

THE TAXONOMIC STATUS OF *LUPINUS CUSICKII* (FABACEAE)

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ABSTRACT

We have reviewed the taxonomic status of *Lupinus cusickii* S. Watson, a rare Oregon lupine. Our research included study of herbarium collections, field populations, and a taximetric comparison of *L. cusickii* with related taxa. *Lupinus cusickii* is an element of the *Lupinus caespitosus-lepidus* complex and is best treated taxonomically as *L. lepidus* var. *cusickii*. Although the *L. caespitosus-lepidus* complex is widely distributed throughout western North America, var. *cusickii* is known from only five sites, all in western Baker County, Oregon. Further field survey work will be needed to determine the full extent of its distribution and its status as a rare and possibly endangered plant taxon. Keys and diagnoses to the varieties of *L. lepidus* occurring in eastern Oregon are presented.

Lupinus cusickii S. Watson has been considered a rare and possibly endangered Oregon plant species by Siddall et al. (1979) and by Meinke (1982). Efforts by the U.S. Bureau of Land Management and the Oregon Department of Agriculture to assess the status of *L. cusickii* in the field have been confounded by identification problems. The purpose of the research reported here was to review the taxonomic status of *L. cusickii*. Our investigation included studies of herbarium collections and extant populations in the field and a taximetric study of morphological variation within *L. cusickii* and closely related taxa.

TAXONOMIC HISTORY

Lupinus cusickii was described by Watson (1887) from specimens collected in July of 1886 by William Cusick along the Burnt River in what is now Baker County, Oregon. C. P. Smith (1924) reduced the epithet *cusickii* to varietal status under the name *Lupinus aridus* Douglas ex Lindley without comment. Later, he noted that var. *cusickii* "is an interesting connecting link between *L. aridus* and *L. caespitosus*, which also, perhaps, should be treated as a variety of *L. aridus*" (Smith 1927, p. 25). Smith considered *L. aridus* as part of a group he called the "caespitosi" in which he also included *L. caespitosus* Nutt, *L. lepidus* Douglas ex Lindley, and *L. lyallii* A. Gray. By 1946 Smith referred to the *caespitosi* as the "*caespitosus-lepidus* complex" consisting of "one to several species, according to the view-point of the botanist concerned" (Smith 1946, p. 547).

Detling (1951) concluded that the *L. caespitosus-lepidus* complex consisted of one species—*L. lepidus* Douglas ex Lindley—and described seven intergrading subspecies. He retained the epithet *cusickii* at the subspecific level. Phillips (1955), in his review of perennial *Lupinus* in western North America, reduced the epithet *cusickii* to synonymy under *L. lepidus*. Dunn (1956), however, maintained that the *L. caespitosus-lepidus* complex consisted of separate species. Following this view, Cox (1972a, b, 1973a, b, 1974a, b, c) described 10 species and 30 intra-specific taxa within the group. Both Dunn and Cox treated *cusickii* at the specific level; Cox (1973b) described three subspecies within *L. cusickii*. In floristic treatments, Smith (1944) and Peck (1961) listed *cusickii* as a variety of *L. aridus*. Hitchcock et al. (1961), Hitchcock and Cronquist (1973), Barneby (1989), and Sholars (1993) retained *cusickii* at the varietal level under *L. lepidus*. Historically, therefore, lupine populations referable to the epithet *cusickii* have been treated variously as a species and as a subspecies, variety, or synonym of *Lupinus lepidus*. For the remainder of this paper, we will discuss *cusickii* and other elements of the *caespitosus-lepidus* complex as varieties of *Lupinus lepidus* sensu lato.

MATERIALS AND METHODS

To get an overview of the *Lupinus caespitosus-lepidus* complex, we examined approximately 850 herbarium specimens from OSC, WILLU, ORE, WTU, WS, ID, IDS, MO, UMO, and NY and from herbaria maintained by the Bureau of Land Management at the Vale, Burns, Prineville, and Lakeview district offices in eastern Oregon.

During the summers of 1989 and 1993, the senior author visited 30 populations of caespitose lupine in Linn, Jefferson, Lake, Deschutes, Klamath, Crook, Harney, Grant, Baker, and Malheur counties in central and eastern Oregon to collect and make field observations. Three to fifteen plants were collected from each population visited; individual plants within populations were collected systematically so that the range of morphological variation present at the site would be represented in the study specimens.

Ninety-four individual plants collected from 13 populations studied in the field (Table 1) were incorporated into a taximetric study of morphological variation within the *L. caespitosus-lepidus* complex as it occurs in eastern Oregon. An additional 15 herbarium specimens of *L. lepidus* var. *utahensis* from Idaho and Wyoming and 20 herbarium specimens of *L. lepidus* var. *aridus* from the Columbia River Basin in eastern Washington and north-central Oregon were added to this study because collections of both *aridus* and *utahensis* have been made in eastern Oregon. We did not encounter either taxon in the field. All 129 specimens were measured for the

TABLE 1. LOCATIONS OF EASTERN OREGON POPULATIONS OF THE *L. LEPIDUS*-*CAESPITOSUS* COMPLEX INCLUDED IN THE TAXIMETRIC STUDY.

Population	Location				
	County	Township	Range	Section (s)	Elevation
A Hoodoo	Linn	T135	R8E	S26	1450 m
B Sisters	Jefferson	T135	R9E	S32	1015 m
C La Pine	Deschutes	T22S	R10E	S27	1300 m
D Ft. Rock	Lake	T26S	R13E	S28	1380 m
E Brothers-1	Deschutes	T22S	R18E	S6/7	1460 m
F Brothers-2	Deschutes	T21S	R18E	S19/30	1400 m
G Brothers-3	Deschutes	T21S	R19E	S11	1400 m
H Divine Ridge	Harney	T20S	R31E	S22	1600 m
I Baldy Mt.	Grant	T14S	R33E	S19	2130 m
J Oregon Canyon	Malheur	T40S	R40E	S11	2350 m
K Unity-1	Baker	T135	R37E	S1/2	1200 m
L Unity-2	Baker	T135	R37E	S10/11	1235 m
M Unity-3	Baker	T135	R37E	S3	1280 m
N var. <i>utahensis</i>	15 herbarium specimens from Idaho and Wyoming				
O var. <i>aridus</i>	20 herbarium specimens from Oregon and Washington				

20 morphological traits listed in Table 2. Means of three to five measurements were calculated for vegetative traits, inflorescence traits, and flower lengths. Data on additional floral characteristics are based upon one dissected flower from each specimen. Flower dissections were made using a technique modified from that described by Dunn (1954) for *Lupinus* flowers.

The final data-set was standardized. Relationships among the 15 populations listed in Table 1 were then analyzed by cluster analysis. Generalized distance (Mahalanobis' D^2) between populations was calculated using the programs POOLVCV and CVA of the NTSYS-pc program package (Rohlf 1987); cluster analysis was performed using the SAHN program of NTSYS-pc.

RESULTS

Herbarium studies. The *caespitosi* (Smith 1927) are readily recognizable from other species complexes of perennial lupines in western North America and appear to form a natural monophyletic unit (Detling 1951; Cox 1972a). In addition to the caespitose habit, the *caespitosi* are distinguished by the persistence of floral bracts during anthesis, by rather stout, short pedicels (usually <4 mm), by the lack of a spur on the calyx tube, and by a dorsally glabrous banner.

The *caespitosi* are widely distributed in western North America, occurring in Washington, Oregon, California, Idaho, Wyoming, Utah, and Colorado. Morphological variation within the complex is extensive. Taxa traditionally described within the *caespitosi* are relatively distinct and usually have different geographic distributions.

TABLE 2. MORPHOLOGICAL TRAITS INCLUDED IN TAXIMETRIC STUDIES OF THE *LUPINUS LEPIDUS*-*CAESPITOSUS* COMPLEX.

1) plant height to the top of the foliage (cm); 2) petiole length (cm); 3) number of leaflets; 4) average leaflet length (mm); 5) average leaflet width (mm); 6) complete inflorescence length (cm); 7) raceme length (cm); 8) number of flowers; 9) pedicel length (mm); 10) flower length (mm); 11) upper calyx lobe length (mm); 12) upper calyx lobe notch depth (mm); 13) lower calyx lobe length (mm); 14) banner petal length (mm); 15) banner petal width (mm); 16) wing petal length (mm); 17) wing petal width (mm); 18) keel petal width (mm); 19) number of ovules; 20) anther length of the longest anther present (mm).

However, herbarium collections contain numerous specimens that are morphologically intermediate between the entities traditionally described, particularly in areas where the geographic distributions of the various described taxa overlap.

Our study of herbarium specimens led us to conclude the following: (1) due to morphological intergradation, the *caespitosi* are best treated as a single polymorphic species consisting of nine (or more) varieties; (2) taken together, the recent taxonomic treatments of Barneby (1989) and Sholars (1993) present a complete treatment of all major elements within group; and (3) five of the nine varieties delimited by Barneby (1989)—var. *sellulus*, var. *utahensis*, var. *aridus*, var. *lobbii*, and var. *cusickii*—occur in eastern Oregon.

Field observations. We studied 30 populations of caespitose lupines in Linn, Jefferson, Deschutes, Klamath, Lake, Harney, Malheur, Grant, and Baker counties in central and eastern Oregon during the summers of 1989 and 1993. These populations ranged in elevation from 1200–2350 m and occurred in a variety of vegetation types including openings in subalpine forests, the *Pinus ponderosa* Zone, the *Juniperus occidentalis* Zone, and the shrub-steppe-*Artemisia tridentata* Zone (Franklin and Dyrness 1973). They were usually found in deep, sandy soils located in the lowest areas of the local landscape, often in vernal wet basins or along roadsides in places of water accumulation. Populations K, L, and M (Table 1) are unique because of their location on steep, exposed hillsides of eroding volcanic ash.

Phenology varied with elevation, location, and, seemingly, size of plant within a location. In populations visited in June and July of 1989 in eastern Deschutes County, larger plants appeared to flower in late June and early July whereas smaller plants did not commence flowering until late July. If larger plants are taken to be older, there may be some phenological isolation between older and younger plants growing in the same population.

Racemes of caespitose lupines flower acropetally and elongate as flowering progresses; peduncles also elongate during the flowering

process. In early stages of flowering, when only the proximal flowers in a raceme have opened, the raceme may appear to be capitate and be completely hidden by the foliage. In non-capitate types, both the raceme and the peduncle elongate; by the time distal flowers in the raceme have opened later in the season, the raceme emerges partially or completely beyond the leaves. Keys written for identification of different forms of caespitose lupine (including the one presented below) often use the trait of raceme exposure above the vegetative base to distinguish intraspecific taxa within the group. Assessment of raceme exposure is best made after distal flowers in the raceme have opened. When identifying plants collected earlier in the season, one should attempt to take subsequent raceme elongation into consideration.

Taximetric analyses. Figure 1 displays the dendrogram resulting from a Complete Linkage cluster analysis of the 13 field populations and the two collections of herbarium specimens included in the morphometric study (Table 1). The cophenetic correlation between the Generalized Distance matrix and the results shown in Figure 1 is 0.839. Similar results were obtained with other clustering strategies (UPGMA, Single Linkage, etc.) and with Canonical Variate Analysis (results not shown). We interpret these results to indicate that the 15 populations included in the study consist of five groups (Figure 1) corresponding to the five varieties of *L. lepidus* delimited by Barneby (1989).

DISCUSSION

The *Lupinus caespitosus-lepidus* complex consists of approximately nine relatively distinct but intergrading morphological entities. In our opinion, treatment of these morphological variants as separate species gives a false impression that they are more distinct than they appear to be in the herbarium record or in the field. We believe that the morphological extremes within the complex are best treated taxonomically as members of one polymorphic species *Lupinus lepidus* Douglas ex Lindley. The taxonomic treatments of Barneby (1989) and Sholars (1993) taken together offer a complete overview of the complex.

Our taximetric study indicated that at least five of the nine varieties of *Lupinus lepidus* occur in eastern Oregon. Populations of caespitose lupine from Jefferson, Deschutes, and Lake counties (populations B through G) included in the study are similar to one another and are referable to var. *sellulus*. Plants collected from Grant (population I) and Harney (population H) counties during this study clustered with specimens of var. *utahensis* from Idaho and Wyoming. Higher elevation, prostrate populations studied here (popu-

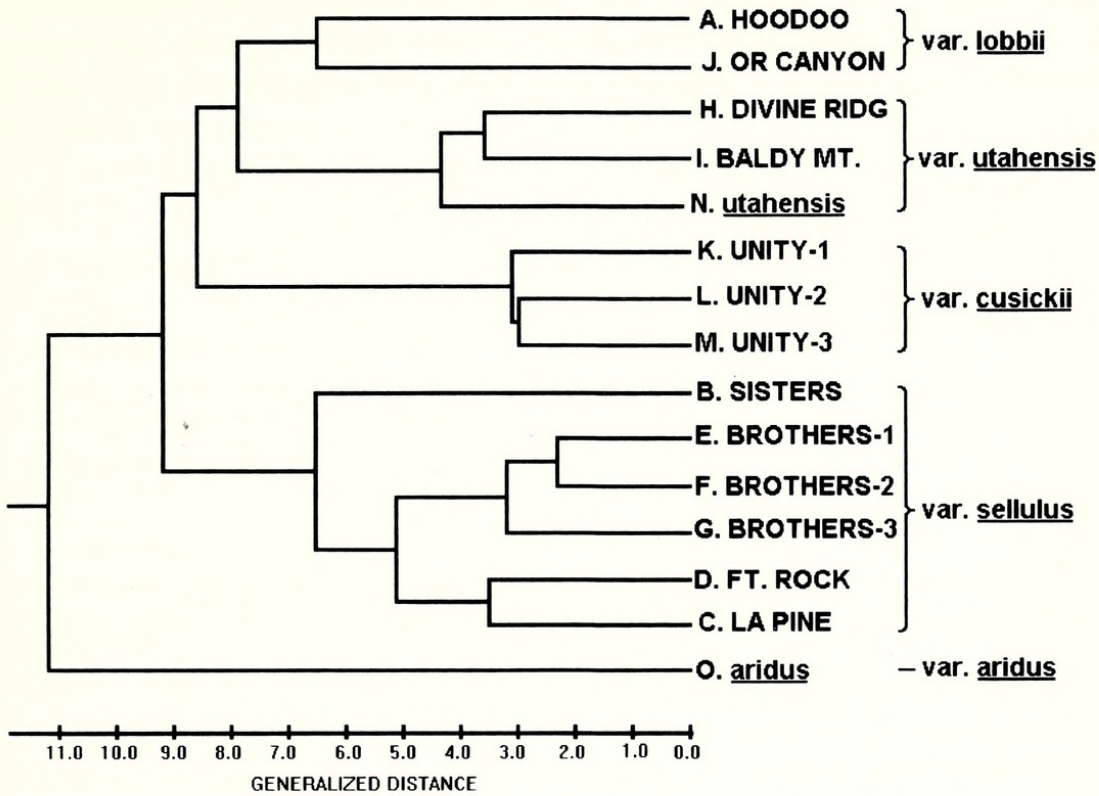


FIG. 1. Results of a Complete Linkage cluster analysis of the 15 populations of *L. lepidus* listed in Table 1.

lations A and J) are similar to one another and are best referred to var. *lobbii*. The collection of 20 herbarium specimens of var. *aridus* included in our taximetric studies proved to be quite distinct from other elements of the *caespitosus-lepidus* complex in eastern Oregon.

An isotype of *L. cusickii*, collected on a “sterile hillside of the upper Burnt Rio—above the forks” in July of 1886 by William Cusick (deposited in ORE) resembles plants collected from the three Unity sites (populations K, L, and M) included in our study. We conclude that the epithet *cusickii*, as originally conceived by Watson (1887), is referable to these Unity populations, interpreting the results of the taximetric study presented here to indicate that the Unity populations are distinctive. We believe that var. *cusickii* should be recognized within the *Lupinus caespitosus-lepidus* complex.

Cox (1973b) described two additional subspecies within his concept of *Lupinus cusickii*: subsp. *abortivus* (Greene) B. J. Cox and subsp. *brachypodus* (Piper) B. J. Cox. Type specimens of *L. abortivus* Greene and *L. brachypodus* Piper, deposited in ORE, appear to us to be referable to *L. lepidus* var. *aridus*.

A key to and diagnoses of the varieties of *L. lepidus* present in eastern Oregon is presented below. A more complete nomenclatural treatment for these taxa can be found in Barneby (1989).

A KEY TO THE VARIETIES OF *LUPINUS LEPIDUS* IN EASTERN OREGON

1. Plants usually prostrate; peduncles 1.5–2.0 times longer than racemes; bases of caudices often woody; plants of alpine and subalpine meadows and forests. . . . 1. var. *lobbii*
- 1'. Plants erect (although low growing); peduncles subequal to or shorter than racemes; bases of plants usually not woody; plants of lower elevation pine forests or sagebrush steppe 2
2. Stem internodes extremely short (<1 cm), leaf bases telescoped into a caespitose clump; banners 2–3 mm wide 2. var. *utahensis*
- 2'. At least some stem internodes elongated to 1–3 cm, leaf bases of upper leaves usually clearly separate; banners 4–6 mm wide 3
3. Mature racemes held above the basal tuft of leaves 3. var. *sellulus*
- 3'. Mature racemes partly or completely covered by foliage 4
4. Plants generally >1 dm tall, upper stem nodes rarely branched; flower pedicels stout, 1–3 mm long 4. var. *aridus*
- 4'. Plants generally <1 dm tall, upper stem nodes often branched; flower pedicels slender, 4–5 mm long 5. var. *cusickii*

1. *Lupinus lepidus* Douglas ex Lindley var. *lobbii* (A. Gray ex Greene)
C. L. Hitchcock (common synonyms: *L. lyallii* A. Gray; *L. lepidus* subsp. *lyallii* (A. Gray) Detling.)

Plants usually prostrate, sprawling, stems 4–10 cm long, sparingly branched at base, often arising from a woody caudex, upper stem internodes to 1 cm long, upper stem nodes usually unbranched; petioles 2–7 cm long, leaflets 5–21 mm long, 2–6 mm wide; peduncles 5–8 cm long, racemes 2–6 cm long, held above or away from the vegetative crown; pedicels 1–2 mm long at anthesis; banner blades 4–6 mm wide.

Habitat and distribution. montane and subalpine habitats along the Cascade-Sierra axis from British Columbia to central California extending eastward at higher elevations (>2000 m) in the Blue Mountains and into eastern Idaho; 1300–3000 m; in eastern Oregon: Clackamas, Crook, Douglas, Harney (Steen's Mt.), Hood River, Jackson, Klamath, Lake, Malheur (Trout Creek Mts.), and Wallowa counties.

Variety *lobbii* is readily identifiable on the basis of its prostrate habit, its long peduncles holding the capitate racemes beyond the foliage, and its distribution in higher elevation habitats. Variety *lobbii* appears to intergrade with var. *sellulus* along the eastern flank of the Cascade Mts. in Oregon (see the discussion of var. *sellulus*).

2. *Lupinus lepidus* Douglas ex Lindley var. *utahensis* (S. Watson)
C. L. Hitchcock (common synonyms: *Lupinus caespitosus* Nutt. ex T. & G.; *L. lepidus* subsp. *caespitosus* Detling)

Plants more or less erect, 5–17 cm tall, stems sparingly branched

at base, upper stem internodes extremely short, leaves telescoped into a caespitose clump from which 1–3 inflorescences emerge; petioles 2–11 cm long, leaflets 10–30 mm long, 3–6 cm wide; peduncles to 1 cm long, racemes 2–8 cm long, usually barely emerging from the caespitose clump when distal flowers are mature; pedicels 1–2 mm long at anthesis; banner blades 2–3 mm wide.

Habitat and distribution. mountain meadows, gravel bars, streambeds, and lake shores, ascending up to stony crests near and above timberline (Barneby 1989) in eastern Oregon and extending east into Idaho, Wyoming, Utah and Colorado; 1200–2400 m; in Oregon: Union, Grant, Harney, and Umatilla counties.

Variety *utahensis* represents the most caespitose form of the *L. lepidus-caespitosus* complex and is distinctive for its lack of stem elongation that places the raceme within the vegetative clump.

3. *Lupinus lepidus* Douglas ex Lindley var. *sellulus* (Kellogg) Barneby

Plants erect, 3–14 cm tall, stems sparingly branched at base, upper stem internodes 1–3 cm long, upper stem nodes usually unbranched; petioles 3–9 cm long, leaflets 10–19 mm long, 3–7 mm wide; peduncles 5–8(–10) cm long, racemes 2–7 cm long, usually emerging well above the foliage when distal flowers are mature; pedicels 1–2 mm long at anthesis; banner blades 4–5 mm wide.

Habitat and distribution. vernal wet areas in ponderosa pine forests descending into juniper-sagebrush regions; east slopes of the Cascades from Deschutes County south into northern California; 1000–1900 m; in Oregon: Deschutes, Crook, Lake, Klamath, and Jackson counties.

Detling (1951) described a separate subspecies of *L. lepidus*—subsp. *medius* Detling—to include many of the lower elevation populations found on the eastern flanks of the Cascade Mts. in central Oregon. He believed *medius* to be an ancestral form within the complex. We find it difficult to recognize *medius* as a separate taxonomic entity. Central Oregon, from Sherman and Wasco Counties in the north to Lake, Klamath, and Jackson counties in the south, appears to be an area of general intergradation for the *lepidus-caespitosus* complex. Variety *sellulus* intergrades with var. *lobbii* along elevational gradients on the eastern flanks of the Cascades, and, seemingly, intergrades with var. *aridus* in Jefferson County and to the north. Varieties *sellulus* and *aridus* typically grow erect; var. *lobbii* is a prostrate form. Varieties *sellulus* and *aridus* differ mainly in plant height, peduncle length, and raceme length. This intergradation may be natural or it may be due to widespread disturbance of the vegetation in the area since European settlement. Whatever

the cause, it is well to recognize that assigning names to caespitose lupine populations in this area can be, at best, an inexact science.

4. *Lupinus lepidus* Douglas ex Lindley var. *aridus* (Douglas ex Lindley) Jepson

Plants erect, 1–2+ dm tall, stems sparingly branched at base, upper stem internodes 1–3 cm long, upper stem nodes usually unbranched; petioles 5–15 cm long, leaflets 20–35 mm long, 6–9 mm wide; peduncles 5–15 cm long, racemes 6–18 cm long, often emerging only partially from the vegetative clump when distal flowers are mature; pedicels 1–2 mm long at anthesis; banner blades 4–6 mm wide.

Habitat and distribution. lower elevations on bluffs and sandy or gravelly hillsides dominated by sagebrush or juniper woodland (Barneby 1989) in the Columbia River Basin and extending south and east; 100–1500 m; in Oregon: Baker, Crook, Deschutes, Galliam, Grant, Harney, Jefferson, Malheur, Morrow, Sherman, Umatilla, Wasco, and Wheeler counties.

Variety *aridus* intergrades with var. *sellulus* in Jefferson County, Oregon. In general, var. *aridus* tends to be taller and more robust than var. *sellulus* and, typically, the racemes of var. *aridus* emerge only partially from the foliage. The discussion of var. *sellulus* contains further details on intergradation in central Oregon.

5. *Lupinus lepidus* Douglas ex Lindely var. *cusickii* (S. Watson) C. L. Hitchcock

Plants erect, 2–11 cm tall, stems sparingly branched at base, upper stem internodes 1–3 cm long, each upper stem node often bearing a lateral branch terminating with an inflorescence; petioles 2–6 cm long, leaflets 7–19 mm long, 3–7 mm wide; peduncles 1–6 cm long, racemes 1–6 cm long, held at about the height of the vegetative crown; pedicels 4–5 mm long at anthesis; banner blades 4–6 mm wide.

Habitat and distribution. eroding hills of volcanic ash found along the Burnt River in Baker County, Oregon; 1200–1300 m; possibly also in Grant, Harney, Malheur, and Umatilla Counties.

Lupinus lepidus var. *cusickii* is unique in its cauline branching habit and its habitat. At the present time, populations of var. *cusickii* have been verified for five sites in eastern Baker County. We recommend that similar habitat in surrounding areas be surveyed to ascertain more completely the range of var. *cusickii* along the southeastern flanks of the Blue Mountains and to determine its status as a rare and possibly endangered plant taxon.

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ANNOUNCEMENT

CALIFORNIA BOTANICAL SOCIETY
16TH GRADUATE STUDENT MEETINGS

February 24, 1996
at Rancho Santa Ana Botanic Garden, Claremont

ATTENDANCE: Anyone may attend; registration is \$5.00. If you are presenting a paper, you must be a current or recent graduate student. Membership in the California Botanical Society is **not** required.

PRESENTATIONS: 10–12 minutes, plus 3–5 minutes for questions, on proposed, ongoing, or completed research in **any aspect of plant science**.

AWARDS: Cash awards will be given for best presentations in each research category. Students not giving talks, but with prior experience, are needed as awards judges.

BANQUET: The California Botanical Society Annual Banquet will be held at RSA following the graduate student meetings.

GUEST SPEAKER: Ken Berg, National Botanist for the Bureau of Land Management

TITLE: *Conservation of Native California Plants in the Changing Political Landscape*

HOUSING: A list of local hotels will be sent on receipt of registration. Limited space *may* be available with local students/faculty.

DEADLINE: **January 22, 1996** for registration materials and abstracts.

INFORMATION & FORMS: Forms will be available soon at botany/biology department offices. The \$5.00 graduate student meeting registration fee does not include the Annual Banquet. For further information, contact Lisa Schultheis, Graduate Student Representative, Integrative Biology, Valley Life Sciences Building, UC Berkeley, Berkeley, CA 94720, or (510) 643-7008, or lschult@violet.berkeley.edu.



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