Ricegrasses: Rocks, Rodents, and Rarity

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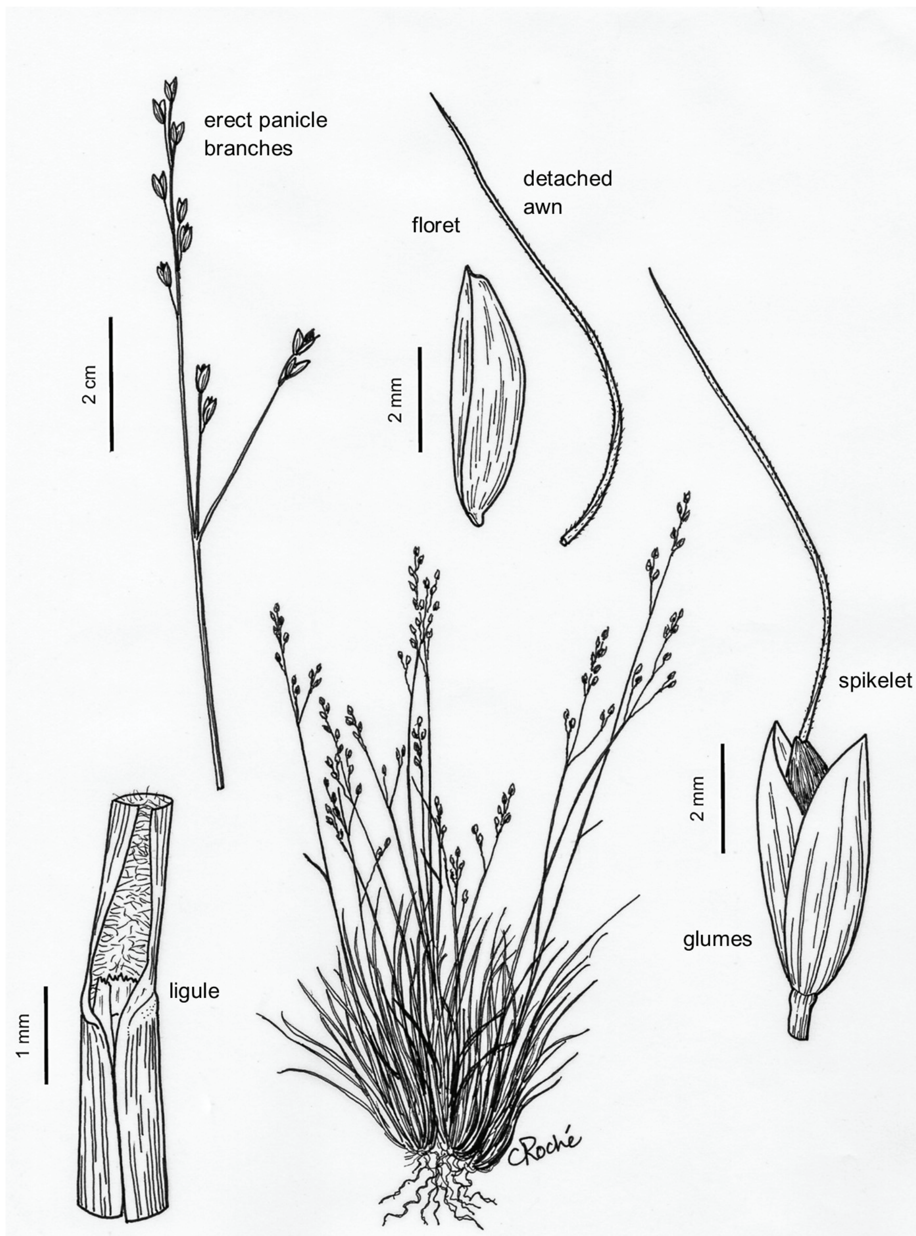
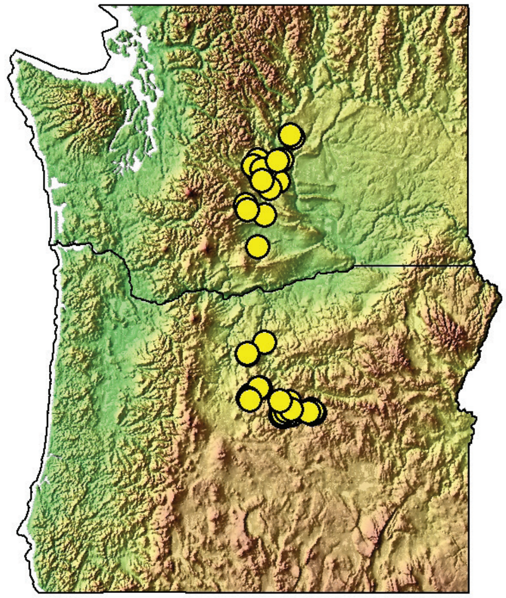
Eastern Oregon is home to two rare endemic ricegrasses. Henderson's ricegrass (*Eriocoma hendersonii*) is a regional endemic, limited to Oregon and Washington, and Wallowa ricegrass (*Eriocoma wallowaensis*) grows only in Oregon. Both taxa are Forest Service "Sensitive Species" and BLM "Special Status Species." Details on other designations of rarity may be found at Natureserve (https://www.natureserve.org/) or Oregon Biodiversity Information Center (https://inr.oregonstate.edu/orbic).

For many years, Henderson's ricegrass was known from only two disjunct populations, one in south-central Washington and the other in the Ochoco Mountains (Hitchcock 1971). Gradually, additional populations were discovered (Vrilakas 1990), extending the range northward in both states, but a large gap remained between populations in Washington and those in Oregon. Then, in the 1970s, Henderson's ricegrass was discovered in Wasco County, Oregon (Winward and Youtie 1976); this placed a dot on the map directly within the wide gap between the two population centers at the time. The known distribution of Wallowa ricegrass has not changed since it was described in 1996. Most of the populations grow in north end of the Wallowa Mountains, with a small outlier group in the Ochoco Mountains 300 km to the southwest.

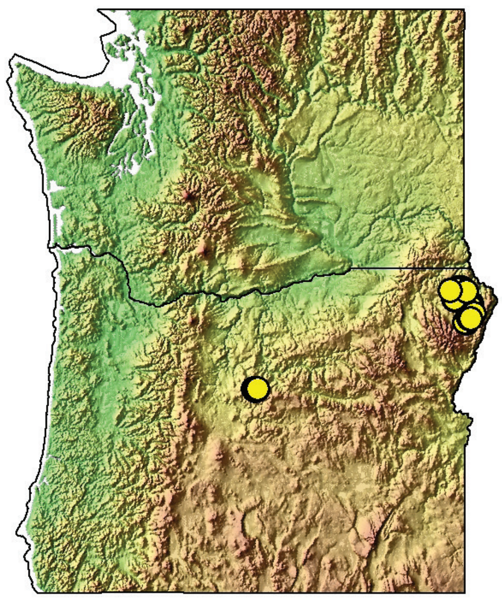
No one knows why such long distances occur between the two population centers of each species, or why they are rare. Both species grow in scablands communities, commonly on ridges, where the soil is shallow over bedrock. There is no shortage of scabland habitat in the areas



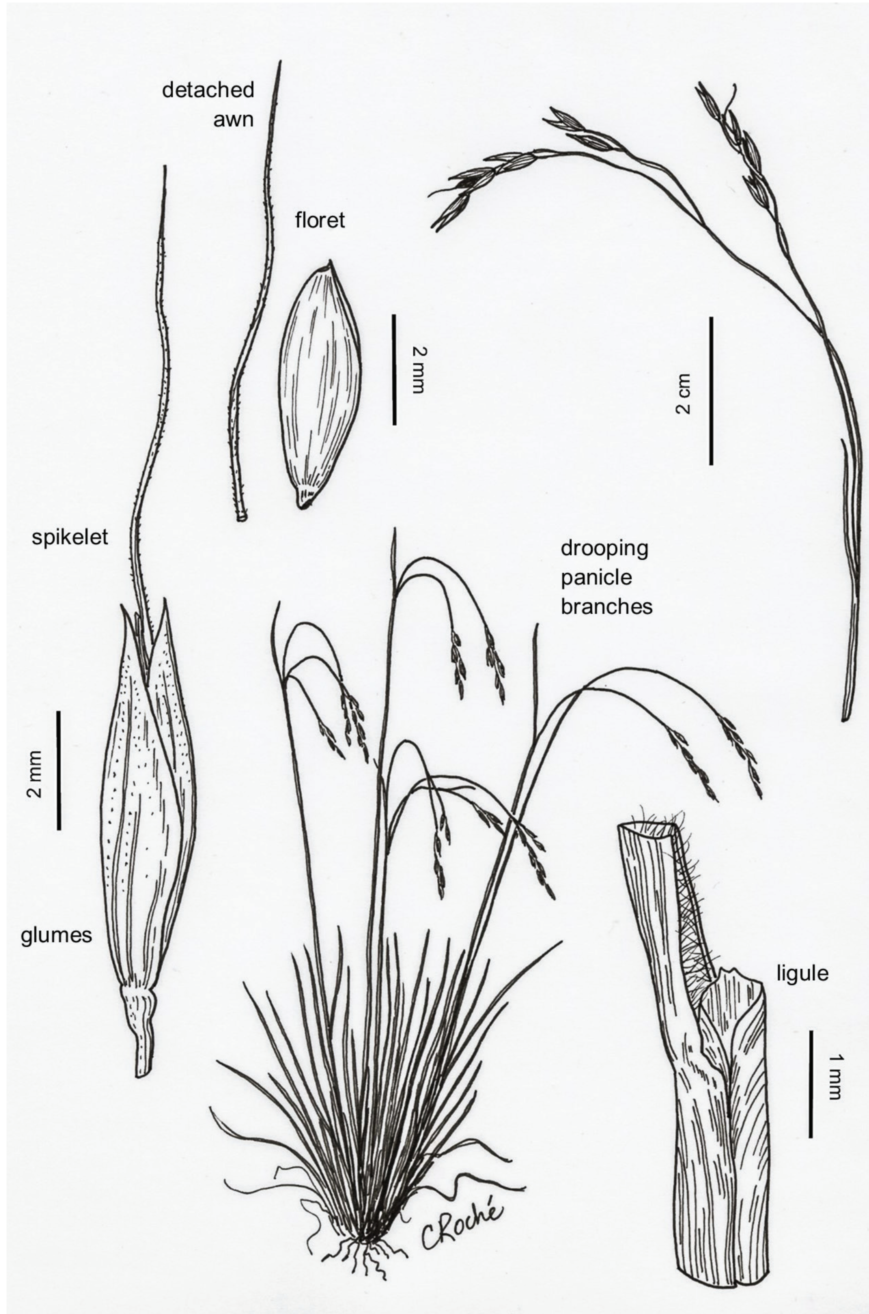
Henderson's ricegrass has erect panicles. Illustration by Cindy Roché.



Distribution of Henderson's ricegrass in Oregon and Washington. Map by Katie Mitchell with the Oregon Flora.



Distribution of Wallowa ricegrass in Oregon. Map by Katie Mitchell with the Oregon Flora.



Wallowa ricegrass has drooping panicles. Illustration by Cindy Roché.

between populations. Scablands are a common landscape feature east of the Cascade Mountains in Oregon and Washington, occupying over 600,000 acres in eastern Oregon alone (Kari Littrell, Natural Resources Conservation Service, pers. comm.).

Binney (1997) recommended an intensive exploration of both biotic and abiotic factors to unravel why Henderson's ricegrass grows where it does. In this article we present our detailed observations of the habitat of Henderson's ricegrass in Oregon and suggest which factors could explain why Henderson's ricegrass is rare. Habitat details are important because it can improve the efficiency of surveys for its presence and provide a foundation for management guidelines to favor survival of the species. We include comparisons with Wallowa ricegrass, its closest relative, because current descriptions of the habitats of the two species are the same: both species are restricted to scablands (non-forested, shallow, rocky soils).

Meet the rare ricegrasses

Henderson's and Wallowa ricegrasses are small bunchgrasses with long, fibrous roots with relatively few branches (see the photos comparing roots of Henderson's ricegrass with those of Sandberg bluegrass on page 23). The stiff, erect leaves are rolled or folded, with fine hairs on the

Name changes in the needlegrass tribe

Ricegrass is a common name for members of the needlegrass tribe (Stipeae) that have short, rounded or oval florets. The species with long, narrow, sharp-pointed lemmas are called needlegrasses. Years ago, most of the needlegrasses were in the genus *Stipa* and the ricegrasses were *Oryzopsis* (which reminds us of the rice-shaped pasta called orzo). In North America, *Stipa* was subsequently divided into *Achnatherum, Hesperostipa, Jarava* or *Pappostipa, Nassella,* and *Piptatherum* or *Piptatheropsis* (Barkworth *et al*. 2007). More recently, most *Achnatherum* species became *Eriocoma* (Peterson *et al*. 2019). For those who detest new names for plants, *Eriocoma* is not a new name. It dates back to 1818 for *Eriocoma cuspidata*, Thomas Nuttall's early name for silk-grass, which is our Indian ricegrass! The name erio (wool) and coma (head of hair) was used for the copious silky hairs on the lemma (Nuttall 1818). The name combination of *Eriocoma hymenoides* was published by Per Axel Rydberg (1912).

Spikelet of silk-grass *(a.k.a.* Indian ricegrass) showing the dense silky hairs on the floret. Photo by Cindy Roché.

Five species in the Pacific Northwest bear the common name ricegrass: Indian ricegrass (*Eriocoma hymenoides*), roughleaf ricegrass (*Oryzopsis asperifolia*), little ricegrass (*Piptatheropsis exigua*), Henderson's ricegrass (*Eriocoma hendersonii*) and Wallowa ricegrass (*Eriocoma wallowaensis*). Henderson's, Indian, little, and roughleaf ricegrass were all at one time *Oryzopsis*. Wallowa ricegrass wasn't recognized until the early 1990s, but keep reading, because we'll share that story shortly. Roughleaf ricegrass doesn't grow in Oregon and little ricegrass isn't particularly rare. Indian ricegrass is common and widespread, especially on sandy sites east of the Cascade Range. This article focuses on Henderson's and Wallowa ricegrasses, the first of which was named 100 years before the second one was recognized.

inner surface of the blades. The basal sheaths become flat and stiff with age and persist to form a coarse shield around the shoots above the crown. The membranous ligules are 0.5 to 1.5 mm long. The inflorescence is a panicle, with spikelets bearing one floret each. The elliptic glumes with pointed tips are longer than the body of the floret. The florets are elliptic and laterally flattened, a shiny, dark brown when mature. A single, curved or slightly bent awn, attached slightly off-center at the tip of the lemma, falls off at maturity. The most obvious difference between the two species is the inflorescence. Henderson's ricegrass has an erect panicle with ascending branches, with the spikelets oriented upward. The panicle of Wallowa ricegrass is drooping with thin, lax branches with the spikelets oriented downward.

Habitat differences between Henderson's and Wallowa ricegrasses

Even though Henderson's and Wallowa ricegrasses occupy what appears to be the same type of shallow soil habitat, they do not grow in the same locations. The maps suggest that their ranges overlap in the Ochoco Mountains, but the closest populations are separated by about 20 km (Farris 2013). Specific characteristics of the Wallowa ricegrass sites have not been studied, but the underlying geology clearly differs at the sites where the two species grow in the Ochoco Mountains. Wallowa ricegrass grows over the John Day Formation (a mixed-up jumble of basalts, tuffs, and rhyolites) dating back 30 to 18 million years. In contrast, Henderson's ricegrass grows over younger formations: mainly Picture Gorge Basalts, but also occurs on some rhyolitic tuffs (Paulson 1977). The Picture Gorge Basalts are 17 individual layers of flood basalts over 400 m (1300 feet) thick. The flows occurred from 16.4 to 15 million years ago in the early to middle Miocene and contain layers of buried ancient soils that developed in intervals between flows.

Existing reports do not describe geologic conditions at Wallow ricegrass sites in northeastern Oregon, but all of the sites are on relatively flat ridges and south-facing slopes north of the Wallowa Mountains proper (Paula Brooks, pers. comm.). Thus, these sites were probably not glaciated during the Pleistocene. Like the unglaciated Ochoco Mountains, this area was probably subject to cycles of soil deposition and erosion (Johnson and Clausnitzer 1992). About 12,000 years ago, eruptions of Glacier Peak blanketed the Blue Mountains and Ochocos with ash, with a second hefty addition of sandy volcanic ash about 7,700 years ago when Mt. Mazama erupted (Fryxell 1965). Both wind and water erosion reworked the deposits of ash and loess to create shallow soil on the ridges and deep soil in the drainages.

The soils on the Wallowa ricegrass sites on the Wallowa-Whitman Forest are very sparsely vegetated, and the rocks are red and pebbly, with a mulch of pea-sized rocks on the surface. Potential habitat is easily detected on

Pattern of scablands (shallow soils) and stringers (deeper soils), both created by erosion and deposition during the Pleistocene in the Ochoco Mountains. Deeper soils support trees and appear green in the photo. Image from Google Earth.

aerial photos, but many locations that looked appropriate on photos did not support plants when checked (Paula Brooks, pers. comm.).

Scabland characteristics in the Ochoco Mountains for Henderson's ricegrass

Scablands are a habitat of harsh extremes. Two factors (the underlying bedrock and a thin layer of clay soil above it) prevent free drainage of water from snowmelt or rainfall, resulting in extreme water saturation and alternating freeze/thaw cycles in late winter and early spring. Summer arrives early on exposed ridges and slopes, creating parched, bone-dry conditions early in the growing season. Humans tend to evaluate soils in light of their own uses, for example, agriculture and livestock grazing. Sites that are "more rocks than soil" were judged worthless by European settlers. But Native Americans valued lithosols as important foraging sites for *Lomatium* and other edible roots. The scablands are also critical habitat for Henderson's and Wallowa ricegrasses.

Henderson's ricegrass grows only on very shallow lithosols, but it doesn't grow on all scablands (if it did, it wouldn't be rare, as the Ochoco Forest has over 250,000 acres of scab/stringer landscape). In Oregon, it grows on relatively few and then only on small parts of those scablands. In our examination of the particular sites where Henderson's ricegrass grows, perhaps the most obvious factor is plant competition. Shallow rocky soils support a variety of plant communities, ranging in vegetative cover from sparse to nearly continuous. The ricegrass consistently grows on sites with sparse vegetation. Binney (1997) found that Henderson's ricegrass is not a vigorous competitor with other species (or itself), and Farris (2013) reported that vegetation in all of the Henderson's ricegrass sites was sparse, averaging 18% total plant cover. Our observations in Ochoco scablands are consistent with these studies: we didn't find Henderson's ricegrass in scablands that support a high vegetative cover.

On the Ochoco National Forest, we found that the most vigorous populations of Henderson's ricegrass grow in extremely rocky sites. Rocks appear to an important factor in ricegrass habitat, but not all rocks are created equal. So next we describe the soil at Henderson's ricegrass locations, the parent material (rocks) from which they were derived, and their effect on the habitat.

"More Rocks than Soil"

Rocks provide numerous benefits; they act as heat sinks, moderating temperature extremes and insulating the soil surface; they funnel water into the soil, preventing surface

Henderson's ricegrass growing in a rock matrix. Photo by Cindy Roché.

erosion and evaporation; they protect plants from herbivory, both above and below ground; they reduce competition from other plants, and provide favorable sites for seedling establishment. Indeed, rocks may provide one of the keys to understanding the rarity of the two ricegrasses.

Soil parent material determines fertility, rock characteristics, and water capacity

Although it was known that scabland soils are very rocky in the surface horizon, David (2013) documented the ways in which particular properties of those rocks influence a wide array of factors important to plant distribution. Henderson's ricegrass in the Ochoco Mountains grows primarily on two types of lithosolic habitats: basalt and rhyolitic tuff. Both sites are very shallow (less than 25 cm), with soil depths ranging from 11 to 18 cm on the basalts and from to 10 to 19 cm on the rhyolitic tuffs. Soil textures are similar between the basalt scablands and rhyolitic tuff scablands (Table 1).

Clearly, both sites provide suitable habitat for the ricegrass, so there must be ways in which the two types of soils compensate for differences in the rock parent material. This section gets technical, so if you aren't into soils and geology, you have our permission to skip over it.

What are the differences between the two rock types, basalt and rhyolite, and how do they affect plant growth? Basalt is high in magnesium and iron and low in silica and feldspar. Silica increases viscosity; lower silica content makes the lava more fluid, creating fine-grained, black rocks when cooled rapidly. In contrast, rhyolite is rich in silica and low in iron and magnesium. It is highly viscous and typically cools slowly in place as dikes or volcanic plugs or is ejected explosively as ash and cinders. (Obsidian is the product of non-explosive quick cooling of rhyolite.) Rhyolitic tuff is the product of explosive volcanic eruptions, in which ash rains down from the sky, solidifying into relatively soft rock layers. Water, ice, lichens, and humic acid subsequently weathered these laminar layers of ashfall tuffs into small flat rocks. Tuff is high in silica and is at least 75% ash; the other 25% may be particles of volcanic glass and small fragments of crystals and/or volcanic rock and lava. Because of the chemical differences, basaltic soils are three times more fertile than the rhyolitic tuff soils and may strongly affect plant vigor (Farris 2013).

Based on this chemistry, basalt and rhyolite rocks also differ in shape and specific gravity. Shape and specific

Table 1. Comparison of study sites on Picture Gorge basalt and rhyolitic tuff scablands. (adapted from David 2013)

Lithology	Average Elevation (range)	Average Soil Depth (range)	Soil Classification	Closest Soil Series Concept
Basalt	4,729 ft. (4,386 to 5,106)	14.8 cm (11 to 18)	Lithic Argixerolls; loamy-skeletal, mixed, superactive, frigid	Canest Series
Rhyolitic Tuffs	4,375 ft. (4,200 to 4,500)	12.5 cm (10 to 19)	Lithic Argixerolls; loamy-skeletal, mixed, superactive, frigid	Tweener Series

gravity of rocks determine the water storage capacity of the soil and accessibility of plants to herbivores. Basalt rocks are spherical or cube-shaped rocks, classified in order of increasing size as gravel, cobbles, and stones (Table 2). On the rhyolitic sites, the rocks are flat instead of round. The cobble-sized rocks are called channers (Table 2).

Basalt rocks are heavier than rhyolite rocks (except for welded tuff): density of the basalt rocks averages 2.9 g/cm^3 compared to 2.4 g/cm^3 for rhyolite channers or 2.2 g/cm^3 for rhyolitic tuff. The heavier basalt is less mobile than the lighter rhyolite, providing a more stable substrate for plant growth and formation of a cryptogamic crust. Another effect of differences in bulk density is porosity, which is

Table 2. Comparison of A Horizon and surface characteristics of the Picture Gorge basalt scablands and the rhyolitic tuff scablands.

A Horizon characteristics	Basalt	Rhyolitic Tuff
Gravels 2-75 mm (≤ 3 inches)	15 %	
Cobbles 45-250 mm (3-10 inches)	57 %	
Stones 250-600 mm (10-24 inches)	2 %	
Channers (flat rocks) 2-150 mm (≤ 6 inches)		63 %
Flagstones (flat rocks) 150-380 mm (6-15 inches)		6 %
Stones (flat rocks) 380-600 mm (15-24 inches)		0.5 %
Gravel mulch (distinct layer of loose surface gravel)		2 cm (0-4 cm range)
Surface texture	Extremely Cobbly (60-90% cobbles) Sandy Loam	Extremely Channery (60-90% channers) Sandy Loam to Coarse Sandy Loam
Cryptogamic crust thickness	0-10 mm	0-1 mm

Henderson's rice grass on a basalt site. Photo by Robert Korfhage.

Henderson's ricegrass on rhyolitic tuff, showing tuff gravel and channers (Refer to Table 2 for rock sizes). Photo by Robert Korfhage.

Rhyolitic tuff gravel forms a mulch over the soil. Photo by Robert Korfhage.

lower for basalts and higher for rhyolitic tuffs. Available water capacity (AWC) correlates positively with porosity. The tuff sites (higher porosity = greater water capacity) store enough water for plants that normally only occur on sites with higher precipitation. For example, on the Snow Mountain District of the Ochoco National Forest, ponderosa pine normally requires 356 mm (14 in.) or more of annual rainfall on basalt substrates, but it can grow on tuff sites with only 305 mm (12 in.) of precipitation. So, bottom line, the basalt sites are more fertile, but the rhyolite sites store more water.

Freeze/thaw cycles, erosion

All of the soils in the study sites are in the frigid soil temperature and xeric soil moisture regime and lie below the persistent snow zone, which makes them more susceptible to rain-on-snow events and subsequent erosion. Without an insulating cover of snow, day and night soil temperatures oscillate widely, cycling each day from below freezing temperatures at night to thawing by mid-day. As the water in the soil freezes, the expanding ice lifts the soil above it. As the ice thaws, the soil collapses downward again. When this occurs on a slope, the process is called solifluction. With each thaw cycle, the soil settles a bit downslope in response to gravity, creating a net downslope movement. The little puddle of soil on the surface is particularly vulnerable to overland water flow carrying it further downslope. Freeze/thaw cycles or the looseness of rhyolitic gravel result in thinner cryptogam crusts to protect the soil from erosion (David 2013). Diurnal freeze/thaw cycles repeated every winter for thousands of years were part of the erosion process that created the scablands.

Rocks and root stability

The roots of the various grass species found on scablands differ from each other. These differences interact with the characteristics of the rocks. Binney (1997) found that Henderson's ricegrass roots are much longer than roots of its most common associate, Sandberg bluegrass (*Poa secunda*). Although the roots of Sandberg bluegrass are shallower, we observed that they are much more densely branched. Henderson's ricegrass roots have a cork-like layer in the root cortex which allows the outer covering of the root to move when the soil expands and contracts, without damaging the inner root (Maze 1981). The root remains anchored and able to take up water and nutrients from the soil despite frost action that moves the soil. Roots of the other common grass on the scablands, one-spike oatgrass (*Danthonia unispicata*), have a branching pattern similar to Henderson's ricegrass.

On the basalt scablands, rock cover ranges from scattered to nearly total cover of the soil. Henderson's ricegrass usually grows as isolated clumps amongst a tight matrix of cobbles and stones solidly embedded in the soil surface. In contrast, Sandberg bluegrass and one-spike oatgrass do not show a strong association with the microsites created by dense rock cover. Wedged tightly together, the heavy basalt rocks are not easily lifted by ice in the soil, but just as importantly they insulate the soil underneath from temperature fluctuation, damping the freeze/thaw cycles (Poesen and Lavee 1994). In addition, as the roots of the ricegrass grow deeper into the soil, they probe for fractures in the underlying bedrock. The roots follow these cracks to access additional water and further stabilize the plant.

Because the rhyolitic tuff is lighter and stores more water it is more subject to frost-heaving than the basalt. We saw much more frost-heaving of grass bunches growing in bare soil or with a loose rhyolitic gravel mulch than in the basalt rock matrix. Sandberg bluegrass plants are commonly thrust out of the ground or left perched on pedestals by frost heave events. However, this is less serious for the bluegrass than it is for the ricegrass. Densely branching roots cling to enough soil to allow it to survive through flowering and seedset in early spring. By the time the exposed soil dries out, the bluegrass has gone dormant for the summer. In contrast, Henderson's ricegrass plants depend on deep soil moisture because they flower in June and ripen seed during the summer drought. When Henderson's ricegrass is heaved out of the ground, its roots are unable to retain the uplifted

Eriocoma hendersonii roots are less densely branched than roots of *Poa secunda*. Note: the full root length was not excavated. Photo by Robert Korfhage.

Densely branched fibrous roots of *Poa secunda*. Photo by Robert Korfhage.

The density of root branching in *Danthonia unispicata* more closely resembles roots of *Eriocoma hendersonii* than those of *Poa secunda*. Photo by Robert Korfhage.

Frost-heaved clump of *Poa secunda*. Photo by Robert Korfhage.

When the soil washes or blows away from the exposed roots, the ricegrass plant dies. Photo by Robert Korfhage.

Wild ungulates pull up plants when the soil is moist in late winter/early spring. Photo by Cindy Roché.

soil. When wind or water expose the roots going into the summer drought, the ricegrass plant dies.

Plant phenology and stored soil moisture

In addition to providing insulation that dampens temperature swings, rocks prevent surface evaporation, so that soil underneath stores more moisture (Poesen and Lavee 1994). Because Sandberg bluegrass flowers early in the spring and is dormant during the hot dry summer, it doesn't require as much stored moisture. Ricegrass plants flower later than bluegrass and depend on deep soil moisture to ripen seed during the summer drought. The rock matrix may also contribute to successful seedling establishment. As seeds falls between anchored rocks, they produce seedlings that are protected from frost heaving, soil erosion, and surface evaporation. The rocks limit the number of adjacent competitive plants, a clear benefit to the ricegrass. Using common garden experiments, Binney (1997) found that Henderson's ricegrass had a slower growth rate than Sandberg bluegrass and that the ricegrass appeared to grow best without any neighboring plants, regardless of whether the neighbors were ricegrass or bluegrass.

Rocks and accessibility

The rhyolitic sites are more accessible to ungulates and off-road vehicles, providing a more comfortable surface for hooves and tires than angular basalt rocks, especially sites with boulders (rocks > 400 mm, 16 inches). Jim David observed that elk, mule deer, and antelope graze Henderson's ricegrass as soon as snow melts from the rhyolitic scablands. When the soil is moist, grazing ungulates can easily pull plants out of the loose gravelly soil and leave them exposed on the soil surface. In contrast, he seldom saw ricegrass plants pulled up in the basalt scablands. Roots confined to interspaces between large rocks require more force for removal than from a loose gravelly mulch. In addition, the matrix of angular rocks with little open soil protects plants from trampling and grazing by domestic livestock, particularly cattle. Rhyolitic sites are comparable to bare soil scablands in their vulnerability to livestock trampling and grazing and off-road vehicles.

Nature's energetic excavators: pocket gophers

Northern pocket gophers (*Thomomys talpoides*) are a common inhabitant of scablands in eastern Oregon. These fossorial (digging) rodents profoundly affect the microtopography, soils, plants, and other animals in their environments. Their tunnels help alleviate soil compaction by increasing aeration and water infiltration and producing fluffy mounds of soil on the surface.

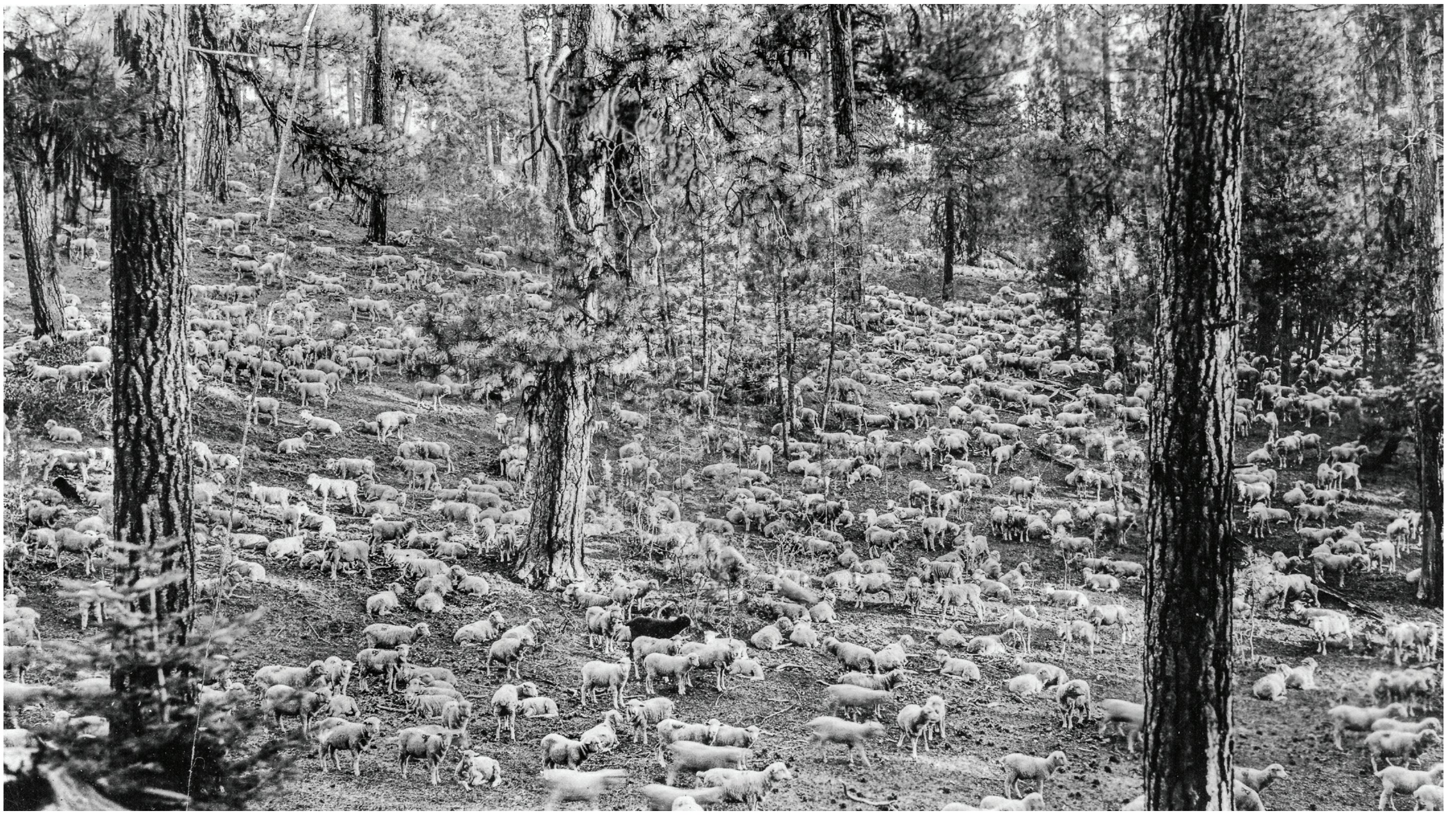
Pocket gophers are active year-round, excavating systems of tunnels that they maintain to obtain and cache food. In the winter they may tunnel through the snow to obtain additional food plants; snow tunnels are later filled with soil from the underground tunnels. Digging and tunnel maintenance burns massive amounts of energy: estimates of the energy cost of burrowing range from 360 to 3400 times that of aboveground travel (Huntly and Inouye 1988). Pocket gophers lift between 1 and 8.5 $kg/m^2/year$ of soil to the surface (Huntly and Inouye 1988). As a result, energy flow through pocket gopher populations is comparable to that of some large grazers. Not surprisingly, gophers prefer tap-rooted forbs over fibrous-rooted grasses, especially plants with succulent / starchy belowground storage organs like *Lomatium* and *Lupinus* species (Cox 1989). Over long periods of time, as gophers remove soil from under rocky areas and deposit it on adjacent terrain, they sort the rocks from the fine soil particles. As the rocks become more concentrated without underlying soil, they collapse to form swales, which channels runoff that increases the removal of soil. Their soil mining activities are credited for creating sharply defined beds of sorted stones that encircle the mounds of biscuit and swale scablands in eastern Oregon (Cox and Allen 1987). In Wasco County, Oregon, Henderson's ricegrass is found only in these stony swales and not on the adjacent mounds. Populations of fleshy-rooted plants (*Allium*, *Lomatium, Lupinus, Trifolium*) also increase where the stony soil protects the roots from gopher herbivory. Compared to the finely fibrous roots of Sandberg bluegrass, the corky roots of Henderson's ricegrass may appear positively succulent to pocket gophers. Although less preferred than succulent forbs, ricegrass plants establishing in soils with lower rock content would be vulnerable to gopher herbivory. Annual and short-lived plants thrive with gopher disturbance of the soil, especially members of the sunflower family. In contrast, long-lived slow-growing perennials (*Eriocoma*, *Lomatium,* and *Allium*) decrease with gopher herbivory. Fewer of those plants grow on the rhyolitic tuff sites and less rocky scablands, which are attractive sites for gophers.

Pocket gopher mound on a rhyolitic site. Photo by Robert Korfhage.

After the snow melts, soil-filled gopher tunnels appear on the soil surface. Photo by Cindy Roché.

Henderson's ricegrass in a changed world

We observed high mortality of Henderson's ricegrass on the rhyolitic tuff sites and dwindling populations on scablands without dense rock cover. Our conclusion is consistent with a 2013 report assessing the status of Henderson's ricegrass (Farris 2013). Of the 49 populations known in Oregon, 48 occur on federal land, with 33 sites on the Ochoco National Forest and 15 sites on the BLM Prineville District. In 2006, 17 populations on the Ochoco National Forest were revisited; populations on 15 of those sites had decreased since the previous census in the early 1990s (Farris 2013). In a little over 10 years, five of the fifteen sampled populations had plummeted from over 150 individuals to zero. The rapid downward trend suggests that the species was more abundant and widespread prior to the introduction of livestock and invasive annual grasses on western rangelands. While a changing climate with more severe and frequent droughts may be one factor causing the decline of Henderson's ricegrass, domestic livestock grazing, soil erosion and loss of the cryptogam layer, noxious weed competition, and human recreational activities are also major contributors.



Sheep grazing in the Ochocos, 1900. Photo courtesy of the Bowman Museum, Prineville.

Livestock grazing: the cryptogam crust, soil erosion, and invasive annual grasses

Dr. Fred Hall, with dual doctorates in Plant Ecology and Range Management, established the first ecology program in the Forest Service, in the Pacific Northwest Region. As a prominent range ecologist in eastern Oregon, he gathered extensive data for over 50 years. During the years before and after Dr. Hall's retirement, Jim David assisted him in organizing several decades of data from long-term research plots throughout the Ochoco National Forest. Dr. Hall believed that the impacts of heavy grazing in the Ochocos were never fully appreciated by the younger generations of resource managers. Populations of some rare species were permanently eliminated or reduced to a few remnants during this period of overgrazing. Examples of extirpated grasses in Oregon and Washington include *Agrostis hendersonii, Eragrostis lutescens*, and *Sporobolus neglectus*. *Melica smithii* and *Muhlenbergia minutissima* have been reduced to only one or two known populations in Oregon. In addition to direct damage to rare native species by grazing, livestock also contributed to the loss of the cryptogam layer, soil erosion, and the introduction of aggressive exotic plants adapted to disturbance.

History of livestock introduction

Starting in the mid- to late 1800s, the Ochoco Mountains were severely grazed by domestic livestock, primarily sheep and cattle, but also horses. Large bands of sheep

Moss may dominate the cryptogam layer; here the dark surface is moss and the rhyolitic rocks appear light. The other common plant is bighead clover (*Trifolium macrocephalum*). Photo by Cindy Roché.

stripped the rangelands bare and were often bedded on the flatter ground (scablands) along the spine of the Ochocos. By 1900, even the cattlemen were adding sheep to their eastern Oregon operations, believing that "cattle and sheep together used range better than either alone; they ate different things ...What they did not realize was that together the two stripped the range clean, speeding the environmental degradation that would soon plague cattle- and sheepmen alike" (Cox 2019, p. 63). Shaniko, the county seat of Wasco County was "the Wool Capital of the World." In 1903 alone, nearly 5 million pounds of wool were shipped by rail out of the town (Cox 2019).

Cryptogam layer and soil erosion

The cryptogam crust, a fragile layer over the surface of the soil, is made up of mosses, lichens, algae and bacteria. The crust is important for retaining soil moisture by impeding evaporation. It contributes to soil fertility and provides microsites for establishment of native plant seedlings. In her study of scabland habitat of Henderson's ricegrass, Binney (1997) found greater diversity in the vegetation on scablands with an intact cryptogamic crust than where the crust was disturbed. Continued livestock grazing and the impact of recreational vehicles prevent recovery of cryptogam crusts destroyed by past excessive grazing.

The cryptogam crust also protects the soil surface from erosion by wind and water. Fred Hall told Jim David that a particular black lichen (shown in the photo) requires at least 50 years to cover the bare surface of a rock. The area of bare rock between the lichen and the soil surface indicates either erosion or frost heaving. It is like a high-water mark on rocks along a river or lake. The bare space below the lichen may indicate one to two inches of soil lost at the rhyolitic tuff site where the rock was photographed.

The lower edge of the black lichen indicates the level of the soil surface (prior to erosion); the pale area was previously covered by soil. Photo by Robert Korfhage.

Invasive annual grasses

Invasive annual grasses, particularly ventenata (*Ventenata dubia*), have been implicated in the decline of Henderson's ricegrass on the Ochoco National Forest (Dewey 2013). Hall noted that the annual bromes and ventenata were introduced to the Ochocos during the period of habitat degradation a 100 to 150 years ago. In 50 years of observing eastern Oregon rangeland, Hall saw weedy annual grass populations gradually decline during decades of improved management of the cattle and sheep. He also watched annual plant populations expand and contract with changes in precipitation (drought or above normal), soil disturbance, increased or decreased competition from perennial native species, and fire cycles. On seasonally saturated (clay influenced) soils, ventenata and medusahead (*Taeniatherum caput-medusae*) are more competitive than annual bromes. Two sources indicate the presence of ventenata since the 1950s and 60s. When Hall worked on the Ochoco National Forest in the mid to late 1950s, he regularly flew his plane to the old airstrip at Cinnabar Flat on the Paulina Ranger District. At that time, he recorded the presence of ventenata on the scabland around the airstrip. He believed that at some locations ventenata was probably misidentified as *Deschampsia danthonioides*, a native annual of seasonally saturated soils. His observation is supported by aerial photos from the 1960s in which Jim David saw areas of dense fine-textured light-colored annual grass with the appearance of ventenata. Both ventenata and medusahead have been increasing on scabland sites in recent decades (Dewey 2013).

Why are we sharing our observations?

Henderson's ricegrass appears to be retreating to extremely rocky refuges in the Ochoco scablands. Time may be running out for Henderson's ricegrass in Oregon, so we hope to inspire research that focuses on specific habitat requirements of both Henderson's and Wallowa ricegrass. Investigations might test our interpretations of site characteristics (rocks, frost heaving, underground herbivory) in relation to the population dynamics of the species, leading to recommendations for better management of the habitat and conservation of the species.

In support of our suggestion that scientists choose the ricegrasses for a research subject, Jack Maze offers some time-tested advice that worked well for him: choose a plant that grows in a place that's beautiful. These two ricegrasses meet that criterion exceptionally well. He reminiscences about sitting in the open area below Skookum Rock or on the ridge above Boner Gulch, just looking and enjoying. He captured the experience in this Haiku:

And to distant mountains
forests and grassland—
comfort and freedom.

Wallowa ricegrass (*Eriocoma wallowaensis*). Photo by Robert Korfhage.

Overview of scablands along the North Fork of the Crooked River, Ochoco National Forest. Photo by Robert Korfhage.

The Naming of Henderson's Ricegrass and Wallowa Ricegrass

Oryzopsis hendersóni was named by George Vasey (1822-1893), curator of the US National Herbarium, for Louis Henderson, who collected it on dry, rocky ground 14 June 1892 near the summit of Mount Clements [Cleman Mountain, northwest of Naches, Washington] (Vasey 1893, Hitchcock 1971). Marcus E. Jones (1912) reduced it to a variety of *O. exigua*, but Mary Barkworth (1993) reinstated it as a species with the name *Achnatherum hendersonii* 100 years after Vasey first described it. It now bears the name *Eriocoma hendersonii*, having been moved to the "new" genus along with the other species previously called *Achnatherum* (Peterson *et al.* 2019).

In 1960-61 Jack Maze was a graduate student in the Department of Botany at the University of Washington, where he started to work on grasses that were then called *Stipa.* He did several different types of studies over the next 35 years or so, but the ones that are especially memorable involve Oregon. It started with Henderson's ricegrass, an endemic with a restricted distribution on scablands in central Oregon and the east slope of the Cascades in Washington. From 1990-93 he and Kathleen (Kali) Robson were doing research with the short-lived Rare Plant Consortium at the Forestry Sciences Lab in Wenatchee, Washington. One plant of interest was Henderson's ricegrass, which was on the "Watch List" because of its restricted distribution.

In addition to the sites in Washington, much of Jack's and Kali's research was done in two National Forests in Oregon: the Ochoco and Wallowa-Whitman. On one collecting trip, Wallowa-Whitman Forest north zone botanist Marty Stein took them to some of their Henderson's ricegrass sites. They noticed the plants were a bit different from the Henderson's ricegrass plants in other places. Their inflorescences were laxer and more open, the panicle branches drooping. It looked to all of them like it might be a new species, so they asked Marty if he wanted to describe it and offered to help. He declined, so Jack and Kali published it as a new species, *Achnatherum wallowaensis* (Maze and Robson 1996). They collected the type specimen near Boner Gulch on the Wallowa-Whitman National Forest, and paratypes from other locations on that Forest and from the Ochoco National Forest. The name has since been changed to *Eriocoma wallowaensis* (Maze and Robson) Romansch (Peterson *et al.* 2019).

Type specimen of *Eriocoma hendersonii* collected by L.F. Henderson. Image courtesy of the US National Herbarium, Smithsonian Institution.

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In her "Adopt-a-Scab" project, Jill Welborn, former botanist on the Paulina Ranger District, introduced the scablands to Cindy, leading to a fascination with the elusive ricegrasses and ultimately this article. Bob Korfhage gamely participated in many camping adventures to the Ochoco Mountains and photographed plants and habitats. Sue Vrilakas (ORBIC) and Sarah Canby (Prineville District BLM) assisted with locations. Elizabeth Binney, Paula Brooks, Jill Welborn, and Sue Vrilakas reviewed the manuscript. Cindy credits her long-time friend Tom Brannon, who succinctly summed up Henderson's ricegrass habitat on the Colockum (northcentral Washington) with just four words: "more rocks than soil." Kareen Sturgeon provided editorial advice on numerous draft versions. We dedicate the article to Marty Stein (1955-2022), who died on May 3.

References

Barkworth ME. 1993. *Achnatherum hendersonii* (Vasey) Barkworth. Phytologia 74(1):7.

Barkworth ME, Capels KM, Long S, Anderton LK, Piep MB. 2007. Stipeae. *Flora of North America Vol. 24*. Oxford University Press, New York. pp. 109-186.

Binney EP. 1997. Comparative analysis of community and population levels of organization in the rare grass *Achnatherum hendersonii*. PhD Thesis, University of British Columbia, Vancouver, Canada.

Cox GW. 1989. Early summer diet and food preferences of northern pocket gophers in north central Oregon. Northwest Science 63(3):77-82.

Cox GW, Allen DW. 1987. Sorted stone nets and circles of the Columbia Plateau: a hypothesis. Northwest Science 61:179-185.

Cox TR. 2019. *The Other Oregon. People, Environment, and History East of the Cascades*. OSU Press, Corvallis. 398 pp.

David J. 2013. Henderson's ricegrass (*Achnatherum hendersonii*) – Soil & Site Relationships. Unpublished report, Ochoco National Forest, Prineville, Oregon.

Dewey R. 2013. Conservation Assessment for Henderson's Needlegrass (*Achnatherum hendersonii*) and Wallowa Needlegrass (*Achnatherum wallowaense*). USDA Forest Service Region 6 and USDI BLM, Oregon and Washington. (https://www.fs.fed.us/r6/sfpnw/issssp/documents2/ca-va-achnatherum-species-2013-04.docx)

Farris K. 2013. Long Term Monitoring and Habitat Assessment of Henderson's and Wallowa Needlegrass Populations, Final ISSSSP Report ACHE10, Region 6 Forest Service, Pacific Northwest Region.

Fryxell R. 1965. Mazama and Glacier Peak volcanic ash layers: relative ages. Science 147(3663):1288-1290.

Hitchcock AS. 1971. *Manual of the Grasses of the United States*. 2nd Ed. (rev. by Agnes Chase). Dover Publications, New York. Vol. 1, p. 438.

Huntly N, Inouye R. 1988. Pocket gophers in ecosystems: patterns and mechanisms. BioScience 38(11):786-793.

Johnson CG, Clausnitzer RR. 1992. Plant Associations of the Blue and Ochoco Mountains. USDA Forest Service Pub. R6-ERW-TP-036-92. p. 2.

Jones ME. 1912. *Oryzopsis exigua* var. *Hendersoni*. Contrib. West. Bot. 14:11.

Maze J. 1981. A preliminary study on the root of *Oryzopsis hendersonii* (Gramineae). Syesis 14: 151-154.

Maze J, Robson KA. 1996. A new species of *Achnatherum* (*Oryzopsis*) from Oregon. Madroño 43:393-403.

Nuttall T. 1818. *Eriocoma cuspidata* Nutt. Genera of North American Plants. 1:40-41.

Paulson DJ. 1977. Ochoco National Forest Soil Resource Inventory. USDA Forest Service, Pacific Northwest Region. 291 pp. plus 56 mapping sheets.

Peterson PM, Romaschenko K, Soreng RJ, Reyna JV. 2019. A key to the North American genera of Stipeae (Poaceae, Pooideae) with descriptions and taxonomic names for species of *Eriocoma*, *Neotrinia*, *Oloptum*, and five new genera: *Barkworthia*, ×*Eriosella*, *Pseudoeriocoma*, *Ptilagrostiella*, and *Thorneochloa*. PhytoKeys 126:89-125.

Poesen J, Lavee H. 1994. Rock fragments in top soils: significance and processes. Catena 23:1-28.

Rydberg PA. 1912. *Eriocoma hymenoides* (R. & S.) Rydb. comb. nov. Bull. Torrey Bot. Club 39:102.

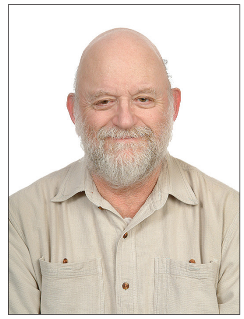
Vasey G. 1893. *Oryzopsis hendersoni* Vasey. Contr. U.S. Natl. Herb. 1:267

Vrilakas S. 1990. Draft species management guide for *Oryzopsis hendersonii*. Part of the challenge cost share program with Wallowa-Whitman NF, Oregon Dept. of Agriculture, and Oregon Natural Heritage Program. Document on file at ONHP and ODA.

Winward A, Youtie B. 1976. Ecological inventory of the Lawrence Memorial Grassland Preserve. Unpublished document on file at the Nature Conservancy, Portland, Oregon.

Cindy Roché joined the Native Plant Society of Oregon in 1998 when she moved to Oregon from Washington state, where she earned BS and MS degrees from Washington State University and a PhD at the University of Idaho. Her interest in grasses dates back to the late 1970s working as a range conservationist with the Forest Service. She illustrated grasses for volumes 24 and 25 of the *Flora of North America*, published in 2003 and 2007. More recently, she collaborated with the Carex Working Group and Robert Korfhage to publish a *Field Guide to Grasses of Oregon and Washington*, published in 2019 by OSU Press. She started teaching grass identification at the Siskiyou Field Institute in 2005 and continues to offer intensive field workshops on grass identification. She and her husband enjoy exploring Oregon and Washington in search of rare grasses and other adventures.

Jim David was born in John Day, Oregon, and raised in the Klamath Mountains of California. He earned a BS in Range and Wildland Science and a MS in Range Ecology at the University of California, Davis. He has worked as a soil scientist with the BLM in Nevada with specific experience in soil/vegetation mapping, hydrology and range condition mapping which included evaluating the effects of cattle, sheep, and wild horses on rangelands. For over 30 years he has been working on the Ochoco National Forest and Crooked River National Grassland as the Forest Soil Scientist, which has included mapping soils and vegetation relationships for use and management interpretations.



Jack Maze was born in San Jose and raised in Hollister, California, birthplace of the American biker. He has a BA in Biology from Humboldt State University (College when he was there), an MS in Botany from the University of Washington with CL Hitchcock as his thesis supervisor, and a PhD in Botany from the University of California, Davis. He has done research in taxonomic revision in grasses, distributional changes during the Pleistocene, population differentiation in *Abies,* plant development, plant morphology, the expression of increasing complexity that accompanies development and evolution and the relationship between ontogeny and phylogeny. He is a Professor Emeritus of Botany at the University of British Columbia and resides in Vancouver, British Columbia.