whether they are California native taxa and whether or not they are serpentine soil endemics. Of the 498 native taxa there are 57 taxa or 11 percent that are endemic to serpentine soil habitats (Table 2). None of the 75 (13 percent) non-native taxa are serpentine soil endemics.

TABLE 2

Vascular Plants Endemic to Serpentine Soil Habitats in Lake County, California

Species	Family
Allium cratericola	Alliaceae
Allium dichlamydeum	Alliaceae
Allium fimbriatum var. purdyi	Alliaceae
Antirrhinum breweri	Scrophulariaceae
Asclepias solanoana	Asclepiadaceae
Aster radulinus	Asteraceae
Astragalus breweri	Fabaceae
Astragalus clevelandii	Fabaceae
Astragalus gambelianus	Fabaceae
Astragalus rattanii var. jepsonianus	Fabaceae
Calamagrostis ophitidus	Poaceae
Calochortus venustus	Liliaceae
Calochortus vestae	Liliaceae
Calycadenia multiglandulosa var. cephalotes	Asteraceae
Calycadenia pauciflora	Asteraceae
Calyptridium quadripetalum	Portulaceae
Calystegia collina ssp. oxyphylla	Convolvulaceae
Carex mendocinensis	Cyperaceae
Ceanothus divergens	Rhamnaceae
Ceanothus jepsonii var. albiflorus	Rhamnaceae
Chaenactis glabriuscula var. gracilenta	Asteraceae
Claytonia saxosa	Portulaceae
Collinsia greenei	Scrophulariaceae
Collomia diversifolia	Polemoniaceae
Cryptantha hispidula	Boraginaceae
Delphinium uliginosum	Ranunculaceae
Eriogonum nervulosum	Polygonaceae
Eriogonum vimineum	Polygonaceae
Erythronium heleniae	Liliaceae
Fritillaria purdyi	Liliaceae
Fritillaria recurva var. coccinea	Liliaceae
Helianthus exilis	Asteraceae
Hesperolinon adenophyllum	Linaceae
Hesperolinon bicarpellatum	Linaceae
Hesperolinon didymocarpum	Linaceae
Hesperolinon disjunctum	Linaceae
Hesperolinon drymarioides	Linaceae
Hesperolinon spergulinum	Linaceae
Lomatium ciliolatum var. hooveri	Apiaceae
Lupinus bicolor ssp. tridentatus	Fabaceae
Madia hallii	Asteraceae
Mimulus brachiatus	Scrophulariaceae

TABLE 2 continued

Vascular Plants Endemic to Serpentine Soil
Habitats in Lake County, California

Species	Family
Mimulus nudatus	Scrophulariaceae
Montia gypsophiloides	Portulacaceae
Navarretia jepsonii	Polemoniaceae
Navarretia mitricarpa	Polemoniaceae
Nemacladus montanus	Lobeliaceae
Senecio clevelandii var. *clevelandii*	Asteraceae
Senecio greenei	Asteraceae
Silene campanulata ssp. *glandulosa*	Caryophyllaceae
Streptanthus barbiger	Brassicaceae
Streptanthus brachiatus	Brassicaceae
Streptanthus glandulosus ssp. *secundus*	Brassicaceae
Streptanthus hesperidis	Brassicaceae
Streptanthus morrisonii	Brassicaceae
Thlaspi montanum var. *montanum*	Brassicaceae
Trifolium macraei	Fabaceae

Plant Communities

Six plant communities, serpentine chaparral, northern interior cypress forest, serpentine digger pine-chaparral woodland, serpentine bunchgrass grassland, knobcone pine forest (serpentine phase), and serpentine riparian woodland were observed during this study as occurring on serpentine soil in Lake County. Five of these communities correspond to those included in the terrestrial community classification produced by the California Natural Diversity Data Base (Holland, 1986). The sixth community, serpentine riparian woodland, is recognized in this study as distinct and deserving recognition.

Serpentine Chaparral

There are three distinctive types of serpentine chaparral: 1) *Quercus durata* dominated; 2) *Arctostaphylos viscida* dominated; and 3) multispecies co-dominated. These three types of serpentine chaparral have not as yet been recognized in the literature to any extent. Many of the detailed observations presented here are the result of this study.

1) *Quercus durata* dominated community: This community type occurs on rocky south-facing slopes and flats where the soil profile is very poorly developed. This type of soil corresponds to the Montara soil series (Lake County Soil Survey unpubl.). This community type is characteristically sparsely vegetated with a shrub cover of less than 30 percent. Over 80 percent of the vegetation cover is *Q. durata*. Associated species include *Ceanothus jepsonii* var. *albiflorus* and *Pinus sabiniana* (Kruckeberg, 1984; Hanes, 1988).

2) *Arctostaphylos viscida* dominated community: This community type can form extensive stands (up to 10 hectares), of pure *A. viscida*, not unlike the occurrence of this species on non-serpentine substrates. The pure stands most often are found on ridge tops and gentle north facing slopes such as along Walker Ridge east of Indian Valley Reservoir and west of Lake Pillsbury. The soil is generally highly weathered and oxidized appearing orange-red with a relatively high clay content (25-40 percent) and has a red hue characteristic of the Henneke soil series (Lake County Soil Survey unpubl.) Associated species include *Garrya congdonii*, *Pinus sabiniana*, *Ceanothus jepsonii* var. *albiflorus* and *Quercus durata* (Kruckeberg, 1984; Hanes, 1988).

3) Mixed serpentine chaparral: This community occupies the largest area of all serpentine plant communities in Lake County. This is one of the more diverse plant communities in terms of shrub species. Several equally important co-dominants include *Arctostaphylos viscida*, *Ceanothus jepsonii* var. *albiflorus*, *Heteromeles arbutifolia*, *Rhamnus californica*, *Quercus durata*,

Adenostoma fasciculatum and Garrya congdonii (Kruckeberg, 1984; Hanes, 1988). Other associated species, though not co-dominants, include Pinus sabiniana and Toxicodendron diversilobum. This community type occurs on all slopes and aspects and grows in moderate to well developed serpentine soil characteristic of the Okiota and Henneke soil series (Lake County Soil Survey unpubl.).

Northern Interior Cypress Forest

Two distinct community types of cypress forest occur in Lake County: 1) Cupressus sargentii dominated and 2) Cupressus macnabiana dominated.

1) Cupressus sargentii dominated community: C. sargentii occurs in more mesic habitats than C. macnabiana. This difference is reflected in C. sargentii woodlands being found mostly in moist ravines on south-facing slopes or on cooler north-facing slopes. Due to increased aridity in eastern Lake County, C. sargentii is replaced by C. macnabiana (Griffin and Critchfield, 1972). The serpentine soils for interior cypress woodland have a deeper soil profile than the chaparral community. These serpentine soils correspond with the Henneke soil series. Forests of C. sargentii most often occur on the upper south facing and north-facing slopes and in moist ravines particularly along Harbin Ridge northeast of Middletown and north of Indian Valley Reservoir.

2) Cupressus macnabiana dominated community: Forest or woodlands of C. macnabiana occur on shallow slopes or flats. The serpentine soils are deep red due to extensive oxidation and have a high clay content characteristic of mature Henneke soil series (Lake County Soil Survey unpubl.). Forests of C. macnabiana are most common along Walker Ridge on the Lake-Colusa County line east of Indian Valley Reservoir. Both this and the previous interior cypress community type occur adjacent to serpentine digger pine-chaparral woodland and serpentine chaparral.

Serpentine Digger Pine-Chaparral Woodland

Dense serpentine chaparral, particularly on north-facing slopes, can have a gradient of densities of Pinus sabiniana. Serpentine chaparral dominated by Arctostaphylos viscida is the most common type to have a higher percentage of P. sabiniana. The occurrence of P. sabiniana in the serpentine chaparral appears to be related to fire history of a site (Hanes, 1988). Areas that have not had fires for some time show a higher density of mature P. sabiniana. The soil profiles for this community are relatively well developed and correspond to the Henneke soil series (Lake County Soil Survey unpubl.).

Serpentine Bunchgrass Grassland

Bunchgrass communities are relatively rare in the Lake County serpentines primarily due to the steep, rocky, highly erodible slopes common throughout the area. Moderately sloping areas in the Big Canyon drainage support native bunchgrass species such as _Sitanion jubatum_, _Melica torreyana_, _M. imperfecta_, _Stipa pulchra_, _Festuca idahoensis_ and _Koeleria macrantha_. Many of the larger serpentine bunchgrass grasslands are heavily grazed. This grazing disturbance has allowed the invasion of non-native annuals such as _Lolium multiflorum_. Two additional bunchgrass species, _Calamagrostis ophitidis_ and _Elymus glaucus_, primarily occur in moister situations and often are understory to chaparral shrubs (see serpentine chaparral). The soil substrates are mostly very clayey and are the result of colluvial deposits from up-slope erosion of serpentine soil.

Knobcone Pine Forest (Serpentine Phase)

Primarily on north-facing slopes at higher elevations (1,000-1,500 meters) dense forest of _Pinus attenuata_ occurs. This plant community most commonly characterizes the upper slopes immediately above serpentine digger pine-chaparral woodland. Similar to the serpentine digger pine-chaparral woodland this community is temporally restricted to areas that have not been recently burned and often represents a single age-class climax forest (Holland, 1986, p. 100).

Serpentine Riparian Woodland

Perennial and summer-dry creeks on serpentinite substrate are habitat for a distinct riparian vegetation dominated by _Calycanthus occidentalis_ and _Rhododendron occidentale_. In moist narrow ravines these two species may become understory to large (10-15 meters tall) individuals of _Cupressus sargentii_. An associated species of this community is _Rhamnus californica_ ssp. _tomentella_.

Unclassified Plant Habitats

Three distinct serpentine habitats are: 1) serpentine barrens; 2) serpentine herb field; and 3) serpentine seeps. Due to the ephemeral and often sparse cover of vegetation these are not included in any previously recognized community classifications.

1) Serpentine barrens: Areas of coarse fractured serpentinite rock forming steep slopes characteristically having exceedingly low vegetation cover (<< 1 percent) and support plant species not found in any other community type. In particular,

several rare plants, including Allium fimbriatum var. purdyi, Eriogonum vimineum, E. nervulosum, Streptanthus brachiatus and S. morrisonii, occur on serpentine barrens. Other plants, though not rare, that occur on or in ravines of serpentine barrens include Lewisia rediviva, Montia gypsophiloides, Salix breweri, Strepthanthus breweri, S. glandulosus, S. glandulosus ssp. hesperidis.

2) Serpentine herb field: This habitat is characterized by a dominance of herbaceous dicotyledonous plants, most of which do not have showy flowers characteristic of the wild flower field community (Holland, 1986, p. 37,). Two rare species Hesperolinon didymocarpum and H. bicarpellatum are occasionally found in this habitat but are more common in openings of serpentine chaparral. Non-rare species include Achillea lanulosa, Arenaria (Minuartia) douglasii, Calycadenia pauciflora, Chaenactis glabriuscula, Hemizonia clevelandii, Lasthenia california (chrysostoma), Lessingia ramulosa, Micropus californica and Rigiopappus leptocladus. Soils of this habitat are derived from colluvium and are shallow (10-15 cm) with relatively high clay concentrations (20-30 percent). Occasionally, native bunchgrasses such as Sitanion jubatum occur in low abundance. This habitat is found between serpentine chaparral and serpentine bunchgrass grassland.

3) Serpentine seep: Ephemeral seeps occur in numerous locations throughout the Lake County serpentines. Many of these flow across dirt roads that have cut across drainages. Characteristic rare plant taxa include Astragalus clevelandii, Delphinium uliginosum, Helianthus exilis, Mimulus nudatus and Thelypodium brachycarpum. More common species include Mimulus nasutus, M. guttatus and Stachys albens.

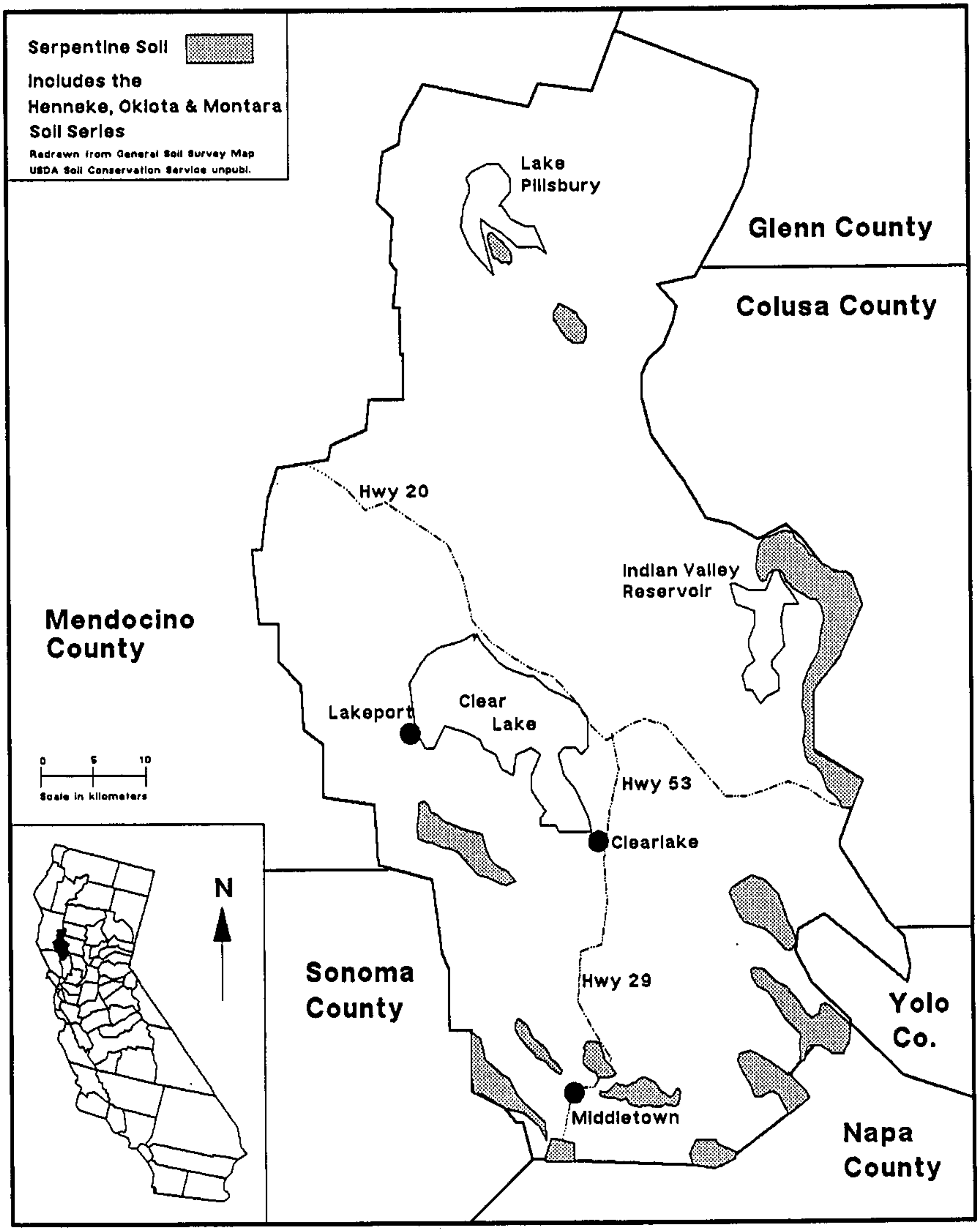
Serpentine Soils and Geology

Serpentine Soil

Lake County includes 64,560 acres of serpentine soils that have been mapped in the Lake County Soil Survey (unpubl.). This represents nine percent of the total 756,976 acres of land area in Lake County. Thirteen major areas of serpentine soils occur in Lake County (Figure 1). Most of these serpentine areas occur near the county line where they extend into other counties such as Colusa, Napa and Sonoma.

Three different serpentine soil series, Henneke, Okiota and Montara are recognized in Lake County (Lake County Soil Survey, unpubl.). The Henneke soil series displays the higher level of profile development of the three soil series, and accounts for 39 percent of the serpentine soil mapping units. This soil is shallow and excessively drained. The profile is gravelly loam

FIGURE 1
Distribution of Serpentine Soil in Lake County, California



over gravelly clay loam with fractured serpentinite parent material at a depth of 47 cm. Okiota soils are shallow and well drained. The profile is very gravelly clay loam over clay loam with fractured serpentinite at a depth of 35 cm. Montara soils are the least developed of the three serpentine soil types. It is shallow and well drained. The profile is clay loam with fractured serpentinite at a depth of less than 30 cm.

Mean soil values for calcium, magnesium and manganese cation concentrations, calcium to magnesium ratio, pH, cation exchange capacity, phosphorus and nitrogen from habitats supporting seven of the rare plant species studied are given in Table 3. A comparison of the calcium and magnesium cation concentrations for those seven rare plants is provided in Figure 2. Also, a non-serpentine soil, Los Osos series, is given in Figure 2 as a comparison of calcium and magnesium cation concentrations. The non-serpentine Los Osos series is a common soil that predominantly supports chaparral or oak woodland types of vegetation.

The soil data show that important nutrients for plant growth such as calcium, phosphorus, and nitrogen are extremely low in their concentrations. These data are in common agreement with other published values on serpentine soil nutrients (Proctor and Woodell, 1971; Willet and Batey, 1977; Kruckeberg, 1984; Alexander et al., 1985; Brooks, 1987). Further, the relatively high concentration of magnesium cations is found in all serpentine soil samples.

Although the soil nutrients calcium, phosphorus, and nitrogen are relatively low in all serpentine soil samples, there is an important divergence in all component concentrations between some samples. In particular, all soil factors are extremely low for samples from the rocky serpentine barrens habitats which support _Eriogonum nervulosum_, _Streptanthus brachiatus_ and _S. morrisonii_. Non-barrens habitats, or habitats that generally support a significant perennial vegetation cover, have considerably more soil development and display higher concentrations of the soil factors measured. Rare species in these habitats include _Hesperolinon adenophyllum_, _H. didymocarpum_, _H. drymarioides_ and _Madia hallii_.

The cation exchange capacity (CEC) is relatively high in the serpentine soil samples. The CEC, which reflects the concentration of available cations, show that the additive concentrations of calcium and magnesium cations accounts for the majority of available cations. Therefore, all other cations in the soil, such as sodium, potassium, and manganese are in relatively low concentrations. The serpentine soil pH values are neutral to slightly acidic (Table 3). These pH values are within the range of allowing maximum availability of the soil nutrients (Truog in Larcher, 1980). Thus, soil pH would not further

TABLE 3

Mean Values of Serpentine Soil Components for Rare Plant Habitats

Species/Soil Site [1]	Ca++ [2]	Mg++ [2]	Ca/Mg	Mn++ [2]	CEC	P [3]	N [3]	pH
ERNE site 2	0.61	1.79	0.34	0.02	2.14	0.68	0.013	6.5
ERNE site 8	0.18	0.95	0.20	0.02	3.95	0.08	0.015	6.5
HEAD site 1	3.57	21.34	0.17	0.18	29.10	0.17	0.16	6.5
HEAD site 9	4.80	21.03	0.23	0.16	19.55	0.31	0.06	6.4
HEDI site 7	1.80	11.30	0.11	0.06	19.62	0.53	0.04	6.5
HEDR site 1	1.75	18.00	0.10	0.08	26.30	0.23	0.05	6.0
HEDR site 2	3.72	35.33	0.11	0.21	42.45	0.25	0.11	5.9
MAHA site7	1.62	15.43	0.10	0.05	18.05	0.59	0.03	6.4
STBR site 8	0.18	0.95	0.19	0.02	3.95	0.08	0.06	6.9
STMO site 2	0.34	1.79	0.34	0.02	2.14	0.68	0.01	6.5

[1] Species Codes, see Figure 1 for site # locations

ERNE = Eriogonum nervulosum

HEAD = Hesperolinon adenophyllum

HEDI = Hesperolinon didymocarpum

HEDR = Hesperolinon drymarioides

MAHA = Madia hallii

STBR = Streptanthus brachiatus

STMO = Streptanthus morrisonii

[2] concentrations in milliequivalents

[3] values in percent

Ca++ = Calcium

Mg++ = Magnesium

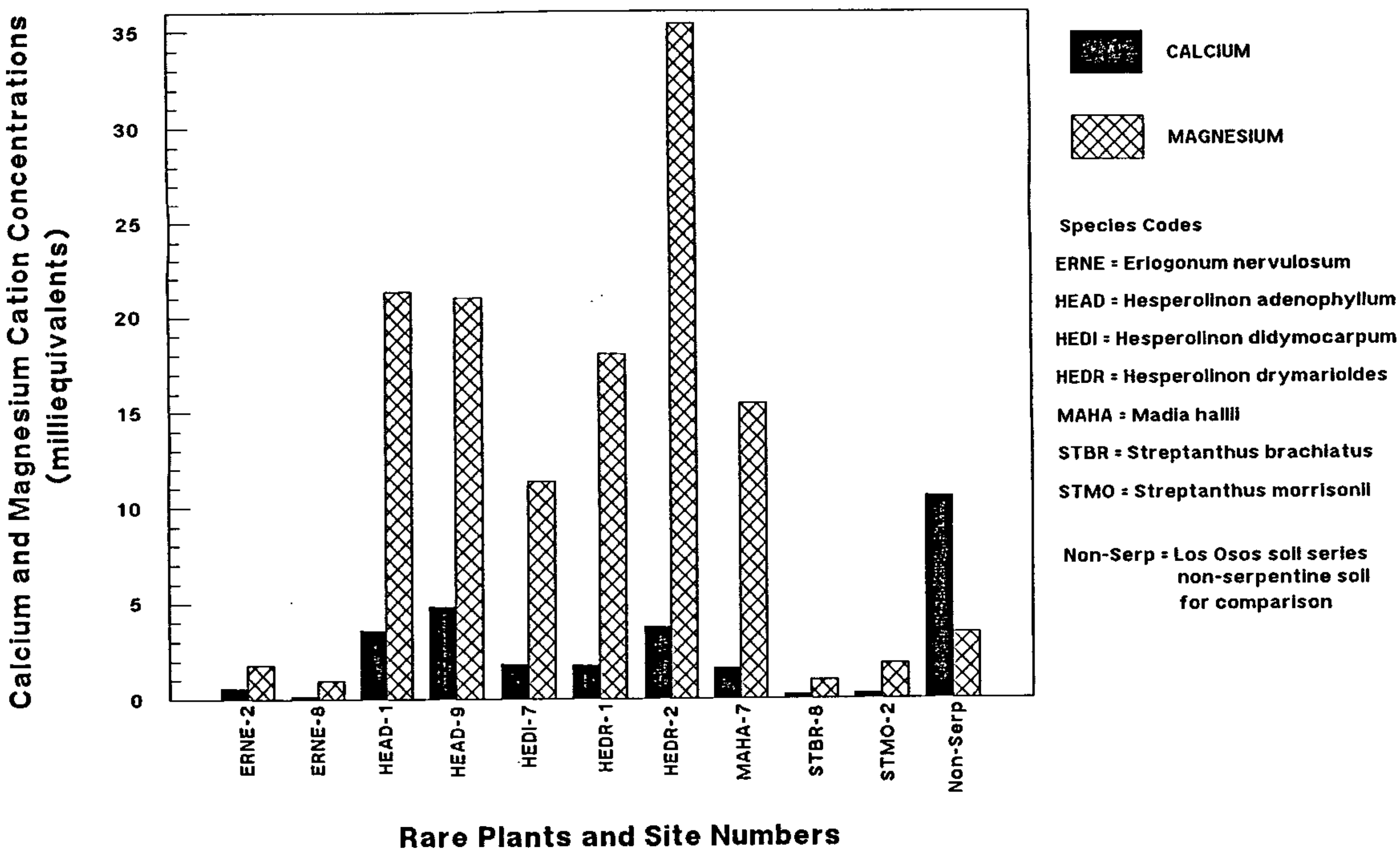
Mn++ = Manganese

CEC = Cation Exchange Capacity

P = Phosphorus

N = Nitrogen

FIGURE 2
Calcium and Magnesium Concentrations for Serpentine Soils in Lake County that support Rare Plant Species



inhibit the availability of the already low concentrations of important soil nutrients such as calcium, phosphorus, and nitrogen.

Geology

A general model for the formation of ultramafic rocks such as serpentinite is metamorphosis of the mineral peridotite under high pressure and temperature (Dixon, 1977; Alexander et al., 1985; Brooks, 1987). Peridotite or its derivative serpentinite intruded into a variety of geological formations during the Mesozoic (Norris and Webb, 1976). The combined serpentinite and other geologic formations of similar age along the California Coast Ranges are collectively called the Franciscan formation or Mesozoic Franciscan-Knoxville group (Norris and Webb, 1976).

During the late Tertiary these Mesozoic formations were covered by a variety of other formations including the Sonoma volcanics (Axelrod, 1966). Uplifting during the Quaternary raised the Franciscan formation exposing much of this older set of formations. Some covering of Franciscan formation may have occurred during the Mt. Konocti volcanic event approximately 400,000 years ago (Kelley, 1981). The time of exposure for any particular area of serpentinite is not known. However, some areas have been exposed considerably longer than others, perhaps as long as 1 million years. In general the larger the serpentinitic mass the older it is. Many of the younger, smaller serpentine areas occur in the southern end of Lake County near Middletown. There, non-serpentine Tertiary sediments are eroding away and exposing new serpentine habitats. It is these new habitats that some of the rare plants occur such as *Hesperolinon didymocarpum*. The age of some of these habitats may only be a couple thousand years old (McCarten, 1988a).

The serpentinite formations exposed in the inner Coast Ranges are mostly associated with a series of thrust faults. Major faults along which serpentinite formations occur are the Stony Creek fault, Collayomi fault, Cobb Mountain fault, Morgan Valley fault and the Coast Range thrust fault (Bortugno, 1982).

Mineralogy

The ultramafic mineralogy class includes metamorphic minerals in the serpentine family such as antigorite, chrysotile (asbestos) and lizardite, as well as igneous minerals such as those in the gabbroic family. The ultramafic class is characterized by a low calcium to magnesium ratio (Alexander et al., 1985). Serpentine minerals are iron-magnesium silicates (Alexander et al., 1985; Brooks, 1987). Parent material is generally low in calcium and other mono- and divalent cations except for magnesium.

Serpentine minerals weather into iron-rich montmorillonite under the climatic conditions in the California Coast Ranges (Wildman et al., 1968). Due to the smaller size of magnesium cations, these cations are weathered at a faster rate than calcium cations. The result is older more developed serpentine soils have proportionally higher concentrations of calcium and lower concentrations of magnesium than in younger soils (Wildman et al., 1968; Dixon, 1977; McCarten, 1988a).

DISCUSSION

The Lake County serpentine soil habitats have been found to have a high plant species diversity. Using 5,500 as an estimate of the number of California native taxa (Jepson Herbarium, unpubl.), then the 498 taxa found on the serpentine soils in Lake County represents approximately nine percent of the native taxa found in California.

The results of this study and others on serpentine soil provide a basis for understanding habitat characteristics of plants growing on these soils. Further, these studies allow an analysis of which factors may be important in plant adaptation to serpentine soil habitats. The following discussion outlines some of the more important aspects of plant and soil interactions associated with the serpentine soil habitats.

Plant and Serpentine Soil Ecology

It has been recognized that several serpentine soil factors play a major role in the occurrence and distribution of plants on these substrates (Proctor and Woodell, 1975; Kruckeberg, 1984; Brooks, 1987; McCarten, 1987a, 1988a). These factors can be separated into three categories; 1) low calcium to magnesium cation concentrations, 2) generally low nutrient concentrations such as nitrogen and phosphorus, and 3) toxic heavy metals. The significance of each of these categories to plants will now be discussed individually.

1) Calcium and Magnesium Cation Concentrations

Both calcium and magnesium cations play an important physiological role in plants. Calcium has both a structural and a functional role. It occurs as a bridge between proteins and phospholipids in cell membranes which affects the permeability of those membranes (Mengel and Kirkby, 1982). In addition, calcium is an activator or a substrate binding factor for a number of enzymes including ATPase (Hochman and Carmeli, 1981) and root phosphatase (Woolhouse, 1969; Willet and Batey, 1977). This last enzyme is very important because it is directly involved in the uptake and mobilization of organic phosphorus (Woolhouse, 1969; Willet and Batey, 1977; Baliger, 1985) which was found to be a nutrient in low abundance in serpentine soil samples in this study and by others (Turitzen, 1982). Magnesium is an important cation particularly in photosynthesis since it is part of the chlorophyll molecule. Magnesium is in relative overabundance in serpentine soil. Experiments have found that magnesium outcompetes calcium in the uptake of these cations (Mengel and Kirkby, 1982) and can act as an inhibitor in calcium activated reactions such as ATP formation (Hochman and Carmeli, 1981).

Populations of serpentine soil adapted species have been shown to have overcome the problems of disproportionately high concentrations of magnesium and low concentrations of calcium (Johnson and Proctor, 1981; Turitzen, 1982; Fitter and Hay, 1983). Root acid phosphatase activity has been found to be higher in serpentine adapted species than in non-serpentine adapted species when grown and compared in low nutrient conditions (Willet and Batey, 1977). The exact mechanisms of adaptation to the calcium-magnesium imbalance are, however, unknown.

2) Low Nutrient Concentrations

In addition to calcium, other soil nutrients such nitrogen and phosphorus are biochemically important elements that are generally in limited supply in serpentine soil. Relatively slow growth rates, especially in annual species, may represent one of the mechanisms or perhaps trade-offs utilized in growing in nutrient poor soil. Additions of calcium or nitrogen to serpentine soil does not increase growth of serpentine adapted plants, but does increase growth in non-serpentine plants (Proctor and Woodell, 1975; Mengel and Kirby, 1982; Turitzen, 1982). Other nutrient deficiencies in serpentine soil are in the form of trace elements. Walker (1948) found the trace element molybdenum to have an extremely low concentration in serpentine barrens.

3) Toxic Heavy Metals

Emphasis has often been placed on the toxic effects of heavy metals such as nickel and chromium to account for adaptation to serpentine soil (Proctor and Woodell, 1975; Kruckeberg, 1984; Brook,s 1987). Indeed there are many examples, particularly outside of California, where nickel concentrations are exceedingly high in serpentine soil (Brooks 1987). Correlations between soil nickel concentrations and the hyperaccumulation of nickel in plants have been used to argue for specific adaptations to those soils (Kruckeberg, 1984; Brooks 1987). It has been found that in species of Calochortus hyperaccumulation of heavy metals, including nickel, chromium and cobalt, is not always correlated with high soil concentrations of those metals (Fiedler, 1986). It has also been recognized that the toxic effects of heavy metals is pH dependent (Mengel and Kirkby, 1982). The significance of heavy metal toxicity to plants is dependent on the occurrence of heavy metals in the soil. Several studies in the California central coast ranges (McCarten, 1987a; Mooney and others at Stanford University, unpubl.) have found that heavy metal concentrations are not abnormally high in soils supporting serpentine grassland and chaparral communities. Certainly the occurrence of nickel or other heavy metals in soil would add another challenge to plants adapting to serpentine soil.

Genetics of Serpentine Soil Adaptation

Kruckeberg's (1951) study on plant adaptation was perhaps the first to demonstrate genetically controlled adaptation to serpentine soil. Kruckeberg showed that different populations of the same species were either genetically adapted or not adapted to growing on serpentine soils in California.

Physiological and biochemical studies have demonstrated genetic differences between populations and within populations for the ability to grow on serpentine soil. Johnson and Proctor (1981) found that serpentine adapted plants of Festuca rubra grew faster in solutions made from serpentine soil rather than non-serpentine soil. In addition, non-serpentine plants were found to be inhibited by high concentrations of magnesium. In particular, the study by Willet and Batey (1977) found that root surface acid phosphatases in serpentine adapted plants were adapted to low calcium concentrations, while non-serpentine adapted plants of the same species of grass showed increased growth with added calcium.

Rare Plant Adaptation to Serpentine Soil

Although no direct evidence is available on how or to what degree rare plants are adapted to serpentine, the studies on non-rare species probably apply. In fact, the soil and rare plant distribution data from this study, and others (see McCarten, 1987a, 1988a,b) provide a pattern suggesting that the rare plants have a very narrow range of soil adaptation. Among the nine rarer plant species in this study two major groups, serpentine barrens and non-barrens taxa, are distinguishable based on the soil data. Among the non-barrens taxa there are differences in the calcium to magnesium cation ratios that differentiates some taxa such as Hesperolinon adenophyllum as occurring on less extreme serpentine soil than the other species. However, the concept of extreme serpentine soil is a relative one. Studies on Hesperolinon (McCarten, 1988a,b) found that the serpentine soil endemic species, including H. adenophyllum, H. didymocarpum, and H. drymarioides, occur on soil with a calcium to magnesium ratio that is generally less than 0.3. Serpentine soil samples from habitats supporting Hesperolinon species that are not restricted to serpentine soil were found to have calcium to magnesium ratios generally greater than 0.5. The study on Hesperolinon demonstrates a pattern that serpentine soil endemics occur on soil having a much lower calcium concentration. The observed calcium to magnesium ratios for the rare species studied in this report suggest that all are adapted to more extreme serpentine conditions.

CONCLUSIONS

The results of this and other studies make a strong case of genetically controlled physiological and biochemical adaptation by some plant taxa to serpentine soil. There are differences in the level of adaptation between related species and between populations of a species. Interspecific and intraspecific differences coincide with the localized and patchy serpentine soil habitats that can vary over short distances of only 1 meter or less (McCarten, 1987a, 1988a). These differences are sufficient to restrict the potential geographic range expansion of a rare plant species either naturally or artificially. Such is the case of Hesperolinon didymocarpum that has populations in close proximity to H. bicarpellatum and H. californicum. The later two species have very different soil nutrient and development characteristics that are found within 1 meter of H. didymocarpum habitat conditions (McCarten, 1988a).

The soil data have provided several pieces of important information on the habitats of some of the rare plants in Lake County. It has shown that the serpentine habitats are quite distinct with respect to soil nutrient availability and the level of soil development. The results can be interpreted that while some rare species such as Eriogonum nervulosum and Streptanthus brachiatus can share a similar serpentine habitat, this is not the same habitat, for instance, as that of Hesperolinon didymocarpum or Madia hallii. Therefore, rare serpentine endemic plant taxa cannot be transplanted to any serpentine habitat. In fact a lot of soil data and carefully controlled growth studies would have to be done and analyzed prior to moving any rare serpentine endemic. Further, the soil data show that there may be relatively small, yet important differences between populations and species that occur on what appears to be similar habitats such as serpentine barrens. Physical or chemical changes to a rare plant habitat could seriously change that habitat's nutrient conditions and potentially destroy those conditions on which the rare plants are adapted.

Causes of Rarity

Fiedler (1987) outlined 13 main categories that deal with aspects of plant rarity. Among those categories is edaphically restricted species such as the serpentine soil endemics in Lake County. It is probably safe to claim that in the case of serpentine soil endemics, narrow habitat restriction is the primary cause of rarity in those species. Such a claim may not necessarily be made for rare non-serpentine species in Lake County. With increases in development in Lake County the relatively rare serpentine soil habitats may no longer be the isolated natural refuges they have been. It becomes a matter of careful planning to recognize the significance of the serpentine soil habitats and their associated vegetation and protect them.

Reasons for Protecting Plant Species and Genetic Diversity

California is second only to Hawaii and Florida in the number of endemic plants species and overall species diversity in the United States. This high level of species diversity is an important resource both from a natural heritage and an agronomic perspective. Lake County is certainly an important component of California's overall plant species diversity. The natural heritage resources of the Lake County can only be appreciated by those whom have taken the time to visit the habitats and experience that diversity. This report merely presents an index of some of the natural resources in the county, but it does not relay the experience associated with observing those resources.

The agronomic considerations for preserving plant species diversity is considerable. For agricultural purposes, just preserving one population is insufficient. This is especially true when species populations vary genetically to the degree found in serpentine endemic species. The five rare Hesperolinon species, as well as the four non-rare species of the genus, could provide important genetic resources for future crops of flax (Linum usitatissimum) the source of linen fiber and linseed oil (Griggs and Dibble, 1979; Durant, 1979). Members of the mustard family (Brassicaceae) such as the two rare species of Streptanthus and one rare species of Thelypodium could provide genetic material for a suite of important vegetable crops such as cabbage, mustard, radish, turnip, and cauliflower. Another rare serpentine soil endemic, *Helianthus exilis*, has already been considered as a potential source of genetic material for increasing genetic diversity in the sunflower, *Helianthus annuus* (Jain et al., 1977).

Land Use and Threats

In Lake County, geothermal energy development is considered to have had the greatest negative impacts on the flora associated with serpentine soil (Kruckeberg 1984, 1987). However, in eastern Lake County near the Napa County line, gold mining has had a devastating impact on the serpentine flora. Some populations of at least 12 species of rare plants included in this report have been extirpated as a direct result of gold mining projects (Callizo, pers. comm.). Both geothermal energy development and mining have and will continue to be a threat to both rare as well as the more common plants that occur in these habitats.

Overgrazing in some parts of Lake County has reduced the diversity of the serpentine flora especially with respect to native bunchgrasses. Further, the grazing has disturbed the soil which has resulted in the establishment of non-native weedy plants. Off-road vehicles have accounted for serious negative impacts to rare serpentine soil endemic plants and their associated communities elsewhere in California (Kruckeberg 1984). Off-road vehicles are not known to have had a significant impact in Lake County serpentine soil habitats. However, off-road vehicles do utilize jeep trails on Bureau of Land Management property in eastern Lake County, along which rare species including the southern-most distribution of *Hesperolinon drymarioides* and other species occur. These types of impacts cause direct physical damage by removal of the plants and, in particular, the soil that account for the very localized habitat conditions.

In theory, damage only to the vegetation, such as by light grazing, may be reversed once grazing is stopped or significantly decreased. However, damage to the habitat through soil disturbance may be irreversible in terms of revegetation by the same species. As has been found in this study, particular plant communities are restricted to particular types of serpentine soil. Shallow, rocky and poorly vegetated serpentine soil habitats may be able to recover quicker than ones that have a deep soil horizon and have more vegetation. The deeper soils, once disturbed, will have increased erosion, loss of soil texture resulting in lower water holding capacity, and loss of some important nutrients such as calcium and phosphorus. The result will be revegetation by native and non-native disturbance adapted species.

Vegetation recovery of physically disturbed serpentine soil habitats can be observed along roadcuts and spoils areas. These types of disturbed areas most often only support native annuals such as *Aira caryophyllea*, *Lotus subpinnatus*, and *Vulpia micrantha*, in addition to several non-native annuals, including *Lolium multiflorum*. Road banks and spoils areas that have deeper soil deposits show low density establishment of perennial species such as *Eriodictyon californica* and the bunchgrass *Sitanion jubatum*. Areas in Colusa County that have been burned then chained show a much sparser cover of reestablishment vegetation than do areas that have only been burned.

Major threats to serpentine soil habitats that do not involve physical damage are the use of fertilizers and herbicides. Fertilizers enrich the nutrient poor serpentine soil which creates conditions allowing non-native weeds to invade. The application of herbicides can directly damage or kill plants and their use could damage or destroy some rare plant populations.

Goals for Protection

With the high plant species diversity found in the Lake County serpentine soil habitats, a goal to preserve that diversity includes preserving the rare plants. The reason, as mentioned earlier, is that seven percent of the native plant taxa on the serpentine soils are rare. Ideally we wish to permanently protect the rare plant species from extinction. To achieve this goal no longer means protecting a single population of a rare species, unless that is all that remains of that species. Rather it means protecting both the habitat and the genetic diversity encompassed by the series of populations that comprise a particular species.

The question then arises is how best to protect the species diversity and rare plants in the Lake County serpentine soil habitats? Harris (1984) has recommended that when selecting sites for preserves that some should include rare species, while others should be chosen because they increase within species genetic diversity, overall species diversity, habitat diversity including unique situations, the geographical ranges of species and successional stages to name a few.

Recommendations

In Lake County there are several areas that are significant because they have rare plants, high species diversity, habitat diversity, different plant communities, unique situations and would contribute to the genetic diversity and geographical variation of some of the rare plants. Figure 3 shows five serpentine areas that given protection would significantly contribute to preserving rare plants, plant communities and genetic diversity as well as other features of serpentine soil habitats. The political boundaries of Lake County, however, should not be used to develop a preserve planning strategy, nor should the areas not specifically mentioned be ignored or considered unimportant. A broader preserve design for rare serpentine plants and plant communities must consider the neighboring areas in Napa, Sonoma and Colusa counties.

There are two main recommendations: 1) Develop a series of serpentine habitat preserves; and 2) develop management plans for the preserves. Below, under each of these main two recommendations is a list of additional recommendations and set of examples that should be considered for conserving rare plants, plant communities, plant species diversity and other resources associated with serpentine soil habitats in Lake County.

1) Serpentine Soil Habitat Preserve Design

The approach to preserve design in this case is one that plans to develop a series of preserves that have some relationship to one another. The approach is considered to be synergistic in the sense that diversity is maximized, but some redundancy in species and communities is inherent in the overall plan. This redundancy may not be real since the species at the different preserve sites may, in fact, be genetically different. With or without genetic differences, species redundancy in preserves is a better hedge against the potential for local extinction of the rare species. The following list is an outline for developing an integrated system of preserves.

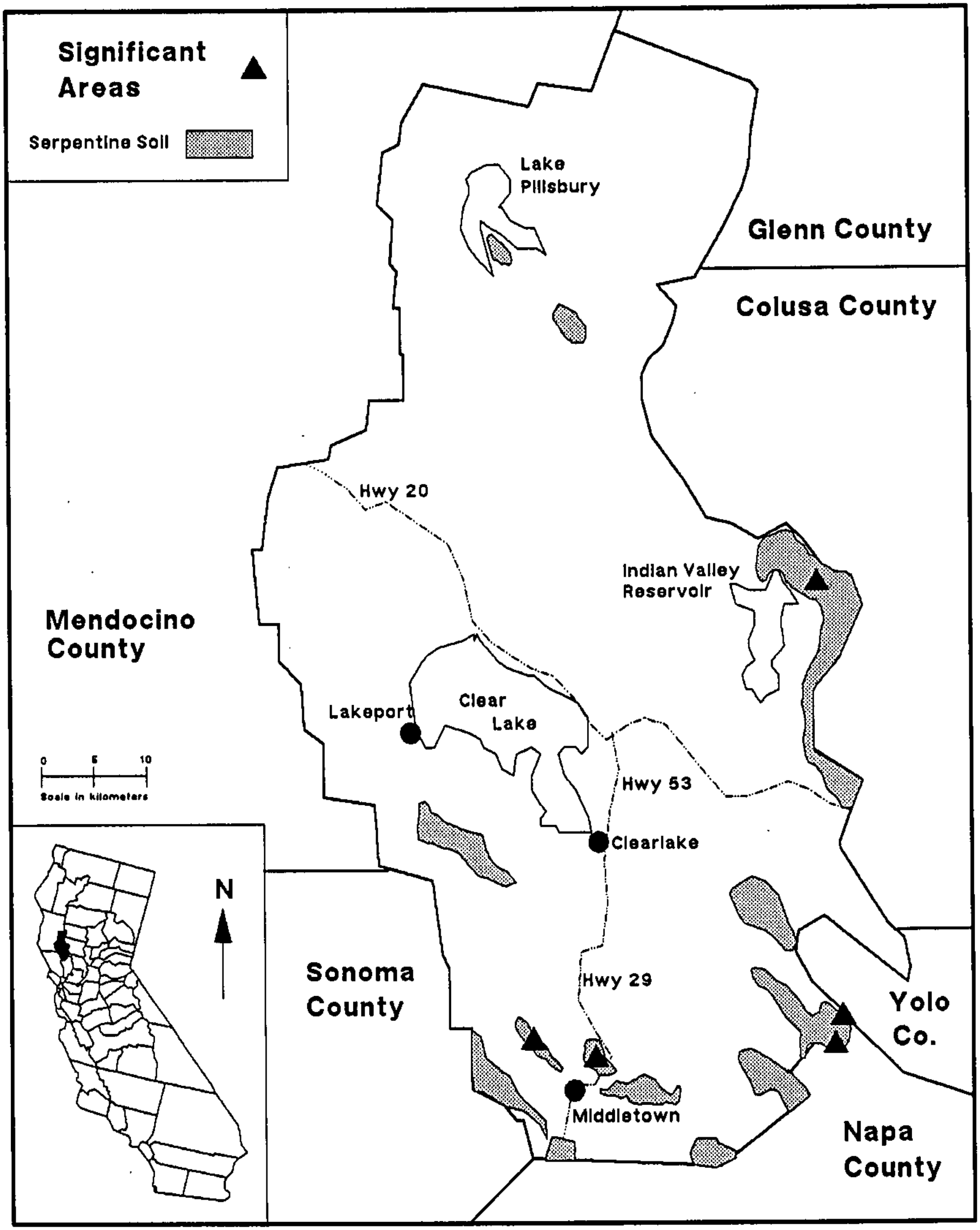
a) Develop a general plan for selecting areas to be included in the proposed preserve system, i.e. prepare a list of criteria that include maximizing rare plant populations, different plant communities, and a variety of serpentine habitats (viz. Harris, 1984).

b) Use a site ranking method to determine the number of rare species, plant communities and other important features in terms of their presence and quality.

c) Map the distribution of individual species, communities, etc. on a topographic map to see how they might be grouped into areas conforming with the topography so that boundaries could be made that follow landscape contours or include natural drainages or water sheds.

d) Determine land ownership, in particular public versus private land. Identify land use and management practices such as agriculture, grazing, mining development.

FIGURE 3
General Locations of Significant Serpentine Soil Habitats in Lake County, California



e) Compare the different areas studied to determine how and to what degree each will contribute to the general preserve plan.

f) Outline individual clusters of elements with a buffer zone of at least 150 meters between rare populations and boundary. Larger buffer zones may be needed depending on land use of neighboring areas.

g) Determine the land use of neighboring areas and the potential for further development that may represent a future threat to the preserve.

h) Select the larger areas that are high quality and will contribute multiple features to the preserve general plan and have defensible boundaries as the core of the integrated preserve system.

i) Select the smaller sites that contribute primarily rare rare plant populations, but have a less defensible border, or nearby development, as satellite botanical areas. These smaller areas would primarily act to increase genetic diversity for rare plant species.

The procedure outlined above basically follows the preserve design method used by the California Nature Conservancy. Two important aspects included above are not generally incorporated into preserve design, the development of a general plan to have a integrated preserve system, and second the use of a detailed quantitative site ranking as described by McCarten (in press).

Using the procedure just described a series of five serpentine habitat preserves were designed as an example of the method, and as a major recommendation of areas of potential future preserves. The general plan followed the recommendations of Harris (1982) for selecting major sites. Detailed topographic maps for the elements were developed from the data gathered in this study and other sources (see D'Appolonia Engineers, 1982; McCarten, 1985; WESCO, 1986). Recommended preserve boundaries were mapped on 7.5 minute U.S. Geological Survey topographic quads (Appendix C). A list of known rare plants, plant communities, and other important habitat features associated with each of the five serpentine habitat preserve designs accompanies each map (Appendix C). The detailed maps of the significant serpentine areas do have boundaries that extend into other counties (e.g Napa County). The justification for extending the boundaries into Napa County is to be more inclusive in the number of rare species populations, and plant communities, and to design the boundaries to follow the natural topography and habitat limits. The five significant serpentine areas mapped (Appendix C) include at least one population of 27 (75 percent) of the 35 rare plants included in this study. Seven of the nine rarer plant species in this study are included in the five reserves. The only two extremely rare plant species not represented in the five preserves are Ceanothus divergens and Hesperolinon adenophyllum. Five of the six plant communities, including the two types of northern interior cypress forest, and the three types of serpentine chaparral, are represented within the five preserve areas. Only the knobcone pine (serpentine phase) community is not included.

The area of each significant serpentine area preserve is given on the information sheet for each preserve (Appendix C). The total area covered by all five serpentine areas mapped is 7,350 acres. The total acreage in Lake County is 6,950 acres with 400 acres occurring in Napa County in the Dunnigan Hill significant serpentine area. Therefore, one or more populations of 75 percent of the rare plants and a large part of the plant community and plant species diversity could be partly preserved in an area approximately 10 percent of the total serpentine acreage in Lake County. It is further recommend that smaller satellite areas should be used to protect more isolated rare plant species and additional populations that are not included in the five large significant areas mapped and described. This is especially true for the rare plants in the Geysers geothermal area where no satisfactory boundary can be established that excludes development. In this case, individual habitats, such as the serpentine barrens, should be recognized and protected for the one or two species that occur in those areas.

2) Management of Serpentine Areas and Preserves

Dawson (1987) has emphasized the importance of active management in the protection of rare plants and other resources. He is explicit in stating that designating an area and posting signs is wholly inadequate for protection of the resource (Dawson, 1987). The following list outlines important aspects of developing a management plan for serpentine habitat preserves:

a) Inventory the elements including rare taxa, plant communities, and unique features.

b) Develop a schedule for monitoring the rare plants. Annual species should be monitored annually or at a minimum ever other year. Perennial shrubs, such as Ceanothus confusus, can be monitored every three to five years.

c) Determine land use conflicts bordering or outside of the preserve and coordinate with other land owners on developing a larger buffer zone or negotiate a change in local land use if necessary.

d) Determine whether site improvement or added protection is needed. This may include removing illegally dumped refuse and locally establishing some fences (see McCarten 1987b).

e) Develop a vegetation management program and schedule. Since a majority of the Lake County serpentine habitats are chaparral, a controlled burning program is needed. Many of the rare plants, such as Hesperolinon drymarioides, increase their population sizes after fire (Griggs and Dibble, 1979; McCarten, 1988b).

f) Coordinate with research organizations, such as universities, and educational and conservation groups such as the California Native Plant Society for developing research and monitoring programs on individual species and communities (see Dawson, 1987).

g) Develop a trail system so there is access to the preserve that does not disturb the rare elements (see McCarten, 1987b).

h) Avoid the use of herbicides and fertilizers. Fertilizers on serpentine soil create conditions that could allow weedy species, including non-native plants to invade. Herbicides could destroy the rare plants (see McCarten, 1987b).

i) Develop management plans for the individual rare plant species in the preserve. This may include aspects of monitoring. In addition, information on life-history and demography of the particular species should be gathered.

j) Limit the number of people walking directly on the serpentine barrens. When monitoring barrens rare plants have only two or three people doing the counting at one time. This will reduce the potential for increased erosion of the steep, friable barrens slopes.

The opportunities for developing an integrated series of preserves that would ultimately recognize individual sites in Lake County for protecting rare serpentine plants, communities, habitats and general biotic diversity are great. The high habitat quality that currently exists for serpentine areas in Lake County and neighboring counties would provide an excellent beginning to developing a state wide serpentine habitat preserve system. This California serpentine preserve system already has a couple of areas that are protected such as the Department of Fish and Game's Harrison Grade Ecological Reserve in Sonoma County (McCarten, 1987b), the Mendocino National Forest's Frenzel Creek Research Natural Area in Colusa County (McCarten, 1988b), the Bureau of Land Management's Cedar Roughs Research Natural Area in

Napa County, and The Nature Conservancy's Ring Mountain Preserve in Marin County to name a few.

There is a high diversity of plant species, rare plants and plant communities that occur on serpentine soil and other ultramafic soils in California. These areas encompass a relatively small area of the state but clearly contribute significantly to the overall biotic diversity in California. Careful planning of a coordinated California serpentine preserve system would make an enormously important contribution toward preserving rare plants found in these areas as well as plant species diversity throughout the state. This report has focused on Lake County to describe the rare plants, plant communities and plant diversity associated with serpentine soil habitats in this region. With the data collected during this study a set of recommendations for developing and managing a system of serpentine habitat preserves has been outlined. It is hoped that these recommendations can be used directly for protecting the plant diversity in Lake County, and indirectly as a preliminary model for protecting serpentine soil habitat diversity throughout California.

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APPENDIX A

This appendix includes individual discussions on the 35 taxa of rare plants included in this study. The first nine plant species are considered the rarest of the 35 and are included in list 1B of the CNPS inventory (Smith and Berg, 1988). These nine species have expanded discussions that include their discription, taxonomy, and distribution including maps of their occurrence in Lake County, and in some cases neighboring counties, topographic maps of element occurrences, land ownership, habitat and ecology, and land use and threat information. The remaining 26 taxa have a brief discussion on their distribution and are accompanied by a map of their occurrence in Lake County.

Element occurrences are mapped for some rare taxa. An element occurrence (EO) is one or more localized populations that occur within an area that is one quarter mile or less in distance from the nearest other population(s) of the same taxon. When several element occurrence numbers appeared to indicate a particular population locality the occurrence number having the most specific locality data was used. For details on specific populations contact the Natural Diversity Data Base (NDDB), Department of Fish and Game, Sacramento, California.

CEANOTHUS CONFUSUS J.T. Howell

Family: Rhamnaceae
Common Name: Rincon buchthorn

Description

Perennial prostrate or low-growing shrub, 5-40 cm. tall, rooting at the nodes, branch tips turning upward, branches 20-60 cm long; leaves opposite, evergreen, leaves 0.-2 cm. long, leaf blades ovate, 3-11 straight teeth that are short and broad, veins on upper surface faintly visible, margins slightly revolute, glabrous and green on upper surface grey pubescent on lower surface; flowers blue; fruit 0.4-0.6 cm in diameter, horns 0.3 cm.; flowering February to April.

Related Species

Ceanothus confusus has most often been considered closely related to another rare species, *C. divergens* (see below), of which *C. confusus* is sometimes considered a variety (Munz and Keck 1968). According to J.T. Howell (unpubl. note at the California Academy of Sciences on herbarium label), *C. divergens* has a more erect habit with larger leaves that have more prominent veins and teeth, and larger fruit with shorter horns. McMinn (1939, p. 313) followed Howell's taxonomy and recognized *C. confusus* as a distinct species. C.L. Schmidt, in his treatment of *Ceanothus* in the new Jepson Manual (unpubl.), intends to place *C. confusus* as a subspecific taxon under *C. prostratus*.

Distribution

Ceanothus confusus has 15 element occurrences on file with the Natural Diversity Data Base. This species has been reported from Lake, Napa and Sonoma counties. Currently this species is known to occur in Lake County (Figure A1) along Harbin Ridge northwest of Middletown (Figure A2, element occurrence 15, NDDB). Approximately 50 plants occur on the Harbin Ridge site. Historical collections report this species from unspecified locations on Bartlett Mountain and Cobb Mountain (Howell, 1939). This species is more abundant in Sonoma County on Rincon Ridge, the type locality.

Land Ownership

Plants occurring on Bartlett Mountain are either on lands administered by the Mendocino National Forest or private. Cobb Mountain populations are either on Bureau of Land Management properties or occur on land belonging to geothermal development corporations. The Harbin Ridge populations are privately held.

Habitat and Ecology

Ceanothus confusus occurs in openings in chaparral and northern interior cypress forest (e.g. at the Harbin Ridge site). Associated species in Lake County include *Salvia sonomensis*, *Cupressus sargentii*, *Ceanothus jepsonii* var. *albiflorus* and *Rhamnus californica*. Soil habitats for *C. confusus* include serpentine, as well a soils derived from rhyolite or basalt.

Land Use and Threats

Major threats to this species appear to be development in counties other than Lake County. The Harbin Ridge population occurs in close proximity to a proposed utility line along the ridge (see WESCO 1986).

FIGURE A 1
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

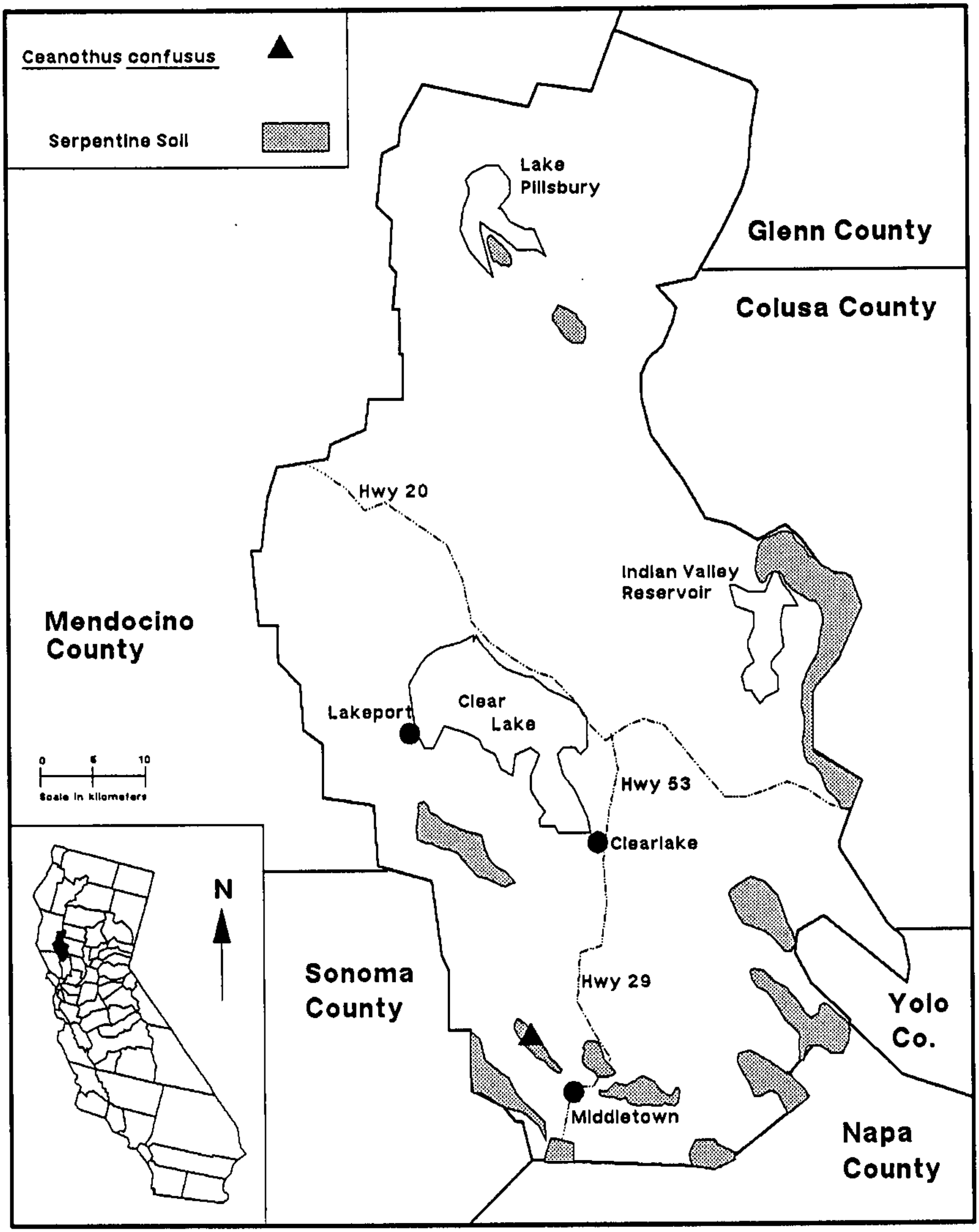
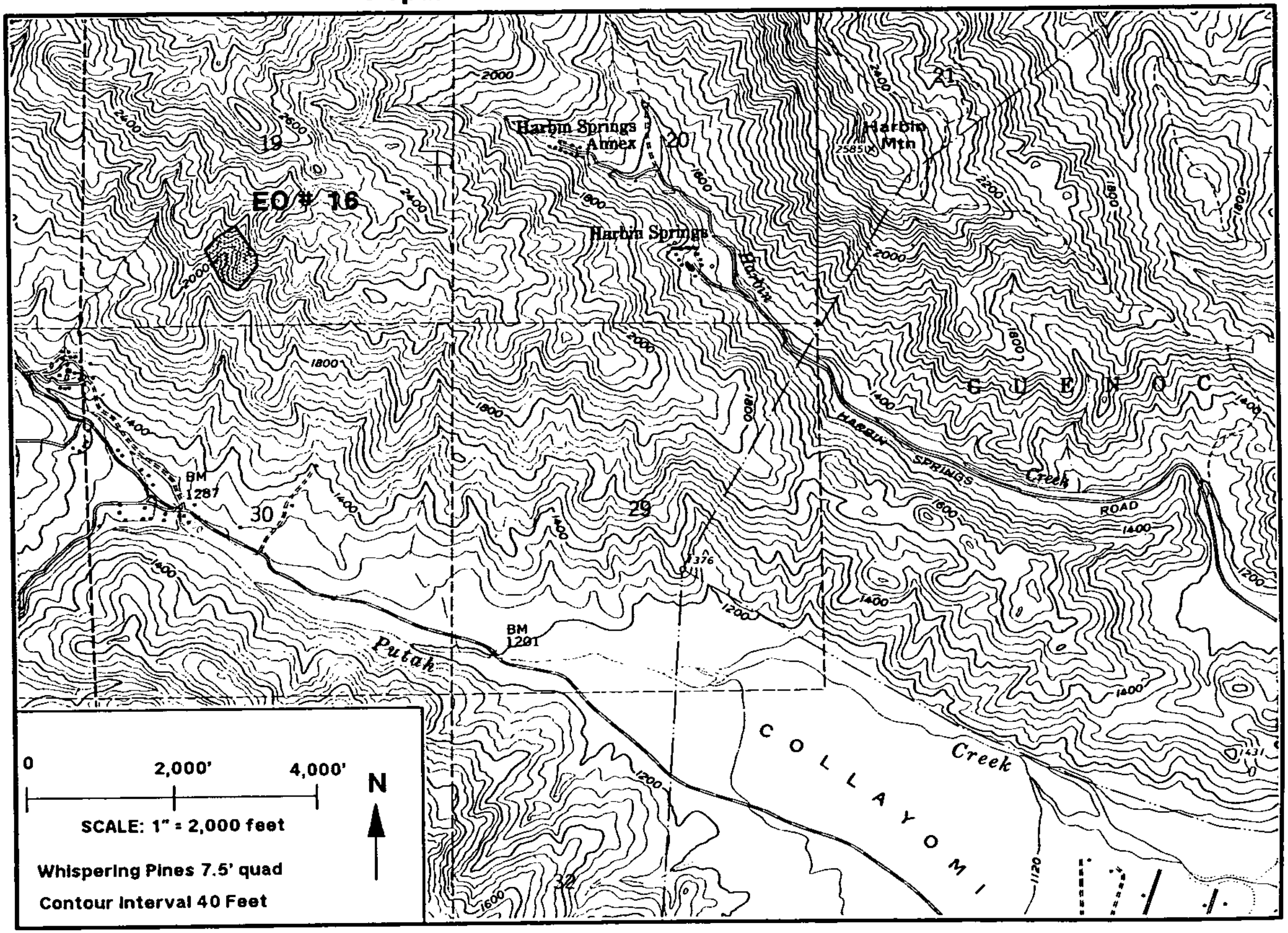


FIGURE A2

Population Locations of Ceanothus confusus



CEANOTHUS DIVERGENS Parry

Family: Rhamnaceae
Common Name: Calistoga Ceanothus

Description

Perennial erect or sprawling low growing shrub, 60-150 cm tall, branches arching; leaves opposite, evergreen, 1.2-2.5 cm long, leaf blades ovate, with 5-8 divaricate teeth that are almost pinnatifid, veins on upper surface prominent, margins revolute, glabrous and green on upper surface, gray-pubescent on lower surface; flowers blue; fruit 0.6-0.7 cm in diameter, horns 0.1-0.2 cm long; flowering February to April.

Related Species and Taxonomy

Ceanothus divergens has most often been considered closely related to *C. prostratus*, as well as to *C. confusus*. *Ceanothus divergens* is treated as a variety of *C. prostratus* in Munz and Keck (1968, p. 984). The main differences between *C. divergens* and *C. prostratus* are the later species has a prostrate habit and roots at the nodes. According to J.T. Howell (unpubl. note at the California Academy of Sciences on herbarium label), *C. divergens* differs from *C. confusus* in that the former species has a more erect habit, larger leaves with more prominent veins and teeth, and larger fruit with shorter horns. C.L. Schmidt's treatment of *Ceanothus* in the new Jepson Manual (unpubl.) places *C. divergens* as a subspecific taxon under *C. purpureus*. Previous treatments including McMinn (1939, p. 313) and Munz and Keck (1968) recognize *C. divergens* as a distinct species.

Distribution

Ceanothus divergens has 17 element occurrences on file with the Natural Diversity Data Base. This species occurs in Lake County on Cobb Mountain on the Lake-Sonoma County line (Figure A3 and A4). This species is more abundant in Sonoma County. Approximately 20-30 plants were observed in 1985, 1986, and 1987 on Cobb Mountain. Neilson and McQuaid (1981, p. 64 Figure 3) mapped a location for *C. divergens* north of Cobb Mountain approximately 0.5 kilometers south of the Lake-Sonoma-Mendocino county line intersection.

Land Ownership

Populations on top of Mt. St. Helena, Napa County are in the Robert Louis Stevenson State Park where they receive some protection due to the undeveloped nature of the park. The populations occurring on Cobb Mountain are either under geothermal exploration leases from the Bureau of Land Management property or belong to geothermal development corporations.

Habitat and Ecology

Ceanothus divergens grows in serpentine chaparral and is associated with *Ceanothus jepsonii* var. *albiflorus* and *Rhamnus californica*. Because of their shorter growth habit, *Ceanothus divergens* shrubs occur along margins and openings of serpentine chaparral.

Land Use and Threats

Major threats to this species appear to be development of the geothermal energy resources in the Cobb Mountain area. In particular, road development has extirpated some plants in the populations on Cobb Mountain. Habitat loss should be considered major threat.

FIGURE A3
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

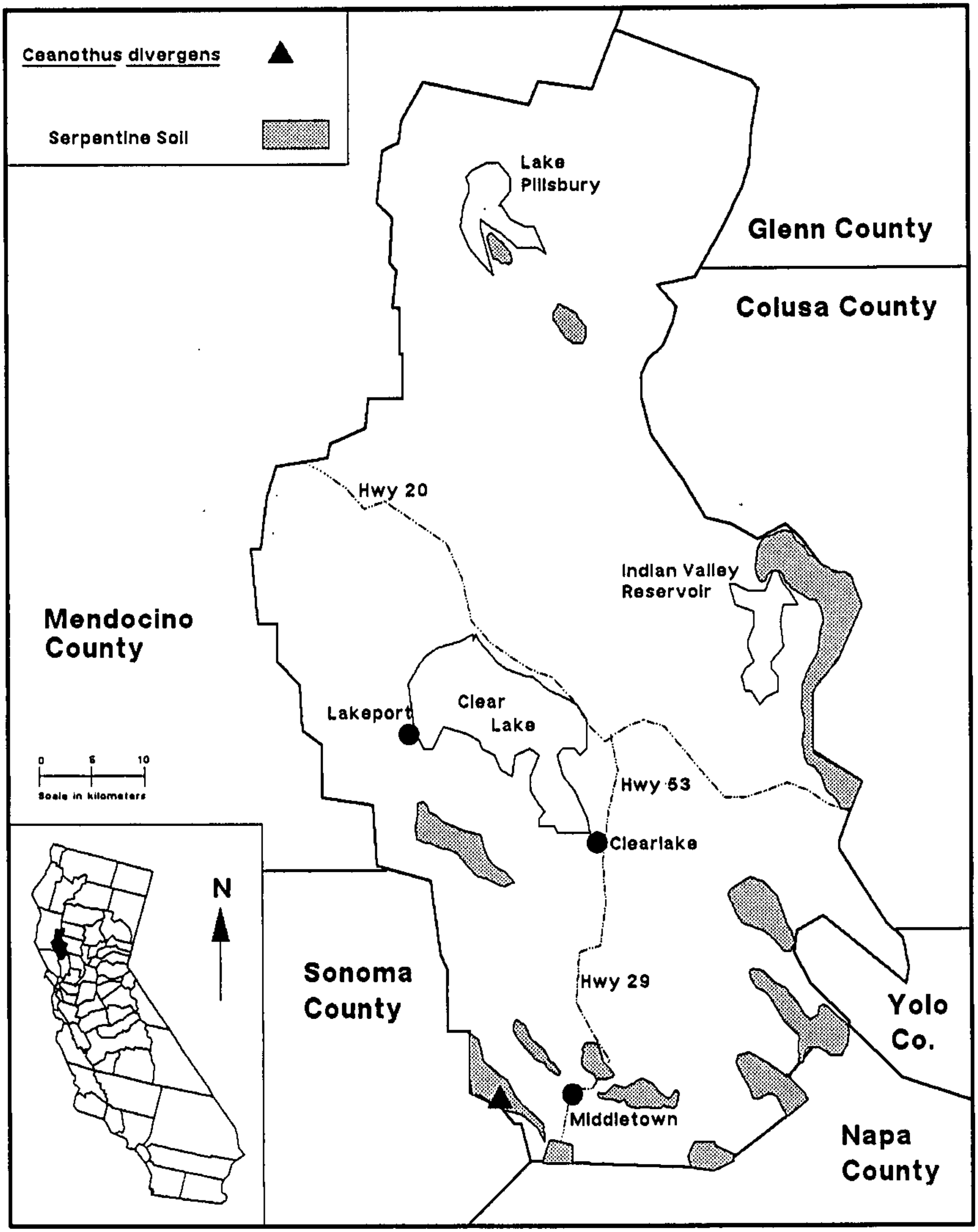
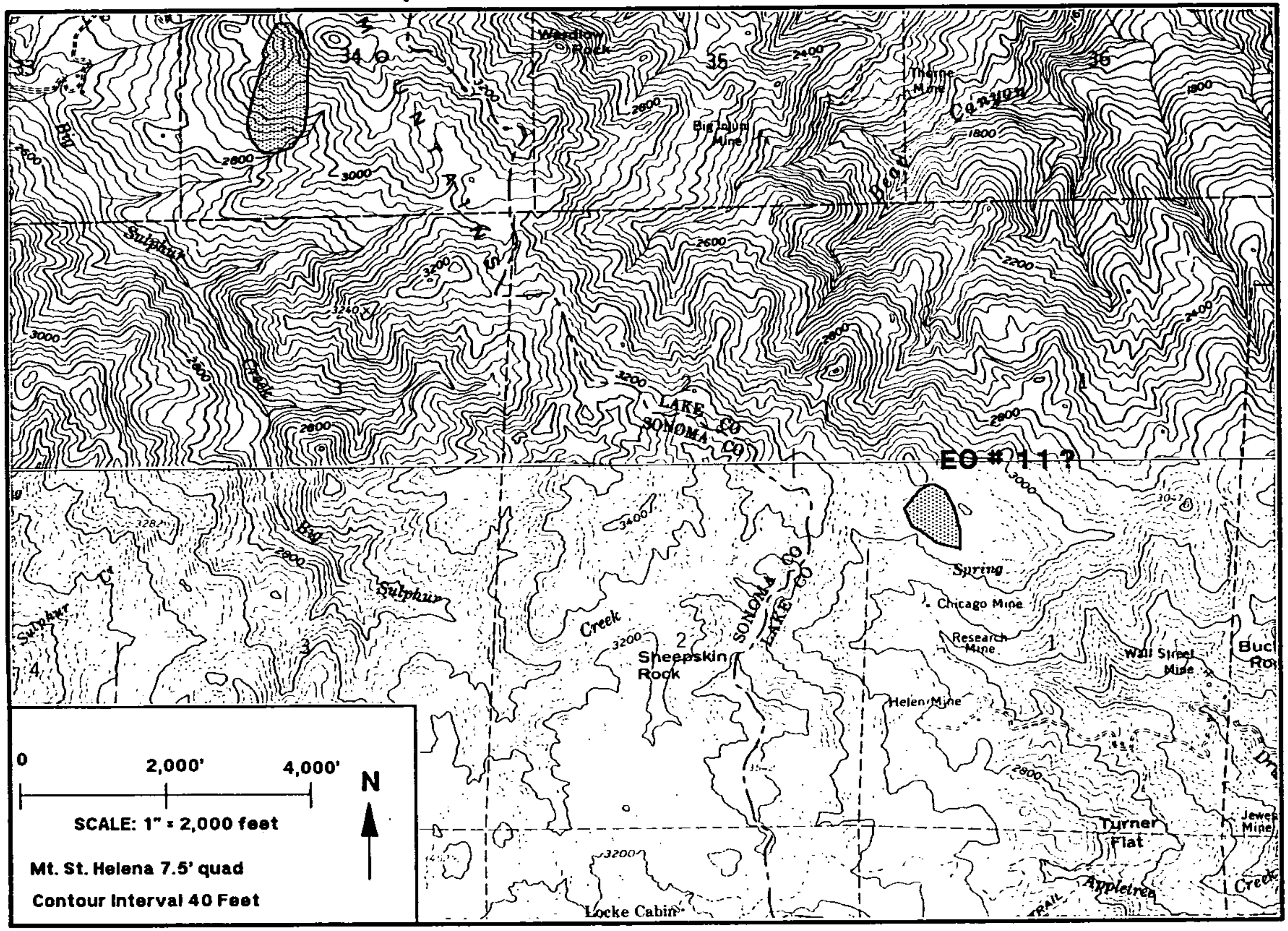


FIGURE A4

Population Locations of Ceanothus divergens



ERIOGONUM NERVULOSUM (S.Stokes)Reveal

Family: Polygonaceae
Common name: Snow mountain buckwheat

Description

Low-growing perennial, 10 cm tall, rhizomatous; branched from the base, branches spreading along ground and sometimes rooting; Leaves ovate, 0.4-1.5 cm long, 0.5-1 cm wide, upper surface lightly pubescent or glabrous, lower surface more densely pubescent often with brownish hairs; scapes 4-6 cm long; inflorescence short and congested subumbellate, with pubescent leafy main bracts (= rays) and smaller bracts (involucres), involucres solitary on each ray, turbinate; flowers composed of petaloid calyces in 2 series of 3, pink to red in color, glabrous, 0.4 cm long; achenes light brown, 0.4-0.5 cm long, with a 3-angled beak; flowering from June through September.

Related Species and Taxonomy

Eriogonum ursinum is the only species having a similar set of characteristics. *Eriogonum nervulosum* differs from *E. ursinum* by having a longer scape, congested subcapitate inflorescence and by being restricted to serpentine barrens habitat.

Distribution

Eriogonum nervulosum has 14 element occurrences on file with the Natural Diversity Data Base. It occurs on a series of serpentine barrens distributed in Lake (Figure A5), Colusa, Napa and Sonoma Counties. Element occurrence 9 (Figure A6) is in the same general vicinity of EOs 6, 7, 8, 12, and 13 (NDDB). Element occurrences 10 and 11 are reported from the Mayacmas Mountains and are presumably from the same areas. There were approximately 85 plants observed in 1987 at the site considered to be EO 9. Element occurrence 9 is used here since that location specifically coincides with the areas mapped in this report. Element occurrence 14, from Dunnigan Hill (Figure A7), has numerous small populations that total approximately 150 plants. The population south of Complexion Springs (Figure A8) apparrently does not have an EO number. This population was observed to have approximately 45 plants in 1987 (Figure A8). One element occurrence, from Snow Mountain West the type locality of this species, is in Glenn County although it is reported as occurring in Lake County (NDDB files).

Land Ownership

Most populations in Lake County occur on Bureau of Land Management property. Some of these areas are currently under mining leases in the Geysers area for geothermal development. Some of the populations in the Geysers geothermal area may occur on land belonging to geothermal development corporations.

Habitat and Ecology

This species is restricted to serpentine barrens. Associated species include *Streptanthus brachiatus*, *S. morrisonii* and *Allium falcifolium*. These rocky barrens are generally highly erodible and lack soil development. Soils are low in all nutrients and show a low calcium/magnesium typical of serpentines. This species often co-occurs with other serpentine barrens species including *Streptanthus brachiatus* and *S. morrisonii*. *Eriogonum nervulosum* does not, however, grow directly with those other species. It generally grows in areas where the barrens slopes are less steep, such as the ridge-top or base of the barrens.

Land Use and Threats

The main threats currently are from development such as geothermal energy development or mining. Off-road vehicles (ORV) and the potential development of and ORV park on Bureau of Land Management property could pose a threat near Dunnigan Hill in eastern Lake County. These types of activities would physically disturb the highly erodible serpentine barrens habitat and destabilize the plants.

FIGURE A5
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

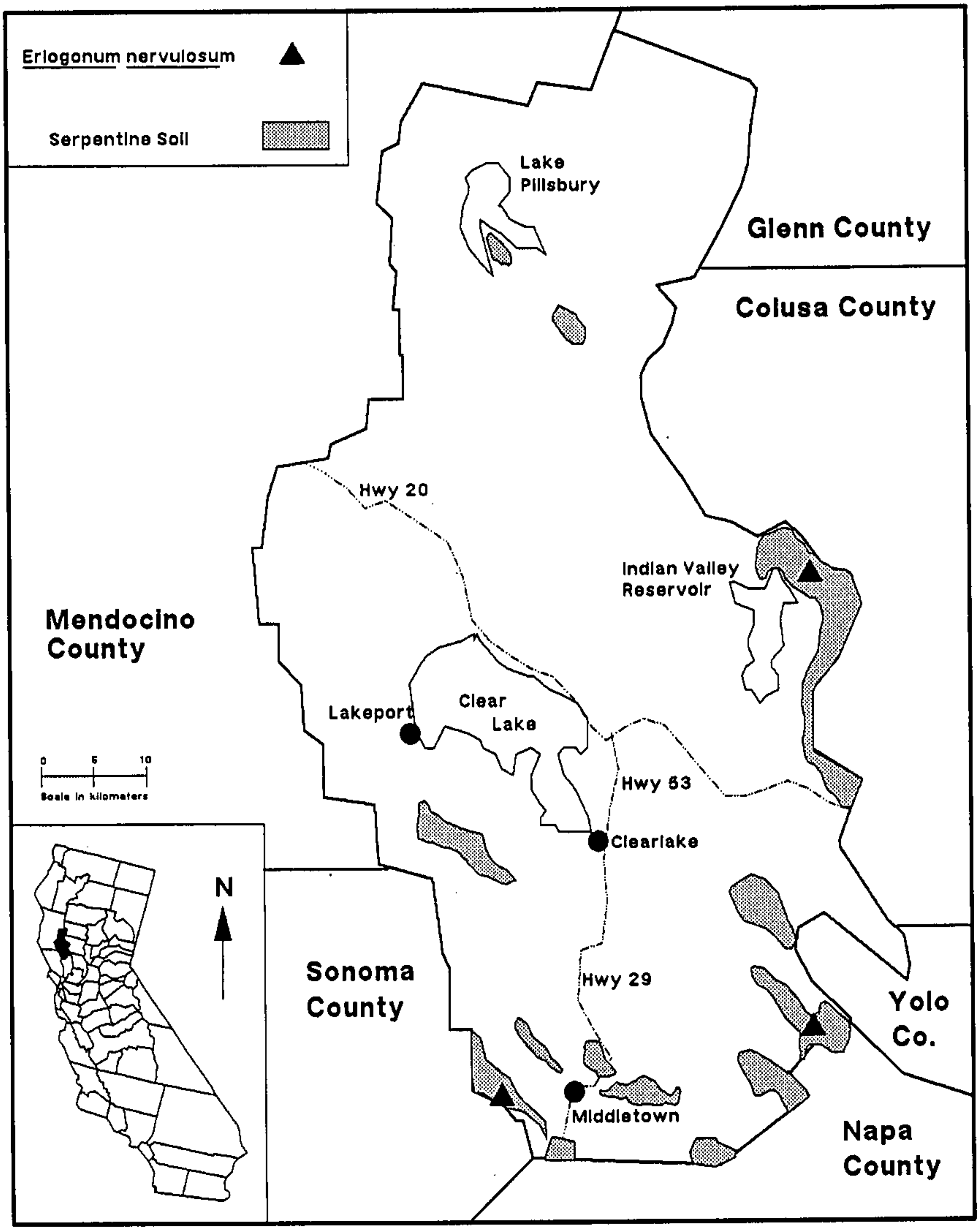


FIGURE A6

Population Locations of Eriogonum nervulosum

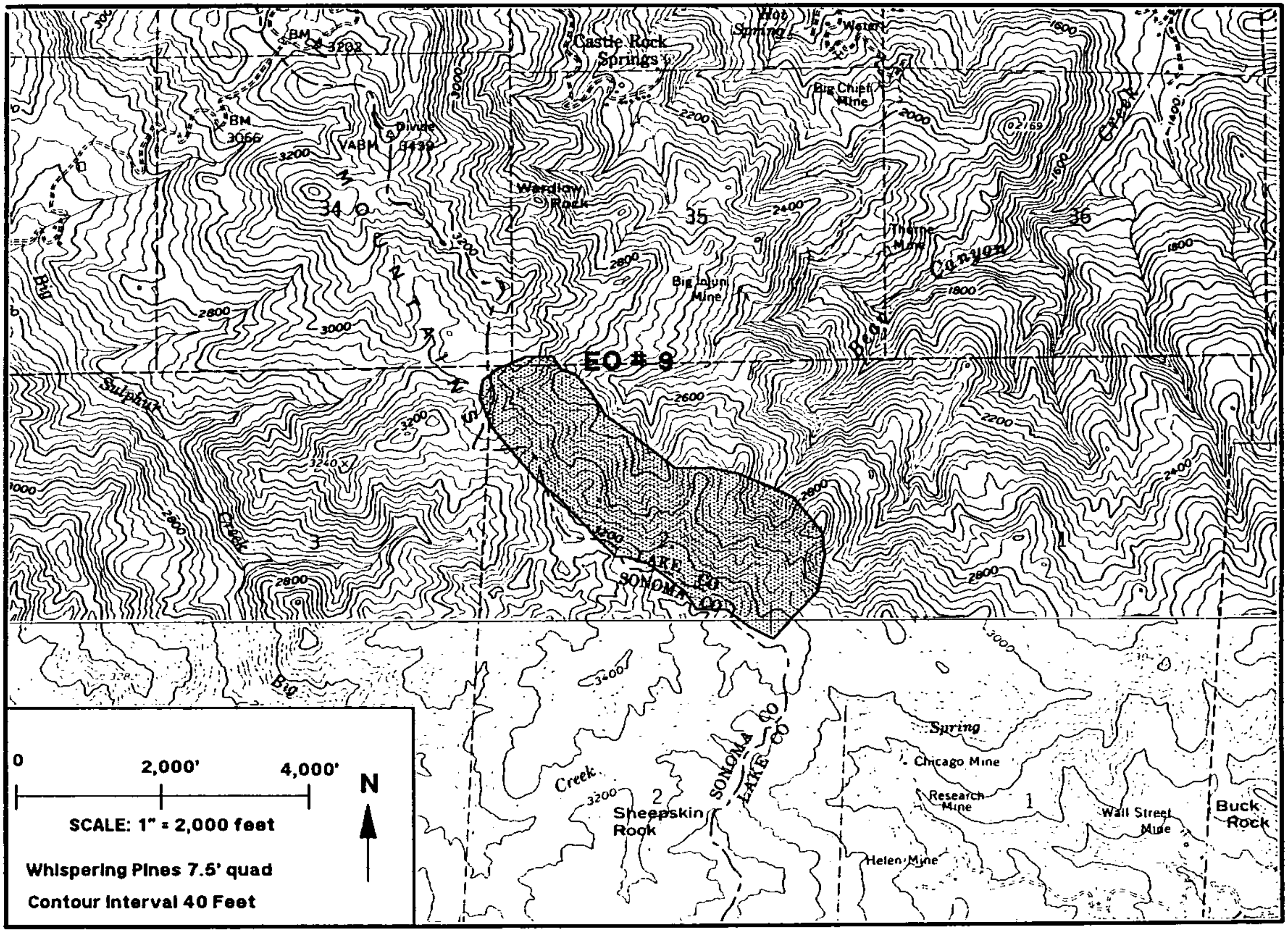


FIGURE A7

Population Locations of Eriogonum nervulosum

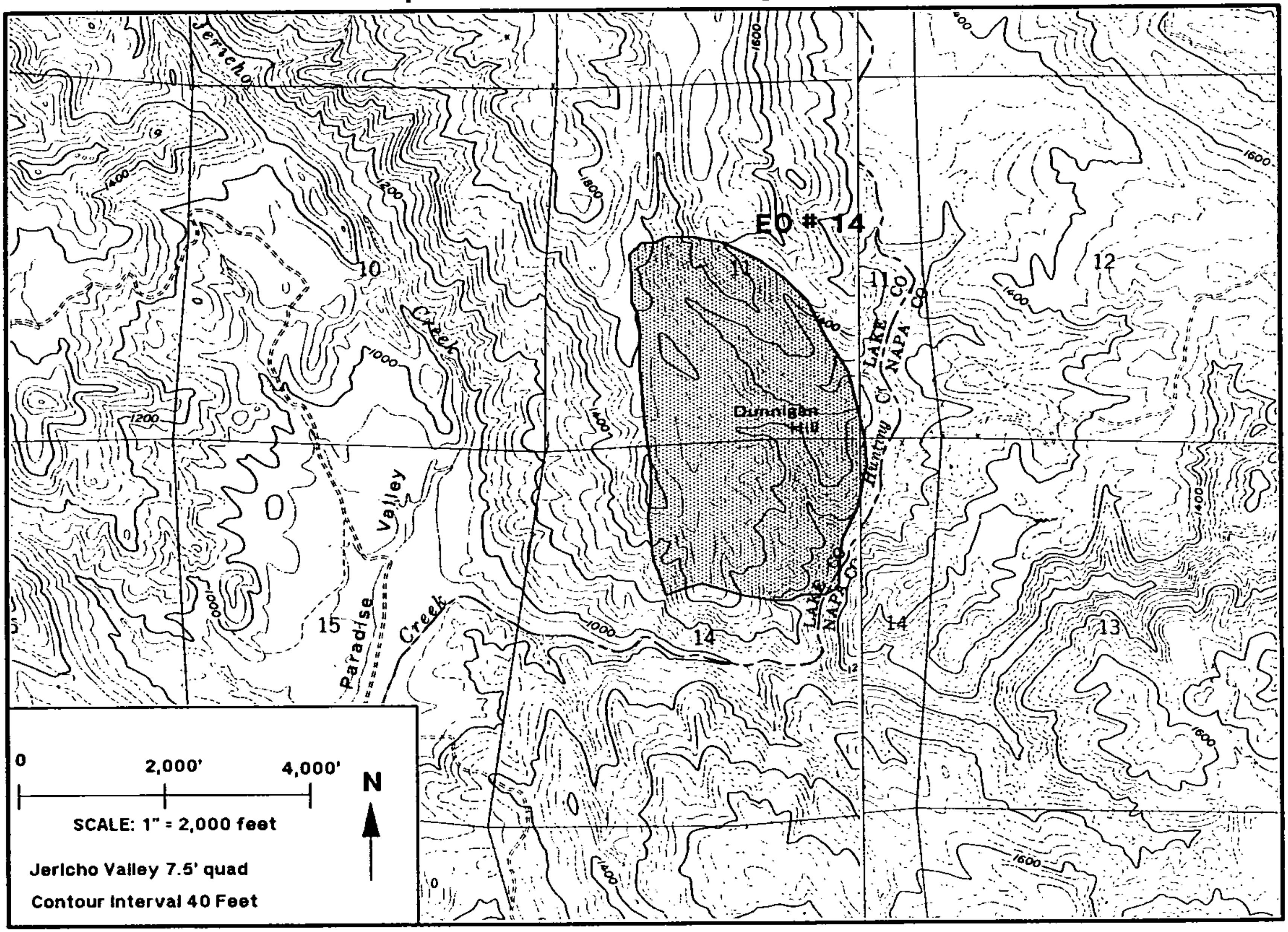
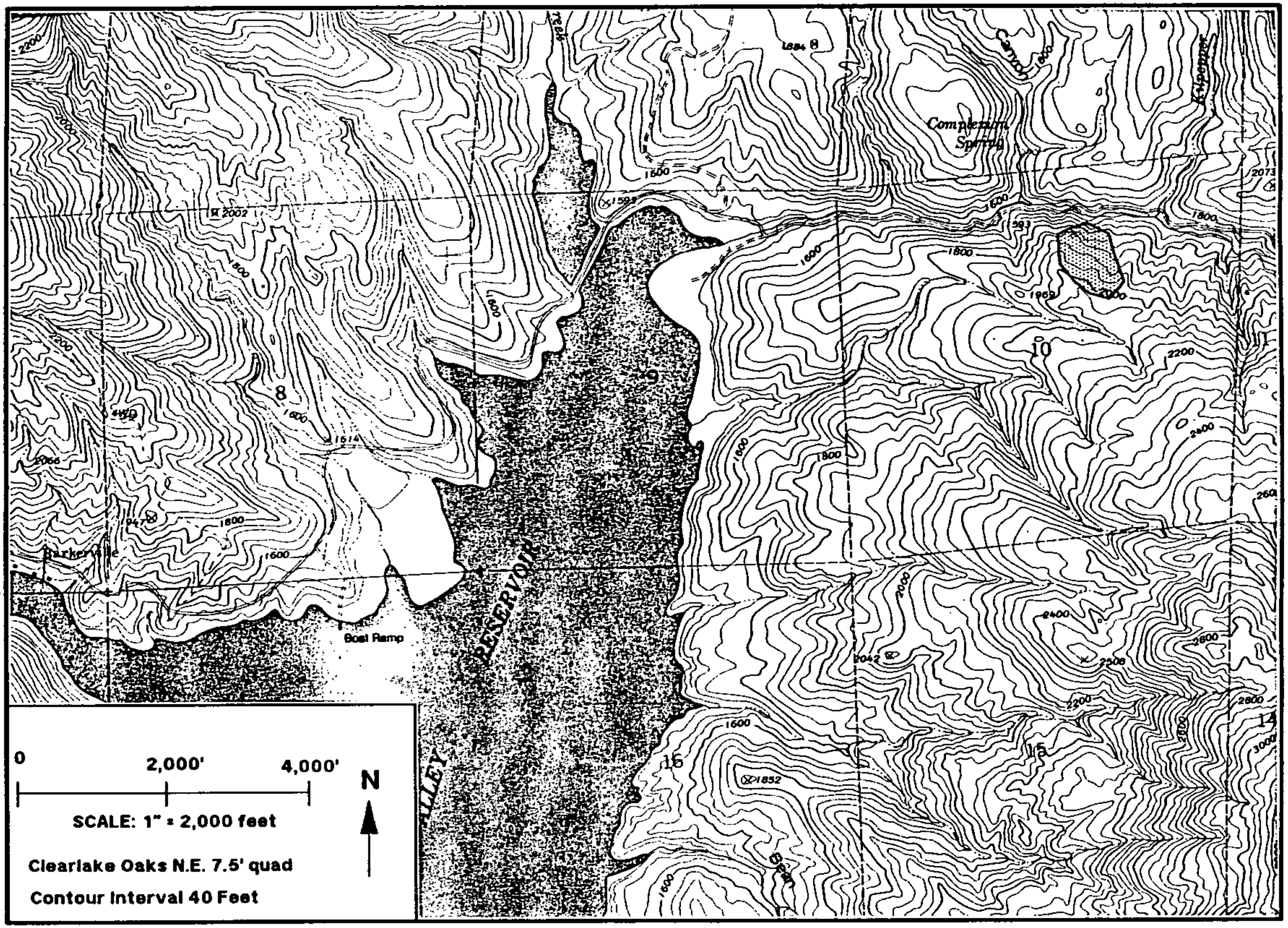


FIGURE A8

Population Locations of Eriogonum nervulosum



HESPEROLINON ADENOPHYLLUM (Gray) Small

Family: Linaceae
Common Name: glandular western flax

Description

Annual herb 10-35 cm tall, glabrous except for short pubescence at internodes immediately above bracts. Leaves alternate except lower most which are opposite or in a whorl of 4; linear to lanceolate, 0.5-2 cm long, 0.1-0.25 cm wide, arcuate, clasping the stem near their base, margins glandular-toothed with up to 3 rows of minute teeth near leaf base; bracts of inflorescence like reduced leaves; pedicels of flower 0.3-1.5 cm long; petals 5, yellow sometimes tinged red, 0.3-0.4 cm long and ca. 0.2 cm wide, petals deciduous after fertilization; sepals green, 0.2-0.3 cm, long sometimes with microscopic glandular teeth on margin; carpels and styles 3, style length equal to stamens, then growing longer after fertilization, carpels each producing two dark brown seeds; flowering from June to July.

Related Species and Taxonomy

This species is very distinctive due to its prominent glandular teeth on the leaves, and having lanceolate instead of linear or ovate leaves. *Hesperolinon bicarpellatum* occurs in the general vicinity and also has yellow flowers but differs in having only 2 styles and carpels, and lacks the glandular teeth. *Hesperolinon clevelandii* also occurs in the area but has yellow flowers that are only 0.2 cm long, as compared to 0.3 to 0.4 cm long for *H. adenophyllum*, and it lacks glandular leaves. *Hesperolinon tehamense* and *H. breweri* are both yellow-flowered, but neither of occurs within the range of *H. adenophyllum*, nor does either possess leaves with glandular teeth.

Distribution

Hesperolinon adenophyllum is mainly distributed in Lake County (Figure A9). It has also been reported from Humboldt and Mendocino counties (Sharsmith, 1961). Known populations are in Lake County are on Figures A10, A11, A12, and A13. The highest concentration of populations are near Lake Pillsbury (Figure A10) and Potato Hill (Figure A11). Population sizes have been estimated to range from 1,000 to 100,000 individuals, presumably based on potential habitat area (Dibble and Griggs 1979, p. 9). Based on direct populations counts from 1986 to 1988, the largest known populations, near Potato Hill, had approximately 10,000 to 15,000 plants in 1987. All other populations observed had population numbers ranging from 100 to 1,500 individuals. Many of the early reports of this species (see Sharsmith, 1961) have subsequently been found to either be misidentified or not occurring at the locations given on herbarium specimens (Dibble and Griggs, 1979). Therefore, this species is probably rarer in terms of the number of populations than was once thought.

Land Ownership

The majority of populations in northern Lake County occur on Mendocino National Forest lands. There are, however, some private inholdings on the National Forest lands that have Hesperolinon adenophyllum (Dibble and Griggs, 1979). The populations near Mt. Hannah and the west side of Lake Pillbury occur on private land.

Habitat and Ecology

Hesperolinon adenophyllum occur either in openings of serpentine chaparral. Plant associates are Arctostaphylos viscida, Quercus durata, Ceanothus jepsonii var. albiflorus and Adenostoma fasciculatum. Near Rice Creek, individuals occur between patches of serpentine chaparral in an area that is entirely composed of herbaceous plants including Bromus mollis, Calycadenia pauciflora, Lessingia ramulosa and Sitanion jubatum.

Land Use and Threats

In northern Lake County, populations on the Mendocino National Forest are potentially threatened by road grading and expansion (Dibble and Griggs, 1979). These National Forest lands are primarily used for grazing which has been considered a potential threat (Dibble and Griggs, 1979. In southern Lake County the populations on private land are threatened by housing developments. Habitat loss should be considered a major threat to this species.

FIGURE A9
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

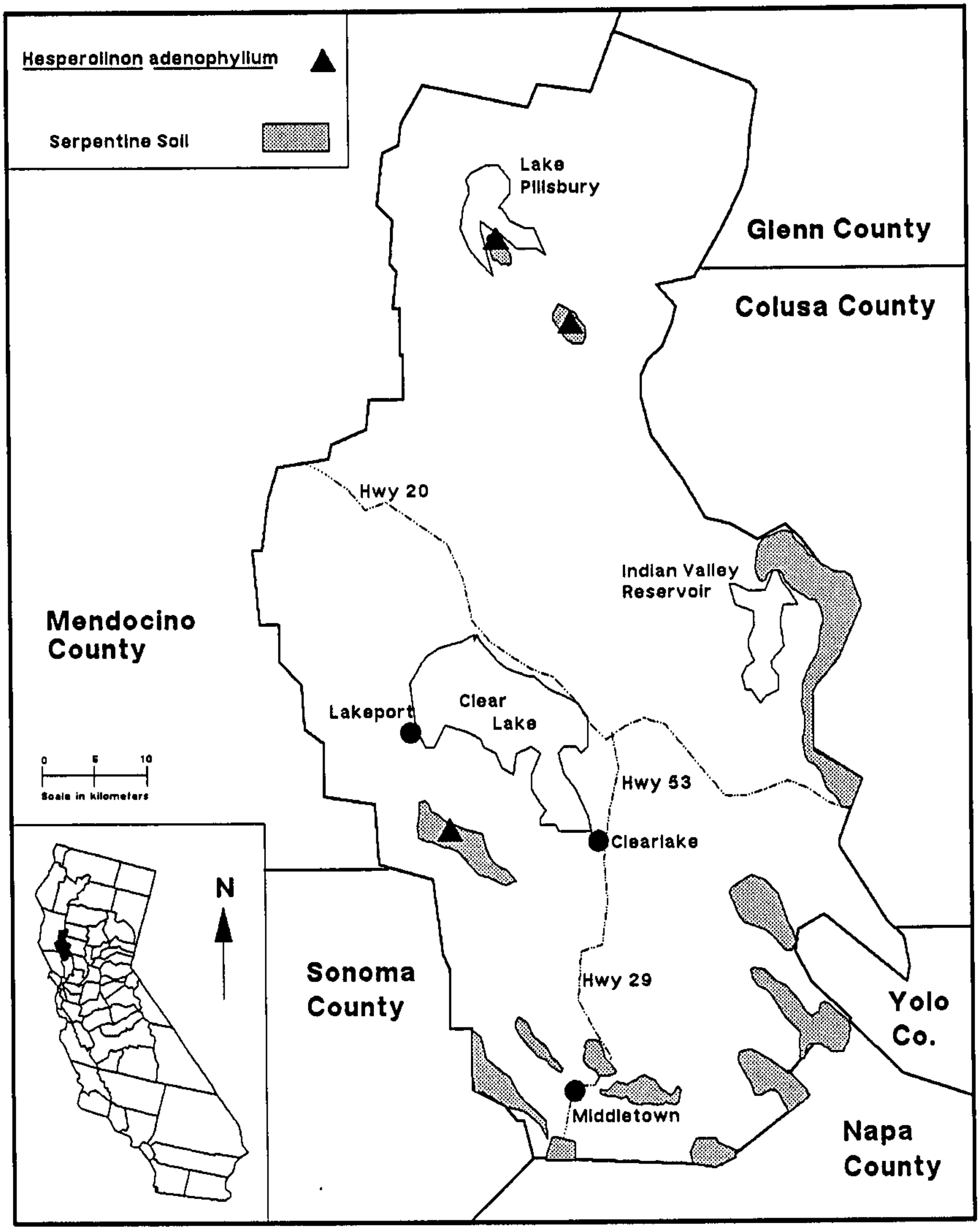


FIGURE A 10

Population Locations of Hesperolinon adenophyllum

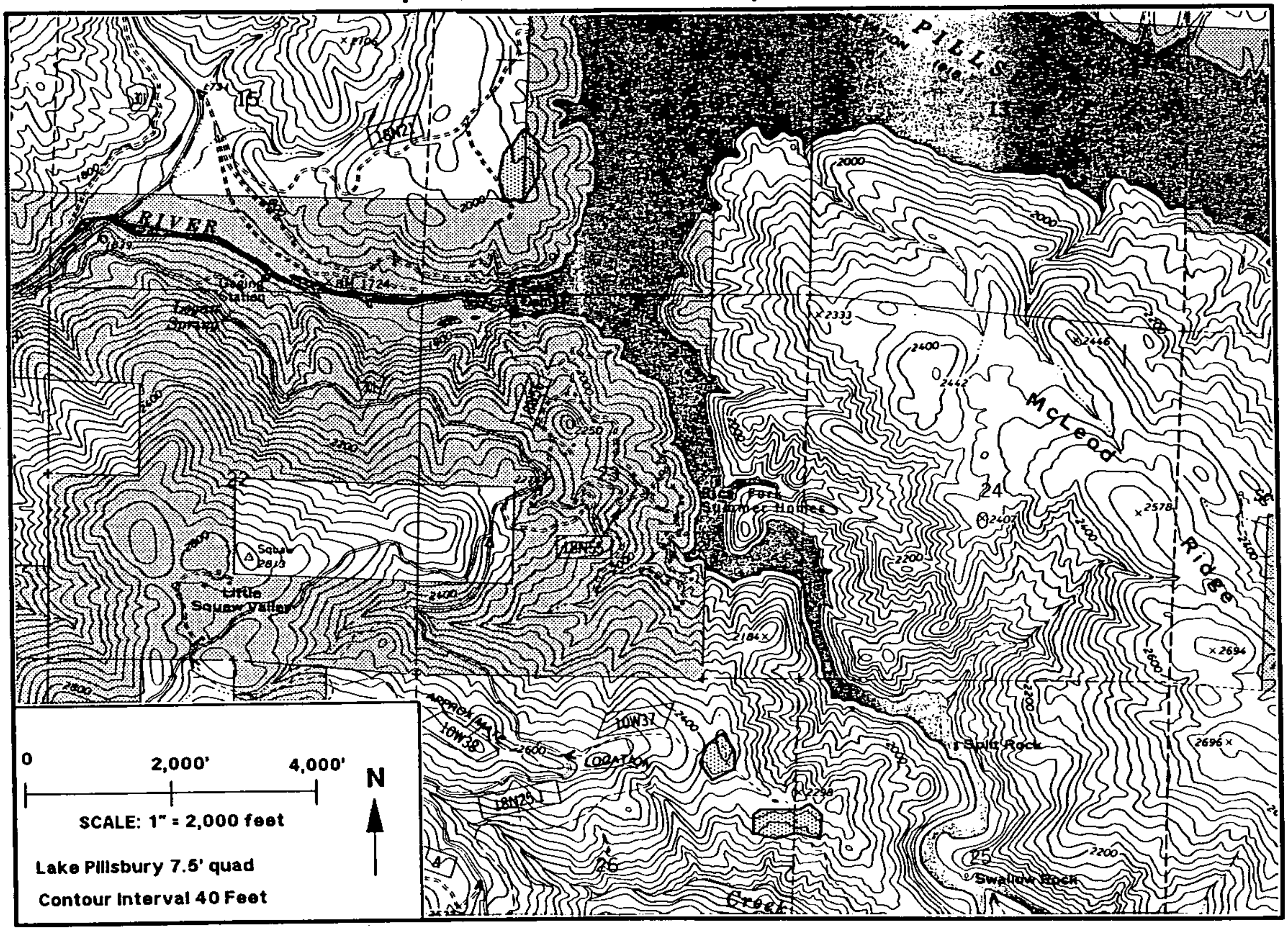


FIGURE A 11

Population Locations of Hesperolinon adenophyllum

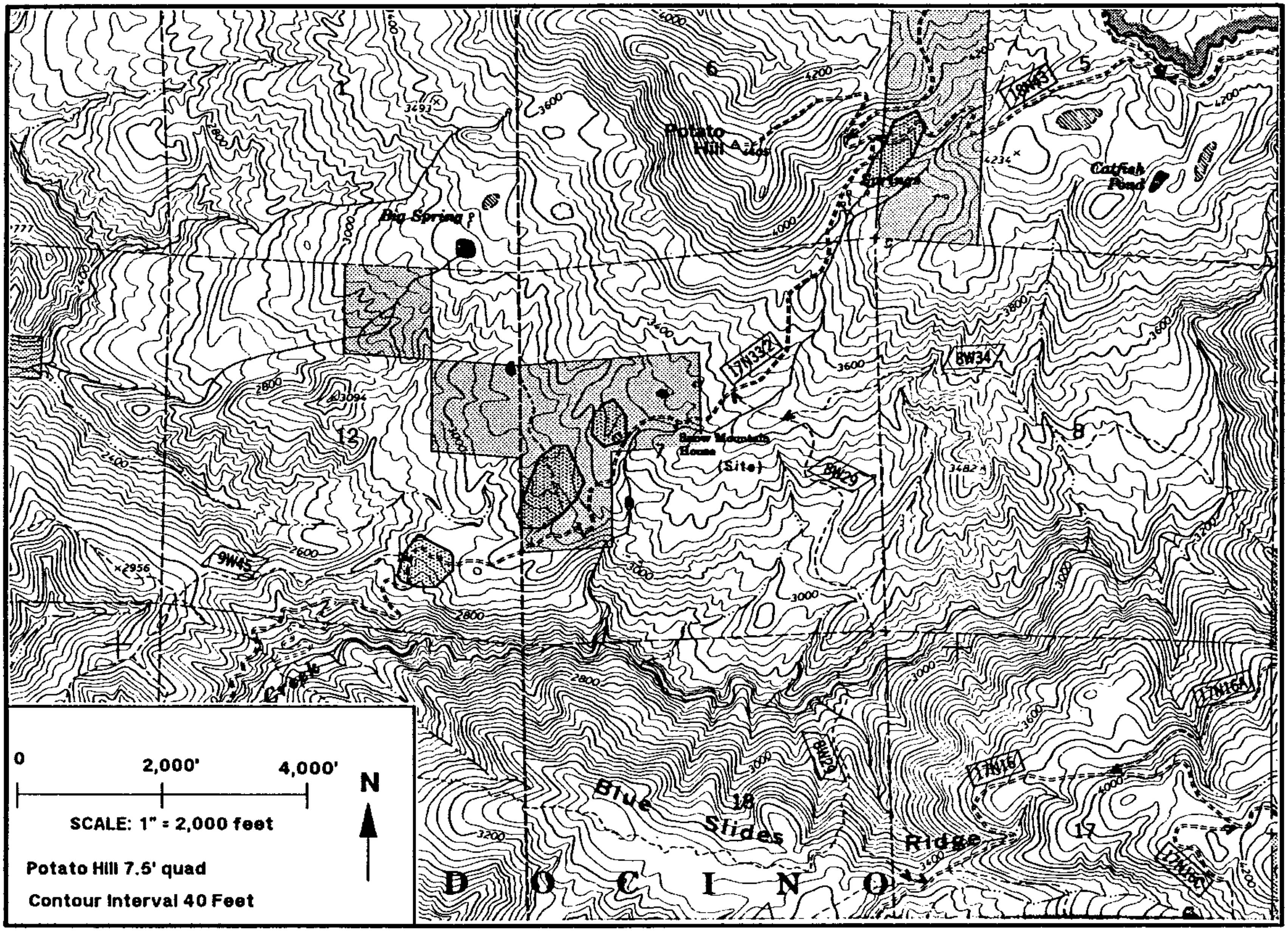


FIGURE A 12

Population Locations of Hesperolinon adenophyllum

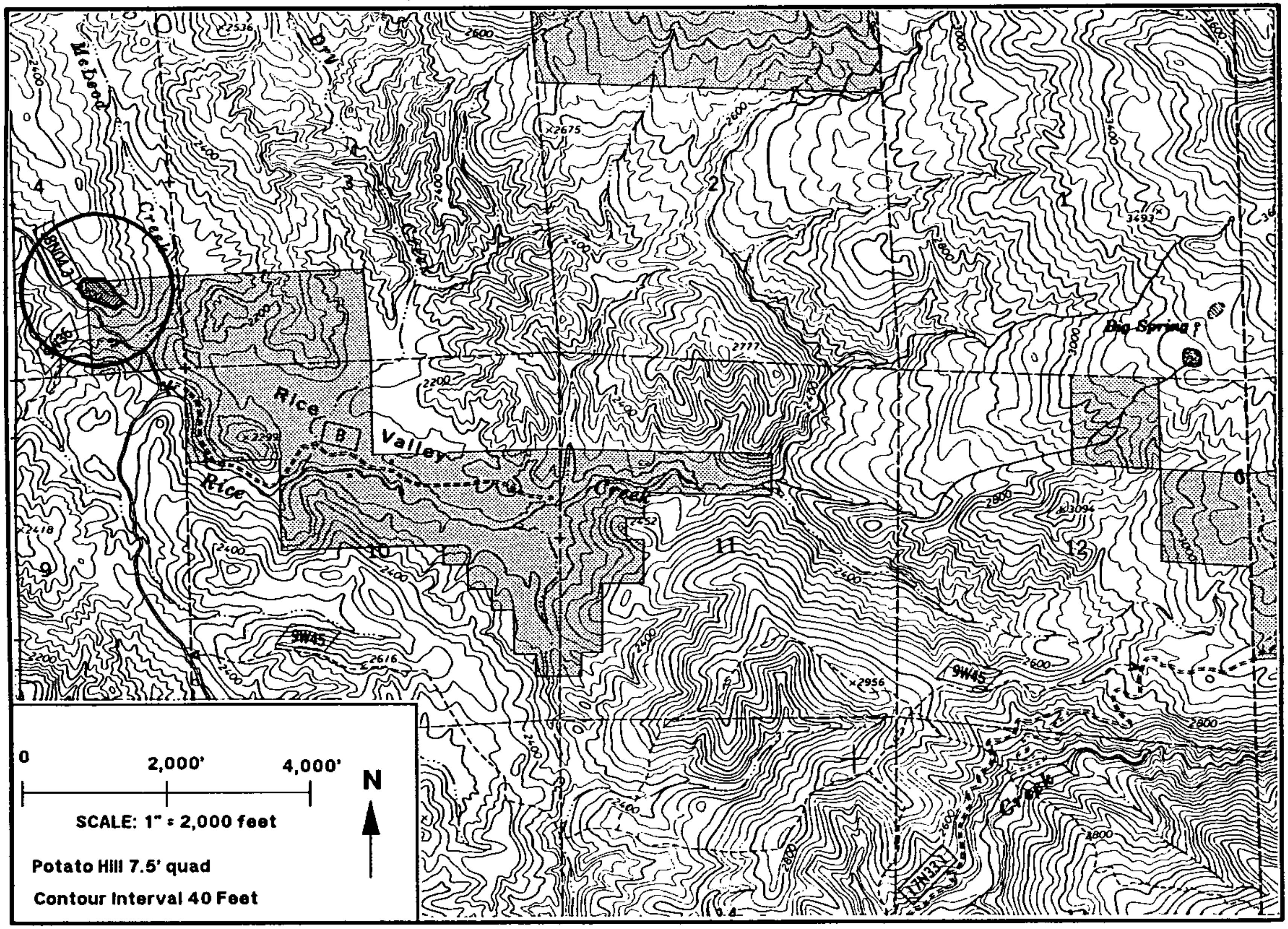
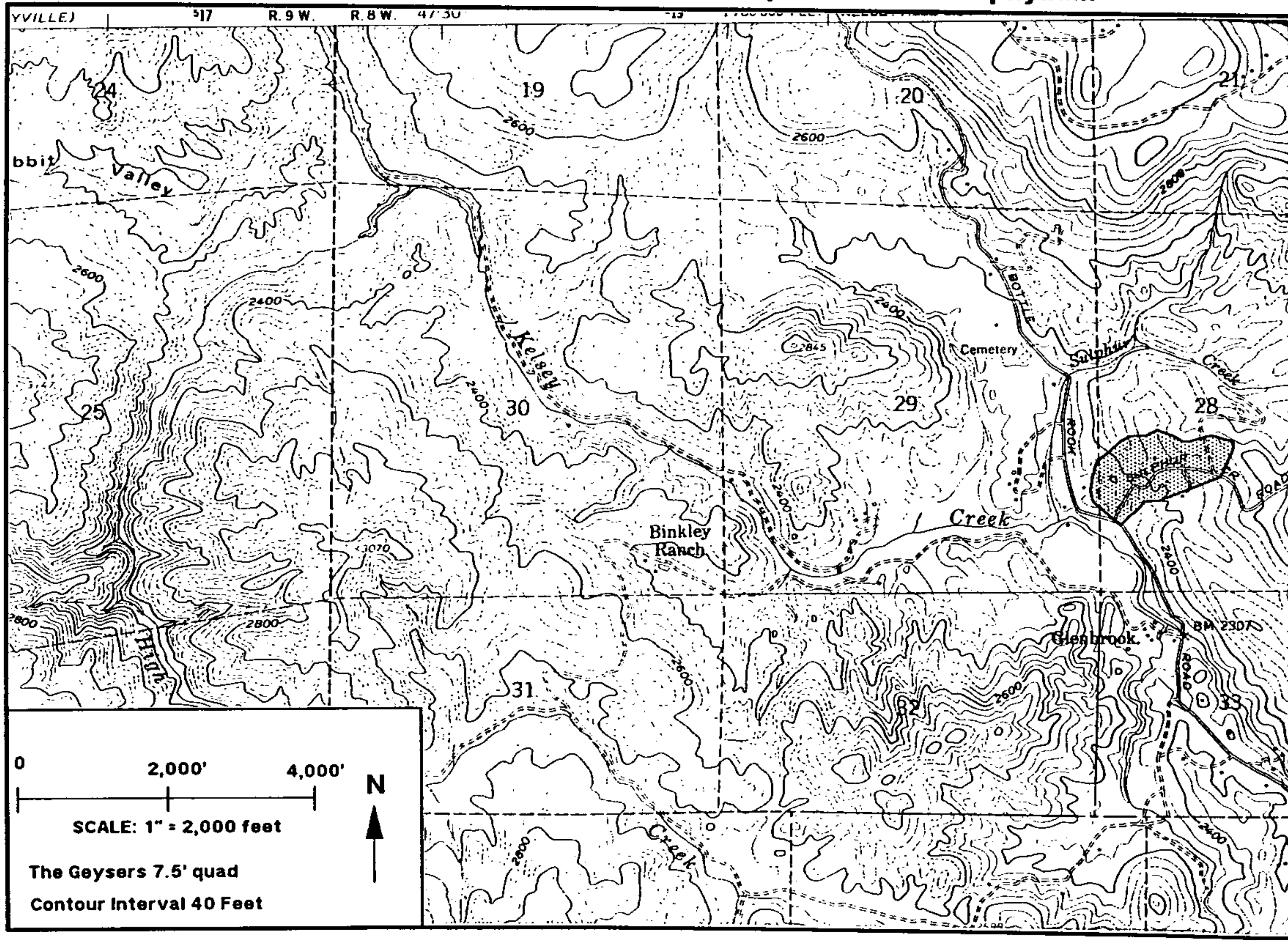


FIGURE A13

Population Locations of Hesperolinon adenophyllum



HESPEROLINON DIDYMOCARPUM SHARSMITH

Family: Linaceae
Common Name: Lake County western flax

Description

Annual herb 10-30 cm tall, glabrous except for short hairs on internodes immediately above bracts. Leaves narrow linear 1.5-2 cm long, 0.1-0.2 cm wide; lower-most leaves in a whorl of four and early deciduous, upper leaves alternate; bracts of inflorescence like reduced leaves, often appearing opposite at branch nodes; pedicels of flower 0.5-0.8 cm long; petals white sometimes tinged pink, 0.2-0.3 cm long and ca. 0.2 cm wide, petals deciduous after fertilization; sepals green, 0.2-0.3 cm long, sometimes with microscopic glandular teeth on margin; carpels and styles 2, style length equal to stamens, then growing longer after fertilization, carpels each producing two dark brown seed; flowering from May to June.

Related Species and Taxonomy

Hesperolinon didymocarpum is the only white flowered species that has 2 styles and 2 carpels. *Hesperolinon bicarpellatum* also has 2 styles and 2 carpels and is considered to be a close relative to *H. didymocarpum* (Sharsmith, 1961; McCarten, 1988). However, *Hesperolinon bicarpellatum* has yellow flowers instead of white. All other known species of *Hesperolinon* have 3 styles and 3 carpels. It should be noted that occassionally a species that typically has 3 styles and 3 carpels will have an couple of flowers with only 2 styles and 2 carpels. Therefore, determination should not be based on observing just one flower.

Distribution

Hesperolinon didymocarpum is restricted to a six square kilometer area north of Middletown in the Big Canyon Creek drainage, Lake County, California (Figure A14). Six element occurrences (Figure A15) of *Hesperolinon didymocarpum* are currently on file at the Natural Diversity Data Base. Element occurrence 1 is the type locality for this species and includes 11 distinct populations (McCarten, 1985); it is bisected by Big Canyon road. The largest individual population in EO 1 occurs on the northwest side of Cockerell Canyon where approximately 5,500 individuals were observed within an area of 30 meters square in 1985 (McCarten, 1985). In 1987 this same population was limited to an area of 10 meters square with only 500 individuals. The variation in population size is probably due to differences in seasonal rainfall. Element occurrence 2 contains eight distinct populations. One of those populations is in close proximity to another rare species Hesperolinon bicarpellatum. Sharsmith (1961, p. 250) describes finding an individual plant that appeared to be a hybrid between H. didymocarpum and H. bicarpellatum. Hybrids between those two species may occur regularly in EO 2, however, recognizing hybrids from plants naturally having slightly washed out flower color could be difficult. The four remaining element occurrences are represented by one or a few small populations. Each of these populations had less than 500 individuals in 1987.

Land Ownership

All populations of Hesperolinon didymocarpum occur on two privately owned ranches north of Middletown. The landowners are aware of the presence of the plants on their property. The Nature Conservancy contacted the owners in 1985, but no formal arrangements for protecting the plants were established. A five year geothermal mining lease on the property that includes EO 1 went into effect as of 1985. Therefore, arrangements with the landowner to protect these populations could not be established as a result of that lease.

Habitat and Ecology

Populations of Hesperolinon didymocarpum occur in open areas with full sunlight, in Serpentine Chaparral dominated by low density Quercus durata with scattered Pinus sabiniana, and in herbaceous serpentine vegetation dominated by H. didymocarpum, Calycadenia pauciflora, Plantago erecta (= P. hookeriana), Bromus rubens and Zygadenus fremontii.

The serpentine soil habitats for this species have only recently been exposed (McCarten, 1988). The soil profile is poorly developed and large pieces of greenish-blue serpentinite parent rock are exposed throughout most of the habitat. The soils are well-drained, very shallow (10-20 cm deep), and are classified in the Montara Soil Series (Lake County Soil Conservation Service unpubl.). Soil texture data characterize the soil as sandy loam to clay loam with a clay percent from 18 to 30. Soil pH is 6.4 to 6.7. Soil available calcium cation concentrations range from 1.62 to 3.18 milliequivalents (meq), and available magnesium cation concentrations range from 9.06 to 25.02 (meq). Mean calcium to magnesium ratio is 0.11.

Land Use and Threats

Currently all populations occur on ranches using the land for cattle grazing. Populations in element occurrence 2 have shown some decline and the habitat appears to be more disturbed than that of other populations as a result of more intense cattle grazing since 1985. Other populations are in areas with relatively light cattle grazing and population size variation appears to be more related to rainfall than grazing. The impacts from cattle grazing are primarily in the form of soil disturbance which increases the number and density of non-native weedy annual plants (e.g. Lolium multiflorum) and disturbance adapted native species. Relatively low levels of cattle grazing, especially in the early spring is not likely to have a negative impact on H. didymocarpum populations, but increases in grazing pressure will.

Geothermal exploration has occurred in the general region, but there are no current plans for geothermal development in the immediate vicinity of the known populations. The increase in energy demands may press for geothermal development nearby. Placement of utility towers in the vicinity of populations in Cockerell Canyon (EO 1) has been proposed (WESCO, 1986) and the future placement of transmission lines may threaten some populations.

FIGURE A 14
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

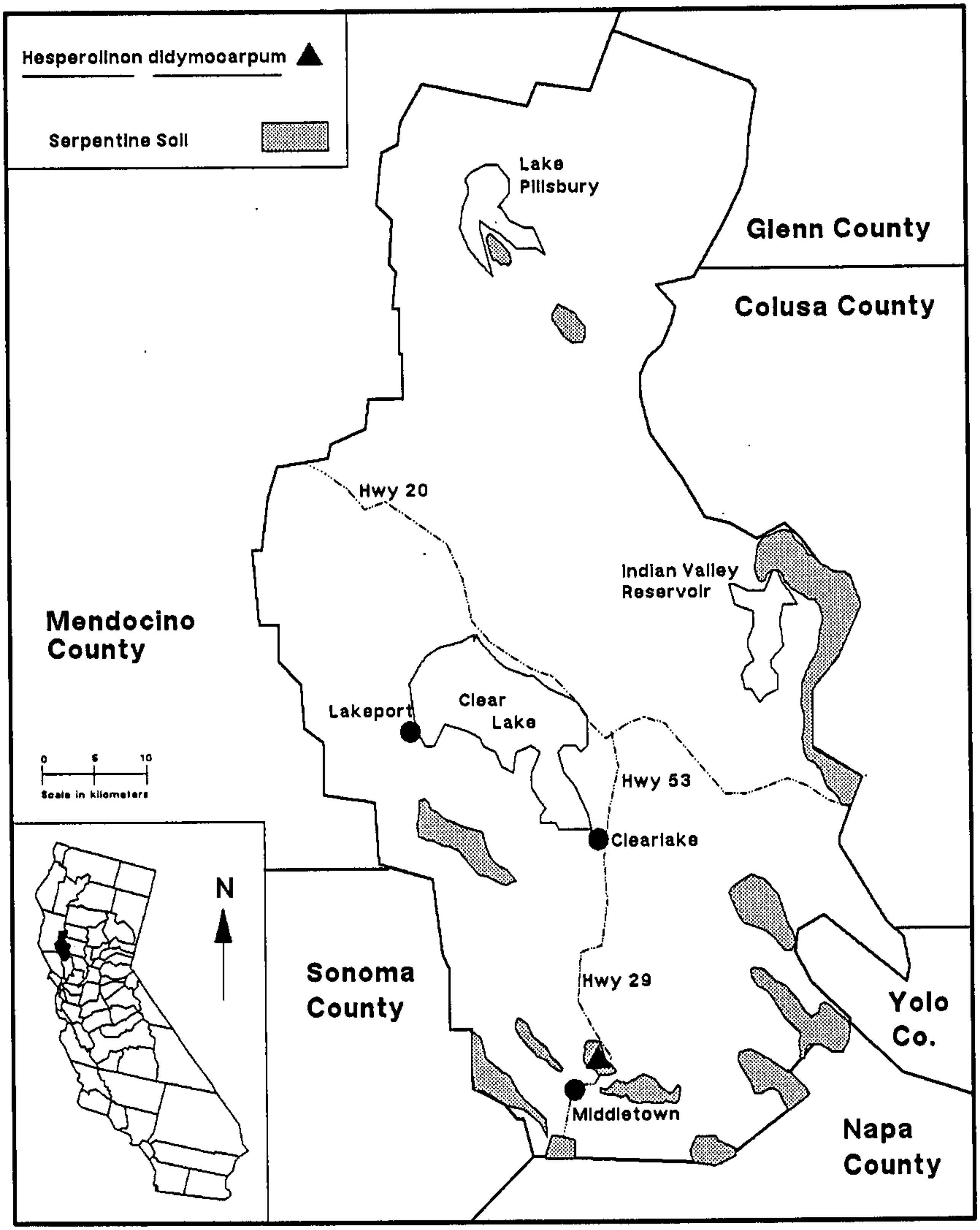
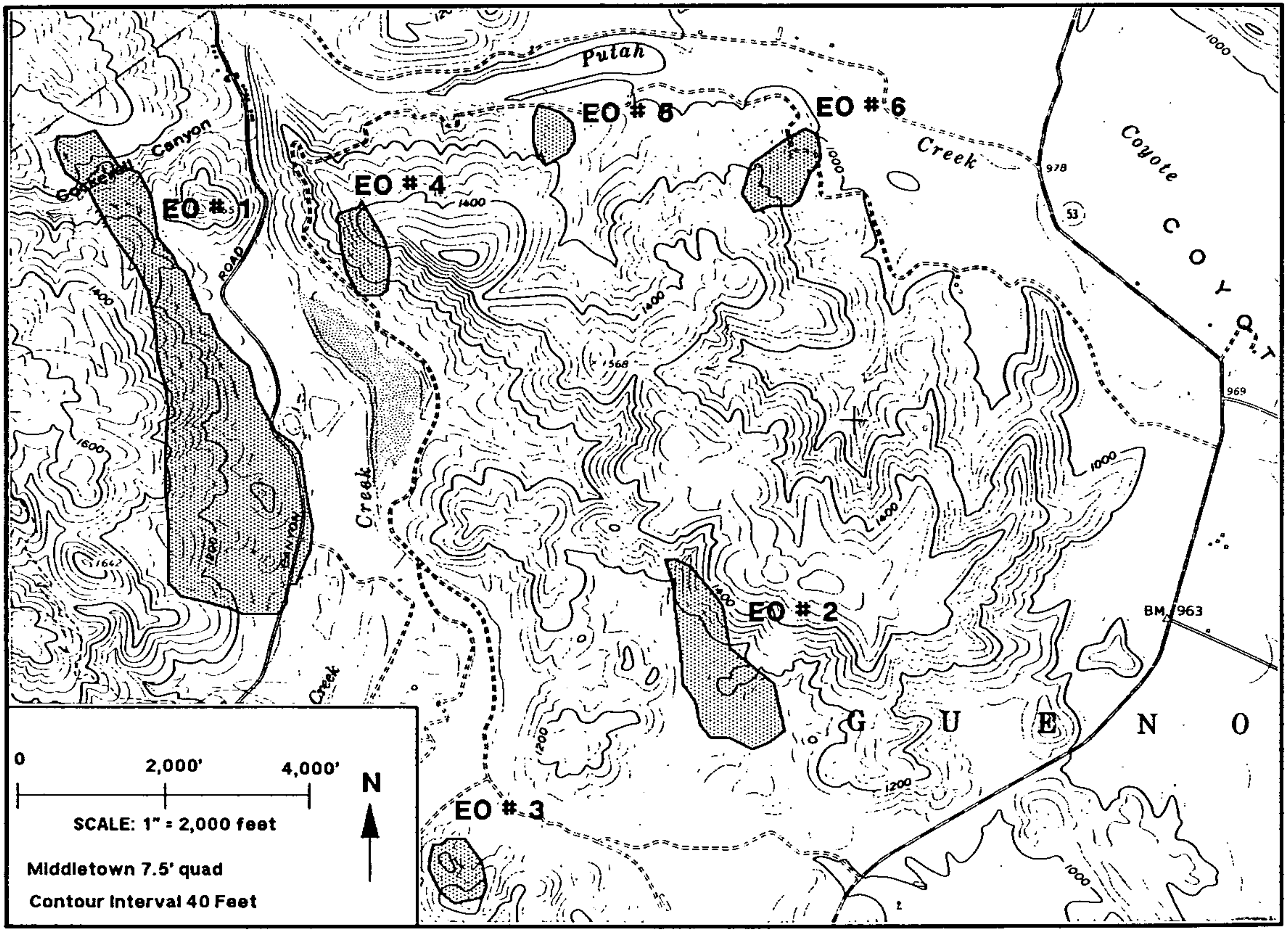


FIGURE A 15

Population Locations of Hesperolinon didymocarpum



HESPEROLINON DRYMARIOIDES (Curran) Small

Family: Linaceae
Common Name: Drymaria-like western flax

Description

Annual herb 10-20 cm tall, short pubescence throughout especially on lower part of plant; branches dichotomous; lower leaves in a whorl of 3-4, upper branch leaves opposite, ovate, 0.4-0.8 cm long, 0.3-0.6 cm wide, clasping stem near their base, margins glandular toothed with up to 2 rows of minute teeth; bracts of inflorescence like reduced leaves, alternate; pedicels of flower 0.1-0.2 cm long; petals 5, white to pink, 0.3-0.5 cm long, petals deciduous after fertilization; sepals glandular-margined, green 0.2-0.4 cm; carpels and styles 3, style length equal to stamens, carpels each producing two dark brown seed; flowering from June to July.

Related Species and Taxonomy

This species is very distinctive due to its ovate, whorled glandular-margined leaves. In addition, H. drymarioides does not drop its lower leaves while flowering like all the other species. Further, H. drymarioides has a branching pattern that appears dichotomous, while all other species having predominately alternating branches.

Distribution

There are eleven element occurrences of Hesperolinon drymarioides on file at the Natural Diversity Data Base. The species is known to occur in Colusa, Glenn, Lake and Napa counties. Four of the element occurrences (EOs 1, 2, 3, and 11) occur in Lake County (Figure A16). Element occurrence 1, at Complexion Springs (Figure A17), was estimated to have 1,000 individuals in 1987 (McCarten, 1988b). Two populations near Complexion Springs (Figure A17), had between 150 and 400 plants in 1987. Element occurrence 2, south of Rice Creek (Figure A18) had only seven plants in 1987 (McCarten, 1988b). In 1979, EO 2 was observed to have less than 100 plants (Griggs and Dibble, 1979). Element occurrence 3, north of Rice Creek (Figure A18) was estimated to have 400 plants in 1987, and 1,000 plants in 1988 (McCarten, 1988b). In 1979, EO 2 was estimated to range between 10,000 and 100,000 plants (Griggs and Dibble, 1979). Element occurrence 11 was estimated to have between 250 to 500 plants in 1987 during this study. The populations in northern Lake County, near Rice Creek, represent the western limit of the species distribution. The largest populations occur in Glenn County (McCarten, 1988b). The southern distribution of the this species is in Napa County, near the eastern Lake County border (D'Appalonia, 1982).

Land Ownership

Element occurrence 1 is partly on Bureau of Land Management property and partly on private land. Element occurrence 2 is on Mendocino National Forest property. Most of element occurrence 3 is also on the Mendocino National Forest, with a small section on private land. The Mendocino National Forests lists *Hesperolinon drymarioides* as a sensitive species. Element occurrence 11 is on Bureau of Land Management property. One element occurrence (EO 4), with approximately 150 plants, is protected in Colusa County in the Frenzel Creek Research Natural Area within the Mendocino National Forest.

Habitat and Ecology

Hesperolinon drymarioides occurs in openings of serpentine digger pine-chaparral, northern interior cypress forest and mixed serpentine chaparral. Plant associates are *Arctostaphylos viscida*, *Quercus durata*, *Ceanothus jepsonii* var. *albiflorus*, *Cupressus sargentii* and *Pinus sabiniana*. Plants are generally clustered in groups of 1-10 in openings between trees and shrubs in dark red serpentine soil of the Henneke soil series (McCarten, 1988b). Plant densities have been positively correlated with low soil concentrations of calcium cations (McCarten, Fig. 7, 1988b). They occur on ridge tops or flat steps on slopes. Populations having high densities (5-20 plants per meter squared), are mostly in areas that have been naturally disturbed such as by tree falls or fires. Therefore, some disturbance such as naturally occurring fires in the chaparral may benefit *Hesperolinon drymarioides* populations by creating more openings in the vegetation.

Land Use and Threats

Populations on the Mendocino National Forest have been considered to be potentially threatened by road grading and expansion (Griggs and Dibble, 1979). In addition, Griggs and Dibble (1979) stated that increases in cattle grazing from neighboring ranches in the vicinity of Rice Creek could reduce the populations in that area. In Napa County, minning is a major threat to those populations.

FIGURE A 16
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

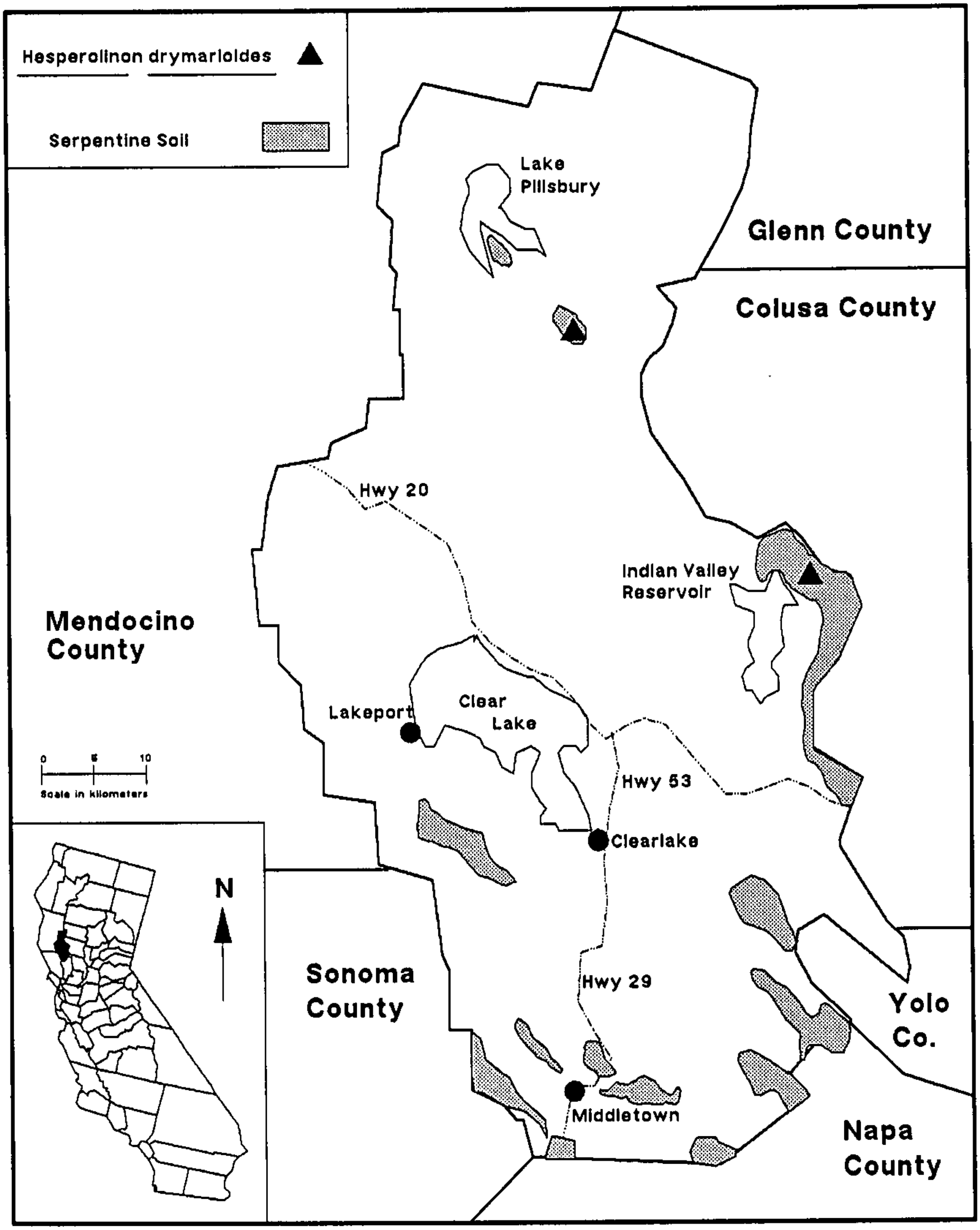


FIGURE A 17

Population Locations of Hesperolinon drymarioides

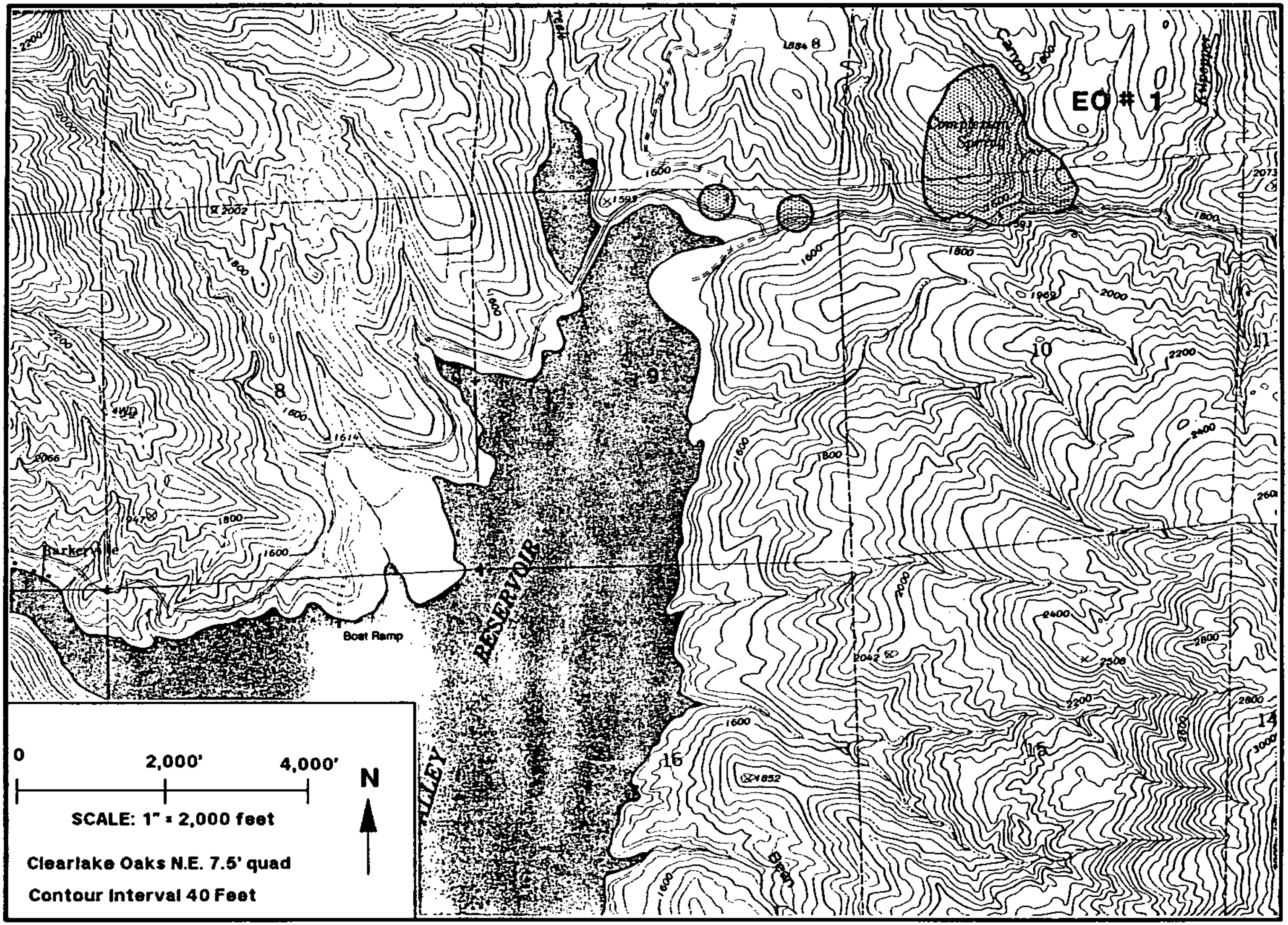
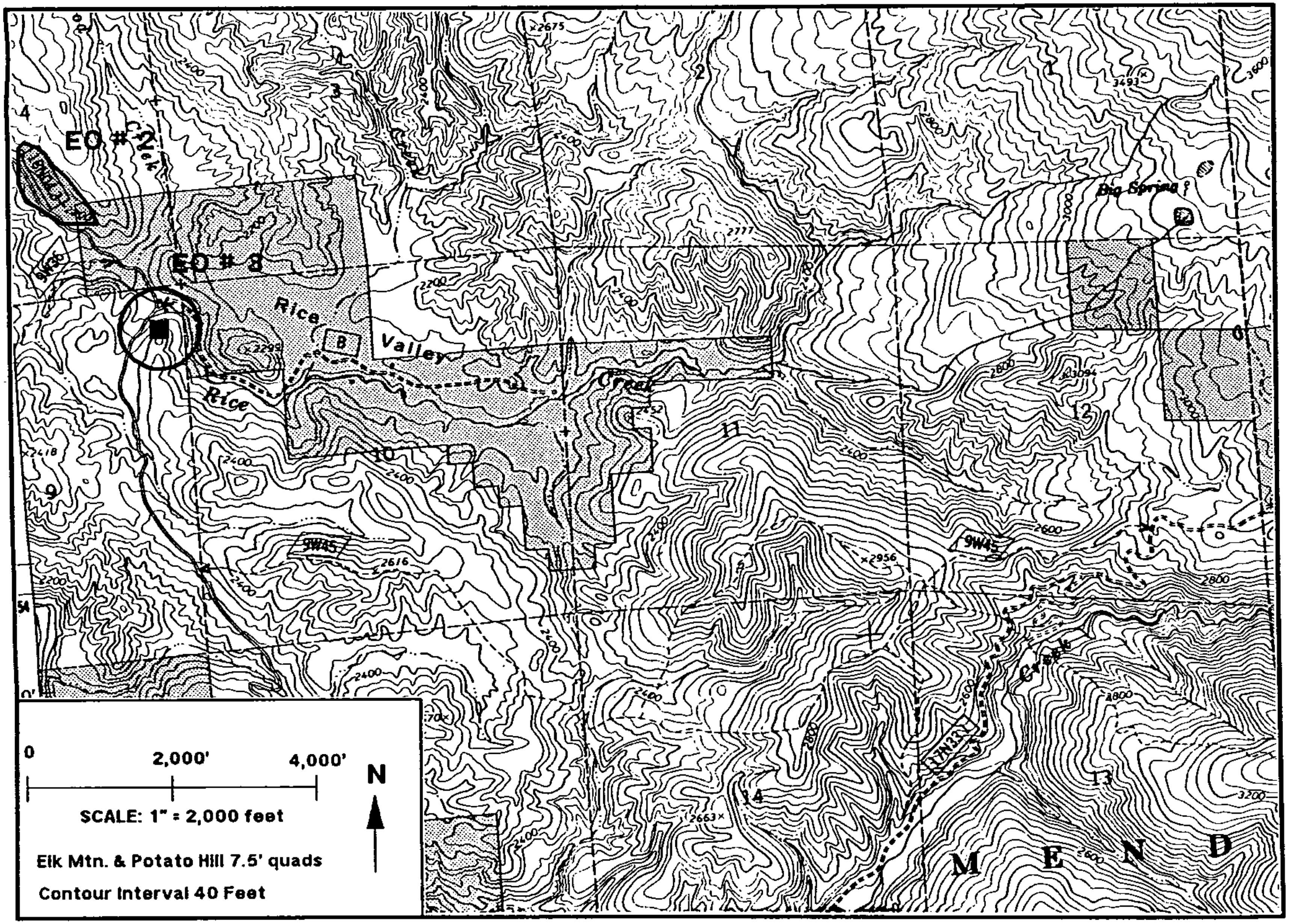


FIGURE A18

Population Locations of Hesperolinon drymarioides



MADIA HALLII Keck

Family: Asteraceae (Compositae)
Common Name: Hall's madia

Description

Short leafy annual, 5-18 cm tall, pubescent; branches leafless, spreading glandular pubescent; leaves in a dense rosette, linear, pubescent, 0.5-3 cm long, ca. 0.1 cm wide; flowering heads solitary on black glandular pedicels, 1-5 cm long; ray flowers 3-6; disk flowers 8-20; flowering in May.

Related Species and Taxonomy

This species is poorly known taxonomically and has only recently been recognized as an extremely rare plant. It shares some morphological characteristics with *Madia nutans*, another rare plant, from which it differs primarily by having a pappus on both the disk and ray achenes, and much shorter disk achenes (Munz and Keck, 1968).

Distribution

This species is only known from Lake, Colusa, Napa and Trinity counties. *Madia hallii* is not currently tracked by the Natural Diversity Data Base but is on the list to be included. One population, 3 miles north of Middletown (Figures A19 and A20) was estimated to have approximately 50 to 100 plants based on findings in 1987 during this study. One herbarium collection at the University of California, Berkeley herbarium report *Madia hallii* from an unspecified location in Butts Canyon, southern Lake County. Yet another at the Berkeley herbarium reports this species near Bucksnort Creek, which runs north and south perpendicular to Butts Canyon. Plants of *Madia hallii*, were not, however, located during this study in the vicinity of Butts Canyon. A population has been reported on the Colusa-Lake County line along Walker Ridge (NDDB). That population has been reported to have 1,000 plants (NDDB). Most other populations outside of Lake County have been generally reported to be very small numbering less than 50 individuals (Bruce Baldwin, U.C. Davis, pers. comm.). More surveys are needed to determine the distribution and rarity of this species. Currently it should be considered as extremely rare.

Land Ownership

The population in north of Middletown in Lake County occurs on two private ranches. Populations that may occur in Butts Canyon are probably on private land. The Walker Ridge population, whether it is in Colusa or Lake County is on Bureau of Land Management land. In Napa County it occurs in a California State Forest and on Bureau of Land Management land. In Colusa County it is on Bureau of Land Management property that has mining leases. Property ownership is unknown for Trinity County. None of the populations are known to be protected in preserves.

Habitat and Ecology

Madia hallii occurs in very open rocky serpentine areas surrounded by mixed serpentine chaparral. Associated species are *Ceanothus jepsonii* var. *albiflorus* and *Quercus durata*. The topography is usually flat or mildly sloping. Soil is very shallow and rocky. Calcium to magnesium ratios are exceedingly low (Ca/Mg = 0.11).

Land Use and Threats

Specific threats are unknown, but cattle grazing on the private ranches represents a potential threat should the grazing pressure increase. Mining, such as has occurred in Napa County would destroy the habitat and lead to extirpation of populations.

FIGURE A 19
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

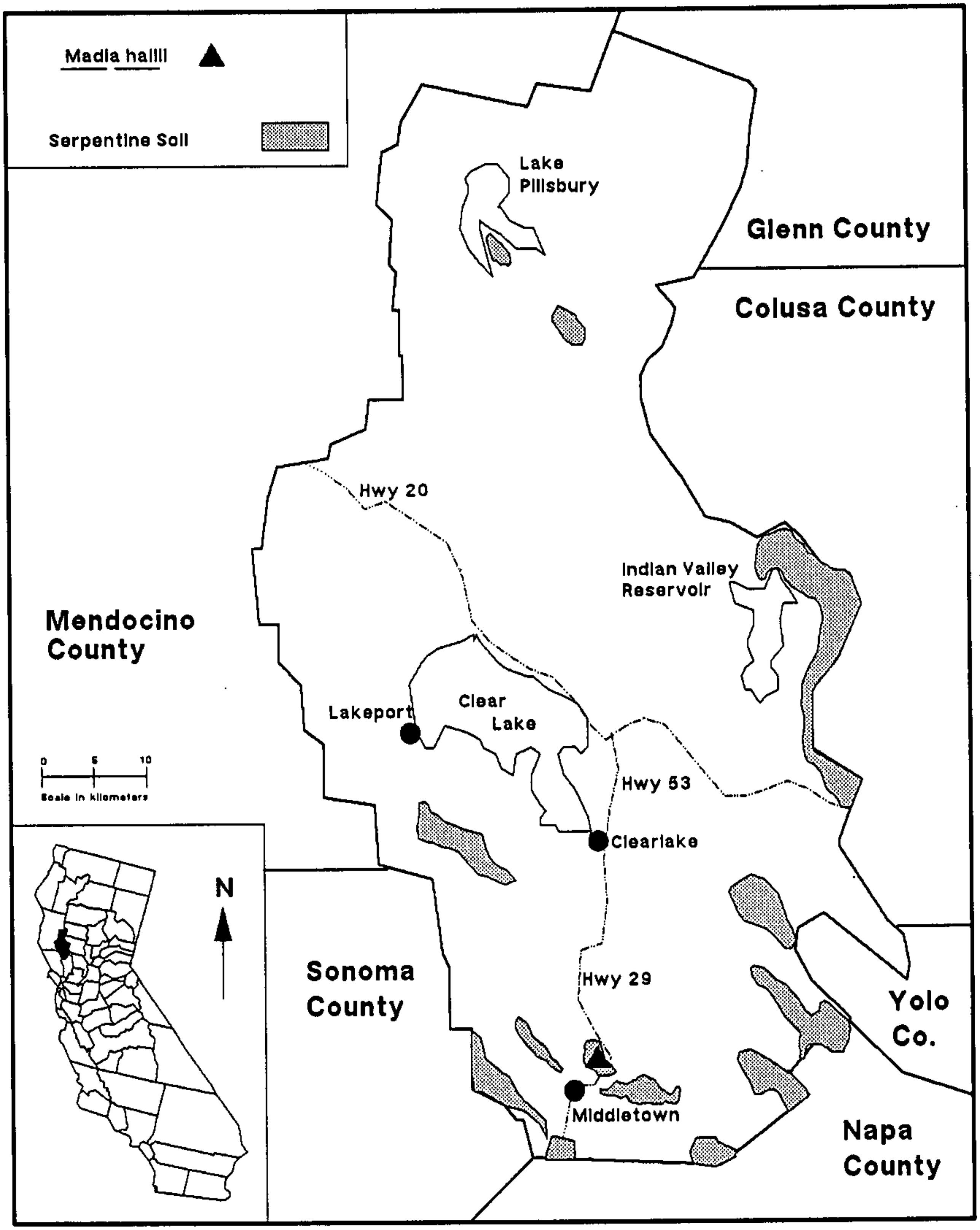
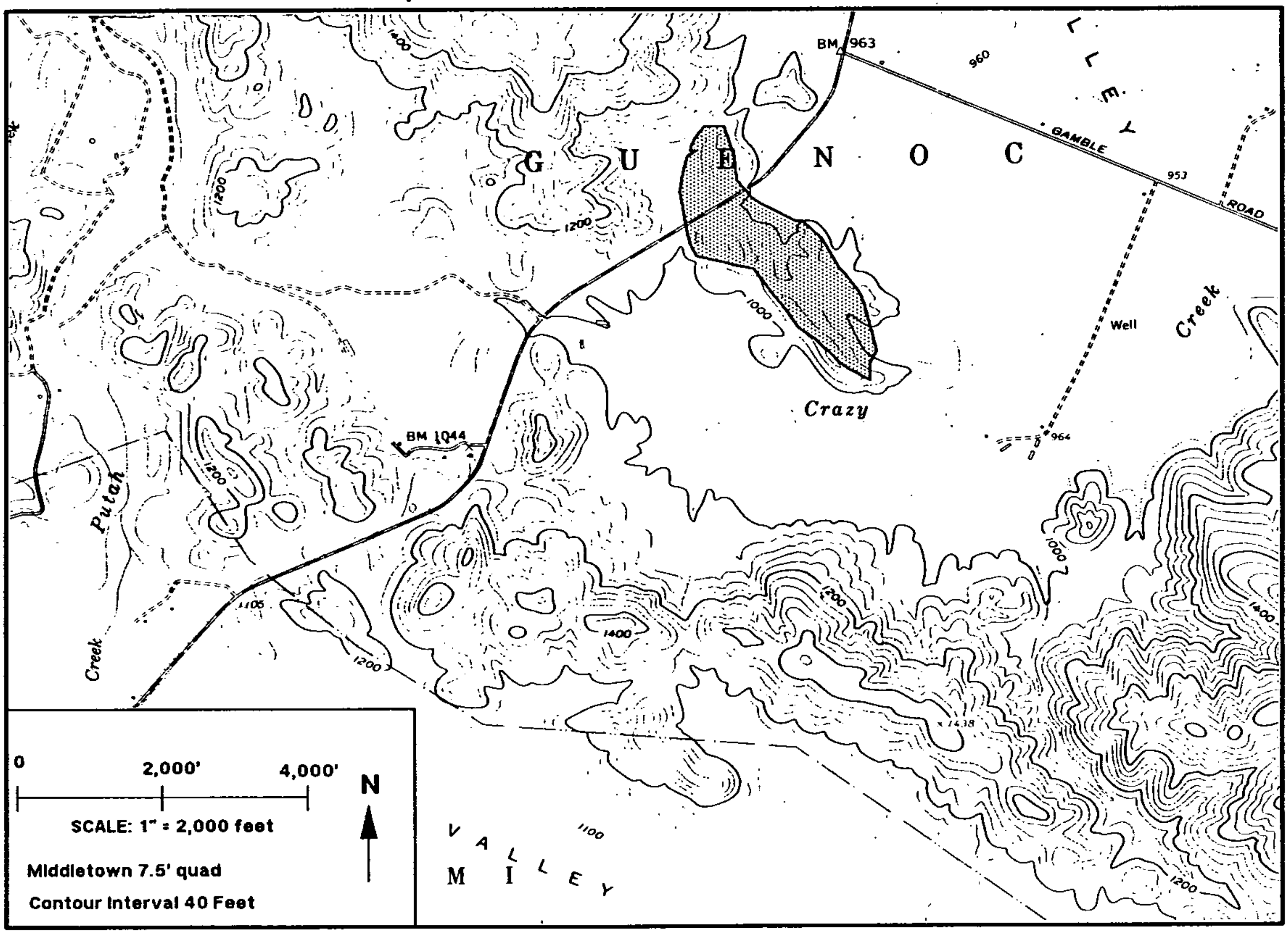


FIGURE A20

Population Locations of Madia hallii



STREPTANTHUS BRACHIATUS F.W. Hoffman

Family Brassicaceae (Cruciferae)
Common Name Socrates Mine Jewel Flower

Description

Glabrous glaucus biennial, 45 cm tall; leaves in a dense rosette, ovate, glaucus, stem leaves auriculate and crisped, up to 5 cm long, ca. 2.5 cm wide, entire to coarsely serrate; flowers 0.8 cm long, petals white, calyx purplish, glabrous; siliques erect, twisted, 6.5 cm long; flowering in May to June.

Related Species and Taxonomy

Streptanthus brachiatus is part of the Streptanthus morrisonii species complex which has been given a variety of taxonomic treatments (Kruckeberg, in the supplement to Munz and Keck, 1971; Kruckeberg, in press; Nielson and McQuad, 1981; LaPre', in prep.). The treatment followed in this report follows LaPre' (in prep.) based on his unpublished study under contract with the Bureau of Land Management, Uhiah district. LaPre's treatment will ultimately add some new subspecific taxa which are not included in this report since they are not published. This report follows the LaPre' study (in prep.) at the specific taxonomic level in distinguishing the two species of concern, Steptanthus brachiatus and Streptanthus morrisonii. The main difference between these two taxa is a difference in flower color, which is white in S. brachiatus and salmon to yellow in S. morrisonii.

Distribution

Streptanthus brachiatus occurs in the geothermal development area on Cobb Mountain and the serpentine area along Harbin Ridge (Figures A21, A22, and A23). Populations occur both in Lake and Sonoma counties. Dr. Larry LaPre' (pers. comm. and unpubl.) has indicated that one of the new subspecies of S. brachiatus will be restricted to Lake County. According to LaPre' (unpubl.) some populations of S. brachiatus have been mapped as S. morrisonii in previous studies (see WESCO, 1986). Currently, the Natural Diversity Data Base is awaiting publication of the LaPre' study in order to update their files. Therefore, element occurrence numbers are not included in this study since these may be changed at the NDDB once the LaPre' report is completed (Bittman, pers. comm.). The populations in the Geysers geothermal area (Figure A22) had an estimated total of 1,000 individuals in 1987. The three populations along Harbin Ridge (Figure A23) were estimated to have 100 to 150 plants.

Land Ownership

The populations along Harbin Ridge occur on private property. A majority of the populations in the geothermal energy area south of Cobb Mountain are on Bureau of Land Management land under mining leases and on geothermal development corporation property.

Habitat and Ecology

Streptanthus brachiatus occurs on moderate to steep rocky serpentine barrens. These barrens are generally devoid of vegetation except for *Streptanthus* species and *Eriogonum nervulosum*. The very rocky soils are highly erodible and extremely nutrient poor. It is likely that the steep eroding slopes create a very unstable condition so that few perennial plant species can become established. As mentioned in the discussion on *Eriogonum nervulosum*, the *Streptanthus* species generally occur on steeper parts of the serpentine barrens than the does the *Eriogonum*. Differences between the locations of *Streptanthus brachiatus* and *S. morrisonii* may be more historical than ecological since the serpentine barrens act as islands it is possible that local differentiation led to the formation of these different taxa. The current ecological data cannot adequately determine whether or not their are ecological differences between these two species.

Land Use and Threats

The main threats are from geothermal development or mining. Both these activities would physically disturb the highly erodible serpentine barrens.

FIGURE A21
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

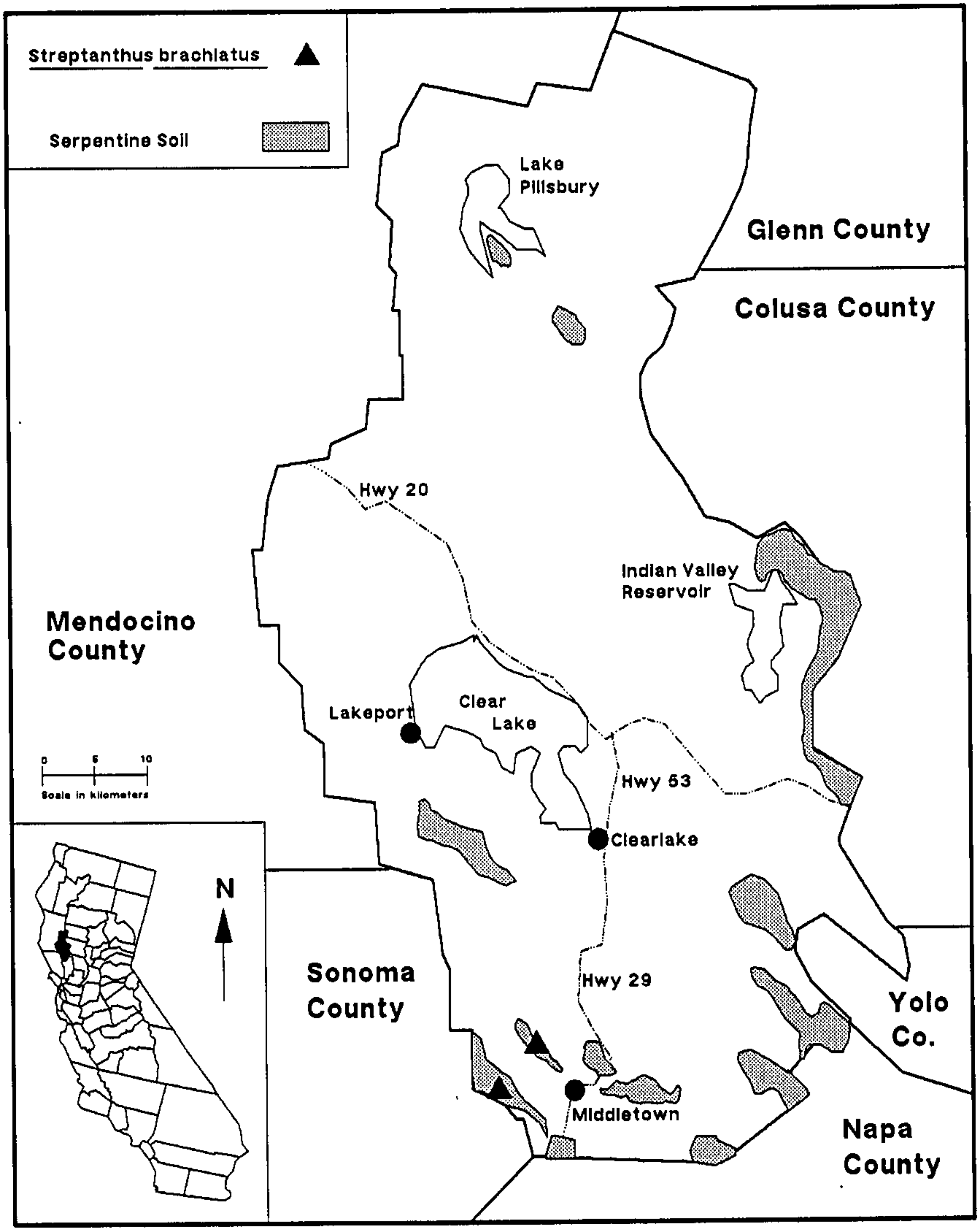


FIGURE A22

Population Locations of Streptanthus brachiatus

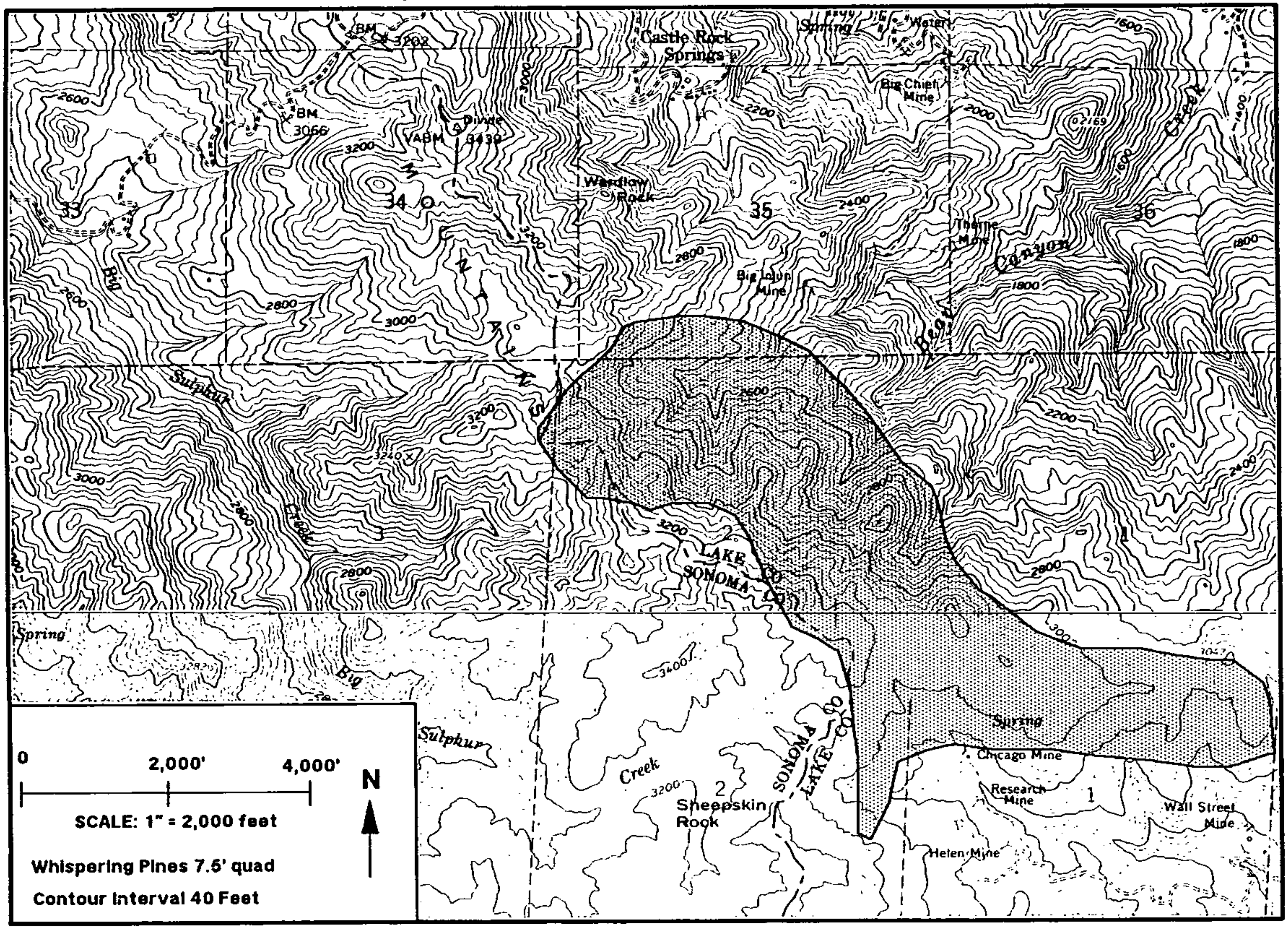
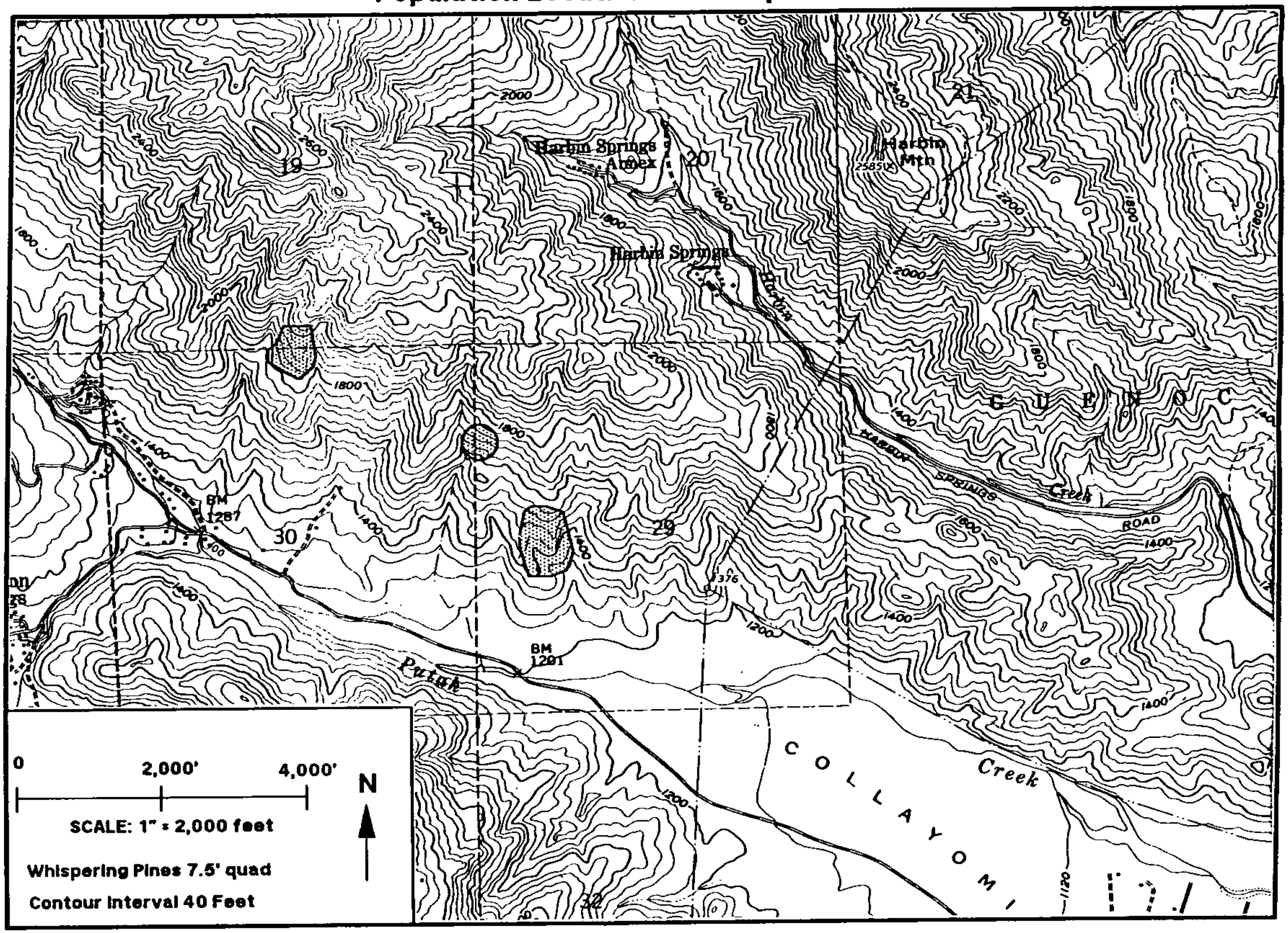


FIGURE A23

Population Locations of Streptanthus brachiatus



STREPTANTHUS MORRISONII F.W. Hoffman

Family Brassicaceae (Cruciferae)
Common Name: Morrison's jewel flower

Description

Glabrous glaucus biennial, 10 cm tall; leaves in a dense rosette, ovate, glaucus, stem leaves auriculate and clasping the stem, up to 5 cm long, ca. 2.5 cm wide, entire to coarsely serrate; flowers 0.8 cm long, petals salmon to yellow with brown veins, petals 1 cm long; calyx greenish-yellow, glabrous or with scattered hairs; siliques erect or divergent, twisted, 2-7 cm long; flowering in May to June.

Related Species and Taxonomy

Streptanthus morrisonii is most closely related to S. brachiatus, with which it has often been confused. A study by LaPre' (in prep.), for the Bureau of Land Management, Ukiah district, proposes to change some of the taxonomy of these two species. Steptanthus morrisonii has salmon to yellow flowers, while S. brachiatus has white flowers.

Distribution

Populations of Streptanthus morrisonii occur in Colusa, Lake, Napa, and Sonoma counties. There are three main areas where this species occurs in Lake County (Figure A24). It occurs in the southern end of the county near Three Peaks, just north of the Napa County line (Figure A25), near Round Mountain (Figure A26) and Dunnigan Hill (Figure A27) just west of the Napa County line, and south of Complexion Springs (Figure A28). The populations at Three Peaks were estimated to be approximately 1,000 plants. The population near Round Mountain was estimated to be approximately 50 plants. In the vicinity of Dunnigan Hill there are approximately 23 small populations each having between 10 and 75 plants. The population south of Complexion Springs had approximately 30 plants.

Land Ownership

Populations in Lake County that are mapped in this report occur primarily on Bureau of Land Management land. Some populations, in the Geysers geothermal development area, occur on private geothermal development corporation property.

Habitat and Ecology

Streptanthus morrisonii occurs on moderate to steep rocky serpentine barrens. These barrens are generally devoid of vegetation except for *Streptanthus* and sometimes *Eriogonum nervulosum*. The very rocky soils are highly erodible and are extremely nutrient poor. It is likely that the steep eroding slopes create a very unstable condition so that few perennial plant species can become established. Both *Streptanthus morrisonii* and *S. brachiatus* occupy similar types of habitats on the serpentine barrens. For the most part, plants occur on steep sections, but can also occur next to large boulders on rocky terraces. The soil and other ecological data cannot at this time adequately differentiate the habitats of the two *Streptanthus* species.

Land Use and Threats

The main threats are from geothermal development and mining. Both these activities would physically disturb the highly erodible serpentine barrens. Any activity tht would cause development or unnecessary trampling by humans would negatively impact the populations directly.

FIGURE A24
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

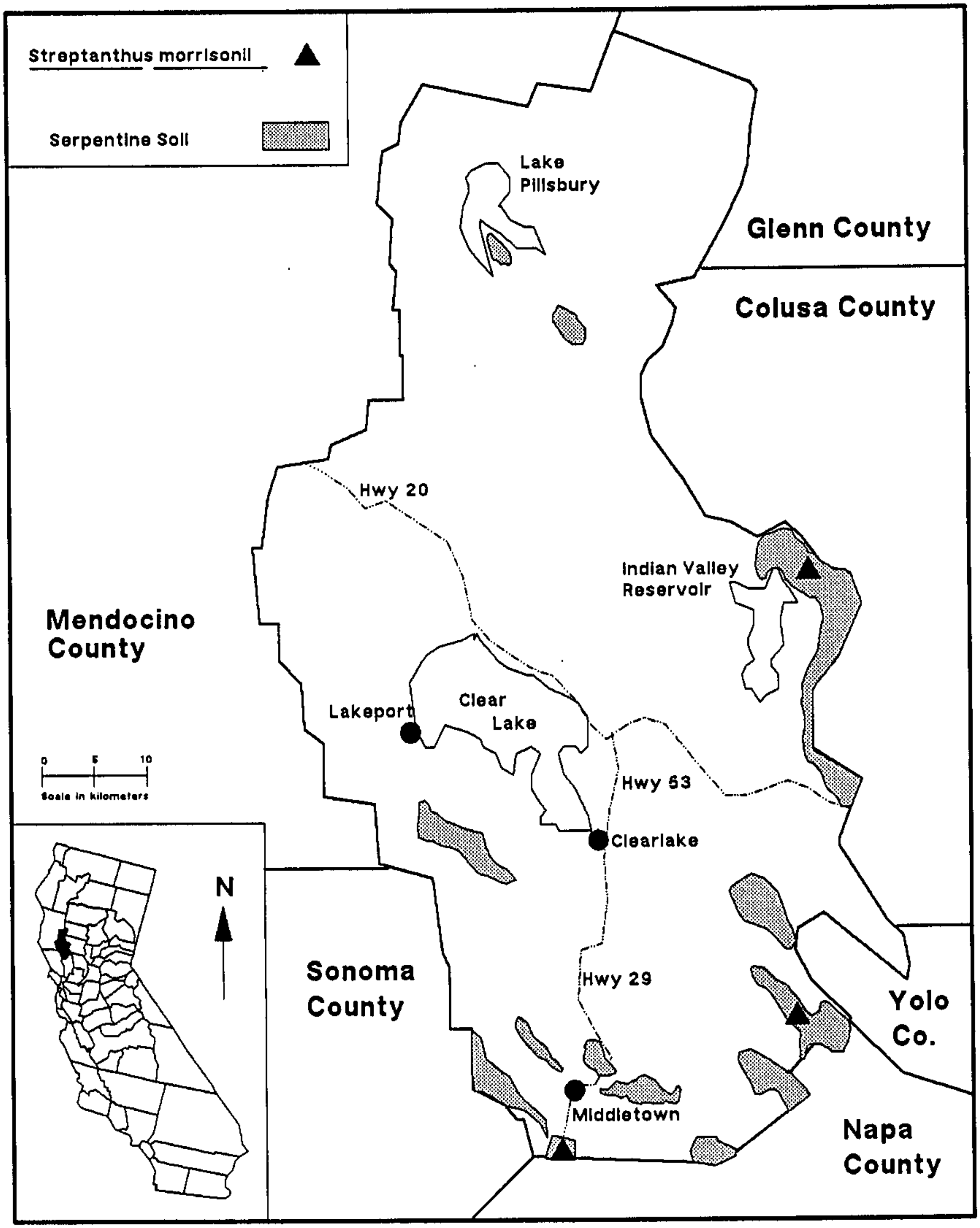


FIGURE A25

Population Locations of Streptanthus morrisonii

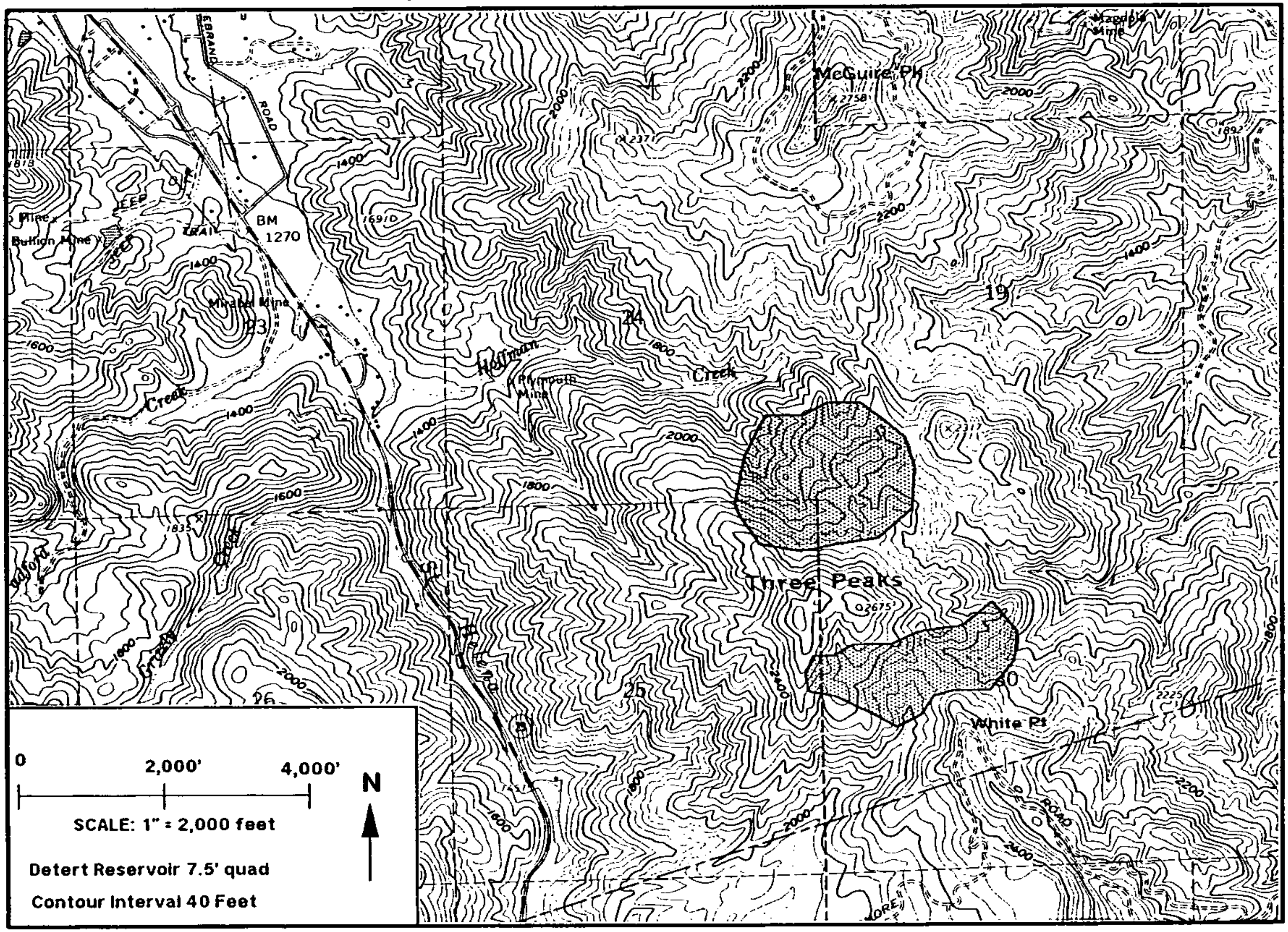


FIGURE A26

Population Locations of Streptanthus morrisonii

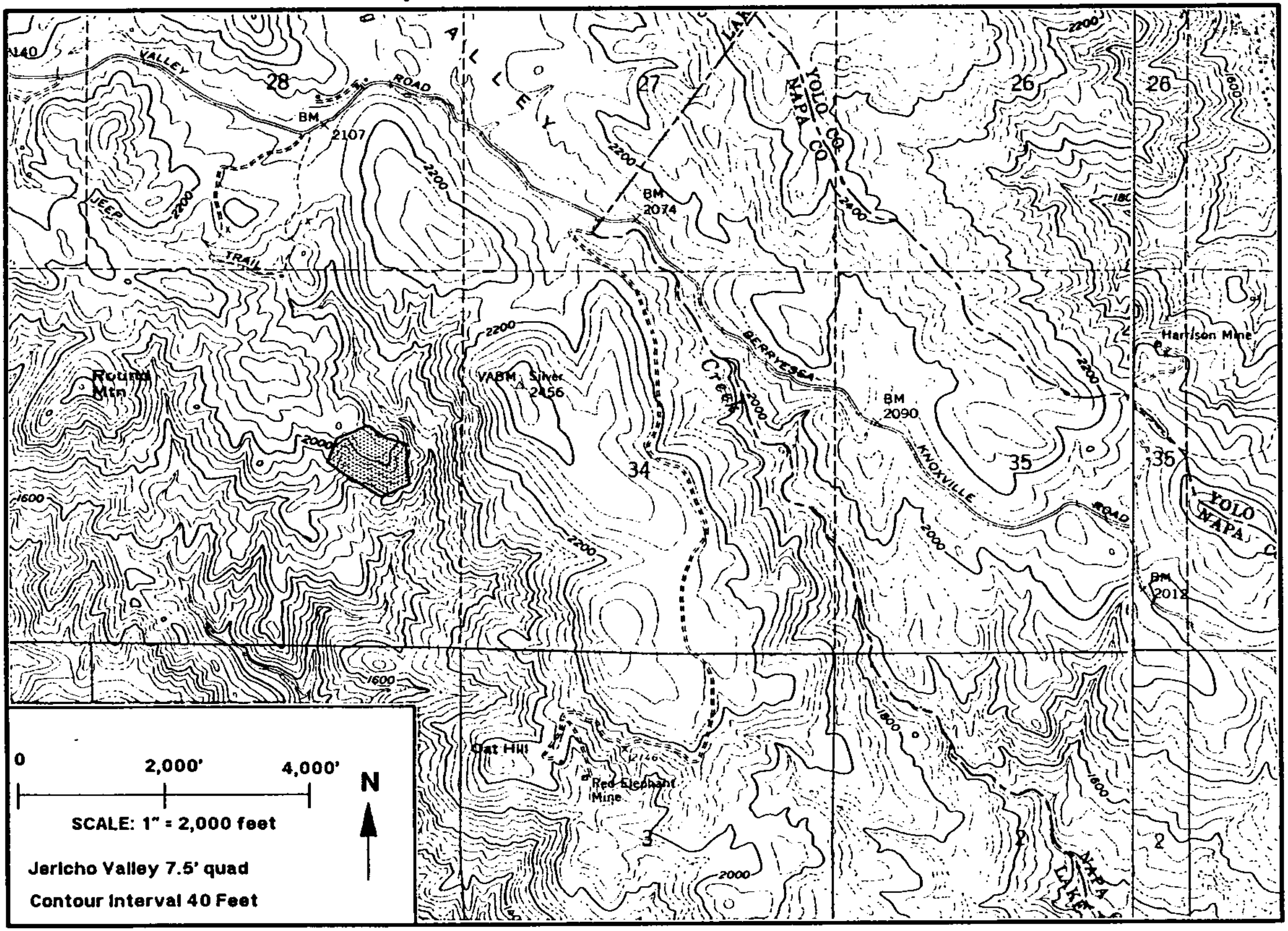


FIGURE A27

Population Locations of Streptanthus morrisonii

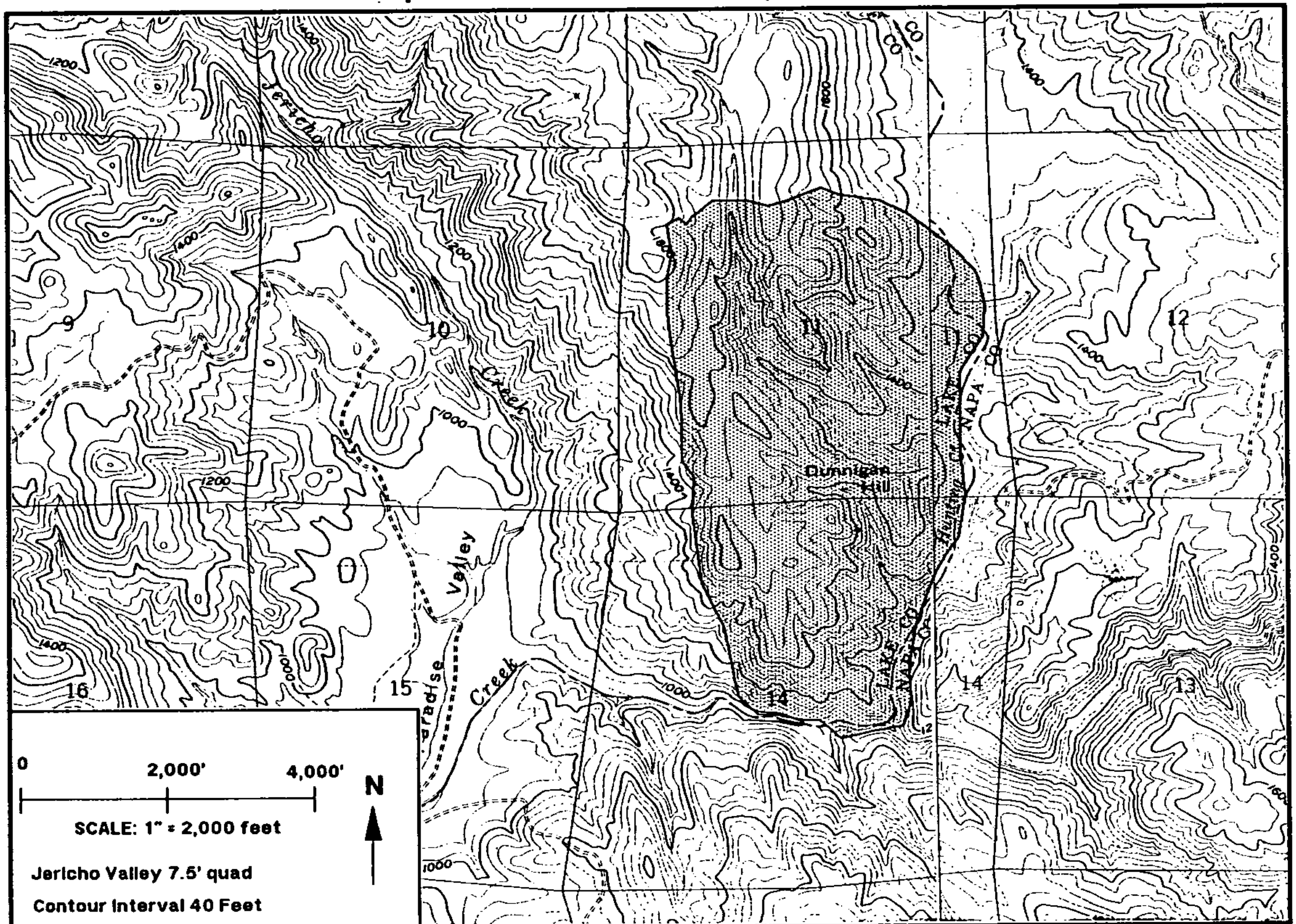
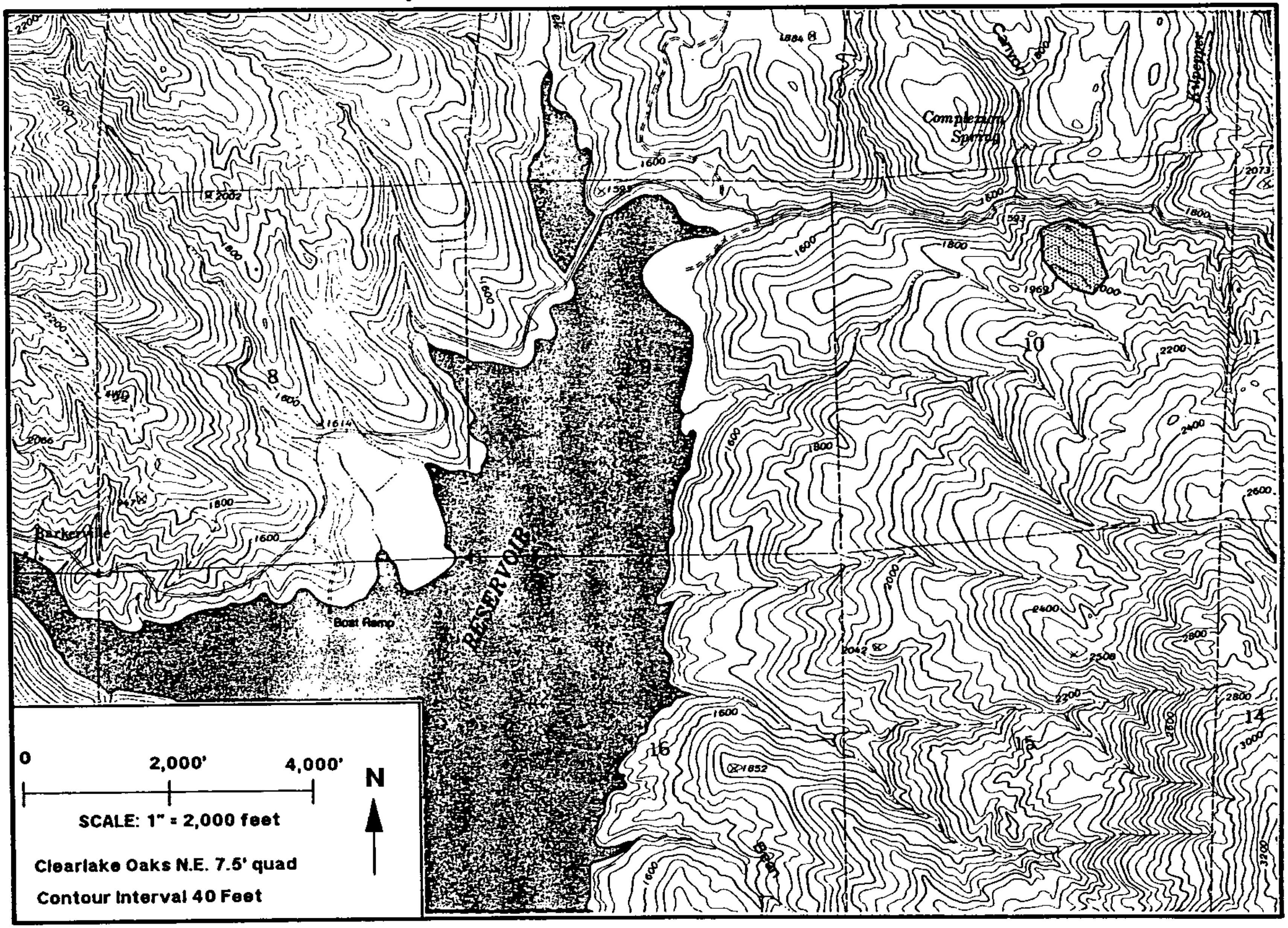


FIGURE A28

Population Locations of Streptanthus morrisonii



ADDITIONAL RARE PLANT SPECIES

The remaining 26 rare plants also occur on serpentine soil in Lake County. The species are not considered, at this time, to be as rare as the nine species just discussed. The following 26 species have more populations, and generally have wider geographical distributions than the last nine species. However, little is known about the population sizes and numbers of some of the following 26 rare plants. Additional field surveys may, in fact, find some of these 26 species to be as rare or rarer than the nine just mentioned. Each will be briefly characterized and a map of their distribution in the county provided.

Allium cratericola- a leaf ephemeral from a perennial bulb; leaves 1, falcate; flowers numerous, pale to dark purple; flowering March to May; distribution Lake, Trinity, Napa, Mendocino and Colusa counties (Figure A29).

Allium fimbriatum var. *purdyi*- a leaf ephemeral from a perennial bulb; leaves 1, terete; flowers 8-40, rose-purple; flowering in May; distribution in Lake and Colusa counties (Figure A30).

Asclepias solanoana- perennial from a woody rootstock; branches 1-3, prostrate; leaves ovate, pubescent; flowers purple and white; flowering in June; distribution in Lake, Napa, Colusa, Mendocino and Trinity counties (Figure A31).

Astragalus breweri- low-growing herbaceous annual; compound leaves 2-6 cm long, leaflets 7-13, cuneate; flowers white to light pink, keel half to a third the length of the wing petals; flowering April to May; distribution Lake, Napa, Marin and Mendocino counties (Figure A32).

Astragalus clevelandii- perennial from a taproot, stems 50-100 cm tall; leaves 4-14 cm long, pinnately compound, 13-25 leaflets; petals white; flowering June to September; distribution Lake, Napa, Colusa and San Benito counties (Figure A33).

Astragalus rattanii var. *jepsonianus*- small herbaceous annual, prostrate; compound leaves 1.5-3 cm long, leaflets 7-13; flowers white to pink, banner purple tipped, keel purple tipped, keel half to a third the length of the wing petals; flowering April to June; distribution Lake, Napa, Colusa, Tehama and Marin counties (Figure A34).

Calamagrostis ophitidis- perennial tufted bunchgrass, 40-60 cm tall; blades 0.2-0.4 cm wide, gray-scabrous, involute; spikelet 5-12 cm long, straw colored; flowering May to June; distribution Lake, Marin and Sonoma counties (Figure A35).

FIGURE A29
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

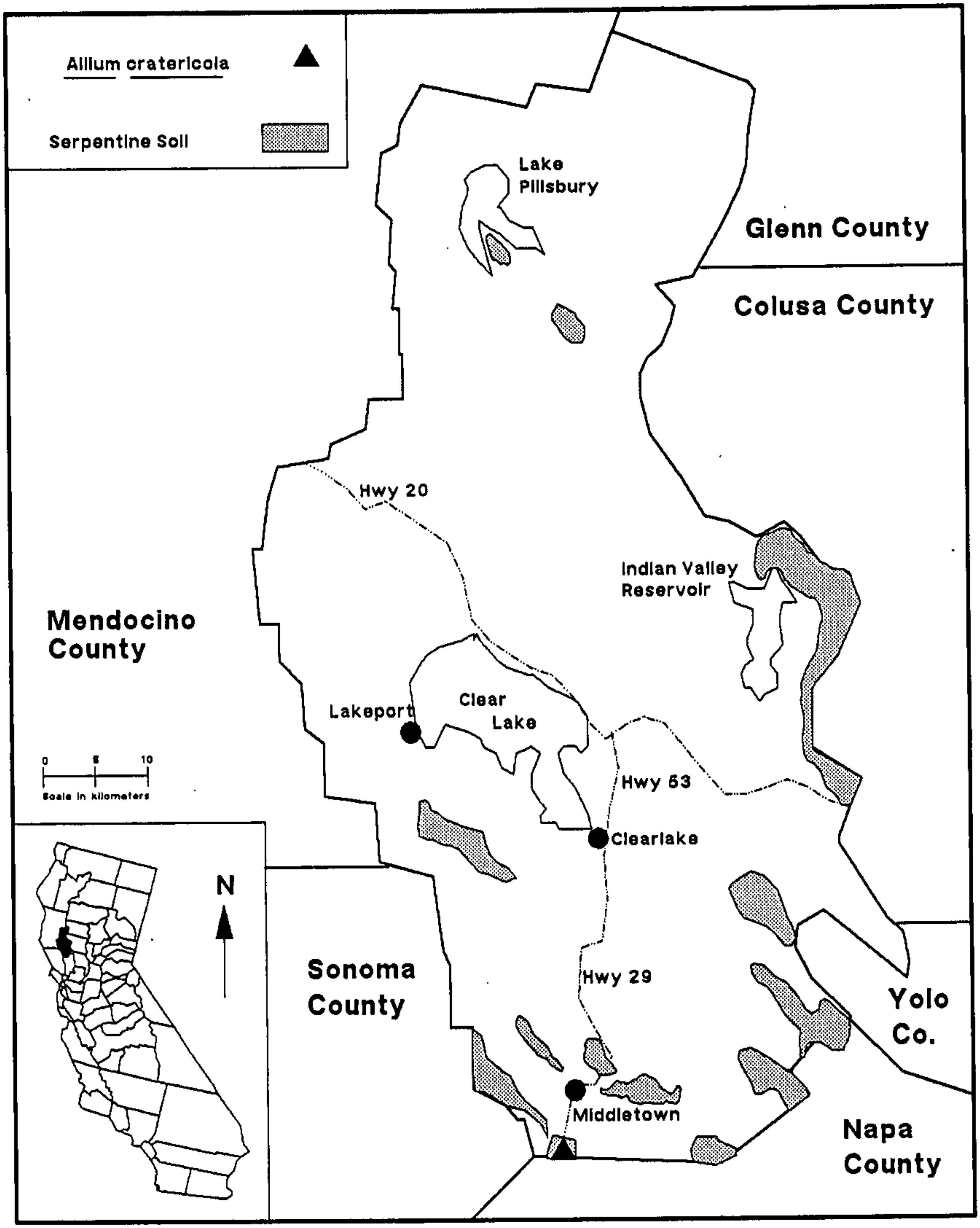


FIGURE A30
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

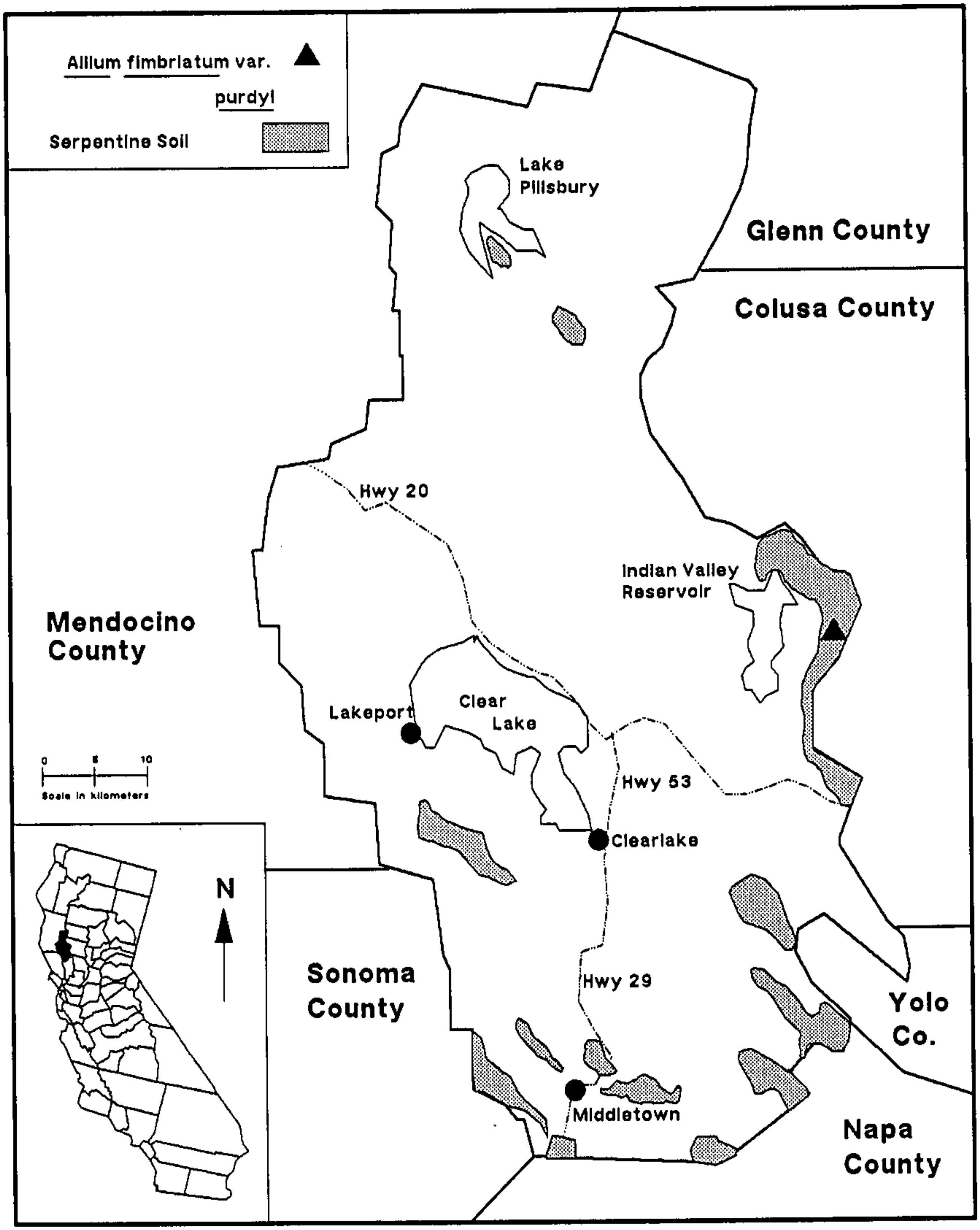


FIGURE A31
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

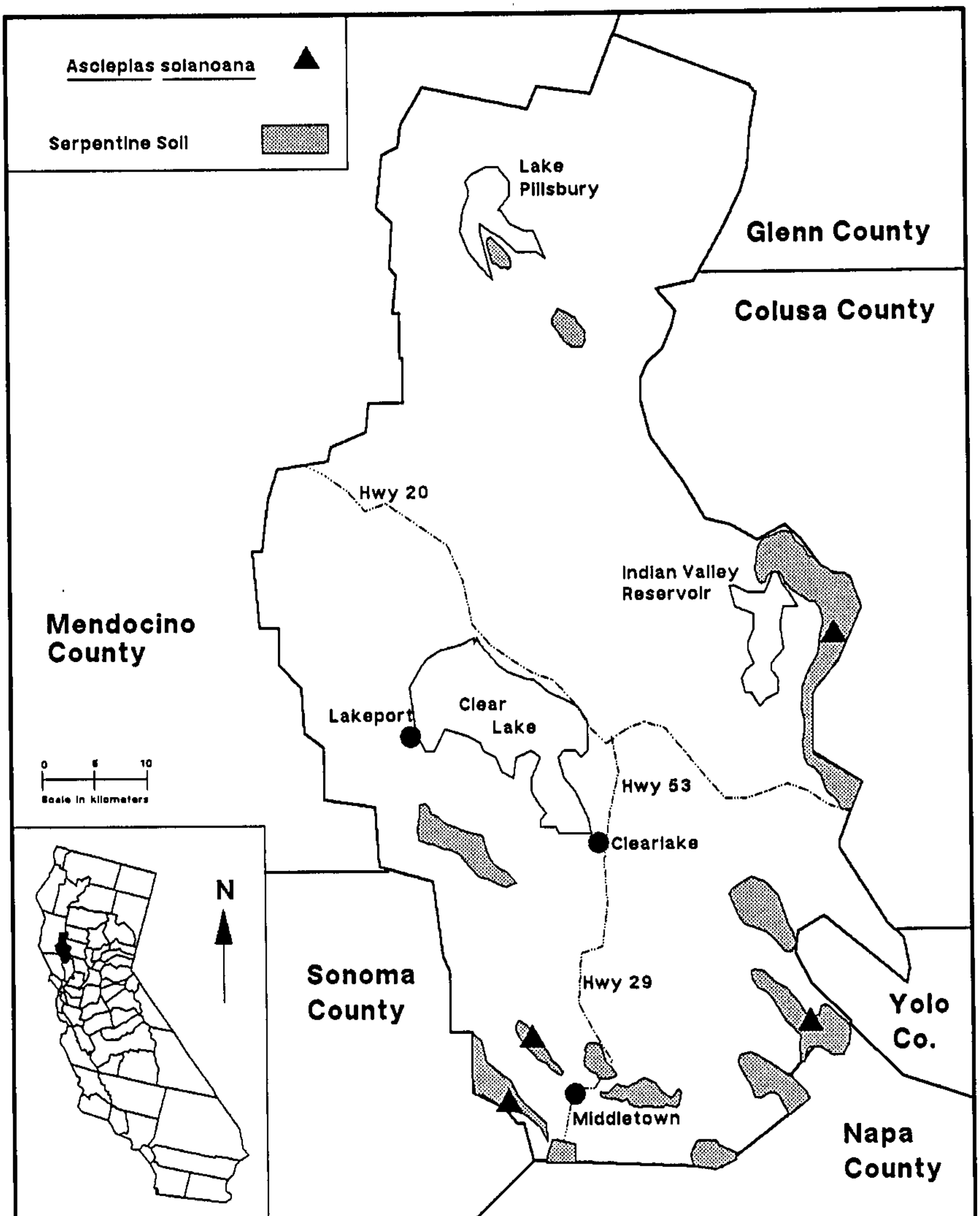


FIGURE A32
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

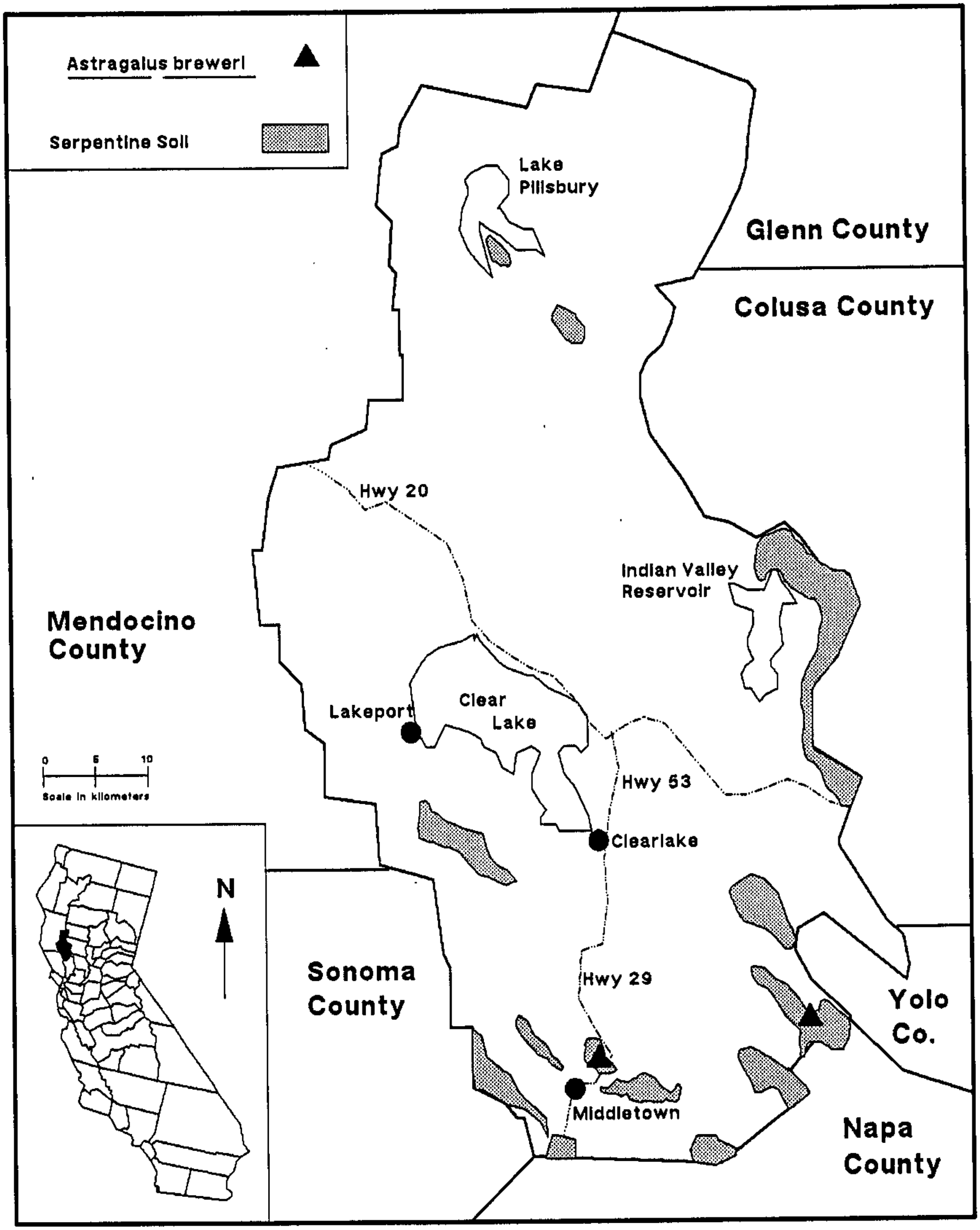


FIGURE A33
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

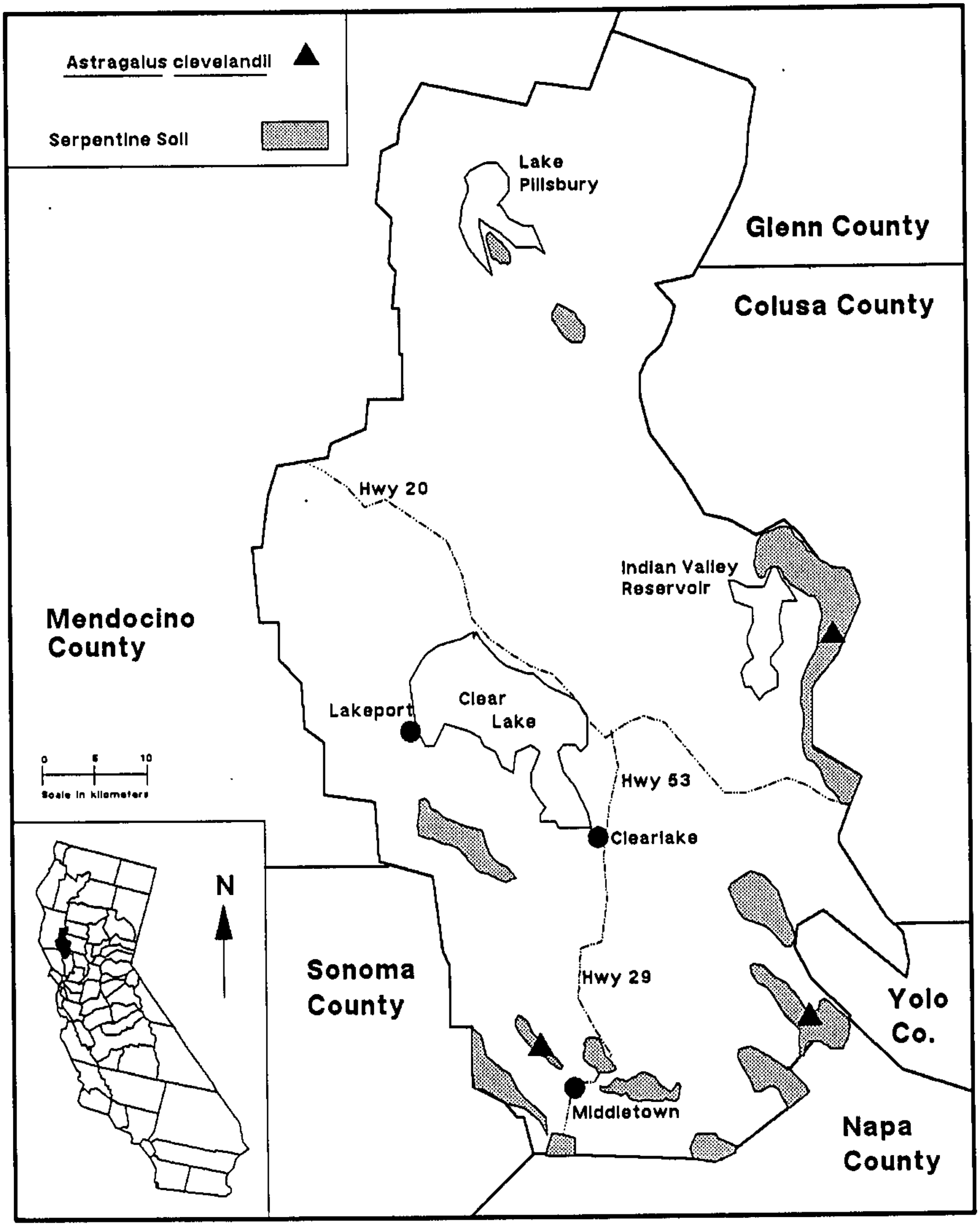


FIGURE A34
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

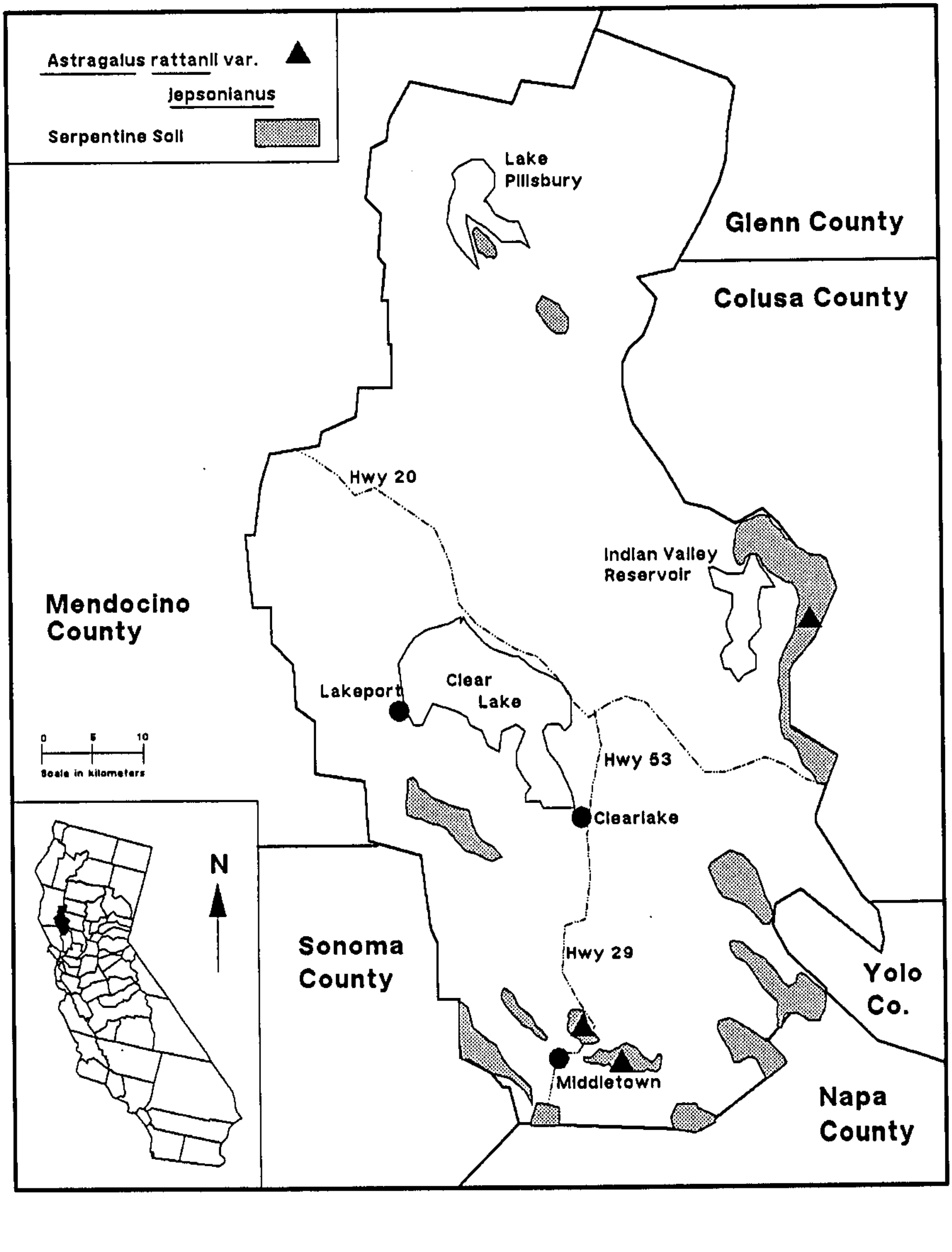
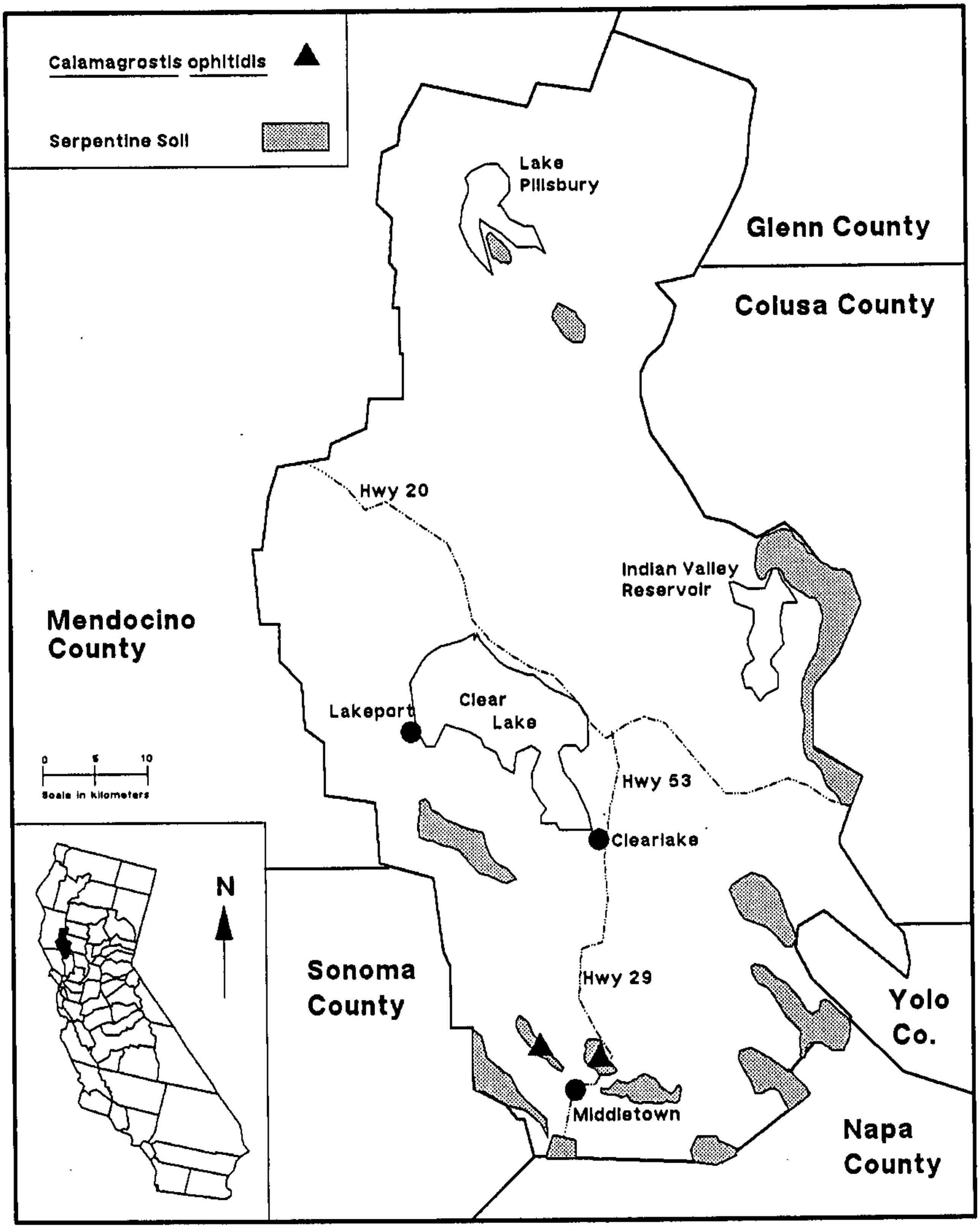


FIGURE A35
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California



Calyptridium quadripetalum- semi-succulent annual, stems erect, 3-12 cm long; leaves basal and cauline, spatulate, 2-6 cm long; sepals ovate, white to pink; petals 4, 0.2 cm long; flowering April to June; distribution Lake, Napa, Sonoma and Glenn counties (Figure A36).

Calystegia collina ssp. oxyphylla- tufted perennial, 5-10 cm tall; leaves hastate with an extra set of lobes on outer blade, 2-4 cm long, grayish pubescent; flowers cream-white; flowering April to June; distribution Lake and Napa counties (Figure A37).

Collinsia greenei- herbaceous annual, 10-30 cm tall; leaves lanceolate, 1-3 cm long, pubescent with gland-tipped hairs; flowers in whorls of 1-5, petals funnelform, 1-1.2 cm long, purplish blue; flowering May to June; distribution Lake, Napa, Sonoma, Trinity and Humboldt counties (Figure A38).

Collomia diversifolia- short, many-branched annual; leaves opposite, 0.5-1 cm long, glandular pubescent; flowers funnelform, 0.6-1.2 cm long, pink drying blue; flowering April to August; distribution Lake, Napa, Colusa and Mendocino counties (Figure A39).

Cryptantha hispidula- erect strigose annual, 10-30 cm tall; leaves linear, 0.6-1.5 cm long; flowers 0.2 cm long, white; nutlet smooth; flowering April-June; distribution Lake and Napa counties (Figure A40).

Delphinium uliginosum- perennial from a cluster of fusiform roots, 30-50 cm tall, basal leaves 3-cleft, 2-4 cm wide, division entire, few toothed or crenately lobed; sepals blue, ovate; upper petals white, lower petals violet, spur slender; flowering May to June; distribution Lake, Napa and Colusa counties (Figure A41).

Fritillaria pluriflora- leaf ephemeral from a perennial bulb; leaves clustered near base, obovate, 6-12 cm long, light green; flowers 1-12, bell-shaped, pinkish purple; flowering February to April; distribution Lake, Napa, Mendocino, Colusa, Glenn, Butte and Solano counties (Figure A42).

Fritillaria purdyi- leaf ephemeral from a perennial bulb; leaves clustered near base, obovate, 4-8 cm long; flowers 1-7, white to pinkish with purple spots, campanulate; flowering March to June; distribution Lake, Napa, Mendocino and Trinity counties (Figure A43).

Helianthus exilis- herbaceous slender annual, 30-120 cm tall; leaves ovate to lanceolate, pubescent and somewhat glandular; flowering heads red or yellow; flowering July to November; distribution Lake, Napa, Colusa, Glenn counties (Figure A44).

FIGURE A36
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

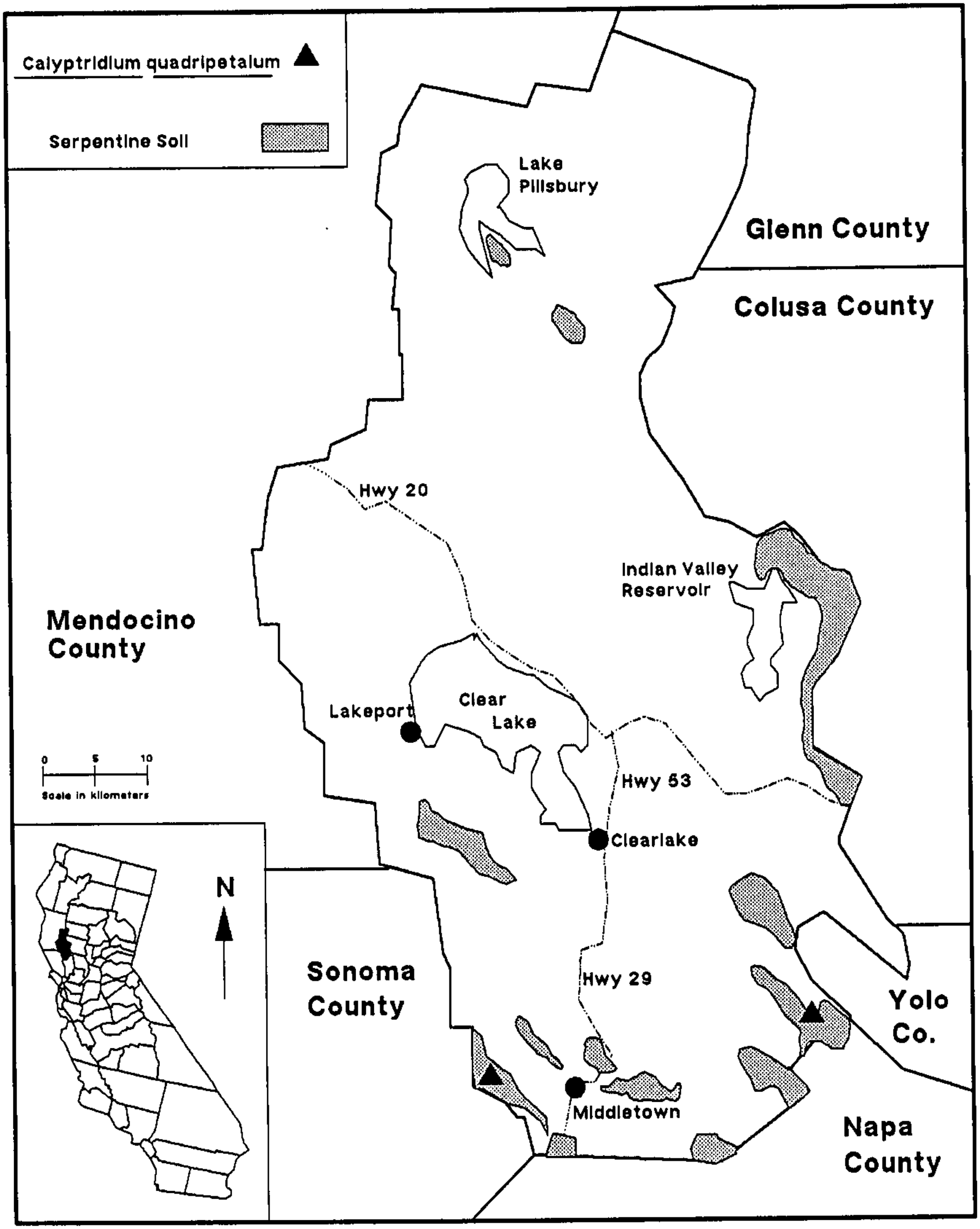


FIGURE A37
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

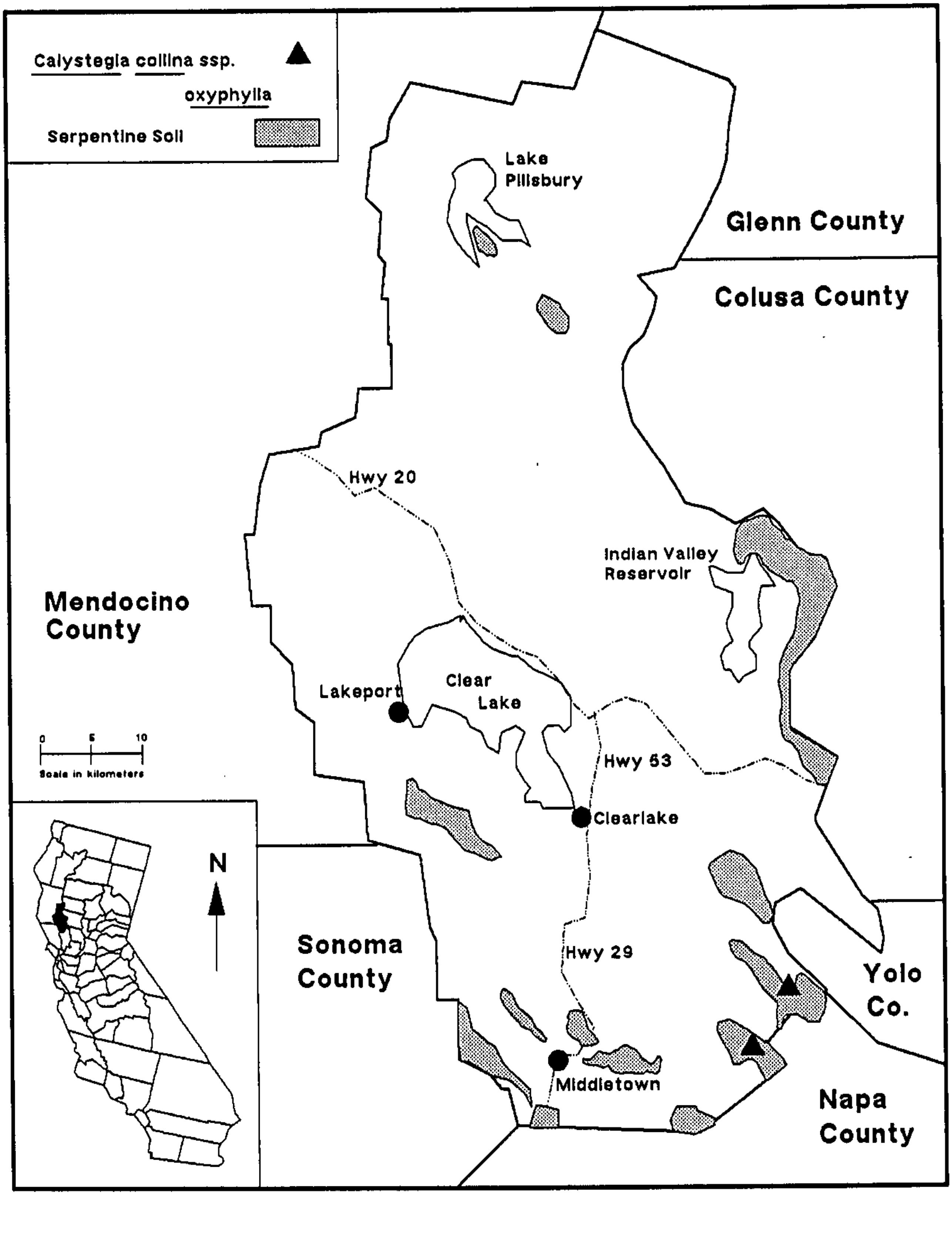


FIGURE A38
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

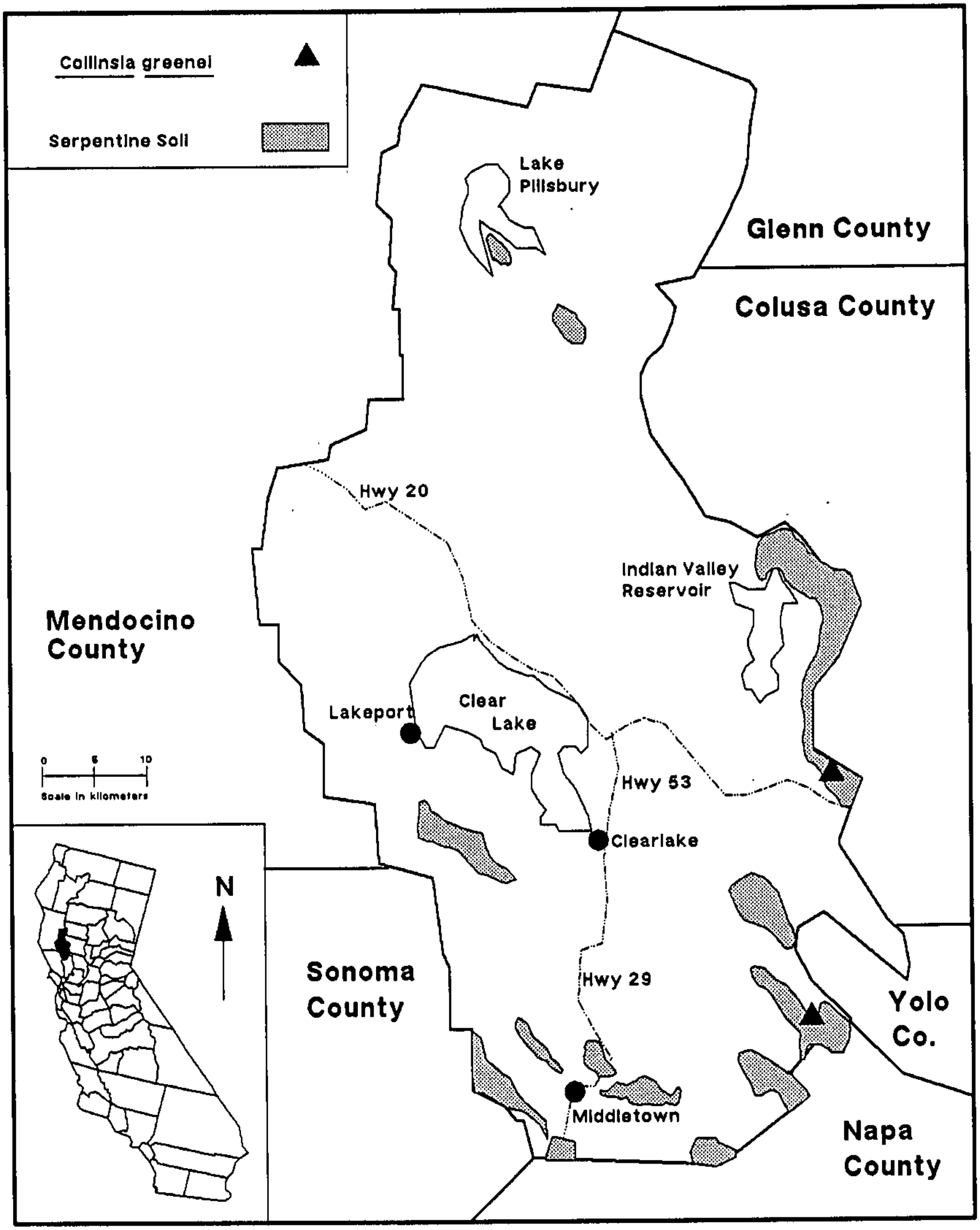


FIGURE A39
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

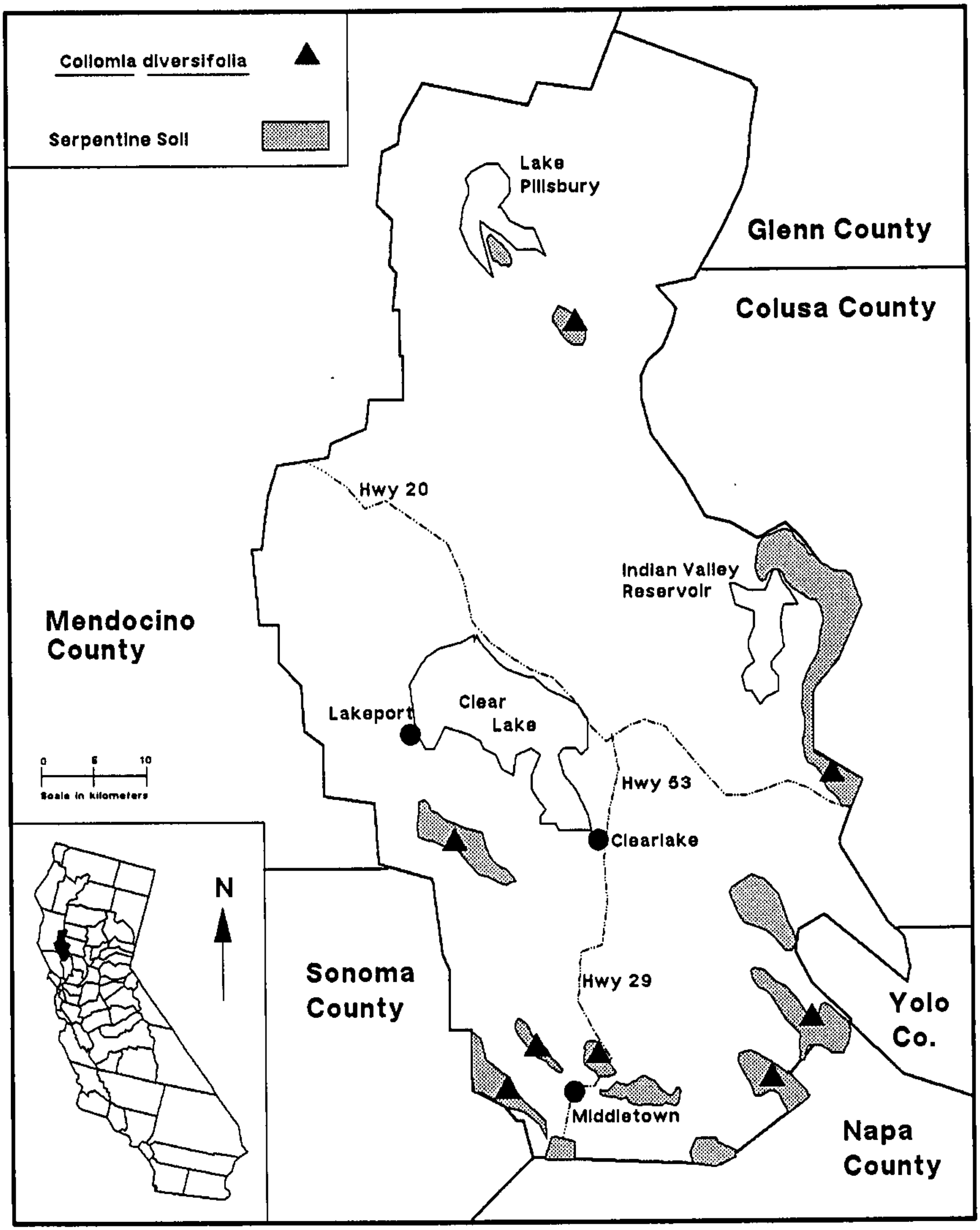


FIGURE A40
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

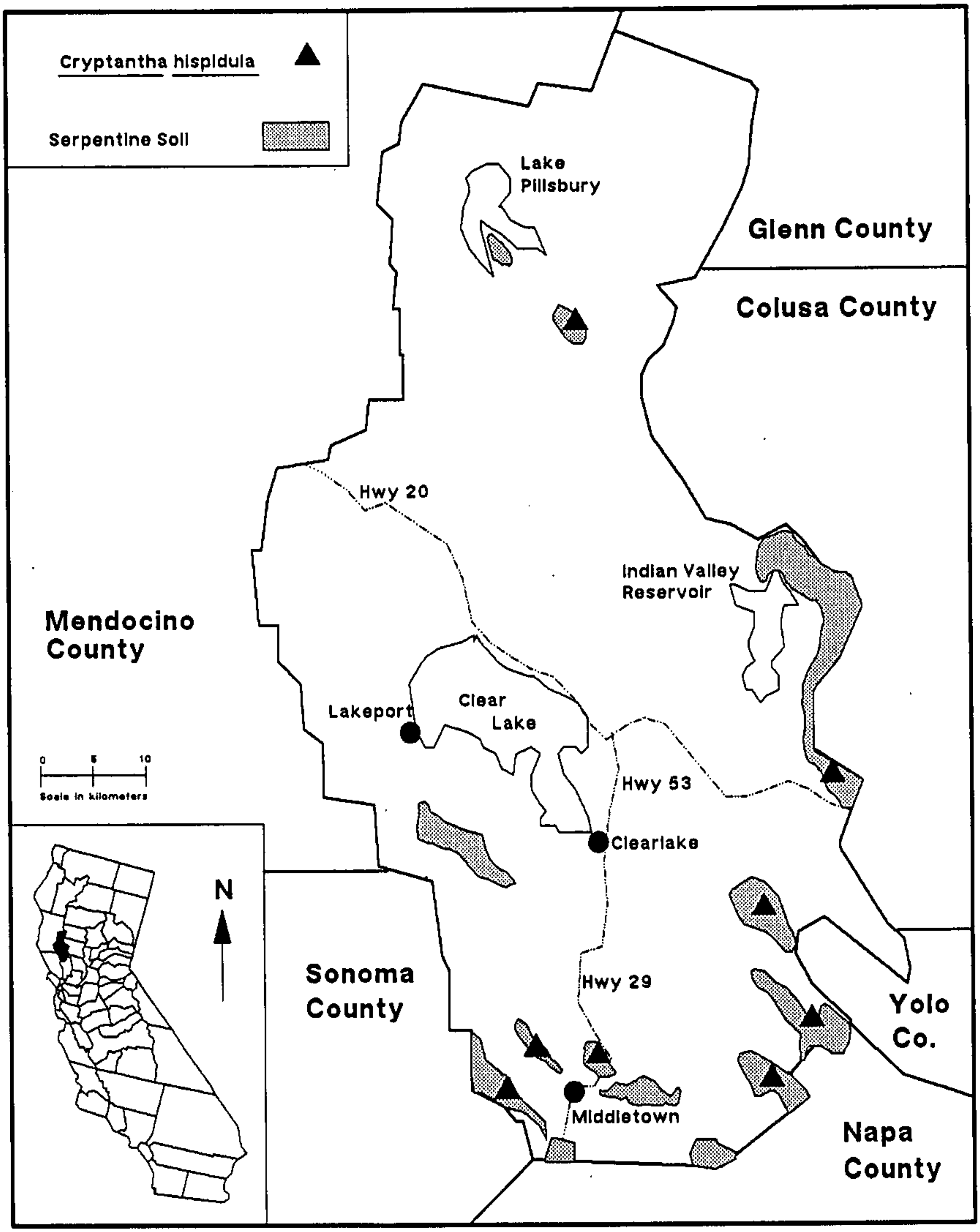


FIGURE A41
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

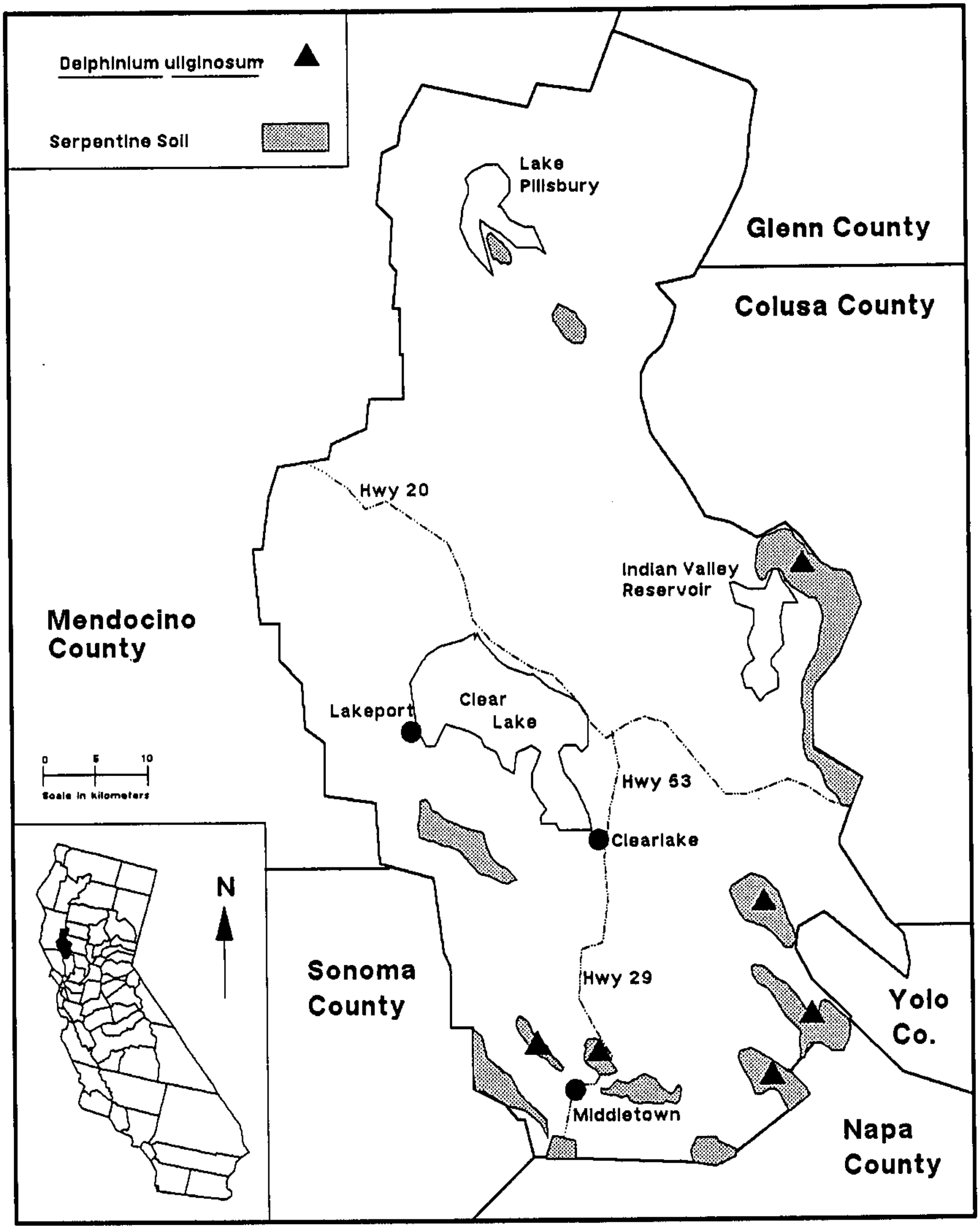


FIGURE A42
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

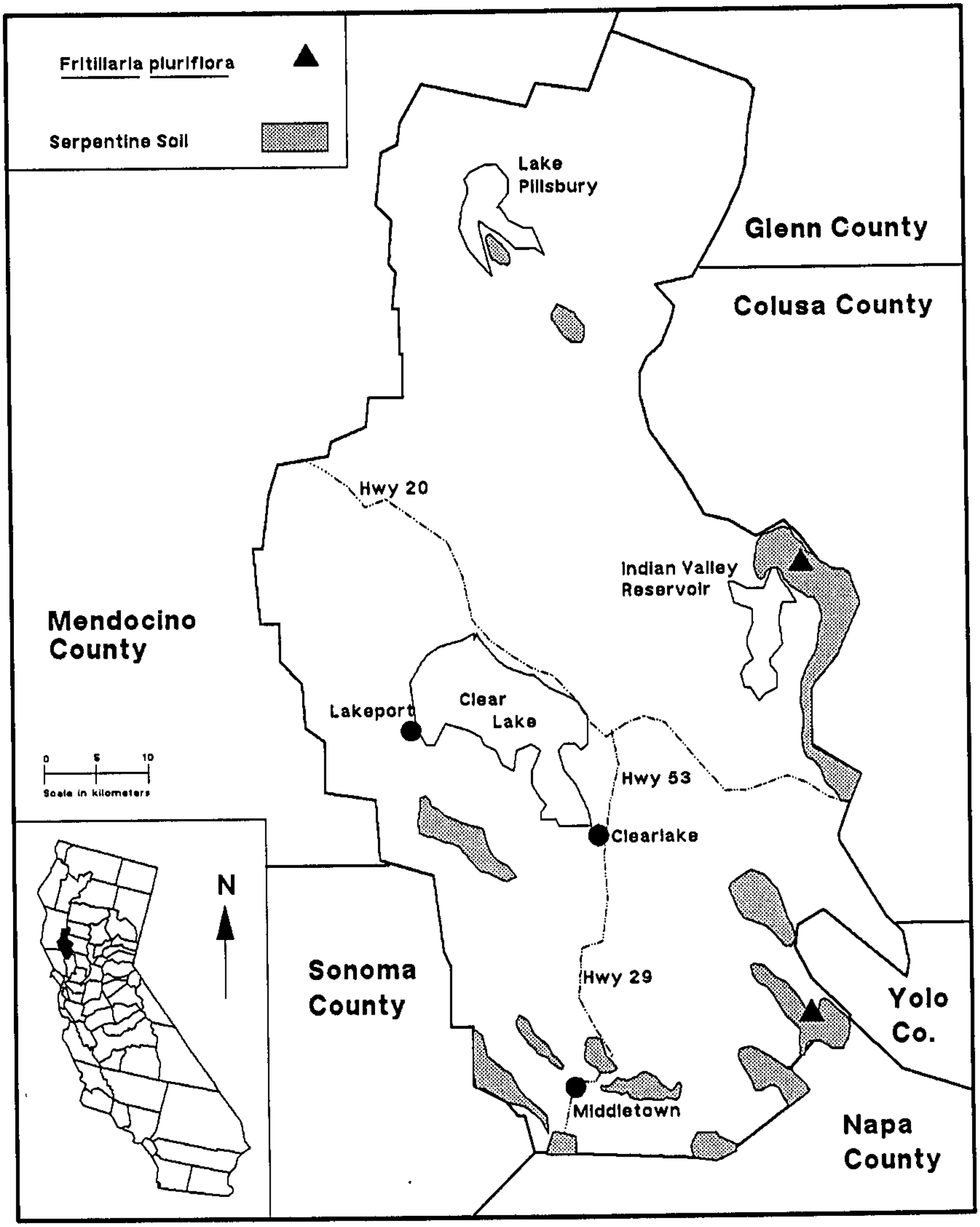


FIGURE A43
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

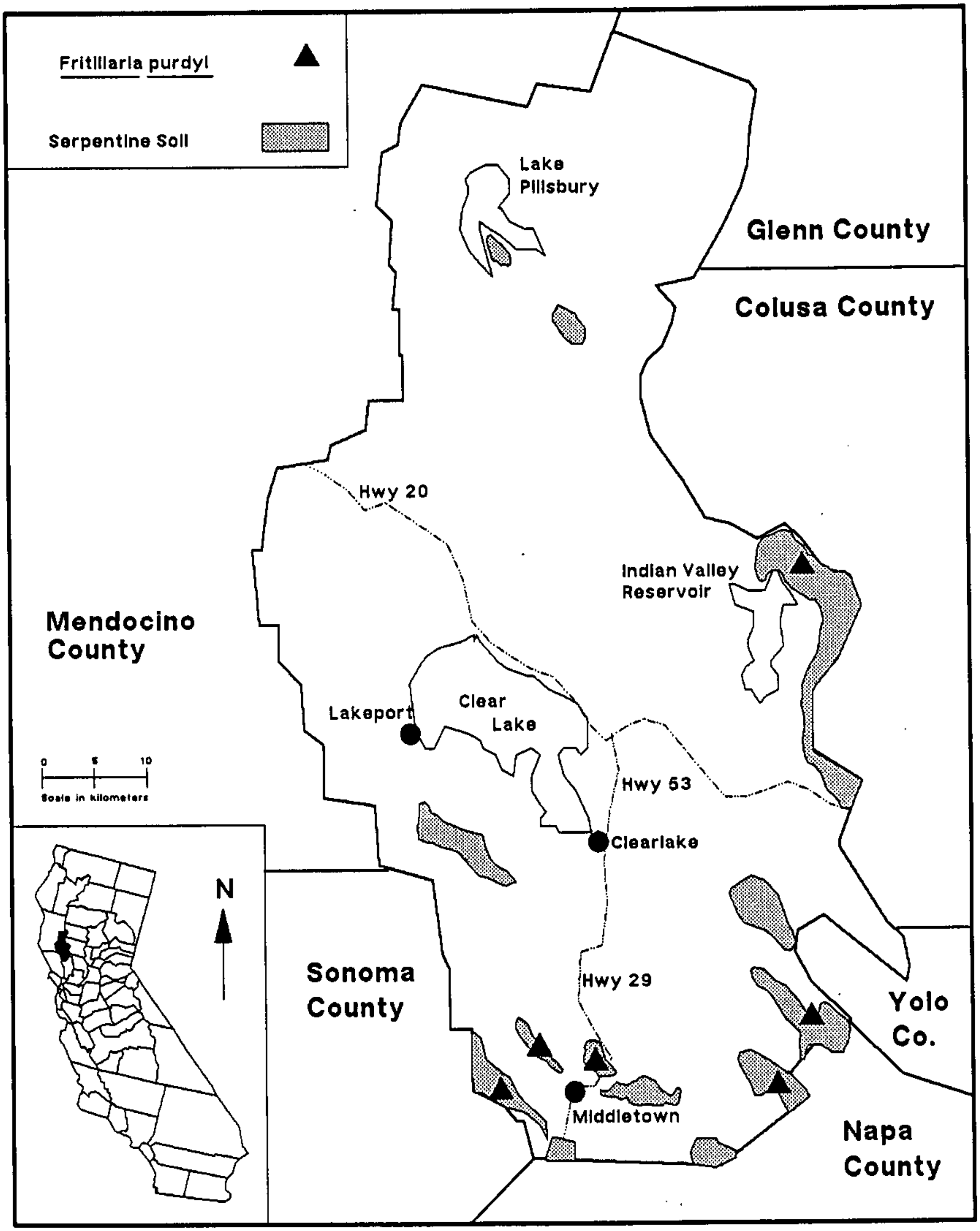
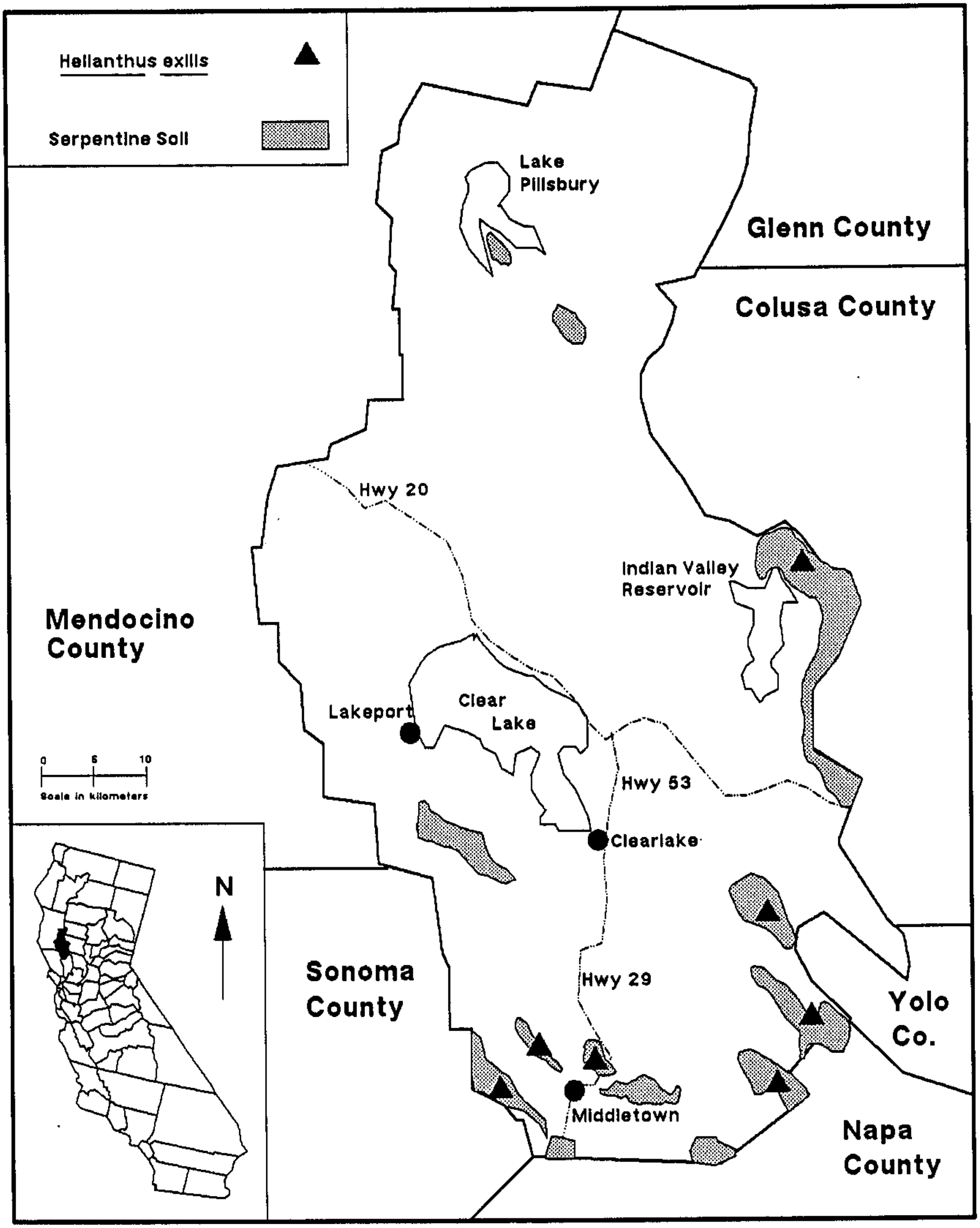


FIGURE A44
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California



Hesperolinon bicarpellatum- thin-stemmed glabrous herbaceous annual, 10-25 cm tall; upper leaves alternate, lowermost leaves opposite or whorled, linear 1 cm long, deciduous; petals 0.3-0.7 cm long, ovate, yellow, styles and carpels 2; flowering May to July; distribution Lake, Napa and Mendocino counties (Figure A45).

Hesperolinon spergulinum- thin-stemmed glabrous herbaceous annual, 10-25 cm tall; upper leaves alternate, lowermost leaves opposite or whorled, linear 1 cm long, deciduous; pedicels 0.6-1.4 cm long, flowers nodding in bud, petals 0.3-0.7 cm long, ovate, white or tinged pink, styles and carpels 3; flowering May to July; distribution Lake, Napa, Sonoma, Mendocino, Humboldt and Santa Clara counties (Figure A46).

Lomatium ciliolatum var. hooveri- perennial from a woody rootstock, 10-30 cm tall; leaves deltoid in outline, compound, leaf segments linear; bracts purplish; flowers in umbels, purple; flowering May to June; distribution Lake, Napa and Colusa counties (Figure A47).

Mimulus brachiatus- pubescent annual, stems with gland-tipped hairs, 4-15 cm tall; flowers red-purple, 1-1.3 cm long, pubescent; flowering May to July; distribution Lake County (Figure A48).

Mimulus nudatus- herbaceous annual, 10-30 cm tall; leaves lanceolate, few, 0.5-1.5 cm long; flowers 1.5-2 cm long, yellow with red spots; flowering May to June; distribution Lake and Napa counties (Figure A49).

Navarretia jepsonii- erect stiff annual, 5-20 cm tall, branching from the base into dense flowering heads; leaves and bracts bipinnate, 1-5 cm long; flowers funnelform, 1 cm long, purple with darker spots; flowering May to June; distribution Lake, Napa and Glenn counties (Figure A50).

Nemacladus montanus- zigzag branched annual, 10-20 cm tall; leaves in basal rosette, oblanceolate, glabrous, 1-1.5 cm long; flowers white-purplish, 0.1-0.2 cm long, irregular; flowering May to July; distribution Lake and Napa counties (Figure A51).

Orobanche valida ssp. howellii- root parasite on shrubs, stems mostly underground, 10-35 cm long, inflorescence blackish purple, flowers 1.2-1.8 cm long; plants found June through September. Parasitizing Garrya congdonii; distribution Glenn, Lake, Napa, and Sonoma counties (Figure A52). Major information source Heckard and Collins (1982).

FIGURE A45
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

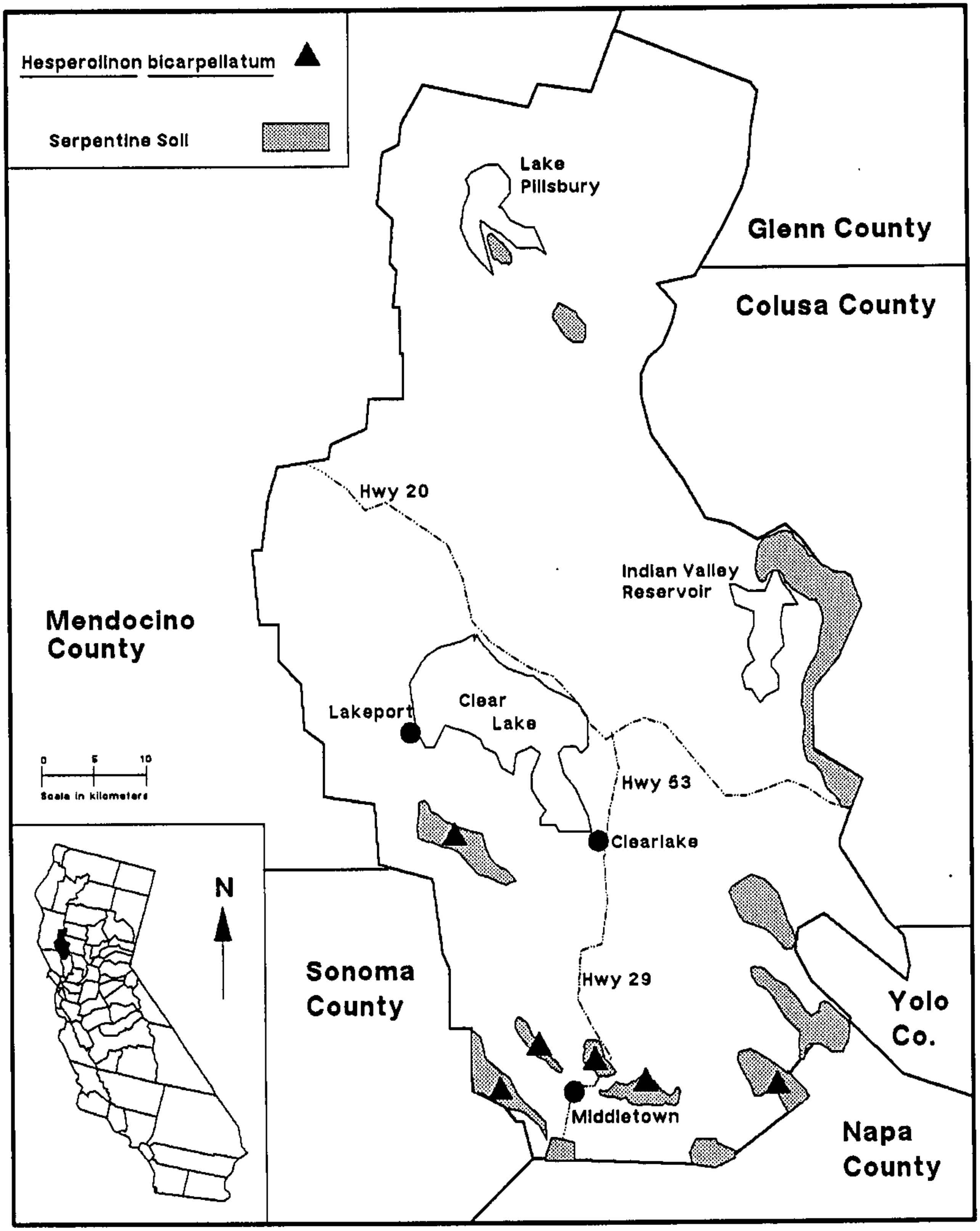


FIGURE A46
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

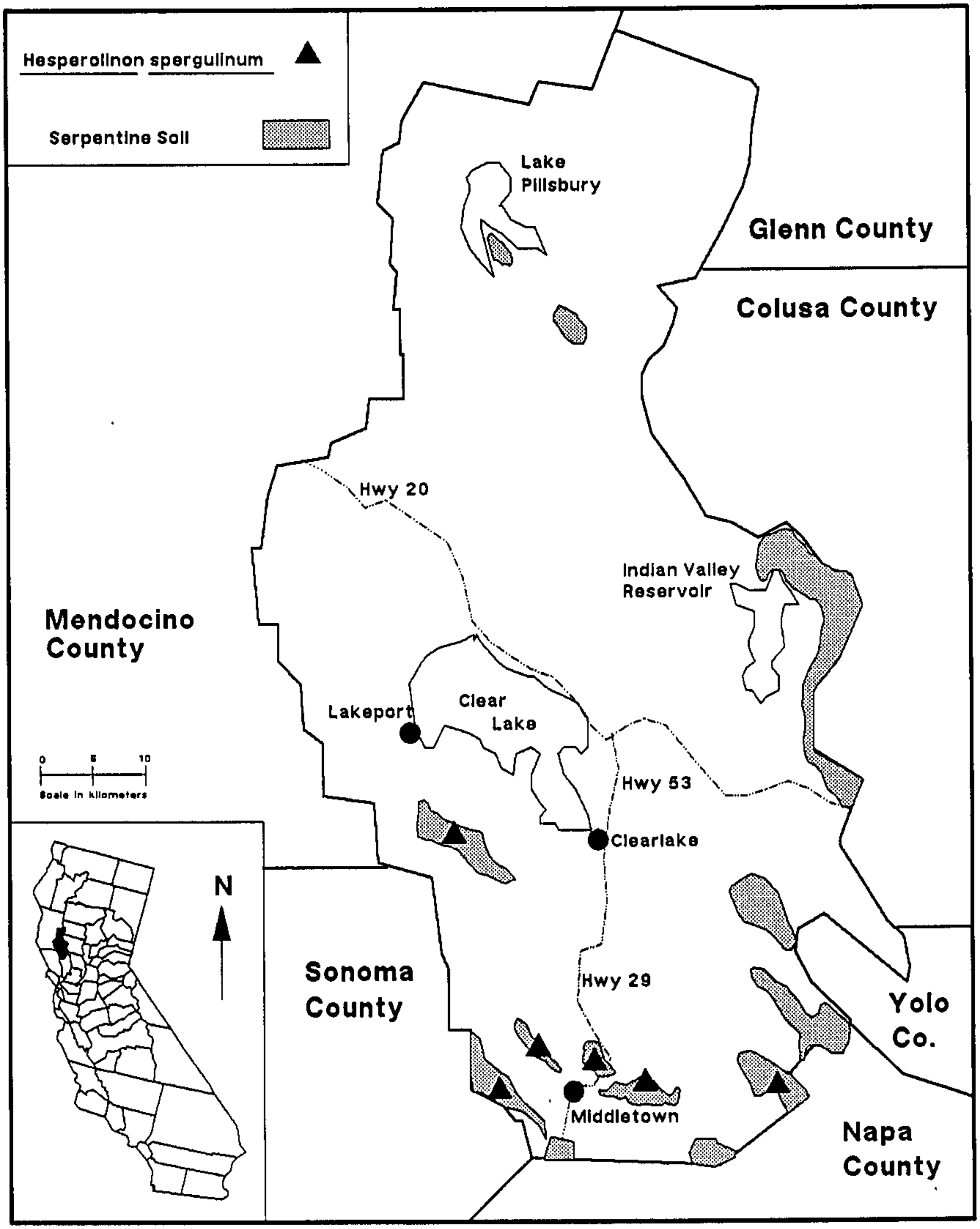


FIGURE A47
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

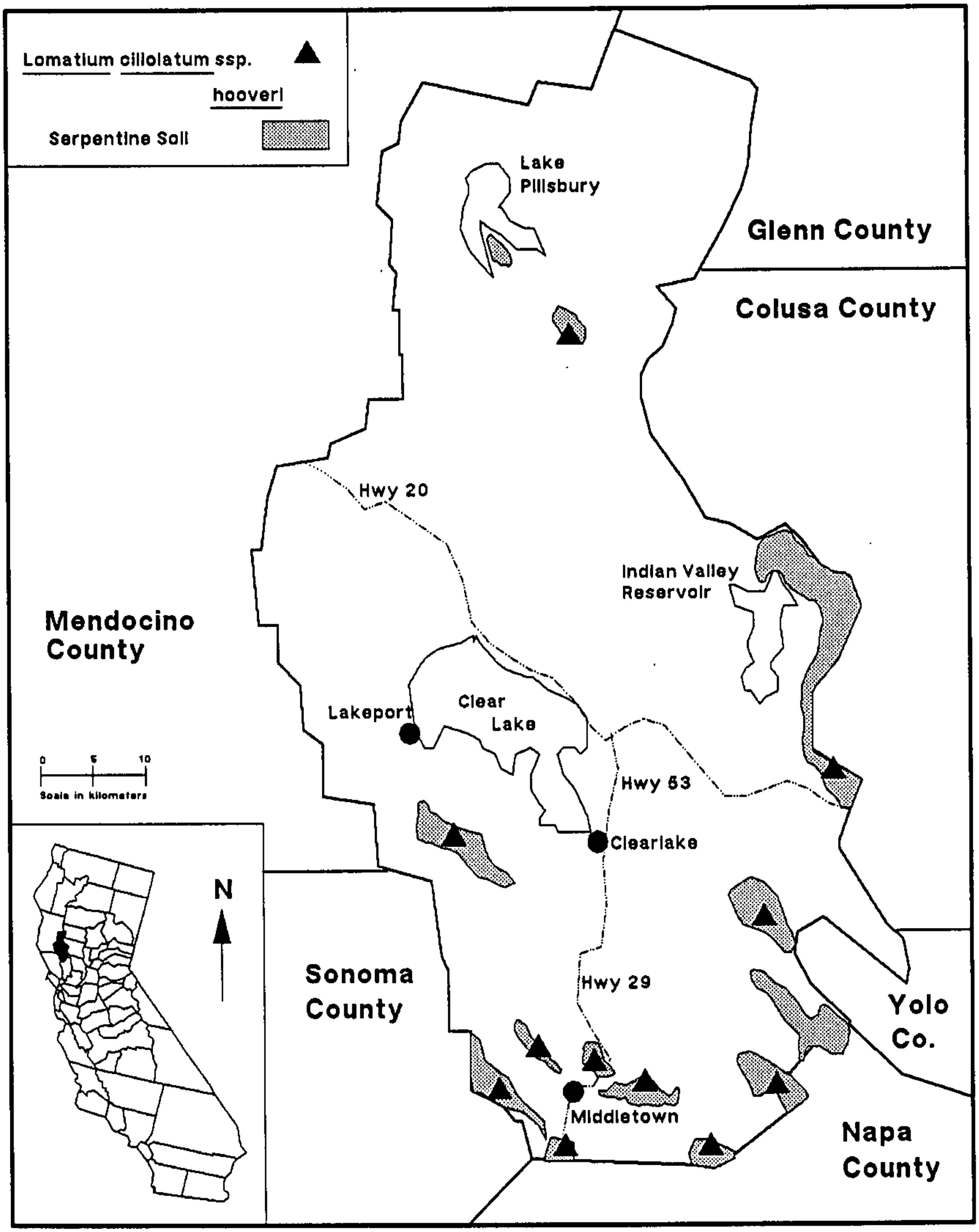


FIGURE A48
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

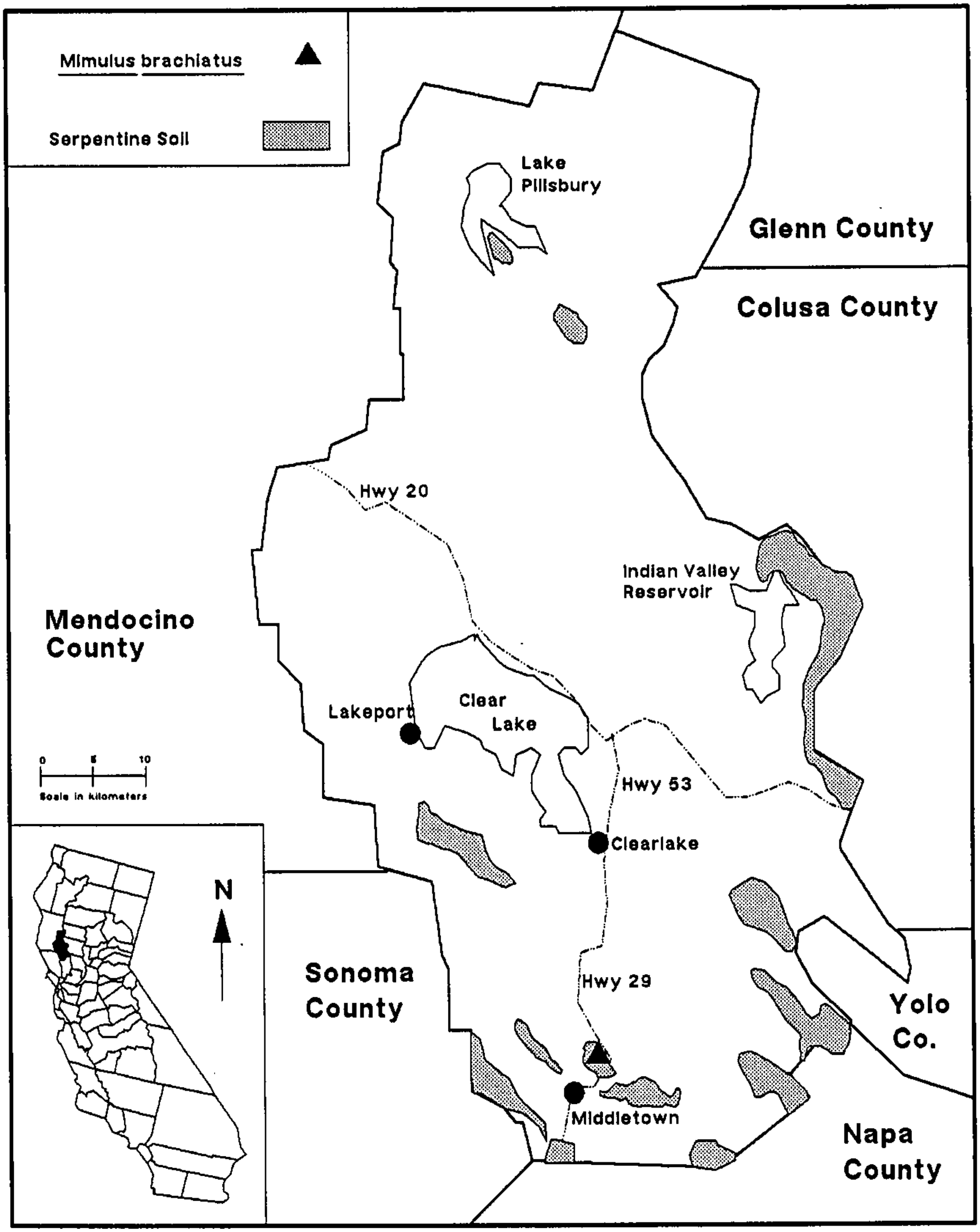


FIGURE A49
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

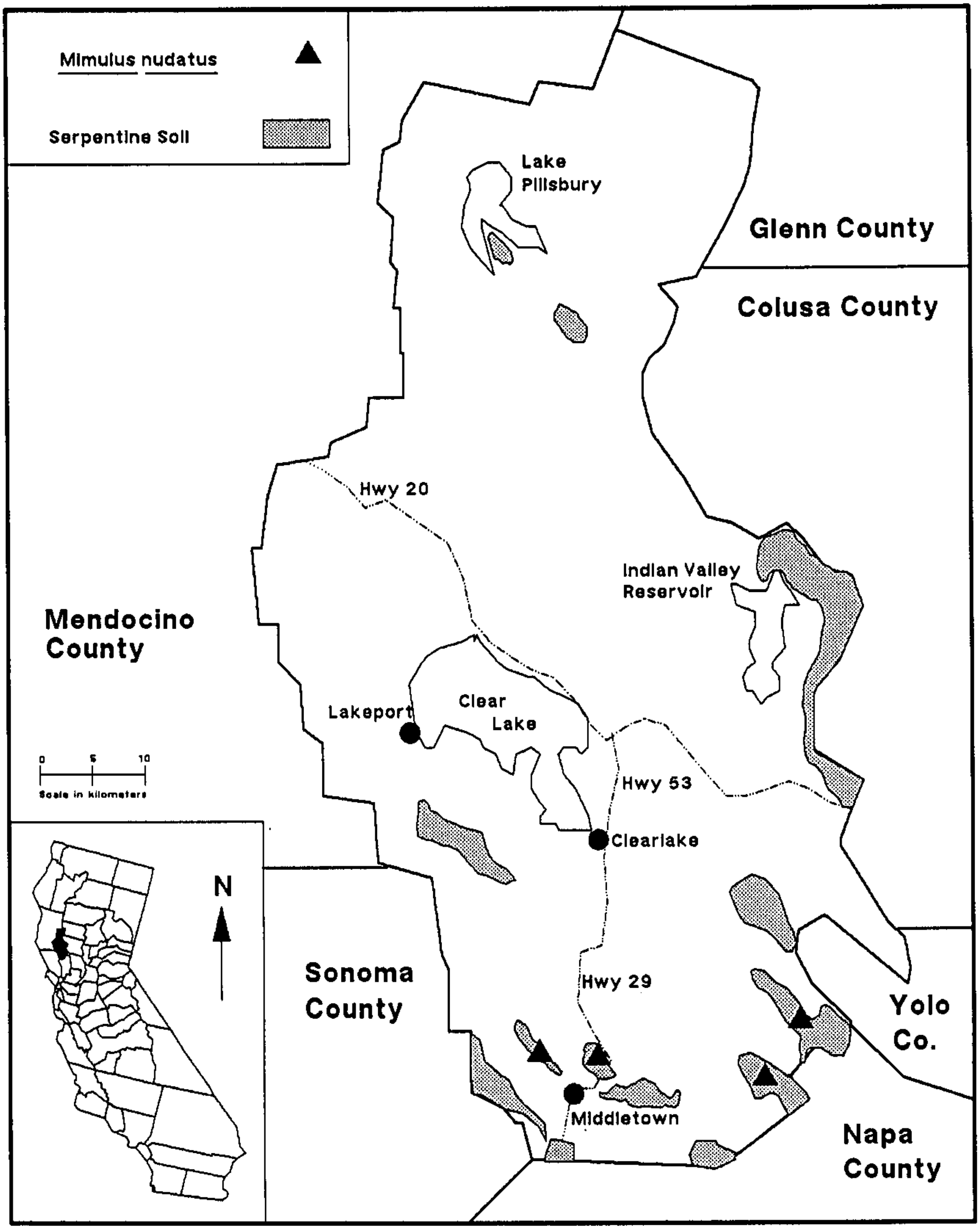


FIGURE A50
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

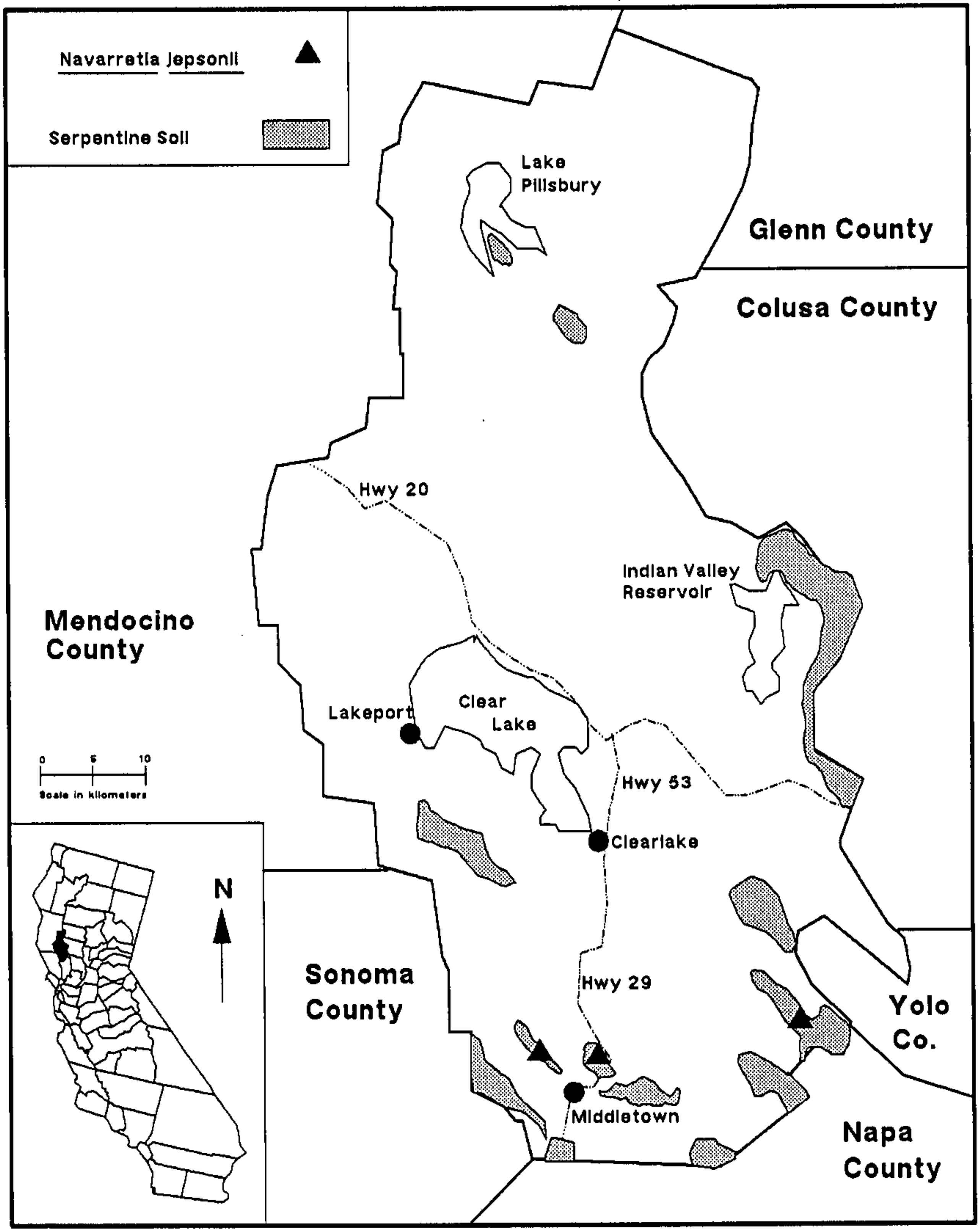


FIGURE A51
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

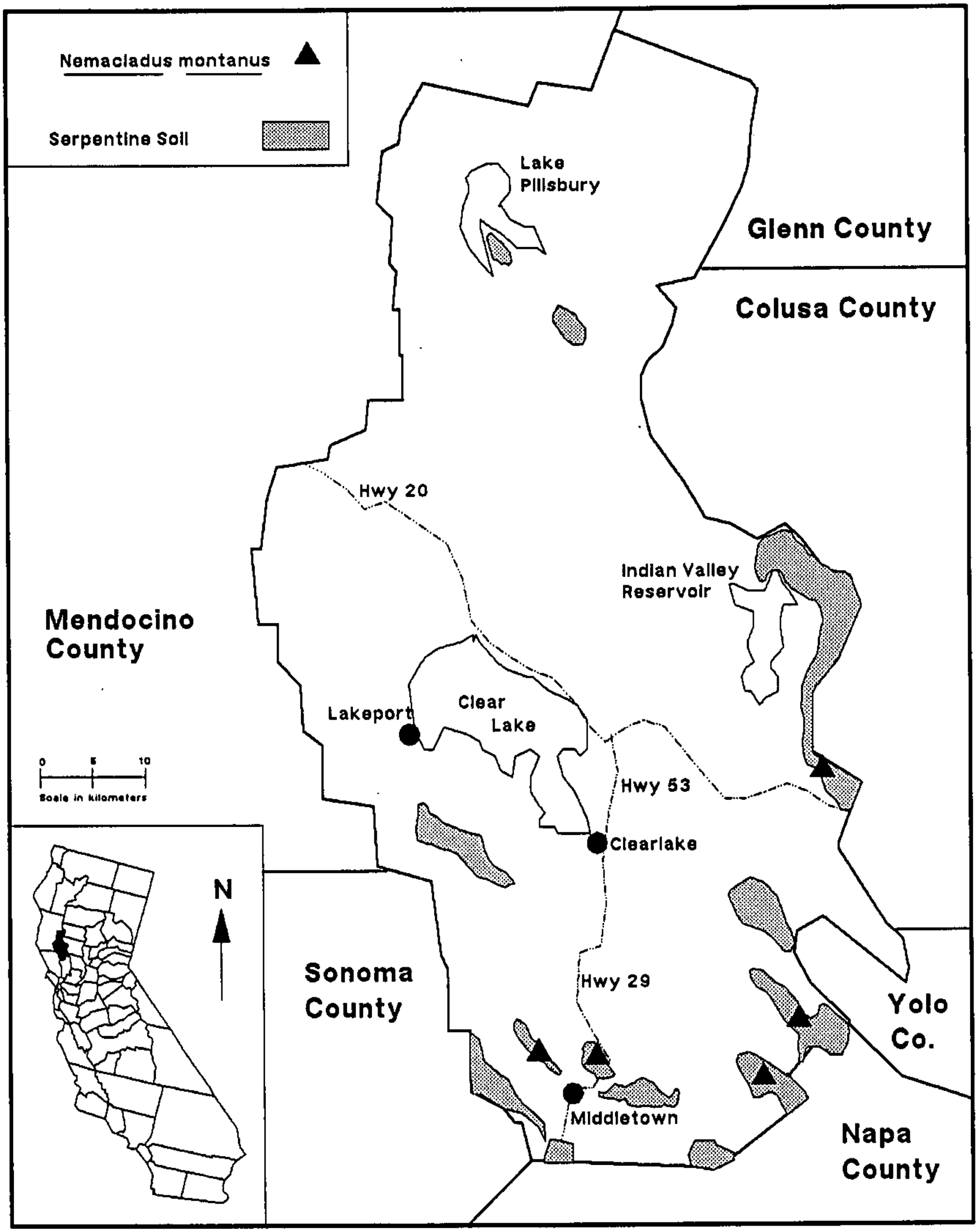
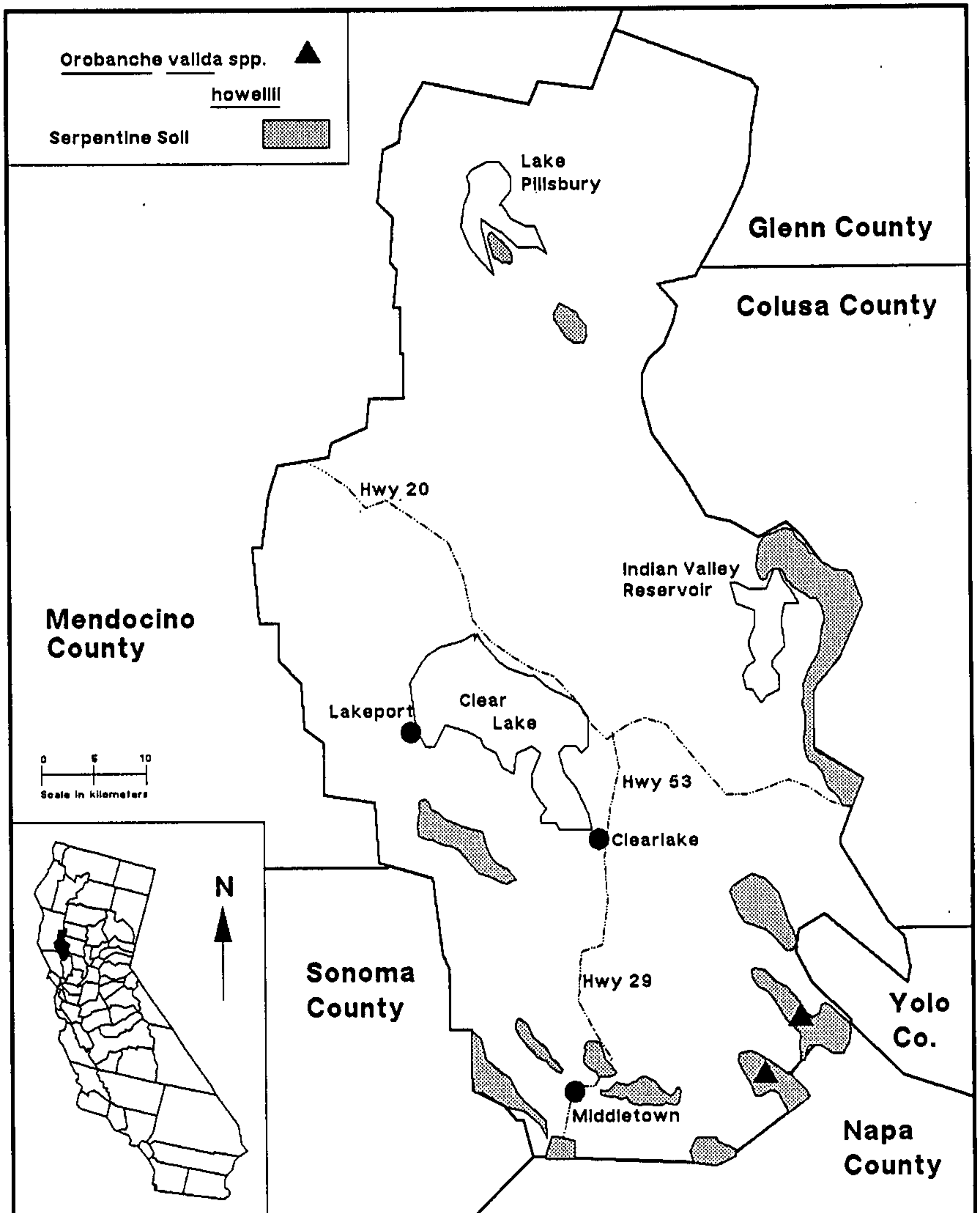


FIGURE A52
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California



Senecio clevelandii- herbaceous perennial, 10-20 cm tall; leaves roundish, 2-5 cm long, dentate, pubescent, purple tinted on lower surface; flower heads 1-1.4 cm tall, ray flowers orange, 1-2.5 cm long; achenes glabrous; flowering May to June; distribution Lake, Napa, Colusa and Trinity counties (Figure A53).

Thelypodium brachycarpum- glabrous biennial or short lived perennial, 15-40 cm tall; basal leaves spatulate, pinnatifid, 3-6 cm long, cauline leaves sagitate; four petals linear, 8-1.4 cm long, white; flowering June to August; distribution Lake, Napa, Colusa and Siskiyou counties (Figure A54).

Additional Taxa:

Brodiaea coronaria ssp. rosea- This species is reported to be associated with ultramafic soil and is known from Lake County (Smith and Berg, 1988). However, habitat information suggest that this plant most likely occurs on non-serpentine soils in oak woodlands that are surrounded by or down slope from serpentine and may be influenced by them due to run-off of the serpentine minerals. The only known location in Lake County is in the vicinity of Indian Valley Reservoir.

Arabis modesta- This species is reported in the CNPS inventory (Smith and Berg, 1988) for Lake county. However, no specimens were found that were attributable to this species growing on serpentine in Lake County. The Homestake Mine botanical survey (D'Appalonia, 1982) has maped Arabis modesta in Napa County very near the Lake County border at Dunnigan Hill. Joe Collizo (pers. comm.) believes plants from the serpentine soil habitats in Napa County to be different from typical Arabis modesta.

FIGURE A53
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California

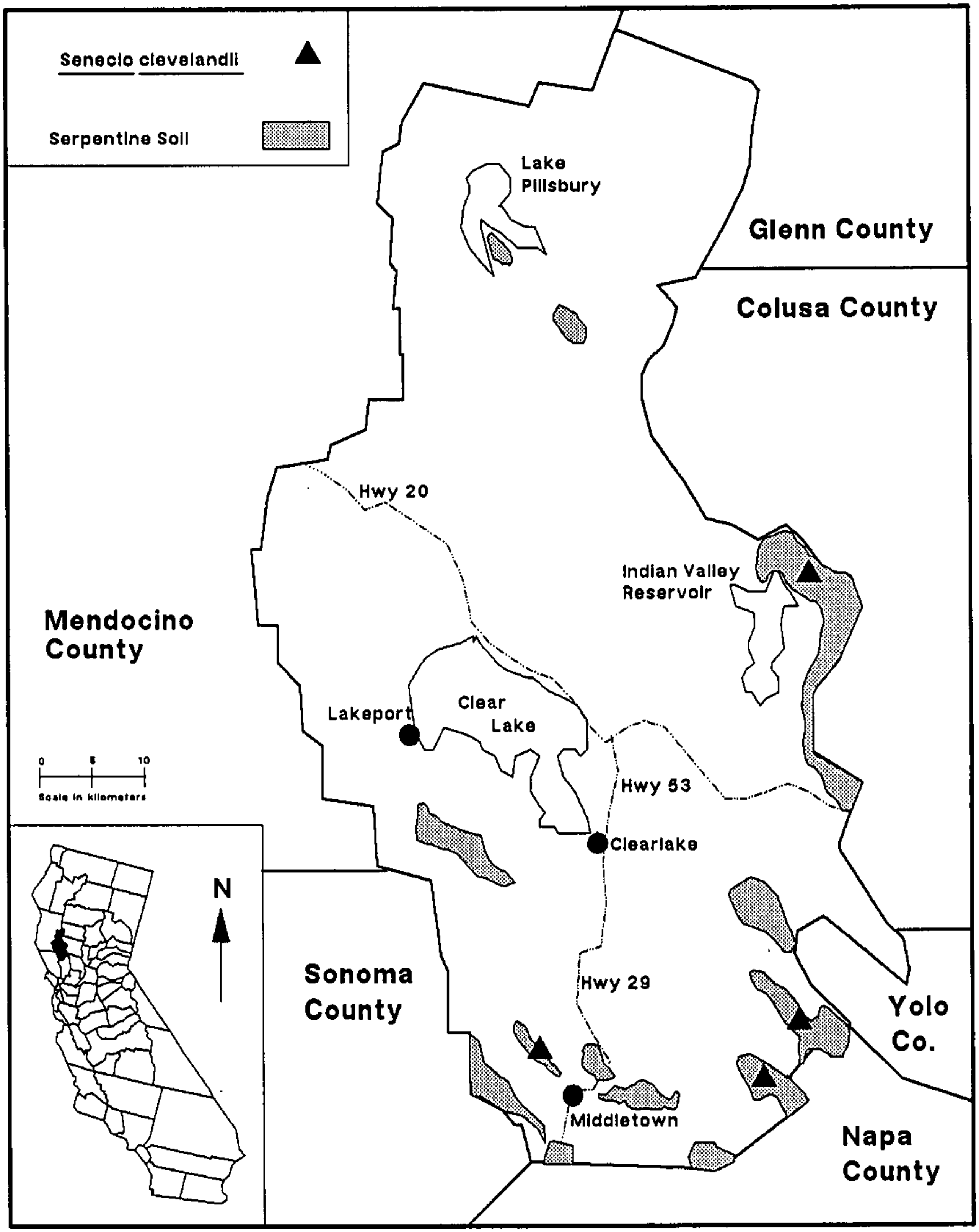
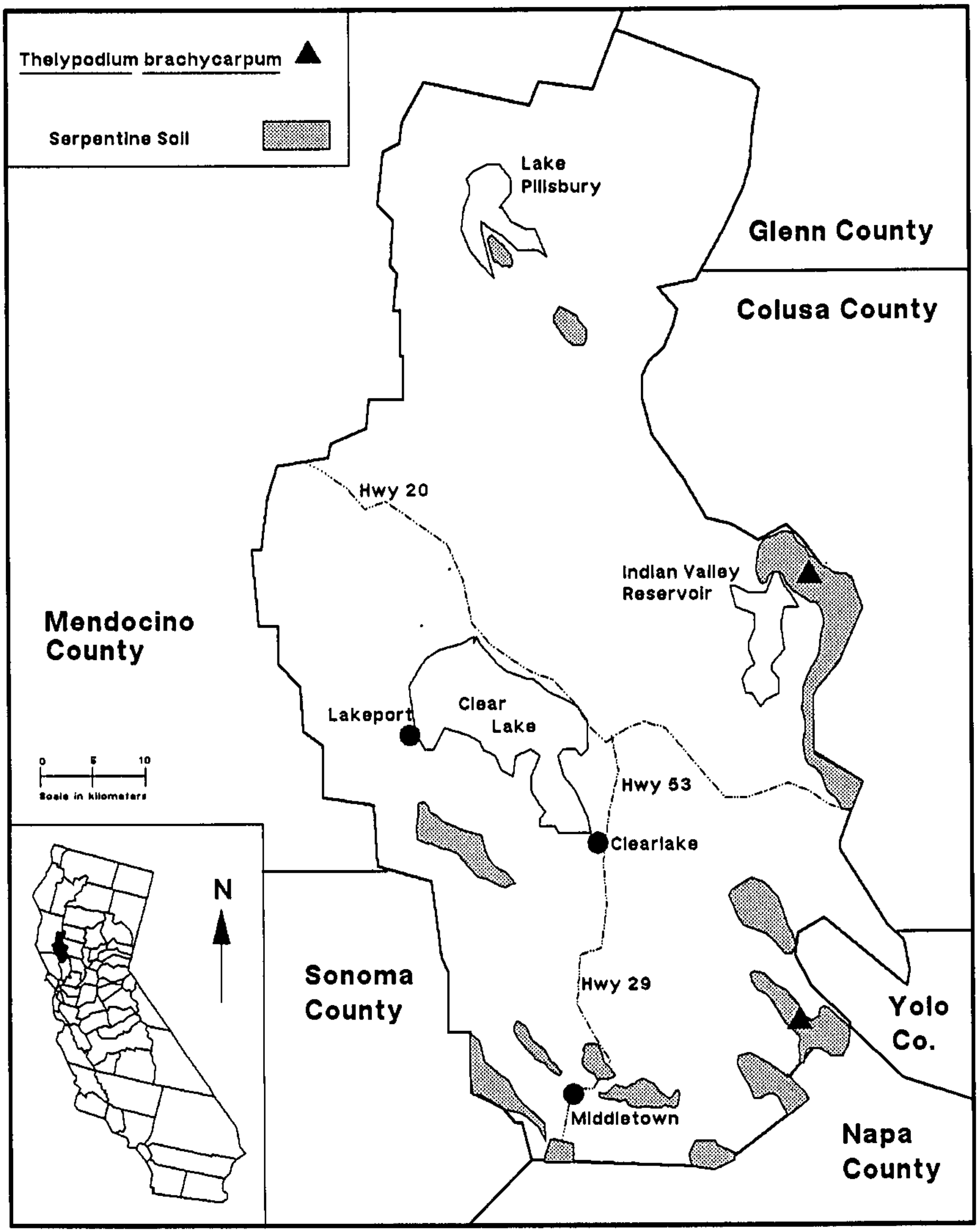


FIGURE A54
Distribution of Rare Plants in Serpentine Soil Habitats in Lake County, California



APPENDIX B

List of taxa grouped alphabetically by plant family found growing in serpentine soil habitats in Lake County, California. The column titled California Native indicates that it is a native species if there is a plus sign, or non-native if there is a minus sign. The column titled Serpentine Endemic indicates the species is only known to occur on serpentine soil if there is a plus sign, or occurs both on and off of serpentine soil if there is a minus sign.

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Vascular Plants Occurring Serpentine Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
** Alliaceae		
Allium amplectens	-	+
Allium breweri	-	+
Allium cratericola	+	+
Allium dichlamydeum	+	+
Allium falcifolium	-	+
Allium fimbriatum var. purdyi	+	+
Allium lacunosum	-	+
Allium serratum	-	+
Allium triquetrum	-	+
Allium unifolium	-	+
Muilla maritima	-	+
** Amaryllidaceae		
Brodiaea congesta	-	+
Brodiaea coronaria	-	+
Brodiaea elegans	-	+
Brodiaea peduncularis	-	+
Brodiaea pulchella	-	+
Triteleia hyacinthina	-	+
Triteleia laxa	-	+
Triteleia lutea	-	+

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Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
** Anacardiaceae		
Rhus trilobata var. quinta	-	+
** Apiaceae		
Angelica tomentosa	-	+
Apiastrum angustifolium	-	+
Bowlesia incana	-	+
Caucalis microcarpa	-	+
Daucus pusillus	-	+
Foeniculum vulgare	-	-
Lomatium californicum	-	+
Lomatium ciliolatum var. hooveri	+	+
Lomatium dasycarpum	-	+
Lomatium macrocarpum	-	+
Lomatium marginatum	-	+
Lomatium utriculatum	-	+
Perideridia kelloggii	-	+
Sanicula arctopoides	-	+
Sanicula bipinnatifida var. bipinnatifida	-	+
Sanicula bipinnatifida ssp. patula	-	+
Sanicula crassicaulis	-	+
Sanicula tuberosa	-	+
Scandix pecten-veneris	-	-

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Tauschia kelloggii	-	+
** Asclepiadaceae		
Asclepias fascicularis	-	+
Asclepias solanoana	+	+
** Asteraceae		
Achillea millefolium	-	+
Achyrachaena mollis	-	+
Agoseris apargioides	-	+
Agoseris grandiflora	-	+
Agoseris heterophylla	-	+
Artemisia douglasiana	-	+
Aster chilensis ssp. chilensis	-	+
Aster radulinus	+	+
Baccharis pilularis var. consanguinea	-	+
Balsamorhiza macrolepis	-	+
Bidens laevis	-	+
Brickellia californica	-	+
Calycadenia mulitglandulosa var. cephalotes	+	+
Calycadenia multiglandulosa ssp. robusta	-	+
Calycadenia pauciflora	+	+
Carduus pycnocephala	-	-

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Centaurea calcitrapa	-	-
Centaurea melitensis	-	-
Centaurea solstitialis	-	-
Chaenactis glabriuscula var. megacephala	-	+
Chaenactis glabriuscula var. gracilenta	+	+
Chaetopappa alsinoides	-	+
Circium breweri	-	+
Cirsium cymosum	-	+
Cirsium proteanum	-	-
Cirsium vulgare	-	-
Erigeron foliosus	-	+
Erigeron inornatus var. angustatus	-	+
Erigeron inornatus var. inornatus	-	+
Eriophyllum confertiflorum	-	+
Eriophyllum lanatum var. achillaeoides	-	+
Eriophyllum lanatum var. lanceolatum	-	+
Evax sparsiflora	-	+
Filago californica	-	+
Filago galica	-	-
Gnaphalium beneolens	-	+
Gnaphalium californicum	-	+

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Gnaphalium chilense	-	-
Gnaphalium purpurium	-	+
Grindelia camporum var. camporum	-	+
Grindelia hirsutula	-	+
Grindelia procera	-	+
Gutierrezia californica	-	+
Helenium bigelovii	-	+
Helianthella californica	-	+
Helianthus exilis	+	+
Hemizonia clevelandii	-	+
Hemizonia luzulaefolia var. lutescens	-	+
Hemizonia luzulaefolia ssp. luzulaefolia	-	+
Hemizonia luzulaefolia ssp. rudis	-	+
Hemizonia multicaulis ssp. vernalis	-	+
Hemizonia pungens ssp. maritima	-	+
Hieracium albiflorum	-	+
Holocarpha virgata	-	+
Hypochoeris glabra	-	-
Hypochoeris radicata	-	-
Lactuca saligna	-	-
Lactuca serriola	-	-

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Lagophylla minor	-	+
Lagophylla ramosissima	-	+
Lasthenia californica	-	+
Lasthenia glabrata	-	+
Layia platyglossa ssp. campestris	-	+
Lessingia germanorum var. tenuipes	-	+
Lessingia hololeuca var. hololeuca	-	+
Lessingia ramulosa	-	+
Madia elegans ssp. densifolia	-	+
Madia exigua	-	+
Madia gracilis	-	+
Madia hallii	+	+
Madia sativa	-	+
Malacothrix floccifera	-	+
Micropus californicus	-	+
Microseris acuminata	-	+
Microseris bigelovii	-	+
Microseris decipiens	-	+
Microseris douglasii ssp. douglasii	-	+
Microseris lindleyi	-	+
Microseris linearifolia	-	+

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Psilocarphus tenellus	-	+
Rafinesqia californica	-	+
Rigiopappus leptocladus	-	+
Senecio clevelandii var. clevelandii	+	+
Senecio eurycephalus	-	+
Senecio greenei	+	+
Silybum marianum	-	-
Sisymbrium altissimum	-	-
Solidago californica	-	+
Solidago occidentalis	-	-
Sonchus asper	-	-
Stephanomeria virgata	-	+
Stylocline filaginea	-	+
Wyethia angustifolia	-	+
Wyethia glabra	-	+
Wyethia helenioides	-	+
** Boraginaceae		
Amsinckia intermedia	-	+
Amsinckia retrorsa	-	+
Chorizanthe membranacea	-	+
Cryptantha affinis	-	+

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Cryptantha flaccida	-	+
Cryptantha hispidula	+	+
Cryptantha muricata	-	+
Cynoglossum grande	-	+
Heliotropium currisavicum var. occulatum	-	+
Pectocarya penicillata	-	+
Pectocarya pusilla	-	+
Plagiobothrys canescens	-	+
Plagiobothrys diffusus	-	+
Plagiobothrys fulvus var. campestris	-	+
Plagiobothrys nothofulvus	-	+
Plagiobothrys tenella	-	+
** Brassicaceae		
Arabis breweri	-	+
Arabis modesta	-	+
Brassica hirta	-	-
Brassica nigra	-	-
Capsella bursa-pastoris	-	-
Cardamine intergrifolia var. sinuata	-	+
Cardamine oligosperma	-	-
Dentaria californica	-	+

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Dentaria pachystigma var. dissectifolia	-	+
Erysimum capitatum	-	+
Lepidium lasiocarpum	-	+
Lepidium nitidum	-	+
Streptanthus barbiger	+	+
Streptanthus brachiatus	+	+
Streptanthus breweri	+	+
Streptanthus glandulosus ssp. secundus	+	+
Streptanthus hesperidis	+	+
Streptanthus morrisonii	+	+
Thelypodium brachycarpum	-	+
Thelypodium lasiophyllum	-	+
Thlaspi montanum var. montanum	+	+
** Calycanthaceae		
Calycanthus occidentalis	-	+
** Campanulaceae		
Heterocodon rariflorum	-	+
** Caprifoliaceae		
Lonicera hispidula	-	+
Lonicera interrupta	-	+
Sambucus caerulea	-	+

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Sambucus mexicana	-	+
Symphoricarpos mollis	-	+
Symphoricarpus albus var. laevigatus	-	+
** Caryophyllaceae		
Linaria texana	-	+
Minuartia californica	-	+
Minuartia douglasii	-	+
Sagina apetala var. barbata	-	+
Sagina occidentalis	-	+
Scleranthus annuus	-	-
Silene californica	-	+
Silene campanulata ssp. glandulosa	+	+
Silene campanulata ssp. campanulata	+	+
Silene gallica	-	-
Silene verecunda ssp. platyota	-	+
Stellaria media	-	-
Stellaria nitens	-	-
Velezia rigida	-	-
** Chenopodiaceae		
Chenopdium californicum	-	+
Chenopodium album ?	-	-

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Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
** Convolvulaceae		
Calystegia collina ssp. collina	+	+
Calystegia collina ssp. oxyphylla	-	+
Calystegia malacophylla	-	+
Calystegia polymorpha	-	-
Calystegia purpurata ssp. solanensis	-	+
Calystegia subacaulis	-	+
Convolvulus occidentalis	-	+
** Cornaceae		
Cornus sericea ssp. occidentalis	-	+
** Crassulaceae		
Crassula erecta	-	+
Dudleya cymosa	-	+
** Cucurbitaceae		
Marah watsonii	-	+
** Cupressaceae		
Calocedrus decurrens	-	+
Cupressus macnabiana	-	+
Cupressus sargentii	-	+
** Cuscutaceae		
Cuscuta californicum	-	+

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SCIENTIFIC NAME	Serpentine Endemic	California Native
** Cyperaceae		
Carex mendocinensis	+	+
Carex serratodens	-	+
Eleocharis palustris	-	+
** Ericaceae		
Arbutus menziesii	-	+
Arctostaphylos manzanita	-	+
Arctostaphylos viscida	-	+
Rhododendron occidentalis	-	+
** Euphorbiaceae		
Euphorbia crenulata	-	+
Euphorbia spathulata	-	+
** Fabaceae		
Astragalus Purshii var. tinctus	-	+
Astragalus breweri	+	+
Astragalus clevelandii	+	+
Astragalus gambelianus	+	+
Astragalus rattanii var. jepsonianus	+	+
Lotus corniculatus	-	+
Lotus crassifolius	-	+
Lotus humistratus	-	+

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Lotus micranthus	-	+
Lotus purshianus	-	+
Lotus subpinnatus	-	+
Lupinus albifrons ssp. collinus	-	+
Lupinus bicolor	-	+
Lupinus bicolor ssp. tridentatus	+	+
Lupinus densiflorus	-	+
Lupinus nanus	-	+
Lupinus sericatus	-	+
Lupinus subvexus	-	+
Lupinus succulentus	-	+
Medicago polymorpha	-	-
Melilotus indicus	-	-
Pickeringia montana	-	+
Psoralea macrostachya	-	+
Spartium junceum	-	-
Thermospsis macrophylla var. macrophylla	-	+
Trifolium albopurpureum	-	+
Trifolium amplectens	-	+
Trifolium barbigerum	-	+
Trifolium bifidum var. decipiens	-	+

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Trifolium ciliolatum	-	+
Trifolium dubium	-	-
Trifolium fucatum var. fucatum	-	+
Trifolium fucatum var. virescens	-	+
Trifolium gracilentum	-	+
Trifolium macraei	+	+
Trifolium microcephalum	-	+
Trifolium microdon	-	+
Trifolium olivaceum var. griseum	-	+
Trifolium tridentatum	-	+
Trifolium variegatum	-	-
Vicia angustifolia	-	+
Vicia angustifolia var. segetalis	-	+
** Fagaceae		
Quercus chrysolepis	-	+
Quercus durata	-	+
** Garryaceae		
Garrya congdoni	-	+
** Gentianaceae		
Centaurium davyi	-	+
Centaurium muehlenbergii	-	+

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Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Centaurium tricanthum	-	+
Githopsis specularioides	-	+
Microcala quadrangularis	-	-
** Geraniaceae		
Erodium cicutarium	-	-
Erodium obtusiplicatum	-	-
Geranium carolinianum	-	-
Geranium dissectum	-	-
Geranium molle	-	-
** Grossulariaceae		
Grossularia californica	-	+
** Hydrophyllaceae		
Eriodictyon californicum	-	+
Eriodyctyon trichocalyx	-	+
Nemophila heterophylla	-	+
Nemophila menziesii var. atomaria	-	+
Nemophila menziesii var. menziesii	-	+
Phacelia californica	-	+
Phacelia corymbosa	-	+
Phacelia distans	-	+
Phacelia divaricata	-	+

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Phacelia heterophylla	-	+
Phacelia imbricata	-	+
** Hypericaceae		
Hypericum concinum	-	-
** Iridaceae		
Iris macrosiphon	-	+
Sisyrinchium bellum	-	-
** Juncaceae		
Juncus bufonius	-	+
Juncus effusus var. brunneus	-	+
Juncus effusus var. pacificus	-	+
Juncus patens	-	+
Juncus phaeocephalus	-	+
** Lamiaceae		
Lepichinia calycina	-	+
Mentha pulegium	-	-
Monardella douglasii ssp. douglasii	-	+
Monardella odoratissima ssp. pinetorum	-	+
Monardella villosa ssp. neglecta	-	+
Monardella villosa ssp. villosa	-	+
Pogogyne serpylloides	-	+

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SCIENTIFIC NAME	Serpentine Endemic	California Native
Prunella vulgaris ssp. lanceolata	-	+
Salvia columbariae	-	+
Salvia sonomensis	-	+
Scutellaria austinae	-	+
Scutellaria californica	-	+
Scutellaria tuberosa	-	+
Stachys albens	-	+
Stachys arvensis	-	-
Stachys bullata	-	-
Stachys pycnacantha	-	-
Stachys rigida ssp. quercetorum	-	+
Stachys stricta	-	+
Trichostema laxum	-	+
** Lauraceae		
Umbellaria californica	-	+
** Liliaceae		
Calochortus albus	-	+
Calochortus amabilis	-	+
Calochortus coeruleus var. fimbriata	-	+
Calochortus luteus	-	+
Calochortus superbus	-	+

APPENDIX B

Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Calochortus umbellatus	-	+
Calochortus venustus	+	+
Calochortus vestae	+	+
Chlorogalum pomeridianum var. minus	-	+
Erythronium heleniae	+	+
Fritillaria lanceolata	-	+
Fritillaria pluriflora	-	+
Fritillaria purdyi	+	+
Fritillaria recurva var. coccinea	+	+
Smilacina racemosa var. amplexicaulis	-	+
Trillium chloropetalum	-	+
Zygadenus fontanus	-	+
Zygadenus fremontii	-	+
Zygadenus micranthus	-	+
** Linaceae		
Hesperolinon adenophyllum	+	+
Hesperolinon bicarpellatum	+	+
Hesperolinon californicum	-	+
Hesperolinon clevelandii	-	+
Hesperolinon didymocarpum	+	+
Hesperolinon disjunctum	+	+

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Hesperolinon drymarioides	+	+
Hesperolinon micranthum	-	+
Hesperolinon spergulinum	+	+
Linum bienne	-	-
** Lobeliaceae		
Nemacladus montanus	+	+
** Malvaceae		
Malva parviflora	-	-
Sidalcea diploscypha	-	+
Sidalcea malvaeflora	-	-
** Oleaceae		
Fraxinus dipetala	-	+
** Onagraceae		
Clarkia affinis	-	+
Clarkia concinna	-	+
Clarkia gracilis	-	+
Clarkia purpurea ssp. purpurea	-	+
Clarkia purpurea ssp. viminea	-	+
Clarkia purpurea var. quadrivulnera	-	+
Clarkia rubicunda ssp. rubicunda	-	+
Epilobium ciliatum ssp. ciliatum	-	+

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Epilobium foliosum	-	+
Epilobium minutum	-	+
Epilobium paniculatum	-	+
Gayophytum humile	-	+
Oenothera ovata	-	+
** Orchidaceae		
Epipactis gigantea	-	+
** Orobanchaceae		
Orobanche californica ssp. jepsonii	-	+
Orobanche fasciculata	-	+
Orobanche valida ssp. howelii	-	+
** Papaveraceae		
Eschscholtzia caespitosa var. hyperecoides	-	+
Eschscholtzia californica	-	+
Platystemon californicus	-	+
** Pinaceae		
Pinus attenuata	-	+
Pinus sabiniana	-	+
** Plantaginaceae		
Plantago hookeriana var. californica	-	+
Plantago lanceolata	-	-

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
** Poaceae		
Agropyron trachycaulum	-	+
Agrostis exarata	-	+
Agrostis hallii	-	+
Agrostis microphylla	-	+
Aira caryophyllea	-	+
Avena barbata	-	-
Avena fatua	-	-
Briza minor	-	-
Bromus carinatus	-	-
Bromus diandrus	-	-
Bromus madritensis	-	-
Bromus mollis	-	-
Bromus rubens	-	-
Bromus tectorum var. glabratus	-	-
Calamagrostis ophitidis	+	+
Danthonia californica	-	+
Deschampsia caespitosa	-	+
Deschampsia danthonoides	-	+
Elymus caput-medusae	-	-
Elymus glaucus	-	+

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Festuca californica	-	+
Festuca idahoensis	-	+
Festuca rubra	-	+
Gastridium ventricosum	-	-
Hordeum brachyantherum	-	+
Hordeum brachyantherum	-	+
Hordeum californicum	-	+
Hordeum geniculatum	-	-
Hordeum leporinum	-	-
Koeleria macrantha	-	+
Lamarckia aurea	-	-
Lolium multiflorum	-	-
Melica californica	-	+
Melica hardfordii	-	+
Melica imperfecta	-	+
Melica torreyana	-	-
Phalaris californica	-	+
Poa annua	-	-
Poa melitensis	-	-
Poa scabrella	-	+
Polypogon monspeliensis	-	-

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Scribneria bolanderi	-	-
Sitanion hystrix	-	+
Sitanion jubatum	-	+
Stipa lemmonii var. jonesii	-	+
Stipa lemmonii var. lemmonii	-	+
Stipa lepida	-	+
Stipa pulchra	-	+
Vulpia microstachys	-	+
Vulpia myuros	-	+
Vulpia pacifica	-	+
** Polemoniaceae		
Collomia diversifolia	-	+
Collomia grandiflora	-	+
Collomia greenei	+	+
Collomia tinctoria	-	+
Gilia achilleaefolia ssp. achilleaefolia	-	+
Gilia capitata	-	+
Gilia clivorum	-	+
Gilia leptalea ssp. pinnatisecta	-	+
Gilia tricolor	-	+
Linanthus ambiguus	-	+

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Linanthus androsaceous	-	+
Linanthus bicolor	-	+
Linanthus dichotomus	-	+
Linanthus liniflorus	-	+
Linanthus pygmaeus	-	+
Linanthus rattanii	-	+
Microsteris gracilis ssp. humilis	-	+
Navarretia divaricata	-	+
Navarretia heterodoxa ssp. rosulata	-	+
Navarretia intertexta	-	+
Navarretia jepsonii	+	+
Navarretia mitricarpa	+	+
Navarretia pubescens	-	+
** Polygalaceae		
Polygala californica	-	+
** Polygonaceae		
Eriogonum compositum var. compositum	-	+
Eriogonum nervulosum	+	+
Eriogonum nudum	-	+
Eriogonum strictum ssp. proliferum	-	+
Eriogonum umbellatum	-	+

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Eriogonum vimineum	+	+
Eriogonum virgatum	-	+
Pterostegia drymarioides	-	+
Rumex crispus	-	-
Rumex pulcher	-	-
Rumex salicifolius var. salicifolius	-	+
** Polypodiaceae		
Polypodium californicum	-	+
** Portulacaceae		
Calandrinia ciliata var. menziesii	-	+
Calyptridium quadripetalum	+	+
Claytonia saxosa	+	+
Claytonia spathulata var. exigua	-	+
Claytonia spathulata var. tenuifolia	-	+
Lewisia rediviva	-	+
Montia gypsophiloides	+	+
Montia hallii	-	+
Montia perfoliata	-	+
Montia spathulata var. exigua	-	+
** Primulaceae		
Anagallis arvensis	-	-

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Dodecatheon hendersonii ssp. cruciatum	-	+
Dodecatheon hendersonii ssp. hendersonii	-	+
** Pteridaceae		
Adiantum jordanii	-	+
Aspidotis carlotta-halliae	-	+
Cheilanthes intertexta	-	+
Cheilanthes siliquosa	-	+
Onychium densum	-	+
Pellaea andromedaefolia	-	+
Pellea mucronata	-	+
Pityrogramma triangularis	-	+
** Pyrolaceae		
Pyrola picta ssp. integra	-	+
** Ranunculaceae		
Aquilegia eximia	-	+
Delphinium hesperium	-	+
Delphinium uliginosum	+	+
Delphiniun variegatum	-	+
Ranunculus californicus	-	+
Ranunculus occidentalis var. ultramontanus	-	+

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
** Rhamnaceae		
Ceanothus confusus	-	+
Ceanothus cordulatus	-	+
Ceanothus cuneatus	-	+
Ceanothus divergens	+	+
Ceanothus intergerrimus var. californicus	-	+
Ceanothus jepsonii var. albiflorus	+	+
Ceanothus parryi	-	+
Rhamnus californica	-	+
Rhamnus californica ssp. tomentella	-	+
Rhamnus crocea	-	+
Toxicodendron diversilobum	-	+
** Rosaceae		
Adenostoma fasciculatum	-	+
Alchemilla occidentalis	-	+
Heteromeles arbutifolia	-	+
Holodiscus boursieri	-	+
Horkelia elata	-	+
Horkelia tridentata ssp. flavescens	-	+
Rosa californica	-	+
Rubus ursinus	-	+

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
** Rubiaceae		
Galium andrewsii	-	+
Galium aparine	-	+
Galium bolanderi	-	+
Galium nuttallii	-	+
Galium parisense	-	+
Sherardia arvensis	-	+
** Salicaceae		
Salix breweri	-	+
** Saxifragaceae		
Parnassia palustris var. californica	-	+
Saxifriga californica	-	+
Whipplea modesta	-	+
** Scrophulariaceae		
Antirrhinum breweri	+	+
Antirrhinum cornutum	-	+
Antirrhinum virga	-	+
Bellardia trixago	-	-
Castilleja foliosa	-	+
Castilleja martinii	-	+
Castilleja stenantha	-	+
Castilleya applegatei var. fragilis	-	+

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Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Collinsia franciscana	-	+
Collinsia greenei	+	+
Collinsia heterophylla	-	+
Collinsia rattanii	-	+
Collinsia sparsiflora var. collina	-	+
Cordylanthus pilosus	-	+
Cordylanthus rigidus	-	+
Cordylanthus tenuis ssp. brunneus	-	+
Keckiella breviflora ssp. glabrisepala	-	+
Keckiella corymbosa	-	+
Keckiella lemmonii	-	+
Mimulus aurantiacus	-	+
Mimulus brachiatus	+	+
Mimulus douglasii	-	+
Mimulus floribundus	-	+
Mimulus guttatus	-	+
Mimulus nudatus	+	+
Mimulus pilosus	-	+
Orthocarpus attenuatus	-	+
Orthocarpus densiflorus	-	+
Orthocarpus erianthus var. erianthus	-	+

APPENDIX B

Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
Orthocarpus floribundus	-	+
Orthocarpus lithospermoides	-	-
Orthocarpus purpurascens var. purpurascens	-	+
Orthocarpus pusillus	-	+
Pedicularis densiflora	-	+
Penstemon heterophylla	-	+
Penstemon purpusii	-	+
Scrophularia californica	-	+
Verbascum blattaria	-	-
Veronica perigrina ssp. xalapensis	-	+
** Solanaceae		
Solanum parrishii	-	+
Solanum umbelliferum	-	+
** Sterculiaceae		
Fremontodendron californicum var. crassifolium	-	+
** Valerianaceae		
Plectritis ciliosa ssp. ciliosa	-	+
Plectritis ciliosa ssp. insignis	-	+
Plectritis congesta	-	+
Plectritis macrocera	-	+

APPENDIX B

Vascular Plants Occurring Serpentine
Soil Habitats in Lake County, California

SCIENTIFIC NAME	Serpentine Endemic	California Native
** Verbenaceae		
Verbena lasiotachys	-	+
** Violaceae		
Viola douglasii	-	+
Viola ocellata	-	+
Viola purpurea ssp. purpurea	-	+
** Viscaceae		
Phoradendron bolleanum ssp. densum	-	+
Phoradendron villosum	-	+
** Vitaceae		
Vitis californica	-	+

APPENDIX C

Mapped areas of significant serpentine habitats in Lake County, and lists of rare plant taxa and plant communities or other significant features associated with each area.

SIGNIFICANT SERPENTINE AREA 1

Name: Complexion Springs (Figure C1)

Rare Taxa (rarer taxa listed first):

Eriogonum nervulosum
Streptantus morrisonii
Asclepias solanoana
Collomia diversifolia
Delphinium uliginosum
Senecio clevelandii
Hesperolinon drymarioides
Allium fimbriatum var. *purdyi*
Astragalus clevelandii
Cryptantha hispidula
Helianthus exilis

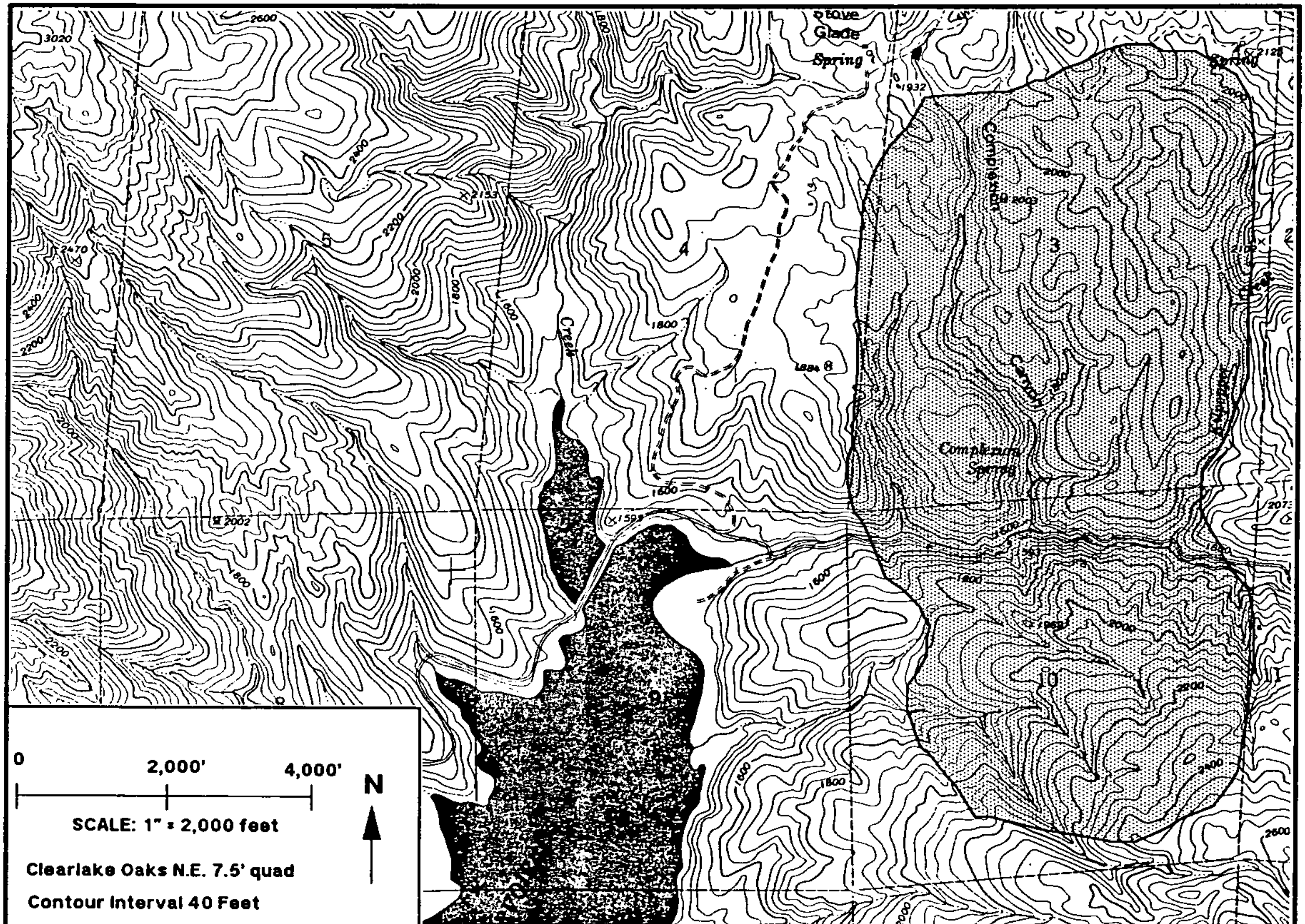
Plant Communities and Habitat Features:

Serpentine barrens
Serpentine Riparian
Cupressus macnabiana type northern interior cypress forest
Mixed type serpentine chaparral
Arctostaphylos viscida type serpentine chaparral
Serpentine seep

Total Area: 1,100 acres

FIGURE C1

Significant Areas of Serpentine Soil Habitats in Lake County



SIGNIFICANT SERPENTINE AREA 2

Name: Middletown (Figure C2)

Rare Taxa (rare taxa liste first):

Hesperolinon didymocarpum | Madia hallii
Astragalus breweri | Astragalus rattanii var. jepsonianus
Collomia diversifolia | Delphinium uliginosum
Hesperolinon bicarpellatum | Navarretia jepsonii

Plant Communities and Habitat Features:

Serpentine grassland

Mixed type serpentine chaparral

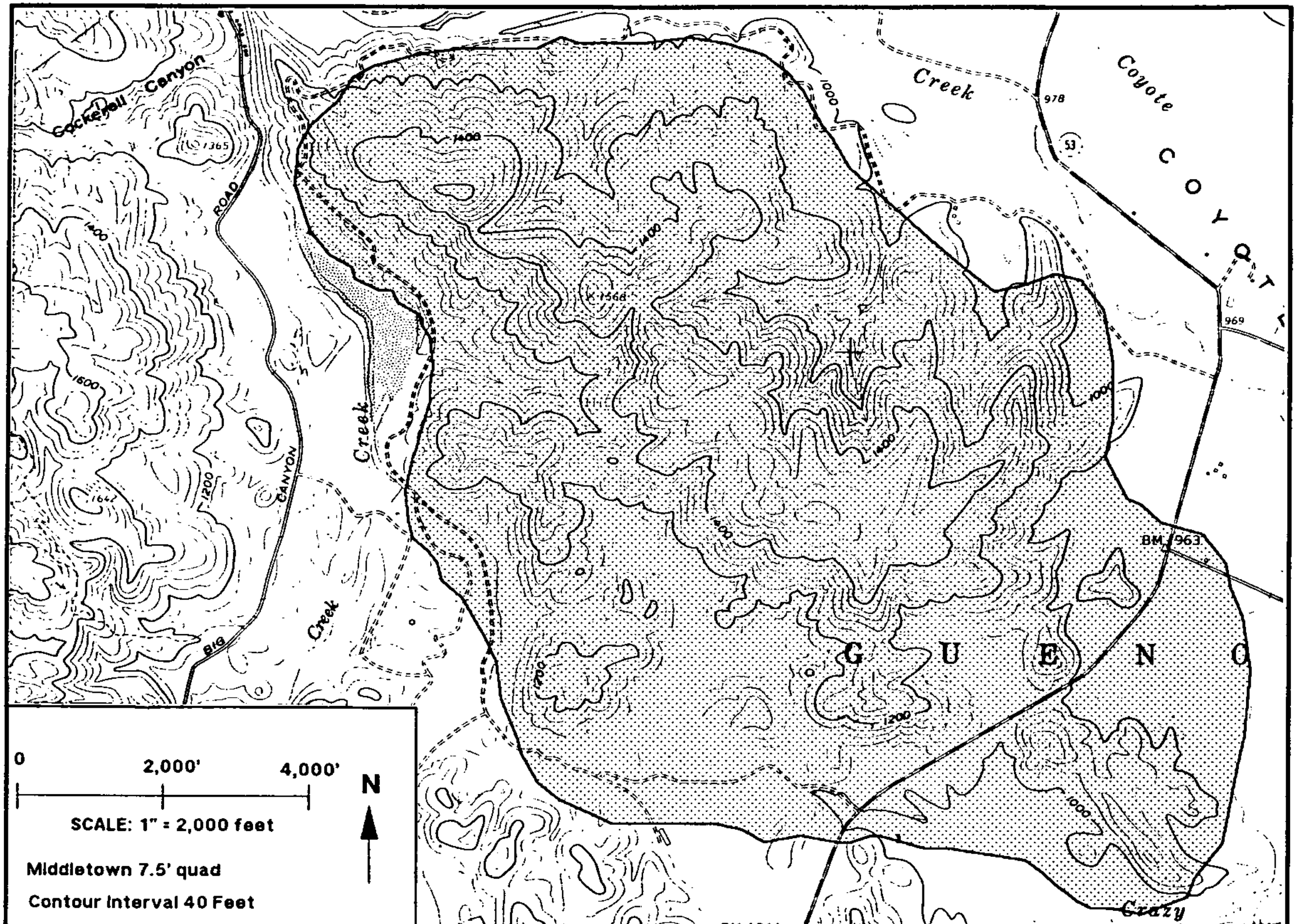
Quercus durata type serpentine chaparral

Serpentine seep

Total Area: 2,300 acres

FIGURE C2

Significant Areas of Serpentine Soil Habitats in Lake County



SIGNIFICANT SERPENTINE AREA 3

Name: Harbin Ridge (Figure C3)

Rare taxa (rarer taxa listed first):

Ceanothus confusus

Astragalus clevelandii

Calamagrostis ophitidis

Cryptantha hispidula

Fritillaria purdyi

Hesperolinon bicarpellatum

Mimulus nudatus

Streptanthus brachiatus

Asclepias solanoana

Collomia diversifolia

Delphinium uliginosum

Helianthus exilis

Hesperolinon spergulinum

Navarretia jepsonii

Plant Communities and Habitat Features:

Mixed type serpentine chaparral

Arctostaphylos viscida type serpentine chaparral

Quercus durata type serpentine chaparral

Cupressus macnabiana type northern interior cypress forest

Cupressus sargentii type northern interior cypress forest

Serpentine riparian woodland

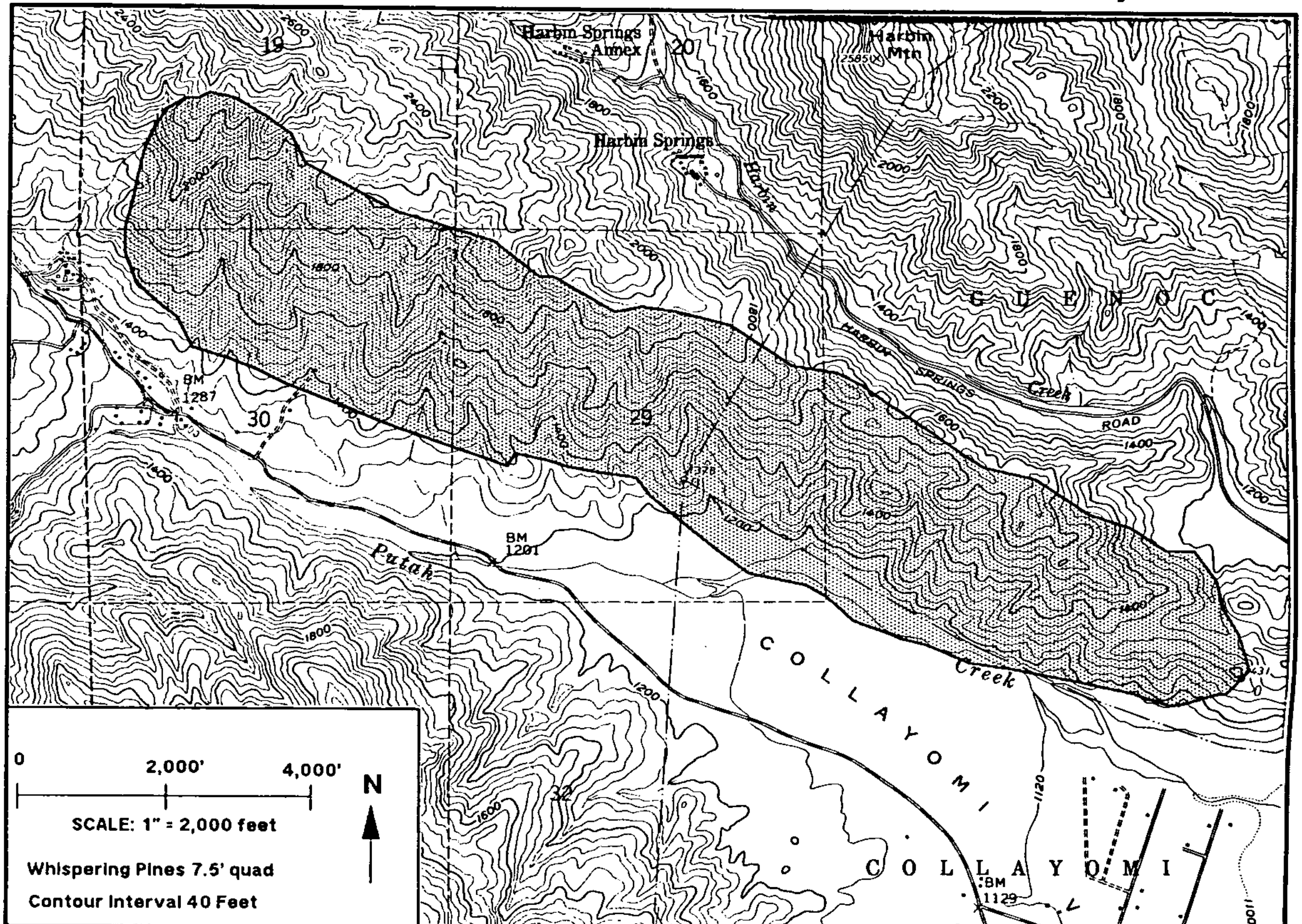
Serpentine barrens

Serpentine seep

Total Area: 1,100 acres

FIGURE C3

Significant Areas of Serpentine Soil Habitats in Lake County



SIGNIFICANT SERPENTINE AREA 4

Name: Dunnigan Hill (includes parts of Napa County) (Figure C4)

Rare Taxa (rarer taxa listed first):

Eriogonum nervulosum	Hesperolinon drymarioides
Streptanthus morrisonii	Astragalus clevelandii
Asclepias solanoana	Collomia diversifolia
Cryptantha hispidula	Delphinium uliginosum
Helianthus exilis	Mimulus nudatus
Navarretia jepsonii	Nemocladus montanus
Orobanche vallida ssp. howellii	Senecio clevelandii

*Arabis modesta is also mapped in D'Appalonnia (1982) as occurring in this area. See discussion in Appendix A of this report for note.

Plant Communities and Habitat Features:

Mixed type serpentine chaparral

Arctostaphylos viscida type serpentine chaparral

Cupressus macnabiana type northern interior cypress forest

Serpentine barrens

Serpentine riparian woodland

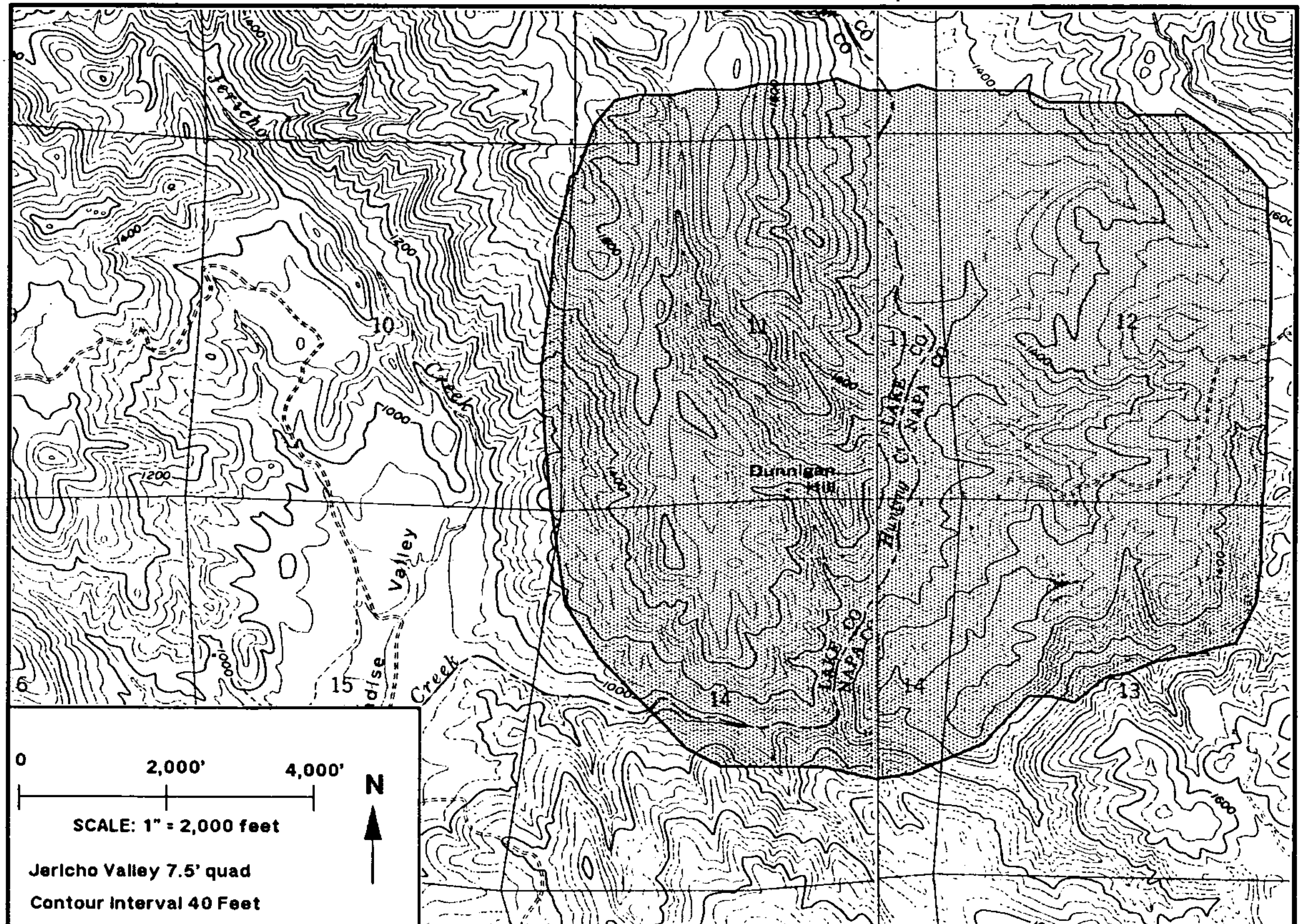
Serpentine seep

Serpentine digger pine-chaparral woodland

Total Area: 1,740 acres

FIGURE C4

Significant Areas of Serpentine Soil Habitats in Lake County



SIGNIFICANT SERPENTINE AREA 5

Name: Round Mountain (Figure C5)

Rare plant taxa (rarer taxa listed first):

Streptanthus morrisonii

Calyptridium quadripetalum

Delphinium uliginosum

Fritillaria purdyi

Mimulus nudatus

Nemocladus montanus

Senecio clevelandii

Astragalus clevelandii

Collomia diversifolia

Fritillaria pluriflora

Helianthus exilis

Navarretia jepsonii

Orobanche vallida ssp. *howellii*

Plant Communities and Habitat Features:

Mixed type serpentine chaparral

Arctostaphylos viscida type serpentine chaparral

Curpessus macnabiana type northern interior cypress forest

Serpentine seep

Serpentine barrens

Total Area: 1,110 acres

FIGURE C5

Significant Areas of Serpentine Soil Habitats in Lake County