

***LOMATIUM REFUGIANUM* (APIACEAE),
A NEW SPECIES FROM THE CASCADES OF WASHINGTON STATE**

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ABSTRACT

Lomatium refugianum Darrach & Brill, **sp. nov.**, is a narrowly endemic species on unglaciated felsic to mafic volcanic and hypabyssal intrusive substrates of the early Miocene Fife's Peak Formation along the east slope of the Cascade Mountains in Yakima Co., Washington. The species is closely similar both morphologically and genetically to *Lomatium papilioniferum*. Mature *L. refugianum* plants are distinguished from *L. papilioniferum* by their much smaller stature, fewer and largely planar leaves, crowded leaflet arrangement, lack of retained senescent peduncles, fewer inflorescences, fewer mature fruit, and longer fruit with a significantly greater aspect ratio. The species is known from four populations at subalpine to alpine elevations. The population at the type locality area is the largest and is composed of approximately 3000 individuals. All plants are within the W.O. Douglas Wilderness of the Okanogan-Wenatchee National Forest. The species is of conservation concern, but short-term threats to the species appear to be minimal.

Lomatium is the largest genus in Apiaceae in North America with approximately 100 species (FNA v. 13 2024). Over the last three decades over a dozen newly-described species attest to the reality that *Lomatium* remains a challenging genus with a wealth of biodiversity surely yet to be described.

Morphological and molecular investigations (George et al. 2014; Smith et al. 2018; Ottenlips et al. 2020; Ottenlips et al. 2021) have allowed for new circumscriptions. Recently described species include *L. tamanitchii* Darrach & Thie (2010), *L. ochocense* Helliwell (2010), *L. bentonitum* Carlson & Mansfield (Carlson et al. 2011), *L. pastorale* Darrach & Wagner (2011), *L. brunsfeldianum* McNeill et al. (2012), *L. swingeriae* McNeill (2014), *L. tarantuloides* Darrach & Hinchliff (2014), *L. knokei* Darrach (2014) and *L. roneorum* Darrach (2018).

Lomatium refugianum was first encountered and recognized as unusual on and around Mt. Aix in western Yakima Co., Washington, by naturalist/botanist Gary Brill in 2015. Later investigations in the general area by David Giblin in 2021 revealed the presence of a large population of the plants in a much more easily accessible location. Study of further collections revealed consistent character differences with other taxa in the genus.

LOMATIUM REFUGIANUM M.E. Darrach & G.A. Brill, **sp. nov.** **TYPE: USA. Washington.** Yakima Co.: 2.41 km ENE of summit of Burnt Mtn., William O. Douglas Wilderness, Okanogan-Wenatchee National Forest, 47.714603° N, 121.166541° W, codominant on open gentle to steeply-sloped felsic ashflow tuff, weathered basalt and weathered andesitic volcanics, 5% slope, aspect ~145°, elev. 1930 m (6330 ft), 21 Jul 2022, *M.E. Darrach 1296* (holotype: WTU; isotypes: NY, US, SRP). Figures 1–9.

Lomatium refugianum combines character states distinct from all other species of the genus. Characters in the following table are diagnostic in discriminating *Lomatium refugianum* from its phenotypically similar and phylogenetically sister species *Lomatium papilioniferum* Alexander & Whaley.

Table 1. Character distinctions between *Lomatium refugianum* and *Lomatium papilioniferum*

Character	<i>Lomatium refugianum</i>	<i>Lomatium papilioniferum</i>
<i>Leaflet Crowding</i>	Typically Strongly Crowded	Typically Diffuse
<i>Leaflet Distribution</i>	Typically Planar Distribution	Distributed in 3-Dimensions
<i>Terminal Leaflet Pattern</i>	Strongly Pseudo-fasciculate	Open, non-fasciculate
<i>Number of Leaflets Per Leaf</i>	Ranging From 100 – 1,800	Ranging From 300 – 4,000
<i>Plant Size & Stature</i>	Sub-pulvinate	Fruticose
<i>Plant Height</i>	Range: 4–17 / Ave: 10 cm	Range: 28–46 / Ave: 35 cm
<i>Mature Mericarp Aspect Ratio</i>	Range: 1.5 – 3.8 / Ave: 2.4	Range 1.5 – 3.2 / Ave: 1.8
<i>Mericarps Per Umbellet</i>	1 – 9 / Ave: 4	4 – 18 / Ave: 10
<i>Retention of Peduncles</i>	No retention from previous years	Previous Years Retained

Long-lived perennial herbs, pseudoscape wanting, herbage pungently aromatic when crushed. Plants 4–17 cm in height with typical plants approximately 10 cm tall when in mature fruit. Plant stature increasing somewhat from anthesis through to fruit maturity. **Roots:** taproot (Figure 5), lacking swellings, plants difficult to excavate owing to wedging into rock joints with longest excavated root 22 cm long, width ranging from 5.5–20 mm in breadth at maximum diameter. Roots surmounted by a buried crown with a multicapital caudex in mature specimens (Figure 2). Annual root crown scars usually prominent and generally easily counted with ages evaluated ranging from 36–128 years (Figure 5). **Leaves:** a few cm of old sheathing leaf bases usually retained and present just below the soil surface typically somewhat obscuring the root crown, leaves 6–40, most typically about 15–20, compound, ternate-bipinnate to pinnate-1 pinnatifid to weakly ternate tripinnate (Figure 6). **Leaflets:** entire, oblong to broadly or narrowly triangular in outline, crowded, strongly and irregularly minutely pappillate with pappillae non-photosynthetic (Figure 7). Most terminal leaflet clusters somewhat to strongly sub-fasciculate, venation obscure. Number of leaflets per leaf ranging from approximately 100–1,800. Leaf blade dimensions 1.1–8.4 cm in length excluding petiole x 0.7–6.7 cm in width, leaf blade outline quadrate-rhomboidal, elliptical to broadly elliptical, oblong, or triangular. Leaf winged petiole proximal portion 0–4.9 cm long, leaf unwinged petiole distal portion 0–6.6 cm long. Leaf winged portions herbaceous photosynthetic to laterally non-photosynthetic scarious-stramineous or

chartaceous with age. Prominent nerves on winged petioles 7–16. Leaves largely planar. **Inflorescences:** compound umbel, 1–10 with 2–8 being typical; peduncles terete, strongly spreading to nearly prostrate to ascending semi-strict or becoming semi-strict distally from a sigmoidally spreading base. 4.5–17.3 mm at maturity, elongating approximately 20–40% with age as fruit develops; involucre bracts wanting. Peduncles equaling to significantly exceeding the leaves as the infructescence approaches maturity. Rays equivalent to number of umbellets 2–12 with typical range 5–9, unequal in length at maturity and in flower. Rays per inflorescence that are entirely ♂ 0–11, rays of mixed sex 0–8, rays that are entirely ♀ 0–9, but uncommon. The large majority of individual flowers are either ♂ or ♀, hermaphroditic flowers are rare. Ray length range for all rays in flower (composite of ♂, ♀ and mixed ♂/♀) 2.5–23.0 mm, average ~10 mm. Ray length range for all rays in fruit (composite of ♂, ♀ and mixed ♂/♀) 4.5–50.0 mm, average ~20 mm. Thus, on average, rays elongate upon maturity by ~100%. The shortest rays usually bearing umbellets with entirely male flowers that do not tend to lengthen with plant maturity. These short, staminate umbellets are typically clustered at the umbel center, they are irregularly deciduous by maturity and tend to bear fewer flowers. Umbellets 1–26 with typical range of 13–21 on most specimens. **Involucel:** bracts free to base or occasionally fused for about 1mm proximally, herbaceous to scarious with a green photosynthetic nerve, glabrous to moderately papillate, very narrowly lanceolate to linear, rarely branched (Figure 8); bract number 0–7 with typically values of 3–5, distribution dimidiate to occasionally radial. Involucel bracts 0.5–4.0 mm in length, 0.1–0.6 mm in width. **Flowers:** monoecious on all plants evaluated, but some plants or individual inflorescences may be weakly andromonoecious or polygamo-monoecious. Male flower pedicels smooth, glabrous, 1.3–3.3 mm, female flower pedicels smooth, glabrous, 1.3–4.0 mm. Female flowers have very short but well-developed triangular calyx teeth that senesce as the fruit matures; male flowers typically have more obscure to wanting calyx teeth. Flowers glabrous 8–25 per umbellet with values of 11–19 typically encountered, flower sex per umbellet widely variable with female flowers ranging from 0–15 and male flowers ranging from 1–25. Petals bright yellow, 0.7–1.3 mm long, 0.6–1.1 mm wide, ovate with an adaxially strongly incurved short apiculus 0.4 mm; stamens 5 and alternating with the 5 petals, anthers bright yellow, 0.5–0.7 mm long x 0.4–0.5 mm wide with thecae sutures finely papillate under 20x magnification, filaments 1.2–1.5 mm. Stylopodia poorly-developed, greenish yellow to green, becoming reddish purple post-pollination. Styles rounded, strongly curved, divergent 1.1–2.0 mm; ovaries green and glabrous. **Fruit:** glabrous, very loosely hemispherically arranged with 0–9 fruit per umbellet; 4–6 being the most typical range, pedicels on mature fruit irregularly spreading-ascending to suberect, 3.5–10.1 mm with typical values of 4.3–7.3 mm encountered on most specimens. Mature fruits 7.3–12.8 mm long with typical material 8.3–10.9 mm, 2.8–5.7 mm wide with typical material 3.4–5.0 mm (Figure 9). Fruit wing width 0.5–1.2 mm, papery, not thickened. Fruit strongly dorsi-ventrally compressed, typically with obtuse base and distal acute margin. Fruit aspect ratio 1.5–3.8. Fruit shape most typically oblong, but ranging to broadly to narrowly elliptical. Fruit colour with intervals a rich tannish brown, ribs tan coloured and wings a contrasting paler tan. Dorsal fruit surfaces with 3–5 well-developed ribs flush with the fruit surface; vittae obscure, 2–4 in the intervals, typically 4 along the commissure, 0–2 on the wings. **Carpophore:** cleft to the base, persistent. A composite illustration of the plant derived from the holotype specimen and photographs is provided in Figure 1.

Paratype: Washington. Yakima Co.: Burnt Mountain, 46.70699, -121.21198, 1797 m (5,895 ft), 15 Jul 2020, *Giblin 76290* (WTU)

Etymology. The epithet “refugianum” alludes to the species's restriction to pre-ice age erosional surfaces — refugia — that escaped glaciation during Pleistocene glacial stages. The species has not been found at any sites where glacial scouring resulted in a primary successional reset.

Habitat. *Lomatium refugianum* is known from four populations in subalpine-alpine habitats. Three of the populations have less than a few hundred plants. The type locality population has approximately 3,000 plants, documented during a multi-person census conducted on 7 July 2022.

Range. *Lomatium refugianum* is known from very small suitable sites embedded within an approximately 75 km² overall polygon in the east-central Cascade Mountains of Yakima County (Fig. 10).

In an effort to quantify the possible extent of suitable habitat for the species, J. Glant obtained a clipped LIDAR-based digital terrain model (WA-DNR 2022) from the Washington Department of Natural Resources (WA-DNR) and used these data as the foundation for raster creation of elevation and aspect variables. These data were in turn overlain with a spatial geologic unit data raster obtained from the WA-DNR Division of Geology and Earth Resources for the 1:100,000 scale geologic map of the Mt. Rainier Quadrangle (Schasse 1988). Elevation raster data was constrained to values at or above 1,768 meters (the lowest known elevation for the species) and aspect data was confined to the range 112.5° to 202.5° which corresponds to the known aspect breadth on the ground for the species. Geologic units chosen for inclusion in the model correspond with the known lithologies identified on the ground in the immediate type locality area and the other three known populations. These units comprise the late Oligocene–early Miocene intrusive/volcanic complex of the Mt. Aix Caldera, andesites and rhyolite ash-flow pyroclastics of the Fife’s Peak Formation, hypabyssal approximately andesitic lithologies and olivine basalts of Bethel Ridge. These three layers were intersected using Raster Calculator to create a final projected product depicting possible suitable sites for further investigation as depicted in Figure 10. Owing to the fact that the LIDAR digital terrain model is of limited areal extent it is likely that suitable habitat for the species can be modeled further afield with more extensive terrain data. The total area of modeled suitable habitat for the species is approximately 928 hectares which equate to <1% of the evaluated area.

Similarities and relationships. *Lomatium refugianum* is most morphologically similar to *Lomatium papilioniferum* Alexander & Whaley. The two geographically most closely approach each other at the type locality with approximately 9-km and 1050 m in spatial and elevation separation respectively. Table 1 presents character states that separate the two species. Figures 11 and 12 show photographs of *Lomatium papilioniferum*.

Molecular analysis of leaf tissue was conducted by Michael Ottenlips in Dr. James Smith’s lab at Boise State University. The extracted DNA was included in a broader suite of *Lomatium* and allied genera samples in Apiaceae subfamily Apioideae as part of a separate phylogenetic study (Ottenlips et al. 2020). This allowed for a phylogenetic comparison with the putatively closely related *L. papilioniferum* (formerly identified as *L. grayi*, misapplied), which proves to be the sister species to *L. refugianum*.

Phenology, ecology, and conservation. Emergence of *Lomatium refugianum* each year probably occurs in mid-May, depending upon snowpack depth and associated year-to-year variation in weather conditions. However, all known population locations are restricted to barren exposed windswept ridgeline sites where snowpack is likely to be reduced or even largely absent. Thus, plants may sometimes emerge earlier as soil temperature and light conditions allow. Plants are at anthesis from late June through early to mid-July and are in full fruit by mid to late July and into early August. By mid-August dormancy sets in and the above-ground portions of the plants senesce and become largely unrecognizable.

As with other recently described *Lomatium* species (Darrach & Wagner 2011; Darrach & Hinchliff 2014; Darrach 2014), *L. refugianum* is a long-lived perennial species. Analysis of well-defined annual root crown scars on 11 specimens yield ages ranging from 36 to 128 years with an average of 88 years and 1 standard deviation of 25 years. Figure 5 shows the cleaned taproot of *Darrach 1265* with well-defined root crown scars.

Distances between the four known localities range from 3 to approximately 20 km. Population health at the type locality site appears to be excellent with strong recruitment and a range of reproducing plant size classes suggesting that recruitment is most probably consistent.

While the species is clearly of conservation concern based upon rarity, observations at the type locality indicate that neither invasive species nor habitat disturbance are significant threats. The most salient concern for the species is what role climate disruption may play for the species. Subfamily Apioideae taxa, including *Lomatium*, are considered to be an obligate multi-cycle protogynous outcrossing group (Schlessman & Barrie 2004) — the presence of numerous recruits at the type locality suggests that pollination is adequate.

Table 2. Vascular plant species associated with *Lomatium refugianum* at the type locality

<i>Family</i>	<i>Species</i>	<i>Family</i>	<i>Species</i>
Amaryllidaceae	<i>Allium acuminatum</i>	Ericaceae	<i>Arctostaphylos nevadensis</i>
Apiaceae	<i>Lomatium brevifolium</i>	Fabaceae	<i>Astragalus whitneyi</i>
Apiaceae	<i>Lomatium watsonii</i>	Fabaceae	<i>Lathyrus lanszwertii</i>
Apiaceae	<i>Sanicula graveolens</i>	Fabaceae	<i>Lupinus latifolius</i>
Asteraceae	<i>Achillea millefolium</i>	Hydrophyllaceae	<i>Hydrophyllum capitatum</i>
Asteraceae	<i>Artemisia michauxiana</i>	Hydrophyllaceae	<i>Phacelia hastata</i>
Asteraceae	<i>Crepis sp.</i>	Lamiaceae	<i>Monardella odoratissima</i>
Asteraceae	<i>Ericameria greenei</i>	Orobanchaceae	<i>Castilleja thompsonii</i>
Asteraceae	<i>Erigeron linearis</i>	Plantaginaceae	<i>Penstemon fruticosus</i>
Asteraceae	<i>Eriophyllum lanatum</i>	Poaceae	<i>Bromus carinatus</i>
Asteraceae	<i>Hieracium cynoglossoides</i>	Poaceae	<i>Elymus elymoides</i>
Asteraceae	<i>Senecio integerrimus</i>	Poaceae	<i>Melica bulbosa</i>
Asteraceae	<i>Stenotus lanuginosus</i>	Polemoniaceae	<i>Collomia tinctoria</i>
Brassicaceae	<i>Boechera sp.</i>	Polemoniaceae	<i>Phlox diffusa</i>
Brassicaceae	<i>Noccaea fendleri</i>	Polygonaceae	<i>Eriogonum pyrolifolium</i>
Brassicaceae	<i>Physaria alpestris</i>	Polygonaceae	<i>Eriogonum umbellatum</i>
Caprifoliaceae	<i>Symphoricarpos oreophilus</i>	Ranunculaceae	<i>Delphinium glareosum</i>
Caryophyllaceae	<i>Moehringia macrophylla</i>	Rubiaceae	<i>Galium sp.</i>
Cupressaceae	<i>Juniperus communis</i>	Saxifragaceae	<i>Heuchera cylindrica</i>
Cyperaceae	<i>Carex rossii</i>	Violaceae	<i>Viola purpurea</i>

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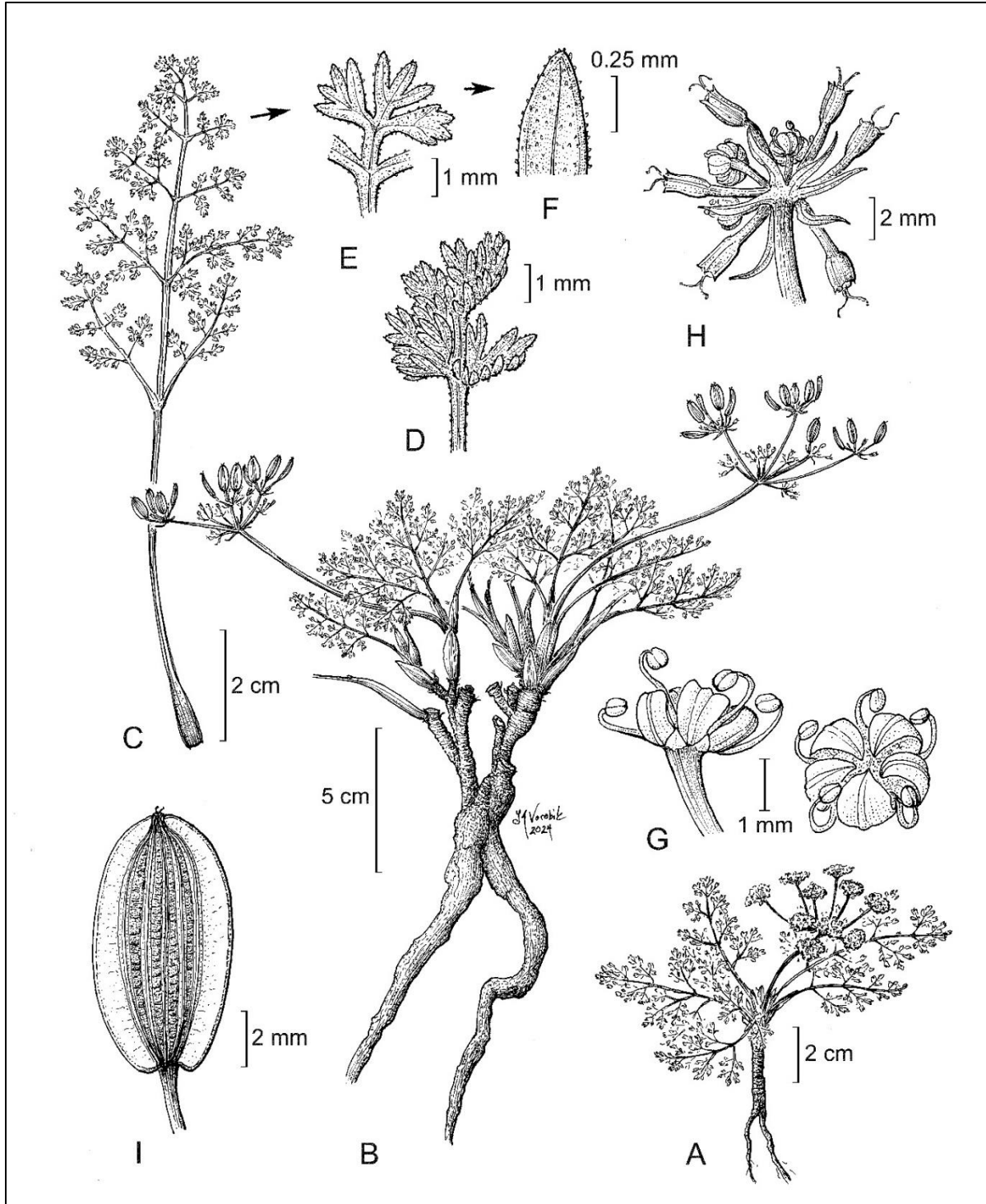


Figure 1. *Lomatium refugianum* Darrach & Brill. A. Habit of plant in flower. B. Habit of plant in fruit. C. Leaf. D. Close-up of leaflet tip in natural position. E. Close-up of pressed leaflet tip. F. Leaflet vestiture close-up. G. Flower close-up. H. Immature umbellet with involucrel. I. Mature schizocarp. Illustration by Linda Ann Vorobik from HOLOTYPE! and supplied images.



Figure 2. *Lomatium refugianum*. Typical plant.



Figure 3. *Lomatium refugianum*. Typical in situ plant at the type locality.



Figure 4. *Lomatium refugianum*. Typical habitat at the type locality.



Figure 5. *Lomatium refugianum* taproot morphology showing distinct annual root crown scar rings. This plant is estimated to be ~128 years of age.



Figure 6. *Lomatium refugianum*. Typical leaf morphology.



Figure 7. *Lomatium refugianum*. Typical leaflet morphology, showing abundant triangular non-photosynthetic papillae.



Figure 8. *Lomatium refugianum*. Involucels.



Figure 9. *Lomatium refugianum*. Mature fruit.

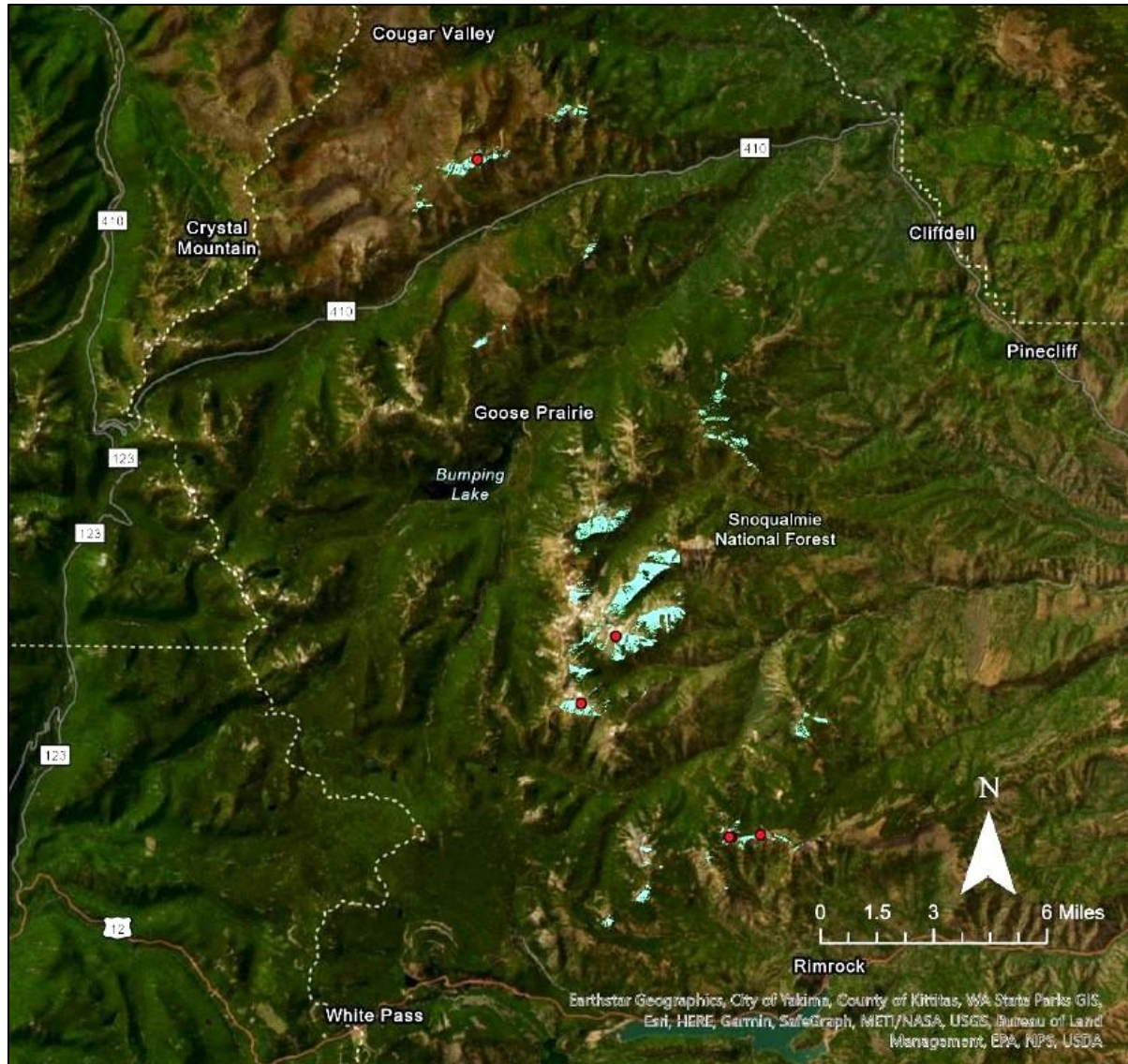


Figure 10. Possible range of *Lomatium refugianum* (turquoise). White dashed lines are county boundaries. US Hwy 12 crosses the bottom portion of figure. Mount Rainier stratovolcano and national park is closely adjacent to the northwest off the edge of the image. Red dots are the known population sites. The type locality is at lower right in the figure. The turquoise-coloured polygons are GIS habitat model outputs representing potential suitable unsurveyed habitat for the species.



Figure 11. *Lomatium papilioniferum*. A typical stand in Klickitat Co., Washington.



Figure 12. *Lomatium papilioniferum*. Typical *in situ* plants, showing numerous senescent peduncles from previous year's blooming.