

Climate Change Vulnerability Index Report

Luzula arcuata ssp. *unalaschcensis* (Curved woodrush)

Date: 19 November 2021

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington

Heritage Rank: G5T4T5/S1

Index Result: Highly Vulnerable

Confidence: Very High

Climate Change Vulnerability Index Scores

Section A: Local Climate	Severity	Scope (% of range)
1. Temperature Severity	>6.0° F (3.3°C) warmer	0
	5.6-6.0° F (3.2-3.3°C) warmer	0
	5.0-5.5° F (2.8-3.1°C) warmer	0
	4.5-5.0° F (2.5-2.7°C) warmer	0
	3.9-4.4° F (2.2-2.4°C) warmer	100
	<3.9° F (2.2°C) warmer	0
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	33.3
	-0.074 to -0.096	66.7
	-0.051 to -0.073	0
	-0.028 to -0.050	0
	>-0.028	0
Section B: Indirect Exposure to Climate Change		Effect on Vulnerability
1. Sea level rise		Neutral
2a. Distribution relative to natural barriers		Somewhat Increase
2b. Distribution relative to anthropogenic barriers		Neutral
3. Impacts from climate change mitigation		Neutral
Section C: Sensitivity and Adaptive Capacity		
1. Dispersal and movements		Somewhat Increase
2ai Change in historical thermal niche		Increase
2aii. Change in physiological thermal niche		Greatly Increase
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		Neutral/Somewhat Increase
2c. Dependence on specific disturbance regime		Neutral
2d. Dependence on ice or snow-covered habitats		Increase
3. Restricted to uncommon landscape/geological features		Somewhat Increase
4a. Dependence on others species to generate required habitat		Neutral
4b. Dietary versatility		Not Applicable
4c. Pollinator versatility		Neutral
4d. Dependence on other species for propagule dispersal		Neutral
4e. Sensitivity to pathogens or natural enemies		Neutral
4f. Sensitivity to competition from native or non-native species		Somewhat Increase
4g. Forms part of an interspecific interaction not covered above		Neutral
5a. Measured genetic diversity		Unknown

5b. Genetic bottlenecks	Unknown
5c. Reproductive system	Neutral
6. Phenological response to changing seasonal and precipitation dynamics	Neutral
Section D: Documented or Modeled Response	
D1. Documented response to recent climate change	Neutral/Somewhat Increase
D2. Modeled future (2050) change in population or range size	Unknown
D3. Overlap of modeled future (2050) range with current range	Unknown
D4. Occurrence of protected areas in modeled future (2050) distribution	Unknown

Section A: Exposure to Local Climate Change

A1. Temperature: All six of the extant and historical occurrences of *Luzula arcuata* ssp. *unalaschcensis* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4 ° F (Figure 1).

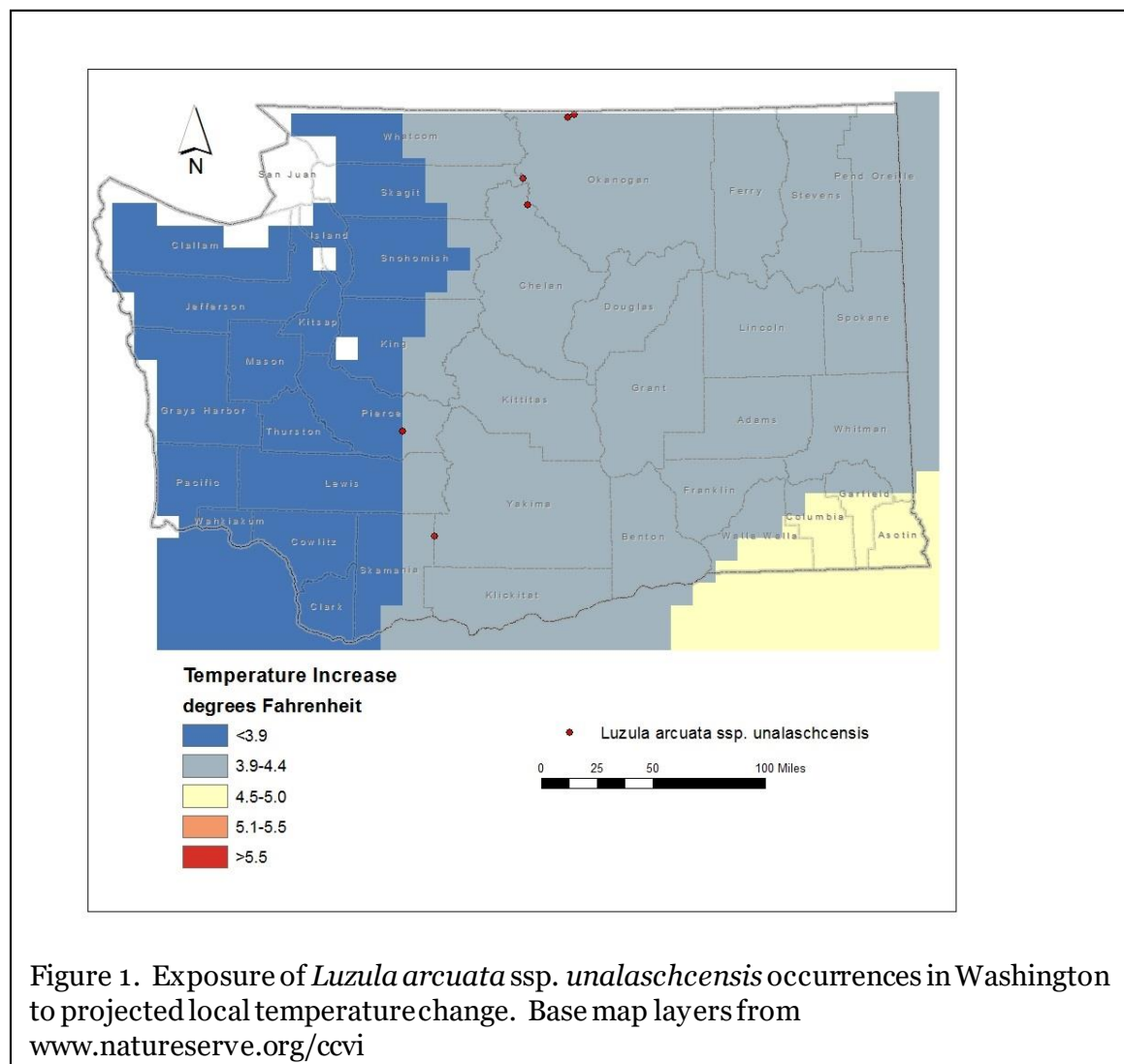


Figure 1. Exposure of *Luzula arcuata* ssp. *unalaschcensis* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Four of the 6 occurrences (66.7%) of *Luzula arcuata* ssp. *unalaschcensis* in Washington are found in areas with a projected decrease in available moisture (as measured by the ratio of actual to potential evapotranspiration) in the range of -0.074 to -0.096 (Figure 2). The other two occurrences (33.3%) are from areas with a projected decrease of -0.097 to -0.119.

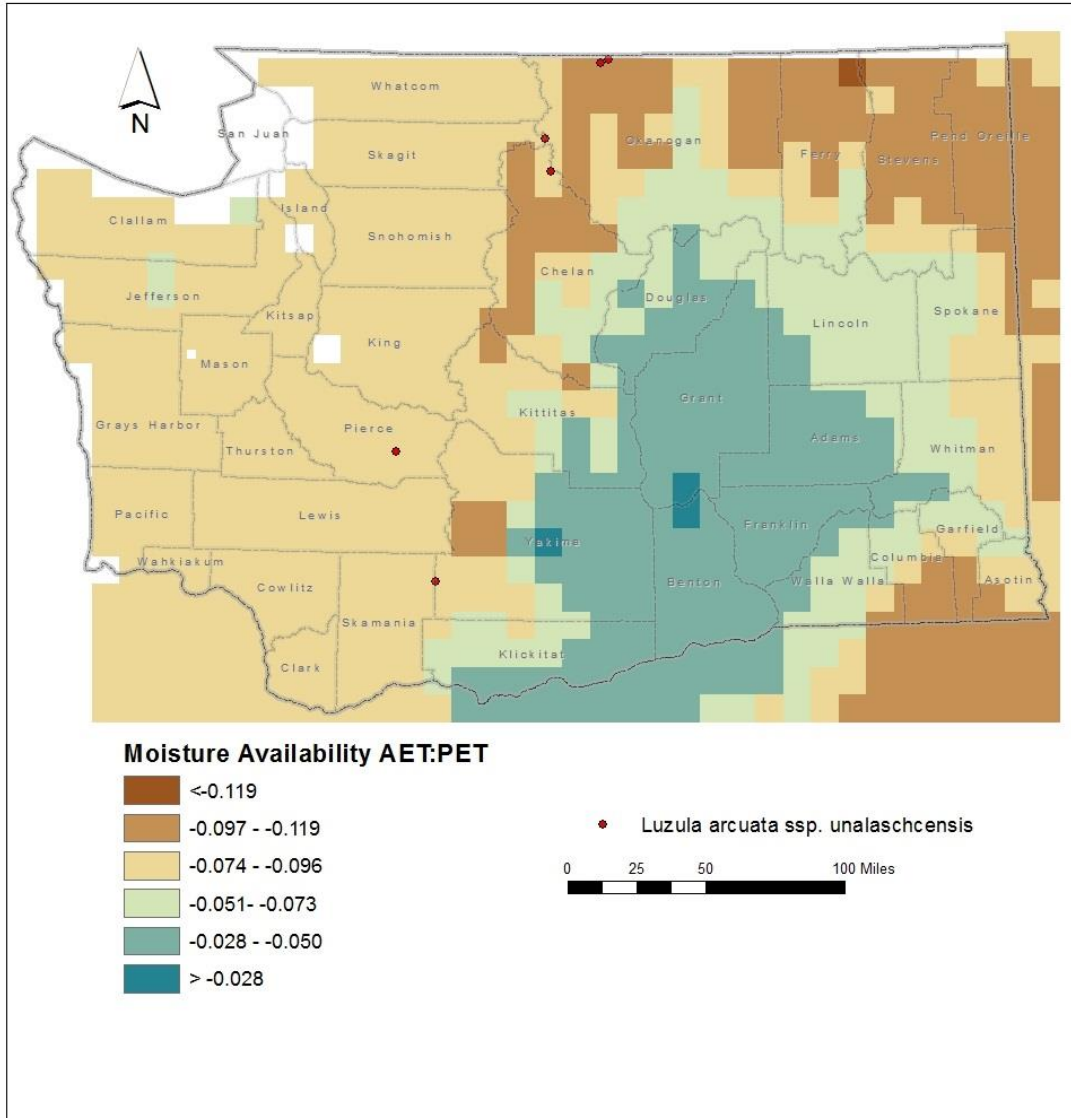


Figure 2. Exposure of *Luzula arcuata* ssp. *unalaschcensis* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.

Washington occurrences of *Luzula arcuata* ssp. *unalaschcensis* are found at 7040-8230 feet (2145-2510 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.

Luzula arcuata ssp. *unalaschcensis* occurs primarily in alpine to subalpine moraines, turf meadows, rocky ridges, and bare patches of soil associated with snowfields (Camp and Gamon 2011, Washington Natural Heritage Program 2021). This habitat is part of the Rocky Mountain Alpine Bedrock & Scree and Rocky Mountain Alpine Dwarf-Shrubland, Fell-Field, & Turf ecological systems (Rocchio and Crawford 2015). Populations may be isolated from each other by 2.7-116 miles (5.2-186 km) of unoccupied habitat, most of which is probably unsuitable. This species is small and could be over-looked, so additional alpine habitat may be present along the crest of the Cascades, but alpine areas themselves are isolated by unsuitable lower elevation forest and valley sites that would provide a barrier to dispersal.

B2b. Anthropogenic barriers: Neutral.

The alpine habitat of *Luzula arcuata* ssp. *unalaschcensis* in Washington is naturally patchy and mostly associated with designated wilderness (Mt. Adams and Pasaysten wilderness areas) and national parks with minimal human footprints.

B3. Predicted impacts of land use changes from climate change mitigation: Neutral.

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.

Luzula arcuata ssp. *unalaschcensis* produces 8-15 dense clusters of flowers per plant, with each cluster containing 3-5 flowers. Individual flowers produce 3 seeds with a few small hairs at one end. These seeds are released passively and may spread by wind or gravity. Many *Luzula* species have a nutrient-rich appendage (caruncle) that may entice insects or rodents to transport and cache seeds (Swab 2000), although the caruncle appears to be poorly developed in this species. Average dispersal distances are probably short (<1000 m) though occasional, long-distance movement by wind likely occurs.

C2ai. Historical thermal niche: Increase.

Figure 3 depicts the distribution of *Luzula arcuata* ssp. *unalaschcensis* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 (“historical thermal niche”). All 6 of the known occurrences in the state (100%) are found in areas that have experienced small variation (37-47° F/20.8-26.3° C) in temperature during the past 50 years and are considered at increased vulnerability to climate change (Young et al. 2016).

C2aii. Physiological thermal niche: Greatly Increase.

The alpine talus and tundra habitat of *Luzula arcuata* ssp. *unalaschcensis* is entirely within a cold climate zone during the flowering season and highly vulnerable to temperature increase from climate change.

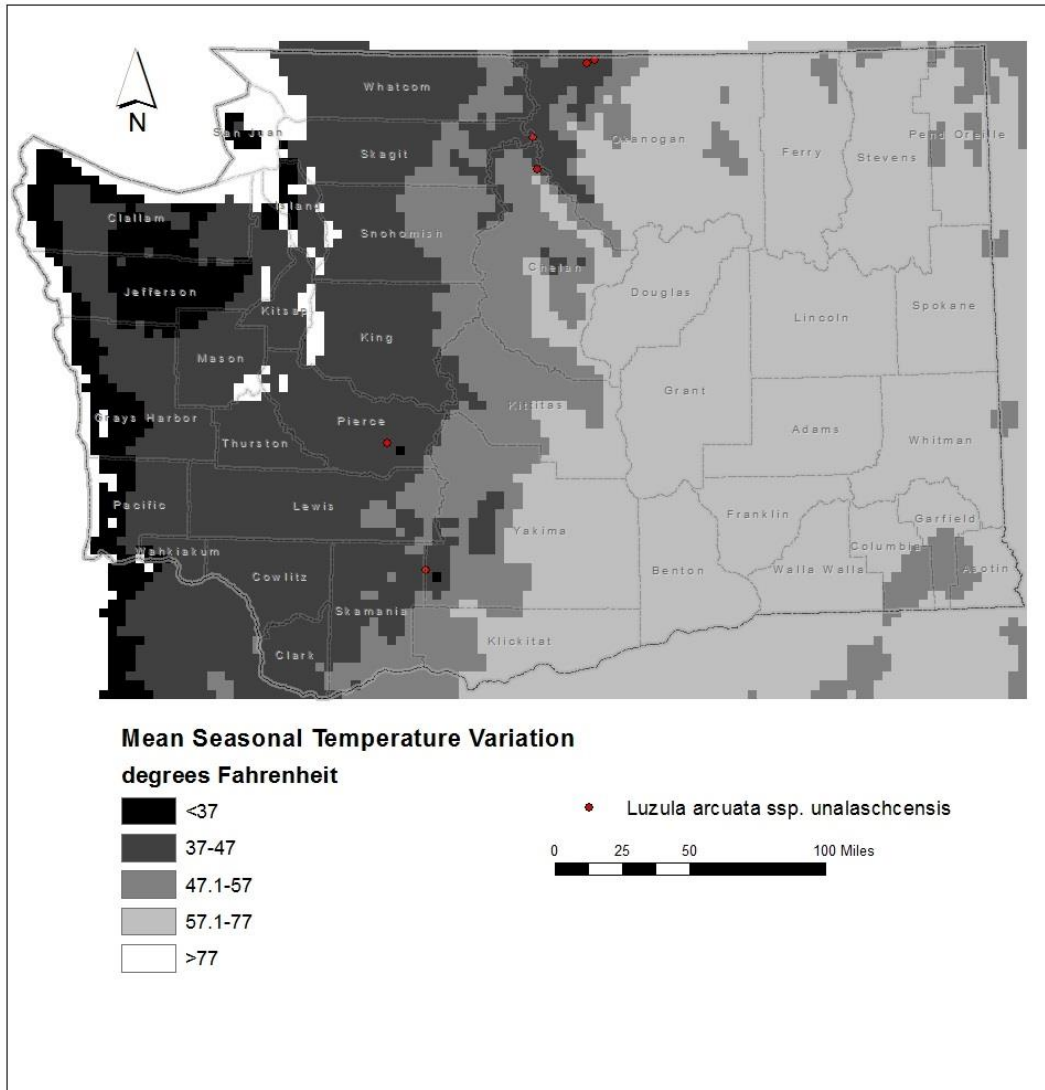


Figure 3. Historical thermal niche (exposure to past temperature variations) of *Luzula arcuata* ssp. *unalaschcensis* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.

All of the known populations of *Luzula arcuata* ssp. *unalaschcensis* in Washington are found in areas that have experienced greater than average precipitation variation in the past 50 years (>40 inches/1016 mm) (Figure 4). According to Young et al. (2016), these occurrences are neutral for climate change.

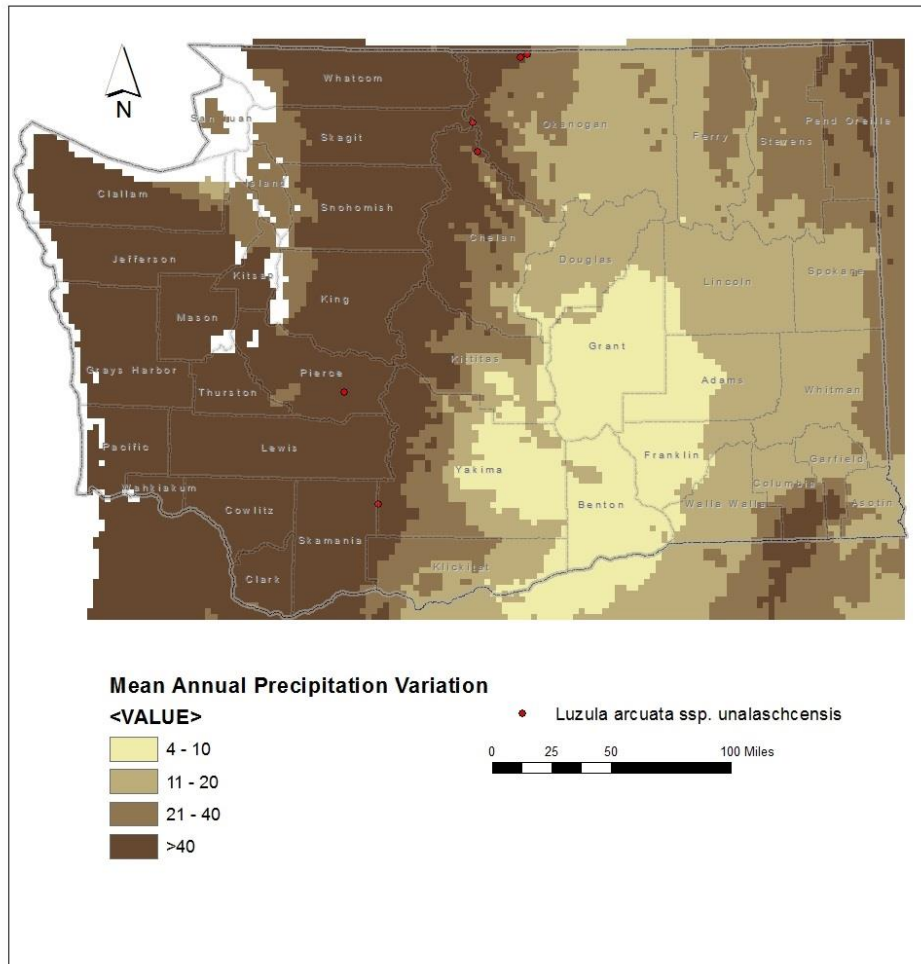


Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Luzula arcuata* ssp. *unalaschcensis* occurrences in Washington. Base map layers from www.natureserve.org/cvi

C2bii. Physiological hydrological niche: Neutral/Somewhat Increase.

This species is probably more dependent on adequate winter snowpack and timing of snowmelt (see section C2d below) than on spring or summer precipitation for its moisture requirements. Increased temperatures could reduce the amount and timing of precipitation, however, making alpine sites more suitable for lower elevation shrubs, trees, and herbaceous species to become established (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.

In Norway, *Luzula arcuata* is an early successional species that can colonize recently exposed areas following the retreat of glaciers (Robbins and Matthews 2009). Washington populations

are adapted to sites that are subjected to high winds that may restrict the accumulation of soil or the establishment of taller plant species from lower elevations.

C2d. Dependence on ice or snow-cover habitats: Increase.

The populations of *Luzula arcuata* ssp. *unalaschcensis* in Washington are mostly found in alpine ridges, talus slopes, or turf meadows associated with high winter snow accumulation. Reductions in the amount of snow, shifts from snow to rain, or changes in the timing of snowmelt due to higher temperatures could impact the amount of moisture available to this species in the growing season (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Somewhat Increase.

Luzula arcuata ssp. *unalaschcensis* is found on a variety of geologic substrates in the Cascade Range and Okanogan Plateau, including the Golden Horn and Cathedral batholiths, Fifes Peak and Mount Adams andesites, and Bald Mountain tonalite (Washington Division of Geology and Earth Resources 2016). These granitic and volcanic formations are often of limited distribution, and may account for the few records of this species in Washington.

C4a. Dependence on other species to generate required habitat: Neutral.

The alpine talus and turf meadow habitat occupied by *Luzula arcuata* ssp. *unalaschcensis* is maintained largely by natural abiotic conditions.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.

Luzula arcuata ssp. *unalaschcensis*, like most other brown-flowered *Luzula* species, is primarily wind-pollinated.

C4d. Dependence on other species for propagule dispersal: Neutral.

Seeds produced by *Luzula arcuata* ssp. *unalaschcensis* have a few short hairs on one end to facilitate wind dispersal. Unlike many other species of *Luzula*, *L. arcuata* ssp. *unalaschcensis* appears to lack a nutritious caruncle (an outgrowth of the seed coat) that may attract insects or rodents to feed on or cache the seeds (Swab 2000). Secondary dispersal by animals is still possible, but *L. arcuata* probably does not depend entirely on one or a few species for seed dispersal.

C4e. Sensitivity to pathogens or natural enemies: Neutral.

Not known, but probably not a limiting factor.

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.

Under present conditions, competition from non-native species is minor, as few introduced plants are adapted to the harsh environmental conditions of the alpine zone. Under projected climate change, competition could increase if lower elevation plant species are able to expand their range into formerly unsuitable habitat (Rocchio and Ramm-Granberg 2017).

C4g. Forms part of an interspecific interaction not covered above: Neutral.

Does not require an interspecific interaction.

C5a. Measured genetic variation: Unknown.

No data are available on the genetic diversity of Washington populations. Dawe (1979) found *ssp. unalaschcensis* to be a hexaploid ($2n = 36$) based on samples from Russia, Alaska, and Alberta. By contrast, *ssp. arcuata* from Eurasia can be a hexaploid, septaploid ($2n = 42$) or octoploid ($2n = 48$). Purported hybrids have been reported from Alaska between *L. arcuata* *ssp. unalaschcensis* and *L. confusa* (Dawe 1979). Hybrids are not known from Washington.

C5b. Genetic bottlenecks: Unknown.

Not known.

C5c. Reproductive System: Neutral.

Luzula arcuata *ssp. unalaschcensis* appears to be an obligate outcrosser and is not limited by pollinators or dispersal, so is presumed to have average genetic variation. Washington populations, being located at the far southern edge of its geographic range, are likely to have lower overall genetic diversity due to inbreeding or founder effects.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.

Based on herbarium records in the Consortium of Pacific Northwest Herbaria website (pnwherbaria.org), *Luzula arcuata* *ssp. unalaschcensis* has not changed its typical blooming time since it was first reported in the state in 1919.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral/Somewhat Increase.

One population from Mount Rainier National Park has not been relocated since 1919 (Biek 2000) and may be extirpated. Otherwise, no major changes have been detected in the distribution of *Luzula arcuata* *ssp. unalaschcensis* in Washington.

D2. Modeled future (2050) change in population or range size: Unknown

D3. Overlap of modeled future (2050) range with current range: Unknown

D4. Occurrence of protected areas in modeled future (2050) distribution: Unknown

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