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WASHINGTON NATIVE PLANT SOCIETY

To promote the appreciation and
conservation of Washington's native plants
and their habitats through study, education,
and advocacy.



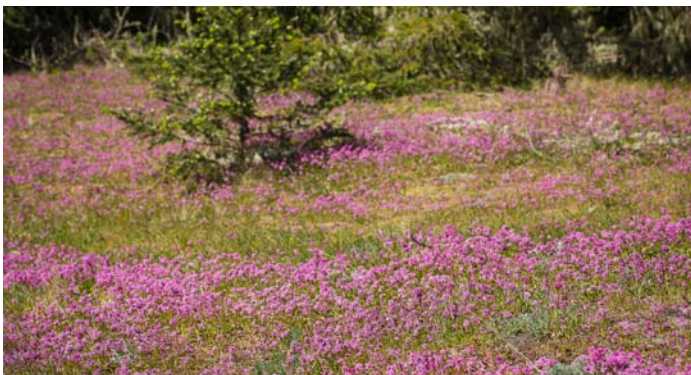
Editorial Notes

by Jim Kling, Editorial Committee Chair

Spring is here, and this issue of *Douglasia* celebrates the changing season and the 50th anniversary of the Washington Native Plant Society with an overview of the society's conservation efforts, by Erik Erstgaard. Erik documented our many achievements and reached out to grant recipients, who shared stories about how WNPS funds made their work possible. Stay tuned in the coming issues for reports 50th anniversary reports on research and education.

Research is well represented, with a report of an investigation into unexplained mortality among sword ferns at Seattle's Seward Park, as well as in-depth conservation assessments of old-growth specklebelly lichen (*Pseudocyphellaria rainierensis*) and the Washington State endemic Jacob's ladder (*Polemonium pectinatum*), which will help guide efforts to protect these important species.

This issue also has the epilogue of Ed Alverson's outstanding series of articles documenting the life of David Douglas, and the Washington Bee Atlas informs us how native plant enthusiasts can use iNaturalist to contribute to pollinator research.



Rosy plectritis (*Plectritis congesta*) at Deception Pass State Park. PHOTO: MARK TURNER

Information for Contributors

Members and others are invited to submit material for publication in *Douglasia*. We now accept scientific manuscript submissions that will be peer-reviewed. Other articles, book reviews, poetry, photography, or illustrations are welcome. All materials submitted should relate to the study of Washington's native plants. Acceptance will be based on space and appropriateness, and materials are subject to copyediting (substantive editing with author's permission). Contributors are reminded that the *Douglasia* audience ranges from the professional botanist to the interested enthusiast. For more information about how to contribute, see: wnps.org/douglasia/contribution.

Email submissions to Douglasia@wnps.org.

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* The WNPS Arthur R. Kruckeberg Fellow is the highest honor given to a member by our society. This title is given to those who have made outstanding contributions to the understanding and/or preservation of Washington's flora, or to the success of WNPS.

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On the cover: Pacific dogwood (*Cornus nuttallii*). PHOTO: MARK TURNER

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President's Message: The View from Here

by Casey Leigh

Dear WNPS Members,

I am honored to be your new President and thank the Board for their confidence in me. I joined WNPS shortly after moving to Wenatchee from Hawai'i in 2014. As a retired environmental law professor with a passion for native plants, I knew I needed to get to know the new ecosystem I found myself in. I started by getting my Master Gardener Certification during the winter. Fortunately, WNPS member Susan Ballinger was offering her naturalist course at Wenatchee Valley College that spring.



Through that course I learned about WNPS and, encouraged by Susan, joined the Wenatchee Valley Chapter. I became active in chapter activities, was elected to the chapter board, joined the State Board's Conservation Committee, and eventually was elected to the state board. By taking advantage of WNPS field trips, Study Weekends, and excellent educational programs, my appreciation for and knowledge of Washington's native plants has grown.

Through my involvement as a volunteer with WNPS I learned the significant role the organization has played in education, research, and advocacy for native plants in Washington and beyond. I am thrilled to be able to now use my talents to lead WNPS as it begins its 51st year of fighting for native plants and their habitats.

As past president Gail Sklar alluded to in her last message, 2026 will be an exciting time for WNPS. With our strategic plan in place and an implementation committee developing tools for the board to use to bring the plan to life, we are prepared for the second 50 years of WNPS' fulfillment of its mission: To promote the appreciation and conservation of Washington's native plants and their habitats through study, education, and advocacy.

WNPS will be celebrating our 50th Anniversary with activities throughout the year, in addition to our recurring excellent programs and field trips. Join us for Botany Washington being held at Camp Delaney Environmental Learning Center in Coulee City from May 1–3 and Study Weekend from May 29–31, hosted by the Wenatchee Valley Chapter.

Check out the WNPS website for ways to get involved as a volunteer and to see a calendar of activities. If you aren't familiar with who is leading your chapter, the administration page lists the officers of each chapter, with an email address to get in touch. If you would like to know more about the state board and opportunities to volunteer with the board, send me an email at President.Leigh@wnps.org.

Best wishes to all in the new year.



Botany Washington: Spring in the Columbia River Basin

This year's Botany Washington will be held May 1–3 at the Delaney Environmental Learning Center in Sun Lakes State Park in central Washington. This area is renowned for its sheer physical beauty, high diversity of vascular plant species, rich variety of plant communities, and remarkable geologic history associated with the Ice Age Floods. In addition to two full days of field trips and workshops, there will be two evening presentations: "Conserving Rare Plants of Eastern and Central Washington" by Tara Callaway, U.S. Fish and Wildlife Service, and "Endemic Plants of the Columbia River Basin" by David Giblin, University of Washington Herbarium, Burke Museum.

Botany Washington is co-sponsored by the Washington Native Plant Society and the University of Washington Herbarium at the Burke Museum. Our goal is to provide an outstanding learning opportunities for participants of all botanical skill levels. To learn more about the event and registration instructions please visit the event website (<https://www.wnps.org/wnps-annual-events/botany-wa>).



Sun Lakes. PHOTO: COURTESY WASHINGTON STATE PARKS



Pacific Flowering Dogwood (*Cornus nuttallii*)

by Katherine Darrow

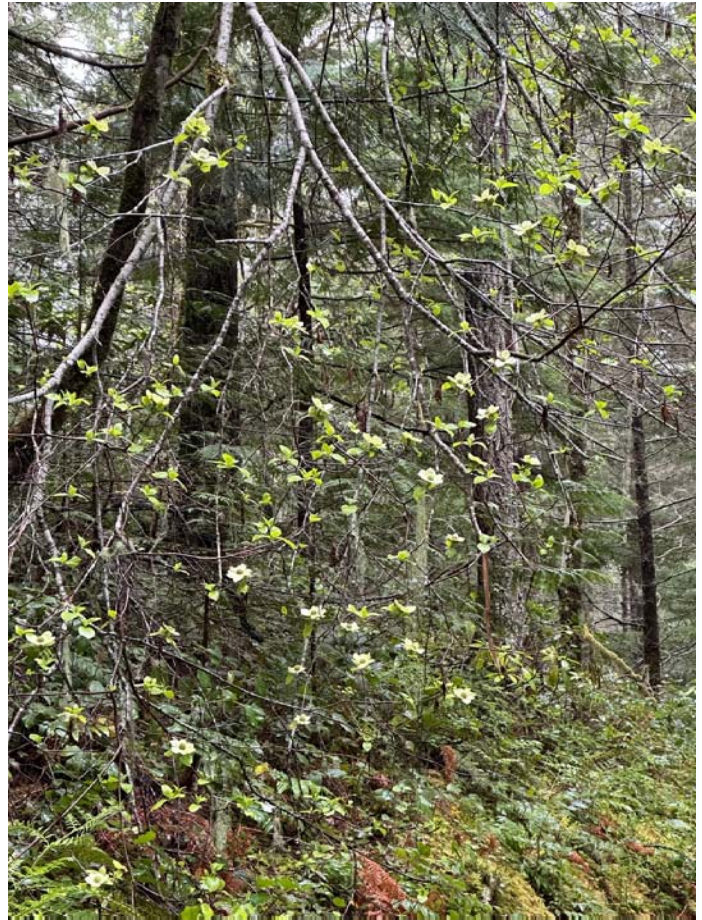
Near the end of April last year, while hiking up the steep trail on Mount Walker in east Jefferson County, I came face to face with Pacific dogwood (*Cornus nuttallii*) in bloom. A young tree had fallen across the trail in a recent windstorm, so we had to push the slender branches aside to move past it. Looking up, we noticed several other dogwoods on the slope above us, with hundreds of white-bracted flower clusters scattered on thin branches, glowing in the sun light like tiny lanterns. This was significant, because I had hiked that trail at least 150 times at that point, about once a week over three years, and had never noticed this species there before. How could this be, that I had not seen what turned out to be a small grove of at least six dogwood trees right next to the trail? What else was I missing?



Pacific dogwood (*Cornus nuttallii*) at Mt. Walker. PHOTO: KATHERINE DARROW

As naturalists, we are curious and attentive, eager to learn more about the tremendous diversity of life around us. Even though some of my earliest memories are of walking among flowering dogwoods in forests near my childhood home near Bellevue, WA, I realized I didn't know much about them. They are pretty, yes, and that seems to be the most notable feature in many chronicles of *C. nuttallii*: "...the most beautiful flowering tree in Northwest forests," according to Arno and Hammerly (2020); dubbed "the queen of our native hardwoods" in Kruckeberg and Chalker-Scott (2019); "magnificent" according to Thomas Nuttall, who collected a specimen at Fort Vancouver, WA in 1834.

Descriptions and photos of our various native dogwoods are abundant in field guides and other resources, but the trees themselves are relatively uncommon. This is partly because so much of the forest that they originally thrived in has been converted to urban and agricultural development or has been



Pacific dogwood (*Cornus nuttallii*). PHOTO: KATHERINE DARROW

repeatedly harvested and cultivated for lumber. If you are lucky to have wild dogwoods in a forest near you, take time to admire and appreciate them.

There is more to the dogwoods than their beauty, however. Here are some interesting tidbits I learned while poring through the literature on this and related species:

- The common name for the dogwood family, *Cornaceae*, and the genus *Cornus* in particular, has nothing to do with canines, but is derived from the Old English word "dagge," meaning "sharp-pointed instrument" or "dagger." In European lore, related species have supplied strong wood for use as skewers, knitting needles, toothpicks, spears, javelins, nails, and other pointy tools for millennia, as well as less pointy things such as printing blocks, cog wheels, piano keys, spindles, and shuttles for weaving looms.
- According to Zomlefer (1994), you can verify the identity of a dogwood leaf by using the "*Cornus* test:" "if the leaf blade is carefully torn in two, the main veins remain connected by delicate threads, the unraveled spiral thickenings in the vessel elements." (This should work for any of the approximately 65 species of *Cornus* worldwide, including the five species native to Washington.)
- The Cornelian cherry (*C. mas*), native to Eurasia, has a bright red edible fruit about the size and shape of an olive that is used to make preserves, syrup, vodka, and wine, the latter known as *vin de cornouilles* in France.



"Cornus test" with Pacific dogwood (*Cornus nuttallii*). PHOTO: GABRIEL CAMPBELL

- Despite the edibility of closely related European species, fruits of Pacific dogwood were not regarded as choice edibles by indigenous people of the region. However, the bitter fruit and bark have been employed as medicines having emetic and laxative effects.
- If you're a fan of floral essences, water infused with flowers of *C. nuttallii* could be helpful for healing emotional or physical trauma. According to McIntyre (1996), an essence of Pacific flowering dogwood, "helps to restore grace and harmony in the body and warmth and softness to the emotions despite living in adversity."
- John James Audubon illustrated Pacific flowering dogwood in his painting of the band-tailed pigeon, which is known to feast on the fleshy fruits, and thereby helps to disperse the seeds that pass through their gut. Many other birds and mammals also eat the fruit, including pileated woodpeckers and black bears.
- *Cornus nuttallii* was declared the Provincial Floral Emblem of British Columbia (BC) in 1956, where it is common in southwestern coastal forests and on Vancouver Island.
- More than two decades before becoming BC's floral emblem, the Dogwood Protection Act was passed in 1931 by

the BC legislature and later expanded to include protection for Pacific rhododendrons (*Rhododendron macrophyllum*) and trilliums (*Trillium ovatum*), exacting penalties of \$25 to anyone who was caught injuring or destroying any of these species. The Act was repealed in 2002, with no records of having ever being enforced.

- In 2012, a century after Japan gifted the United States with 3,000 cherry trees that famously grace the nation's capital, the United States made a similar offering to Japan in a gesture dubbed "dogwood diplomacy." Three thousand eastern American dogwoods (*C. florida*) were planted in Tokyo and throughout Japan as a symbol of renewed friendship between the two countries.
- In urban and suburban areas of the Pacific Northwest, planted dogwoods are most likely a hybrid cultivar of eastern dogwood (*C. florida*) and Pacific dogwood, or a variety of Asian dogwood (*C. kousa*). Our native species are more difficult to propagate and are susceptible to non-native fungal diseases inadvertently introduced from Asia in the 1970s.
- Peak flowering for Pacific dogwoods is from mid-April to early June in our mixed coniferous forests west of the Cascades, and in early autumn when similar light, temperature, and moisture conditions trigger a second bloom. Be on the lookout not only for the showy bracts and clusters of flowers, but the bright red fruits and colorful autumn leaves of these iconic northwest trees.



Pacific dogwood (*Cornus nuttallii*) with Band-tailed pigeon. J.J. Audubon (illustrator), R. Havell (engraver, printer). Engraving. 1837. PHOTO: COURTESY OF AUDUBON.ORG

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A Conservation Assessment of the Globally Rare Washington Endemic Species, Washington Jacob's-ladder

by Mark Darrach and Katy Beck

Introduction

We received a plant conservation research grant from the WNPS to support us in conducting a conservation assessment of the Washington endemic plant Washington Jacob's-ladder (*Polemonium pectinatum*) (Fig. 1). In addition to assessing population numbers and habitat quality, we investigated other aspects of Washington Jacob's-ladder's natural history, including pollination and reproductive ecology, life history, seed set, associated plant species and threats to populations and associated habitats. Our overarching goal was to explore the likely long-term viability of existing occurrences and the species as a whole.

survey efforts on EOs that: Have larger populations and/or higher ecological habitat quality; are largely on publicly owned lands; have had longer periods between documented surveys; and represent the ecological breadth of habitat types occupied by the species.

We did not focus on surveying EOs restricted to private land holdings, although a few were visited. We also largely excluded EOs that were assessed as being in poor or fair condition as of their last field visit. Thus, the 10 EOs we ultimately chose to evaluate were deemed to have the largest populations with possibly the best prospects for long-term viability.

Washington Jacob's-ladder is a large, attractive, deeply tap-rooted, tufted, perennial species in the phlox family (*Polemoniaceae*). It blooms from May to as late as early July in some high-precipitation years. Washington Jacob's-ladder plants range from 30 cm to 100 cm in height and can reach 150 cm or more in breadth in robust specimens. The number of flowering stems on adult plants ranges from 1 to 150 or more on mature specimens. Flowers are pale lavender to purple (rarely white), rotate, 5-petaled, and with exserted to weakly included anthers. The flowers are arranged in sparse, open, glandular-hairy cymose



Fig. 1. Washington Jacob's-ladder plants and flood plain habitat at Coal Creek. PHOTO: MARK DARRACH

Background

Washington Jacob's-ladder is a Washington Threatened, Bureau of Land Management Sensitive, narrowly endemic species restricted to four counties in eastern Washington. The range of the species spans a polygon approximately 180 km east-west by 80 km north-south (WNHP 2025). There are 36 element occurrences of Washington Jacob's-ladder in the Washington Natural Heritage Program (WNHP) database that are likely still extant (WNHP 2025). An element occurrence (EO) is a biologically and spatially defined population where a species is, or was formerly, present. Of these 36 EOs, we focused our

inflorescences. Fruits are dry capsules, have 3 locules, and are many-seeded. The species shares the trait of numerous other species in the genus in having a distinctly 'skunky' odor to the herbage, while the nectar has a pleasant smell. The species is noteworthy both as a genetic entity unknown to hybridize with other taxa within the genus, and for the unusually large size of the mature plants.

Many botanists have contributed significantly to the knowledge and understanding of this species, including Cynthia Gilbert (1998), who conducted her Ph.D. dissertation on the species at the University of Washington, Rex Crawford and Joe

Rocchio (2012), and numerous other WNHP botanists and surveyors.

Habitat

Washington Jacob's-ladder is confined to the cold desert landscape east of the Washington Cascade Mountains where precipitation averages about 26.5 cm per year across the range of the species. The elevation of the documented EOs range from 165 m to 700 m (WNHP 2025). Its habitat is restricted to seasonally or occasionally perennially moist settings in a variety of habitats. These include: 1) perennial and ephemeral streams and their flood plains, 2) flood plains adjacent to artificially altered, down-cut streambanks, 3) precipitation-fed topographic swales (Fig. 2), and to a lesser degree, 4) spring-fed localities, and 5) bases of talus slopes along coulee walls. The plants grow on soils of mixed volcanic ash, alluvium, colluvium and loess-based substrates (Fertig 2020; Gamon and Baxter 1995).



Fig. 2. Moist swale habitat with dense vegetation eliminating bare soil substrate and preventing Washington Jacob's-ladder recruitment. PHOTO: MARK DARRACH

Vegetation Communities and Plant Species Associates

Washington Jacob's-ladder is found in several vegetation communities, (Gilbert 1998; Rocchio and Crawford 2015), including:

- Great Basin wildrye (*Leymus cinereus*) alkaline wet meadow
- Threetip sagebrush (*Artemisia tripartita* ssp. *tripartita*) / Idaho fescue (*Festuca idahoensis*) shrub grassland
- Big sagebrush (*Artemisia tridentata* ssp. *tridentata*) / Great Basin wildrye shrubland

Commonly observed vascular plant associates include: yarrow (*Achillea millefolium*), western serviceberry (*Amelanchier alnifolia*), prairie sage (*Artemisia ludoviciana*), cheatgrass (*Bromus tectorum*), Wood's rose (*Rosa woodsii*) and tall butterweed (*Senecio serra*). We observed a total of 143 vascular plant species and infrataxa growing in conjunction with Washington Jacob's-ladder at the 10 EOs we assessed.

Allelopathy

Allelopathy is the chemical inhibition of one plant by another due to the release into the environment of substances that act as germination or growth inhibitors. An interesting feature of some areas within several of the ecologically higher quality

Washington Jacob's-ladder EOs is an unusually high density of plants, to the nearly complete exclusion of other, even weedy, species (Fig. 3). As mentioned above, the sticky glandular hairs present on the inflorescences have a distinct skunky odor. A study conducted by Dorsett and Pike (1995) analyzed secondary chemical compounds in another Jacob's-ladder species and found that its resinous glandular hairs produced the chemicals α -pinene and β -pinene, amongst other terpenoid compounds.

They surmised that the pronounced skunky odor of the hairs is produced by a thiol (mercaptan). Both terpenes (including α -pinene) and thiols have well-documented allelopathic properties in other unrelated taxa (Abraham et al. 2000; Singh et al. 2006). Based on research into allelopathic effects of thiols and terpenes and our field observa-

tions, it seems very likely that in some of the EOs Washington Jacob's-ladder plants exude sufficient inhibitory compounds that other species, even noxious weeds, have difficulty establishing and competing.



Fig. 3. Large, recently colonized area of Washington Jacob's-ladder plants on Lind Coulee floodplain. PHOTO: MARK DARRACH

Mating System

The genus *Polemonium* has a diverse range of mating strategies (Grant and Grant 1965; Hill et al. 2008), with both self-compatibility (self-fertile) and obligate outcrossing (requires another plant to reproduce) well documented (Galen 1985; Gilbert 1998). The mating system of Washington Jacob's-ladder has not been studied. Limited observations in the field suggest that, like other taxa in the genus (Zych et al. 2013), the anthers of Washington Jacob's-ladder flowers release pollen prior to stigma receptivity (protandry), thus promoting a pollinator-mediated cross-fertilization mating strategy.

Plant longevity

There is no documented information about the longevity of Washington Jacob's-ladder, as individual plants have not been tracked for mortality. However, one interesting field-based observation does provide a clue regarding the possible lifespan of individuals.

In 1925, a large flood event on Crab Creek washed out a section of railroad tracks. To reduce the possibility of railroad infrastructure damage in the future, Crab Creek was subsequently artificially straightened and channelized. The stream straightening resulted in rapid erosion and downcutting of the creek bed with subsequent decoupling between the stream and its floodplain. This in turn resulted in the *Polemonium* plants growing on the decoupled floodplain becoming separated from their normal habitat on slopes above and separated from the active channel and nascently-developing new floodplain. Currently, this portion of the EO consists of many large, mature plants, but no seedlings or plants in smaller size classes, suggesting a long-term lack of recruitment. The plants at this site are all likely quite old and may possibly date back nearly a century to when the stream reach was mechanically altered. Without recruitment, this EO will likely eventually be extirpated.

Pollinator Study

A pollinator study performed by Washington State University master's student Aidan Hersh was conducted on May 20 and 21, 2025 at four of the Washington Jacob's-ladder EOs. Insects observed visiting Washington Jacob's-ladder flowers were collected when possible, while others were photographed. A total of 121 insect individuals were collected. Included were representatives of four bee families, of which there were nine genera representing 24 species.

The majority of bee individuals observed on and collected from flowers were members of the genus *Andrena*, with one, as yet unidentified, species noted as being particularly common (Fig. 4). Of the 121 insects collected, 46 were this *Andrena* species. Other insects included two fly families, ants, a snakefly,



Fig. 4. Female *Andrena* sp. on Washington Jacob's-ladder flower with anthers producing pollen. PHOTO: AIDAN HERSH

a beetle, and a moth. Neither pollen nor pollinator visitation appear to be limiting factors at the four EOs we assessed. The diversity of insect families and species observed visiting the flowers suggest that the species is not overly dependent upon a single insect species to provide pollination services, although pollinator efficiency is likely strongly skewed toward bee taxa. Its round flowers with easy access to pollen and nectar rewards make Washington Jacob's-ladder flowers attractive to a diverse array of insects.

Germination Substrate

Observations made at each of the 10 EOs we surveyed conclusively indicate that bare soil is the substrate most conducive to seed germination. Several of the populations we visited had few to no seedlings or plants in smaller size classes. These areas nearly exclusively tended to have dense vegetation, whether it was non-native weed or native vegetation cover. Sometimes seedlings were noted in isolated areas of bare soil within EOs that otherwise displayed essentially no recruitment. Thus, fresh sediment delivered from flooding events or bare soil areas created via other mechanisms (e.g. Great Basin pocket mouse push-piles) are necessary for the germination and successful recruitment of new plants and ultimately the long-term survival of individual populations and, indeed, the species as a whole (Fig. 5).



Fig. 5. Cluster of Washington Jacob's-ladder seedlings on bare soil in Lind Coulee. PHOTO: MARK DARRACH

Seed Production, Germination and Propagation

A limited study of Washington Jacob's-ladder seed production was conducted as part of this project. In our small sample, the number of mature seeds produced per capsule averaged between 8 and 10. Assuming averages of 9 seeds per fruit, 10 fruits per inflorescence, and 100 inflorescences on larger plants means that larger plants could potentially average 9,000 seeds per flowering season. This suggests that seed production, at least during 2025, is unlikely to be a limiting factor. Washington Rare Care director Wendy Gible has also observed that seed production in the species is typically prolific, seed germination rates are high, and no stratification or scarification is required (Gible pers. comm. 2025). No seed predation evidence

was noted while we were evaluating fruits under the microscope, nor in the field (e.g. insect entrance holes in capsules).

Seed dispersal and recruitment

While gravity and wind are contributing agents of seed dispersal for the species, field work made it clear that hydrologic transport is an important, and almost certainly the most significant, dispersal vector (Fig. 3). This is particularly apparent at a large EO in Lind Coulee in Adams County which has a dense monoculture of plants of all different size classes that was not documented when the EO was surveyed last in 1994. At least one fairly recent and significant flash flooding event transported large amounts of silt-sized sediment eroded from nearby plowed agricultural fields to the EO. Numerous, possibly seed-banked, *Polemonium* seed prolifically colonized the new site, creating an as yet unmapped, astonishing display of many thousands of plants on private land holdings (Fig 2).

Habitat Types and Climate Change

Washington Jacob's-ladder EOs are intimately tied to the hydrology of the interior Columbia Basin. These populations grow in several discrete well-defined hydrologic settings:

- Moist, deep-soil swales in shrub-steppe with closed drainage, and in which precipitation as both rainfall and snowfall is seasonally retained in depressions (Fig 2).
- Creek margins and associated peripheral flood plains that episodically receive silt and sand size sediment loads during floods (Fig 1). This creates suitable bare soil substrates that set the stage for plant germination and establishment. These creeks have not been artificially channelized, down-cut or decoupled from their flood plains.
- Decoupled flood plains near artificially straightened stream reaches in which *Polemonium* plants are stranded in marginal, often weedy habitat above down-cut channels (Fig 6). These areas no longer receive sediment from flood events that would otherwise provide a suitable bare soil habitat for plant recruitment.
- Peripheral to springs and at the base of coulee margin basalt talus slope. These sites are the most poorly characterized of the hydrologic settings in which the species is found.

Hydrologic and Climate Disruption Vulnerabilities

Populations that grow in moist swale depressions (discussed above in #1) are unconnected to any focused inflow or drainage. As such, they are reliant upon accumulated precipitation that gathers in these otherwise arid settings. As the climate becomes progressively more xeric, with precipitation predicted to become considerably less reliable (Washington Department of Fish and Wildlife 2025), Washington Jacob's-ladder EOs in these habitats are projected to lose long-term viability and attenuate into extirpation.

Populations whose persistence is reliant upon the presence of groundwater dependent ecosystem features, such as springs and seeps, are particularly vulnerable. Groundwater extraction

within the geographic footprint of the species greatly exceeds aquifer recharge (Collins et al. 2025). Extensive groundwater extraction for crop irrigation is widespread, particularly in the Odessa, Washington subarea where the large majority of Washington Jacob's-ladder EOs are found. Extraction rates and groundwater level declines are documented to exceed 10 ft/yr in this portion of the Columbia Basin (Collins et al. 2025). EOs dependent upon these hydrologic features can be expected to be extirpated. Indeed, many of them likely already have and have yet to be documented.

Groundwater recession in this portion of the Columbia Basin also has a deleterious impact on the ecology of stream courses that support Washington Jacob's-ladder EOs. These include the critically important Coal Creek, Crab Creek and Wilson Creek watersheds. Groundwater contributions to the base flow of these streams is currently unconstrained and is likely greatly attenuated, if not already fully lost. Thus, they are likely nearly completely dependent on precipitation runoff and any immediate near-surface storage (e.g. excess irrigation runoff and attendant soil column storage) unconnected to aquifers.

Threats /Discussion / Conclusions

This field-based study investigated 10 EOs amongst a total of 36 that 'presumably' still exist. These 10 EOs were chosen because we wanted to evaluate not only what, on paper, seemed to be the largest still extant populations that likely had the best prospects for long term viability, but also a breadth of hydrologic and habitat settings. This provided an EO sampling likely to be representative of the full suite of putatively extant EOs. The focus was on publicly-owned lands, but some private land holdings were also evaluated.

A combination of the information gained from our field visits to the various EOs, a careful reading of information about each EOs hydrologic and habitat setting in the WNHP database, and our ArcGIS assessment, leads us to believe that the number of likely long-term viable EOs is between four and, liberally, 12.

The most significant threats to the species are:

Hydrologic instability:

The increasing instability of the hydrologic settings of most of the populations has been made clear by our field efforts.

Lack of Recruitment Substrate:

The absence of a significant component of bare soil near or within the EOs that is necessary for adequate recruitment.

Habitat degradation:

Many of the EOs are quite weedy with significant infestations of listed noxious weeds and other aggressive invasive taxa. Common weed species include: Russian knapweed (*Rhaphanistrum repens*), Canada thistle (*Cirsium arvense*), kochia (*Bassia scoparia*), whitetop (*Lepidium chalepense*), reed canarygrass (*Phalaris arundinacea*), meadow foxtail (*Alopecurus pratensis*), and cheatgrass (*Bromus tectorum*).



Fig. 6. Channelized, down-cut, straightened and decoupled creek drainage section in Lind Coulee. PHOTO: MARK DARRACH

Wildfire:

Fire is considered to be a significant, yet largely unevaluated, risk factor for Washington Jacob's-ladder. We did not observe evidence of past wildfires at any of the 10 EOs we investigated. However, the increasing prevalence of wildfire in the present climate regime is well-documented (Shinneman and McIlroy 2016; Higuera and Abatzoglou 2021). It can be reasonably assumed that at some point, some Washington Jacob's-ladder EOs will be affected. At the very least some populations can be expected to be badly damaged or perhaps extirpated by wildfire as the species has perennating buds that are at or slightly above the ground surface, thus likely leaving them vulnerable to direct fire effects.

Lack of Regulatory Mechanisms:

EOs need robust protections on all public lands. The long timelines between some EO survey visits (some > 30 years), even on public lands, indicates that there is a notable lack of attention to the species even though it has protected status on both state and federal land holdings. EOs also need protection on as many private land holdings as can be managed. As an example of the risks to the species on private land holdings, we surveyed one EO on land owned by the Burlington-Northern Railroad where the last survey was conducted in 1994. We found that the apparent majority of the EO, that previously had a high density of plants, had been bulldozed and has no remaining *Polemonium* plants at all in that portion of the EO.

Cattle Grazing:

While active grazing was noted on only a few of the EOs, and the EO at the BLM-owned Coal Creek ACEC has had a complete cessation of grazing, grazing impacts were observed. One private land holding that previously harbored an EO had clearly been extirpated by grazing activity—likely largely as a result of trampling. Jacob's-ladder plants themselves have not been observed as having been grazed (although a few plants may have been sampled by deer), and it is almost certain they are generally unpalatable.

Pollinator Decline:

Our field observations indicate that there were sufficient numbers of pollinating insects; ground-nesting bees in particular were deemed to be abundant. Seed set information would tend to corroborate this supposition. However, we lack any baseline information regarding pollinating insect abundances prior to major modifications to the encompassing landscape, and before climate degradation became a more salient concern.

Habitat Fragmentation:

The landscape in which the breadth of the 36 EOs are embedded has been intensely modified – particularly by agricultural conversion to hay, alfalfa and grain production (Fig. 7). This fragmentation has resulted in what is likely a nearly complete truncation of gene flow among most populations.

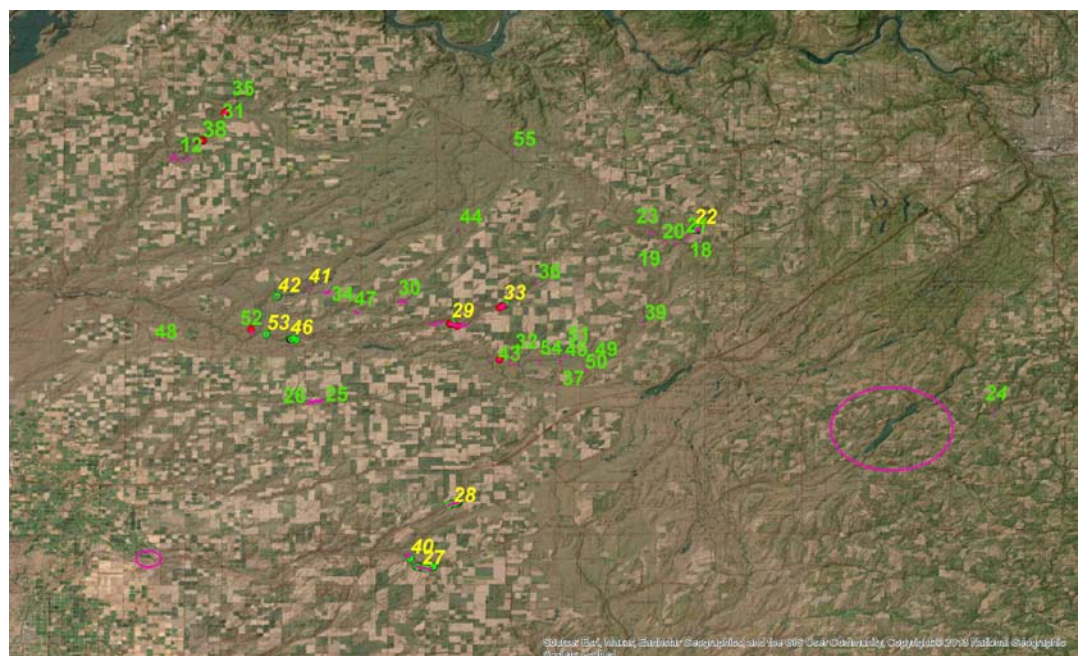


Fig. 7. The suite of *Polemonium pectinatum* EO's displaying the highly fragmented landscape in which the plants are located.

Population genetic analyses by Gilbert (1998) came to this conclusion nearly 30 years ago. It can be reasonably assumed that any gene flow that may have existed at that time has likely attenuated further at present. This can be expected to result in decreased plant fitness – particularly as eternal stressors such as climate change become more pronounced and fewer unique alleles in the genome lead to decreased resiliency.

Conclusions

Recovery of Washington Jacob's-ladder into a long-term viable metapopulation will likely require multiple strategies including additional research and EO surveys to sites not visited during this effort.

Conservation easements at EOs with larger plant numbers on private lands should be sought.

Strategically creating bare substrate areas in densely vegetated EOs with plants skewed toward the larger size classes may be a useful strategy for increasing plant establishment.

Planning for increasingly xeric habitat conditions due to ongoing climate change may necessitate finding new sites with appropriate habitat in which to outplant the species. It seems likely that the species could do well outside the boundaries of its immediate geographic range, because the species is easy to grow, has a well-defined substrate preference and no obvious germination or seed production restrictions at the present time.

Based on our findings, we believe that Washington Jacob's-ladder warrants listing under the federal Endangered Species Act.

Gratitude

The authors would like to thank the Washington Native Plant Society for funding support. We would also like to thank the Spokane District of the Bureau of Land Management and the WNHP for in-kind support. We are especially grateful for the field assistance of Walt Fertig of the Marion Ownbey Herbarium, and Gwendolyn McManus of the Center for Biological Diversity. And, lastly, we are grateful for our collaboration with the excellent, bee-obsessed entomologist Aidan Hersh.

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Research and Plant Inventory Grants: 50 Years of Native Plant Science

by Erik Ertsgaard, Committee Chair

The Research and Plant Inventory Committee is thrilled to celebrate its 50th Anniversary as one of the Washington Native Plant Society's founding committees. The main function of the committee is to award grant funding to member-researchers for projects extending our knowledge of Washington's native plants.

Grant proposals are reviewed on an annual basis by five to seven committee members, whose expertise spans the entirety of the research field, from molecules to ecosystems and from rainforest wetlands to dry shrub-steppe landscapes. Results of each funded research project are shared with WNPS members in return for their donations and dues that make each grant possible. Results are often shared as *Douglasia* articles, webinars, and, historically, *Occasional Papers* (WNPS's typically single-article print publication of the late 1980s to 2006).

Both the committee and the projects it funds have changed continually over these 50 years. Pamela Camp, who served as committee chair from 2003 to 2020, provided steady leadership. She also documented the history of the Research and Inventory Committee in the 40th Anniversary issue of *Douglasia* (Camp 2016), which this article expands upon.

Committee Inception

What is now called the Research and Plant Inventory Committee was formed during the first WNPS meetings. At inception, the committee sported the name, "Conservation/Data Bank Committee," rivaling the wordiness of today's name (Mulligan 1977). The first chair was the late Ron Taylor, Professor of Ecology and Botany at Western Washington University, who was integral to the early success of the WNPS and deeply impactful to research on and education about Washington's native plants.

With a budget of \$1,000, the committee supported inventories, rare plant surveys, and other native plant science, which was largely conducted by universities (often the students of founding members). There are no comprehensive records of how the committee operated at the time, but anecdotal accounts and archived documents indicate funding decisions were more informal and *ad hoc* than they are today.

The outcomes of funded projects were shared in scattered publications in the pre-internet times, especially when *Douglasia* functioned more like a newsletter than a journal. So, it is helpful that Ron Taylor and Richy Harrod compiled an Occasional Paper titled "Vegetation Studies Funded by the Washington Native Plant Society" (Taylor and Harrod 1998), so that member-funded projects would not end up as "Obscure reports in near-forgotten files." Drawing from their efforts, I will share

the first 10 (documented) projects funded by the Research and Plant Inventory Committee:

- 1979 – "A Report on Some Rare, Threatened, Endangered or Endemic Plant Species of the Wenatchee National Forest" by Stewart S. Higgins
- 1979 – "Flora of the Pasayten Wilderness Area in the Vicinity of Harts Pass" by Robin Leshner
- 1979 – "A Rare Plant Survey" [In the North Cascades, Olympic Peninsula, and Columbia River Gorge] by Lisa Standley
- 1979 – "A Reconnaissance of the Vascular Cryptogrammic Plants on the Sulphur Creek Lava Flow, Mount Baker, Washington" by Mark C. Whitmore and Phil Jenkins
- 1980 – "Survey of the Flora in and Around the Trout Lake Area" by Nancy Olmsted Zehr
- 1981 – "Botanical Reconnaissance of the Thunder Creek Study Area, North Cascades National Park, WA" by Kathryn Beck
- 1981 – "Floristic Survey of The North Twin Sister Peak, Whatcom County, Washington" by Rebecca Samson
- 1982 – "In Search of the Elusive *Pellaea glabella*" by Martin E. Hicks
- 1982 – "Pollination Ecology of an Alpine Fell-Field" by David C. Shaw
- 1983 – "Steppe by Step: Understanding Priest Rapids Plants" by Joy D. Mastrogioseppe and Steven J. Gill

Other notable projects partially funded by the committee include: WNPS past-president Clay Antieau's graduate thesis on oceanspray (*Holodiscus discolor*), which began his involvement with the WNPS (Antieau 1985); a centenary survey retracing Louis F. Henderson's 1892 collection trip across Washington, conducted by another past-president, Sarah Gage (Gage and Rodman 2006); a newly described rush species (*Juncus trilocularis*; Zika 2012); and the 2nd Edition of the *Flora of the Pacific Northwest* (Hitchcock and Cronquist 2018).

Project Stories

Because project titles, or even results presented in *Douglasia* articles, fail to tell the full story of Research and Plant Inventory grants, I spoke with three former awardees willing to share their stories from the field. From different corners of Washington, these three represent a diversity of scientific interests in the WNPS. Of course, their examples do not exhaustively represent the scope of research and researchers we fund.

From 2003 to 2006, Dana Visalli completed two WNPS-funded botanical inventories of the Wolf Creek and Roger Lake Research Natural Areas near his home in the Methow Valley, landscapes he had visited often before formally documenting them. After going back to school and learning how to key plants, he started bidding on Forest Service contracts to inventory areas across the region.

Visalli describes learning how to key out plants as “the best thing that ever happened to [him],” and how quickly he fell in love with the “enjoyment, pleasure, and challenge of learning about the natural world.”

This work led to an encounter not many botanists in Washington can say they’ve had. He recalls trying to key out an aster on the banks of Roger Lake, engrossed in Hitchcock (a.k.a. *Flora of the Pacific Northwest*), when a moose emerged from a thicket of lodgepole pines into the opening he was in. Undisturbed by his silent botanizing, the moose went about her business as usual amongst the willows, joining him long enough to have her picture taken and for Visalli to finish identifying the aster.



The moose (*Alces alces*) Dana Visalli encountered in the meadows surrounding Roger Lake, chewing on willow branches and unperturbed by the silent botanist. PHOTO: DANA VISALI

In 2005, Bertie Weddell applied for a Research and Plant Inventory grant to survey remnant Palouse Prairie sites for rare and/or endemic plant species. Weddell, then an instructor at Lewis-Clark State College in Lewiston, ID, recalls that the appeal of the grant lay less in the funding itself than the opportunity to collaborate with David Skinner, a colleague at



The Palouse meadow-steppe as seen from Kamiak Butte—an endangered ecosystem that has been highly modified by agriculture. PHOTO: BERTIE WEDDELL

the nearby USDA-NRCS Plant Materials Center in Pullman, whose passion for the Palouse was infectious.

Dave and Bertie found no signs that the plant communities in their study areas were changing in a predictable way toward a “climax” or stable state. Their work documented the association of rare and/or endemic Palouse prairie forbs with native perennial grasses as well as the ubiquity of alien annual grasses, including ventenata (*Ventenata dubia*), a relative newcomer to the Palouse (Weddell and Skinner 2007). This study stands as a testament to the importance of monitoring changes in the occurrence of species of conservation value in an endangered ecosystem. Weddell remains involved with the WNPS, attending Study Weekends and field trips, and has since shifted her attention toward the intersection of conservation and social justice.

In 2019, Ron Bockelman was awarded funding to track the phenology and early-life history of basalt cactus (*Pediocactus nigrispinus*) in the shrub-steppe of central Washington. A retired Environmental Project Manager, Bockelman was well acquainted with writing and administering these kinds of grants. In retirement, he spent his spring seasons botanizing extensively at the Wild Horse Wind Farm, just northeast of Ellensburg. The Research grant offered him the opportunity to more formally study one of the wind farm’s most charismatic inhabitants, the basalt cactus, particularly following its designation by the Washington Natural Heritage Program as Sensitive in Washington.

Reflecting on the motivation for his proposal, Bockelman said, “you can only spend so much time wandering around and taking pictures...this study provided focus and really jump-started my objective to add to the knowledge of the cactus’s natural history.”

Indeed, the work yielded valuable insights into how the basalt cactus lives, including empirical information on when they flower (typically early May; Bockelman 2021a) and how seeds germinate and cacti develop through early life stages (Bockel-



An action shot of Ron Bockelman measuring the height of a basalt cactus (*Pediocactus nigrispinus*) at the Wild Horse Wind Farm. PHOTO: JENNIFER GALBRAITH

man 2021b). Since those studies, Bockelman has remained steadfast in his research and advocacy for *Pediocactus nigrispinus*, including efforts to designate the species as Washington's State Cactus (S.B. 5325) and continuing to publish regionally in *Douglasia* and nationally in *Cactus and Succulent Journal*.

Trends

The types of research topics funded by the Research and Plant Inventory Committee have evolved in tandem with the native plant scientific community. The first 10 funded projects listed above represent scientific interests very much alive today: plant inventories, rare plants, and unique habitats.

New scientific techniques have added to, rather than replaced, these botanical endeavors, with DNA sequencing, advanced geospatial resources (GPS and GIS), and computing capabilities augmenting the modern array of funded research projects.

Simultaneously, native plant science has grown to include more focus on the relationships of plants. While pressures of invasive species and climate change mount, scientists have conceptualized a broader web of interconnectedness affecting and being affected by native plants. While present from the beginning, projects investigating relationships with plant pollinators, symbiotic fungi, and soil microbes have increased significantly in the last two decades. Recent studies have even flipped the perspective to use plants as indicators of broader processes, such as using mosses to trace ancient glacial refugia (Berkey 2024) or investigating whether the roots of a native pea (*Dalea ornata*) contain novel medical compounds (Belofsky et al. 2025).

Reflections

The Research and Inventory Committee is committed to frequent reflection and improvement on how it is serving the WNPS membership and the diverse community of researchers in the state.

Longtime committee member Peter Dunwiddie recently offered the perspective that “the committee is well-suited to fund fields of study not typically supported by larger funding sources such as federal grants.”

We are proud to support plant inventories, natural history, and many other native plant research topics that may not be *en vogue* with larger funding bodies (although methods must be defensible).

Particularly poignant in current times is the funding cuts to research at the intersection of conservation and social equity and justice, topics that we both welcome and encourage. We also give special consideration to graduate students and to individuals or groups traditionally underrepresented in the botanical sciences, with the goal of helping a new, diverse generation of plant researchers flourish.

Ultimately, the purpose of the Research and Plant Inventory Committee is to support native plant science that interests the WNPS membership. If you have any particular interests,

feedback, or proposals (for review in 2027), you can email the committee at researchinventory@wnps.org.

Acknowledgements

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In addition to serving as chair of the WNPS Research and Plant Inventory Committee, Erik Ertsgaard is a Research Assistant at the University of Washington Herbarium, where he researches the ecology and evolution of alpine plants. Eric can be reached at erik.ertsgaard@gmail.com.



The Missing Half of a Bee Record

Why Washington's Bee Atlas Needs Plant Experts on iNaturalist

by Kyle Roslund

On a warm spring day in Washington, a Washington Bee Atlas (WaBA) volunteer sweeps a net through flowers, carefully transfers a bee into a vial, and records a collection number. It looks like the story is about the bee. But in many ways, the most important part of that moment is the plant. Washington is home to more than 600 species of native bees—excluding honeybees and other managed species. These bees vary widely in size, shape, and color, and many look so different from the familiar honeybee that they are often overlooked or not recognized as bees at all.

What's less visible—but just as critical—is that WaBA is not only documenting bees. It is also documenting bee–plant relationships, and that work depends heavily on the quality of plant identifications in iNaturalist.

Bee Atlas Data Depends on Plants

WaBA is a statewide community science program led by the Washington State Department of Agriculture (WSDA) Pollinator Program. WaBA trains volunteers to collect native bees in a standardized, museum-quality way, with specimens ultimately identified by the Washington State's bee taxonomist, Karen Wright, and permanently archived for research, conservation, and policy use.

When WaBA volunteers collect bees, they also document the host plant the bee was visiting. Those plant observations—photos of flowers, leaves, and whole plants—are uploaded to iNaturalist and added to the Washington Bee Atlas project.

iNaturalist is used to document the *plants*, not the bees. The bees themselves are curated and identified separately through WSDA's taxonomic process. This distinction matters. The value of a bee specimen increases dramatically when it is linked to a confidently identified plant species. That connection allows

researchers and land managers to move beyond “what bees are here?” toward “what plants are actually supporting them?”

Right now, the Washington Bee Atlas iNaturalist project includes 9,544 plant observations. Of those, 4,543 are at Research Grade, or 47.6%. That is a strong start—but it also means that more than half of the host plant records are not yet fully usable for analysis.

This is where plant experts can make an immediate difference.

Why Research Grade Matters

On iNaturalist, a plant observation reaches Research Grade when the community agrees—generally by a two-thirds majority—on an identification at species (or lower) level, and when the observation meets basic data quality standards (date, location, wild organism, and sufficient media).

For the Bee Atlas, Research Grade plant IDs are not about prestige or completeness. They are the bridge that connects a physical bee specimen to ecological meaning. Without a solid plant ID, we lose resolution on questions like:

- Which plants are supporting early-season bees?
- Which native species are disproportionately important to specialist bees?
- How do bee–plant relationships vary across ecoregions?
- Which restoration plantings are most likely to succeed?

The state perspective is direct. As Karen Wright, WSDA's bee taxonomist, puts it: “Much of the Bee Atlas work depends on having research grade IDs in iNaturalist connected to the bee specimens we collect.”

That connection—between plant expertise and pollinator science—is exactly where the Washington Native Plant Society membership excels.

WNPS members are uniquely positioned to help

Many of the plant observations associated with bee collections are not showy or easy. They include graminoids, composites, early-season shrubs, and “green things” that pollinators rely on but that often languish in iNaturalist as *Needs ID*. Genera like *Salix*, the family *Asteraceae*, and subtle native forbs are common sticking points.

For someone with regional plant knowledge, however, these are solvable problems.

A confirming ID, a careful genus placement, or even a comment explaining what diagnostic features are missing can move an observation forward—and when enough knowledgeable identifiers participate, records stabilize and become usable.

You don't need to catch bees to contribute

One of the most important things to understand is that you can meaningfully support the Washington Bee Atlas without ever picking up a net.



Brown-tailed bumblebee (*Bombus mixtus*) on silky phacelia (*Phacelia sericea* var. *sericea*). PHOTO: MARK TURNER

Plant experts can contribute by:

- Using the iNaturalist *Identify* tool to review Washington plant observations marked *Needs ID*
- Prioritizing observations associated with the Washington Bee Atlas project
- Adding species or genus-level IDs
- Commenting with guidance when photos are insufficient
- Helping observations cross the threshold to Research Grade

Each of these actions strengthens the dataset that links bees to habitat.

WaBA Needs Your Help

Washington is investing real effort into understanding and protecting its native bees. Volunteers are trained. Specimens are curated. Data are being archived. But the system only works if the plant side of the equation is just as strong as the insect side.

Right now, fewer than half of Bee Atlas plant observations have reached Research Grade. That is not a failure—it is an invitation.

If you know plants, your expertise is needed. A few minutes spent identifying host plants on iNaturalist can have an outsized impact on pollinator science, restoration guidance, and conservation decisions across the state.

Kyle Roslund is a volunteer with the Washington Bee Atlas and serves on the board of the Washington Native Bee Society. He is also the founder of the Vancouver Bee Project, which seeks to create pollinator habitat and educate the public about the importance of pollinators. Through Kyle's efforts, Vancouver, WA is designated as a Bee City USA.



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A Comprehensive Conservation Assessment for the Old-growth Specklebelly Lichen, *Pseudocyphellaria rainierensis*

by Stephen Sharett

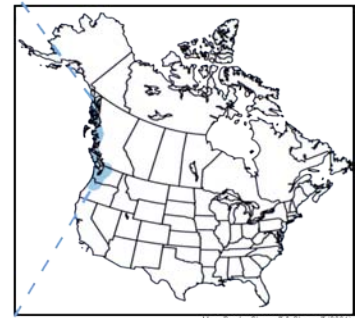
Lichens & Biodiversity Conservation

Lichens embody the symbiosis (living together) of fungi and/or cyanobacteria and algae—one of Earth's most iconic and enigmatic symbiotic relationships. To date, more than 19,000 species of lichens have been described from terrestrial environments across the globe (Scharnagl et al., 2023). Contributing to food webs, nutrient cycles, humidity regimes, and overall biomass and biodiversity, lichens play invaluable roles in ecosystems as extreme as the polar deserts of Antarctica and as biodiverse as the Amazon Rainforest.

Despite their global distribution, high species diversity, and critical ecosystem services, lichens have been overlooked in global biodiversity conservation efforts. According to the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species, only 123 *Lecanoromycetes*, the largest class of lichen-forming fungi, have been assessed for their conservation status, representing less than 0.01% of known lichen species. Like other forms of biodiversity loss, declines in lichen biodiversity are driven by habitat degradation and loss, pollution, and climate change. A 2019 paper by Allen et al. examined lichen conservation in North America, highlighting several factors hindering lichen conservation, including knowledge gaps, data deficiencies, limited long-term monitoring of rare or threatened species, a narrow understanding of threats to lichens, and a lack of lichen education and engagement.



Pseudocyphellaria rainierensis



Map: Bradie Sharnoff & Sharnoff (2017)

Fig. 1. Photograph and range map for *Pseudocyphellaria rainierensis*, a charismatic and threatened Northwest endemic lichen. PHOTO: STEPHEN SHARETT

Pseudocyphellaria rainierensis, commonly known as the old-growth specklebelly lichen, is an epiphytic lichen endemic to the Pacific Northwest. The species occurs throughout the coastal temperate rainforests of southeastern Alaska, extending

south through British Columbia to the western Cascades and Coast Range of Oregon (Fig. 1). In Washington State, *P. rainierensis* is found on the Olympic Peninsula within the Northwest Coast ecoregion and along the western slope of the West and North Cascades ecoregions (Fig. 2A). Considered an old-growth associate, *P. rainierensis* is widely used as an indicator of high-conservation-value forests, where it colonizes bark and bryophyte (moss) mats on the branches and boles of a wide variety of host tree species. Common hosts of the species include conifers, such as Pacific silver-fir (*Abies amabilis*), yellow-cedar (*Callitropsis nootkatensis*), Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and Pacific yew (*Taxus brevifolia*), as well as hardwoods, such as red alder (*Alnus rubra*) and vine maple (*Acer circinatum*).

Pseudocyphellaria rainierensis was described in 1950 by Henry Imshaug (1925–2010) from collections he made along the Ohanapecosh River in Mount Rainier National Park. The body (thallus) of the species has a distinctive blue-green to blue-gray upper surface and a white to tan lower surface covered in woolly hairs (tomentum) that is speckled with tiny pores (pseudocyphellae). Spore-dispersing sexual reproductive structures (apothecia) have seldom been observed in *P. rainierensis*, and dispersal primarily occurs asexually via the detachment of two types of vegetative outgrowths of the thallus (lobules and isidia). As a tripartite lichen species, *P. rainierensis* has a green algal partner distributed throughout the thallus and a cyanobacterial partner that is sequestered within specialized internal structures (cephalodia). The nitrogen-fixing capabilities of the cyanobacterial photobiont underscore one of the vital roles that *P. rainierensis* and other tripartite and cyanolichens play in the forest food webs and nutrient cycles of the Pacific Northwest.

The distribution of *P. rainierensis* has frequently been described as “patchy” due to its dispersal mode and strong association with climatic conditions specific to old-growth forests (Glavich, 2013). Both the sparse occurrence of the species and its habitat specificity have established habitat loss as a clear threat to populations across the Pacific Northwest. However, the rapid acceleration of global climate change and increases in the severity and frequency of climate-driven fires have led to further habitat loss, a threat to the species historically driven by logging and development. Notably, one of the largest known populations in Oregon was extirpated by the Beachie Creek Fire that burned 193,572 acres in the Willamette National Forest from August to November in 2020 (Villella et al. 2023).

The global conservation status of *P. rainierensis* according to NatureServe is vulnerable (G3). In the states of Washington and Oregon, the species is ranked as vulnerable (S3), and in Alaska, it is considered imperiled to vulnerable (S2-S3). The species is ranked as imperiled to vulnerable (N2/N3), provincially in British Columbia and nationally across Canada.

The overarching goal of this research was to address conservation knowledge gaps for *P. rainierensis* and inform conservation assessments and actions for the species. Our main objectives were to 1) delimit the current status and abundance of *P.*

rainierensis populations in Washington State and 2) characterize the conservation genetics of the species in Washington State.

The status of *Pseudocyphellaria rainierensis* in Washington State

To delimit the conservation status of *P. rainierensis* populations, we first gathered all available records of the species in Washington State. Our searches resulted in a total of 310 records from the Consortium of Lichen Herbaria, National Park Herbaria, the United States Forest Service (USFS) National Threatened and Endangered Species Program (TESP), and the USFS Forest Inventory and Analysis (FIA) database. According to NatureServe criteria, unique occurrences for a species population must be spatially separated by 1 km. To obtain a complete dataset of unique occurrence records for *P. rainierensis* in Washington, we developed a workflow to spatially thin the records using their coordinates in R, a statistical computing software application. Our results were plotted in maps produced using ArcGIS Pro (see next page).

Our final dataset comprised 143 unique occurrences of the species in Washington State recorded between 1948 and 2016. We conducted a series of revisits, surveying unique occurrences of *P. rainierensis* from June 2021 to September 2022. During our surveys, we successfully recovered *P. rainierensis* at 18 of the 31 occurrences we revisited (Fig. 2B). The 13 occurrences where we were unable to relocate the species reflect an overall decline of 9% based on all unique records for the species. When grouped by ecological region (ecoregion), the North Cascades and Northwest Coast had the highest number of sites where we did not relocate *P. rainierensis*, with the lowest rates of recovery in the northern portions of both ecoregions.

In addition to targeted surveys of known occurrences, we conducted opportunistic surveys of suitable habitat during field work and recreation. Our opportunistic surveys resulted in the discovery of four previously undocumented *P. rainierensis* occurrences (Fig. 2B). Three of those new occurrences are located in Olympic National Park (Northwest Coast) and one in the Mount Baker-Snoqualmie National Forest (North Cascades). At both relocated occurrences and new occurrences, we classified the abundance of the species and characterized the habitat.

To incorporate community science data into our research, we created an iNaturalist project tracking observations of *P. rainierensis* across Washington and Oregon. Our project amassed 21 observations of the species in Washington State, made from 2021 to 2024 when we completed this portion of our research program. Eleven of those observations were made during our revisits and excluded from downstream analyses. Using the same spatial thinning workflow described above on the remaining observations, we were left with 10 observations separated by 1 km, eight of which represent new occurrences for the species (Fig. 2C). Of those new occurrences, four are within 1.5 km of previously known occurrences, and the remaining four are situated at distances of 5.5 km, 6.5 km, 14.2 km, and 16.3 km from previously known occurrences, respectively.

The Conservation Genetics of *Pseudocypbellaria rainierensis* in Washington State

To characterize the conservation genetics of *P. rainierensis* populations, we executed population genetic analyses to measure genetic diversity, population differentiation, and infer clonal reproduction. Additionally, we performed landscape genetic analyses using spatial and environmental data to characterize gene flow, the dispersal and exchange of genetic material, among populations across Washington State. To perform these analyses, we produced a population genetic dataset using whole-genome shotgun sequencing, a technique that sequences many DNA fragments in parallel. Those sequences are then assembled into more complete sequences using bioinformatics and a complete reference genome. Sequences for each individual were generated by extracting the DNA from a 3 x 3 cm thallus fragment. Our final population genetic dataset represents 111 individuals from 14 populations across Washington State (Fig. 3A). All molecular laboratory work and bioinformatic workflows were performed according to established protocols outlined in Pfeffer et al. (2023) and developed in the Allen Lichen Lab at Eastern Washington University in Cheney, WA.

We used standard population genetic metrics to measure genetic diversity and population differentiation. Genetic diversity was quantified using allelic richness (Ar), which is the number of genetic variants (alleles) in a population after rarefaction, correcting for differences in sample size. Population differentiation was measured using population-specific F_{ST} , which compares the amount of genetic variation within each population to the total variation across all populations. Higher F_{ST} values indicate populations that are more genetically distinct. Genetic mixing was measured using the standardized index of association ($\bar{r}D$), the frequency of alleles occurring together in comparison to expectations if genes were randomly mixing across the genome.

We found that Ar was relatively consistent across populations, ranging from 1 to 1.08, indicating similar and low levels of genetic diversity (Fig. 3B). In contrast to genetic diversity, we found that population-specific F_{ST} was considerably more variable among populations, with some populations exhibiting strong differentiation ($F_{ST} > 0.9$) and others exhibiting low to zero F_{ST} values indicating genetic similarity to all other populations sampled (Fig. 3C). Likewise, $\bar{r}D$ showed considerable variation among populations with some populations reaching values >0.70 , reflecting limited genetic mixing among populations and higher rates of clonal reproduction, whereas others had low $\bar{r}D$ values (<0.11), suggesting genetic mixing and sexual reproduction (Fig. 3D).

Landscape genetics is an interdisciplinary field of study that employs population genetics, landscape ecology, and spatial statistics to understand how landscapes influence gene flow and population genetic patterns. We used TESS3, an R-based algorithm that integrates geographic and genetic data, to identify genetically similar clusters in our data and estimate the ancestry (genetic origins) of *P. rainierensis* individuals within

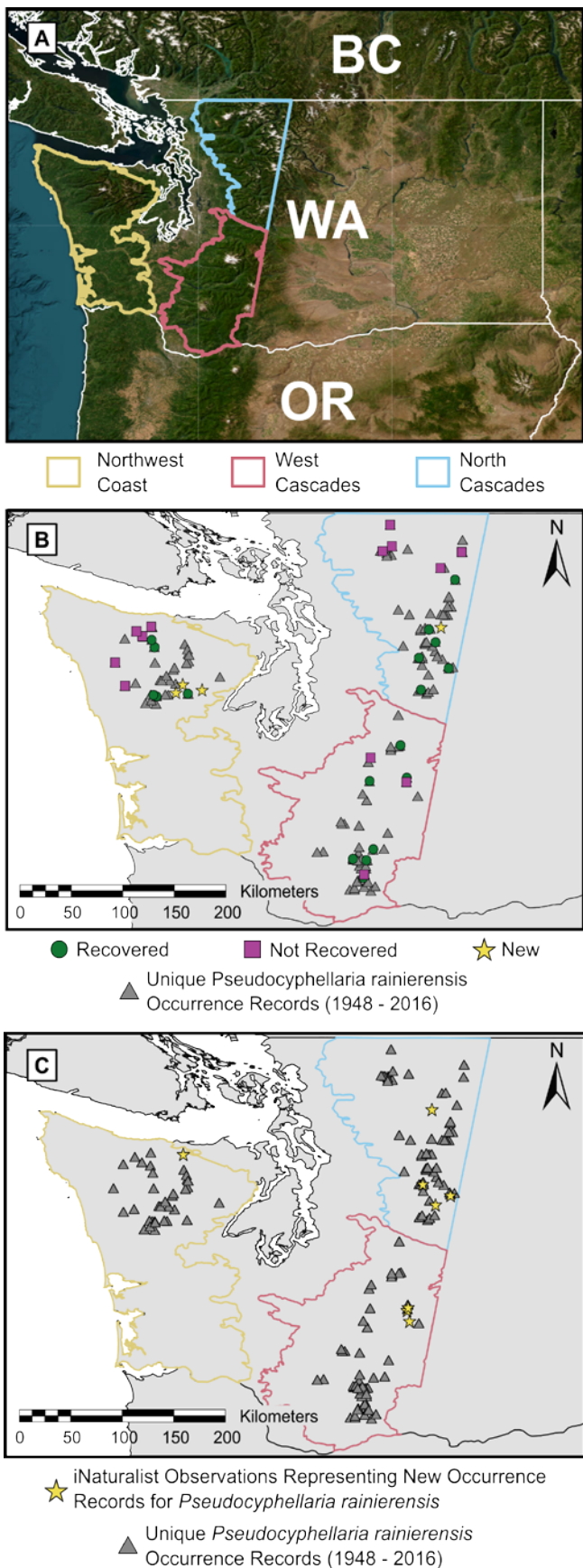


Fig. 2. Maps for revisits to known *Pseudocypbellaria rainierensis* occurrences in Washington State. A. The study area for our research. Each distinct ecoregion is outlined in a different color. B. Result from revisits to previously known occurrences and opportunistic surveys. C. Results of an assessment of observations of *P. rainierensis* in iNaturalist.

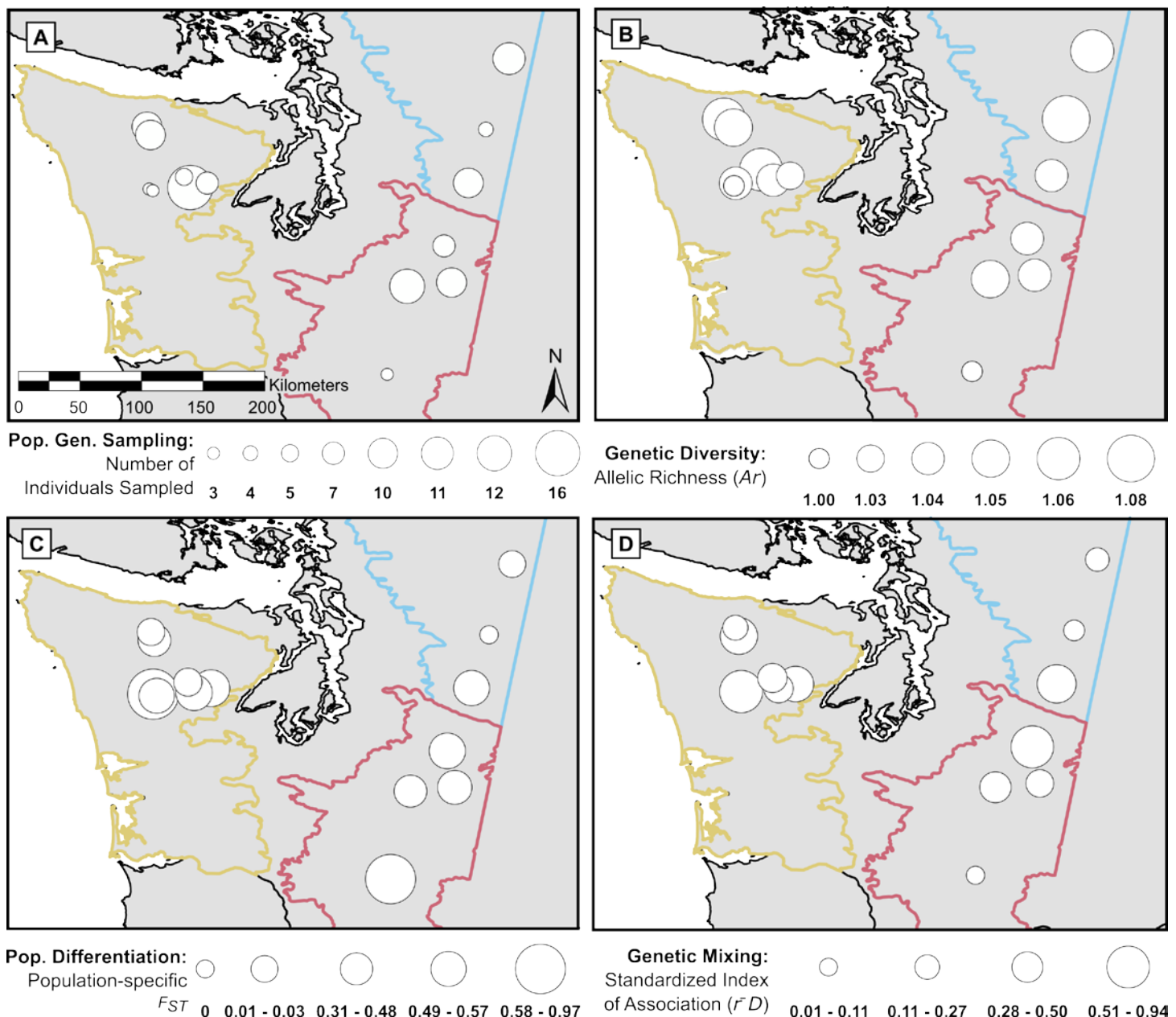


Fig. 3. Population genetic sampling and analyses. Each dot represents a population, and dot size reflects the value of the metric shown in each panel. A. Population genetic sampling sites and sample sizes. B. Genetic diversity measured using allelic richness (A_r), the number of genetic variants (alleles) in a population after rarefaction to account for differences in sample size. Higher A_r indicates higher genetic diversity. C. Population differentiation measured using population-specific F_{ST} , which compares the amount of genetic variation within each population to the total variation across all populations. Higher F_{ST} values indicate populations that are more genetically distinct. D. Genetic mixing measured using the standardized index of association (r_D), which reflects how often alleles occur together compared to what would be expected if genes were randomly mixed. Higher r_D values indicate reduced genetic mixing suggesting clonal or limited sexual reproduction.

those groups. When mapped across the landscape, these patterns of ancestry provide insight into the movement of genes among populations. We identified three genetic clusters across Washington State with limited mixing between each cluster, reflecting restrictions in gene flow among populations within each cluster (Fig. 4D).

Populations can become genetically isolated when gene flow is restricted by geographic distances, resulting in isolation-by-distance (IBD), or by the species' ability to establish in heterogeneous environments, resulting in isolation-by-environment (IBE). To understand what factors are limiting gene flow

among *P. rainierensis* populations, we tested for IBD and IBE using Mantel Tests. Mantel tests were performed using genetic distances as a response variable, and geographic distances and environmental distances as explanatory variables. Genetic distances were quantified using pairwise F_{ST} , a measure of genetic differentiation between pairs of populations. Environmental distances were quantified using variation in climatic conditions, such as temperature, precipitation, and humidity, among population genetic sampling sites. We did not find a significant correlation between genetic and geographic distances ($r = 0.06$, p -value = 0.64), indicating that *P. rainierensis* populations are not experiencing IBD. We found a significant positive correla-

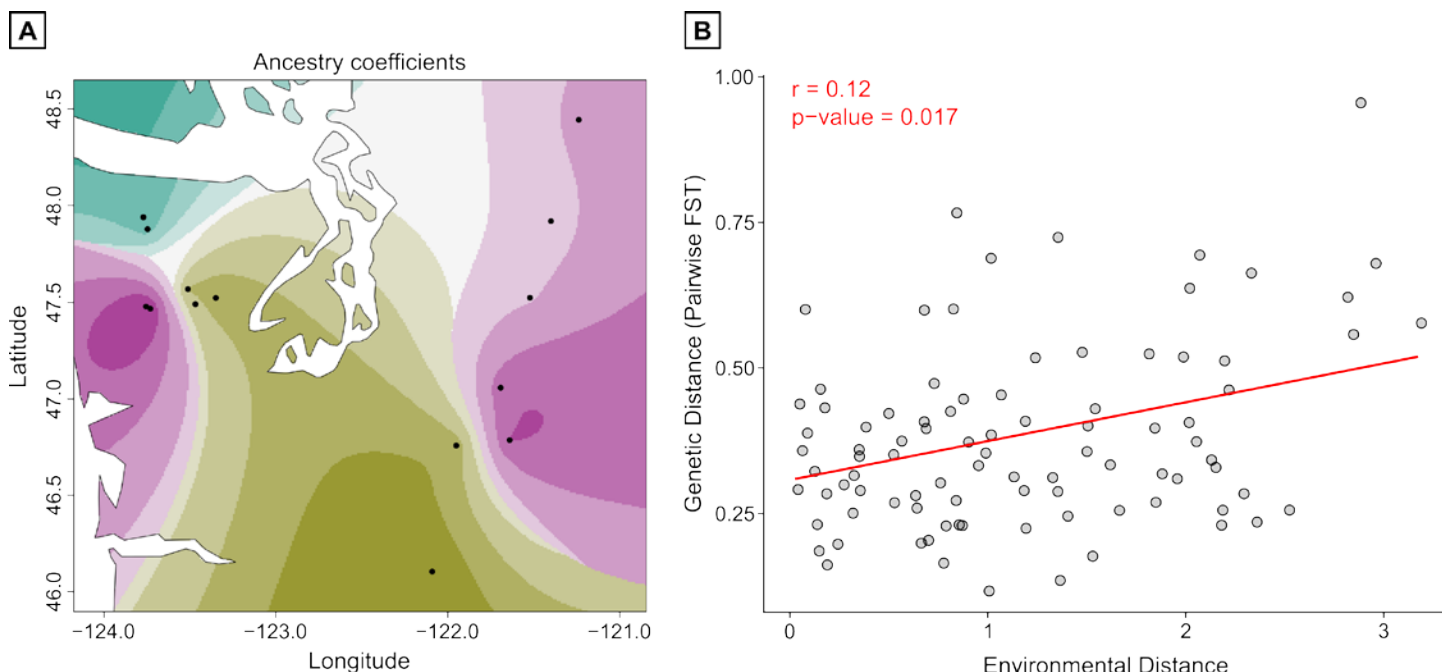


Fig. 4. Landscape genetic analyses. A. Map of genetic ancestry for *Pseudocypbellaria rainierensis* populations in Washington State showing three distinct genetic clusters. Black dots represent population genetic sampling sites. Each color represents a distinct genetic cluster. Zones with intermediate colors indicates areas of genetic exchange among populations. B. Mantel test for isolation-by-environment (IBE) showing a significant positive relationship (p -value < 0.05) between genetic distances and environmental distance. Each point represents a pair of populations. The red line indicates the overall trend of correlation between genetic and environmental distances.

tion ($r = 0.12$, p -value = 0.017) between genetic and environmental distances while accounting for geographic distances, indicating that *P. rainierensis* populations are experiencing IBE (Fig. 4B).

Putting it all together: Towards a comprehensive conservation assessment of *Pseudocypbellaria rainierensis*



Fig. 5. Dr. Lalita Calabria and Stephen Sharrett collecting population genetic samples of *Pseudocypbellaria rainierensis* at Staircase in Olympic National Park in June 2022. PHOTO: A. RESTREPO

We identified a substantial (9%) overall decline in the species across Washington during revisits to known occurrences. The observed decline is especially concerning given that almost half of the occurrences where we did not relocate *P. rainierensis*

were located within National Parks and Wilderness Areas, public lands protected from logging. Our findings from revisits were reported to the Washington Natural Heritage Program, and the State conservation rank for *P. rainierensis* was changed from secure (S4) to vulnerable (S3) in Washington in 2024 (Miller and Fertig, 2024). Overall, this portion of our research highlights the importance of continuous, long-term monitoring of rare and threatened species, while emphasizing the invaluable role that public institutions and community science initiatives play in supporting regional conservation efforts.

Our examination of the population genetics for *P. rainierensis* revealed that populations in Washington have similar and low levels of genetic diversity, and that most populations exhibit strong population differentiation and higher rates of clonal reproduction. Landscape genetic analyses identified three distinct genetic clusters of *P. rainierensis* in Washington State, and gene flow among populations may be limited by climatic variation rather than geographic distance. Genetic diversity can enable adaptation to environmental changes. Given the low levels of genetic diversity we observed across *P. rainierensis* populations and the importance of climatic conditions for establishment during dispersal, it is essential that we preserve highly connected suitable habitat areas, such as wilderness and late-successional forest reserves (LSR). Using forest connectivity models, a recent publication by Halsey (2024) illustrated how the conversion of timber harvest forests to LSRs facilitates the development of cool microclimates that make forests resilient to climate change and wildfire and would likely serve as refugia for *P. rainierensis*. Moving forward, we plan to conduct a series of adaptive genetic analyses to understand the specific climatic

conditions that different *P. rainierensis* populations are adapted to and how those populations will respond to the changes we all face under climate change.

Cumulatively, this research represents the first-ever study to address common gaps in the conservation knowledge of a lichen species associated with old-growth forests in the Pacific Northwest. Moreover, it provides the first comprehensive look at the status, health, and resilience of *P. rainierensis* populations in Washington State. We hope that this research will guide further efforts to preserve and protect lichen biodiversity both regionally and globally.

This research would not have been possible without the financial support of the Washington Native Plant Society, and I would like to extend a huge thank you to everyone who supports the WNPS! I am eternally grateful for the support of my mentors, Lalita M. Calabria and Jessica L. Allen, PhDs. I also thank Silas Cranmer, Britt Glenn, Andrew Restrepo, John Villella, and Franny Waldear for their contributions to the field and laboratory work essential to this research.

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Sword Fern Die-off in the Puget Lowlands

by Kaiss Jarrahy, Ben Schilpp, Timothy Billo, Ph.D., and Paul Shannon

In 2014, a pure stand of sword ferns (*Polystichum munitum*) died in the heart of a rare remnant of old-growth forest in Seattle's Seward Park. Only a few months passed between the appearance of first symptoms and the subsequent 90% mortality of all the sword ferns in a quarter-acre area.



Sword ferns, famously robust and long-lived, dead and dying in Seward Park's old-growth forest. PHOTO: Paul Shannon

By late 2014, the Friends of Seward Park (FoSP) grew concerned by this die-off. The affected region grew concentrically at about 100 feet per year in the following two years. No other species showed any signs of decline. Sword ferns have been dying at Seward ever since, leaving holes in the ecological fabric of this 120-acre, 500-year-old urban Douglas-fir (*Pseudotsuga menziesii*) forest. Thanks to the work of University of Washington students and numerous citizen observers, the sword fern die-off phenomenon has now been documented at 50 other sites in the Puget Lowlands of Washington state.

Based on these alarming observations, we immediately asked, is the die-off novel and is it consequential? For example, if all sword ferns at a site were a clonal group, perhaps they could all die in the same year due to normal senescence. But we know clonality in sword ferns is uncommon. Furthermore, what we see in the field is mortality progressing outward concentrically from an affected site, year after year, which is more characteristic of a disease agent.

No comprehensive study of sword fern life history has yet been published. Background sword fern mortality rates are unknown. But we do know that sword ferns typically colonize disturbed ground under an open sky, such as after fire or flood. Once established, they rarely reproduce and are very long lived. *Polystichum* genus systematist David Barrington, in a personal communication, offers:



In the center of the forest a pure stand of waist-high ferns succumbs to the blight. Left: September 2022. Right: October 2025. PHOTOS: PAUL SHANNON

I very much like the idea that they are old individuals, established at a remote time when there was disturbance in the forest. Fire would create such a disturbance. As to age, 1000 years is not out of the question, possibly much longer. But there are no data at all for deciding. There are very few sites for the establishment of new plants via gametophyte in the stable mature forests of the Northwest, though a single treefall would create such an opportunity. Polystichum munitum is essentially unbranched, which lends support to the idea that the populations are made up of independently originated individuals, not fragments of some giant clone.

This sketch of sword fern life history, and the findings we present below, suggest that the mortality we report here is highly unusual, could be related to anthropogenic factors, and is driven primarily by a pathogen or a perturbed microbiome. The loss of this foundational Douglas-fir forest understory species, in combination with the very slow subsequent natural regeneration of bare ground beneath a closed canopy, means that sword fern mortality potentially poses a threat to overall forest health by setting up a cascade of degradation. Shockingly, after 10 years, in the initial half acre die-off zone at Seward Park, natural regeneration (not including our own

attempts at experimental restoration) consisted of only five fringe cup (*Tellima grandiflora*) plants. This raised the possibility that without our intervention, a process of cascading understory degradation might in fact be underway.

Given the above observations, and the fact that to the best of our knowledge this blight is novel, we hypothesize that 1) there is a pathogen, 2) a cascade of degradation might be underway, and 3) this might not be limited to Seward Park (although comparative studies elsewhere certainly also contribute to understanding 1 and 2). To investigate our hypotheses, we set about making observations, running experiments, and collecting regional reports.

2015: No Evidence of *Phytophthora* Infection

Washington State University plant pathologist Marianne Elliott worked with us closely for two years pursuing the initially most plausible explanation for the blight: that a non-native species of *Phytophthora* (fungi-like plant pathogens sometimes called water molds) had been unintentionally introduced to the forest. Marianne has published widely on *Phytophthora* spp. and recently analyzed the unintentional introduction of pathogens from regional Pacific Northwest native plant nurseries. In her 2015 visit to the initial sword fern die-off site (which we call Ground Zero) at Seward Park, Marianne noticed a number of dead western redcedar (*Thuja plicata*) saplings (of the 10,000 bare root cedars planted across Seward's forest in 2011, less than a dozen are known to have survived).

Marianne hypothesized that in the planting of these western red cedar saplings, *Phytophthoras* may have been introduced to Seward Park's forest.

We brought samples of healthy and affected sword ferns to the WSU Puyallup lab over a two-year span that Marianne and her staff used to attempt to culture *Phytophthora* species. At the conclusion of these two years, no *Phytophthoras* were found, and Marianne concluded that *Phytophthoras* were unlikely to have caused the sword fern blight.

2018: The 36 fern (3x12) Nursery Fern 4-year Experiment

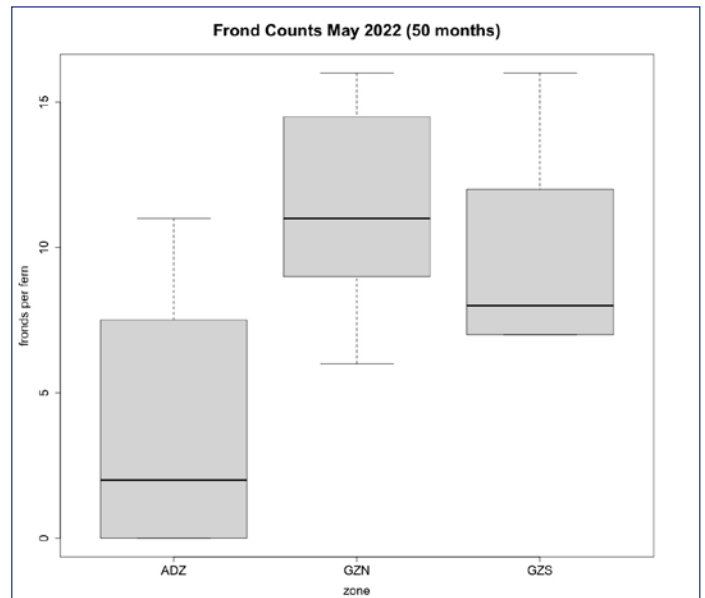
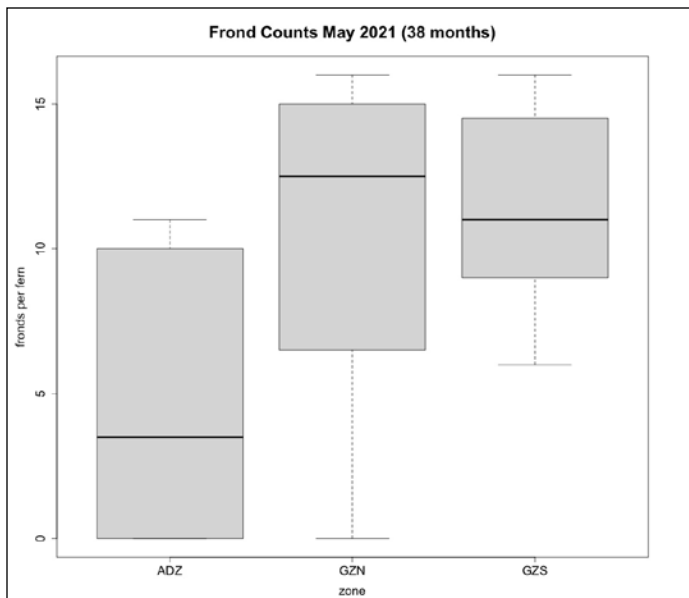
Our observations suggested two contrasting modes by which infection of the presumed pathogen may travel: contiguous spread and "leaping."

Sea Star Wasting Disease (SSWD)

The recent identification of the cause of Sea Star Wasting Disease (SSWD) is instructive. A similar approach may be needed with the sword fern die-off.

In the case of SSWD, billions of sunflower sea stars (*Pycnopodia helianthoides*) as well as many other sea star species were lost to an unknown infection between 2013 and the present. Losses in this keystone species led to a sea urchin population explosion and then to broad declines in kelp forests. A causal virus was proposed in 2014 but dismissed in 2018.

In 2025, after more than a decade, the answer was found. University of British Columbia researchers extracted coelomic fluid from an affected sea star and identified a bacterium, *Vibrio pectenicida*, via DNA sequencing. Subsequent introduction of this bacterium into unaffected sea stars caused disease and death. The authors predict that by identifying the pathogen, recovery of sea stars and their ecosystems now becomes possible (Prentice et al. 2025).



Median frond count of 12 ferns planted into the active die-off zone (ADZ) drops from 3 to 2, while unaffected ferns, planted in two lines of 12 into the original Ground Zero (GZN, GZS) continued to produce a normal healthy number of fronds each year. The presumed pathogen is no longer active at GZ.

We conducted a four-year field experiment focusing on contiguous spread. Our support for leaping spread is anecdotal: we regularly see fern mortality emerge in distant parts of the forest, with no obvious animal vector, water flow, or nearby pre-existing infection.

In January of 2018, supported by Seattle Parks, FoSP planted 36 young nursery-grown sword ferns at and near Ground

Zero in Seward Park, divided into three lines of 12 ferns each: two lines planted at Ground Zero, and one line planted just north of what was then the boundary of the expanding die-off region. We hypothesized that the agent of the die-off was no longer active at Ground Zero, but was likely to be active and virulent at the die-off's leading edge; if correct, the Ground Zero plantings would survive, and the twelve northerly ferns would show decline.



All 36 ferns were planted with the same method and all were watered weekly during summer drought, two liters per plant for three summers. Now seven years later, all of the Ground Zero ferns are thriving, whereas ones in the northern line (active die-off zone, ADZ) are 70% dead. Mortality in that group appeared in the first year. Fern mortality within the forest has since spread far beyond this 2018 boundary.

New frond (fiddle-head) production is a proxy of plant health, so for four years in spring we counted new fronds. The continued emer-

The typical 8-year progression from first symptoms to moss-covered crown. In regions with more than 50" of rain, this progression may happen more quickly. PHOTOS: PAUL SHANNON

gence of new fronds in ferns planted at Ground Zero leads us to conclude that the active agent that killed Ground Zero fronds in 2013 is no longer present there. This suggests that the agent did its work, traveled on, and currently has no direct path by which to reinfect these new Ground Zero ferns.

The agent may yet return in an instance of leaping spread, or via contiguous spread if restoration re-establishes a path from an active die-off site.

2018: The “Beer Bottle” Experiment

We conducted an informal experiment looking for water-borne transmission of the presumed pathogen. We cut twelve complete fronds from the forest, nine of them from healthy plants, three from dying plants. Six casually cleaned beer bottles were filled with tap water. Three bottles then received healthy/healthy frond pairs. Three bottles received healthy/affected frond pairs. We watched the ferns for three weeks, photographing them to keep a record.

After three weeks, in the healthy/affected bottles the healthy fronds looked like the diseased fronds: wilted, starting to turn brown. Meanwhile, in the healthy/healthy pairings, there was no difference between the fronds in the pair, (i.e., they both remained relatively healthy) and the two fronds in the healthy/healthy pairing were distinctly different from those in the healthy/unhealthy pairing. This is consistent with the possibility that there is a waterborne pathogen which had moved within the bottle from the affected frond to the healthy one, but also cannot rule out other hypotheses such as airborne transmission or direct frond to frond transmission.

November 2019: A More Rigorous Transmission Experiment

With funds donated from Seattle’s 100 Women Who Care, FoSP hired forest ecologist Dylan Mendenhall to improve upon the “beer bottle” experiment, testing for possible pathogen transmission with more rigorous laboratory protocols in the University of Washington Center for Urban Horticulture greenhouse. Mendenhall replicated the findings from our preliminary “beer bottle” experiment. We quote from the abstract of his report below:

The regional decline of sword ferns (Polystichum munitum) in the Puget Sound lowlands remains unexplained... We used sword fern fronds as a bioassay in a paired-sample greenhouse experiment

Time-lapse Photography on the Windfall Trail (2022 to present)

We set up a Chronolog photography station to track die-off on the Windfall Trail. 350 forest visitors have contributed 550 photos over three years. Chronolog’s software and website, which costs \$100 a year, makes it easy to upload photos, of the same scene, which are assembled into a time-lapse series, visible at www.chronolog.io/site/SEW101.

to determine if symptoms could be transmitted from symptomatic fronds to healthy fronds with water as a shared medium. After 5 days, fronds in the infected treatment group were significantly more desiccated and had significantly lower foliar moisture content than fronds in the control group which were grown in water with apparently healthy fronds. We were not able to identify whether the causal agent was transmitted through physical contact, an above-ground vector or through the water. (Mendenhall et al. 2019).

While we were not able to identify the precise mechanism of infection, the finding that infected ferns fail to take up water (despite being placed in water), thus becoming desiccated, is important. It suggests that the putative pathogen acts within the vasculature of the frond. Mendenhall et al. (2019) conclude:

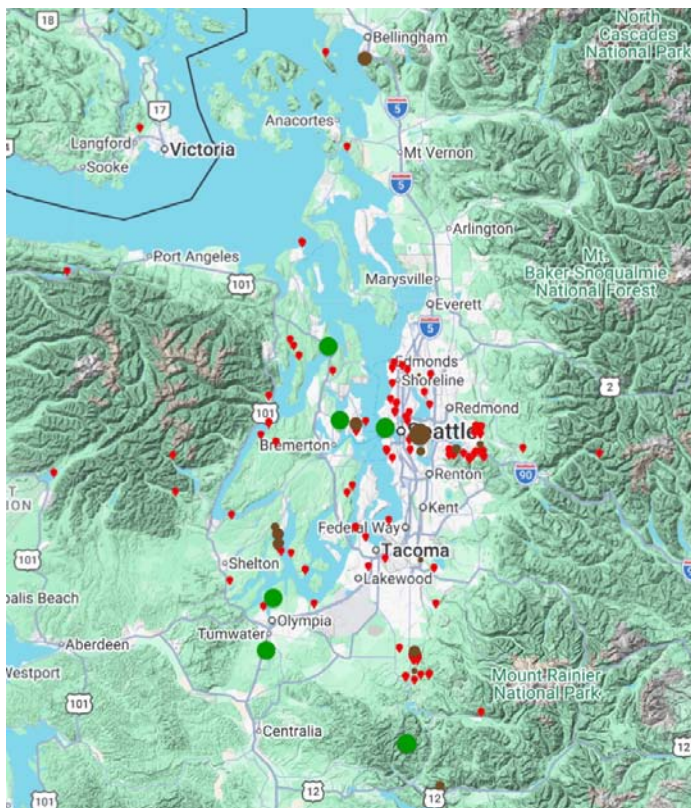
...our results suggest that a vascular pathogen is present in the foliage of sword ferns located at the edge of an active die-off site in Seward Park.

A vascular pathogen would make the ferns particularly susceptible to stress during the dry summer months. We have conducted ecophysiological experiments demonstrating that in fact, healthy sword ferns do experience physiological stress during the summer, but recover once rains start in the fall (Kildisheva et al. 2019). In our experience, infected ferns do not recover, however, and eventually fail to produce new fronds, leading to death within a few years. While we have not experienced a trend of unusually low rainfall rates in the last 15 years, we have experienced at least a decade of unusually warm summers across the Pacific Northwest (Climate.gov 2021), potentially pushing infected ferns to the brink. Vascular stress can also be caused by sucking insects such as thrips. With the help of University of Washington entomologist Patrick Tobin, we have looked for but not found any thrips (or other insect outbreaks) on sword ferns in our study site.

2020: A Documentary Film

Having failed after seven years to attract researchers and funding for sustained, multi-disciplinary study of the die-off, and still witnessing the ongoing spread of mortality, Friends of Seward Park (FoSP) hired filmmaker Daniel Harm to make a documentary (<https://www.youtube.com/watch?v=NRlrcbBitVQ>) about the problem. Among the many virtues of Daniel’s film is testimony from distinguished Pacific Northwest forest ecologist Jerry Franklin (transcript edited for concision):

“You have to start with a hypothesis and the hypothesis is that it is a pathogen ... one of the most important opportunities they have is to pursue this question of what’s causing the mortality of the sword fern, a really, really important understory species throughout the Douglas-fir region. We need to know what’s going on there, what factors are involved, whether or not a pathogen is involved, and if [so] ... we need to deal with that in order to avoid having it spread. That’s one of the very best opportunities, to do good both for the park itself and for the region as a whole.”



UW Puget Lowland Sword Fern Survey, Summer 2025. Guided by 200 iNaturalist reports (red) and focusing on the intersection of those reports with Washington State Parks, 55 sites were assessed with a standard protocol. Brown circles have high sword fern mortality, diameter proportional to dead fern count. Green constant-sized circles indicate healthy sword fern sites. Full map, narrative, data and download at <https://pshannon.net/fernSurvey2025>.

Summer 2025: A Regional Survey of the Puget Lowlands

We started an iNaturalist project in 2018: “Western Sword Fern Decline in the Pacific Northwest” to which 200 reports have been contributed. Many of these are credible and most of them display symptoms similar to what we see at Seward Park. These reports indicate the presence of the sword fern blight beyond Seattle’s Seward Park. To confirm the reliability of these reports and the extent of die-off, two University of Washington fourth-year Environmental Studies students, Kaiis Jarrahy and Ben Schilpp, travelled 966 miles across the Puget Lowlands in June and July 2025 surveying for sword fern die-off and quantifying the extent of die-off in a strategic way. They examined sites that had been previously reported through iNaturalist, in a strategic way. This was not a systematic gridded search for the blight, nor a regional randomized search, but an attempt to survey all known credible reports from our iNaturalist project along with lowland forested Washington State Parks (we had permission to work in all of Washington’s state parks). We now have reproducible reports from all sectors of the Puget Lowlands, definitively establishing that the blight is not simply a phenomenon of Seward Park’s urban old-growth forest. Their work also creates a baseline useful for the future if tracking the phenomenon over time is pursued.

A subset of the data illustrates the protocol, applied to a large die-off site in Larrabee State Park south of Bellingham. See Table 1.

2025: Seward’s “Split Site”: A Natural Experiment in Sword Fern Mortality

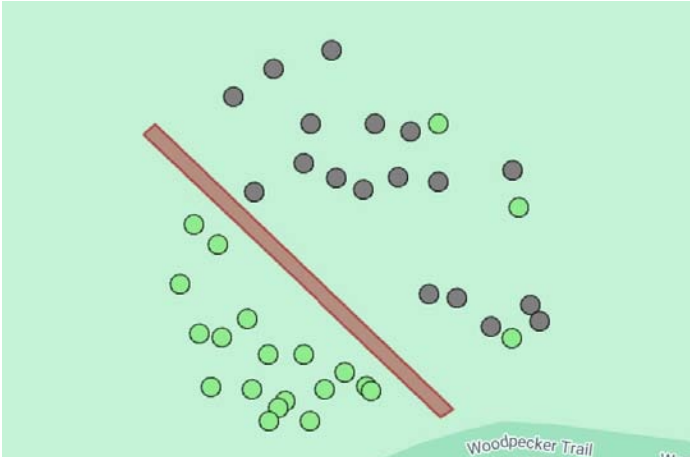
The site provides a natural experiment. The two adjacent halves have apparently identical abiotic conditions, are nearly equal in fern density and count, have the same slope and aspect, have no obvious canopy differences and are separated only by a fallen Douglas-fir log which, in the site, has a ground clearance averaging three inches allowing easy passage of air, insects, small mammals and rainwater below it. There are 39 ferns, 21 on the east, 18 on the west. Most east ferns are dead (18/21). All west ferns are healthy.

The remnant dead fern crowns indicate that mortality struck here about five years ago. This summer a few of the previously healthy ferns west of the log show their first signs of blight. On the affected half-site, the survival of 3 of 21 ferns (14%) fits our informal sense that even in heavily affected pure stands, perhaps due to genetic variability, 10% of a pure stand typically survives the blight.

A simple chi-square calculation shows that the die-off rates on each side of the log are significantly different from each

Latitude	48.65382
Longitude	-122.4898
Date	2025-07-07
Time	23:48:18
Elevation	212
Area	2074
Slope	26
Aspect	263
Canopy Type	Mixed
Canopy Density	60
Healthy Fern Count	23
Sick or Dead Fern Count	73
Mortality Type 1	5
Mortality Type 2	11
Mortality Type 3	50
Mortality Type 4	7

Table 1: Die-off at Larrabee State Park



A natural experiment, where nature presents contrasting outcomes from side-by-side, ostensibly identical situations. Here a fallen Douglas-fir, which does not touch the ground as it separates the two halves of this site, may somehow protect the left-side ferns from the presumed pathogen. PROGRAMMING BY PAUL SHANNON

other ($p < .001$), i.e., it is extremely unlikely this contrast happened by chance.

Four soil samples were collected on each subsite to a depth of three inches. These were pooled to create two aggregate samples, one for each side, and sent to EarthFort of Corvallis Oregon for analysis. There is a lower abundance of fungi, bacteria, biological carbon and nitrogen on the east (dead) side, as compared to the west (healthy) side. Due to the two sides being contiguous, on the same soil type, and with identical (nearly flat) slope and aspect, the contrasting values across the two sides are likely to be the result of east side fern mortality rather than its cause. See Table 2.

	E (dead)	W (alive)	Range
Moisture	11	10.78	20 to 80
pH	5.8	5.9	5.5 to 9
Electrical Conductivity $\mu\text{S}/\text{cm}$	30	10	200 to 1000
Total Fungi $\mu\text{g}/\text{g}$	316.65	726.54	> 600
Total Bacteria $\mu\text{g}/\text{g}$	352.65	408.68	> 600
Total Fungi to Total Bacteria Ratio	0.92	1.78	> 1
Biological Carbon ppm	329.66	567.61	> 600
Biological Nitrogen ppm	39.56	52.98	> 70
Biological Carbon to Biological Nitrogen ratio	8.33	10.71	> 8.57

Table 2. Soil tests performed by EarthFort of Corvallis Oregon. www.earthfort.com

Current Project: California Plant Pathology Lab

The UW students did a literature search as part of their summer regional mortality survey. One recent publication they found by nematologist Sergei Subbotin of the California Department of Food and Agriculture’s Plant Pathology lab, describes a new genus of nematode parasitizing sword ferns on the Olympic Peninsula. FoSP contacted Dr. Subbotin, received a warm welcome, and an offer to study the problem. We shipped samples to the lab on October 13th, 2025 and heard back on December 3rd, 2025 from Dr. Cheryl Blomquist, a colleague of Subbotin: “Based on floating fern cross sections under the microscope...we see changes in the fern vascular system over time...It really looks like a pathogen that is an obligate parasite. We are working...to get a sequence right now,” she said.

Current Project: Adaptive Restoration Planting

Two members of FoSP are Green Seattle Partnership forest stewards. Learning over many years that native plant restoration can be a hit-or-miss affair, we have developed a strategy of “adaptive restoration”, in which bare ground is prepared a year or two in advance with deep (12 inch) mulching, followed by planting of native species for which five years of tracking data

indicate have high survival even in the absence of summertime watering. One current preparation and planting effort—of a half-acre mid-forest site at Seward with 601 dead fern stumps – is documented here: <https://pshannon.net/splitSite2025/>.

Conclusion

A decade of work on sword fern mortality at Seward Park and in the Puget Lowlands establishes the pathogenic nature of the blight and its regional distribution. Our work has led to the recent and most welcome collaborations which we hope will contribute to the improved health of the rare urban old-growth forest of Seward Park (now 500 years old), such that it remains a thriving natural community 500 years from now. Ultimately, we hope that what we learn from Seward’s forest will be useful throughout the region.

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Work Starts to Produce *Flora of the Pacific Northwest*, 3rd edition

by David E. Giblin, University of Washington
Herbarium, Burke Museum

In 2017, my colleagues at the University of Washington Herbarium, Burke Museum and I submitted the manuscript for *Flora of the Pacific Northwest*, 2nd edition to the University of Washington Press for publication in Fall 2018. This was a long-overdue revision, given that 45 years had passed between publication of the two editions. At the time we thought that it would be 10 years before the book would need to be updated. Well, here we are in 2026 and our prediction for the need of a third edition has proven accurate based on the number of changes to our flora that have accumulated since 2018.



Figure 1. Two new species described from Washington's flora since publication of *Flora of the Pacific Northwest*, 2nd edition: *Ranunculus basalticus* (basalt buttercup) and *Lomatium refugianum* (refuge biscuitroot). PHOTOS: DAVID GIBLIN (L) AND ADAM SCHNEIDER (R)

University of Washington Herbarium researchers alone have described or are in the processing of describing more than a dozen new taxa (species, subspecies, or variety) from our flora region (Figure 1). Moreover, our field work, along with that of our colleagues at herbaria across the Pacific Northwest, have documented existing species, both native and introduced, that are new to our flora region. Many of those finds, along with significant range extensions that are not included in *Flora of Pacific Northwest*, 2nd edition, have been published in the scientific journal *Madrono* (<https://calbotsoc.org/home/about-madrono/>).

In addition to our local taxonomic and floristic research, ongoing molecular systematics research across the globe has improved our understanding of evolutionary relationships in ways

that impact our knowledge of the Pacific Northwest flora. For example, two commonly encountered genera in the *Rosaceae*, *Horkelia* and *Ivesia*, are more correctly treated as belonging to the genus *Potentilla* (cinquefoils). Consequently, keys need to be revised to accommodate these changes, and the updated names need to be added to the book (e.g., *Ivesia gordonii* becomes *Potentilla gordonii* and needs to be inserted into the *Potentilla* key).

Collectively, all these distribution updates and taxonomic changes mean that we currently do not have a book that allows us to identify all the known wild-growing, native and non-native plants in our region. This becomes particularly problematic for land managers responsible for conserving rare plants or controlling potentially invasive non-native species. Additionally, because *Flora of the Pacific Northwest*, 2nd edition is used in undergraduate plant taxonomy classes throughout the region, we fall short in providing the next generation of botanists with the most contemporary taxonomy for understanding the region's vascular plant diversity.

The time and effort to publish a 3rd edition will be less than that required for the 2nd edition, but it is still substantial. We estimate the project to last 18–24 months, require approximately 20% of the book to be updated, include an additional 75 new illustrations, and add 20–30 pages of new text. We hope to have the same level of support and interest that made producing the 2nd edition successful. Please contact David Giblin (dgiblin@uw.edu) with questions or to learn more.

David Giblin is Collections Manager and Research Botanist at the University of Washington Herbarium, Burke Museum. David is lead editor and co-author of Flora of the Pacific Northwest, 2nd edition. He conducts field and collections-based research on the taxonomy and distribution of Pacific Northwest vascular plants.



David Douglas, Botanical Explorer: Part 4, The Legacy of David Douglas

(continued from the previous issue)

by Ed Alverson

David Douglas' legacy is cemented by the very tangible results of all his seasons in the field, especially in the Pacific Northwest and California, and to a lesser degree South America, Hawaii, and central Canada. As noted in previous entries to this series, Douglas brought over 600 vascular plant species to the attention of European science.

The Appendix is apparently the first attempt to fully document Douglas' botanical contributions, and has been compiled from a variety of sources, including published floras and online databases. While Mitchell and House (1999) included an appendix listing 425 plants discovered, introduced, or named by David Douglas, they specifically indicate that the list, which had been compiled by Glasgow Botanical Gardens, includes only Douglas' better-known plants, and the taxa are not distinguished by their connection to Douglas' role.

The list here may be considered as a preliminary analysis, as other archives, not yet tapped, may provide further information. Also, the numbers will invariably fluctuate with future scholarship to clarify nomenclatural priority and species delimitations, so if there is ever to be a "final" list, it will likely be long in the future.

Douglas introduced about 200 species of plants to cultivation with the packets of seed and roots he collected in the wild and shipped back to Britain. This may be an undercount, as our source is an appendix in his journal that was published 80 years after his death (Douglas 1914), and it may be that the actual contents of Douglas' seed packets were not well archived. He is credited with describing over 140 species of vascular plants, though in many cases his names and descriptions were left in manuscript form, to be brought into print later by other botanists.

Douglas was also responsible for naming three genera, *Garrya* (*Garryaceae*), *Hosackia* (*Fabaceae*), and *Triteleia* (*Aspar-*

agaceae). According to my current tally, he has 47 recognized vascular plant taxa named in his honor, as well as one moss. An additional 45 taxa (not listed here) were named in Douglas' honor but are no longer recognized, either because species boundaries have changed, or older names have come to light and thus have priority. In some cases the common names still honor Douglas; an example of this is the Douglas-fir (*Pseudotsuga menziesii*).

Douglas collected type specimens, the specimen upon which a species is founded, for over 500 species, which includes most if not all species named for Douglas (eponyms); taxa for which Douglas was the author (though the level or generic placement may have changed since then); as well as many additional species that were studied and named by a wide network of British and European botanists. Douglas also collected animals, and two species of mammals, the Douglas squirrel (*Tamiasciurus douglasii*) and the Pygmy Short-horned Lizard (*Phrynosoma douglasii*), are named for him.

Another way to reflect on Douglas' legacy is to consider his place in the world in which he lived. In the chapters of this biographical essay, one can see that Douglas the botanist was at the center of a series of paradoxes that portray both the promise and problems of the 19th century.

Though written 200 years ago, Douglas' journal is still very readable. Reading it makes one wonder how a working-class boy, of humble origins, whose native language must have been Scot's English, became such a skilled writer of standard English. This is especially curious given the class restrictions prevalent in British society at that time that limited access to elite education. One has to suspect that there was genius at play. Certainly, we are the beneficiaries of his talents.

The scientific world that Douglas operated in was a product of the Enlightenment, but transitioning toward the Victorian era. His adventures in and observations of wild nature reflect the life of a Romantic, as Romanticism as a world view was influential in Britain and Europe at this time, in part a reaction against the emphasis on rationalism and commerce of the Enlightenment. This is demonstrated by passages from his journal, such as his perception of the landscape upon his initial arrival at Fort Vancouver in 1825: "The scenery from this place is sublime - high well-wooded hills, mountains covered with perpetual snow, extensive natural meadows and



Iris douglasiana. ILLUSTRATION: CURTIS'S BOTANICAL MAGAZINE



Pseudotsuga menziesii, originally published as *Pinus douglasii*. ILLUSTRATION: DESCR. OF THE GENUS PINUS

plains of deep fertile alluvial deposit covered with a rich sward of grass and a profusion of flowering plants” (Douglas 1959).

While Douglas’ most important legacy is scientific documentation of the western North American flora, his mission was essentially mercantile, to document and collect new species of plants for British gardens and to provide profits to British nursery businesses that received Douglas’ seeds.

Douglas’ biography shows that he was a sensitive documentarian of indigenous cultures, but was also a representative and beneficiary of imperialism and colonialism, which severely impacted these cultures.

Douglas helped to introduce the temperate world to a unique flora, but at the same time he was also a part of a movement that we can see, from our present-day perspective, has led to ecological destruction and the homogenization of the world’s floras.

While it is easy to think of David Douglas as a botanical hero, his legacy is both more complicated and more interesting than a rather one-dimensional story of the botanist-explorer as hero. We still have much to learn from the life and times of David Douglas, about the historic landscape, and the way it has come to be what it is now.

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Ed Alverson currently works as the Natural Areas Coordinator for Lane County Parks in Eugene, Oregon. Ed has a BS in Biology from The Evergreen State College and a MS in Botany from Oregon State University and has worked as a field botanist and stewardship ecologist in the Pacific Northwest for 45 years. Ed has also authored or co-authored more than 50 popular and scientific articles on a variety of botanical and ecological topics, from plant taxonomy and ecology to botanical history and exploration. This essay was prepared for the “Plant Hunters” project, which was convened by Art Kruckeberg and Rhoda Love.



Appendix:
The Botanical Contributions of
David Douglas

	Eponym	Author	Type	Introduced
Mosses: Bryopsida				
Neckeraceae				
<i>Neckera douglasii</i>	E		T	
Lycophytes: Lycopodiopsida				
Selaginellaceae				
<i>Selaginella douglasii</i>	E		T	
Ferns: Polypodiopsida				
Aspleniaceae				
<i>Asplenium douglasii</i>	E		T	
Cystopteridaceae				
<i>Cystopteris douglasii</i>	E		T	
Marattiaceae				
<i>Marattia douglasii</i>	E		T	
Marsileaceae				
<i>Marsilea vestita</i>			T	
Conifers: Pinopsida				
Cupressaceae				
<i>Juniperus occidentalis</i>			T	
Pinaceae				
<i>Abies amabilis</i>		A	T	I
<i>Abies bracteata</i>			T	
<i>Abies grandis</i>		A	T	I
<i>Abies lasiocarpa</i>			T	
<i>Abies procera</i>			T	I
<i>Picea sitchensis</i>				I
<i>Pinus contorta</i>		A	T	
<i>Pinus coulteri</i>				I
<i>Pinus lambertiana</i>		A	T	I
<i>Pinus monticola</i>		A	T	I
<i>Pinus ponderosa</i>		A	T	I
<i>Pinus radiata</i>				I
<i>Pinus sabiniana</i>		A	T	I
<i>Pseudotsuga menziesii</i>				I
Flowering Plants: Magnoliophyta				
Adoxaceae				
<i>Viburnum ellipticum</i>			T	
Amaranthaceae				

	Eponym	Author	Type	Introduced
<i>Grayia spinosa</i>			T	
Amoryllidaceae				
<i>Allium douglasii</i>	E		T	
<i>Allium falcifolium</i>			T	
<i>Allium scilloides</i>		A	T	
Anacardiaceae				
<i>Toxicodendron diversilobum</i>			T	
Apiaceae				
<i>Cicuta douglasii</i>	E		T	
<i>Gymopterus terebinthinus</i>			T	
<i>Eryngium petiolatum</i>			T	
<i>Lomatium caruifolium</i>			T	
<i>Lomatium dasycarpum</i>			T	
<i>Lomatium macrocarpum</i> var. <i>douglasii</i>	E		T	
<i>Lomatium parvifolium</i>			T	
<i>Perideridia gairdneri</i>			T	
<i>Sanicula bipinnata</i>			T	
<i>Sanicula bipinnatifida</i>		A	T	
<i>Sanicula laciniata</i>			T	
<i>Yabea microcarpa</i>			T	
Apocynaceae				
<i>Asclepias fascicularis</i>			T	
<i>Asclepias vestita</i>			T	
Aristolochiaceae				
<i>Asarum caudatum</i>			T	
Asparagaceae				
<i>Dichelostemma congestum</i>				I
<i>Triteleia grandiflora</i>				I
<i>Triteleia hyacinthina</i>			T	I
<i>Triteleia ixioides</i>				I
<i>Triteleia laxa</i>			T	I
<i>Triteleia peduncularis</i>			T	
Asteraceae				
<i>Achyrrachaena mollis</i>			T	

	Introduced	Type	Author	Eponym
<i>Acourtia microcephala</i>		T		
<i>Ageratina occidentalis</i>		T		
<i>Ambrosia acanthicarpa</i>		T		
<i>Artemisia campestris</i> var. <i>wormskioldii</i>		T		
<i>Artemisia douglasiana</i>	E	T		
<i>Artemisia ludoviciana</i> subsp. <i>lindleyana</i>		T		
<i>Artemisia michauxiana</i>		T		
<i>Baccharis pilularis</i>		T		
<i>Baccharis pilularis</i> subsp. <i>consanguinea</i>		T		
<i>Baccharis salicifolia</i>		T		
<i>Balsamorhiza hookeri</i>		T		
<i>Blepharipappus scaber</i>		T		
<i>Brickellia californica</i>		T		
<i>Brickellia grandiflora</i>		T		
<i>Calycadenia multiglandulosa</i>		T		
<i>Calycadenia truncata</i>		T		
<i>Calycadenia villosa</i>		T		
<i>Centromadia pungens</i>		T		
<i>Chaenactis douglasii</i>	E	T		
<i>Chaenactis glabriuscula</i>		T		
<i>Chaenactis glabriuscula</i> var. <i>lanosa</i>		T		
<i>Chrysothamnus viscidiflorus</i>		T		
<i>Cirsium douglasii</i>	E	T		
<i>Cirsium remotifolium</i>		T		
<i>Coreopsis calliopsidea</i>		T		
<i>Crocidium multicaule</i>		T		
<i>Deinandra corymbosa</i>		T		
<i>Deinandra fasciculata</i>		T		
<i>Dieteria canescens</i> var. <i>canescens</i>				I

	Introduced	Type	Author	Eponym
<i>Ericameria linearifolia</i>		T		
<i>Erigeron chrysopsidis</i>		T		
<i>Erigeron linearis</i>		T		
<i>Erigeron speciosus</i>		T		I
<i>Eriophyllum confertiflorum</i>		T		
<i>Eriophyllum lanatum</i>				I
<i>Eriophyllum lanatum</i> var. <i>integrifolium</i>		T		
<i>Eriophyllum multicaule</i>		T		
<i>Gaillardia aristata</i>				I
<i>Grindelia integrifolia</i>		T		
<i>Gutierrezia californica</i>		T		
<i>Helenium puberulum</i>		T		
<i>Helianthella uniflora</i> var. <i>douglasii</i>		T		
<i>Helianthella uniflora</i> var. <i>douglasii</i>	E	T		
<i>Helianthus annuus</i>				I
<i>Helianthus californicus</i>		T		
<i>Hemizonia congesta</i>		T		
<i>Hemizonia congesta</i> subsp. <i>lutescens</i>		T		
<i>Holocarpa macradenia</i>		T		
<i>Hymenopappus filifolius</i>		T		
<i>Lasthenia californica</i>				I
<i>Lasthenia glaberrima</i>		T		
<i>Lasthenia glabrata</i>				I
<i>Lasthenia microglossa</i>		T		
<i>Lasthenia minor</i>		T		
<i>Layia chrysanthemoides</i>		T		I
<i>Layia heterotricha</i>		T		
<i>Leptosyne douglasii</i>	E	T		
<i>Madia elegans</i>		T		I
<i>Malacothrix floccifera</i>		T		
<i>Malacothrix saxatilis</i> var. <i>commutata</i>		T		
<i>Matricaria discoidea</i>		T		
<i>Microseris douglasii</i>	E	T		
<i>Microseris laciniata</i>		T		
<i>Mikania scandens</i>				I

	Introduced	Type	Author	Eponym
<i>Monolopia major</i>		T		
<i>Packera subnuda</i>		T		
<i>Pseudognaphalium californicum</i>		T		
<i>Pyrrocoma carthamoides</i>		T		
<i>Senecio flaccidus</i> var. <i>douglasii</i>	E	T		
<i>Senecio serra</i>		T		
<i>Tetradymia canescens</i>		T		
<i>Townsendia florifera</i>		T		
<i>Uropappus lindleyi</i>		T		
<i>Venegasia carpesoides</i>		T		
<i>Wyethia angustifolia</i>		T		
<i>Wyethia helenoides</i>		T		
Berberidaceae				
<i>Mahonia aquifolium</i>				I
<i>Mahonia nervosa</i>				I
Betulaceae				
<i>Betula occidentalis</i>		T		
Boraginaceae				
<i>Adelinia grandis</i>	A	T		
<i>Amsinckia douglasiana</i>	E	T		
<i>Amsinckia lycopsoides</i>		T		I
<i>Amsinckia vernicosa</i>		T		
<i>Cryptantha flaccida</i>	A	T		
<i>Cryptantha muricata</i>		T		
<i>Hackelia ciliata</i>	A	T		
<i>Hackelia diffusa</i>	A	T		
<i>Lithospermum ruderae</i>	A	T		
<i>Oreocarya leucophaea</i>	A	T		
<i>Pectocarya penicillata</i>		T		
<i>Plagiobothrys nothofulvus</i>		T		
Brassicaceae				
<i>Arabis blepharophylla</i>		T		
<i>Athysanus pusillus</i>		T		
<i>Cardamine angulata</i>		T		
<i>Caulanthus lasiophyllus</i>		T		
<i>Cusickiella douglasii</i>	E	T		

	Introduced	Type	Author	Eponym
<i>Erysimum capitatum</i>		T	A	
<i>Idahoia scapigera</i>		T		
<i>Lepidium latipes</i>		T		
<i>Lepidium oxycarpum</i>		T		
<i>Physaria douglasii</i>	E	T		
<i>Rorippa curvisiliqua</i>		T		
<i>Streptanthus glandulosus</i>		T		
<i>Thelypodium laciniatum</i>		T		
<i>Thysanocarpus curvipes</i>		T		
<i>Tropidocarpum gracile</i>		T		
Calycanthaceae				
<i>Calycanthus occidentalis</i>		T		
Campanulaceae				
<i>Downingia elegans</i>		T	A	I
<i>Downingia pulchella</i>		T		I
Caprifoliaceae				
<i>Lonicera ciliosa</i>		I		
<i>Lonicera hirsuta</i>		I		
<i>Lonicera hispidula</i>		I		
<i>Symphoricarpos albus</i> var. <i>albus</i>		I		
Caryophyllaceae				
<i>Eremogone franklinii</i>	A	T		
<i>Moehringia macrophylla</i>		T		
<i>Sabulina douglasii</i>	E	T		
<i>Silene douglasii</i>	E	T		
Celastraceae				
<i>Euonymus occidentalis</i>		T		
Cleomaceae				
<i>Cleomella lutea</i>		T		
Convolvulaceae				
<i>Calystegia subacaulis</i>		T		
<i>Cuscuta californica</i>		T		
Cornaceae				
<i>Cornus occidentalis</i>		T		I
Crassulaceae				
<i>Sedum spathulifolium</i>		T		
Cucurbitaceae				
<i>Marah oregana</i>		T		

	Introduced	Type	Author	Eponym
Cyperaceae				
<i>Carex amplifolia</i>		T		
<i>Carex aperta</i>		T		
<i>Carex douglasii</i>		T	E	
<i>Carex exsiccata</i>		T		
<i>Carex hoodii</i>		T		
<i>Carex rossii</i>		T		
Ericaceae				
<i>Arbutus menziesii</i>		I		
<i>Arctostaphylos columbiana</i>		I		
<i>Arctostaphylos glauca</i>		T		
<i>Arctostaphylos tomentosa</i> subsp. <i>bracteosa</i>		T		
<i>Gaultheria shallon</i>		I		
<i>Vaccinium membranaceum</i>		T	A	
<i>Vaccinium ovatum</i>		I		
Euphorbiaceae				
<i>Croton setiger</i>		T		
Fabaceae				
<i>Acemispom americanus</i>		T		
<i>Acemispom cytisoides</i>		T		
<i>Acemispom decumbens</i>		T		
<i>Acemispom grandiflorus</i>		T		
<i>Acemispom junceus</i>		T		
<i>Acemispom parviflorus</i>		T		
<i>Astragalus agrestis</i>		T	A	
<i>Astragalus collinus</i>		T	A	
<i>Astragalus crassicaupus</i>		I		
<i>Astragalus diaphanus</i>		T	A	
<i>Astragalus didymocarpus</i>		T		
<i>Astragalus douglasii</i>		T	E	
<i>Astragalus drummondii</i>		T	A	
<i>Astragalus flexuosus</i>		T	A	
<i>Astragalus inflexus</i>		T	A	
<i>Astragalus kentrophyta</i> var. <i>douglasii</i>		T	E	

	Introduced	Type	Author	Eponym
<i>Astragalus lentiginosus</i>		T	A	
<i>Astragalus macrodon</i>		T		
<i>Astragalus miser</i>		T	A	
<i>Astragalus pectinatus</i>		T	A	
<i>Astragalus purshii</i>		T	A	
<i>Astragalus purshii</i> var. <i>glareosus</i>		T	A	
<i>Astragalus reventus</i>		T		
<i>Astragalus sclerocarpus</i>		T		
<i>Astragalus succumbens</i>		T	A	
<i>Astragalus tener</i>		T		
<i>Astragalus whitneyi</i> var. <i>sonneanus</i>		T		
<i>Dalea ornata</i>		T	A	
<i>Hoita macrostachya</i>		I		
<i>Hoita orbicularis</i>		T		
<i>Hoita strobilina</i>		T		
<i>Hosackia crassifolia</i>		T		
<i>Hosackia gracilis</i>		T		
<i>Hosackia pinnata</i>		T		
<i>Hosackia stipularis</i>		T		
<i>Lespedeza capitata</i>		I		
<i>Lupinus affinis</i>		T		
<i>Lupinus albicaulis</i>		T	A	
<i>Lupinus albifrons</i>		T		
<i>Lupinus albifrons</i> var. <i>douglasii</i>		T	E	
<i>Lupinus arbustus</i>		T	A	
<i>Lupinus benthamii</i>		T		
<i>Lupinus bicolor</i>		T		
<i>Lupinus concinnus</i>		T		
<i>Lupinus hirsutissimus</i>		T		
<i>Lupinus latifolius</i>		T		
<i>Lupinus lepidus</i>		T	A	
<i>Lupinus lepidus</i> var. <i>aridus</i>		T	A	
<i>Lupinus leucophyllus</i>		T	A	
<i>Lupinus littoralis</i>		T	A	
<i>Lupinus microcarpus</i> var. <i>densiflorus</i>		T		
<i>Lupinus nanus</i>		T	A	
<i>Lupinus polyphyllus</i>		T		
<i>Lupinus rivularis</i>		T	A	
<i>Lupinus sabinianus</i>		T	A	

	Introduced	Type	Author	Eponym
<i>Lupinus sericeus</i>		T	A	
<i>Lupinus sericeus</i> var. <i>flexuosus</i>		I		
<i>Lupinus succulentus</i>		T	A	
<i>Lupinus sulphureus</i>		T	A	
<i>Oxytropis campestris</i> var. <i>spicata</i>		T		
<i>Oxytropis deflexa</i> var. <i>foliolosa</i>		T		
<i>Oxytropis splendens</i>		T	A	
<i>Rupertia physodes</i>		T	A	
<i>Thermopsis macrophylla</i>		T		
<i>Trifolium albopurpureum</i>		T		
<i>Trifolium cyathiferum</i>		T		
<i>Trifolium depauperatum</i> var. <i>amplectens</i>		T		
<i>Trifolium dichotomum</i>		T		
<i>Trifolium douglasii</i>		T	E	
<i>Trifolium fucatum</i>		T		
<i>Trifolium gracilentum</i>		T		
<i>Trifolium latifolium</i>		T		
<i>Trifolium obtusiflorum</i>		T		
<i>Trifolium plumosum</i>		T	A	
<i>Trifolium willdenovii</i>		T		
<i>Vicia nigricans</i> var. <i>gigantea</i>		T		
Fagaceae				
<i>Chrysolepis chrysophylla</i>		T	A	
<i>Quercus douglasii</i>		T	E	
<i>Quercus garryana</i>		T	A	
<i>Garryaceae</i>				
<i>Garrya elliptica</i>		T	A	
Gentianaceae				
<i>Frasera albicaulis</i>		T	A	
<i>Frasera speciosa</i>		T	A	
<i>Gentiana affinis</i>		T		
<i>Gentiana douglasiana</i>		T	E	
<i>Gentiana sceptrum</i>		T		
<i>Zeltnera exaltata</i>		T		
<i>Zeltnera muehlenbergii</i>		T		

	Introduced	Type	Author	Eponym
<i>Zeltnera trichantha</i>		T		
Geraniaceae				
<i>Geranium carolinianum</i>		I		
Gesneriaceae				
<i>Sinningia douglasii</i>		T	E	
Grossulariaceae				
<i>Ribes aureum</i>		I		
<i>Ribes bracteosum</i>		T	A	
<i>Ribes californicum</i>		T		
<i>Ribes cereum</i>		T	A	
<i>Ribes divaricatum</i>		T	A	
<i>Ribes hudsonianum</i>		T	A	
<i>Ribes lacustre</i>		I		
<i>Ribes malvaceum</i>		I		
<i>Ribes menziesii</i>		I		
<i>Ribes niveum</i>		T		
<i>Ribes oxyacanthoides</i> var. <i>irriguum</i>		T	A	
<i>Ribes oxyacanthoides</i> var. <i>setosum</i>		I		
<i>Ribes sanguineum</i>		I		
<i>Ribes sanguineum</i> var. <i>glutinosum</i>		T		
<i>Ribes viscosissimum</i>		I		
Hydrophyllaceae				
<i>Emmenanthe penduliflora</i>		T		
<i>Eucrypta chrysanthemifolia</i>		T		
<i>Hesperochiron pumilus</i>		T	A	
<i>Hydrophyllum capitatum</i>		T	A	
<i>Nemophila parviflora</i>		T	A	
<i>Nemophila pedunculata</i>		T	A	
<i>Phacelia brachyloba</i>		T		
<i>Phacelia ciliata</i>		T		
<i>Phacelia divaricata</i>		I		
<i>Phacelia douglasii</i>		T	E	
<i>Phacelia grandiflora</i>		T		
<i>Phacelia hastata</i>		T	A	
<i>Phacelia linearis</i>		I		
<i>Phacelia malvaefolia</i> var. <i>loasaefolia</i>		T		
<i>Phacelia phacelioides</i>		T		

	Introduced	Type	Author	Eponym
<i>Phacelia ramosissima</i>		T	A	
<i>Phacelia tanacetifolia</i>	I	T		
<i>Phacelia vicida</i>	I	T		
<i>Pholistoma auritum</i>	I			
<i>Pholistoma membranaceum</i>		T		
Hypericaceae				
<i>Hypericum scouleri</i>		T		
Iridaceae				
<i>Iris douglasiana</i>		T	E	
<i>Iris tenax</i>	I	T	A	
<i>Olsynium douglasii</i>		T	E	
Lamiaceae				
<i>Agastache urticifolia</i>	I	T		
<i>Clinopodium douglasii</i>		T	E	
<i>Lepechinia calycina</i>		T		
<i>Monardella douglasii</i>		T	E	
<i>Monardella odoratissima</i>		T		
<i>Monardella undulata</i>		T		
<i>Pogogyne douglasii</i>		T	E	
<i>Salvia apiana</i>		T		
<i>Salvia carduea</i>		T		
<i>Salvia columbariae</i>		T		
<i>Salvia dorrii</i> var. <i>incana</i>	I			
<i>Salvia leucophylla</i>		T		
<i>Salvia mellifera</i>		T		
<i>Salvia sonomensis</i>		T		
<i>Salvia spathacea</i>		T		
<i>Scutellaria tuberosa</i>		T		
<i>Trichostema lanatum</i>		T		
<i>Trichostema lanceolatum</i>		T		
<i>Trichostema oblongum</i>		T		
Liliaceae				
<i>Calochortus albus</i>	I	T	A	
<i>Calochortus luteus</i>	I	T	A	
<i>Calochortus macrocarpus</i>	I	T	A	
<i>Calochortus nitidus</i>		T	A	
<i>Calochortus pulchellus</i>	I	T	A	

	Introduced	Type	Author	Eponym
<i>Calochortus splendens</i>	I	T	A	
<i>Calochortus uniflorus</i>		T		
<i>Calochortus venustus</i>	I	T	A	
<i>Erythronium grandiflorum</i>	I			
<i>Fritillaria biflora</i>		T		
<i>Fritillaria liliacea</i>		T		
<i>Fritillaria pudica</i>	I			
Limnanthaceae				
<i>Limnanthes douglasii</i>	I	T	E	
Linaceae				
<i>Linum lewisii</i>	I			
Loasaceae				
<i>Mentzelia albicaulis</i>		T	A	
<i>Mentzelia gracilentia</i>		T		
<i>Mentzelia laevicaulis</i>		T	A	
<i>Mentzelia laevicaulis</i> var. <i>parviflora</i>		T	A	
<i>Mentzelia lindleyi</i>	I	T		
<i>Mentzelia micrantha</i>		T		
Lythraceae				
<i>Lythrum californicum</i>		T		
Malvaceae				
<i>Ilamna rivularis</i>		T	A	
<i>Sidalcea diploscypha</i>		T		
<i>Sidalcea malachroides</i>		T		
<i>Sidalcea virgata</i>	I			
<i>Sphaeralcea munroana</i>	I	T	A	
Melanthiaceae				
<i>Trillium chloropetalum</i> var. <i>giganteum</i>		T		
<i>Xerophyllum tenax</i>	I			
Montiaceae				
<i>Calandrinia menziesii</i>	I			
<i>Claytonia exigua</i>		T		
<i>Claytonia parviflora</i>		T	A	
<i>Montia linearis</i>		T	A	
Myrtaceae				
<i>Caulanthus flavescens</i>		T		
Namaceae				
<i>Eriodictyon californicum</i>		T		

	Introduced	Type	Author	Eponym
Nyctaginaceae				
<i>Abronia mellifera</i>	I	T	A	
<i>Mirabilis laevis</i> var. <i>crassifolia</i>		T		
Oleaceae				
<i>Fraxinus dipetala</i>		T		
Onagraceae				
<i>Camissonia campestris</i> subsp. <i>campestris</i>	I			
<i>Camissonia contorta</i>		T	A	
<i>Clarkia pulchella</i>	I			
<i>Clarkia purpurea</i>		T		
<i>Clarkia purpurea</i> subsp. <i>quadrivulnera</i>	I	T	A	
<i>Clarkia purpurea</i> subsp. <i>viminea</i>	I	T	A	
<i>Clarkia rhomboidea</i>	I	T	A	
<i>Clarkia rubicunda</i>	I	T		
<i>Clarkia speciosa</i>		T		
<i>Clarkia tenella</i>	I			
<i>Clarkia unguiculata</i>		T		
<i>Epilobium densiflorum</i>	I	T		
<i>Epilobium minutum</i>	I			
<i>Eremothera boothii</i>		T	A	
<i>Eremothera boothii</i> subsp. <i>alyssooides</i>		T		
<i>Eremothera pygmaea</i>		T	A	
<i>Oenothera albicaulis</i>	I			
<i>Oenothera biennis</i>	I			
<i>Oenothera elata</i> subsp. <i>hookeri</i>		T		
<i>Oenothera pallida</i>	I	T		
<i>Oenothera speciosa</i>	I			
<i>Oenothera triloba</i>	I			
Orchidaceae				
<i>Tetrapteron graciliflorum</i>		T		
<i>Brassavola nodosa</i>	I			
<i>Corallorhiza striata</i>		T		
<i>Cypripedium montanum</i>		T	A	
<i>Epipactis gigantea</i>		T	A	
<i>Gomesa planifolia</i>	I			
<i>Gomesa pubes</i>	I			
<i>Platanthera dilatata</i> var. <i>leucostachys</i>		T		

	Introduced	Type	Author	Eponym
<i>Platanthera elegans</i>		T		
<i>Platanthera stricta</i>		T		
<i>Pogonia ophioglossoides</i>	I			
<i>Spiranthes porrifolia</i>		T		
Orobanchaceae				
<i>Agalinis aspera</i>		T	A	
<i>Aphyllon californicum</i> subsp. <i>grayanum</i>		T		
<i>Castilleja ambigua</i> var. <i>ambigua</i>		T		
<i>Castilleja densiflora</i>		T		
<i>Castilleja densiflora</i> subsp. <i>gracilis</i>		T		
<i>Castilleja exserta</i> var. <i>exserta</i>		T		
<i>Castilleja hispida</i>		T		
<i>Castilleja miniata</i>		T	A	
<i>Castilleja parviflora</i>	I			
<i>Castilleja rubicundula</i> var. <i>lithospermoides</i>		T		
<i>Cordylanthus rigidus</i>		T		
<i>Orthocarpus bracteosus</i>		T		
<i>Pedicularis canadensis</i>	I			
<i>Pedicularis densiflora</i>		T		
<i>Pedicularis racemosa</i>		T	A	
<i>Triphysaria eriantha</i>		T		
<i>Triphysaria floribunda</i>		T		
<i>Triphysaria pusilla</i>		T		
Oxalidaceae				
<i>Oxalis trillifolia</i>		T		
Paeoniaceae				
<i>Paeonia brownii</i>	I	T	A	
Papaveraceae				
<i>Dendromecon rigida</i>	I	T		
<i>Ehrendorferia chrysantha</i>		T		
<i>Eschscholzia caespitosa</i>	I			
<i>Eschscholzia hypocoides</i>		T		
<i>Hesperomecon linearis</i>	I	T		

	Eponym	Author	Type	Introduced
<i>Papaver heterophyllum</i>			T	I
<i>Platystemon californicus</i>			T	I
Phrymaceae				
<i>Diplacus douglasii</i>	E		T	
<i>Diplacus linearis</i>			T	
<i>Erythranthe alsinoides</i>		A	T	
<i>Erythranthe cardinalis</i>		A	T	I
<i>Erythranthe floribunda</i>		A	T	I
<i>Erythranthe guttata</i>				I
<i>Erythranthe lewisii</i>				I
<i>Erythranthe microphylla</i>			T	
<i>Erythranthe moschata</i>		A	T	I
<i>Erythranthe primuloides</i>			T	
<i>Mimetanthe pilosa</i>			T	
Plantaginaceae				
<i>Collinsia grandiflora</i>		A	T	I
<i>Collinsia heterophylla</i>			T	I
<i>Collinsia parviflora</i>		A	T	I
<i>Keckiella breviflora</i>				I
<i>Neogaerrhinum strictum</i>			T	
<i>Nothochelone nemorosa</i>		A	T	I
<i>Penstemon acuminatus</i>		A	T	I
<i>Penstemon attenuatus</i>		A	T	I
<i>Penstemon centranthifolius</i>				I
<i>Penstemon confertus</i>		A	T	I
<i>Penstemon deustus</i>		A	T	I
<i>Penstemon fruticosus</i> var. <i>scouleri</i>		A	T	I
<i>Penstemon gairdneri</i>			T	
<i>Penstemon glandulosus</i>		A	T	I
<i>Penstemon gracilis</i>				I
<i>Penstemon hesperius</i>				I
<i>Penstemon heterophyllus</i>				I
<i>Penstemon nitidus</i>		A	T	

	Eponym	Author	Type	Introduced
<i>Penstemon ovatus</i>		A	T	I
<i>Penstemon procerus</i>		A	T	
<i>Penstemon pruinosus</i>		A	T	I
<i>Penstemon richardsonii</i>		A	T	I
<i>Penstemon serrulatus</i>				I
<i>Penstemon speciosus</i>		A	T	I
<i>Penstemon triphyllus</i>		A	T	I
<i>Penstemon venustus</i>		A	T	I
<i>Sairoparpus multiflorus</i>			T	I
<i>Veronica regina-nivalis</i>		A	T	
<i>Veronica rubra</i>		A	T	
Poaceae				
<i>Agrostis microphylla</i>			T	
<i>Bromus sitchensis</i> var. <i>carinatus</i>			T	
<i>Bromus sitchensis</i> var. <i>marginatus</i>			T	
<i>Bromus vulgaris</i>			T	
<i>Deschampsia elongata</i>			T	
<i>Festuca occidentalis</i>			T	
<i>Melica imperfecta</i>			T	
<i>Pleuropogon californicus</i>			T	
<i>Poa douglasii</i>	E		T	
Polemoniaceae				
<i>Allophyllum gilioides</i>			T	
<i>Allophyllum glutinosum</i>			T	
<i>Collomia grandiflora</i>		A	T	I
<i>Collomia heterophylla</i>		A	T	
<i>Collomia linearis</i>				I
<i>Enemion occidentale</i>			T	
<i>Eriastrum densifolium</i>			T	
<i>Eriastrum luteum</i>			T	
<i>Gilia achilleifolia</i>			T	I
<i>Gilia achilleifolia</i> subsp. <i>multicaulis</i>			T	I
<i>Gilia capitata</i>			T	I
<i>Gilia sinuata</i>		A	T	
<i>Gilia tenuiflora</i>			T	I

	Eponym	Author	Type	Introduced
<i>Gilia tenuiflora</i> subsp. <i>arenaria</i>			T	
<i>Gilia tricolor</i>			T	I
<i>Ipomopsis aggregata</i>				I
<i>Ipomopsis congesta</i>			T	
<i>Leptodactylon californicum</i>			T	
<i>Leptosiphon androsaceus</i>			T	I
<i>Leptosiphon grandiflorus</i>			T	
<i>Leptosiphon liniflorus</i>			T	I
<i>Leptosiphon parviflorus</i>			T	
<i>Linanthus dianthiflorus</i>			T	
<i>Linanthus dichotomus</i>			T	
<i>Linanthus pungens</i>				I
<i>Linanthus pungens</i> subsp. <i>hookeri</i>		A	T	
<i>Microgilia minutiflora</i>			T	
<i>Microsteris gracilis</i>		A	T	I
<i>Navarretia atractylodes</i>			T	
<i>Navarretia cotulifolia</i>			T	
<i>Navarretia intertexta</i>			T	
<i>Navarretia pubescens</i>			T	
<i>Phlox douglasii</i>	E		T	
<i>Phlox longifolia</i>				I
<i>Phlox rigida</i>			T	
<i>Polemonium micranthum</i>			T	
<i>Saltugilia splendens</i>		A	T	
Polygonaceae				
<i>Chorizanthe douglasii</i>	E		T	
<i>Chorizanthe membranacea</i>			T	
<i>Chorizanthe pungens</i>			T	
<i>Chorizanthe staticoides</i>			T	
<i>Eriodictyon tomentosum</i>			T	
<i>Eriogonum angulosum</i>			T	

	Eponym	Author	Type	Introduced
<i>Eriogonum compositum</i>		A	T	I
<i>Eriogonum douglasii</i>	E		T	
<i>Eriogonum elatum</i>		A	T	
<i>Eriogonum fasciculatum</i>			T	
<i>Eriogonum niveum</i>		A	T	
<i>Eriogonum nudum</i>		A	T	I
<i>Eriogonum nudum</i> var. <i>auriculatum</i>			T	
<i>Eriogonum sphaerocephalum</i>		A	T	
<i>Eriogonum strictum</i>			T	
<i>Eriogonum umbellatum</i> var. <i>ellipticum</i>			T	
<i>Eriogonum vimineum</i>		A	T	
<i>Mucronea californica</i>			T	
<i>Polygonum douglasii</i>	E		T	
<i>Polygonum majus</i>			T	
Primulaceae				
<i>Androsace nivalis</i>			T	I
<i>Primula latiloba</i>			T	
Ranunculaceae				
<i>Anemonastrum deltoideum</i>		A	T	
<i>Anemone multifida</i>				I
<i>Clematis ligusticifolia</i>				I
<i>Delphinium menziesii</i>				I
<i>Delphinium nudicaule</i>			T	
<i>Delphinium variegatum</i>			T	
<i>Emmenanthe penduliflora</i>			T	
<i>Ranunculus glaberrimus</i>			T	
<i>Ranunculus hebecarpus</i>			T	
<i>Ranunculus orthorhynchus</i>			T	
Rhamnaceae				
<i>Ceanothus cuneatus</i>			T	
<i>Ceanothus dentatus</i>			T	
<i>Ceanothus incanus</i>			T	

Review of Belomo 10× Triplet Loupe Magnifier

by Eric Worden

For years I have been using a very cheap Chinese-made loupe in the field. For the price of \$6, I don't complain about it: it gets the job done well enough. But earlier this year I borrowed a friend's high-quality loupe. On seeing that stunningly clear microscopic view, I instantly



developed a craving: I had to have one. Thankfully, I have a mother who still likes to buy me toys for Christmas, and I was recently overjoyed to tear back the gift wrap and find a Belomo brand 10× triplet loupe magnifier. It's a nice device, and now I see all the tiny things with beautiful clarity. Here, I'll share my experience of the loupe with you, with a few notes about shopping, about the usability of the device, and about its optics.

Shopping

First, about shopping: it's not easy. According to various obscure jeweler and geologist forums online, good quality magnifiers are supposedly made by Bausch & Lomb, Zeiss, Nikon, and Belomo. However last October, I found them out of stock almost everywhere I looked. The American, European, and Japanese brands are expensive, with options \$100 and higher. What about Belomo? It is manufactured in the obscure country of Belarus in eastern Europe. Its government is a dictatorship and a vassal state of Russia. Yet, a manufacturer there produces high quality, inexpensive loupes and you can buy direct from Belarus (perhaps). Many sellers on Ebay also offer them for under \$50. My mother was told that she would have to pay a tariff, but none was collected.

Construction

The Belomo device has sturdy steel construction: it clearly will never break. The hinge is tight, but usable. The other cheaper device is partly steel but mostly plastic: it feels robust enough as long as you don't drop it on a hard surface. The cheaper device has a built-in light which is nice sometimes, though it often flickers annoyingly. I discovered that the superior optics of the

	Introduced	Type	Author	Eponym
<i>Arceuthobium douglasii</i>		T		E
Sapindaceae				
<i>Acer circinatum</i>		I		
<i>Acer glabrum</i> var. <i>douglasii</i>		T		E
<i>Acer macrophyllum</i>		I		
<i>Acer negundo</i> var. <i>californicum</i>		T		
Sarcobataceae				
<i>Sarcobatus vermiculatus</i>		T		
Saxifragaceae				
<i>Boykinia occidentalis</i>		T		
<i>Hemieva ranunculifolia</i>		T		
<i>Heuchera cylindrica</i>		T	A	
<i>Heuchera micrantha</i>		T	A	
<i>Lithophragma heterophyllum</i>		T		
<i>Tellima grandiflora</i>		T	A	
Solanaceae				
<i>Nicotiana quadrivalvis</i> var. <i>quadrivalvis</i>		I		
<i>Solanum douglasii</i>		T		E
Valerianaceae				
<i>Plectritis congesta</i>		T		
<i>Plectritis macrocera</i>		T		
Violaceae				
<i>Viola douglasii</i>		T		E
<i>Viola nuttallii</i> var. <i>praemorsa</i>		T	A	
<i>Viola nuttallii</i> var. <i>vallicola</i>		T		
<i>Viola ocellata</i>		T		
<i>Viola pedunculata</i>		T		
<i>Viola sempervirens</i>		T		

	Introduced	Type	Author	Eponym
<i>Ceanothus integerrimus</i>		T		
<i>Ceanothus oliganthus</i> var. <i>sorediatus</i>		T		
<i>Ceanothus papillosus</i>		T		
<i>Ceanothus velutinus</i>		T	A	
Rosaceae				
<i>Amelanchier alnifolia</i>		I		
<i>Aruncus dioicus</i> var. <i>acuminatus</i>		T	A	
<i>Crataegus douglasii</i>		T		E
<i>Dryocallis arguta</i>		I		
<i>Dryocallis glandulosa</i>		T		
<i>Horkelia congesta</i>		T	A	
<i>Horkelia cuneata</i>		T		
<i>Malus fusca</i>		I		
<i>Potentilla bipinnatifida</i>		T	A	
<i>Potentilla douglasii</i>		T		E
<i>Potentilla douglasii</i> var. <i>capitata</i>		T		
<i>Potentilla effusa</i>		T	A	
<i>Potentilla flabellifolia</i>		T		
<i>Potentilla gracilis</i>		T	A	
<i>Potentilla pensylvanica</i>		I		
<i>Prunus emarginata</i>		T	A	
<i>Prunus pumila</i> var. <i>depressa</i>		I		
<i>Purshia tridentata</i>		I		
<i>Rubus leucodermis</i>		T	A	
<i>Rubus nivalis</i>		T	A	
<i>Rubus parviflorus</i>		I		
<i>Rubus spectabilis</i>		I		
<i>Rubus ursinus</i> var. <i>macropetalus</i>		T	A	
<i>Spiraea douglasii</i>		T		E
<i>Spiraea lucida</i>		T	A	
Rubiaceae				
<i>Galium angustifolium</i>		T		
<i>Galium californicum</i>		T		
Santalaceae				
<i>Arceuthobium campylopodum</i>		T		



Douglas-fir needles viewed through the Belomo loupe (left) and the cheap loupe (right). PHOTO: ERIC WORDEN

Belomo device reduce the need for extra lighting. The Belomo device comes with a charming sturdy leather case with a snapping flap; the case does not seal so you must keep it away from dirt. The cheaper device comes with a plastic box that, while not charming, closes completely to exclude dirt.

Optics

The Belomo device says 10× magnification while the cheaper device says 40×. In reality, the two devices deliver the same amount of magnification.

To compare the optics of the two devices, I improvised using my smartphone camera. I changed my camera app settings to save with the highest jpeg quality available, then placed the loupes directly against my phone with the camera lens centered in the loupe's lens. I took many photos of a Douglas fir sprig with each loupe, saving the sharpest image from each one. I cropped the photos to show the same content, and saved the resulting images in the png lossless digital format.

The photo from the Belomo loupe is obviously clearer. Though the two devices have the same magnification, I couldn't capture a clear image from the cheaper device. Much of the problem of the cheaper device seems attributable to chromatic



Chromatic aberration with the cheap loupe. PHOTO: ERIC WORDEN



Grand fir needle damage, seen with the Belomo loupe. PHOTO: ERIC WORDEN

aberration, meaning that different colors of light refract differently and have different focal planes: i.e., it makes rainbows. This aberration is most glaring on the edges of the fir needle, which seems to glow blue on one edge and red on the other. In reality, the colors are shifted and mixed together all through the image, resulting in the muddy overall appearance, while the Belomo image colors are crisp with greater contrast.

I'm enjoying my new toy quite a lot and also included an intriguing photo of some grand fir needles that seem to have been mined by a minute insect, or perhaps a tiny fungus. May you also continue finding new discoveries in our native plants.



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