Conservation Assessment

for ***Cypripedium fasciculatum*** **and** ***Cypripedium montanum***

Region 5-USDA Forest Service

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Disclaimer

This Conservation Assessment was compiled to synthesize published and unpublished information on two species of lady's slipper orchid, and was prepared by the Institute for Applied Ecology, a not-for-profit organization. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Regional Botanist at the USDA Forest Service, Pacific Southwest Regional Office, 1323 Club Dr., Vallejo, California, 94592.

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Executive Summary

Purpose

The impetus for developing the Conservation Assessment for *Cypripedium fasciculatum* and *Cypripedium montanum* arose from the Sierra Nevada Forest Plan Amendment Environmental Impact Statement, 2001. While, the primary goal of this document is to determine the conservation status of these species throughout the Sierra Nevada, the document's scope also includes discussion of both species throughout Region 5, and in the context of the species' range as a whole.

This conservation assessment addresses the biology, management and conservation of *Cypripedium fasciculatum* (clustered lady's slipper) and *C. montanum* (mountain lady's slipper). Conservation assessments may cover one to several species, where life history characteristics, habitat and distribution, and management concerns make grouping more effective and efficient. Due to the similar nature of these two species of lady's slipper, they are treated together in this document. This conservation assessment provides the foundation for guiding the development of management and monitoring plans for these species.

Management Status

Given the relatively wide geographic distribution of clustered and mountain lady's slipper in the western U.S, at the national level, Natural Heritage Programs give these species a global ranking of G4 (up to G5 for mountain lady's slipper) indicating that these species are apparently secure throut their range. Both of these lady's slipper species are listed as Sensitive Species by the U.S Forest Service Region 5, which encompasses the National Forests in California. They are also Sensitive Species in Region 6, Oregon and Washington. The Bureau of Land Management lists clustered and mountain lady's slippers as a Bureau Sensitive Species.

The California Native Plant Society ranks these species as a List 4 or watch list species. This ranking indicates that these species are of limited distribution in California and are also considered to be rare outside the state. Rankings by state agencies for clustered lady's slipper (S3.2 in California, and S3 in Oregon and Washington) also indicate that this species is rare, threatened or uncommon on a statewide basis. The state ranking for mountain lady's slipper is S4 in California, and S3S4 in Oregon and Washington. These orchids were formerly treated as Survey and Manage Species under the Northwest Forest Plan (Record of Decision 2004, www.or.blm.gov/nwfpnepa/index.htm#Survey _and_Manage).

Range and Habitat

Clustered and mountain lady's slipper have large geographic ranges and similar habitat requirements. Clustered lady's slipper occurs in widely disjunct locations from north central Washington south to California and east to the mountains of Idaho, Montana, Colorado, Wyoming, and Utah. The species has high concentrations of populations in the Sierra Nevada (e.g., Plumas National Forest), northern California and southwestern Oregon. Mountain lady's slipper is found from southern Alaska, British Columbia, and western Alberta south to Montana, Idaho, Wyoming, and California. Its greatest abundance in California is on the Klamath National Forest, but it is widely distributed throughout National Forests (except Tahoe) of the Sierra Nevada.

These species are most often found on north facing slopes in mixed coniferous forests of >60% canopy closure. Douglas-fir is the most common associated tree, but other frequently noted forest components include white fir, mountain dogwood, sugar pine, and incense cedar. Clustered lady's slipper is known to occur at elevations of 600-5800 feet, and mountain lady's slipper at 1300-6350 feet. Both species have

complex life-histories and depend on specific mycorrhizal fungi (Tulasnellaceae) for seed germination and growth. These mycorrhizal fungi may determine where and in which specific habitats these lady's slipper species can grow and how they respond to disturbance, but little information is available on the fungi, their requirements, associated tree species, and their function in forest ecosystems.

Threats

These orchids are sensitive to disturbances that damage their current year's growth, rhizomes, soil surrounding their root systems, and forest canopy (too much light appears to negatively affect them). The primary project related threats to clustered and mountain lady's slipper species include mechanical disturbances and alteration of forest and understory canopy by timber harvest activities, construction of fire lines, power/gas transmission line construction and maintenance, culvert relocation, and other ground disturbing activities. High intensity wildfires which remove canopy and incinerate the soil organic layers, also rank very high as a widespread threat to both species. Other threats include plant collectors, road building and maintenance, recreation, livestock grazing, fuel reduction practices, fire suppression, erosion, prescribed burns, alteration of local hydrology, mining, and invasive species. More than half of the populations of both species have fewer than 10 plants, placing them at high risk. Population declines and losses of both species have been significant over the last two decades, and population extinction has occurred at a high rate (44%-55%) for small populations (<10 plants).

Conservation

Tools and practices to conserve lady's slipper orchids in the Sierra Nevada and throughout the National Forests in Region 5 emphasize maintaining habitat elements for the species, including:

- sufficient forest canopy cover and stand structure to provide shade and filtered light which influences understory temperatures and humidity for plant establishment and growth, as well as suitable habitat conditions for vascular plant associates,
- decayed down logs as well as snags for future log recruitment to favor habitat conditions for mycorrhizal fungi, which may attract fungus gnats that in turn play a role in the pollination of lady's slipper orchids (i.e. clustered lady's slipper),
- adequate cover and depth of the forest floor organic layer (e.g. duff and litter) for retention of soil moisture that affects both the lady's lipper orchids and their fungal associates.

Treatment of areas with high concentrations of fuels to reduce the risk of high intensity fire will protect some populations, but some fuel reduction actions also may damage or compromise these species. Site management that includes entire populations plus surrounding areas to capture dormant plants as well as minimizing edge effects will conserve the species more effectively than partial or unbuffered population protection.

Actions that benefit these species at a regional scale may also help with their overall conservation. Region-wide coordination among public agencies would improve conservation for clustered and mountain lady's slippers to alleviate the cumulative impacts of such activities as timber harvest and grazing, as well as high intensity wildfire. Coordinated approaches that consider habitat connectivity to allow for the spatial and temporal (e.g. dormancy) variations inherent to these species would provide for movement of genetic material among populations and perhaps accommodate the meta-population dynamics of these species.

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Introduction

Goal

The objective of this conservation assessment is to determine the conservation status of clustered lady's slipper (*Cypripedium fasciculatum*) and mountain lady's slipper (*C. montanum*) in Region 5, California. Information used to conduct this assessment emphasizes the best scientific information, literature, and professional expertise currently available. This conservation assessment provides the foundation for guiding the development of management and monitoring plans for these species. The goal of collating and analyzing information on these species is to facilitate the coordination of their conservation across National Forest lands in California.

Scope

The geographic scope of this assessment emphasizes the Sierra Nevada of California, but includes all National Forests in Region 5. The species assessed here have very large geographic ranges and information on their ecology and response to disturbance and management is available from various locations. Little research on them has been conducted within the Sierra Nevada bioregion. Therefore, this assessment draws from studies and observations from areas outside the Sierra Nevada in California as well as other states, especially Oregon and Washington. When information from outside the Sierra Nevada was cited and used to draw inferences about these species and their behavior within the region, the text of this document states so. In addition, study results and observations synthesized here vary in uncertainty, and these limitations are noted where appropriate.

This assessment is also supported by analyses conducted specifically for this document based on a database of information on all known occurrences of clustered and mountain lady's slippers in California (Carothers 2003), including occurrence location, habitat characteristics, population size and monitoring history through 2002 (the terms "population" and "occurrence" are used as synonyms in this document). This information was used by the Institute for Applied Ecology and National Forest GIS staff (John Babin, Tahoe National Forest) to characterize the habitat of these species on National Forests in the Sierra Nevada as well as elsewhere in California, determine the presence of occurrences on lands in different management categories or environmental condition (e.g., grazing allotments, areas in mineral withdrawal, forest fire history), and conduct a preliminary viability analysis. In some cases, these analyses were conducted with the database for all of California rather than just the Sierra Nevada because the increase in available data made conclusions much more robust. Further, Carothers (2002) assembled information that was synthesized and used in this report for a threat assessment for the species in the Sierra Nevada and elsewhere in California.

National Forests within the Sierra Nevada include the Eldorado, Lassen, Modoc, Plumas, Tahoe, and Stanislaus. Yosemite National Park is also within the Sierra Nevada. Those Forests outside this region that have significant populations of lady's slipper orchids and were included in several analyses include the Six Rivers, Shasta-Trinity, Mendocino, and Klamath National Forests.

Management Status

Clustered lady's slipper – Clustered lady's slipper is currently considered a Sensitive Species in Regions 5 and 6 of the USDA Forest Service. National Forests covered under the Northwest Forest Plan recently treated these as Survey and Manage Species, but this designation was converted to Sensitive Species (Record of Decision 2004, www.or.blm.gov/nwfpnepa/index.htm#Survey_and_ Manage). The USDI Bureau of Land Management lists clustered lady's slipper as a Bureau Sensitive

species in California and Oregon. The California Native Plant Society places it on the watch list which indicates that it of limited distribution and rare outside the state. The Oregon Natural Heritage Information Center (ORNHIC) lists clustered lady's slipper as List 2 (threatened with extirpation), and their database indicates a global ranking of G4 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences) (Oregon Natural Heritage Information Center 2004). Clustered lady's slipper is ranked S3.2 on the California list, and S3 on Washington and Oregon lists.

Mountain lady's slipper – Mountain lady's slipper is also currently considered a Sensitive Species in Regions 5 and 6 of the USDA Forest Service. National Forests covered under the Northwest Forest Plan recently treated it as a Survey and Manage Species, but this designation was converted to Sensitive Species (Record of Decision 2004, www.or.blm.gov/nwfpnepa/index.htm#Survey_and_Manage). The USDI Bureau of Land Management lists mountain lady's slipper as a Bureau Sensitive species in California and Oregon. The California Native Plant Society places it on the watch list which indicates that it is of limited distribution and rare outside the state. The Oregon Natural Heritage Information Center (ORNHIC) lists mountain lady's slipper as List 4 (conservation concern), and their database indicates a global ranking of G4G5 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences) (Oregon State University 2003). Mountain lady's slipper is ranked S4 on the California list, and S3S4 on Washington and Oregon lists.

Existing regulatory mechanisms, management plans, and conservation strategies

The Forest Service Handbook defines Sensitive plant species as those plants identified by the Regional Forester for which population viability is a concern (R-5 FSH 2609.25). As a part of the environmental assessment process, Sensitive species receive special management emphasis to ensure their viability and to preclude trends toward endangerment that would result in the need for Federal listing (R-5 FSH 2609.25, 1.21).

The Sierra Nevada Forest Plan Amendment provides for the viability of native plant and animal species associated with old forest ecosystems well-distributed across Sierra Nevada national forests (USDA 2004). The Amendment contributes to maintaining long term viability of U.S. Forest Service sensitive species and contribute to the recovery of threatened, endangered, and proposed plant species and ensure that management activities do not contribute to population declines.

In regards to management plans or related documents, a management plan was drafted for clustered lady's slipper in conjunction with the Northwest Forest Plan Survey and Manage Program (Vance et al., 2004).

Taxonomy

Systematics and synonymy

In 1737, Linnaeus coined the genus *Cypripedium* for members of the orchid family (Orchidaceae) commonly known as lady's slippers. He chose *Cypripedium* from Cyprus, the island on which Aphrodite, Greek goddess of love, was born and *pedilum*, Latin for "shoe" or "slipper." The genus *Cypripedium* contains 45 species, all in the Northern Hemisphere. The center for *Cypripedium* diversity is China, where 30 species are found. Eleven species are native to North America and three species are native to California, *C. californicum*, *C fasciculatum*, and *C. montanum* (Cribb 1997, Coleman 1995). This Conservation Assessment deals with *C. fasciculatum* and *C. montanum*, which are both members of the orchid subfamily Cypripedioideae.

Clustered lady's slipper

Scientific name – *Cypripedium fasciculatum* Kellogg ex S. Watson

Clustered lady's slipper (or brownie's lady slipper) was originally described by Sereno Watson (1882) from a collection made by Wilhelm Suksdorf in May 1880, "on the White Salmon River, Washington Territory, above the falls." Other collections mentioned in the description were made in Plumas County and probably in Del Norte County, California.

Citations – *Cypripedium fasciculatum* Kellogg ex S. Watson, Proceedings of the American Academy of Arts and Sciences 17:380. 1882. LECTOTYPE: White Salmon River, above the falls, Washington Territory, May 1880, W. N. Suksdorf.

Synonyms – *Cypripedium pusillum* Rolfe, Kew Bulletin 1892:211.
Cypripedium fasciculatum Rolfe var. *pusillum* Hooker f., Botanical Magazine plate 7275. 1893.
Cypripedium knightae A. Nelson, Botanical Gazette 42:48. 1906.

Two species of *Cypripedium*, *C. pusillum* Rolfe (1892) and *C. knightae* A. Nelson (1906), were later described as being notably different from *C. fasciculatum*. However, Hitchcock et al. (1969) suggest that differences between *C. knightae* and *C. fasciculatum* do not merit specific or infraspecific recognition. The name *C. pusillum* Rolfe was based on a cultivated plant of uncertain origin and was considered a synonym of *C. fasciculatum* by Hitchcock et al. (1969). Plant characteristics that have been proposed for separating eastern and western races of *C. fasciculatum* are inconsistent, and formal recognition of infra-specific taxa is not warranted on the basis of existing information (Brownell and Catling 1987).

Technical and non-technical descriptions – The following description of clustered lady's slipper is from Hitchcock et al. (1969) (additional technical description is available in Hickman, 1993):

> Stem 0.5-2 dm. tall, lanate-pilose, usually with a single sheathing bract near ground level, a pair of opposite leaves at to well above midlength, and often 1 or 2 lanceolate bracts near the inflorescence; leaves sessile, broadly elliptic to oblong-elliptic or elliptic-oval, mostly 4-8 cm. broad, rounded-obtuse to slightly acute; flowers (1) 2-4 in a rather tight cluster, subtended by conspicuous greenish bracts usually as long as the densely pilose ovary; sepals lanceolate-acuminate, 12-25 mm. long, greenish-brown or greenish-purple and usually purple-lined or -mottled, the lower pair fused completely or free at the tips only; petals similar to the sepals but usually somewhat broader; lip depressed-ovoid, shorter than the sepals, greenish-yellow with brownish-purple margins and often with a purplish tinge; staminodium 2.5-3 mm. long, about equaling the longest lobe of the stigma.

Clustered lady's slipper is small, measuring under 18 cm, from the base to the apex. It has two fuzzy, opposite, elliptical leaves with a total leaf span of about 30 cm. In most cases, there is a single miniature bract between the leaves and the flowers. The flowers are tiny by lady's slipper standards, only 4.5 cm from tip to tip. Flower color ranges from brown markings on a green or golden background to brown dominating, appearing nearly red. Also, some almost blond and pre green flowers have been observed (Coleman 1995). The flowers are found in clusters of six or seven and up to ten at the end of the stem, often causing the stem to droop under their weight. This species cannot be mistaken for any other lady's slipper growing in the same range, because of its small size, two sub-opposite leaves on a hairy stem, and the tight cluster of greenish-brown flowers with large pouches (Knight 1994). The stem is often weak and the disproportionately large leaves may arch down from it to touch the ground (Luer 1975). The fruits are 2-cm oblong capsules that contain thousands of small dust-like seeds.

Mountain lady's slipper

Scientific name – *Cypripedium montanum* Douglas ex Lindley

Mountain lady's slipper (or moccasin slipper) was first described by Lindley based on a specimen collected by David Douglas in the Blue Mountains of Washington State (Cribb 1997) "on high grounds, among low brushwood," June 28 or 29, 1826 (Douglas 1959). This was the only *Cypripedium* collected by Douglas in the range of *C. montanum*.

Citation – *Cypripedium montanum* Douglas ex Lindley, Genera and Species of Orchidaceous Plants: 528. 1840.

Synonyms – *Cypripedium occidentale* Watson, Proceedings American Academy of Arts and Sciences 11:147. 1876.

Technical and non-technical descriptions – The following is a technical description of *Cypripedium montanum* from Hitchcock *et al* (1969) (additional technical description is available in Hickman, 1993):

> Stem (1) 2-6 dm tall, glandular-pubescent, leafy throughout; leaves broadly elliptic to ovate-elliptic, 5-15 cm long, up to 7 cm broad, somewhat glandular-pubescent, sessile and usually sheathing; flowers usually 2, but occasionally 1 or 3, each subtended and usually exceeded by an erect leaf-like bract; sepals and petals light to rather deep brownish-purple, narrowly to broadly lanceolate, usually more or less twisted and wavy, the upper sepal mostly (3) 4-5 cm long, the lower pair not quite so long, fused except for the slender terminal tooth-like lobes; petals slightly longer than the sepals (up to 6.5 cm long); lip obovoid and strongly pouched, 2-3 cm long, dull white to purplish-tinged, usually purplish-veined; staminodium up to 10 (12) mm long, yellowish-white and usually purplish-spotted, ovate, only rarely auriculate at the base.

Mountain lady's slipper is generally 25 cm to 60 cm tall. It has green stems with leaf-like bracts and 4-6 downy alternating leaves. Generally, leaves are pleated and about 7 cm wide by 12 cm long. Flowers usually number between one and three and have tan to deep brown sepals and petals with a fuzz on the backs and near the pouch. The pouch-like lip is white with purple venation and occasionally a purple rim. The pistil and stem are yellow with red spots. Flowers are found at the apex of the stem and have a licorice scent. Flowering usually occurs from May to early July, with sites at lower elevations blooming earlier than those at higher elevations.

Biology and Ecology

Range, distribution and abundance

The abundance of lady's slipper stems at any one site may range from one to over 1000. In California, the mean population size is 27 stems for clustered lady's slipper and 23 for mountain lady's slipper (Carothers database, 2003). Over half the populations of both species have fewer than 10 stems and over 90% have under 100 stems. Large populations, though the exception, occur occasionally and one population of clustered lady's slipper on the Plumas National Forest in the Sierra Nevada has over two thousand stems. This pattern of population size is similar to that observed in the Pacific Northwest. Nearly all sites in Oregon and Washington (96%) have stem counts less than 100, with most ranging between 1 and 20. Most sites of these species on federal land were discovered during pre-disturbance surveys for proposed projects, primarily timber sales. The total number of extant sites is lower than original sighting reports indicate because some populations have declined or dropped to zero (see Population Trends and viability analysis for California, below).

The current status of most populations of clustered and mountain lady's slipper is unknown. Some populations have not been revisited since 1980 and the majority of clustered lady's slipper occurrences in the Sierra Nevada have not been visited in ten years. Information for mountain lady's slipper in the Sierra Nevada is more up to date; the median time since observation is four years. In California overall, median time since last visit is seven years for clustered lady's slipper and ten years of mountain lady's slipper. The situation is similar or longer elsewhere in the range of the species, such as Region 6 (Vance et al. 2004).

Clustered Lady's slipper – In the Sierra Nevada, clustered lady's slipper occurs on three National Forests included in the Sierra Nevada Forest Plan Amendment (SNFPA). The majority of populations are known from the Plumas National Forest, which has 101 recorded populations. Eight populations are known from the Tahoe National Forest, and one is reported from the Lassen National Forest (Table 1). In northwestern California, the species is more abundant and is known from four National Forests covered by the Northwest Forest Plan (NWFP), including Six Rivers (16 populations), Shasta-Trinity (29), Mendocino (50), and Klamath (97) (Figure 1). Across its range, populations are scattered and widely separated. Table 1 lists population numbers by federal land administration in California.

In the U.S., the species has a broad range that spans eight western states. It occurs in mountainous areas in the coastal and interior far-west, the interior-west and the mid-Rocky Mountain Range. Outside of California, clustered lady's slipper occurs in widely disjunct locations from north central Washington south to southern Oregon and east to the mountains of Idaho, Montana, Colorado, Wyoming, and Utah. Hitchcock et al. (1969) and Luer (1975) report clustered lady's slipper in British Columbia, although Catling (1983) cited by Brownell and Catling (1987) discounts this occurrence. The far west includes the Sierra Nevada Range near the Nevada border, the Santa Cruz Mountains on the central coast of California, the California and Oregon Coast Ranges, the Klamath Mountains, the southern Cascades, and the northern Cascades in Washington. Occurrences in the northern Rockies include the Bitterroot Range in northern Idaho and western Montana, the Mission and Swan Ranges in western Montana, the Clearwater and Coeur d'Alene Mountains in northern Idaho, and the Blue Mountains in northeastern Oregon. *Cypripedium fasciculatum* also occurs in the Rocky Mountains of Utah (Wasatch and Uinta Mountains), Colorado (Park and Front Ranges), and the Medicine Bow and Park Ranges in Wyoming (Brownell and Catling 1987).

Mountain lady's slipper – Mountain lady's slipper is known from six National Forests and one National Park covered by the Sierra Nevada Forest Plan Amendment, including Modoc (34 populations), Eldorado (1), Lassen (5), Plumas (13), Sierra (13), Stanislaus (16), and Yosemite National Park (4) (Table 1). Elsewhere in California it is also known from four National Forests within the Northwest Forest Plan, including Six Rivers (13 populations), Shasta-Trinity (18), Mendocino (9), and Klamath (81) (Figure 2).

Mountain lady's slipper has the widest range of the California lady's slippers. It is found from southern Alaska, British Columbia, and western Alberta south to Montana, Idaho, Wyoming, and California. This species is no longer extant on Vancouver Island (Clark 1976). It is not present west of the Cascade crest in Washington, except along the Columbia River Gorge (Hitchcock et al. 1969). In Oregon, it is widespread east of the Cascades but rare west of the Cascade crest.

Table 1. Number of clustered and mountain lady's slipper occurrences by National Forest and National Park in California (only sites located after 1980 to exclude historic reports). National Forests in California that are not listed here have zero occurrences of both species.

National Forest/Park	No. of clustered lady's slipper occurrences	No. of mountain lady's slipper occurrences
Sierra Nevada		
Eldorado NF	0	1
Lassen NF	1	5
Modoc NF	0	34
Plumas NF	101	13
Sierra NF	0	13
Stanislaus NF	0	16
Tahoe NF	8	0
Yosemite National Park	0	4
Northwest California		
Klamath NF	97	81
Mendocino NF	50	9
Shasta-Trinity NF	29	18
Six Rivers NF	16	13
TOTAL	**302**	**206**

Figure 1. Distribution of clustered lady's slipper (*Cypripedium fasciculatum*) in California.

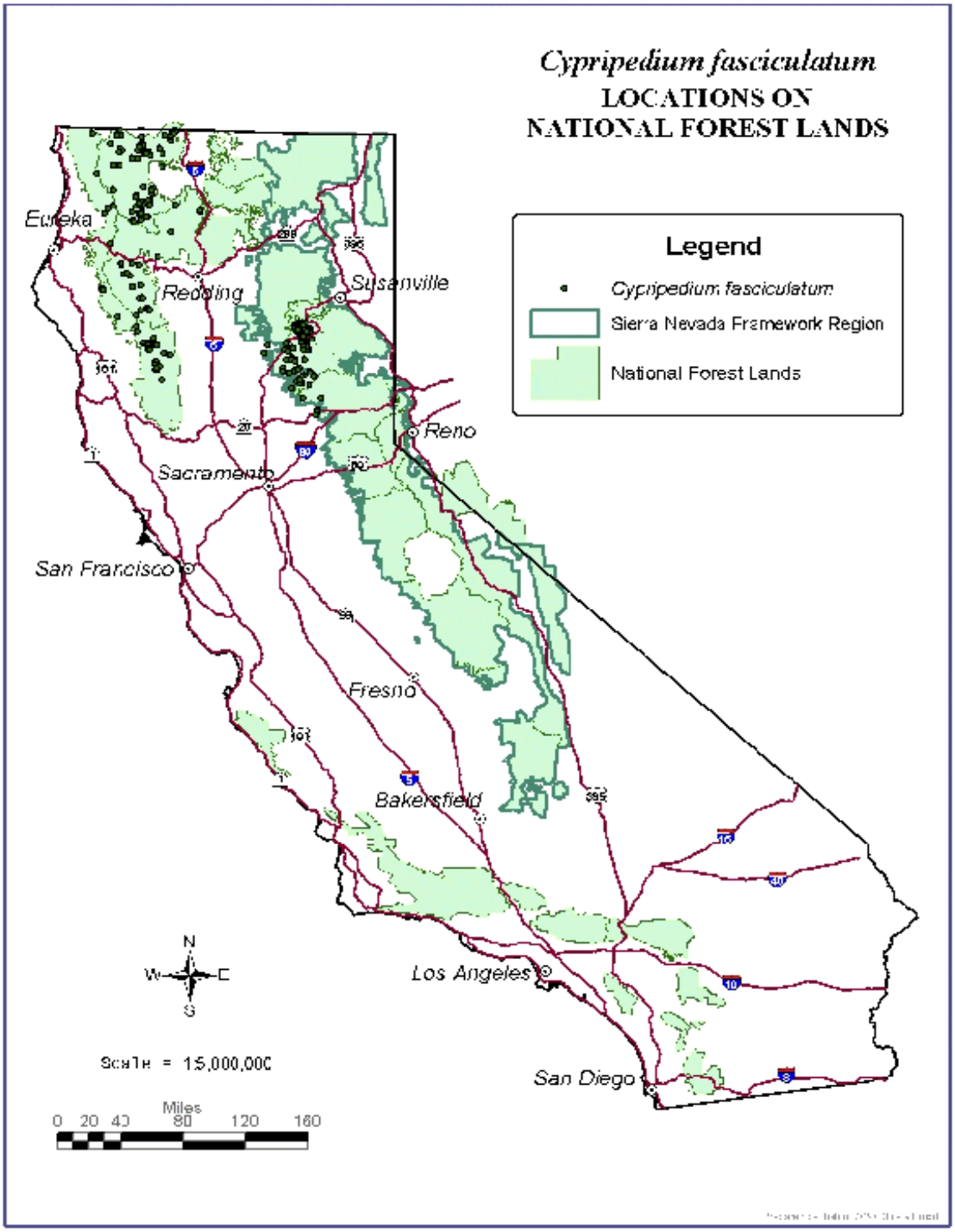
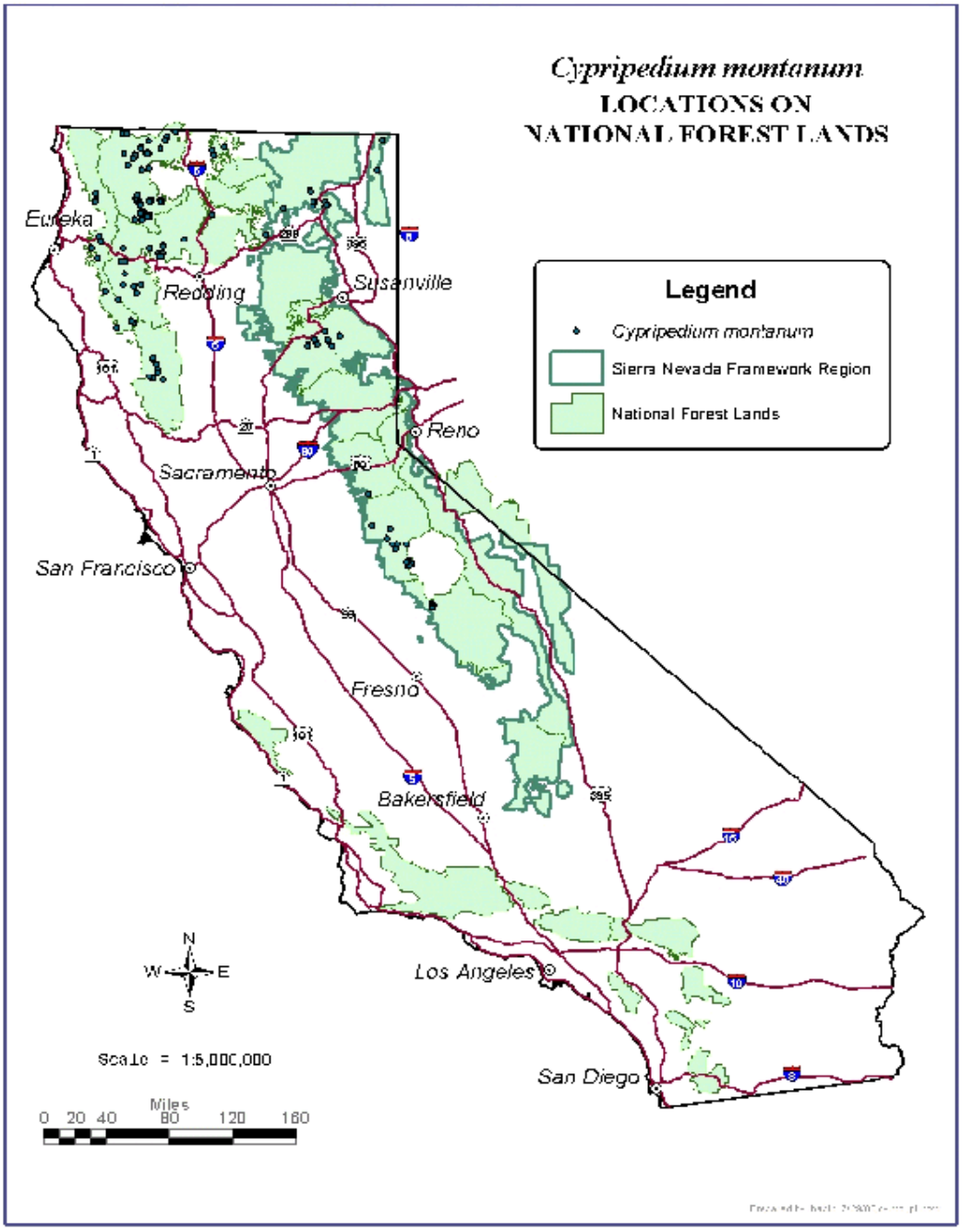


Figure 2. Distribution of mountain lady's slipper (*Cypripedium montanum*) in California.



Habitat

Figure 4. Mountain lady's slipper under mountain dogwood and Douglas-fir in the Sierra National Forest. Photo credit: Laura Colton, California Dept. Fish and Game.

Plant communities – In California, clustered and mountain lady's slipper typically favor similar habitats and in some cases occur together. Data from reported populations in California (Carothers 2003) indicate that both clustered and mountain lady's slipper can occur in a wide variety of plant community types, and these are generally the same for both species (Figure 3, top). This summary was conducted for all of California to make habitat characterizations as broad and robust as possible. The majority of known clustered lady's slipper sites are in mixed conifer (76% of known sites), Douglas-fir (7%), and riparian (4%) forests. Other important community types in which clustered lady's slipper is found include white fir, red fir, yellow pine and mixed conifer-hardwood forests, which together make up about 9% of the known sites. Mountain lady's slipper also typically occurs in mixed conifer (73% of known sites), Douglas-fir (10%), and riparian (2%) forests (Figure 3, bottom). Another 9% of the populations occur in white fir, pine, giant sequoia, and mixed conifer-hardwood forests and oak woodland. *This pattern is generally true in the Sierra Nevada as well as throughout California.*

In addition to forest community-types, both species appear to have generally similar associated vascular plant species (Table 2). Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) are the conifer tree species most frequently found with both orchids. Hardwood trees and shrubs often noted with them include mountain dogwood (*Cornus nuttallii*), hazelnut (*Corylus cornuta* var. *californica*), and oaks (*Quercus chrysolepis* and *Q. kelloggii*). Herbs frequently associated with both lady's slippers include trail plant (*Adenocaulon bicolor*), starflower (*Trientalis latifolia)* and false Solomon's seal (*Smilacina racemosa*).

In southwestern Oregon, the vegetation structure around populations usually consists of high canopy cover in late seral stage stands often in association with a gap in the overstory filled by mid-level hardwood species such as madrone (*Arbutus menziesii*), black oak (*Q. kelloggii*), canyon live oak, mountain dogwood or tanoak (*Lithocarpus densiflorus*), and low abundance of grass species (Latham 2001). Mid- to late-successional forest communities may be optimal habitat for *C. fasciculatum* in the Cascade Ranges of Washington and Oregon, possibly because fungal symbionts are present in these older communities and not in early successional communities (Harrod et al. 1996; Harrod and Knecht 1994). Knecht (1996) observed that most populations of clustered lady's slipper in that region occurred in forests with >60% canopy cover.

The range of habitats in which mountain lady's slipper grows can include both moist and relatively dry conditions (Coleman 1989, Figure 3, bottom). A typical moist habitat in this region is along streams under or near creek dogwood (*Cornus stolonifera*) and western azalea (*Rhododendron occidentale*) or with mountain dogwood (*Cornus nuttallii*) with queen's cup bead-lily (*Clintonia uniflora*) as a ground cover. A typical drier site is a seasonally dry hillside in coniferous forests with few associated understory species. Populations of both species at low elevations in the southern portions of their ranges, such as on the Mendocino National Forest, may more often be associated with moist habitats, while those further north or at higher elevations may more typically be found on dry sites. The Jepson Manual (Hickman 1993) describes California habitat of mountain lady's slipper as moist areas, dry slopes, mixed evergreen or coniferous forests and clustered lady's slipper as open coniferous forest. Sheviak (pers. comm.) reports

mountain lady's slipper in California from mesic to dry (rarely wet) coniferous, deciduous, and broadleaf evergreen forests, openings, and thickets, and around shrubs on open slopes. It typically grows on a variety of substrates in forested communities with 60%-80% canopy closure. In the Pacific Northwest, mountain lady's slipper is generally found growing in mid- to late-successional mixed coniferous forests and mixed evergreen/oak woodland plant communities. Peck (1961) refers to Oregon habitats as moist open woods, and Hitchcock et al. (1969) cite dry to fairly moist, open to shrub- or forest-covered valleys or mountainsides. In propagation, clustered and mountain lady's slippers require acidic, sandy soil, and fairly dry conditions (Whitlow 1983).

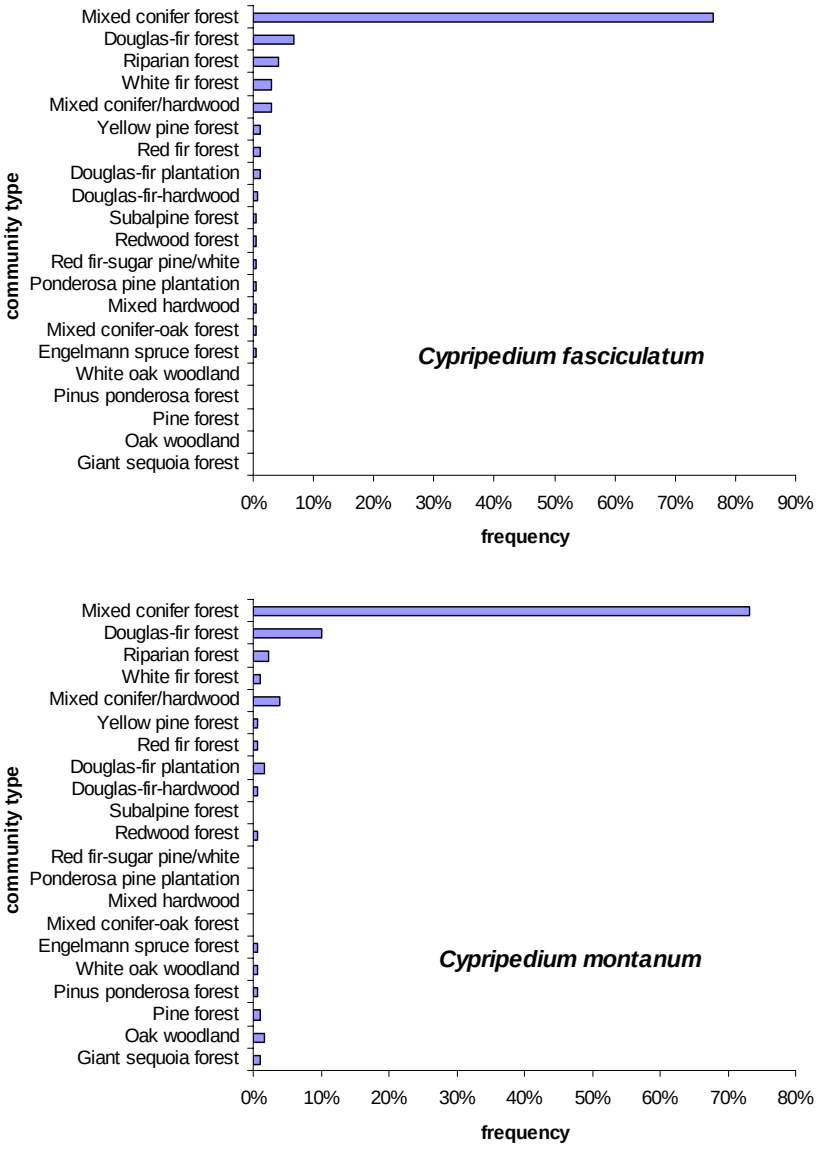


Figure 3. Frequency of clustered lady's slipper (top) and mountain lady's slipper (bottom) populations in various forest community-types in California (from information in Carothers [2003] on 267 populations of clustered lady's slipper and 179 of mountain lady's slipper).

Aspect and elevation – These summaries were conducted with information from throughout California to increase the amount of information available. No regional differences between the Sierra Nevada and other locations were detected during reviews of the available data (Carothers 2003). In California, both clustered and mountain lady's slippers grow at a wide range of elevations. Clustered lady's slipper generally occurs from 1650 to 5600 feet (500-1700 m) in California although it has been documented as low as 600 feet (183 m) and as high as 5800 feet (1772 m). Mountain lady's slipper predominantly occurs from 1650 to 5900 feet (500-1800 m), but it has been found as low as 1315 feet (401 m) and at a

maximum of 6250 feet (1934 m).

In addition, both species appear to occur on similarly oriented hill-slopes. Records from California populations indicate that both taxa prefer north-facing slopes, but can be found to some extent on all aspects (Figure 5). The steepness of the slopes is typically between 25% and 50%.

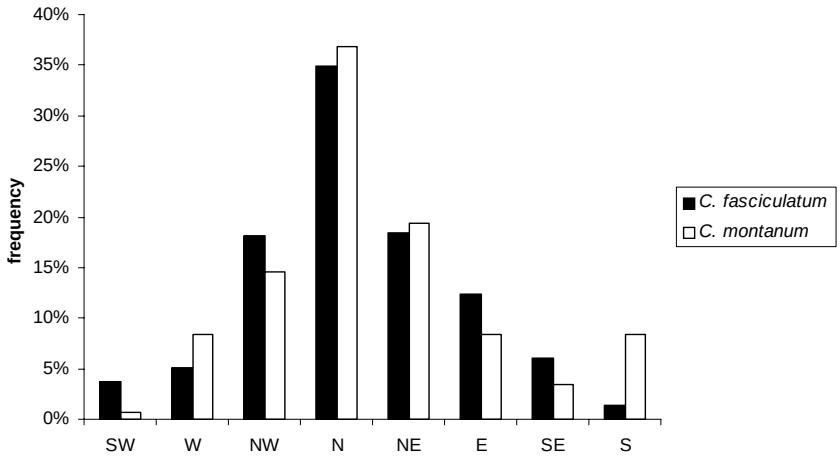


Figure 5. Frequency of occurrence of clustered (*C. fasciculatum*) and mountain (*C. montanum*) lady's slipper on hill-slopes of various aspect in California.

Soils – Lady's slipper species are not restricted to a particular parent material. Populations have been found on soils derived from such diverse parent materials as ultrabasic and granitic rocks, schist, limestone, and quartz-diorite. Fowlie (1988) noted that clustered lady's slipper occurred on serpentine landslides in northwestern California, but the plants were growing in organic matter in a serpentine landslide of vast extent, matted with fallen Douglas-fir needles, and that the plants sometimes grew between the roots of Douglas-fir. This might indicate that soil organic matter accumulation is more important than, or can moderate the influence of, parent material.

Because of the well-known association between orchids and fungi and the heterotrophic mode of fungal nutrition for orchids, important environmental factors controlling the distribution of clustered and mountain lady's slippers may include characteristics of the upper organic layer of the soil profile and how these characteristics influence mycorrhizal fungi, rather than the nature of the parent or mineral soil. Some soil factors that may affect mycorrhizal fungi include development of the soil organic layer, soil depth, rate of decomposition of organic matter, moisture content, and pH. Based upon personal observation, bryophyte communities that often cover shallow soils in which clustered and mountain lady's slippers rhizomes may also be important for water retention. Coarse woody material may provide microsite moisture, shade, and protect duff and litter layers from disturbance.

Table 2. Most common plant associates for clustered and mountain lady's slipper in Sierra Nevada and Northwestern California National Forests and their frequency of occurrence as reported on sighting forms (summarized from database compiled by Carothers [2003]). See Appendices IV and V for a complete list of plant associates by forest.

species	Frequency (%) with clustered lady's slipper	Frequency (%) with mountain lady's slipper
Pseudotsuga menziesii	74.7	72.4
Abies concolor	49.8	46.8
Cornus nuttallii	49.4	30.8
Pinus lambertiana	31.5	28.2
Calocedrus decurrens	30.7	37.8
Smilacina racemosa	29.0	24.4
Adenocaulon bicolor	28.6	37.8
Rosa spp.	27.4	27.6
Quercus chrysolepis	22.4	11.5
Corylus cornuta var. *californica*	22.0	35.9
Trientalis latifolia	21.2	25.0
Pinus ponderosa	20.7	32.7
Chimaphila umbellata	20.3	11.5
Symphoricarpos mollis	20.3	16.0
Disporum hookeri	19.9	20.5
Goodyera oblongifolia	19.9	16.7
Arbutus menziesii	19.1	22.4
Quercus kelloggii	18.7	18.6
Hieracium albiflorum	15.8	10.9
Pyrola picta	15.8	--
Acer macrophyllum	14.9	21.2
Pteridium aquilinum var. *pubescens*	14.9	13.5
Rubus parviflorus	14.5	17.3
Berberis nervosa	13.7	25.0
Chrysolepis chrysophylla	10.4	11.5
Toxicodendron diversiloba	10.0	14.1
Osmorhiza chilensis	--	10.3

Response to disturbance

Damage to plants – Lady's slipper plants that lose their growth (from grazing animals, fire or other disturbance) before midsummer may commonly appear the next year but may not bloom (Whitlow 1983).

If new spring growth is destroyed by fire, late frost, foraging animals, disease, accident, or management practices that disturb vegetation or soil, lady's slippers cannot replace the lost tissues until the following year. Although dormant buds may be present, they will not initiate growth. The root system will remain, and a new bud may form, or a dormant bud may enlarge, but the plant will suffer a setback, and it may die by the next growing season (Sheviak 1990). Lady's slipper plants that lose their growth before midsummer will commonly appear the next year but may require two or more subsequent vegetative seasons before blooming again (Case 1987; Primack et al. 1994; Vance 2001b).

Herbivory and livestock grazing – Grazing affects lady's slippers through consumption of leaves, flowers and fruits by cows and sheep and through trampling. Anecdotal evidence from botanists on National Forests in the Sierra Nevada and elsewhere in California indicate that ground disturbance from herbivory and cow trampling affects clustered lady's slipper on the Plumas, Six Rivers, Klamath, Shasta-Trinity, and Mendocino National Forests. Mountain lady's slipper populations are similarly threatened by grazing in allotments on the Klamath, Lassen, Mendocino, Modoc, Six-Rivers, Shasta-Trinity, Sierra, and Stanislaus National Forests. On the Modoc National Forest, occurrences of mountain lady's slipper appear to be associated with lighter livestock grazing (Bruce Davidson, pers. comm.). The largest mountain lady's slipper population on the Modoc National Forest is along Rush Creek, which has had very limited livestock grazing in recent years. Other occurrences on the Modoc seem to be in habitats that are not severely impacted by cattle, such as steep slopes with difficult access.

Many lady's slipper populations in grazing allotments appear unaffected by grazing. This discrepancy may have to do with the level of cover from other species. Although lady's slipper orchids are palatable to cows, they are not ideal forage. Thus, when other palatable species are present on the site, the cows may preferentially choose those species. However, in areas devoid of co-occurring vegetation, lady's slipper species may represent the only forage opportunity for cattle and thus they are at greater risk, especially late in the growing season (July-August) when many other forage species have died back but lady's slippers persists.

In southwest Oregon, on the Medford District BLM, monitoring of clustered lady's slipper has been conducted on several grazing allotments. Impacts of grazing differ greatly depending on the number of animals and the timing of grazing. During the non-emergent period of the lady slipper life cycle, herbivory may have little or no direct impact. However, ground disturbance from trampling during over-wintering may cause damage to next year's stem and root buds which form in the autumn months. Herbivory of mature fruit capsules by deer has been reported as frequent on the Siskiyou National Forest (Kagan 1990) and Medford District BLM (Knight 1994). Continuous grazing by cattle or sheep has been shown to depress fruit production and seedling recruitment in the orchid *Ophrys sphegodes* (Hutchings 1987a, 1989).

Fire ecology – Fire has been a primary ecological factor throughout the Sierra Nevada and Cascade Mountains for thousands of years (Agee 1994). The effects of fire on lady's slipper species appears to depend on fire intensity and landscape scale. In forests of Washington, clustered lady's slipper tolerated a light fire where the duff layer and the forest canopy remained intact, but plants in an intensely burned area were killed (Harrod et al. 1999). The killed plants were replaced naturally a few years later by seedlings that recruited from nearby, undamaged flowering plants, but if the intense fire had affected a larger portion of the landscape, this might not have been possible.

Effects of fire on mountain lady's slipper appear to be site specific. Observations of a post-fire event on the Klamath National Forest in 1989 found one mountain lady's slipper individual in an area where wildfire

had left no trees standing. Although the specimen was yellowing, it had one flower (Marla Knight, pers. comm.). In eastern Oregon, Karl Urban noted the rapid reappearance of mountain lady's slipper after a wildfire on the Umatilla National Forest, an observation that suggested the original plants in the area were not killed by the burn (Seevers and Lang 1999). In contrast, a 1981 population of 50 plants on the Shasta-Trinity National Forest was reduced to three individuals after a 1987 fire (Seevers and Lang 1999), but it was not known if the population decline had occurred prior to the burn. These varying reports suggest that the short-term response to fire of this orchid, like clustered lady's slipper, is confounded by variations in fire behavior and fire intensity. It is also unknown at this time whether those individuals surviving immediately after a fire, persisted in time.

Canopy and understory disturbance – Little research on the effects of forest disturbance on either clustered or mountain lady's slipper is available from any portion of their geographic ranges. What is known comes from local studies, project monitoring or anecdotal observations of mountain lady's slipper and suggests that canopy and forest floor disturbance can have negative effects on populations. For example, Coleman (1995) observed that after forest harvest in northern California, a population of mountain lady's slipper dropped from several hundred widely scattered plants to just a few individuals at the edge of the clearcut. Project monitoring on the Plumas National Forest showed a marked effect of clearcutting on clustered lady's slipper. While the number of individuals along the control transect varied from 59 individuals in 1997 to 35 individuals in 2001, individuals along the treatment transect dropped to zero within one year post-harvest and remained as such over the five year course of monitoring.

In a long-term (14 yr) study of mountain lady's slipper conducted by the Medford District BLM in the Foots Creek watershed of southwestern Oregon (Kaye 1999), populations were monitored in clearcuts, shelterwood cuts, second growth (20-30 yr), and unmanaged forests. In clearcut habitat, the population declined by 85% in the seven years after harvest and had poor plant health. The populations in a shelterwood cut that emphasized forest thinning to an average 23% tree cover generally remained steady or increased in size, and plant health was generally highest compared to all other sites. One of the two control populations in this study did not perform well, decreasing by 70%, while the other remained relatively stable. This study did not provide conclusive evidence that forest harvest is detrimental to this species, but it suggested that managers may have reason to be cautious and favor habitat protection or alternative forest harvest methods that thin forests (Kaye 1999).

In the Pacific Northwest, clearcut forest harvests resulted in local extinctions of four orchid species, spotted coral-root (*Corallorhiza maculata*), striped coral-root (*C. mertensiana*), rattlesnake plantain (*Goodyera oblongifolia*), and heart-leaved twayblade (*Listera cordata*) (Halpern and Spies 1995). Rattlesnake plantain, in particular, appeared to be as sensitive to tree canopy removal as to fire, and the authors suggested some local extirpations were the result of poor re-colonization due to inadequate seed dispersal and inherently slow growth rates (Halpern and Spies 1995). Schoonmaker and McKee (1988) also reported local extirpation of striped coral-root in their comparison of post-harvest stands and adjacent old growth forests.

Life history and reproductive biology

Reproductive biology

Clustered and mountain lady's slippers are rhizomatous perennials that may propagate by both sexual and asexual means. Clonal propagation from buds on rhizomes often produces tightly-grouped clumps of ramets. Spring growth of orchids arises from over-wintering buds produced the preceding growing season. Lady's slipper species reproduce asexually when older parts of a branching rhizome dieback, leaving younger, still living branches as separate plants (Summerhayes 1951). Above-ground growth of clustered lady's slipper begins from a top-shaped protocorm that develops into a rhizomatous structure from which rhizomes with multiple shoots may develop (Cribb 1997). Although asexual spread can

enlarge local patches, the species do not appear able to colonize new locations via dispersal of fragments. Clonal spread in clustered lady's slipper appears to occur only over very short distances as determined through genetic mapping of individuals; in such studies clones were never more than several centimeters apart. These species appear to rely primarily on sexual reproduction for expanding populations and maintaining genetic diversity (Vance et al., manuscript in progress; Knecht 1996). Clustered lady's slipper has a small, shallow rhizome with fibrous roots that produces a dormant bud during the current year's growing season (Harrod 1994b). This bud may remain inactive through the winter, but then bolts in April to produce an aerial stem. At the same time, a new bud is initiated and developed during the photosynthetic period. It may be possible to age plants by counting the number of adventitious roots or corresponding stem scars.

Clustered and mountain lady's slippers are non-rewarding orchids (no nectar benefits to the pollinator) and as such may have difficulty attracting pollinators and setting fruit. Nectarless orchids generally have low fruit-set, averaging around 20% in North America (Neiland and Wilcock 1998). Correll (1950) and Barker (1984) indicate that clustered lady's slipper has low fruit production, which may be due to infrequent pollination (Barker 1984). Others have reported a wide range of fruit-set values over a broad geographic area, including low values from Colorado (18%), Idaho (29%) (Lipow et al. 2002), and Washington (31%) (Harrod 1993b) and relatively high rates (69%) from one site in Oregon (Lipow et al. 2002). Reports from the Sierra Nevada and other regions of California are not available for clustered lady's slipper. Fruit production in mountain lady's slipper averaged 61% in three large California populations (Coleman 1995), and ranged from 30%-50% at a southwestern Oregon site over a ten year period (Kaye 1999). The large number of seeds per fruit produced by orchids, which averages 3,874 per fruit in clustered lady's slipper (Harrod and Knecht 1994), may compensate for relatively low levels of fruit production. Data on seed production in mountain lady's slipper are not available.

The lack of seedling recruitment in wild populations of lady's slippers is cause for concern. Several researchers have noted that seedling recruitment is uncommon or lacking in both clustered and mountain lady's slippers. Long-term monitoring of mountain lady's slippers failed to document the occurrence of large numbers of new plants, suggesting that seedling recruitment may be limited in this species, despite local seed production and dispersal (Kaye 1999). Similarly, seedling recruitment appears to be very infrequent in monitored demographic plots for clustered lady's slipper (Rohland and Kaye 2004). Seedling abundance of clustered lady's slipper may be more frequent in stable, old forest conditions than in younger forests or those subject to disturbance (Latham, personal communication).

Phenology

Clustered lady's slipper is the earliest flowering of the California lady's slippers, usually producing flowers in mid-March in the Santa Cruz mountains. On the more northern forests, blooming begins in May and lasts into June. At higher elevations in the Sierras, peak blooming occurs in mid- to late June with flowers often persisting until July (Coleman 1995). Mountain lady's slipper generally blooms somewhat later, usually beginning in May at lower elevations and southern sites and flowering as late as August at higher elevations and more northern locations.

Breeding system and pollination

Clustered lady's slipper is self-compatible and requires insects for successful pollination (Knecht 1996, Lipow et al. 2002). In some orchids the shape of flowers and position of reproductive structures have co-evolved with a particular pollinator to achieve cross-fertilization (Luer 1969; Barker 1984). Recent research on the pollination biology of clustered lady's slipper in southwestern Oregon suggests that stingless parasitic diapriid wasps (*Cinetus* sp., only females) serve as its pollinators (Ferguson & Donham, 1999, Ferguson et al. 2000). Diapriid wasps lay their eggs in dipteran hosts (primarily fungus gnats), which may be attracted to the orchid. The mechanism by which the orchid attracts the wasp is unknown. Pollinators can be limiting at some sites for this species, and resources (e.g., light, moisture, and/or nutrients) may also limit fruit set (Lipow et al. 2002). Luer (1975) observed several small black

bees, tentatively identified as a banded species of *Lasioglossum* pollinating a mountain lady's slipper flower. The bees entered via the lip and left by crawling out an exit under an anther. A large bumblebee (*Bombus* sp.) attempted entry, but departed when it found it could not squeeze into the labellum because of the small size of the opening of the pouch. Little else has been reported regarding pollination or self-compatibility of mountain lady's slipper.

Dispersal mechanisms

The drooping stem bearing the inflorescence of clustered lady's slipper straightens and elongates after fertilization and during capsule development (Doherty 1997). The species produces small, dust-like seeds consisting of an embryo enclosed within a transparent netting called a testa. The testa of clustered lady's slipper is much longer and narrower than that of mountain lady's slipper and other species of *Cypripedium* as well (Harrod and Everett 1999). Clustered lady's slipper seeds have long air-flotation periods correlated with a high percent air space, which may be associated with long-distance dispersal (Arditti 1992). Based on the small size, narrow length, and low mass of clustered lady's slipper, one could expect great potential dispersal distances (Harrod and Everett 1999). Most clustered lady's slipper seeds travel only 1-2 m upon dispersal from the fruit (Harrod and Everett 1999), but a small percentage may disperse much farther. Localized seed dispersal combined with occasional long-distance seed movement is one factor that could lead to a patchy distribution of clustered lady's slipper, and possibly mountain lady's slipper as well. It is unknown how long the seeds remain viable. There is some anecdotal evidence, based on observations of the distribution of clustered lady's slippers, that seed may disperse by water movement during overland flow.

Mycorrhizal associations

Mycorrhizal fungi serve pivotal roles in the biology of orchids. Several stages in the life-cycle of orchids, especially young seedlings, depend on associations with fungi. Orchids appear to require the presence of a fungus before their dust-like seeds will germinate in the wild (Arditti 1967; Doherty 1997; Wells 1981). All orchids are myco-heterotrophic, meaning that they derive a portion of their carbon and other nutrients from fungi whose hyphae penetrate their root tissues. After germination, the young orchid plant, or protocorm, is non-photosynthetic and depends on mycorrhizal fungi for its survival (e.g., Alexander and Hadley 1985, Rasmussen and Whigham 2002). These fungi may also be connected through the soil with other plant species, such as coniferous trees. The role of fungi in the growth and survival of mature orchids is not well understood, and in some cases different fungi may be associated with protocorms vs. adult plants (McCormick, Whigham and O'Neill 2004). Once a lady's slipper reaches maturity and becomes autotrophic (with green leaves), the degree of dependence may change although initial data show that mountain lady's slipper likely requires obligate fungal association throughout its life cycle and it may be assumed that clustered lady's slipper, does as well (Shefferson, pers. comm).

Establishment of new populations requires suitable conditions for forest fungi as well as the orchids, themselves. What constitutes suitable conditions is not completely described, but may include moist condations for part of the growing season, at least partial shade, and adequate organic material to support growth of heterotrophic fungi. Decaying wood may also be an important habitat component associated with mycorrhizae, because it can provide excellent habitat for fungi, and may be an important attractant for fungus gnats, which are a part of some orchids' pollination system.

Because orchids depend on fungi, at least in the early stages of plant development, the presence of appropriate fungi and the environmental factors that affect them may in turn determine where clustered and mountain lady's slippers can grow. Soil and topography, and especially temperature and moisture are the most important factors that control orchid distribution and survival (Correll 1950), and this may be due to the influence of these factors on mycorrhizal fungi. Further, the tree species present at a site may determine which fungi occur there. Although it is generally assumed that fungi play an active nutritional role throughout the life of clustered and mountain lady's slippers (Sheviak, pers comm; Shefferson, pers. comm.), further research is needed to firmly establish the nature and extent of the relationship.

Recent research has documented that lady's slippers are associated with fungi in the Sebacinaceae, Ceratobasidiaceae, and especially the Tulasnellaceae (Shefferson 2004, and personal communication). As a genus, *Tulasnella* primarily occurs in association with dead wood. Recent research indicates that both clustere$ and mountain lady's slippers both show exclusive specificity to fungi in the Tulasnellaceae (Shefferson et al. 2005). Although both species are specific to this family of fungi, clustered lady's slipper appears to be specific to fewer types of tulasnelloid fungi than mountain lady's slipper. The degree of specificity of orchids with fungi is significant because orchids with highly specific associations may be more sensitive to disturbance and environmental change than generalist species (McCormick, Whig`am and O'Neill 2004).

Population trends and viability analysis

Population genetics

No information on the population genetics of mountain lady's slipper is available from California or elsewhere. The following information on clustered lady's slipper is from Vance et al. (2004). The genetic variation within populataons of clustered lady's slipper indicates that variation is well structured despite many populations being widely separated. Several genetic studies show that this species has greater genetic variation within populations than among populations (Aagaard et al. 1999, Vance and Doerksen, unpublished data). Genetic alleles are well dispersed among the populations with little evidence of genetic drift in Washington, Oregon and California. However, population distribution includes isolated populations with little chance of gene flow, so the potential for genetic drift could increase for these populations. For example, an analysis of five populations in southern Oregon showed that a population located in a campground on the edge of the North Umpqua River, which was geographically isolated from most other populations in the Klamath province, had lower genetic diversity than the other populations sampled (Vance 2001).

Aagaard et al. (1999) analyzed the genetic variation among three populations sampled on the Wenatchee NF using isozyme analysis. Genetic variation at the population level was slightly lower than average for long-lived perennial herbaceous plants (Hamrick and Godt 1989), but across the range of the species (data from 33 populations) the variation was higher (Vance and Doerksen, unpublished data). This variation is consistent with other long-lived perennials that reproduce sexually, are in mid-to late-successional status, and have wind-dispersed seed (Hamrick and Godt 1989). Among populations in California, Oregon, and Washington there was little evidence of genetic drift or bottleneck despite the distance among disjunct populations and the widespread and regional distribution of the species (Aagaard et al. 1999, Vance and Doerksen, unpublished data). This suggests that there may have been greater connectivity among populations in the past, and occurrence of gaps in their distribution across the region may be a fairly recent phenomenon. Levels of genetic variability appear similar to other North American species of *Cypripedium* (Case 1994).

Demography

The major life-history stages in lady's slipper orchids include seedling-protocorm, vegetative (green shoots above ground but no flowering stalk), reproductive (flowering), and dormant plants. Dormancy is a state in which plants do not produce above-ground parts for one or more years (usually not more than three) and is a significant process in the population dynamics of clustered and mountain lady's slippers. Plants may move between these stages from one year to the next in patterns that result in a complex life-history (Figure 6). Although vegetative and flowering plants are the stages that are visible to a population visitor, the seedling-protocorm and dormant stages require greater discussion because of their cryptic nature and significance to conservation.

Population structure – Lady's slipper populations appear to be heavily dominated by reproductive and vegetative (non-reproductive) plants, with very few, if any seedlings observed during field visits. Long-term demographic monitoring of mountain lady's slipper in southern Oregon failed to detect significant numbers of seedlings (Kaye 1999). Regional monitoring of clustered lady's slipper in the Medford District, BLM also found little evidence of seedling recruitment (Rohland and Kaye 2004).

Seedling-protocorm – Seedling establishment is a key process in the maintenance and growth of natural populations, but very little quantitative information is available on seedling recruitment processes in clustered and mountain lady's slippers (Figure 6). After seeds germinate they form a non-photosynthetic protocorm that relies on mycorrhizal fungi for water and nutrition before sufficient growth occurs and stored food accumulates in adequate amounts to support leaf production (Case 1987). Mountain lady's slipper protocorms take 2-3 years before emergence above ground (Huber 2002). The plants then require at least 4 additional years until flowering commences and additional time for multi-flowered stem production. This growth pattern is similar to other native orchids (Case 1987), including clustered lady's slipper (Sheviak 1990). Estimates of the length of time necessary for development of other native *Cypripedium* species from seed to flowering vary considerably, with reports of 8 to 16 years for lady's slippers of Wisconsin (Curtis 1943).

Seedling recruitment rates in populations of clustered and mountain lady's slipper appear to be very low, but detailed studies documenting this are few and none are available from California. In southwestern Oregon, observations of mountain lady's slipper populations with high fruit production (and presumably high seed output) failed to detect large numbers of new plants (Kaye 1999), and monitoring plots in several populations of clustered lady's slipper in the same region also have not encountered many new small plants (P. Latham, personal communication). Seedling recruitment appears to depend on formation of mycorrhizal association, and this process may vary substantially from site to site and year to year. The ability or tendency for seeds to remain dormant in a persistent soil seed bank is unknown in these species.

Dormancy – Vegetative dormancy is an important and frequent phenomenon in many orchids (Curtis 1954, Sheviak 1974, Wells 1981, Hutchings 1987a & 1989, Waite 1989, Falb and Leopold 1993), and clustered and mountain lady's slippers are no exception. Kaye (1999) documented patterns of dormancy in mountain lady's slipper from 1984-1999 in southwest Oregon. Estimates from each year and population suggest that the percentage of plants dormant at any given time can vary substantially, ranging from a high of over 30% in a population in a shelterwood cut in 1993 to a low of 0% in a clearcut in 1994. Among years, dormancy overall ranged from 7% to 21%. Also, 23% of the dormant plants in a given year remained dormant the following year (Figure 6). This suggests that in any given population and year, estimates of the number of plants present may habitually under-count the true population size by as much as 30%.

Only one plant was observed by Kaye (1999) to be dormant for more than two years, a pattern also observed in other orchid species. *Ophrys sphegodes* (Hutchings 1987a), for example, very rarely remained dormant more than two years, and a three to four year limit seems the norm for many other orchids (Sheviak 1974, Mehrhoff 1989, Calvo 1990, Gregg 1991, Falb and Leopold 1993).

The factors that lead to dormancy in orchids are difficult to identify. Damage like grazing or trampling has been implicated for some taxa (Case 1987, Sheviak 1990). Also, the amount of resources used by a plant during reproduction has been shown to affect its subsequent growth. In mocassin flower (*Cypripedium acaule*), fruiting lowers the probability of flowering the following year (Primack and Hall 1990), and repeated forced fruit formation reduces leaf area (Primack and Wilcock 1998). Fruit set also reduces subsequent leaf area in crippled cranefly (*Tipularia discolor*) (Snow and Whigham 1989). On the other hand, bee orchid (*Ophrys apifera*) plants with more leaves are more likely to flower the following year than smaller plants (Wells and Cox 1989). Hutchings (1987b) suspected fruiting or flowering might contribute to dormancy in early spider orchid (*Ophrys sphegodes*), but found no evidence for this hypothesis. Instead, he concluded that dormancy was most likely to follow a vegetative state, and had little to do with whether or not a plant had flowered or fruited. In mountain lady's slipper, dormancy is not

more likely after flowering or fruiting, and is equally likely to follow a vegetative or flowering state (Kaye 1999). As in other orchid species examined, however, dormant mountain lady's slipper plants are far more likely to re-emerge as vegetative than flowering plants. Flowering plants are most likely to return as flowering plants and vegetative plants tend to remain so, as well (Figure 6).

Lifespan – Orchid species vary widely in their average life spans. Clustered lady's slipper is a relatively long-lived perennial, lasting 30 years (Harrod 1994b), and perhaps as long as 95 years (Niehaus 1974). Likewise, mountain lady's slipper plants appear to be long-lived; of 80 plants documented in southwestern Oregon in 1990, 71% remained in 1998 (Kaye 1999). Long-term demographic studies by Tamm (1972), Williams (1982), Farrel (1985), Hutchings (1987a, 1987b, 1989), and Wells (1981) on several orchid species noted maximum recorded ages of 10 to 30 years, depending on the taxon.

Population trends and viability analysis for California

Most populations of clustered and mountain lady's slippers have very few individuals. It is difficult to determine if these small sizes are normal and healthy or if they are due to alterations in habitat conditions. Another possible explanation for small population sizes is that in California, these lady's

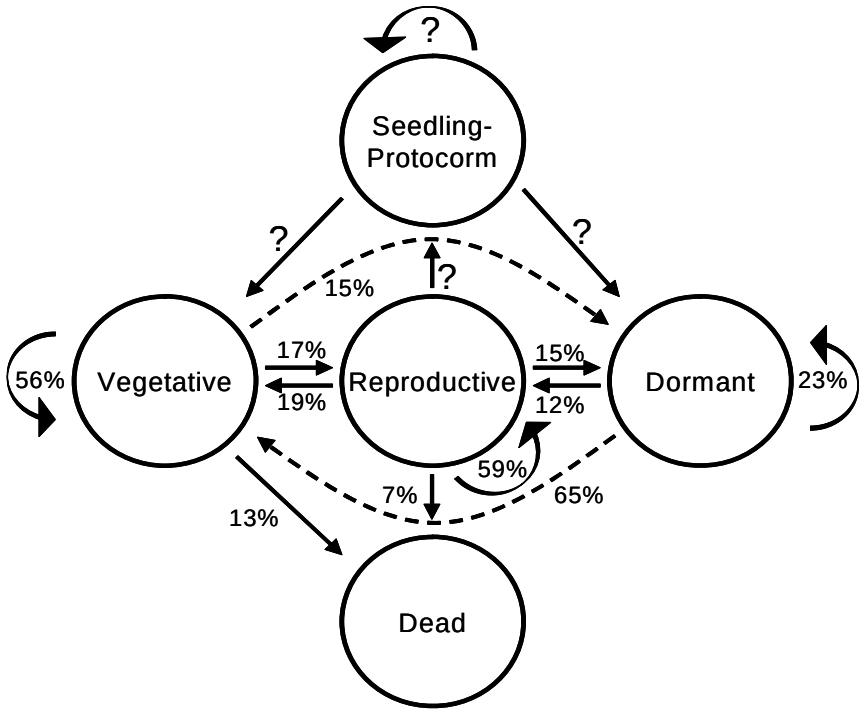


Figure 6. Generalized life-history diagram for a lady's slipper population. Each circle represents a life-history stage, and arrows between them indicate possible transition pathways plants can follow from one year to the next. Percentages next to arrows are derived from a long-term study (Kaye 1999) of mountain lady's slipper, and represent the rate at which plants in a given stage stay the same or move to another stage. For example, 56% of vegetative plants remain in that stage, while 17% become reproductive, 15% go dormant, and 13% die. Note that plants can become and remain dormant. Seedlings-protocorms (which are subterranean and sustained by mycorrhizal fungi) are poorly understood and question marks are placed by arrows to and from this stage due to lack of data on their behavior.

slipper orchids are growing at the edge of their geographic range which may indicate occupation of marginal habitat for the species. Because orchid popuations may typically be small, a decline in number of populations may be more significant than the small size of populations. Small populations may be the result of the slow establishment and growth rate of this species. However, small, declining populations may also indicate that specific habitat requirements are not being met (USDA and USDI 1994a), and may be related to availability of mycorrhizal fungi.

Population trends – No coordinated range-wide monitoring program exists of clustered or mountain lady's slipper, and no population viability analyses have been performed for either species outside of California. However, analysis conducted for this assessment with information from Carothers (2003) suggests an ongoing trend of population decline and local extinction. Multiple-year (two or more) population counts are currently available at 80 populations of clustered lady's slipper and 48 populations of mountain lady's slipper predominantly on the Plumas, Sierra, Klamath, Six Rivers, Sierra and Mendocino National Forests. Over the period of time observations were made (1 to 23 years, depending on the population), 66% of clustered lady's slipper populations declined in size and 30% fell to zero. For mountain lady's slipper, 67% declined and 44% disappeared. In clustered lady's slipper, small populations (<10 plants) disappeared in 55% of the cases while only 7% of large (>=10 plants) populations declined to zero. A total of 62% of small mountain lady's slipper populations disappeared, while 25% of larger populations disappeared.

The current status of many populations is unknown. Some have not been revisited since 1980 and the majority of clustered lady's slipper occurrences in the Sierra Nevada have not been revisited in ten years. Information for mountain lady's slipper in the Sierra Nevada is more up to date; half of the sites have been revisited in the last four years.

Population viability analysis – Population size was significantly correlated with extinction events for both species (logistic regression, $P>0.0001$ for clustered lady's slipper, $P=0.0025$ for mountain lady's slipper). Extinction probability declined as population size increased in roughly the same pattern in clustered and mountain lady's slipper (Figure 7). This analysis used maximum observed number of individuals throughout the monitoring period as a conservative measure of population size. Populations with 100 or more individuals had very low risk of extinction, while populations with 10 plants had a 36% to 45% risk of dying out for clustered and mountain lady's slipper, respectively. Populations with only one individual had a rate of extinction of 58%-61%.

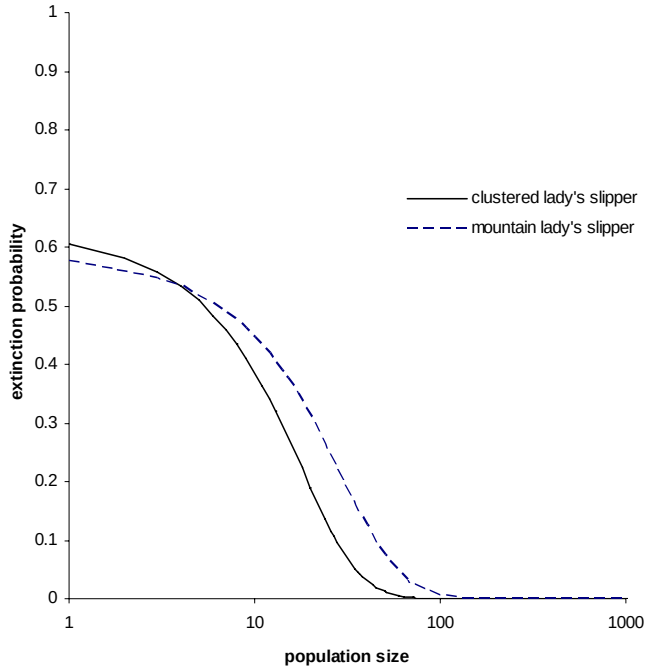


Figure 7. Extinction probability of lady's slipper populations as a function of population size. Small populations of these species are at high risk of extinction. Note the log scale of the x-axis.

Limitations to this analysis include uncertainty in the monitoring data and lack of information on establishment rates of new populations. For example, some of the information used for the analysis came from well documented monitoring projects while other data used here may have come from observations of populations without permanent markers, so that there may be some uncertainty as to whether observations a decade or more apart were made at exactly the same location. Also, these species are capable of dormancy, which means that some reports of zero plants may be the result of synchronous dormancy in a small number of plants. Only one monitored population, however, declined to zero then rebounded during a subsequent visit be field observers. Finally, although local extinction appears to be common in these species, colonization of new sites may also occur frequently and balance these losses on a landscape scale, but the data examined here do not make estimates of establishment rates possible.

Conservation

Threats

A threat analysis was performed for this Conservation Assessment to identify and rank threats to lady's slippers on National Forest lands in within the Sierra Nevada Bioregion and elsewhere in California. Forest staff were asked to list threats that were, in their professional opinion, impacting or likely to impact lady's slippers on their National Forests. Results from this survey were summarized to identify 14 high-priority risks on National Forests statewide (Table 3). For statewide ranking, average threat levels were adjusted for the number of Forests that listed each threat so that threats identified by many forests would be weighted over those listed by only a few. It is recognized that the extent of the threat rendered by the following activities may likely be commensurate with the intensity and extent of the activity.

Wildland fire and prescribed burning – High intensity fires are one of the greatest threats to mountain and clustered lady's slippers. This threat ranked highest in the statewide threat analysis, and is supported by research and literature. As discussed in the previous sections, clustered and mountain lady's slippers are intolerant to fires that burn through the litter layer above mineral soil. The species may tolerate less intense fires that do not eliminate the duff layer and leave the forest canopy fully or partially intact. Heavy fuel loads may pose a threat to many populations by increasing the risk of intense fire. Large scale fires could result in significant negative effects to multiple populations of these species.

Prescribed burns may also pose a threat to lady's slippers, especially if conducted during spring or other growing season months. Depending on the intensity, spring burns, when much of the plants' resources are devoted to the development of above-ground leaves, stems, and flowers, may result in a greater impact than burns conducted in September through February. Spring and early summer is the flowering period for lady's slipper orchids. Fire may not only eliminate the flowers (and pollinators) and thus affect fruit production, but also damage the leaf tissue during photosynthetically active period of the plant. Spring prescribed burns ranked 10th out of 14 threats statewide, while all other prescribed burns ranked 12th.

An analysis conducted for this Conservation Assessment of *Cypripedium* populations overlaid with mapped information on fire perimeters documented from 1915 through 2000 on all Region 5 National Forests shows that 12% (29 out of 239 sites) of clustered lady's slipper and 14% (27 of 189 sites) of mountain lady's slipper populations occur in areas that have burned. It is unknown, however, if these populations were present before these documented wildfires occurred, so it is difficult to make conclusions regarding the response of lady's slipper species to this disturbance.

An analysis of the Interagency Species Management System (ISMS) known site data for northern California's clustered and mountain lady's slipper in relation to fuel condition class (defined as susceptibility to stand replacing fires with class 3 as the most susceptible),shows that the majority (greater than 90 percent) of populations were in condition classes 2 and 3. The analysis, using the Fire and Resource Assessment Program model, indicates that a high percentage of occurrences in northern California (about 80%) within the Northwest Forest Plan area are at high risk of loss from high intensity fire, and the implementation of fuels treatments to reduce this risk is warranted on a case by case basis (McRae 2003).

The Fire Effects Information System (USDA Forest Service and USDI Bureau of Land Management 1994b) discusses fire suppression as a potentially important factor in the decline of mountain lady's slipper. This is based on site information that indicates the species appears to be more abundant and persistent in eastern Oregon where fires have remained more frequent but less intense than in western Oregon. East of the Cascade Range small forest gaps may produce the optimum conditions that balance the high light and mycorrhizal needs of germinating seeds with the shade preference of established plants.

Mechanical disturbance: timber harvest, fire lines, transmission lines, etc. – Disturbances that affect the rhizomes of these species, duff and litter layer, and the structure of the upper soil horizons may threaten plants and populations, as do those activities that remove the forest canopy. Such mechanical disturbances ranked second statewide in the threat analysis, and include timber harvest activities, construction of fire lines, power/gas transmission line construction and maintenance, culvert relocation, and other ground disturbing activities. A high ranking of this disturbance is consistent with information on the species responses to rhizome disturbance and forest canopy removal.

Plant collectors – Plant collectors represent a threat to wild lady's slipper populations in the Sierra Nevada and throughout California. This activity ranked third overall in the threat assessment. On the Stanislaus National Forest, unauthorized plant collecting ranked second after catastrophic fire.

The following is an excerpt from the American Orchid Society (1999):

> The American Orchid Society (AOS) is an advocate of the preservation, maintenance and appropriate management of orchid habitats as a primary goal of international and national conservation policies and practices. Consistent with this objective, the AOS endorses the artificial propagation of orchid species from seed and discourages the collection of orchid species from their natural habitats. However, where appropriate and practical, the AOS supports the rescue and relocation of orchid species from habitats that are endangered or threatened. (American Orchid Society Conservation Committee 1999)

Global trade in wild orchid species is significant. Lady's slippers in particular are actively exported and imported between nations, but this trade is overwhelmingly between Asian countries such as China, Taiwan and North Korea (exporters) and Japan (largest global importer), and wild populations in the U.S. are generally protected (Koopowitz 2004).

Road building and maintenance – Road construction and physical maintenance of the road shoulders, ditches, and banks ranked as the fourth greatest threat to lady's slipper populations in California. It was considered the top threat to clustered lady's slipper on the Tahoe National Forest.

Recreation – Recreational use of lady's slipper habitat ranked fifth in the statewide threat assessment. Off-road vehicles, hiking, construction and maintenance of trails, camping, and other recreational activities may all have negative effects on lady's slipper orchids in the Sierra Nevada Bioregion and statewide in California.

Cattle grazing and trampling – Livestock utilization and trampling of habitat ranked sixth overall in the threat assessment of lady's slipper in California. On the Modoc National Forest, this activity ranked first overall. Although cattle grazing may not affect most populations directly due to the typically low abundance of herbaceous vegetation in lady's slipper habitat, populations near riparian habitats and in areas through which cattle frequently pass may be locally vulnerable.

Numerous clustered lady's slipper and mountain lady's slipper occurrences in Region 5 are found within grazing allotments, and the proportion of populations subject to grazing differs by species among National Forests (Figure 8). In general, where both species are present on the same National Forest, a higher proportion of clustered and mountain lady's slipper populations occur within grazing allotments. For example, on the Lassen, Mendocino and Six Rivers National Forests, 50-55% of mountain lady's slipper populations occur in grazed areas, while 90-100% of clustered lady's slipper populations are subject to livestock influences. On the Modoc, Sierra, and Stanislaus National Forests, mountain lady's slipper is the only species present, and 85-100% of the known locations occur in grazed areas.

Fuels reduction – Fuel reduction activities to reduce the risk of intense wildfires and prescribed burns ranked seventh in the threat assessment. Scraping, digging and pile burning often associated with fuels reduction projects can disturb rhizomes of the orchids, reduce or remove all fruit and seed production in a given year, and alter microsite conditions by reducing shrub and tree cover. On this note, given the potential for intense wildfire in some geographic areas due to accumulation of fuels, careful application of fuels reduction programs can ultimately provide a benefit to the species range-wide.

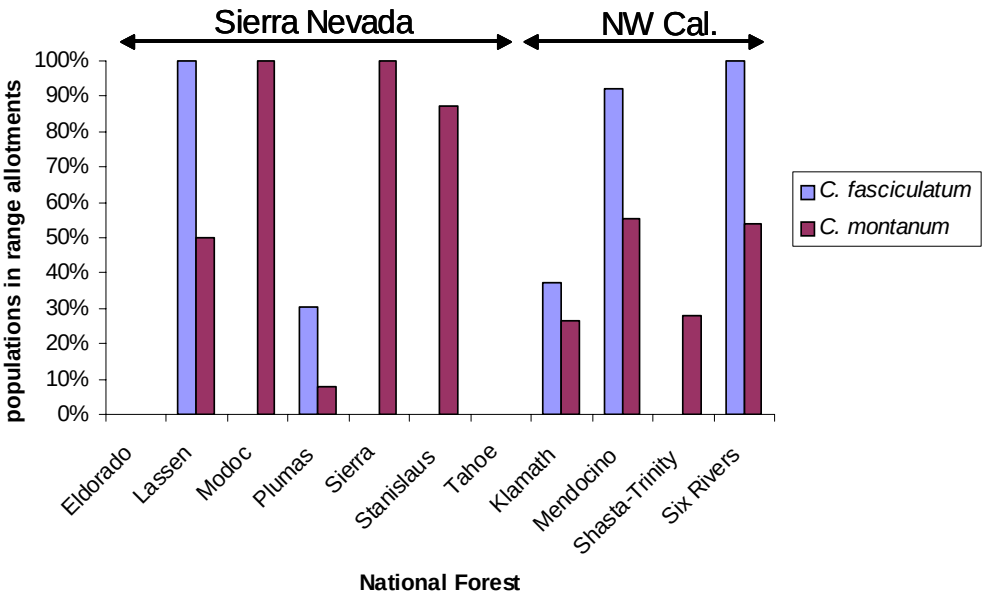


Figure 8. Frequency of clustered (*C. fasciculatum*) and mountain lady's slipper (*C. montanum*) populations in grazing allotments within Region 5 National Forests.

Fire suppression – Fire suppression ranked eighth overall but first on the Eldorado National Forest, which was the only Forest to recognize it as a threat. Fire suppression can create conditions of high fuel loads that increase the likelihood of intense fires that may damage the rhizomes of lady's slipper orchids.

Erosion – Mountain and clustered lady's slipper orchids are often found on steep slopes. Soil erosion can cause rhizomes and root systems of lady's slippers to be exposed and killed. This problem may be most significant in populations in or near riparian habitats that experience erosion caused by runoff as well as livestock trampling. In addition, erosion during winter storms may be a problem in areas where timber has been harvested or following fires. Soil erosion ranked ninth overall in the threat assessment, and highest on the Mendocino National Forest.

Hydrologic alteration – Alteration of moisture regimes in lady's slipper habitat could negatively effect local populations. Draining of moisture from the soil could reduce habitat quality by altering conditions for associated vegetation that provides shade to the species and/or reducing habitat suitability for mycorrhizal fungi. In addition, activities that cause excessive water retention in the soil may make habitat unsuitable. Alteration of hydrology ranked 11th in the threat assessment.

Mining – The removal of vegetation and topsoil necessary for mining activities, as well as the associated water use, alteration of hydrology, road building, equipment storage, and overburden placement make mining a direct threat to *Cypripedium* populations in the Sierra Nevada. Substantial numbers of populations of both clustered and mountain lady's slipper on the Klamath and Lassen National Forests occur in areas that have been withdrawn from mineral extraction (Figure 9), such as Wild and Scenic Rivers, Wilderness Areas, Research Natural Areas, Special Interest Areas and RARE2 (roadless) Areas. On the remaining National Forests, very few populations occur in areas protected from mining activities and most populations remain vulnerable to this threat if ore deposits are present. Mining was identified as a relatively low level threat on two National Forests (Tahoe and Plumas) in the Sierra Nevada.

Invasive species – Invasive species currently pose a minor threat to mountain and clustered lady's slipper populations in California. Invasive species listed by the California Exotic Pest Plant Council (CalEPPC 1999) that were found with lady's slipper occurrences were St. Johnswort (or Klamath weed, *Hypericum perforatum*), especially on the Mendocino National Forest and woolly mullein (*Verbascum*

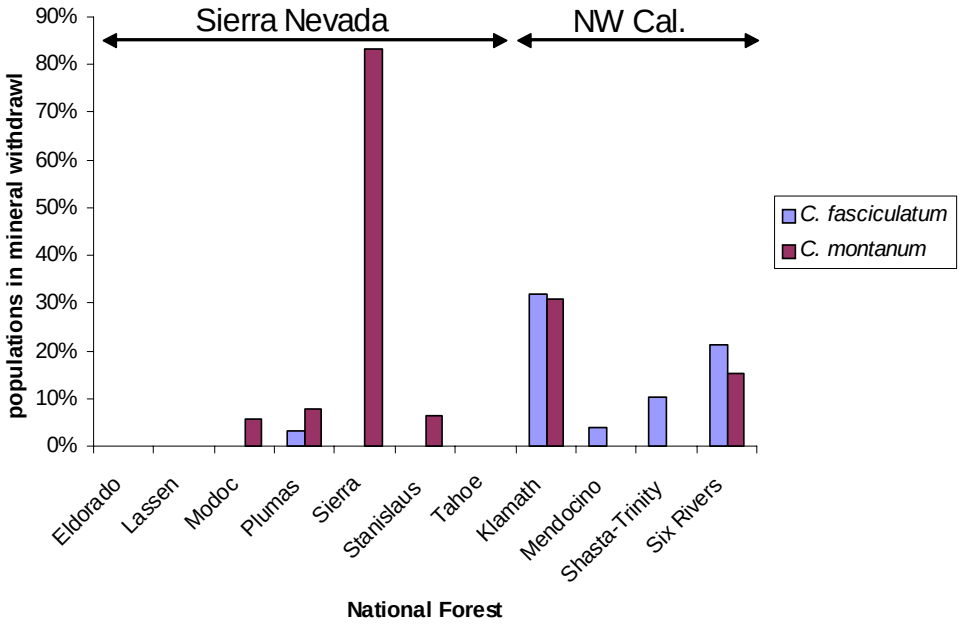


Figure 9. Populations of clustered (*C. fasciculatum*) and mountain lady's slipper (*C. montanum*) in areas that have been withdrawn from mineral extraction such as Wild and Scenic Rivers, Wilderness Areas, Research Natural Areas, Special Interest Ares and roadless areas.

thapsus) on the Stanislaus and Six Rivers National Forests. These species are on the CalEPPC List B: Wildland Plants of Lesser Invasiveness. Roadside populations and those in the vicinity of heavy machinery use are at the greatest risk for invasion by these and other unwanted species. Invasive species ranked last in the threat assessment likely because the disturbed nature of the habitat that is suitable for invasives, renders it unsuitable for lady's slipper orchids.

Conservation summary

Clustered and mountain lady's slippers appear to be at high risk in the Sierra Nevada and elsewhere in Region 5, but there are significant areas of uncertainty in the species' status and biology. Factors that lead to this assessment of high risk include:

< High intensity wildfire and mechanical treatments (e.g. road or fireline construction, logging-related activities) are the most frequently identified threats to both species. Although there is significant uncertainty surrounding the response of these species to these disturbances, the available information suggests that these threats could negatively impact a significant portion of the occurrences in the Sierra Nevada and elsewhere in California.

< While these orchids occur in fairly broad habitats (e.g. coniferous forests with hardwoods), they maintain fairly specific habitat requirements.

< Reproductive failure due to poor recruitment of new individuals into populations appears to be common in both species.

< Both species have complex life-cycles and require mycorrhizal relationships with very specific fungi, which may make them vulnerable to disturbances and may control population expansion and colonization of new sites. Conservation of these orchids may require conservation of their

mycorrhizal associates, but information on the function and ecology of these fungi is currently not available.

- Small population sizes are typical in these lady's slippers (more than half have fewer than ten plants in the Sierra Nevada and NW California). About two-thirds of populations that have been monitored have declined since monitoring began and many have disappeared. Small populations are at a high risk of extirpation.

- The current status of many populations is unknown. Some have not been revisited since 1980 and the majority of clustered lady's slipper occurrences in the Sierra Nevada have not been revisited in ten years. Information for mountain lady's slipper in the Sierra Nevada is more up to date; half of the sites have been revisited in the last four years.

These factors taken together indicate that many clustered and mountain lady's slipper populations are at significant risk of decline or extinction, and are consistent with findings from elsewhere in the range of the species.

Table 3. Threat analysis for lady's slipper species on National Forests in California. Fourteen threat categories were identified and ranked by botany program staff at each National Forest so that threats were ranked for each forest (with the top threat ranked 1). For state-wide ranking, the ranks for each threat were averaged across all forests, weighted by the number/frequency of Forests that identified the threat, then ranked overall. Note: threat ranks were not available for the Klamath NF.

	Sierra Nevada						NW Cal.			statewide ranking			
Threat	Eldorado	Lassen	Modoc	Plumas	Stanislaus	Tahoe	Mendocino	Shasta-Trinity	Six Rivers	average rank	no. Forests	frequency	**Overall rank**
catastrophic fires	6	2	2	3	1	2	2	1	3	2.4	9	1.0	**1**
mechanical treatments (timber harvest, fire lines)		1	3	1	3		3	2	1	2.0	7	0.8	**2**
plant collectors	4	3	5	5	2		6	4	4	4.1	8	0.9	**3**
road building and maintenance	2			2	6	1				2.8	4	0.4	**4**
recreation: hiking, trails, camping, OHVs	5	4	4	7	9	5	5	5		5.5	8	0.9	**5**
cattle grazing and trampling	3	5	1		7		7	3		4.3	6	0.7	**6**
fuels reduction activities				4	4	3			2	3.3	4	0.4	**7**
fire suppression	1									1.0	1	0.1	**8**
erosion	5				5		1			3.7	3	0.3	**9**
prescribed burns- spring				6	8	4				6.0	3	0.3	**10**
hydrologic alteration			6	9			4			6.7	3	0.3	**11**
prescribed burns- any	7					6				6.5	2	0.2	**12**
mining				8		7				7.5	2	0.2	**13**
invasive species (e.g., *Hypericum perforatum*)							8			8.0	1	0.1	**14**

Conservation elements

Tools and practices – The following tools and practices to conserve lady's slipper orchids in the Sierra Nevada are adapted from the management recommendations for clustered lady's slipper in the area covered by the Northwest Forest Plan (Vance et al. 2004). These site-specific management recommendations are applicable to the Sierra Nevada as well because the primary threats and biological processes of these lady's slipper species are similar across geographic regions. Further, these recommendations are consistent with the goals and problem areas identified in Sierra Nevada Forest Plan Amendment (USDA 2003).

< Maintain sufficient cover to avoid any more than intermittent direct solar radiation on clustered and mountain lady's slipper plants.

< Maintain decayed down logs (decay class 4 and 5), snags, and duff layer within the habitat area for favorable forest floor conditions, habitat, soil moisture and mycorrhizal associates. Where fuel concentrations are within the historic range of variability, provide for future recruitment of coarse woody debris.

< Avoid activities that alter, remove, or compact the soil, duff, or organic matter in the habitat area.

< Manage sites to include entire populations plus an area large enough to maintain current habitat and associated microclimate, primarily temperature and moisture. The size should be determined by a field visit and should consider factors such as canopy cover, slope, aspect, topographic position, vegetation structure (such as growth form, stratification, and coverage), and species composition.

< Where fuel concentrations exceed historic range of variability (fuel condition classes 2 and 3), treat fuels within and adjacent to the site to reduce risk of high intensity fire.

< Restrict activities within sites of lady's slippers to months outside of the species' growing season.

< Because individual plants do not appear above ground every year, it is important to buffer species locations in order to capture dormant plants.

< For those situations where lady's slipper orchid populations are locally abundant and prioritization may be warranted, consider the following criteria in determining populations for conservation:
  - Landscape distribution- (e.g. occurrences within the 6th field watershed and an even distribution of occurrences throughout the watershed).
  - Geographic location- such as a population's location relative to the edge of the species' natural range.
  - Habitat type- populations occuring in "under-represented" habitat types for the administrative unit (e.g. serpentine habitat).
  - Plant community composition- populations that include as associates those species (e.g. *Chimaphila umbellata, Goodyera oblongifolia, Corylus cornuta* ….) that most often co-occur with either orchid species.
  - Population size- number of stems greater than 10, or in general, relatively large populations.
  - Studied populations- those subject to active research or monitoring.
  - Land allocation- populations occurring in administratively or legislatively protected areas such as a Research Natural Area, Botanical Area, Wild River corridor or Wilderness Area.

Actions that benefit these species at a regional scale may also help with their overall conservation. The following points are provided for managers to consider when developing regional management plans for

these species.

- Coordinate region-wide conservation (e.g. standardize monitoring protocol, centralized and managed database) among all public agencies including the all Federal, State, and Local levels.
- Maintain habitat continuity from forest to forest by coordinating habitat conservation efforts on adjacent land ownerships.
- Form partnerships with adjacent private landowners, especially those with lady's slipper populations. Offer habitat management cost sharing.
- Facilitate movement of genetic material from southern populations northward to improve viability of populations subject to habitat warming and other climatic changes by maintain suitable habitat corridors and population viability of pollinators.

Research, inventory and monitoring

Monitoring recommendations – The objective of this section is to describe important elements to be considered in developing a monitoring protocol for clustered and mountain lady's slippers.

- High rates of dormancy make estimates of total population size difficult because an unknown number of individuals may be alive but not apparent to the field investigator. Therefore, long-term studies that track individual plants through periods of dormancy are required for accurate population analyses for these lady's slippers.
- Counting stems or ramets may over-estimate population size compared to counting individual plants and may miss dormancy and seedling recruitment. Even so, stem counting is faster and less expensive than demographic monitoring. It may also be effective for estimating sexual reproductive potential (flowering) of a population.
- Monitoring strategies that attempt to track individuals through time will yield substantial information on population size, structure, and seedling recruitment. This information is currently lacking from most populations of these species in the Sierra Nevada.
- Other factors that should be monitored at sites include habitat conditions (canopy cover, plant composition) and evidence of disturbance.
- Implementation monitoring of prescribed fire projects, including fuels reduction, should be planned where clustered and/or mountain lady's slippers occur. Monitoring that includes measurements of retained duff and percent canopy cover in post-project implementation monitoring will inform managers of the effects of these actions in future projects. Prior to any management activities, one year of monitoring data should be collected.

Research questions – Several gaps in research exist throughout the range of both species and especially within the Sierra Nevada. The following research questions will provide information needed to adequately manage these species and ensure their long term viability.

- What level of disturbance (fire and overstory removal) do clustered and mountain lady's slipper plants tolerate?
- What is the optimal light level for growth and reproduction? What is the minimum canopy cover that these lady's slippers can tolerate?
- What conditions promote mycorrhizal fungi in the Tulasnellaceae and what is the ecological function of these fungi?
- What is the maximum livestock density that will have minimal effect of lady's slipper populations?
- What factors affect seedling recruitment, plant growth, reproduction, and population structure? What microclimate/microsite conditions favor the plants survival, growth, reproduction? What specific site characteristics are necessary to maintain existing populations?
- What is the degree of genetic variability in clustered and mountain lady's slippers throughout the Sierra Nevada, California, and their entire ranges?
- What are the proper methods for seed collection and *in situ* propagation of both species? (See Huber

2002).

- What is the average length of dormancy for individuals, both disturbed and undisturbed? In a particular year, what is the percentage of a population that may be dormant?
- What factors control population spread and colonization of new sites, and how often does establishment of new populations occur?
- To address the potential role of climatic conditions (seasonal or long-term), is there any correlation between the distribution of populations and population size with precipitation and temperature?

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Additional Reviewers: Julie Nelson (Shasta-Trinity National Forest), and Linnea Hanson (Plumas National Forest)

Photo credits: Cover photo of *Cypripedium fasciculatum* by John McRae, all other photos by Tom Kaye

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Appendices

Appendix I. Species list for *Cypripedium fasciculatum* occurrences in California.

Species are listed in alphabetical order and are counted individually for each forest. The first line shows the total number of *C. fasciculatum* occurrences for each National Forest for which a species list was made. This list represents a summary of all species lists submitted.

	Klamath		Tahoe		Plumas		Shasta-Trinity		Mendocino		Six Rivers		Total
Total occurrences (with species lists)	84		7		77		22		40		11		241.0
	#	%	#	%	#	%	#	%	#	%	#	%	%
××*Asplenosorus herb-wagneri*	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Abies concolor	34	40	4	57	43	56	13	59	24	60	2	18	49.8
Abies magnifica var. *shastensis*	4	5	0	0	5	6	0	0	4	10	2	18	6.2
Acer circinatum	1	1	0	0	0	0	0	0	0	0	1	9	0.8
Acer glabrum	3	4	0	0	8	10	0	0	0	0	0	0	4.6
Acer glabrum ssp. *torreyi*	2	2	0	0	4	5	0	0	0	0	0	0	2.5
Acer macrophyllum	16	19	0	0	5	6	3	14	9	23	3	27	14.9
Achlys californica	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Achlys triphylla	14	17	0	0	0	0	0	0	0	0	1	9	6.2
Adenocaulon bicolor	17	20	0	0	18	23	3	14	27	68	4	36	28.6
Adiantum aleuticum	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Allium siskiyouense	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Allotropa sp.	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Alnus rhombifolia	2	2	0	0	1	1	0	0	2	5	0	0	2.1
Alnus sp.	0	0	0	0	0	0	1	5	0	0	1	9	0.8
Alnus tenuifolia	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Amaranthus palmeri	1	1	0	0	1	1	0	0	0	0	0	0	0.8
Amelanchier floridanus	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Amelanchier pallida	1	1	0	0	3	4	0	0	1	3	0	0	2.1
Amelanchier sp.	3	4	0	0	0	0	0	0	0	0	0	0	1.2
Amelanchier utahensis	0	0	0	0	2	3	0	0	0	0	0	0	0.8
Amelenchier alnifolia	3	4	0	0	1	1	1	5	2	5	0	0	2.9
Andropogon bicornis	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Anemone deltoidea	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Anemone oregana	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Antitrichia californica (moss)	0	0	0	0	0	0	0	0	2	5	0	0	0.8
Apiastrum angustifolium	0	0	0	0	1	1	0	0	1	3	0	0	0.8
Apocynum androsaemifolium	4	5	0	0	0	0	1	5	2	5	0	0	2.9
Apocynum sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Arabis dispar	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Arabis sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Arbutus menziesii	34	40	1	14	0	0	3	14	4	10	4	36	19.1
Arctostaphylos andersonii	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Arctostaphylos manzanita	0	0	0	0	0	0	0	0	0	0	1	9	0.4
Arctostaphylos nevadensis	4	5	0	0	1	1	0	0	0	0	0	0	2.1
Arctostaphylos patula	3	4	0	0	1	1	0	0	0	0	0	0	1.7
Arctostaphylos sp.	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Arnica cordifolia	3	4	0	0	1	1	0	0	0	0	2	18	2.5
Arnica discoidea	1	1	0	0	1	1	5	23	0	0	0	0	2.9
Arnica sp.	8	10	0	0	1	1	0	0	4	10	3	27	6.6
Asarum hartwegii	1	1	0	0	2	3	1	5	0	0	0	0	1.7
Asarum sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4

Astragalus deanei	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Astragalus sp.	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Balsamorhiza sagittata	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Berberis aquifolium	1	1	0	0	0	0	0	0	1	3	1	9	1.2
Berberis nervosa	25	30	0	0	0	0	5	23	1	3	2	18	13.7
Berberis pumila	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Berberis repens	2	2	0	0	0	0	1	5	1	3	0	0	1.7
Berberis sp.	11	13	0	0	0	0	0	0	2	5	1	9	5.8
Boisduvalia stricta	4	5	0	0	0	0	0	0	0	0	0	0	1.7
Brachythecium albicans (moss)	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Bromus orcuttianus	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Bromus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Cacaliopsis nardosmia	0	0	0	0	0	0	1	5	0	0	0	0	0.4
Calamagrostis deschampsioides	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Calocedrus decurrens	26	31	5	71	24	31	5	23	12	30	2	18	30.7
Calochortus apiculatus	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Calochortus tolmiei	0	0	0	0	0	0	0	0	1	3	1	9	0.8
Calypso bulbosa	6	7	0	0	0	0	0	0	1	3	1	9	3.3
Camassia sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Campanula prenanthoides	5	6	0	0	3	4	2	9	1	3	0	0	4.6
Campanula sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Capsella bursa-pastoris	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Carex brainerdii	0	0	0	0	6	8	0	0	0	0	0	0	2.5
Carex praticola	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Carex pribylovensis	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Carex rossii	0	0	0	0	2	3	0	0	0	0	0	0	0.8
Carex sp.	3	4	0	0	0	0	2	9	0	0	0	0	2.1
Castilleja applegatei	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Castilleja sp.	1	1	0	0	2	3	0	0	0	0	0	0	1.2
Ceanothus cordulatus	0	0	0	0	3	4	0	0	0	0	0	0	1.2
Ceanothus integerrimus	7	8	0	0	5	6	0	0	0	0	0	0	5.0
Ceanothus prostratus	1	1	0	0	2	3	0	0	0	0	0	0	1.2
Cephalanthera austiniae	2	2	0	0	0	0	1	5	3	8	1	9	2.9
Cercocarpus betuloides	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Chimaphila sp.	2	2	0	0	1	1	0	0	0	0	0	0	1.2
Chimaphila umbellata	14	17	0	0	17	22	13	59	4	10	1	9	20.3
Chimophila menziesii	4	5	0	0	4	5	1	5	2	5	1	9	5.0
Chorizanthe membranacea	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Chrysolepis chrysophylla	18	21	0	0	4	5	2	9	0	0	1	9	10.4
Chrysolepis sempervirens	7	8	0	0	9	12	7	32	0	0	0	0	9.5
Chrysolepis sp.	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Cirsium andersonii	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Cirsium sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Claytonia perfoliata	3	4	0	0	1	1	0	0	0	0	0	0	1.7
Clintonia uniflora	3	4	0	0	3	4	1	5	0	0	0	0	2.9
Collinsia linearis	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Collinsia rattanii	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Collomia heterophylla	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Corallorhiza sp.	2	2	0	0	1	1	0	0	1	3	3	27	2.9
Corallorhiza striata	1	1	1	14	2	3	1	5	1	3	2	18	3.3
Corallorrhiza maculata	1	1	0	0	0	0	0	0	3	8	0	0	1.7

Cornus nuttallii	30	36	0	0	54	70	7	32	26	65	2	18	49.4
Cornus sericea ssp. sericea	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Corylus cornuta	0	0	0	0	2	3	0	0	0	0	0	0	0.8
Corylus cornuta var. californica	29	35	2	29	7	9	9	41	1	3	5	45	22.0
Cupressus bakeri	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Cynoglossum grande	1	1	0	0	0	0	1	5	0	0	1	9	1.2
Cynoglossum occidentale	0	0	0	0	0	0	1	5	0	0	0	0	0.4
Cypripedium montanum	12	14	0	0	0	0	1	5	0	0	0	0	5.4
Cystopteris fragilis	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Dendroalsia abietina (moss)	0	0	0	0	0	0	0	0	2	5	0	0	0.8
Deschampsia elongata	0	0	0	0	0	0	0	0	0	0	1	9	0.4
Dicentra formosa	1	1	1	14	1	1	0	0	0	0	0	0	1.2
Dicranium howellii (moss)	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Disporum hookeri	25	30	0	0	6	8	0	0	13	33	4	36	19.9
Disporum smithii	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Disporum sp.	4	5	0	0	1	1	3	14	0	0	0	0	3.3
Dodecatheon hendersonii	1	1	0	0	0	0	0	0	0	0	1	9	0.8
Draba standleyi	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Elymus sp.	0	0	0	0	0	0	1	5	0	0	0	0	0.4
Equisetum sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Equisteum arvense	0	0	0	0	0	0	2	9	0	0	0	0	0.8
Erigeron pulchellus	0	0	0	0	3	4	0	0	0	0	0	0	1.2
Erysimum capitatum	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Erythronium californicum	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Erythronium oregonum	3	4	0	0	0	0	0	0	0	0	0	0	1.2
Erythronium sp.	2	2	0	0	1	1	1	5	0	0	1	9	2.1
Festuca californica	4	5	0	0	0	0	1	5	0	0	1	9	2.5
Festuca idahoensis	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Festuca occidentalis	1	1	0	0	2	3	0	0	0	0	0	0	1.2
Festuca rubra	0	0	0	0	0	0	0	0	0	0	1	9	0.4
Festuca sp.	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Fragaria sp.	4	5	0	0	0	0	2	9	0	0	0	0	2.5
Frasera albicaulis	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Frasera speciosa	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Fritillaria recurva	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Fritillaria sp.	0	0	1	14	0	0	0	0	0	0	0	0	0.4
Galium aparine	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Galium bolanderi	1	1	0	0	3	4	0	0	0	0	0	0	1.7
Galium buxifolium	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Galium nuttallii	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Galium sp.	7	8	0	0	4	5	0	0	2	5	1	9	5.8
Garrya fremontii	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Garrya sp.	4	5	0	0	0	0	0	0	0	0	0	0	1.7
Goodyera oblongifolia	15	18	0	0	17	22	6	27	8	20	2	18	19.9
ground lichens	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Habenaria sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Hackelia sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Helenium microcephalum	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Hieracium albiflorum	13	15	0	0	2	3	1	5	17	43	5	45	15.8
Hieracium sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Holodiscus discolor	3	4	0	0	0	0	1	5	0	0	0	0	1.7

Homalothecium pinnatifidum (moss)	0	0	0	0	0	0	0	0	2	5	0	0	0.8
Homalothecium nevadense (moss)	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Hydrophyllum occidentale	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Hydrophyllum sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Hypnum subimponeus (moss)	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Iris chrysophylla	3	4	0	0	0	0	0	0	3	8	0	0	2.5
Iris hartwegii	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Iris sp.	6	7	0	0	1	1	3	14	0	0	1	9	4.6
Kelloggia galioides	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Lathyrus sp.	6	7	0	0	0	0	0	0	0	0	0	0	2.5
Leseuraca patens (moss)	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Leucothoe davisiae	3	4	0	0	2	3	2	9	2	5	0	0	3.7
Lewisia sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
lichens	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Lilium pardalinum	1	1	0	0	0	0	0	0	0	0	2	18	1.2
Lilium sp.	4	5	0	0	1	1	0	0	1	3	0	0	2.5
Lilium washingtonianum	1	1	0	0	1	1	0	0	0	0	0	0	0.8
Linnaea borealis ssp. longiflora	0	0	0	0	2	3	0	0	0	0	0	0	0.8
Listera convallarioides	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Lithocarpus densiflora	9	11	2	29	1	1	0	0	2	5	6	55	8.3
Lithocarpus densiflora var. echinoides	0	0	0	0	6	8	2	9	0	0	0	0	3.3
Lomatium ciliolatum	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Lonicera ciliosa	3	4	0	0	0	0	0	0	0	0	0	0	1.2
Lonicera conjugialis	6	7	0	0	0	0	0	0	0	0	2	18	3.3
Lonicera hispidula vacillans	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Lonicera sp.	0	0	0	0	2	3	0	0	0	0	0	0	0.8
Lupinus leucopsis var. shermanensis	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Lupinus sp.	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Luzula parviflora	0	0	0	0	0	0	0	0	0	0	1	9	0.4
Luzula sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Mahonia repens	0	0	0	0	0	0	1	5	0	0	0	0	0.4
Melica sp.	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Moehringia macrophylla	4	5	0	0	0	0	0	0	0	0	0	0	1.7
moss	4	5	0	0	1	1	0	0	0	0	1	9	2.5
Nemophila heterophylla	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Nemophila parviflora	3	4	0	0	0	0	0	0	0	0	0	0	1.2
Oemleria cerasiformis	1	1	0	0	0	0	0	0	0	0	0	0	0.4
orchid sp.	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Orobanche uniflora	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Osmorhiza chilensis	2	2	0	0	2	3	2	9	5	13	2	18	5.4
Pachystema myrsinoides	6	7	0	0	0	0	1	5	0	0	0	0	2.9
Pedicularis densiflora	0	0	0	0	0	0	1	5	0	0	0	0	0.4
Pedicularis racemosa	0	0	0	0	2	3	0	0	0	0	0	0	0.8
Peltigera canina (lichen)	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Penstemon anguineus	0	0	0	0	0	0	0	0	3	8	0	0	1.2
Penstemon deustus	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Penstemon personatus	0	0	0	0	12	16	0	0	0	0	0	0	5.0
Phacelia distans	1	1	0	0	0	0	0	0	0	0	0	0	0.4

Philadelphus lewisii	4	5	0	0	0	0	0	0	0	0	0	0	1.7
Phlox adsurgens	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Phlox speciosa	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Pinus attenuata	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Pinus jeffreyi	1	1	0	0	1	1	0	0	0	0	0	0	0.8
Pinus lambertiana	25	30	0	0	26	34	14	64	11	28	0	0	31.5
Pinus monticola	5	6	0	0	1	1	1	5	0	0	1	9	3.3
Pinus ponderosa	25	30	5	71	12	16	3	14	5	13	0	0	20.7
Piperia sp.	3	4	0	0	0	0	2	9	0	0	1	9	2.5
Piperia unalascensis	1	1	0	0	2	3	0	0	0	0	0	0	1.2
Poa sp.	1	1	0	0	1	1	0	0	0	0	0	0	0.8
Polygala cornuta	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Polypodium hesperium	0	0	0	0	0	0	0	0	0	0	1	9	0.4
Polypogon sp.	0	0	0	0	0	0	0	0	0	0	1	9	0.4
Polystichum imbricans	2	2	0	0	1	1	2	9	0	0	0	0	2.1
Polystichum munitum	7	8	0	0	0	0	2	9	3	8	1	9	5.4
Polystichum sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Prunus emarginata	1	1	0	0	1	1	0	0	0	0	0	0	0.8
Prunus virginiana var. demissa	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Pseudosasa japonica	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Pseudotsuga menziesii	78	93	3	43	33	43	22	100	33	83	11	100	74.7
Pseudotsuga menziesii (regen)	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Ptelea angustifolia	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Pteridium aquilinum var. *pub.*	10	12	0	0	11	14	5	23	10	25	0	0	14.9
Pterospora andromedea	1	1	0	0	0	0	1	5	0	0	0	0	0.8
Pyrola picta	7	8	0	0	11	14	6	27	13	33	1	9	15.8
Pyrola sp.	1	1	0	0	1	1	0	0	0	0	0	0	0.8
Quercus chrysolepis	24	29	2	29	2	3	3	14	15	38	8	73	22.4
Quercus chrysolepis var. *nanus*	8	10	0	0	1	1	9	41	1	3	1	9	8.3
Quercus kelloggii	26	31	0	0	9	12	4	18	5	13	1	9	18.7
Quercus sadleriana	5	6	0	0	0	0	0	0	0	0	0	0	2.1
Quercus sp.	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Quercus vacciniifolia	6	7	0	0	7	9	1	5	0	0	1	9	6.2
Rhamnus californica	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Rhamnus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Rhododendron sp.	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Ribes lacustre	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Ribes menziesii	0	0	0	0	3	4	0	0	0	0	1	9	1.7
Ribes roezlii	2	2	0	0	1	1	1	5	0	0	0	0	1.7
Ribes sanguineum	3	4	0	0	0	0	0	0	0	0	1	9	1.7
Ribes sp.	4	5	0	0	0	0	2	9	1	3	0	0	2.9
Roellia roellia (moss)	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Rosa gymnocarpa	6	7	0	0	10	13	6	27	0	0	1	9	9.5
Rosa sp.	27	32	0	0	9	12	7	32	22	55	1	9	27.4
Rubus leucodermis	3	4	0	0	1	1	2	9	1	3	0	0	2.9
Rubus parviflorus	13	15	0	0	13	17	0	0	8	20	1	9	14.5
Rubus sp.	5	6	0	0	0	0	0	0	0	0	0	0	2.1
Rubus ursinus	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Salix scouleriana	1	1	0	0	6	8	0	0	0	0	0	0	2.9
Salix sp.	2	2	0	0	1	1	0	0	0	0	0	0	1.2
Sambucus nigra ssp. cerulea	1	1	0	0	0	0	0	0	0	0	0	0	0.4

Sarcodes sanguinea	0	0	0	0	2	3	0	0	0	0	0	0	0.8
Satureja douglasii	0	0	0	0	0	0	0	0	0	0	1	9	0.4
Saxifraga sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Sedum lanceolatum ssp. lanceolatum	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Sedum sp.	1	1	0	0	0	0	1	5	0	0	0	0	0.8
Silene lemmonii	1	1	0	0	0	0	0	0	1	3	0	0	0.8
Smilacina racemosa var. amplexicaulis	23	27	0	0	26	34	8	36	12	30	1	9	29.0
Smilacina sp.	3	4	0	0	0	0	1	5	0	0	1	9	2.1
Smilacina stellata	6	7	0	0	3	4	0	0	0	0	1	9	4.1
Sorbus californica	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Spiraea douglasii	0	0	0	0	1	1	0	0	0	0	0	0	0.4
Stachys sp.	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Streptanthus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Streptopus amplexifolius var. *amplexifolius*	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Symphoricarpos acutus	1	1	0	0	7	9	3	14	0	0	0	0	4.6
Symphoricarpos albus	5	6	0	0	0	0	0	0	5	13	0	0	4.1
Symphoricarpos mollis	10	12	0	0	9	12	7	32	19	48	4	36	20.3
Symphoricarpos rivularis	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Symphoricarpos sp.	18	21	0	0	5	6	0	0	0	0	0	0	9.5
Synthyris alpina	1	1	0	0	0	0	0	0	1	3	0	0	0.8
Syntrichia princeps (moss)	0	0	0	0	0	0	0	0	3	8	0	0	1.2
Taxus brevifolia	6	7	1	14	4	5	4	18	7	18	0	0	9.1
Tonella tenella	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Toxicodendron diversiloba	16	19	0	0	0	0	3	14	3	8	2	18	10.0
Trichostema lanatum	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Trientalis latifolia	25	30	0	0	9	12	10	45	5	13	2	18	21.2
Trillium chloropetalum	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Trillium ovatum	6	7	0	0	0	0	1	5	0	0	1	9	3.3
Trillium sp.	0	0	1	14	0	0	1	5	0	0	0	0	0.8
Trisetum canescens	0	0	0	0	0	0	0	0	0	0	1	9	0.4
Umbellularia californica	0	0	0	0	0	0	0	0	0	0	1	9	0.4
unknown grasses	3	4	0	0	2	3	1	5	0	0	0	0	2.5
unknown saprophytes	1	1	0	0	1	1	0	0	0	0	0	0	0.8
Vaccinium arbuscula	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Vaccinium membranaceum	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Vaccinium sp.	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Vancouveria hexandra	3	4	0	0	0	0	0	0	0	0	0	0	1.2
Vancouveria sp.	1	1	0	0	0	0	0	0	1	3	0	0	0.8
Venegasia carpesioides	0	0	0	0	0	0	1	5	0	0	0	0	0.4
Vicia americana ssp. *americana*	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Vicia sp.	7	8	0	0	0	0	0	0	0	0	0	0	2.9
Viola glabella	2	2	0	0	0	0	0	0	0	0	0	0	0.8
Viola lobata	1	1	0	0	5	6	1	5	0	0	0	0	2.9
Viola sheltonii	0	0	0	0	0	0	0	0	1	3	0	0	0.4
Vulpia microstachys	1	1	0	0	0	0	0	0	0	0	0	0	0.4
Whipplea modesta	3	4	0	0	0	0	3	14	0	0	2	18	3.3
Woodwardia fimbriata	0	0	0	0	0	0	1	5	0	0	0	0	0.4
Wyethia mollis	0	0	0	0	0	0	0	0	0	0	1	9	0.4
Xerophyllum tenax	3	4	0	0	0	0	0	0	0	0	0	0	1.2

Appendix II. Species list for *Cypripedium montanum* occurrences in California.

Associations are listed in alphabetical order and are evaluated individually for each forest. The first line shows the total number of *Cypripedium montanum* occurrences for each forest for which a species list was made. This list represents a summary of all species lists submitted. Not all occurrences had an associated species list provided.

	Klamath		Modoc		Lassen		Mendocino		Plumas		Sierra		Six Rivers		Stanislaus		Yosemite		Shasta-Trinity		Total
Occurrences with species lists	73		14		2		9		11		5		6		13		2		16		156
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	%
Abies concolor	35	48	7	50	1	50	8	89	4	36	3	60	2	33	10	77	0	0	3	19	46.8
Abies sp.	0	0	2	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Acer glabrum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Acer macrophyllum	25	34	0	0	1	50	0	0	0	0	0	0	1	17	1	8	1	50	4	25	21.2
Achillea millifolium	1	1	1	7	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	1.9
Achlys triphylla	13	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.3
Achnatherum lemmonii	0	0	0	0	0	0	2	22	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Adenocaulon bicolor	24	33	6	43	1	50	2	22	6	55	0	0	4	67	9	69	1	50	6	38	37.8
Adiantum aleuticum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Agrostis humilis	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Allotropa virgata	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Alnus rhombifolia	5	7	0	0	0	0	0	0	0	0	0	0	0	0	2	15	0	0	1	6	5.1
Alnus rubra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50	0	0	0.6
Alnus sp.	1	1	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	1.3
Amelanchier floridanus	1	1	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Amelanchier pallida	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50	2	13	2.6
Amelanchier sp.	4	5	0	0	0	0	0	0	1	9	0	0	0	0	1	8	0	0	0	0	3.8
Amelenchier alnifolia	1	1	1	7	0	0	0	0	1	9	0	0	0	0	1	8	0	0	0	0	2.6
Angelica sp.	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Anemone oregana	0	0	0	0	0	0	0	0	3	27	0	0	0	0	0	0	0	0	0	0	1.9
Apiastrum angustifolium	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Apocynum androsaemifolium	1	1	1	7	0	0	0	0	1	9	0	0	1	17	0	0	0	0	0	0	2.6
Aquilegia formosa	0	0	1	7	0	0	0	0	0	0	0	0	1	17	3	23	0	0	1	6	3.8
Arabis oregana	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Aralia californica	0	0	0	0	1	50	0	0	0	0	0	0	0	0	0	0	0	0	1	6	1.3
Arbutus menziesii	30	41	0	0	1	50	0	0	0	0	0	0	0	0	0	0	1	50	3	19	22.4

Arctostaphylos patula	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Arctostaphylos sp.	3	4	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	2.6
Arnica discoidea	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	1	6	1.3
Arnica sp.	4	5	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	1	6	3.8
Aruncus dioicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0.6
Asarum caudatum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	1.3
Asarum hartwegii	2	3	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	1	6	2.6
Asarum lemmonii	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Asarum sp.	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	2.6
Aster radulinus	0	0	1	7	0	0	0	0	2	18	0	0	0	0	0	0	0	0	0	0	1.9
Aster sp.	0	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Athyrium filix-femina	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Berberis aquifolium	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Berberis aquifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50	0	0	0.6
Berberis nervosa	34	47	0	0	0	0	1	11	0	0	0	0	0	0	0	0	2	100	2	13	25.0
Berberis nevinii	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Berberis piperiana	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Berberis repens	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Berberis sp.	8	11	2	14	2	##	0	0	0	0	0	0	0	0	0	0	0	0	1	6	8.3
Boykinia occidentalis	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Brodiaea lutea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Bromus laevipes	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	0.6
Bromus sp.	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	2	13	1.9
Bromus tectorum	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Bromus vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0.6
bunch grasses	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Calocedrus decurrens	21	29	10	71	1	50	3	33	4	36	2	40	0	0	10	77	0	0	8	50	37.8
Calochortus tolmiei	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Calypso bulbosa	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	3.2
Campanula prenanthoides	6	8	0	0	0	0	2	22	0	0	0	0	0	0	1	8	0	0	1	6	6.4
Carex amplifolia	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Carex sp.	3	4	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	2.6
Castilleja sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Ceanothus cordulatus	0	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	1.3
Ceanothus cuneatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Ceanothus integerrimus	5	7	0	0	0	0	0	0	0	0	0	0	0	0	3	23	0	0	0	0	5.1
Ceanothus prostratus	1	1	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	1.3

Ceanothus sp.	0	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Cephalanthera austiniae	1	1	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	1	6	1.9
Chenopodium foliosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Chimaphila sp.	4	5	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2
Chimaphila umbellata	12	16	0	0	0	0	0	0	2	18	0	0	0	0	0	0	0	0	4	25	11.5
Chimaphila umbellata ssp. *occidentalis*	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Chimophila menziesii	2	3	0	0	1	50	0	0	2	18	0	0	0	0	0	0	0	0	2	13	4.5
Chrysolepis chrysophylla	16	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	11.5
Chrysolepis sempervirens	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.8
Circaea alpina ssp. *pacifica*	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Cirsium vulgare	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Claytonia perfoliata	0	0	0	0	0	0	0	0	1	9	0	0	0	0	1	8	0	0	0	0	1.3
Clintonia sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Clintonia uniflora	5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	3.8
Collinsia parviflora	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Corallorhiza sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Corallorhiza striata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0.6
Corallorrhiza maculata	5	7	0	0	1	50	1	11	0	0	0	0	0	0	0	0	0	0	0	0	4.5
Corallorrhiza sp.	2	3	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	1.9
Cordylanthus pringlei	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	0.6
Cornus nuttallii	35	48	0	0	0	0	2	22	3	27	0	0	0	0	3	23	0	0	5	31	30.8
Cornus sericea ssp. *sericea*	1	1	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	1	6	1.9
Corylus cornuta var. *californica*	43	59	0	0	0	0	0	0	0	0	0	0	1	17	3	23	2	100	7	44	35.9
Cryptantha torreyana	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Cynoglossum grande	0	0	0	0	1	50	0	0	0	0	0	0	2	33	0	0	0	0	0	0	1.9
Cynoglossum occidentale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	1.3
Cyperus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Cypripedium fasciculatum	10	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.4
Deschampsia elongata	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Dicentra formosa	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9
Dichelostemma ida-maia	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	0.6
Disporum hookeri	22	30	0	0	1	50	3	33	0	0	0	0	3	50	3	23	0	0	2	13	21.8
Disporum sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	1.3
Elymus elymoides	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Elymus glaucus	1	1	0	0	0	0	2	22	0	0	0	0	1	17	0	0	0	0	1	6	3.2
Epilobium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0.6

Equisetum sp.	3	4	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	2.6
Erigeron vernus	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	0.6
Eriophyllum lanatum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Erythronium californicum	0	0	0	0	1	50	0	0	0	0	0	0	0	0	0	0	1	50	0	0	1.3
Erythronium sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
ferns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Festuca californica	1	1	0	0	1	50	0	0	0	0	0	0	1	17	0	0	0	0	3	19	3.8
Festuca occidentalis	1	1	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	1	6	1.9
Festuca sp.	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Fragaria sp.	4	5	0	0	0	0	0	0	0	0	0	0	0	0	2	15	0	0	0	0	3.8
Fragaria vesca	2	3	0	0	0	0	0	0	0	0	0	0	0	0	1	8	1	50	0	0	2.6
Fragaria virginiana	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	1.3
Frasera speciosa	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9
Fritillaria affinis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Galium aparine	1	1	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	1	6	1.9
Galium bolanderi	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Galium sp.	8	11	0	0	0	0	1	11	1	9	0	0	0	0	4	31	0	0	0	0	9.0
Galium trifidum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	15	0	0	0	0	1.3
Garrya fremontii	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Garrya sp.	5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2
Gaultheria shallon	0	0	0	0	0	0	0	0	0	0	1	20	0	0	0	0	0	0	0	0	0.6
Gayophytum nuttallii	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Goodyera oblongifolia	18	25	0	0	0	0	1	11	0	0	0	0	3	50	0	0	0	0	4	25	16.7
grasses	2	3	2	14	0	0	0	0	4	36	0	0	0	0	0	0	0	0	0	0	5.1
Hackelia bella	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	0.6
Helenium microcephalum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Hieracium albiflorum	9	12	1	7	0	0	1	11	4	36	0	0	1	17	0	0	0	0	1	6	10.9
Holodiscus discolor	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6
Hypericum perforatum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Iris chrysophylla	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Iris hartwegii	0	0	0	0	0	0	0	0	1	9	1	20	0	0	0	0	0	0	0	0	1.3
Iris sp.	11	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	25	9.6
Juncus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Lathryus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Lathyrus nevadensis	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Lathyrus pauciflorus ssp. *brownii*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Lathyrus polyphyllus	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6

Lathyrus sp.	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	5.1
Leucothoe davisiae	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Ligusticum grayi	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Ligusticum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50	0	0	0.6
Lilium pardalinum	0	0	1	7	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	1.3
Lilium rubescens	0	0	0	0	1	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Lilium sp.	8	11	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	5	31	9.0
Lilium washingtonianum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Linnaea borealis ssp. *americana*	9	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.8
Linnaea borealis ssp. *longiflora*	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Lithocarpus desniflorus	1	1	0	0	0	0	1	11	0	0	1	20	2	33	0	0	0	0	0	0	3.2
Lithophragma parviflorum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Lomatium ciliolatum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Lonicera hispidula var. *vacillans*	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9
Lonicera sp.	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9
Lupinus sp.	6	8	1	7	0	0	0	0	0	0	0	0	1	17	0	0	0	0	1	6	5.8
Madia sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Melica sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	1	6	1.3
Melica subulata	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	1	6	1.3
Minuartia nuttallii ssp. *gracilis*	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Mitella sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
moss	8	11	0	0	0	0	0	0	2	18	0	0	1	17	1	8	0	0	0	0	7.7
Oemleria cerasiformis	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Orthilia secunda	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Osmorhiza ap.	0	0	0	0	0	0	2	22	0	0	0	0	0	0	0	0	0	0	1	6	1.9
Osmorhiza chilensis	3	4	1	7	0	0	0	0	5	45	0	0	3	50	2	15	1	50	1	6	10.3
Boschniakia strobilacea	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Paxistima myrsinoides	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6
Pedicularis sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Peltigera canina	0	0	0	0	1	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Phacelia lemmonii	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Philadelphus lewisii	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9
Phlox gracilis	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Pinus attenuata	3	4	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	2.6
Pinus jeffreyi	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Pinus lambertiana	30	41	0	0	1	50	2	22	0	0	0	0	0	0	4	31	0	0	7	44	28.2
Pinus monticola	5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2

Pinus ponderosa	30	41	6	43	0	0	4	44	0	0	0	0	2	33	4	31	0	0	5	31	32.7
Pinus sp.	0	0	2	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	1.9
Piperia sp.	1	1	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	1.3
Pithecellobium unguis-cati	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Plagiobothrys figuratus	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Plectritis sp.	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Poa douglasii ssp. *macrantha*	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Poa pratensis	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Poa sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	1.3
Polygala cornuta	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Polystichum munitum	11	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.1
Potentilla glandulosa	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Potentilla gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Prunella vulgaris ssp. *lanceolata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Prunella vulgaris ssp. *vulgaris*	1	1	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	1.3
Prunus emarginata	0	0	0	0	0	0	0	0	1	9	0	0	1	17	0	0	0	0	0	0	1.3
Prunus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Prunus virginiana var. *demissa*	0	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Pseudotsuga menziesii	73	##	1	7	1	50	3	33	5	45	0	0	4	67	8	62	2	100	16	100	72.4
Pteridium aquilinum	1	1	0	0	0	0	0	0	2	18	0	0	0	0	0	0	0	0	0	0	1.9
Pteridium aquilinum var. *pubescens*	11	15	0	0	0	0	2	22	1	9	0	0	2	33	1	8	0	0	4	25	13.5
Pterospora andromedea	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	1.3
Puccinellia parishii	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Pyrola asarifolia	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Pyrola asarifolia var. *purpurea*	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Pyrola picta	7	10	0	0	1	50	0	0	1	9	0	0	0	0	0	0	0	0	1	6	6.4
Pyrola sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Quercus × ganderi [agrifolia × kelloggii]	2	3	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	1.9
Quercus chrysolepis	14	19	0	0	1	50	0	0	0	0	0	0	0	0	0	0	0	0	3	19	11.5
Quercus chrysolepis var. *nanus*	15	21	0	0	0	0	0	0	0	0	0	0	1	17	1	8	0	0	2	13	12.2
Quercus garryana	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Quercus garryana var. *breweri*	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Quercus kelloggii	11	15	1	7	0	0	3	33	2	18	0	0	0	0	3	23	0	0	9	56	18.6
Quercus sadleriana	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Quercus sp.	0	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	1.3

Quercus vaccinifolia	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.8
Ranunculus occidentalis	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Rhamnus purshiana	0	0	0	0	0	0	0	0	2	18	0	0	0	0	0	0	0	0	0	0	0	1.3
Ribes lacustre	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Ribes roezlii	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	15	0	0	1	6	2.6
Ribes sanguineum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Ribes sp.	1	1	2	14	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6
Rorippa calycina	0	0	0	0	0	0	0	0	0	0	1	20	0	0	1	8	0	0	0	0	1.3
Rosa gymnocarpa	2	3	0	0	0	0	0	0	1	9	0	0	1	17	0	0	1	50	4	25	5.8
Rosa sp.	28	38	2	14	1	50	2	22	5	45	0	0	1	17	0	0	0	0	4	25	27.6
Rosa woodsii	0	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Rubus leucodermis	4	5	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	3.2
Rubus parviflorus	25	34	0	0	1	50	0	0	0	0	0	0	0	0	1	8	0	0	0	0	17.3
Rubus sp.	8	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	5.8
Rubus ursinus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0.6
Rubus vitifolius	0	0	0	0	0	0	0	0	3	27	0	0	0	0	0	0	0	0	0	0	1.9
Rumex acetosella	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Rumex sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	15	0	0	0	0	1.3
Salix sp.	4	5	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	3.2
Sarcodes sanguinea	1	1	2	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9
Saxifraga sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Senecio aronicoides	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Sequoia gigantea	0	0	0	0	0	0	0	0	0	0	3	60	0	0	0	0	0	0	0	0	1.9
Silene lemmonii	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Smilacina racemosa var. *amplexicaulis*	23	32	0	0	1	50	0	0	4	36	1	20	3	50	2	15	2	100	3	19	25.0
Smilacina sp.	3	4	5	36	0	0	0	0	0	0	0	0	0	0	3	23	0	0	0	0	7.1
Smilacina stellata	4	5	1	7	0	0	0	0	0	0	1	20	0	0	1	8	1	50	1	6	5.8
Smilax californica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0.6
Spiraea densiflora	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	0.6
Stellaria graminea	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Streptopus amplexifolius	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Symphoricarpos acutus	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Symphoricarpos albus	1	1	0	0	1	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Symphoricarpos mollis	16	22	0	0	0	0	3	33	0	0	0	0	2	33	0	0	1	50	3	19	16.0
Symphoricarpos sp.	13	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50	2	13	10.3
Taraxacum officinale	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6

Tauschia kelloggii	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	0.6
Taxus brevifolia	12	16	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	8.3
Thalictrum sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Thelypteris cheilanthoides	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Toxicodendron diversiloba	14	19	0	0	1	50	0	0	0	0	0	0	2	33	1	8	0	0	4	25	14.1
Trientalis latifolia	24	33	0	0	1	50	1	11	2	18	0	0	0	0	1	8	1	50	9	56	25.0
Trifolium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0.6
Trillium angustipetalum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Trillium chloropetalum	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50	0	0	3.2
Trillium ovatum	8	11	0	0	0	0	0	0	0	0	0	0	1	17	0	0	1	50	0	0	6.4
Trillium ovatum ssp. *oettingeri*	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Trillium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0.6
Trisetum canescens	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	0.6
Vaccinium occidentale	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Vaccinium ovalifolium	0	0	0	0	0	0	0	0	0	0	1	20	0	0	0	0	0	0	0	0	0.6
Vancouveria hexandra	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50	0	0	4.5
Vancouveria planipetala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0.6
Venegasia carpesioides	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	2.6
Veratrum californicum	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Veratrum sp.	2	3	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0	0	0	0	1.9
Verbascum thapsus	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Verbena lasiostachys	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Vicia americana	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0.6
Vicia americana ssp. *americana*	0	0	0	0	0	0	0	0	0	0	1	20	1	17	0	0	0	0	0	0	1.3
Vicia sp.	1	1	1	7	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	1.9
Viola glabella	2	3	0	0	0	0	1	11	0	0	0	0	3	50	0	0	0	0	0	0	3.8
Viola lobata	0	0	0	0	0	0	0	0	2	18	0	0	0	0	4	31	0	0	0	0	3.8
Viola purpurea	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0.6
Viola sheltonii	0	0	0	0	0	0	1	11	0	0	0	0	1	17	0	0	1	50	1	6	2.6
Viola sp.	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50	0	0	1.9
Whipplea modesta	5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2
Xerophyllum tenax	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9
Zigadenus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6