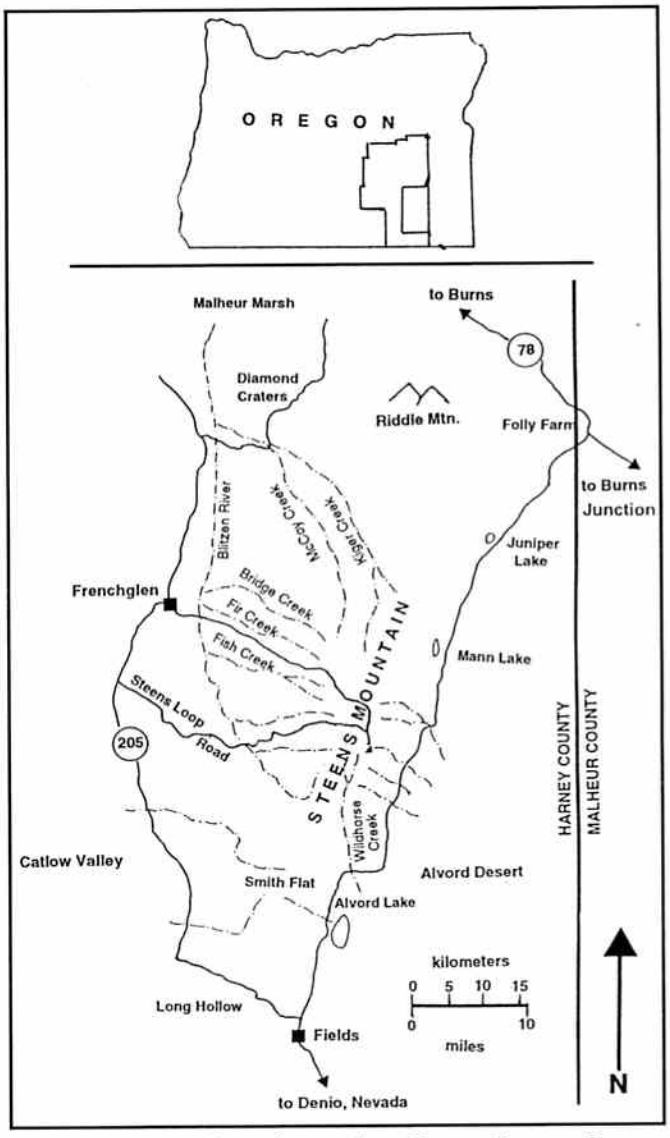
The Unique Botany of Steens Mountain: The Rare and Endemic Plants

By DONALD MANSFIELD

In southern Harney County the landscape rises from the west almost imperceptibly to nearly 10,000 ft. and the top of Steens Mountain. Without passing through even a hint of a forest, those traveling the Steens Loop Road soon find themselves among aspen groves, alpine meadows, cirques, and tarns. The vistas of glacial gorges and precipices dropping nearly 6,000 ft. to the Alvord desert rival any in Oregon. To the botanist, the excitement and intrigue is only beginning. From the desert scablands and riparian meadows and woodlands below to the alpine meadows, rock outcrops, and talus slopes of the "High Steens," wildflower displays abound at every turn. Plants abundant here are found nowhere else in the world. Many plants common in the mountains of California or Idaho can be found here as outliers, somehow lost from their relatives to the southwest or northeast, separated by miles of sagebrush desert.

Steens Mountain is the northern-most fault block mountain range in the Great Basin. When defined to include the mountainous area from Riddle Mountain on the north to the Smith Flat and Long Hollow region near Fields on the south, it occupies an area of approximately 1,000 square miles. The gorges on the west and north drain gradually into the Malheur Marsh and ultimately Harney Lake, while the steep eastern escarpment is drained by several streams that find their way to the Alvord Desert or Pueblo Valley. Southeastern Steens Mountain drains west into the Catlow Valley.

Steens Mountain is unusual physiographically in two respects. First, large basins, approximately 4,000 ft. in elevation, isolate Steens Mountain from other high mountain ranges. Strawberry Mountain in the Blue Mountains, 120 miles to the north, is the closest mountainous area rising above 9,000 ft. Second, Steens has extensive contiguous area (approximately 75 km^2) above 8,000 ft. elevation. The nearest ranges with this much alpine topography are the Cascade-Sierra Range 200 miles to the west and the Wallowa Range 200 miles to the northeast. The combination of isolation and extensive alpine topography results in a unique flora. This article will summarize some of the outstanding features of this unique botanical area and highlight its rare and endemic plant species.



Steens Mountain is located in southern Harney County, Oregon.

Geologic and Phytogeographic History of Steens Mountain

A brief geological history of Steens Mountain is relevant to understanding the unique qualities of the steens flora. The story begins about 30 million years ago during the Oligocene Epoch when the area was forested by a tropical flora. A widespread cooling trend ensued (Wolfe 1978) when the Cascade Range began to rise. By 20 to 25 million years ago (early Miocene) eastern Oregon was forested by a deciduous forest flora much like that in present-day Ohio or eastern China (Chaney 1956). Volcanic eruptions that occurred during this time produced the lowest rocks of what is now Steens Mountain — the red, principally rhyolitic and tuffaceous Pike Creek Volcanic Series (23 million years old). The Alvord Creek Formation of tuffs and plant fossil-bearing lake bed deposits formed approximately 21 million years ago in what appears today as the light-colored beds above Alvord Ranch. The Alvord Creek fossils tell us that annual precipitation at this time was about double the current rate and mean annual temperatures were higher and with less drastic extremes. (Wolfe 1978; Ferguson and Ferguson 1978). The andesitic and basaltic flows that today form the middle elevations of Steens (the Steens Mountain Volcanic Series) and the Steens Mountain Basalt that forms the present-day cliffs above 7,000 ft. flowed over the area from between 13 and 18 million years ago (mid Miocene). Roughly 8-10 million years ago (late Miocene) faulting began and the Steens uplift commenced. By this time,

the Sierra-Cascade Range had uplifted substantially, providing a rain shadow in southeastern Oregon (Fiero 1986). Together, these geological events resulted in a different regional climate and a greater diversity of habitats than had previously existed in the area. By about the end of the Miocene Epoch, the Great Basin floristic province had become established (Cronquist 1978).

By 2-3 million years ago (late Pliocene) the climate was generally cool and moist, though drier than in earlier times and with less summer precipitation. Consequently, the regional flora continued to change as new species emerged that were adapted to these new climatic conditions (Raven and Axelrod 1978; Cronquist 1978). The past few million years have been characterized by alternating glacial and interglacial periods. Three geologically distinct periods of glaciation are evident on Steens Mountain (Lund and Bentley 1976). Initially, glacial ice covered nearly 300 km² in the Fish Lake advance, filling or carving the major gorges — Big Indian, Little Blitzen, and Kiger. A second period (the Blitzen advance) was restricted to the canyons, covered about 130 km² and formed the headwalls of the major gorges. During the final and much smaller glacial advance that ended no later than 12,000 to 13,000 years ago (Thompson et al. 1986), the ice carved the smaller cirques that lie above 8,000 ft. including South Fork Willow Creek and Big Alvord. The past 8,000 years in the northern Great Basin have been characterized by a more xeric climate and a corresponding loss of mesic species from the region (Nowak et al. 1994). On Steens Mountain a roughly twofold increase in sagebrush to grass pollen is observed between 5,500 and 8,000 years ago, indicating that this period was the driest of the Holocene on Steens (Mehringer and Wigand 1985).

During alternating glacial and interglacial periods of the past few million years, two main processes appear to have produced the modern distribution of plant species in the Great Basin. First, during cool, moist periods of glacial advance, species migrated down in elevation (Thompson 1990) and/or into the region from the north (Cronquist 1978); during the warmer, drier interglacial periods species migrated to higher elevations and/or into the region from the south. Second, montane "islands" lost species via local extinctions and gained species by immigration according to the predictions of island biogeography theory (Wells 1983). Based on the current affinity of the flora with Columbia Plateau, Great Basin, and Sierra Nevada floristic elements (McLaughlin 1989), it appears that the present flora of Steens originated with the regional flora primarily during the Pliocene. That is, most of the plants of Steens Mountain are distributed throughout the northern Intermountain region. The unique aspects of the Steens flora, those features which distinguish it from the rest of the region, seem to result from the local extinction, migration, and speciation peculiarities during the geologically recent Quaternary Period.

Brief History of Botanical Exploration

The history of botanical exploration of Steens can be divided into three phases.

Early explorations: In the late 1800s, a few collections were made by William Cusick, John Leiberg, and others. In the early 1900s Morton Peck, Percy Train, Lila Leach, L.F. Henderson, and others briefly visited Steens. Of these, Percy Train's collections were the most extensive and unique, providing the only record of several of Steens plant species.

Expanding collections and classifying the unique flora: Through the mid-1900s collection trips, mainly from Western Oregon and New York Botanical Gardens by such individuals as Albert Steward, Arthur Cronquist, and Bassett Maguire, increased in frequency. At this time several systematists visited Steens to examine unique specimens discovered in earlier collecting forays. Until my recent survey, the most extensive botanical collection was done by Charles Hansen in the early 1950s as part of his doctoral studies on the vertebrates of Steens Mountain (Hansen 1956).

Continuing exploration through Malheur Field Station (MFS) and the BLM: Botany classes at MFS from the mid 1970s to mid 1980s, led separately by Karl Urban and Karl Holte, explored new areas of Steens and continued to contribute to new and unusual records. Collections by Dr. Urban, Dr. Holte, and their students occasionally provide the sole record of Steens' plant species. From the late 1970s through the early 1990s, BLM has contracted with botanists to survey various parts of Steens Mountain and the adjacent Alvord and Malheur basins. Since the late 1980s, I have been collecting extensively (independently, with students through MFS classes, and in cooperation with BLM) to describe the composition, distribution, and variation in the flora and document historical reports lacking vouchers. We now have an adequate sense of the distribution of several species on Steens and in the region and can begin to interpret the original, relationships, and uniqueness of the Steens Mountain flora.

The plant names used in this paper and in the Steens Flora attempt to follow the nomenclature being used in the Oregon Checklist project (Scott Sundberg, personal communication). The resources for identification of Steens taxa include, in roughly this order, the *Jepson Manual* (Hickman 1993), the *Intermountain Flora* (Barneby et al. 1990, Cronquist et al. 1972, Cronquist et al. 1977, Cronquist et al. 1984, Cronquist et al. 1994), the *Flora of North America*, volume 2 (Flora 1993), and the *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1973). Distributional data are also derived from these same sources.

Steens Mountain Flora and Vegetation

At most recent count, the vascular flora of Steens Mountain is composed of 91 families, 381 genera, 1,115 species, and 1,179 subspecies or varieties. Of the 1,179 taxa, 86 (7.3%) are exotics (post-settlement introductions to the area), six are endemic to Steens Mountain or Steens and nearby ranges, and an additional 57 are currently listed in the Oregon Natural Heritage Program's Rare, Threatened and Endangered Plants and Animals or Oregon (ONHP 1993) — see Table 1). Steens Mountain represents well the estimated 4,400 plant taxa in Oregon (Scott Sundberg, personal communication). This diversity is largely attributed to the variety of habitats spanning its 6,000 ft. of relief.

To understand the distribution of rare plants on Steens Mountain, vegetation can be divided into three zones — the low desert (below 4,200 ft., or 4,600 ft. in the Catlow Valley),

montane (4,200 ft. to 8,200 ft.), and alpine (above 8,200 ft.). Within each of these broad vegetation zones exists a variety of habitats, each with a unique flora.

Expansive alkaline desert scrub habitats of the Harney Basin, Alvord Desert, and Catlow Valley below about 4,200 ft. to 4,600 ft. are dominated by greasewood *(Sarcobatus vermiculatus)*, spiny hopsage *(Grayia spinosa)*, shadscale *(Atriplex confertifolia)*, four-winged saltbrush *(Atriplex canescens)*, saltgrass *(Distichlis spicata* var. *stricta)*, and other halophytes (salt-tolerant plants). This bottomland scrub is designated "b" in Table 1. Better drained soils ("s" in Table 1) are dominated by such species as basin big sagebrush *(Artemisia tridentata* ssp. *tridentata)*, basin wild rye *(Leymus cinereus)*, or other non-halophytic species. Ash or sand ("a" in Table 1), barren clay soils ("c" in Table 1), and a variety of wetlands incuding riparian streamsides ("wr" in Table 1), ponds, lakes or marshes ("wp" in Table 1) are also evident throughout the basin deserts.

The lower flanks of Steens Mountain from about 4,200 ft. to roughly 5,500 ft. are dominated by big sagebrush *(Artemisia tridentata* ssp. *wyomingensis*, and *A. tridentata* ssp. *vaseyana)*, low sagebrush *(A. arbuscula)*, gray rabbitbrush *(Chrysothamnus nauseosus* var. *hololeucus)*, and a variety of forbs and grasses. These sagebrush-dominated slopes ("s" in Table 1) are quite prevalent. Between about 5,500 ft. and 6,500 ft., sage scrub is intermixed with the overstory dominant species, western juniper *(Juniperus occidentalis)*. Mountain mahogany *(Cercocarpus ledifolius* var. *intermontanus)*, bitterbrush *(Purshia tridentata)*, squaw currant *(Ribes cereum)*, and Lemon's needlegrass *(Achnatherum lemmonii)* often also dominate. Seasonally moist depressions and vernal pools ("wp" in Table 1), clay barrens ("c" in Table 1), riparian areas ("wr" in Table 1), and gorge-bottom woodlands and mesic north-facing forested slopes ("f" in Table 1) all contribute to the habitat diversity in the montane zone.

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Steens Mountain thistle *(Cirsium peckii)*

Aspen *(Populus tremuloides)* stands dominate sheltered and mesic sites of Steens Mountain between approximately 6,500 ft. and 7,500 ft. ("f" in Table 1). The more exposed and xeric sites between 6,500 ft. and 8,000 ft. ("s" in Table 1) are frequently dominated by mountain big sagebrush *(Artemisia tridentata* ssp. *vaseyana)* and a variety of forbs and grasses including orange sneezeweed *(Hymenoxys hoopesii)*, Steens Mountain thistle *(Cirsium peckii)*, squirreltail grass *(Elymus elymoides* ssp. *californicus)*, and Cusick's bluegrass *(Poa cusickii)*. In this upper montane area of Steens Mountain, meadows dominated by graminoids and perennial forbs ("m" in Table 1) are common. At these elevations in the Northern Rocky Mountains or on the east slope of the Cascades, one would expect to find forests of ponderosa pine and Douglas fir giving way to Engelmann spruce, or perhaps subalpine fir and occasional white bark pine or limber pine near timberline. None of these conifers are present on Steens Mountain. In this respect the "subalpine" zone of Steens Mountain is unique in Oregon. This absence of subalpine conifers is evident in several other Great Basin ranges but none as large as Steens. The remarkable absence of subalpine conifers is probably related to Steens isolation and possibly the biology of such seed dispersers as the Clark's nutcracker (Wells 1983). Hansen (1956) speculated that Native American use of fire permanently eradicated conifers that had been present historically. This interesting feature of Steens warrants future study.

The highest elevations of Steens, above approximately 8,200 ft., lack the tundra character of most other ranges. The highest vegetation zone on Steens has been referred to as either "subalpine grassland" (Mairs 1977) or true alpine tundra (Collins 1978). Like other alpine areas in the western United States, the 'High Steens' lacks trees and receives high precipitation largely in the form of snow, which is irregularly distributed due to the wind. Furthermore, the area exhibits evidence of solifluction, the result of freeze/thaw cycles that move large quantities of soil (Bentley 1970, Collins 1978). Unlike true alpine areas, the "alpine" zone of Steens apparently lacks permafrost (Collins 1978) and permafrost-controlled vegetation, such as many common tundra cushion plants, like the ubiquitous moss campion *(Silene acaulis)*, that typify the alpine zone in the Sierra-Cascade or Rocky Mountains (Zwinger and Willard 1972). Like other Great Basin ranges (Barbour and Major 1977), the alpine vegetation of Steens Mountain is developed best in the wetter sites. Within this alpine belt, several vegetationally distinct habitats can be recognized. The dry, gravelly, windswept summit ridge and the lower lips of the cirques ("dg" in Table 1) come closest to the cushion plant-dominated "fell fields" of the Rocky Mountains. Alpine wet meadows and mesic meadows occur in cirques and pockets where snow accumulates and provides perennial water in the form of springs and a high water table ("m" in Table 1). Talus and scree slopes ("t" in Table 1), rock outcrops ("r" in Table 1), and riparian willow *(Salix* ssp.) -dominated areas ("wr" in Table 1) are evident on Steens as in other alpine areas. Gravelly solifluction zones adjacent to receding snowbanks ("wg" in Table 1) provide a final example of unique alpine habitat on Steens Mountain.

What Makes a Plant Rare?

A plant may be considered rare for one or a combination of the following reasons: 1) it covers a **small geographical range,** 2) it has very **specific habitat requirements,** and 3) it exists in **small populations** or sparsely distributed individuals (Rabinowitz 1981). Clearly, a species will be considered rare by anybody's definition if it has sparse individuals, requires limited and specific symbionts or soils, and is restricted to a small geograhical area. Furthermore, if such a species is threatened by any natural or anthropogenic environmental change (mining, recreation, invasion by exotic plants, etc.), it may be considered in danger of extinction. Conversely, if a plant exists in large populations with a large ecological amplitude, it may not be considered rare even if its geo-

graphical range is very small, especially if its population size is not changing in response to environmental changes. There are numerous permutations between these two extremes, so deciding whether a species is rare is not often a simple matter.

One of the most interesting types of rarity is based on limited geographical distribution. A taxon is endemic if it originated in and its distribution is limited to one area. A plant may be endemic to a large area (such as western North America) or to a small area (such as Steens Mountain). A species may be endemic for a variety of reasons that can be considered to span the range between the two extremes of paleoendemic and neoendemic (Kruckeberg and Rabinowitz 1985, Stebbins and Major 1965). Paleoendemics are relictual-remnants of taxa that were once more widespread. Neoendemics are newly formed taxa that may be in the process of expanding their range from their points of origin.

On Steens Mountain there are at least six endemic taxa (Table 1), all of which are evidently neoendemics for several reasons. All (*Agastache cusickii*, *Castilleja pilosa* var. *steenensis*, *Cirsium peckii*, *Draba sphaeroides* var. *cusickii*, *Penstemon davidsonii* var. *praeteritis*, and *Poa sp. nova*) are species or varieties with closely related counterparts in relatively close geographic proximity. For example, *Castilleja pilosa* var. *pilosa*, the ancestor of Steens' rarest and narrowest endemic (*C. pilosa* var. *steenensis*), is located below 7,000 ft. on Steens Mountain. All Steens Mountain endemics inhabit alpine rock outcrops or gravelly soils. This is an environment which is probably able to retain sufficient moisture during the driest period of the Holocene, yet, no doubt experienced extended periods of drought, imposing selective pressures that may have driven speciation. Three of these endemics (*Agastache cusickii*, *Cirsium peckii*, and *Penstemon davidsonii* var. *praeteritis*) have known populations in other Great Basin mountain ranges (Pueblos Mountains, ranges of northern Nevada, etc.) as well as on Steens Mountain. The fact that of these three, two are distinguished from their closest relatives at the species level and that all have populations outside of Steens Mountain suggests that their origins may be older and/or more geographically distant than the other three endemics.

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Steens Mountain draba
(*Draba sphaeroides* var. *cusickii*)

If we are interested in a plant's rarity because we wish to maintain biological diversity, it matters how genetically diverse rare species' populations are and how genetically differentiated a rare species is from its close relatives. For example, two species with equally small population sizes, habitat requirements, and geographical ranges may not be considered equally "rare" genetically if one represents a small genetic variation (say, a subspecies or variety) from a widely ranging common species and the other represents a large genetic deviation (say, a different genus) from its most closely related species. From this perspective, one would surmise that the endemic plants of Steens Mountain do not provide the genetic diversity that paleoendemic genera (such as *Kalmiopsis* from the Siskiyou Mountains in southwestern Oregon or several of the California endemics) contribute.

For the past two decades Oregon has been developing a database of rare plants. Plants listed as rare, threatened, or endangered by the Oregon Natural Heritage Program (ONHP 1993) can be included for several reasons and those species that may have been considered appropriate to list in 1980 (in the list that predated the existence of the ONHP) or 1989 may not be listed in 1995. For example, some plants previously considered rare by criteria of small range or population size may no longer be considered rare as further populations are discovered and the species is seen to be more widely distributed. This is the case for several annuals found on Steens Mountain, such as *Dimersia howellii* or *Nemacladus rigidus*.

Rare Plants on Steens Mountain

The plant taxa found on Steens Mountain that the ONHP (1993) considered rare, threatened, or endangered are summarized in Table 1. Though Steens Mountain is a center of high plant species diversity, none of the vascular plant taxa of Steens is listed as either endangered or threatened at either the Federal or State level. Only 2 taxa (*Castilleja pilosa* var. *steenensis* and *Lupinus biddlei*) are candidates (C2 status) for consideration, meaning that they require "active protective measures to insure their survival" but that informaion on their biology and distribution is limited (ONHP 1993). The Steens paintbrush (*C. pilosa* var. *steenensis*) exists in several small populations along the summit ridge from the east Kiger rim to south Steens. Biddle's lupine (*L. biddlei*) is not a recognized taxon by the most recent treatment (Barneby 1990). It inhabits sagebrush-dominated sites in the lowlands.

Taxa on ONHP lists 2, 3 or 4 are either a) endemic but have sufficiently large populations to be considered not threatened with extinction or likely to become threatened under existing conditions (e.g. *Agastache cusickii*, *Draba sphaeroides* var. *cusickii*, *Penstemon davidsonii* var. *praeteritis*, or b) rare or well-distributed outside of Oregon but have limited population sizes or disjunct populations in Oregon.

Many Steens Mountain species (e.g. *Carex haydeniana*, *C. nova*, *Cymopterus nivalis*, *Llyodia serotina*, *Saxifraga adscendens*, *Sedum debile*, *Polemonium viscosum*) are widely distributed in the northern Rocky Mountains but are rare in Oregon. Others on Steens that are rare in Oregon are disjuncts from the Sierra Nevada flora (e.g. *Allium companulatum*, *Claytonia nevadensis*, *Salix orestera*). Fewer Steens plants with affinity to the flora of the Sierra Nevada are listed as rare (by ONHP) than plants with Rocky Mountain affinity because many taxa common to Steens and the Sierra Nevada are also found throughout the Southern Cascades and thus are not rare in Oregon. Other Steens taxa that are rare in Oregon are at the northern end

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Steens penstemon *(Penstemon davidsonii* var. *praeteritis)*

of their range in the Great Basin and may not be considered rare in Nevada, for example. These are typically low elevation taxa such as *Chenactis macrantha, C. stevoides, Caulanthus major* var. *nevadensis, Allenrolfea occidentalis, Phacelia gymnoclada,* and *Argemone munita* ssp. *rotundata* but also include a smaller number of taxa in the alpine such as *Ivesia baileyi* var. *beneolens* and *Cryptantha humilis.*

Several taxa on Steens are rare in Oregon because populations tend to be very small and sparse and/or the specific habitat required is rare even though the taxa may be more widely distributed in Oregon (e.g. *Botrychium lunaria, B. pinnatum, Gentiana prostrata, Gentianella tenella, Kobresia bellardii, Carex backii, C. praeceptorum, Allium madidum, Salix arctica).* Each of these has 3 or fewer known populations on Steens Mountain.

Perhaps the most distinctive plant of the Steens Mountain flora is the Steens Mountain thistle *(Cirsium peckii).* To the untrained eye, the plant appears to be the common, widespread (but allopatric) bull thistle of lower elevations. Steens Mountain thistle is not considered rare in Oregon despite its endemism to Steens Mountain because of its abundance and status in the area. The plant is a ruderal species — it thrives on disturbance in an otherwise moderate habitat (see Grimes 1979). Like a garden weed whose population increases after cultivation, Steens Mountain thistle proliferates along open disturbed roadsides, landslides, etc. throughout the montane zone. This is hardly the behavior one expects of a narrow endemic. However, for some reason related to Steens Mountain's isolation and the biology of the plant, the Steens Mountain thistle has not yet left the Steens-Pueblo range since its origin, probably in the late Pleistocene or Holocene.

A number of species on Steens Mountain are not considered rare in Oregon but they have limited distributions on Steens and are unusual in some respect that relates to Steens' unique botanical history and geography. For example, in 1992 I found bog wintergreen *(Pyrola asarifolia)* in the understory of the willows *(Salix planifolia* ssp. *planifolia* and *S. orestera)* of wet cirque bottoms. This plant is found in coniferous forests and shaded wetlands from California to Alaska and east through Canada. It is a "west slope" plant. The populations on Steens are therefore relicts from when cool, moist, closed-canopy wetlands were more continuously distributed from Steens Mountain to the Sierra-Cascade cordillera, possibly via the Wallowa Mountains. Several other taxa are rare on Steens but more abundant elsewhere in Oregon. *Saxifraga debilis* and *S. caespitosa* are found on wet, rimrock cliffs on Steens in only one or a few populations, respectively. Similarly, *Melica stricta* and *Pellea breweri* are rock crevice species that are rather rare on Steens but not regionally. Other Steens taxa, such as *Alopecurus genicalatus* and *Plagiobothrys hispidus,* are morphologically different than other Oregon specimens of the same species (even when observed in the alternating wet and dry years of the 1990s). In the case of the fir *(Abies)* on Steens (in small isolated populations in both Fir Creek and Moon Hill), there is disagreement about the genetic affinity of the taxon on Steens. Whether it is disjunct from the northern *Abies grandis* (Flora 1993) or disjunct from the Sierra Nevada *Abies concolor* var. *lowiana,* the Sierran white fir (Urban 1981), is unclear. This is the only conifer on Steens Mountain, other than western juniper and common juniper. It provides a good example of a relict population from the moist Pleistocene, but whether it is a relict of populations to the southwest or north remains to be determined.

Other taxa are not on the rare plant list because they are in taxonomically difficult groups that are still in the process of being analyzed. An undescribed bluegrass *(Poa sp. nova.)* occurs in the same wet gravels adjacent to receding snowbanks in which we find *Alopecurus geniculatus* and several other rare plants of Steens. This bluegrass has apparent affinity to several high elevation taxa in the *Poa cusickii* complex but seems to be undescribed and is currently under investigation by Robert Soreng (personal communication). Only one record of the blue willow *(Salix glauca* var. *villosa)* is known from Oregon. Having only recently been identified (George Argus, personal communication), this plant from Kiger gorge on Steens will soon be listed as one of the rarest in Oregon.

In light of the existing disjuncts and endemics, and the isolation of Steens, it would not be surprising to find some genetic differentiation among other species that may be obscure morphologically. At the present time, we know virtually nothing about the genetic variation between plant taxa on Steens Mountain and those of other ranges and can only base discussions of rarity on the morphological characteristics we see in herbarium specimens. Even as herbarium specimens are examined, we continue to find novelty in the Steens flora. Further systematic studies that include Steens specimens are warranted.

Synopsis

The alpine plants of Steens Mountain most characterize its unique botany (Table 2). Of the Steens massif, the zone above 8,200 ft. is smallest in area but has the largest number of rare taxa. Table 2 also illustrates that the areas most interesting botanically are the wet areas — wet and subirrigated meadows and wet gravels by receding snowbanks — and the rock outcrops. The alpine wet meadow species (e.g. the Botrychiums, gentians, and graminoids) are alpine disjuncts that were part of a flora shared by other ranges. These habitats on Steens contain several other alpine taxa (e.g. *Pedicularis attollens)* that are not rare and hence not considered here. These wet environments probably lost several species to local (and global?) extinction during the Holocene altithermal period (about 6,000 to 8,000 years ago on Steens Mountain). By monitoring species in these habitats we may have a good biological

indicator of the effects of global warming on the northern Great Basin.

At lower elevations, the botanically unique areas tend to be the drier sites (Table 2), such as ash bed, sandy soils, and clay depressions in the scablands. These habitats have probably also imposed selective pressures, which, combined with population fragmentation (due to the patchy nature of these environments), may have forced speciation throughout the Great Basin during the Pleistocene and Holocene, resulting in new, rare taxa.

At this juncture it is reasonable to ask: What are the effects of juniper encroachment (Miller 1994), grazing, and recreation on the rare flora of Steens Mountain? Few of the taxa listed in Table 1 are threatened by the juniper encroachment that is evident on Steens Mountain. Clearly, if encroachment progresses to the point of monotypic juniper stands, plant diversity is likely to decrease. Thus, from the perspective of maintaining rare plant habitat, a mosaic of diverse communities is desirable and juniper woodlands should be managed accordingly. Most of the alpine zone taxa are fairly secure with current grazing policies that, when enforced, prevent grazing above 8,000 ft. Many of the alpine meadow taxa may have been more widespread before sheep grazing ravaged Steens earlier this century, but this is conjecture. At lower elevations, however, grazing may be taking a toll on rare plants in riparian areas. For example, at least 3 low elevation riparian taxa (*Juncus capillaris*, *Juncus tiehmii*, and *Mimulus evanescens* [the latter is not listed in Table 1 because it was only recently described — Meinke 1995]) are known from Steens Mountain only by historical records. It is quite possible that, as Meinke suggested for *M. evanescens*, these taxa are rare and the Steens populations may have been decimated as a consequence of habitat destruction associated with grazing. Numerous wetland taxa (Table 1) are known from only one or a few populations on Steens (e.g. *Carex backii*, *Allium madidum*, *Downingia laeta*, *D. insignis*, *Myriophyullum sibiricum*, *Potamogeton diversifolius*, *Potamogeton filiformis*). These are indeed threatened by any activity that

Table 1. Rare Plants of Steens Mountain.

Taxa from Steens Mountain listed by the Oregon Natural Heritage Program are of general interest due to their rarity on Steens. ONHP (1993) list numbers (1 to 4) correspond to the list on which the taxon is currently found. Taxa on previous lists or dropped from consideration are also shown here (P). Endemics are denoted by '*'. The zones correspond to different alpine (A), montane (M), or desert (D) elevations as defined in the text. Different habitats discusses in the text are:

a—ash or sand
b—bottomland salt scrub
c—barren, clay soils
dg—dry, gravelly, windswept ridges
f—forested by aspen or riparian woodlands
m—wet or mesic meadows
r—rock outcrops and crevices
s—sagebrush-dominated slopes
t—talus or scree
wp—wetland ponds, pools, lakes, and marshes
wr—wetland stream side, riparian
wg—wet gravels

SPECIES	COMMON NAME	ONHP	ZONE	HABITAT
Aquatics, emergents, and vernal pool species				
Allenrolfea occidentalis	Iodine bush	2	D	wp
Downingia bacigalupii	Downingia	P	M	wp
Downingia insignis	Downingia	4	M	wp
Downingia laeta	Downingia	4	D	wp
Lilaea scilloides	Flowering quillwort	3	M	wp
Myriophyllum sibiricum	Water milfoil	3	M	wp
Potamogeton diversifolius	Diverse-leaved pondweed	2	M	wp
Potamogeton filiformis	Slender-leaved pondweed	3	D	wp
Rotala ramosior	Toothcup	3	D	wp
Ferns and fern allies				
Botrychium lunaria	Common moonwort	2	A	m
Botrychium pinnatum	Northwestern grapefern	2	A	m
Polystichum kruckebergii	Kruckeberg's holly fern	4	A	r
Polystichum lonchitis	Holly fern	P	A	r
Polystichum scopulinum	Rock sword fern	P	A	r
Pellaea brewerii	Brewer's cliff brake	P	M	r
Selaginella watsonii	Alpine spikemoss	4	A	r
Forbs				
Agastache cusickii	Cusick's horsemint	2*	A	t
Allium campanulatum	Sierra onion	4	M	s
Allium lemmonii	Lemmon's onion	4	M	c
Allium madidum	Swamp onion	4	M	m
Argemone munita* ssp. *rotundata	Prickley poppy	2	D	b
Astragalus alvordensis	Alvord milkvetch	4	D	a
Castilleja pilosa* var. *steenensis	Steens Mountain paintbrush	1*	A	dg
Caulanthus major* var. *nevadensis	Nevada jewelflower	2	M	t
Chaenactis macrantha	Mohave pincushion	2	D	a
Chaenactis stevoides	Desert pincushion	2	D	b
Cirsium peckii	Steens Mountain thistle	P*	M	s
Claytonia mevadensis	Sierran spring beauty	4	A	wg
Crepis modocensis	Modoc hawksbeard	3	M	s
Cryptantha humilis	Dwarf cryptanth	3	A	dg
Cymopterus nivalis	Hayden's cymopterus	2	A	r
Draba sphaeroides* var. *cusickii	Steens Mountain draba	4*	A	r
Ericameria discoidea	Discoid goldenweed	4	A	r
Eriogonum caespitosum* var. *hauschnecktii	Tufted buckwheat	P	A	dg
Fritillaria atropurpurea	Chocolate lily	P	M	f
Gentiana prostrata	Pigmy gentian	2	A	m
Gentianella tenella	Slender gentian	2	A	m

will disturb plant population processes, including grazing. Recreation can impose significant threats to rare plants (Losos 1995) but whether recreation threatens rare plants on Steens is largely unstudied. As with grazing in riparian areas, any disturbance to plant population processes can be problematic. Thousands of people now visit Steens annually, however, few travel to the sites inhabited by most rare plants. The Steens paintbrush is perhaps most threatened by recreation because its habitat is one most frequently visited. Because so many of the rare plants exist in only a few populations, it is imperative that all visitors, including botanists, **"tread lightly."**

DONALD MANSFIELD

Steens Mountain paintbrush
(Castilleja pilosa var. *steenensis)*

What makes Steens Mountain interesting botanically, then, is the unique combination of Rocky Mountain and Sierra alpine and, to a lesser extent, montane plants. As a consequence of the isolation of Steens from these floras, to the northeast and southwest, respectively, some of the taxa have differentiated sufficiently to produce new species or varieties that are endemic to either Steens (e.g. *C. pilosa* var. *steenensis* and *D. sphaeroides* var. *cusickii)* or Steens and some combination of the surrounding ranges (e.g. *C. peckii* and *P. davidsonii* var. *praeteritis)*. Other taxa simply remain as populations disjunct from the rest of their species to the northeast or southwest. Being at the northern limit of the Great Basin physiographic province also means that the Steens and surround-

Hackelia patens	Pale stickseed	3	M	s
Ivesia baileyi* var. *beneolens	Owyhee ivesia	P	A	r
Lupinus biddleyi	Biddle's lupine	3	D	s
Lloydia serotina	Alpine lily	3	A	m
Malacothrix glabrata	Desert dandelion	4	D	b
Malacothrix torreyii	Torrey's malacothrix	4	D	b
Orobanche pinorum	Pine broomrape	P	M	s
Pediocactus simpsonii* var. *robustior	Hedgehog cactus	4	D	s
Penstemon davidsonii* var. *praeteritis	Steens penstemon	4*	A	r
Penstemon janishiae	Janish's penstemon	3	D	c
Penstemon pratensis	Early penstemon	3	M	m
Penstemon seorsus	Short-lobed penstemon	3	M	s
Phacelia gymnoclada	Thick-leaved phacelia	2	D	a
Physaria chambersii	Double bladderpod	3	M	f
Polemonium viscosum	Sky pilot	4	A	r
Pyrola asarifolia	Bog wintergreen	—	A	wr
Pyrrocoma uniflora* var. *howellii	One-flowered goldenweed	4	A	dg
Saxifraga adscendens* var. *oregonensis	Wedge-leaf saxifrage	2	A	r
Saxifraga caespitosa* var. *minima	Tufted saxifrage	—	A	r
Sedum debile	Weakstemmed stonecrop	4	A	r
Graminoids				
Achnatherum speciosum	Desert needlegrass	2	D	s
Agrostis humilis	Alpine bentgrass	3	A	m
Alopecurus geniculatus	Water foxtail	—	A	wg
Carex backii	Back's sedge	3	M	wr
Carex haydeniana	Hayden's sedge	4	A	wg
Carex nova	New sedge	2	A	m
Carex praeceptorum	Teacher's sedge	3	A	m
Carex sheldonii	Sheldon's sedge	4	M	wr
Juncus bryoides	Moss rush	3	M	wp
Juncus capillaris	Thin rush	3	D	wr
Juncus hemiendytus* var. *abjectus	Center basin rush	3	M	wp
Juncus tiehmii	Tiehm's rush	3	D	wr
Kobresia bellardii	Kobresia	2	A	m
Melica stricta	Rock melic	—	A	r
Poa* sp. *nova.	undescribed bluegrass	—*	A	wg
Trees and shrubs				
Abies grandis	Grand fir	—	M	f
Populus augustifolia	Narrow-leaved cottonwood	4	M	wr
Salix arctica* var. *petraea	Arctic willow	P	A	m
Salix drummondiana	Drummond's willow	4	A	wr
Salix glauca* var. *villosa	Blue willow	—	A	wr
Salix orestera	Gray-leaved sierra willow	3	A	wr

Table 2. Distribution of rare plants on Steens Mountain.

The taxa from Table 1 are categorized by elevational distribution and by relative moisture regime or habitat.

	WETLAND	WET SOIL	VERNALLY MOIST	MESIC TO DRY	ROCK	**TOTAL**
Alpine	3	15	0	4	15	**37**
Montane	5	2	5	10	2	**24**
Desert	5	0	1	11	0	**17**

ing basins are the only Oregon home to several taxa more common to the south. This is particularly true of the desert flora. Though there are several alpine endemics as a consequence of this unique geographic position, the endemics are all fairly recent in origin owing to the relatively recent geological history of the area and the fairly radical climate change that the area has experienced during the Quaternary Period.

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