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LOMATIUM KNOKEI (APIACEAE), A NEW, NARROWLY ENDEMIC SPECIES FROM WASHINGTON STATE

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ABSTRACT

Lomatium knokei Darrach, **sp. nov.**, is a narrowly endemic species of apparent critical conservation concern growing on seasonally wet soils in Kittitas County along the east slope of the Cascade Mountains in central Washington state. The species is distinguished from all other members of the genus by a combination of features of leaf morphology, fruit shape, pedicel length, root characters, and genetic sequencing data. The single known population is confined to three small patches estimated to include a total of an estimated 3000 sparsely to locally densely clustered plants in a vernally wet meadow on South Cle Elum Ridge near the town of Cle Elum. Off-road vehicle threats to the population are serious and ongoing.

Lomatium is by far the largest genus in Apiaceae in North America. Several new species from the USA have been described over the last few years, including *L. ochocense* Helliwell (2010), *L. bentonitum* Carlson & Mansfield (Carlson et al. 2011), *L. pastoralis* D.H.Wagner ex Darrach & Wagner (2012), *L. brunsfeldianum* McNeill (2012), and *L. tarantuloides* Darrach & Hinchliff (2014).

Retired farmer, botanist, and plant collector Donald Knoke, now 94 years of age, of Thorpe, Washington, encountered a species of *Lomatium* with which he was not familiar in a seasonally wet meadow on South Cle Elum ridge in Kittitas County on the east slope of the Cascade Mountains of Washington state in May 2002. The population at this site (type locality) is confined to seasonally inundated deep fine-textured clay loam soils of the colluvial and basalt bedrock derived argixeroll class Hakker Series (WebSoilsSurvey 2014). This site is at approximately 1207 meters on a nearly flat to shallow easterly aspect on the Okanogan-Wenatchee National Forest. Subsequent morphological examination and comparison of specimens with reference material by David Giblin, Mark Darrach, Ben Legler, and other botanists at the Burke Museum Herbarium (WTU), Washington State University (WS), and Oregon State University (OSC, ORE, WILLU) suggested these collections represented a hitherto undescribed species with some morphological similarities to *L. leptocarpum* (Torr. & Gray) Coult. & Rose.

Since its initial discovery, an additional single very small outlier subpopulation along the margins of a seasonally wet meadow approximately 275 meters west of the two main subpopulations was discovered by David Giblin, Peter Zika, and Donald Knoke. The possibility that other sites exist in the general area should be entertained, with particular attention paid to areas with soils in the Hakker Series. Measurements in the description below represent a combination of characters derived from both herbarium material and live plants.

Lomatium knokei M.E. Darrach **sp. nov.** Figures 1 through 7. **TYPE: USA. Washington**. Kittitas Co.: open seasonally wet meadow, 1.87 km ESE of Cle Elum Point, 0.15 km S of FR 3352, 47.136429 N -120.922246 W, common to locally abundant on clay loam substrate, flat or gentle easterly aspects, elev. 1213 m (3979 ft), 20 Jul 2011, *C.E. Hinchliff 1358* (holotype: WTU; isotypes: NY, OSC, RM , UC/JEPS, US, WS,).

Lomatium knokei combines character states distinct from its immediately associated and regionally contiguous congeners and all other recognized members of the genus. The following characters are particularly diagnostic in discriminating between *Lomatium knokei* and other species: plants strict, fruits small and narrowly elliptical on short pedicels, leaves few with ultimate leaflets extremely narrow and generally less than 10 mm in length, younger plants in particular typically with a well-defined small ovoid to elliptical or oblong tuber directly below the root crown.

Herbs: Perennial, long-lived, non-aromatic, glabrous, acaulescent (caulescent), 7.5–35.8 cm in height with typical plants approximately 20 cm in height when in mature fruit. Plant heights increasing approximately 125% from anthesis through to maturity. **Root**: typical specimens (Figure 2) have a small ovoid, ellipsoidal to oblong or turbinate tuber 6.0–15.0 mm broad by 5.0–20 mm in length that becomes a simple or occasionally weakly moniliform taproot distally. Root length 2.0–27.8 cm. Root surmounted by a simple subterranean root crown and a short narrow terete subterranean pseudoscape, 13–43 mm long that is single in all specimens evaluated. Root crown annual scars, when clearly discernable, 3–93 in number reflecting approximate plant age. Typical material approximately 15 years old. **Leaves**: old sheathing leaf bases occasionally present and obscuring up to 25 mm of the root crown, leaves 2–8, most typically 3, venation obscure, glabrous, compound, ternate to biternate-irregularly pinnate, 3.8–17.0 cm wide, 9.1–17.8 cm in length. Petioles 1.4–10.1 cm long with variably developed winged basal portions, winged bases entire, herbaceous with variably green to discontinuously weak to occasionally moderately-developed light purple anthocyanic coloration at the base. Leaf bases becoming stramineous and chartaceous with age, prominent nerves on leaves with winged petioles 6–12. Reduced, ternate irregularly pinnate axillary leaves often present, petioles of these leaves enclosed within broad-winged bases of larger primary leaves, wings lacking or minimally developed, usually entirely lacking nerves. Pressed leaves usually about equally as broad as wide, the leaf outline quadrate, rhombic, or triangular axillary leaves narrowly rhombic. Leaflets spreading, occasionally weakly overlapping, entire, linear-filiform to occasionally very narrowly elliptical, ultimate segments 3–27 mm long with typical values about 10 mm, 0.2–2.3 mm wide with typical values about 1.0 mm. **Inflorescences**: compound, involucre none, numbering up to 6 in the oldest plants, but typically 1 or 2. Peduncles strongly ascending to strict, terete, often weakly and discontinuously anthocyanic at the base. Peduncle length in flower 5.8–19.8 cm with typical specimens around 13 cm, peduncle length in fruit 15.0–36.5 cm with typical values around 23 cm. Peduncles greatly exceeding the leaves as the inflorescence matures with typical increases in peduncle length of approximately 70% at maturity relative to when plants are at anthesis/early fruit. Rays 3–12, unequal in length in flower, grossly so in fruit with increases in longest rays from flower to mature fruit approximately 115%. Minimum ray length per inflorescence in flower 1.0–16.0 mm, maximum ray length per inflorescence in flower 3.7–27.6. Minimum ray length per inflorescence in fruit 1.6–12.0 mm, maximum ray length per inflorescence in fruit 10.7–53.0 mm. Shortest rays usually bearing umbellets with entirely male flowers that do not lengthen with plant maturity. These short, staminate umbellets are frequently somewhat contorted and are clustered at the umbel center, they are irregularly deciduous by maturity and tend to bear fewer flowers. The longer rays bear umbellets that are a mixture of male, female and, to a lesser extent, perfect flowers. Number of rays with entirely male flowers per inflorescence 0–9; typically 2 or 3, number of rays with entirely female flowers per inflorescence 0–7; typically 1 or 2, number of rays with a mix of male, female and perfect flowers per inflorescence 0–9; typically 3 or 4. Male flower pedicels smooth, glabrous, 0.7–2.6 mm in length with typical values about 2.2 mm, female and perfect flower pedicels smooth, glabrous, 0.8–2.2 mm with typical values about 1.2 mm. **Involucel**:

bracts green, herbaceous, narrow to linear, bract number 0–14 with typically values of 5 to 7, distribution radial to irregularly dimidiate. Involucel bracts 1.5–6.4 mm in length, 0.1–0.8 mm in width, glabrous, free to base, often with a well-developed mid-vein, occasionally inserted on flower pedicels. **Flowers**: primarily andromonoecious on most plants, but some plants are polygamo-monoecious, flowers glabrous 6–41 per umbellet with values of 14–20 typically encountered, petals bright yellow, 0.5–1.4 mm long, 0.4–0.9 mm wide, ovate with an adaxially strongly incurved short apiculus; stamens 5 and alternating with the 5 petals, anthers bright yellow to pale yellow, 0.30–0.50 mm by 0.15–0.40 mm, pollen yellow, filaments 0.6–1.4 mm. Stylopodia yellowish green to greenish yellow prior to pollination, becoming reddish purple post-pollination. Styles laterally flattened, 1.5–1.5 mm, strongly curved, outwardly divergent; ovaries green and glabrous. **Fruit**: hemispherically arranged with 0–17 fruit per umbellet; 7 or 8 being the most commonly encountered numbers, the longer rays usually considerably more fecund, pedicels spreading-ascending to semi-erect, 0.8–5.2 mm with typical values of about 2.2 mm encountered on most specimens. Fruits glabrous, 4.0–7.8 mm long with typical material about 6.0 mm in length, 1.6–2.8 mm wide with typical values approximately 2.2 mm. Fruit wing width 0.2–0.5 mm, not obviously thickened, strongly dorsiventrally compressed with rounded base and distal obtuse margin. Fruit aspect ratio 1.91–3.81. Fruit shape elliptical to narrowly elliptical, color greenish tan in the intervals with RGB values ranging from R: 140–212 / G: 115–199 / B: 15–37 (Colorpicker 2014). Dorsal fruit surfaces with 2–4 well-develop nerves flush with the fruit surface; vittae obscure, 4–5 in the intervals, 2 along the commisure, 0 on the wings. **Carpophore**: cleft to the base, persistent. A composite illustration is provided in Figures 1 and 2 and specimen photographs are in Figures 3 through 7.

Paratypes. **Washington**. Kittitas Co.: ca. 200 yards S of FS road 3350, 1.4 mi E of junction with FS road 3350, T19N R15E Sec. 14, N 47° 08.192′, W 120 ° 55.329 ′, 3350 ft, 8 Jun 2003, *Knoke 304* (WTU), 23 Jun 2003, *Knoke 313* (WTU), 8 Jul 2003, *Knoke 317* (WTU), 11 May 2004, *Knoke 423* (WTU), 8 Jun 2005, *Knoke 753* (WTU), 9 Jun 2007, *Knoke 1303* (WTU); ca. 200 yards S of FS road 3350, N 47.13617, W 120.92193, 1206 m (3956 ft), 22 Jun 2013, *Darrach 1016* (WTU), 13 Jul 2013, *Darrach 1030* (WTU).

Etymology. The epithet "knokei" commemorates the much-respected local botanist and plant explorer Donald Knoke, who initially discovered the populations of the new species and made collections.

Habitat. *Lomatium knokei* is known from a single flat to gentle east-aspect, forb-dominated meadow site on fine-grained clay loam seasonally wet soils of the Hakker Series.

Range. *Lomatium knokei* is presently known only from the type locality with a small outlier subpopulation approximately 275 meters immediately to the west. While comprehensive surveys for the species in the general area have not been conducted and are clearly needed, a GIS soils analysis of approximately 100,000 contiguous hectares clearly indicates the host Hakker Series clay loam soil type is rare throughout the area (Web Soil Survey 2013). If *L. knokei* maintains high fidelity to this soil series, which seems credible, by extension it can be assumed the species is most probably extremely limited in distribution and overall abundance.

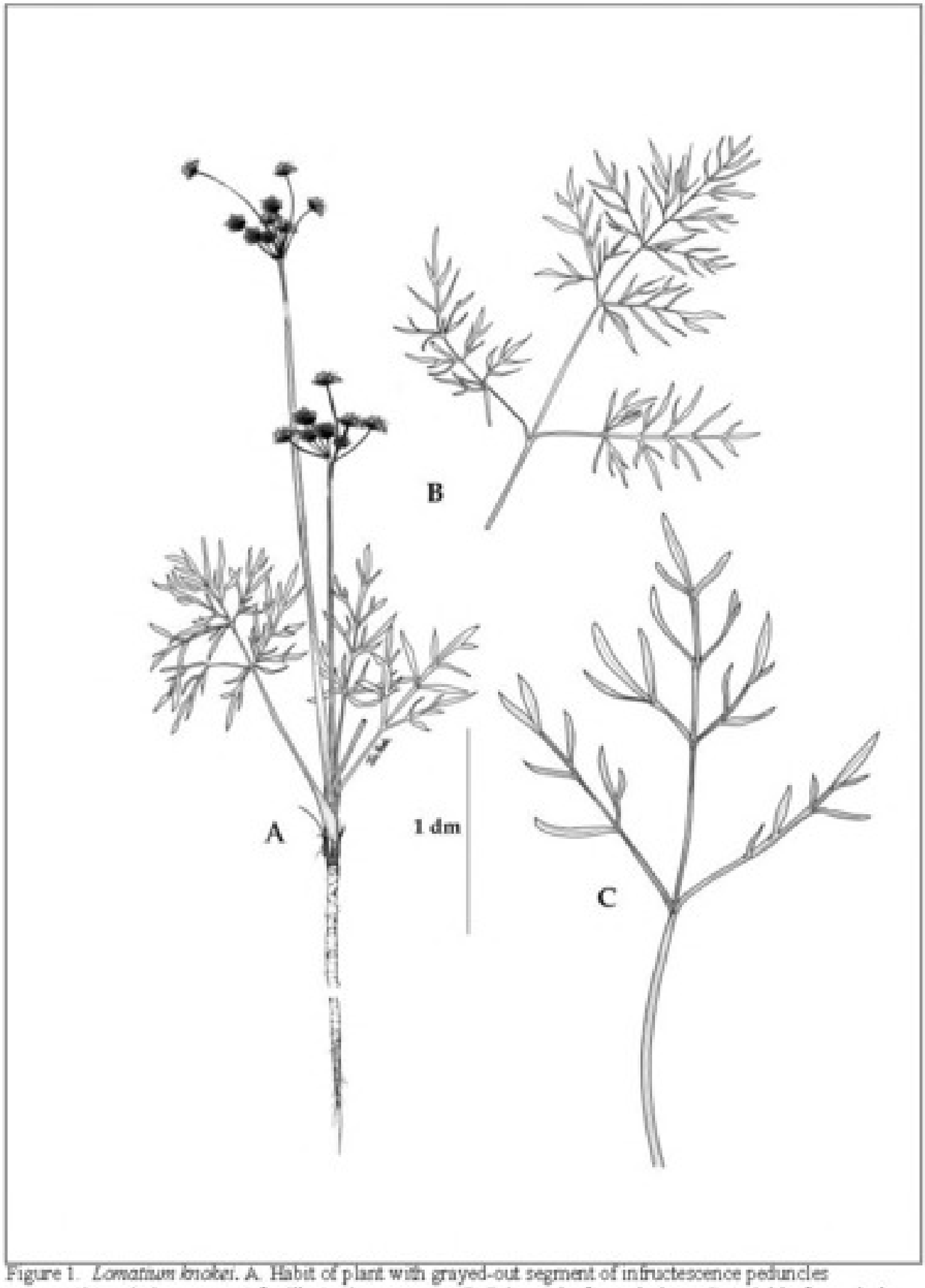

Figure 1. *Lomatium knokei*. A. Habit of plant with grayed-out segment of infructescence peduncles representing missing segment for illustrative purposes. B. Primary leaf morphology. C. Axial leaf morphology.

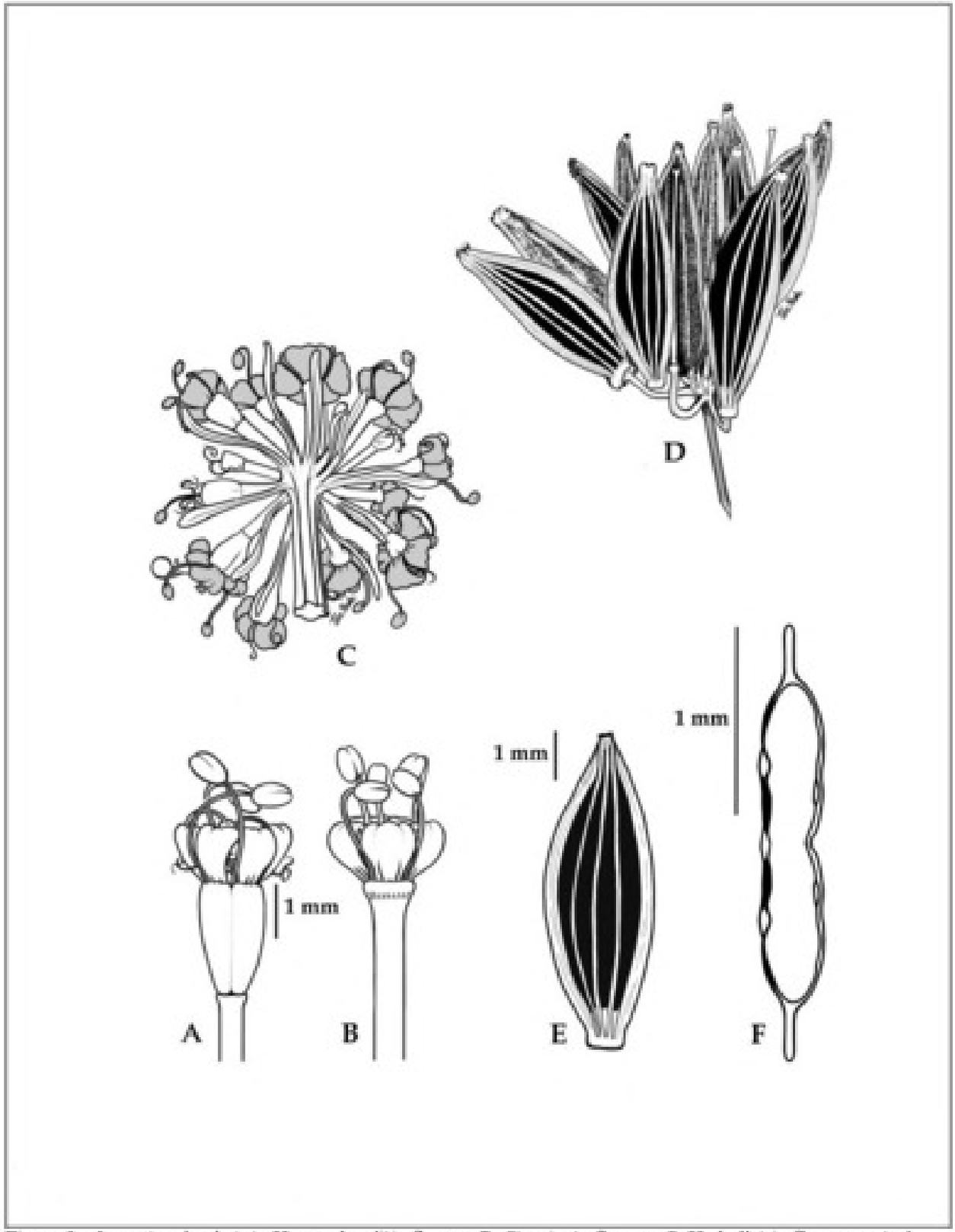

Figure 2. *Lomatium knoxii*. A. Hermaphroditic flower. B. Staminate flower. C. Umbellet in flower ventral view with involucel bracts. D. Umbellet in mature fruit lateral view. E. Mature fruit. F. Mature fruit cross sectional view with vittae.

Figure 3. *Lomatium knokei* leaves depicting the range of variation of leaf morphology typical for the species. Those leaves shown with broad petiole bases are primary while those lacking this feature are axial leaves that arise from inside the broad petiole bases of the primary leaves.

Figure 4. *Lomatium knokei* roots depicting the range of variation of morphology typical for the species. Note the tuberous swelling immediately beneath the root crown on the majority of the specimens.

Figure 5. *Lomatium knokei* inflorescence showing well-developed involucel bracts.

Figure 6. *Lomatium knokei* maturing infructescence umbellet. See illustration for typical scale.

Figure 7. *Lomatium knokei* mature plants in situ at anthesis. Plants are approximately 20 to 25 cm in height in this view.

Figure 8. *Lomatium knokei* habitat at the type locality.

Similarities and relationships

There are recognized morphological similarities between *Lomatium knokei* and other regionally conspecific *Lomatium* taxa. The species with which *L. knokei* is most likely to be confused are *L. leptocarpum*, the recently-described *L. pastoralis* Darrach & Wagner, and *L. tarantuloides* Darrach & Hinchliff (Table 1).

Discriminating Character	*L. knokei*	*L. pastoralis*	*L. tarantuloides*	*L. leptocarpum*
Inflorescence / Infructescence Growth habit	strict	decumbent base and distally ascending to strict	prostrate to weakly ascending	strict
Root Crown Morphology	single pseudoscape, rarely two	usually single pseudoscape	single to mulitcipital pseudoscape	usually single pseudoscape
Root Morphology	unbranched taproot – usually with small tuber near root crown	unbranched taproot	rarely branched taproot	unbranched irregularly tuberous taproot
Mature Fruit Length	4.0 – 7.8 mm; average value 6.2mm	5.3 – 11.4 mm; average value 7.7mm	3.7 – 8.0 mm; average value 5.4mm	7.0 – 14.9 mm; average value 9.9
Mature Fruit Aspect Ratio	1.91 – 3.81	2.40 – 3.26	1.85 – 4.00	3.32 – 13.33
Flower Color	bright yellow	bright yellow	white (bright yellow)	light yellow
Involucel Bracts	0 – 14; typically about 5 – 7	1 – 12; typically 6 – 8	0 – 8; typically 0	typically 5-9
Leaflet Width	0.2 – 2.3mm; average value approximately 1.0mm	0.8 – 9.7mm; average value approximately 3.5mm	0.4 – 3.8mm; average value approximately 2.0mm	0.3 – 1.7mm; average value approximately 0.9mm

Table 1. Comparison of *Lomatium knokei* with similar species.

Lomatium leptocarpum is readily distinguished from *L. knokei* by its long, narrow nearly sessile fruits with a much higher aspect ratio of approximately 6:1 versus approximately 3:1 for *L. knokei*. *Lomatium leptocarpum* also tends to be a somewhat more robust plant with a greater number of leaves and a larger irregularly moniliform tuberous root. *Lomatium pastoralis* displays markedly decumbent peduncle bases immediately proximal to the root crown, has leaflets that are on average several times more broad than those on *L. knokei*, and has larger fruits. *Lomatium tarantuloides* has prostrate peduncles, fruits that are on average smaller, and usually entirely lacks involucel bracts.

In addition to morphological character separation, a recently published molecular genetic study (George et al. 2014) that included leaf material from a *Lomatium knokei* collection provides additional strong evidence for recognition of *L. knokei* at specific rank. In this broad molecular phylogenetic analysis addressing species-level relationships in the genus, *L. knokei* (recognized with placeholder name "*Lomatium* sp. nov. E" in the publication) is included with strong support in a clade immediately sister to the recently published *L. tarantuloides* (Darrach & Hinchliff 2014).

Phenology, ecology, and conservation

Emergence of *Lomatium knokei* each year occurs primarily as a function of the timing of melt-back of the mountain snow pack. In low precipitation years this may occur as early as April or perhaps, in more typical precipitation years, well into May. Inflorescences are at or near anthesis by early-June in most years and in mid-fruit by late June. The plants rapidly senesce thereafter, seed is generally fully dispersed by mid-July, and the plants become largely unrecognizable as they reach full dormancy.

Lomatium knokei is a long-lived perennial species. Analysis of root crown scars, a proxy for age, indicates that some individuals may approach 100-years old. Typical material collected and analyzed for this publication displayed 10 to 20 root crown scars. It is surmised that older plants reside in areas that may be protected somewhat from herbivory.

The apparent dependence of the vernally wet meadow habitat of *Lomatium knokei* to a well-developed winter snowpack each year suggests impending risks to the type locality population. Nearly all climate models indicate that winter snowpack in the Pacific Northwest in general will become increasingly sparse (Barnett et al. 2005). This scenario argues that the *Lomatium* meadow is likely to become dryer earlier in the season, thus placing pressure on the plants to complete their yearly life cycle in a shorter time — with likely deleterious consequences to population viability.

The species occurs as a single known scattered to dense population of an estimated 3000 individuals on a largely non-forested, vernally wet, gently-sloping meadow substrate where it is a co-dominant species. Peripheral margins of the population include the narrow ecotonal edge of adjoining moist coniferous forest in the Pacific silver fir (*Abies amabilis*) plant association group (Lillybridge et al. 1995). Numerous young plants and seedlings scattered throughout the population suggest that reproductive capacity is not a significant limiting factor in the persistence of the species at the type locality at the present time.

Associated vascular plant taxa documented to co-occur with *Lomatium knokei* include the following: *Abies amabilis, Abies grandis, Achillea millefolium, Antennaria rosea, Camassia quamash, Carex hoodii, Carex microptera, Castilleja miniata, Castilleja tenuis, Deschampsia danthoniodes, Epilobium glaberrimum, Erythronium grandiflorum, Fragaria virginiana, Galium* sp., *Geum triflorum, Juncus confusus, Leucanthemum vulgare, Lomatium triternatum* var. *triternatum, Luzula* sp., *Madia glomerata, Moehringia macrophylla, Montia chamissoi, Olsynium douglasii, Orobanche uniflora, Osmorhiza occidentalis, Penstemon procerus, Poa bulbosa, Polygonum polygaloides, Potentilla gracilis, Pseudotsuga menziesii, Pyrrocoma hirta* var. *sonchifolia, Ranunculus uncinatus, Saxifraga nidifica, Senecio integerrimus* var. *exaltatus, Symphoricarpos albus, Taraxacum laevigatum, Taraxacum officinale, Veratrum californicum, Wyethia amplexicaulis,* and *Trifolium* sp.

Field observations within the population indicate that *Lomatium knokei* plants can be, at least periodically, significantly impacted by insect herbivory. Both aphids and minor instances of galling insects have been noted. Aphids in particular have been notably abundant in both the 2013 and the 2014 field seasons. While other instances of insect herbivory in the genus have been noted (Thompson 1998), it is this author's experience that it is atypical in the genus as a whole; likely owing to the general preponderance of inhibitory secondary chemicals so prevalent in many of the species (Asuming et al. 2005).

An additional factor imparting a salient threat to the existence of the species at the type locality is the prevalence of illegal off-road vehicle activities. An unauthorized road is at present being used by 4-wheel drive enthusiasts. It cuts directly through the population and plants are clearly being destroyed accordingly.

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