Castilleja linariifolia

Castilleja

Publication of the Wyoming Native Plant Society

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Announcement: The 2020 Wyoming Native Plant Society Annual Meeting in Laramie is cancelled, we're sorry to report. *Now is a great time to explore native plants close to home!*

Sheltering in Place: Plants Do It!

As we ease out of sheltering in place, we might ponder that some plants have been doing it all along.

Green plants are mainly autotrophs, organisms that get their energy to make organic materials from sunlight. Yet some herbaceous perennial plant species regularly have "no-show years" of remaining below ground all year. This phenomenon has been called **prolonged dormancy** (Lesica and Steele 1994, Shefferson 2009).[1] At face value, a plant that is hunkered down belowground for a whole year makes about as much sense as…social creatures such as Wyoming Native Plant Society members sheltering in place, distant from one another.

Over 52 plant species in 10 plant families have been documented as having prolonged dormancy (Lesica and Steele 1994, Lesica and Crone2007, Shefferson 2009) including many moonworts (*Botrychium* spp.). There is a distinction between belowground years for plants and the sheltering in place practice of people. Perennial plants apparently do not hunker belowground to avoid contagion or one another. In other words, they do not do it in concert but staggered.

A recent paper shows that remaining belowground confers a hedge-betting strategy that favors survival of the individual over current growth and reproduction (Gremer et al. 2012). Authors suggest that it confers net advantage in a variable environment. They found that the fitness advantage is unequal between individuals, and is a net advantage only for shorter intervals such as one year, rather than extended periods of multiple years. In their 24 year dataset from monitoring Bitterroot milkvetch (*Astragalus scaphoides*), they found that individual plants which spent between 10%-20% of years belowground had the highest net reproductive success.

How do they do this? Plants with prolonged dormancy acquire some carbon from their mycorrhizal fungi (Shefferson 2009). The author suggested that saprophytic, non-photosynthetic plant species often become dormant to an even greater extent than autotrophic (i.e., green) dormancy-prone plants. (*Cont. p. 10*)

[1] Prolonged dormancy is not to be confused with the seasonality and year-to-year variation of a species' going dormant at the end of the growing season, or coming out of dormancy at the start of the season.

Above: *Botrychium minganense* (Mingan moonwort) is actually one of the more common moonworts across the state and country, by Ben Legler. See more moonworts and their maps at "Wyoming Field Guide" http://www.uwyo.edu/wyndd/.

In this issue

WYNPS News

Annual Meeting Notice: The Board regrettably cancelled plans for the 2020 Annual Meeting and – setting a record for advance-planning – moved the Laramie preparations to 2021.

2019 Scholarship Announced: The 2020 winners of the Society Scholarship are Sienna Wessel doing restoration research in the Department of Botany, and Madison Crawford doing pollination research in the Department of Zoology, at the University of Wyoming. They received$480 and $500 in scholarship funds, respectively, for their theses work.

New Members: Please welcome the following new members to WYNPS: Benjamin Read, Jackson; Rachel Renne, Missoula, MT; Rory Tendore, Lander.

WYNPS Board – 2020
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Teton Plants: Amy Taylor, Treasurer; (tetonplants@gmail.com). …Check the chapter homepage (https://tetonplants.org/) for events.

Treasurer's Report: Balance as of 25 Apr 2019: Scholarship = $0 after disbursing 2020 scholarships; General = $7903.19. Total = $7903.19.

Message from the President

Greetings!

My warmest thoughts to everyone who reads this as we - and the entire world - deal with a frightening pandemic. For anyone infected with COVID-19, special wishes for you to recover your health quickly. For all caregivers, all healthcare workers and all essential workers, my deepest gratitude for what you do.

For all of us who revere native plants, I'm hoping for the comfort and joy that spring wildflowers bring. My longing for wildflowers intensified when my first April hike was a bit premature for blossoms, but I happily welcomed basal leaves of bitterroot (*Lewisia rediviva*) and dusty maiden (*Chaenactis douglasii*). Widespread plains prickly pear (*Opuntia polyacantha*) will tell you that I was hiking in a xeric area, chosen because it would be snow-free. Early spring wildflowers will appear, providing a much-needed visual treat that reminds us to seek the solace and support of the natural world during this crazy time.

Stay safe and virtual hugs to all!

~Katy Duffy

Left: *Lewisia rediviva* by B. Heidel

Contributors to this Issue: Robert Dorn, Katy Duffy, Bonnie Heidel, Jason Johns, Dorothy Tuthill.

Next Issue: Please send articles and announcements by 15 September to:

Wyoming Native Plant Society
P.O. Box 2449
Laramie, WY 82073

Aquilegia Genetics as a Roadmap to Alpine Evolution

Jason Johns, University of California – Santa Barbara

Aquilegia is a useful evolutionary model group because of its exemplary adaptive radiation story, championed by the advent of the nectar spur, which facilitates both specific and efficient relationships with pollinators. As luck would have it, they also have a relatively short and simple diploid genome, which makes them a nice group to do genetic work on (Kramer 2009).

More tools are available to study plant genetics in other model taxa (like *Arabidopsis thaliana* and some crops like rice and corn), however, due to columbines' exceptional evolutionary history, we have a unique opportunity to use them to answer questions about the genetic basis of plant evolution. They are especially useful for studying traits that appear in this group and not in other model taxa, such as nectar spur petals and extreme alpine adaptation.

Figure 1. *Aquilegia jonesii* by B. Heidel

The focus of my dissertation work is on one particularly anomalous species of columbine, *Aquilegia jonesii* Parry (Jones' columbine) – Figure 1. First, it is the most alpine adapted species for which a reference genome currently exists. As many of you know, it grows from ~8000-14000 feet at the top of limestone peaks, well above the timberline, and has the adaptations to withstand such a challenging environment. Another anomalous trait of this species is that it is the only columbine to not make the unique fifth floral whorl seen in every other species, which is a grouping of modified stamens that surround the carpels in a membranous sheath, staminodia. Preliminary data suggests that staminodia may be associated with anti-herbivory (Voelckel et al., 2010).

The purpose of the 2018 collecting trip was to collect leaves and seeds from alpine columbines (*Aquilegia*) for both genetic analysis and subsequent experiments in the greenhouse at the University of California Santa Barbara. Over the course of about four weeks, I collected leaves and seeds from 322 and 150 individuals, respectively, from 27 different populations across the western United States. Funding from WYNPS went to gas, oatmeal, peanut butter sandwiches, and rice and beans. I was able to camp for free thanks to my 1988 cab-over camper and the USFS, which allows camping on any forest turnoff for free.

Because the WYNPS funded the alpine adapted portion of my research, I will focus on those traits. The most conspicuous of these is *Aquilegia jonesii*'s tiny vegetative stature (dwarf), while importantly still producing robust flowers and fruits. It also makes waxy leaves and stomata on the upper leaf surface, which are common alpine traits (Köerner 1999). Making stomata on the upper leaf surface is a trait that

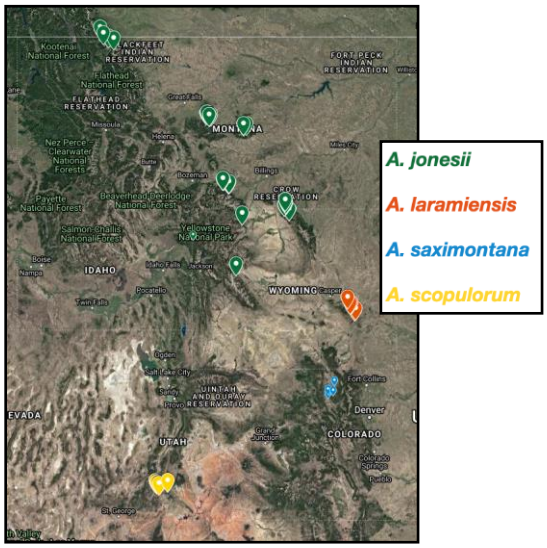

Figure 2. Collection localities from both 2018 & 2019 trips.

has been previously characterized for alpine plants, but hadn't been characterized in *A. jonesii* previous to my observations. Interestingly, it is the only columbine that I have observed to exhibit this trait and I will be using the methods outlined below to elucidate the genetic basis of this trait and others.

The two initial tools I am using in my study both involve whole genome sequencing. One is to sequence the genomes of every individual of a second generation

(F2) hybrid population from a cross between *Aquilegia jonesii* and *A. coerulea* 'origami' to run a quantitative trait locus (QTL) analysis. The QTL analysis will identify regions of the genome associated with *A. jonesii*'s traits of interest (dwarfism, stomata on upper leaf surface, waxy leaves). The next is to use whole genome sequence from field collected individuals to compare the genome of *A. jonesii* to its closest relatives, looking for alleles (versions of genes) unique to *A. jonesii*. Coupling those two methods of analysis, I will narrow down on a list of potential genes responsible for the previously mentioned traits of interest.

For my 2018 collecting trip, in addition to *Aquilegia jonesii*, I wanted to collect other alpine columbine species closely related, but not as alpine adapted as *A. jonesii*. My route took me from southern Utah to collect *A. scopulorum*, up and along the Colorado River to collect *A. saximontana*, and north to eastern Wyoming to collect *A. laramiensis*. I then made my way across to western Wyoming to collect *A. jonesii* in the Wind River Range, up to the peaks north of Cody, north to the Absaroka-Beartooth Mountains of Montana, up to the Lewis and Clark Mountains, southeast to the Bighorns, then all the way west back to Santa Barbara to start processing samples (Figure 2).

Due to the exponentially lower cost of whole genome sequencing in bulk, I waited to do a large sequencing run until I could do another collecting trip to northern Montana last year to collect *Aquilegia jonesii* toward the northern end of its range. I sequenced these field collected individuals along with 350 plants from my F2 hybrid population once the F2s were mature enough to collect tissue from for sequencing in September 2019.

As one might imagine, sequencing the whole genomes of ~450 plants several times over yields quite a bit of data. I am currently in the throes of analyzing these data, both for the F2 population and the field collected individuals. From the F2 cross I produced a genetic map (R/qtl) to run some initial QTL analyses on the phenotypic data I have collected on a subset of the population. Figure 3 shows one of these preliminary QTL maps, showing a region of chromosome 6 highly correlated with plant size (measured as the area of the plant). I will be collecting phenotypic data on my F2 population for more in depth QTL analyses over the next few months. I will also be looking within QTL peaks to identify candidate genes for downstream expression and potential gene knockout experiments. I am eager to pair these results with the population genetic analyses of field collected individuals mentioned previously.

I would like to again express my sincere gratitude to the Wyoming Native Plant Society. Because of your generosity, I have had the opportunity to explore hundreds of miles of the Northern Rockies by foot (many off the trail) and thousands by road (many of them unpaved). I've replaced radiators, axles, and fuel pumps in parking lots, seen some very wild places, and met all kinds of good people along the way. I hope to have an opportunity to meet some of you in person, and I look forward to sharing more results with you as they emerge.

(*Editor's note: Jason Johns is 2018 recipient of the WYNPS Markow Scholarship. He is pursuing his dissertation at the University of California – Santa Barbara*.)

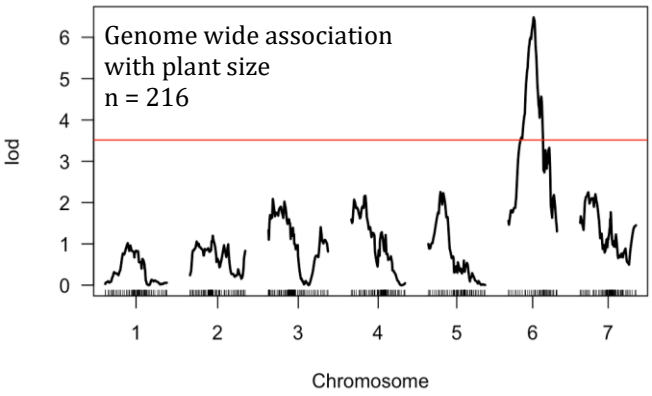

Figure 3. QTL map of plant size. 'lod' scores indicate the association of plant size with a particular genomic region. The red line represents 5% lod false discovery rate; n=216

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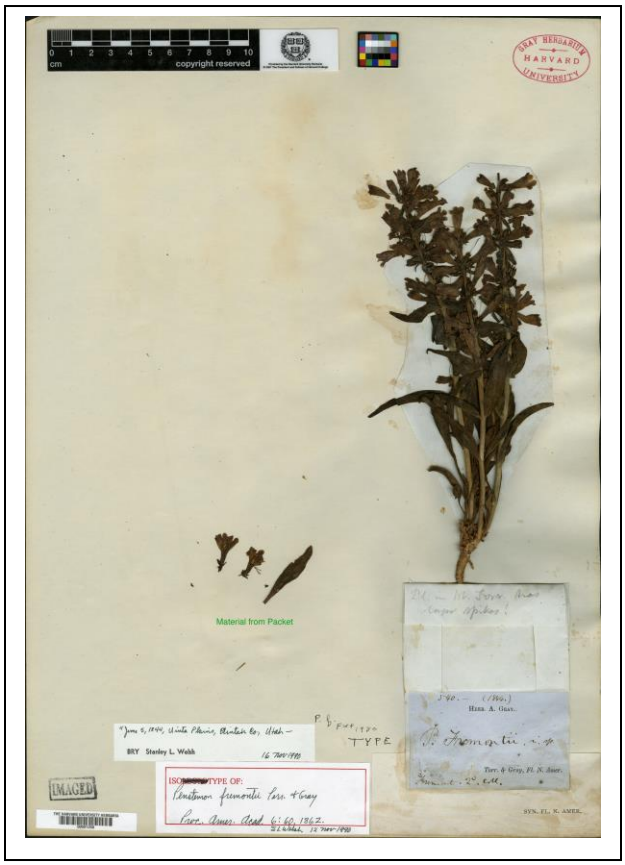
Botanists' Bookshelf

Good reading, not necessarily about plants

Review by Dorothy Tuthill, Biodiversity Institute (Reprinted from RM Friends newsletter, Vol. 5, No. 4 of April 2020)

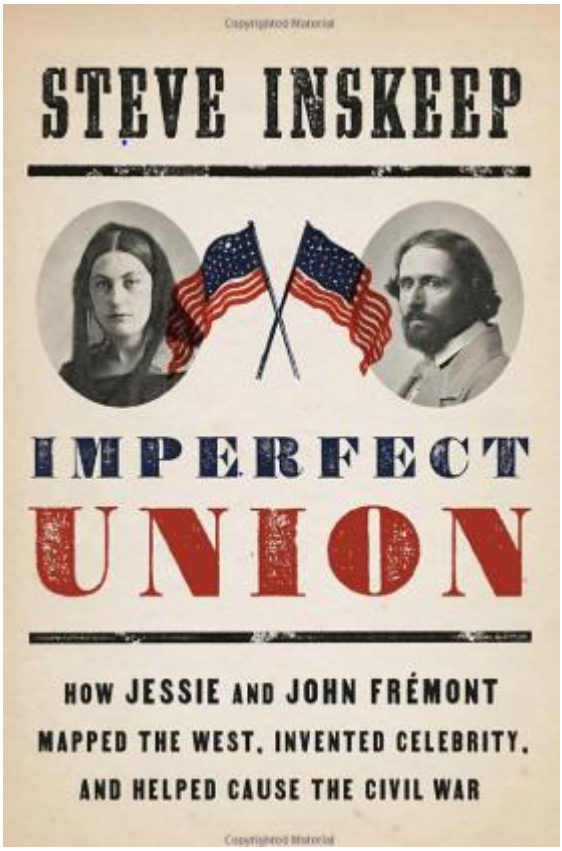
Imperfect Union: How Jessie and John Frémont Mapped the West, Invented Celebrity, and Helped Cause the Civil War. By Steve Innskeep, 2020. Penguin Press, New York, NY. ISBN 9780735224353.

The proverbial *everyone knows* that John Charles Frémont collected the plant that was to become the type specimen of Wyoming's state wildflower, *Castilleja linariifolia*. The year was 1842, and Frémont was leading his first expedition to the west; his goal was South Pass "with a view to the establishment of a line of military posts." Frémont's expeditions were regularly beset by disaster, including to his plant specimens, but a number survived.



Above: *Penstemon fremontii* (Torr. & Gray ex Gray) is named in honor of its discoverer, John C. Fremont. This is the 1844 type specimen (Fremont 540 GY) collected in what is now Utah.

In Wyoming, we have Fremont's goosefoot (*Chenopodium fremontii*), Fremont's dwarf mountain ragweed (*Senecio fremontii* var. *blitoides*), Fremont's stickseed (*Lappula fremontii*), Fremont's bladderpod (*Physaria fremontii*) and Fremont's beardtongue (*Penstemon fremontii*) as reminders of his trespass. Yet J.C. Frémont was far more than a plant collector. With aid from his wife Jessie Benton Frémont, John became one of the most famous men of his time, an adventurer and explorer, and a presidential candidate. This new book about the Frémonts tells a story that us plant-people are less familiar with, a story of ambition, fame and politics in 19th century America.



Left: John C. Fremont ascended Fremont Peak, proclaiming it the highest peak in the Rockies. At 13,751 ft, it is third highest in Wyoming, one of many landforms and place names that bear his name.

Add THIS to your Playlist

By Bonnie Heidel, WYNDD

There's a new online tool that plays the Wyoming flora! It won't crank out your favorite songs or provide a platform to chat with friends, but it WILL download the Wyoming flora by many search criteria of your choosing, in a way that you can use for studies, environmental reviews, or for producing checklists.

At a glance: the current Wyoming flora is maintained and posted by Rocky Mountain Herbarium http://rockymountainherbarium.org/index.php/research/checklists by Nelson (2018): The checklist is posted as a pdf file, a spreadsheet, and portions of it can also be generated for any given part of the state by using the RM Specimen Online Database (drawing a polygon).

IN ADDITION, a new Species List Application is posted by Wyoming Natural Diversity Database (WYNDD) at: https://wyndd.org/species_list/ using exactly the same list and nomenclature as RM (see RM homepage announcement, this issue). It has the benefit of also:

- Including the capacity to search and sort by agency designations/status (Endangered Species Act of U.S. Fish and Wildlife Service, U.S. Forest Service sensitive species of Region 2 and Region 4, BLM Sensitive species) or else by state ranking and scoring (Wyoming Species of Concern). All species that fall in any of these categories can also be queried by their distribution – whether by county name or by public land name.
- Rare plant species (above categories) are hotlinked to take users directly between the Species List Application and the Wyoming Field Guide.
- The non-native flora (Hartman and Nelson 2017) is another sorting category.
- The list outputs can be formatted on the fly and exported into spreadsheets or pdf formats.

The entire flora can also be queried by wetland plant indicator values, if you are doing wetland projects, or looking to find out which weeds or rare plants are in wetlands. .

Many botanists like to play around with lists – this is a handy tool to build study area checklists, downloading it as a spreadsheet, and then add a column to keep a running record of collections. After completing collecting work in the field, and updating the spreadsheet, then a quick "sort" operation will generate a checklist free of spelling errors in scientific and common names – voilá.

Above: *Abies concolor*, by Ben Legler

FROM *ABIES* TO *ZUCKIA*

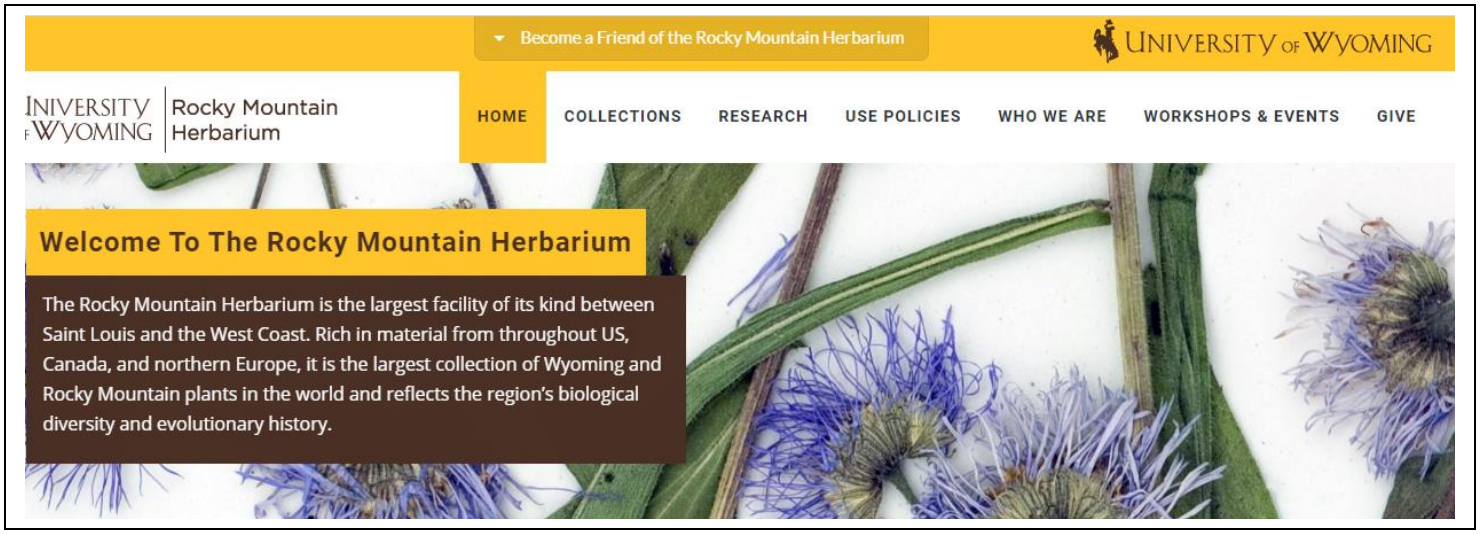
The new WYNDD Species List Application now includes representation of the entire state vascular plant flora, from A(bies) to Z(uckia), posted at: (https://wyndd.org/species_list/). The scientific and common names are consistent with the Rocky Mountain Herbarium, and the Plants Database, respectively. Use it to keep track of plants that you see, or to generate customized lists for an area by multiple criteria (e.g., do a search for U.S. Forest Service Sensitive species of Counties A and B).

Lists also have direct links to species accounts, so that you can go back and forth between the checklist output and species-specific information on rare species, including photos (above).

Literature Cited

Hartman, R. L. and B. E. Nelson. 2017. Working List of Invasive Vascular Plants of Wyoming, 3rd ed. Posted online at: : http://rockymountainherbarium.org/index.php/research/checklists

Nelson, B. E. 2018. Checklist of the Wyoming Flora following nomenclature of the Rocky Mountain Herbarium. Rocky Mountain Herbarium, University of Wyoming, Laramie, WY. Posted online at: http://rockymountainherbarium.org/index.php/research/checklists



The New Face of the Rocky Mountain Herbarium

By Dorothy Tuthill, Biodiversity Institute

(Reprinted from RM Friends newsletter, Vol. 5, No. 4 of April 2020)

The RM has a new, expanded, and attractive website, as befits its status of one of the great herbaria of North America! At the new site, http://rockymountainherbarium.org/, you will find information about the RM, its use policies, strategic plan, and past and present research. The RM database search platform has not changed, but the new site provides additional search opportunities for the non-vascular plants and non-plants, with direct links to the lichenological, mycological and bryological search portals. Additional links are available to the UW Libraries Digital Herbarium and other UW library-based botanical resources. The RM Friends are now included within the site, with enhanced opportunities to join the Friends. As is appropriate with an up-to-date website, it is not finished yet. We have more material to transfer to the new site and to build from scratch. Watch the Events and Workshops page for opportunities to join us, once we are again able to come together for plant-based fun! This much-needed upgrade was made possible by the UW Biodiversity Institute, which donated the time and expertise of their web developer.

And there's more!

The RM is a charter member of the newly-formed University of Wyoming Natural Science Collections Partnership, a consortium of—you guessed it—the natural science collections housed on campus, plus UW Libraries, the Wyoming Natural Diversity Database, and the Biodiversity Institute. The goal of the UWNSCP is to promote a broader understanding and appreciation for the role of natural science collections in stewardship of natural resources, through enhanced education, research and outreach at the University of Wyoming. The partnership can be reached at http://naturalsciencecollections.org/, or directly from the new RM homepage.

Oregon Buttes Flora *and* Fauna

Oregon Buttes and the adjoining Whitehorse Creek landscapes are located along the historic Oregon Trail, current wilderness study areas (WSAs) once at the boundary of "Oregon Territory." They were focus of interdisciplinary inventory by Wyoming Natural Diversity Database staff, documenting over 400 native species of plants and animals – from birds, bats, bees and butterflies to small mammals, submerged aquatic insects ***and*** vascular plants. You can get all the checklists from the online report (http://www.uwyo.edu/wyndd/_files/docs/reports/wynddreports/19hei02.pdfhttp://www.uwyo.edu/wyndd/_files/docs/reports/wynddreports/19hei02.pdf), or the plants through the RM online database.

Lewisia rediviva in bloom atop Oregon Buttes, by B. Heidel

Growing Native Plants

Part 36. More Rock Garden Plants

By Robert Dorn

Eriogonum flavum, Yellow Wild buckwheat, is a tufted perennial to 12 inches tall and wide. The leaves are basal and to 3 inches long. The flower stems are several to many with small yellow flowers in a dense cluster at the tip of each stem. The flowers appear from June to August depending on elevation. The plants occur naturally on dry, open, barren slopes and ridges in the plains, basins, valleys, and mountains. They prefer full sun and dry, rocky, clay soils. It can be grown from seed. Cover lightly for some light exposure.

Eriogonum flavum, Goshen County

Oenothera cespitosa, Fragrant Eveningprimrose, is a perennial with a deep taproot and is to 8 inches tall and 12 inches wide. The leaves are all basal, to 7 inches long and 1.5 inches wide, and form a rosette. The flowers are white and then fade to a deep pink, to 4 inches across, and borne singly from the basal rosette of leaves with many flowers per plant. They open in the evening and wilt by the middle of the next day. They appear from April to August depending on elevation and variety. The plants occur naturally in dry, open, often barren areas of the plains, basins, valleys, and mountains. They prefer full sun and tolerate many soils. They are alkaline and drought tolerant. It can be grown from mature seed sown as soon as collected. Sow .25 inch deep or less. They are difficult to transplant. It is in the nursery trade.

Oenothera cespitosa, Garfield Co., UT

Phlox hoodii, Hood Phlox, is a perennial forming small mats to 6 inches across, or rarely to several feet across, and to 3 inches tall. The leaves are small, narrow, and somewhat prickly. The flowers are white to pinkish, to 0.5 inch across, and often nearly cover the entire mat. They appear from April to June. The plants occur naturally in dry, open places of the plains, basins, valleys, and lower mountains. They prefer full sun and dry, well drained soils. It can be grown from seed surface sown outdoors in the fall.

Phlox hoodii, Albany County

Physaria acutifolia, Pointed Twinpod, is a perennial to 8 inches tall and wide with several to many flower stems arising from a basal rosette of leaves. The leaves are gray-green, the basal to 4

inches long and 2 inches wide. The flowers are yellow, to 0.5 inch long, and scattered along the upper part of the stem. They appear in May and June. The plants occur naturally in dry, open areas in the plains and basins often in clay soils. They prefer full sun and dry soils. They tolerate a variety of soils and are alkaline tolerant. It can be grown from seed covered lightly. Seed is commercially available.

Stenotus armerioides, Thrifty Goldenweed, is a perennial to 10 inches tall forming loose mats to a foot or more across. The leaves are narrow, to 3 inches long, and mostly basal. The ray and disk flowers are yellow, the flower heads to 2 inches across, and solitary at the tip of the many stems. They appear from May to July. The plants occur naturally in dry, open places in the plains, basins, and valleys. They prefer full sun and dry, well drained soils. It is easy to grow from seed.

Physaria acutifolia, Sweetwater County

Stenotus armerioides, Platte County

To see the above plants in color, go to the newsletter on the Society website.

Ronald L. Hartman Excellence in Wyoming Botany – Call for Nominations

Now is a fine time to look for inspiration, and nominate those who inspire us! The WYNPS Excellence Award, dedicated to Ronald Hartman in 2015, recognizes the contributions of professional and amateur botanists and Society members to the mission of the Wyoming Native Plant Society: Promoting appreciation and conservation of Wyoming native plants and vegetation. The award is limited to persons who have made exceptional contributions to botanical knowledge or to the Society.

Nominations can be made by committee or by any members – look for committee contacts in fall. The 3-member committee is appointed by the current president, and will include at least one current Board member and one past board member. The committee is responsible for vetting nominations from members, providing additional supporting documentation as needed, making nominations and preparing publicity.

In addition to nominations from the committee, nominations are solicited from WYNPS members through the newsletter. It only requires that a nomination be submitted by email or mail to a committee member or online, addressing an individual's contributions, and including contact information of the nominator.

Continued from p. 1

This is more than a matter of idle curiosity when it comes to plant conservation and population trends. Not only are some plants hard to find if they are not in flower, it is impossible to observe them if they are belowground. This makes a one-year census of a species with prolonged dormancy incomplete. Moreover, even if that census were repeated for a second year, it is impossible to know if a plant present the first year died in the second year or is having a no-show year belowground. *Even though plants do not move, they may hide.*

This is another example that plants are not as easy to understand as we might think …at a glance! bh

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Wyoming Native Plant Society is a non-profit organization established in 1981 to encourage the appreciation and conservation of the native plants and plant communities of Wyoming. The Society promotes education and research through its newsletter, field trips, annual student scholarship and small grants awards. Membership is open to individuals, families, or organizations. To join or renew, please return this form to:

Wyoming Native Plant Society
P.O. Box 2449
Laramie, WY 82073

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Check one: [ ] New member [ ] Renewing member

[ ] Renewing members, check here if this is an address change.

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Membership

[ ] WYNPS annual membership: $10.00

[ ] WYNPS annual membership + scholarship support: $20.00 ($10.00 for membership and $10.00 for Scholarship fund)

[ ] WYNPS Lifetime membership: $300 ($150 for membership and $150 for Scholarship fund)

[ ] Sublette Chapter annual membership: $5.00

[ ] Teton Chapter annual membership: $5.00

Total enclosed: _____ THANK YOU!

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