PATTERNS OF RARITY IN THE OREGON FLORA: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT

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Abstract: Threatened and endangered species are a significant component of Oregon's flora, comprising 0.2% to over 15% of the state's plant taxa, depending on one's definition of endangerment. With such a potentially large group of plants to conserve, generalizations regarding types of rarity and threats to these species would help improve our basic understanding and management of them. To evaluate the types of rarity in Oregon's threatened and endangered flora, we classified all Oregon Natural Heritage Program species (lists 1 and 2) according to geographic range (wide vs. narrow), habitat specificity (broad vs. restricted), and local population size (large vs. small). This $2 \times 2 \times 2$ classification results in seven possible forms of rarity (and one type that is common). We also listed primary and secondary threats to these rare species and identified each plants' habit (annual, biennial, perennial, etc.). The distribution of rare plant populations in Oregon appears to be positively correlated with the distribution of biological diversity in the state, as well as the distribution of individual rare species and zones of collecting by botanists. The majority of Oregon's rarities have a narrow geographic range, restricted habitat, and small populations. There is also a large group of widely distributed species with small populations in restricted habitats. As might be expected, taxa with wide ranges that occur in several habitats are poorly represented among Oregon's threatened and endangered species. Local planning and conservation efforts will be important to the survival of local rarities, while widely distributed taxa will require the coordination and awareness of many land managers. The primary threats to threatened and endangered species in Oregon are the following, ranked (from greatest to least): livestock grazing, logging, recreation, urbanization, agriculture, mining, natural causes, "other," horticultural collection, fire suppression, dams, and scientific collection. Herbaceous perennial species form the highest percentage of Oregon's rare flora, followed by annuals, shrubs, biennials, and trees. The percentage of annual species appears to increase as categories of rarity increase from "endangered in Oregon but more common elsewhere," to "endangered everywhere," to "possibly extirpated." Therefore, annuals may be especially vulnerable and understudied. Our results support the assertions that rare plants are idiosyncratic and management actions, including ecosystem management, should incorporate species-specific biological information.

Key words: endangered species, plants, threats, life-history, plant distributions

Pages 1–10. T.N. Kaye, A. Liston, R.M. Love, D.L. Luoma, R.J. Meinke, and M.V. Wilson, editors. Conservation and Management of Native Plants and Fungi. Native Plant Society of Oregon, Corvallis, Oregon. 1997.

INTRODUCTION

Rarities are held in high regard for many reasons. They may be uncommon, unusual, beautiful, valuable, mysterious, or have a quality of excellence (Kruckeberg and Rabinowitz, 1985; Gaston, 1994). To the conservationist, rare species are of interest because of the risk of their extinction, which would result in the loss of their potential economic or medical use, as well as their ecosystem function (often with unknown environmental effects). Rare species also represent an

ethical issue in that if we do not protect them, we fail in our self-appointed role as stewards of the land. One of the basic challenges involved in the conservation of rare species is that the group to be protected is heterogeneous, comprising many causes and expressions of rarity. There is no single conservation measure that will sustain all species. Biologists frequently lump many kinds of species under the term rare, partly because our language lacks a consistent vocabulary for the types of rarity we observe, thus obscuring many important features of a diverse group (Rabinowitz *et al.*, 1986; Gaston, 1994). To protect rare species, we must have a clear understanding of the types of rarity that exist and how they differ from one another.

A thorough evaluation of the rare plants in a flora requires sound information as to which species are rare, combined with knowledge of their distributions, threats, and ecology. The federal Endangered Species Act of 1973 inspired a flurry of attention to rare species in Oregon, including an outpouring of enthusiasm from professional and amateur botanists alike. After extensive searches of herbarium records and meetings of interested botanists who were willing to share their knowledge of the flora, the first list of rare, threatened, and endangered plants for Oregon was published in 1979 (Siddall *et al.*, 1979). Since that time, the list has been reviewed, revised and re-published biennially (Oregon Natural Heritage Program, 1995). In 1986, the Oregon legislature passed the state's first endangered species act, providing the legal framework for rare species conservation at the state level. In addition, a database of location and biological information for most listed species has been developed and maintained by the Oregon Natural Heritage Program (ONHP-). Records, both current and historic, of over 7,000 rare plant populations have been accumulated in this database (Figure 1), and used to keep current the list of Oregon's rarities.

With this information in hand, we approached Oregon's rare plants systematically to evaluate the abundance of various types of rarity in our threatened and endangered flora. Specifically, we focused on the taxa considered threatened or endangered by the Oregon Natural Heritage Program. After a brief summary of the official status and size of this region's rare flora, we hope to summarize the 'big picture' of rare species distributions, threats, life-histories, and the types of rarity, in an attempt to understand the complexity of this group and to seek useful patterns. This effort represents the first large-scale use of Rabinowitz' well-known "seven forms of rarity" since they were originally proposed and implemented with the flora of the British Isles (Rabinowitz, 1981; Rabinowitz *et al.*, 1986).

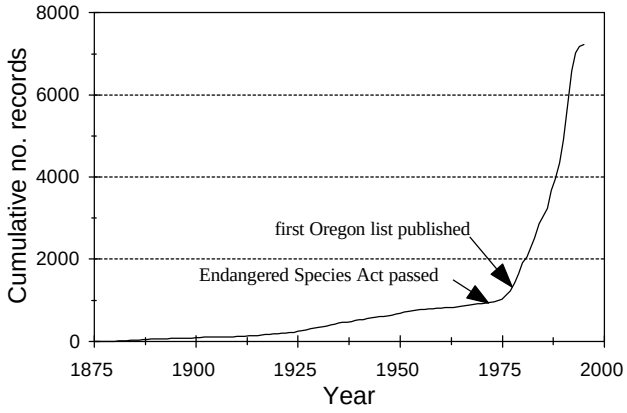

FIG. 1. Cumulative number of population sightings for rare species tracked by the Oregon Natural Heritage Program. Prior to the mid-1970s, records are largely from herbarium specimens.

Official lists: the current status of Oregon's flora

The number of rare species in the state differs substantially among sources. There are three primary listing agencies for rare plants in Oregon: United States Fish and Wildlife Service (USFWS), Oregon Department of Agriculture (ODA), and ONHP. According to USFWS, only about two tenths of one percent (seven taxa) of the state's flora (based on an estimated 4400 vascular plant taxa in Oregon—see Sundberg, this volume) is threatened or endangered, while ODA considers 1.4% (61 taxa) of the flora to be in sufficient jeopardy to merit these ranks (ONHP, 1995). ONHP uses four categories for rare plant species: threatened and endangered throughout range (List 1), threatened and endangered in Oregon but more common or stable elsewhere (List 2), species for which more information is needed before a status can be determined, but which may be threatened or endangered (list 3), and taxa of concern that are not currently threatened or endangered (list 4). Thus, ONHP has the most comprehensive and inclusive estimate of rarities. Lists 1 and 2 combined (all threatened and endangered in Oregon) comprise 8% (349 taxa) of the vascular flora, and the fraction rare enough to be of concern (all lists combined, 679 taxa) is over 15% (derived from published ONHP lists; ONHP, 1995). With such a potentially large and significant group of species that may require special management attention, a greater understanding of the types, threats, and life-histories of these taxa will improve our ability to conserve them.

METHODS

Geographic patterns

To display the distribution of rare plant populations in Ore

TABLE 1. Classification of Oregon's rare taxa. Each rare plant was assigned a type of rarity, threat, and habit.

Type of rarity	Threat	Habit/life history
Large geographic range, wide habitat specificity, small population size	Urbanization and development	Annual
Large geographic range, narrow habitat specificity, large population size	Agricultural activities	Biennial
Large geographic range, narrow habitat specificity, small population size	Logging and associated activities	Herbaceous perennial
Small geographic range, wide habitat specificity, large population size	Mining	Cespitose woody perennial
Small geographic range, wide habitat specificity, small population size	Livestock grazing	Shrub
Small geographic range, narrow habitat specificity, large population size	Recreation	Tree
Small geographic range, narrow habitat specificity, small population size	Fire suppression	
	Dams and water diversions	
	Horticultural collection	
	Scientific collection	
	Natural disaster	
	Other	

*Threats were assigned as primary (one for each taxon) and secondary (as many as needed for each taxon)

gon, we used the ONHP database of point locations for known populations of List 1 and 2 taxa to generate a statewide density map of populations. For this purpose, and the classifications described below, we focused on the 338 taxa on lists 1 and 2 (ONHP, 1993). [Note: The 1995 lists were not available when this phase of the project was conducted.] Location information was current up to May, 1995. The number of records within each Oregon township (a convenient grid of approximately 6 by 6-mile squares) was tallied using ARCINFO geographic information systems software, and the resulting polygons representing population densities were portrayed graphically. This map of Oregon was then used to identify patterns in the Oregon rare flora, such as areas of high and low rare plant population density.

Types of rarity

We used Rabinowitz' classification scheme (Rabinowitz, 1981; Rabinowitz *et al.*, 1986) to categorize each of Oregon's threatened and endangered taxa into one of seven types (Table 1). These types are defined by a $2 \times 2 \times 2$ matrix based on geographic range size (wide vs. narrow), habitat specificity (broad vs. restricted), and population size (large, dominant vs. small, non-dominant). Eight categories result from the combination of these traits, seven that can be considered rare, and one that represents common species (Figure 2). To illustrate, Douglas-fir (*Pseudotsuga menziesii*) has a large range, wide habitat specificity, and large populations, and is considered a common plant. However, Columbia cress (*Rorippa columbiae*) has a large range, wide array of habitats, but chronically small populations (at least in Oregon) and is considered quite rare (List 1; ONHP, 1995). The rarest category includes species such as western lily (*Lilium occidentale*) with small ranges, narrow habitats, and small populations. Examples of taxa in the other rarity-types are presented in Figure 2.

Each co-author drew upon their professional experience and personal opinion of these taxa to place them into categories. Each focused on the species they had direct experience with, and abstained from commenting on species with which they were unfamiliar. The first author then tabulated the results and sought consensus among the co-authors in cases of disagreement. Species that none of the authors classified were evaluated by the first author through herbarium research and consultation with published floras (Hitchcock *et al.*, 1955–69; Peck, 1961; Hickman, 1993). Therefore, most of the classifications reported here represent the opinions of the authors.

Threats

We listed the threats (Table 1) faced by each rare plant in order to identify which affected the greatest number of species. We defined threats as land-use or management activities (or natural processes) with the potential to damage or eliminate populations of rare taxa. Prior to classification, the Oregon Natural Heritage Database was reviewed to identify the types of threats indicated by reporters. Next, we generated a list of types of threats. Finally, each co-author listed the threats faced by each species, and identified the most significant, or primary, threat. As above, each of us focused on the species we knew from professional experience and avoided commenting on species we knew poorly. All species were assigned one or more of the following threats: urbanization and land development; agricultural activities (e.g., cultivation, herbicide application, elimination of fence- and hedge-rows); logging and associated timber harvest activities, including road building and log handling; mining and associated habitat destruction; livestock grazing, especially unsustainable and inappropriate grazing; recreation (e.g., trail construction and use, off road vehicle activities, ski resorts); fire suppression resulting in deleterious changes in commu-

Geographic distribution		Wide		Narrow	
Habitat specificity		Broad	Restricted	Broad	Restricted
pop. size	Large, dominant	**Common:** Douglas-fir (*Pseudotsuga menziesii*)	**Predictable:** cotton grass (*Eriophorum chamissonis*)	**Unlikely:** purple toothwort (*Cardamine nuttallii* var. *gemmata*)	**Endemics:** Greenman's lomatium (*Lomatium greenmanii*)
	Small, non-dominant	**Sparse:** Columbia cress (*Rorippa columbiae*)	tall bugbane (*Cimicifuga elata*)	pumice grapefern (*Botrychium pumicola*)	western lily (*Lilium occidentale*)

FIG. 2. Seven forms of rarity, based on geographic distribution, habitat specificity, and local population size (adapted from Rabinowitz, 1981 and Rabinowitz *et al*., 1986).

nity composition; dams and water diversion projects; overharvesting for horticultural use; excessive scientific collection; natural disasters (e.g., volcanic eruptions, catastrophic floods); and "other" (to capture less common, miscellaneous threats).

Our list of threats focused on land-use practices and did not explicitly include "side-effect" threats such as exotic species, even though invasive weeds compete with and displace native plants and can substantially reduce the biodiversity of a region and undermine ecosystem function (Vitousek 1990; D'Antonio and Vitousek 1992). Instead, such threats were included implicitly; we considered the introduction and spread of exotics integral to land uses such as livestock grazing, timber harvest, development, agriculture, etc.

Life-histories

To determine which life-histories are most and least abundant in Oregon's rare flora, we classified each taxon into one of six habits (Table 1): annual, biennial (including short-lived monocarpic perennials), herbaceous perennial, cespitose (low-growing) woody perennial, shrub, and tree. In addition, we compared the abundance of each life-history within ONHP groupings (List 1, List 2, and possibly extirpated from Oregon or throughout their range) to explore the relationship between life-history and degree of endangerment. List 2 taxa were considered least endangered overall and extirpated plants were most jeopardized.

RESULTS AND DISCUSSION

Geographic patterns

Rare plant populations in Oregon appear to be concentrated in particular geographic areas (Figure 3a). A selection of significant areas is identified in Figure 3b. Areas with a high density of rare plant populations included, for example, the Columbia River Gorge (area 1) and Mount Hood region (area 2). The Willamette Valley (area 3) also represented a region of high density, as did southwestern Oregon (Klamath/Siskiyou region, area 4), a portion of the Ochoco Mountains (area 5), Hells Canyon and associated tributaries (area 6), Wallowa Mountains (area 7), Leslie Gulch-Succor Creek and adjacent Owyhee uplands (area 8), Steens-Pueblo mountains (area 9), and the eastern shore of Malheur Lake (area 10). Regions with a low density of rare plant populations included forests in the far northwest corner of the state (area 11), Coast Range north of the Siskiyou Mountains and south of Lincoln City (area 12), heavily farmed agricultural lands of Morrow and Umatilla counties (area 13), a broad region of eastern Oregon roughly from Christmas Valley in the southwest to Baker City in the northeast (area 14), and the far southeast corner of the state in southern Malheur County (area 15).

The observed distribution of rare plant populations in Oregon appears to be positively correlated with the distribution of biological diversity and individual rare species in the state, as well as the collecting habits of botanists. For example, the high concentration of reported populations in southwestern Oregon coincides with a high degree of diversity, disjunction,

and endemism in the Klamath and Siskiyou regions (Whittaker, 1960; Smith and Sawyer, 1988), as do the high densities in the Wallowa Mountains (Mason, 1975), Leslie Gulch-Succor Creek area (Grimes, 1984), Steens/Pueblo Mountains (Mansfield, 1996 and in review), and Hells Canyon. Another area of abundant rare plant populations, the Columbia Gorge, is also well-known for its botanical diversity (Jolly, 1988), *and* it has been well "botanized" by professionals and amateurs alike. Similarly, the Mount Hood area and Willamette Valley may possess botanical diversity commensurate with their high density of rare plant populations, but they also occur near the state's most populated metropolitan areas and are probably better explored. Therefore, higher than average botanical inventory may have contributed to the large number of sightings in those and other locations. The high-density areas we identified for the Ochoco Mountains and the east shore of Malheur Lake are examples of apparent rare plant concentrations that can be explained largely by the presence of a single species. For example, the patchy distribution of Peck's mariposa lily (*Calochortus longebarbatus* var. *peckii*) accounts for most of the rare plant reports for the Ochoco Mountains region depicted in Figure 3, while a series of small colonies of Columbia watercress (*Rorippa columbiae*) along the west shore of Malheur Lake account for all of the populations in that area.

As with the "hot spots" for rarities, regions of low population density appear to be a combined result of the distribution of plants and habits of botanists. The low frequency of populations in the Coast Ranges and central Oregon probably reflects the low floristic and habitat diversity of these areas. However, we suspect lack of botanical exploration is partly responsible for the paucity of rare plant sightings from the remote desert of southern Malheur County. The "cold spot" in Morrow and Umatilla counties depicted in Figure 3 may reflect low regional diversity, poor floristic documentation, as well as wide-spread farming of available habitat. Documented rare plant populations in Oregon do not appear to be randomly or uniformly distributed. Rather, they appear closely tied to geographic features and centers of floristic diversity, as well as to areas frequented by botanists.

Types of rarity

No single type of rarity appears to characterize Oregon's threatened and endangered plants; Rabinowitz' seven forms of rarity are all represented in the flora (Figure 4a). There appear, however, to be two primary groups of rarity-types, corresponding roughly to ONHP lists 1 and 2. These are: plants with *narrow* geographic ranges, restricted habitats, and large or small populations (List 1 taxa, classic endemics; Figure 4b); and taxa with *wide* ranges, restricted habitats, and large or small populations (primarily List 2; Figure 4c). This concurrence of the two approaches is largely because

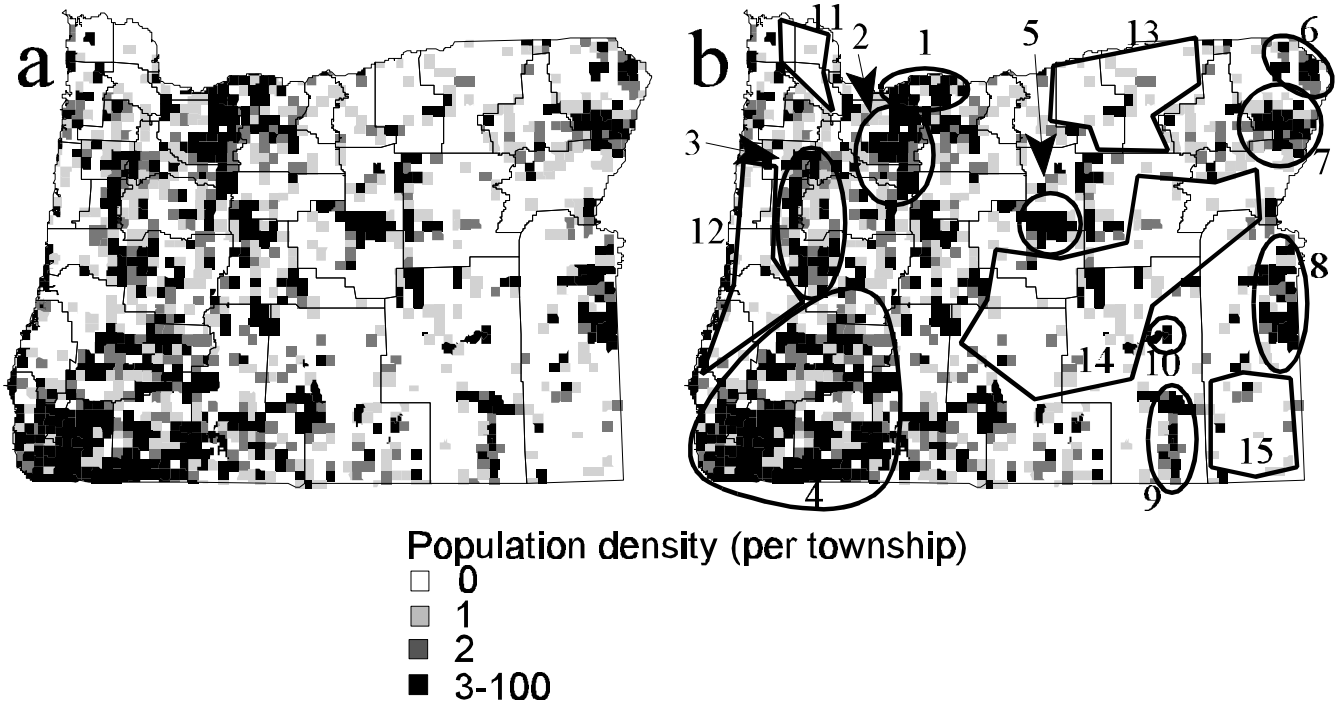

FIG. 3a. County map of Oregon with the density of rare plant populations by township (roughly 6 × 6 miles square). FIG. 3b. The same map repeated with numbered outlines identifying areas discussed in the text. Rounded outlines represent high-density areas and straight-sided outlines indicate low-density areas.

both methods employ range size either directly (Rabinowitz) or indirectly (ONHP—taxa on List 2 that are "more common or stable elsewhere" must occur *elsewhere*, and therefore may have a large range). Rare taxa with small, non-dominant populations consistently outnumbered those with large, dominant populations (Figure 4a). The least common forms of rarity in our threatened and endangered flora are taxa with narrow ranges, wide habitat specificity, and large or small populations (Figure 4a). These were also uncommon forms within the flora of the British Isles. Rabinowitz *et al*. (1986) commented that the condition of having a narrow range, broad habitat, and small populations was biologically unlikely.

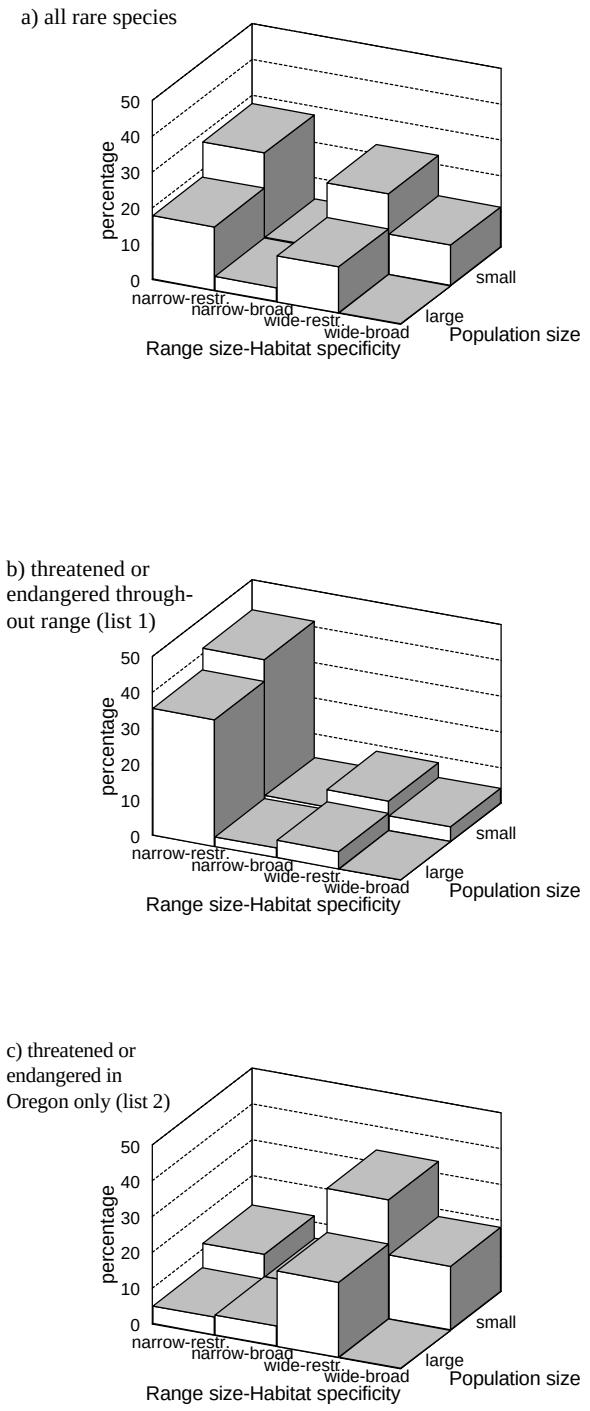

FIG. 4. The percentage of each of seven forms of rarity in Oregon's threatened and endangered vascular flora for a) all rare taxa combined, b) List 1 taxa only, and c) List 2 taxa only.

Some species that occur in Oregon at the margin of their geographic range but are more common elsewhere, such as russet cotton-grass (*Eriophorum chamissonis*) and scheuchzeria (*Scheuchzeria palustris* var. *americana*), are important parts of the state's threatened and endangered flora, and are often found on ONHP List 2. However, no single type of rarity defined here specifically delineates these taxa, and they have been termed "pseudo-rare" (Rabinowitz, 1981). Even so, populations on the margin of a species' range have conservation significance because they may be morphologically and genetically distinct (Lesica and Allendorf, 1995). This can add substantially to the genetic diversity upon which a species' survival may depend. Conservation of peripheral populations may protect evolutionary processes vital for adaptation to a changing environment, because speciation events may occur on range margins (e.g., Schumaker and Babble, 1980; Lesica and Allendorf, 1995). Finally, range collapses leading to endangerment may spread from a species' geographic center outward leaving peripheral populations as the only options for recovery, as has been shown for some mammals (Furlow, 1995; Lomolino and Channell, 1995). The omission of range-limit rarities as a specific category from Rabinowitz' "seven forms" is an artifact of the classification, and was not intended to diminish their conservation value. We discuss them here to emphasize their important standing among Oregon's threatened and endangered species.

Threats

Livestock grazing ranked highest among land-uses impacting rare taxa, representing the primary threat to 44% of Oregon's threatened and endangered plants (Figure 5). Logging and related activities ranked second (27%), followed by recreation (8%), urbanization (6%), agriculture (5%), mining (2%), natural factors (2%), horticultural collection, fire suppression, dams, and others (all less than 2%). Grazing and logging combined represented the top threats to more than two-thirds of Oregon's threatened and endangered plants. When primary and secondary threats were considered together, roughly the same ranking resulted. Grazing alone was estimated to impact 65% of rare taxa to some degree,

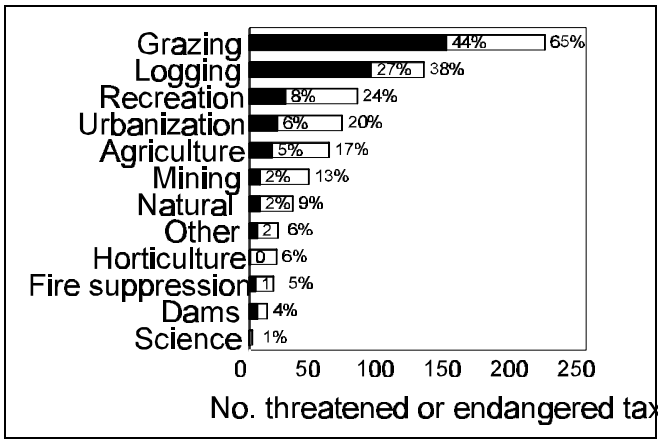

FIG. 5. The percentage of Oregon's rare vascular plants (338 taxa) impacted by each type of land-use. Primary threats are shown as solid bars (with percentage) and a secondary threats as open bars (with percentages of primary and secondary combined).

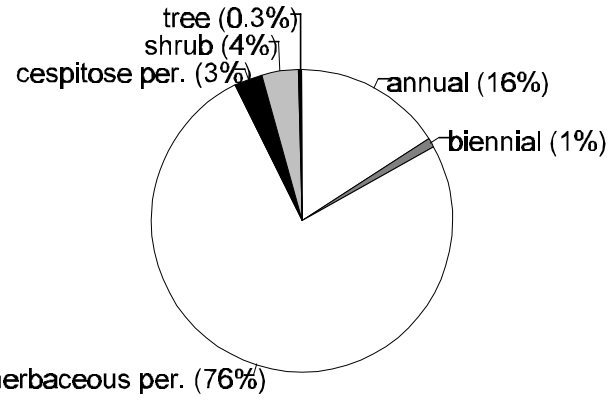

FIG. 6. The percentage of Oregon's rare vascular flora (338 taxa) represented by each of six life-history types ("per." = perennial).

and logging threatened 38% as either a primary or secondary threat (Figure 5). Based on land use patterns in Oregon, we might have predicted the prevalence of livestock grazing and timber harvest as significant threats. An evaluation of state zoning maps showed that agricultural practices (including livestock grazing, especially in eastern Oregon) cover 43% of the state, while forestry encompasses an additional 39%, for a total of 82% of the state's land area (Kaye, unpublished data).

For comparison, a review of recovery plans for 98 endangered species in the United States ranked the top threats as development, recreation (trampling and off-road vehicles), grazing, collecting (presumably both scientific and horticultural), resource mining and water control projects (tied), logging, exotic species, and agriculture (Schemske *et al*., 1994). Fire suppression, roads, military activities, and natural factors each impacted less than 5% of the species considered. In the former Federal Republic of Germany, agriculture, recreation, mining, urbanization, water management, and forestry and hunting were ranked as the top six of eleven causal agents (land uses) for the decline of threatened species (Sukopp and Trautmann, 1981). Although land uses in Oregon rank differently than in other areas, the common theme of habitat alteration and destruction is consistent among regions. No matter where one looks, the "big issues" appear to be agriculture, grazing, development, recreation, and other resource-extraction practices. We have not specifically addressed it here, but the spread of aggressive alien species, a factor that accompanies nearly all of these threats, remains a major obstacle to plant conservation and habitat restoration (see Youtie, this volume).

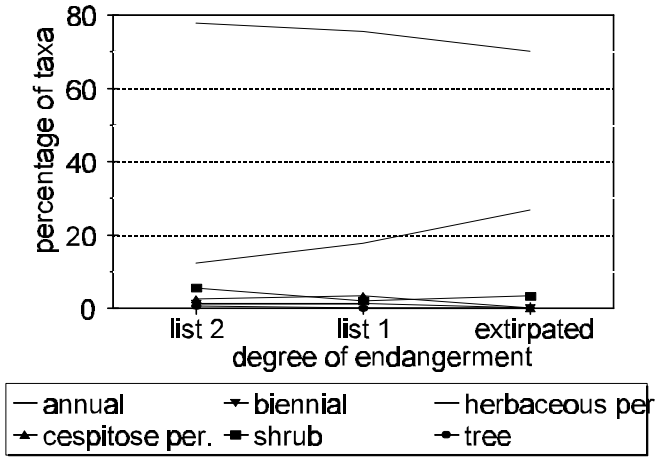

FIG. 7. Relationship between degree of endangerment and percentage of taxa in each category for each of six life-histories. See text for explanation of lists 1 and 2.

Habits

Trees, shrubs, cespitose perennials, and biennials were uncommon life-histories among Oregon's rarities, while annuals and especially herbaceous perennials were the most frequent. Herbaceous perennials represented 76% of threatened and endangered taxa (Figure 6). Annual plants were ranked second, accounting for 16% of the group, followed by shrubs (4%), low growing woody (cespitose) perennials (3%), and biennials (1%) (Figure 6). Only one tree species (0.3% of taxa considered), Baker's cypress (*Cupressus bakeri*), was considered threatened or endangered in Oregon. Some researchers have suggested that there is a positive correlation between body size and rarity (range or abundance) for animals, and this notion has been extended to plants with inconsistent results (see Gaston, 1994 for a review). North American oak species, for example, increase in geographic range with tree height (Aizen and Patterson, 1990), but, con-

versely, Australian plants with taller growth forms tend to have smaller ranges (Oakwood *et al*., 1993). Harper (1979) found that woody plants are strongly under-represented among threatened and endangered species in Utah and Colorado, but over-represented in California, possibly because of the large number of relictual woody species in the latter state. Unfortunately, no complete evaluation of life-histories is currently available for the flora of Oregon *as a whole*, so it is difficult to determine if any habit is over- or under-represented among rare taxa. At this point, we hypothesize that woody species are under-represented and that herbaceous perennials are over-represented.

As degree of endangerment increased from List 2 taxa to extirpated plants, the abundance of herbaceous perennials declined from 78% to 70% while annuals increased steadily from 12% to 27% (Figure 7). No trends were apparent among the other life-histories. The implication that annuals are most likely to become endangered or extirpated from Oregon is intriguing, and suggests that species with short-lived individuals may be inherently more vulnerable than those with long-lived plants. Additional research is needed to confirm this trend, and more information on the population biology of Oregon's rare annuals and the vulnerability of their habitats is necessary before an informed hypothesis explaining this pattern can be proposed.

CONCLUSION: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT

Oregon's threatened and endangered vascular flora consists of a diverse group of taxa of differing types of rarity, threats, and life-histories. Although it is tempting to generalize about the nature of rarity with an eye toward simple conservation prescriptions, our results support the assertion that individual species are idiosyncratic and that useful predictions about rarity and endangered species may be out of reach or should be limited in scope (Harper, 1981; Fiedler, 1987). To illustrate the hazard of over-generalizing, if we were forced to describe the "average" rare plant in Oregon based on the information presented in this paper, we would have to say that it is an herbaceous perennial with a narrow geographic range, restricted habitat, and small populations, threatened primarily by grazing, and occurring in one of several "hot spots" in the state, probably the Klamath/Siskiyou region in Oregon's southwest corner. Unfortunately, this statement leaves out so many species and populations in need of protection that it is virtually useless for conservation planning. It is also misleading: the primary threat to most rare plants in southwestern Oregon is *not* grazing. Clearly, rare plants cannot be managed as though they represent any one type of distribution, rarity, or life-history. Instead, their conservation must be approached individually, with careful attention to the biology of each species (Massey and Whitson, 1980).

Despite this limit to generalizations, information presented here provides a clearer picture of the nature of vascular plant rarity in Oregon, and suggests avenues for additional research and improvements in management. For example, threatened and endangered plants are not randomly distributed but are concentrated in regions reflecting floristic diversity, intensity of botanical exploration, and habitat quality. Some areas of the state represent high-priorities for additional rare plant searches before regional management plans can be considered adequate. The application of Rabinowitz' seven forms of rarity to Oregon's threatened and endangered flora highlights the diversity of this group, emphasizing the split between widespread and local rarities. Preparers of natural resource management plans, such as Bureau of Land Management districts, National Forests, and even small-scale Watershed Councils (Oregon Watershed Health Program, 1995), should be aware of the types of rarities in their region of interest. A local endemic may require special attention because a planning area may encompass the entire range of the species and have the potential for profound impacts on its future. In contrast, planners should recognize that widespread rarities may require careful coordination of many managing agencies and private parties for successful conservation. Also, since rare species are not evenly distributed across the state, threats from humans are more acute in specific areas, and concern and planning for rare species conservation can have a geographic focus.

Ecosystem management as a method to protect functioning habitats has been proposed for widespread implementation through legislation and public policy (Ecological Society of America, 1995a), and as a tool to protect biological diversity (Noss, 1983) and strengthen the federal Endangered Species Act (Ecological Society of America, 1996). However, for ecosystem management to successfully protect (or enhance) large numbers of rare and endangered species, a clear understanding of the threats faced by these taxa and their responses to management practices must be known in advance, or at least early in the implementation phase. We identified livestock grazing and timber harvest as the top threats to rare species in Oregon, but information on the specific biological response of these taxa to such land-uses is largely lacking. Therefore, we urge land-managers and research biologists to collaborate on projects that identify the response of rare species to common land-uses and dominant threats, such as grazing, logging, agricultural practices, burning, etc. Encouraging examples of this type of research include an evaluation of the effects of timber harvest on tall bugbane (*Cimicifuga elata*) in western-Cascades forests (Kaye and Kirkland, 1994) and assessments of range management and restoration practices for Picabo milkvetch (*Astragalus*

oniciformis) in western Idaho (Popavich and Pyke, in press). Also, work with Fender's blue butterfly and its larval host-plant, Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*) in western Oregon prairies is adding to our tools for conserving the interactions of ecosystem components (see Wilson *et al.*, this volume and Schultz, this volume). Studies such as these provide the kind of practical information necessary for integrating endangered species protection with ecosystem management. Charles Darwin (1859) noted that "we see in many cases…rarity precedes extinction." Although meaningful generalizations regarding rare species and the nature of rarity are elusive, we hope that with thoughtful implementation, ecosystem management and endangered species conservation together can successfully protect rare—and common—native species.

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