Climate Change Vulnerability Index Report

Lomatium bradshawii (Bradshaw's desert-parsley)

Date: October 2019

Assessor: Walter Fertig, WA Natural Heritage Program (update from Gamon 2014)

Geographic Area: Washington Heritage Rank: G2/S1

Index Result: Moderately Vulnerable Confidence: Very High

Climate Change Vulnerability Index Scores

Section A	**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	0
	<3.9° F (2.2°C) warmer	100
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	0
	-0.074 to - 0.096	100
	-0.051 to - 0.073	0
	-0.028 to -0.050	0
	>-0.028	0
Section B		**Effect on Vulnerability**
1. Sea level rise		Neutral
2a. Distribution relative to natural barriers		Neutral
2b. Distribution relative to anthropogenic barriers		Somewhat Increase
3. Impacts from climate change mitigation		Neutral
Section C		
1. Dispersal and movements		Somewhat Increase
2ai Change in historical thermal niche		Increase
2aii. Change in physiological thermal niche		Neutral
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		Increase
2c. Dependence on specific disturbance regime		Somewhat Increase
2d. Dependence on ice or snow-covered habitats		Neutral
3. Restricted to uncommon landscape/geological features		Neutral
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		Unknown
5a. Measured genetic diversity		Neutral
5b. Genetic bottlenecks		Unknown
5c. Reproductive system		Neutral

6. Phenological response to changing seasonal and precipitation dynamics	Unknown
Section D	
D1. Documented response to recent climate change	Unknown
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: The single occurrence of *Lomatium bradshawii* in Washington (Figure 1) is found in an area with a projected temperature increase less than 3.9˚F.

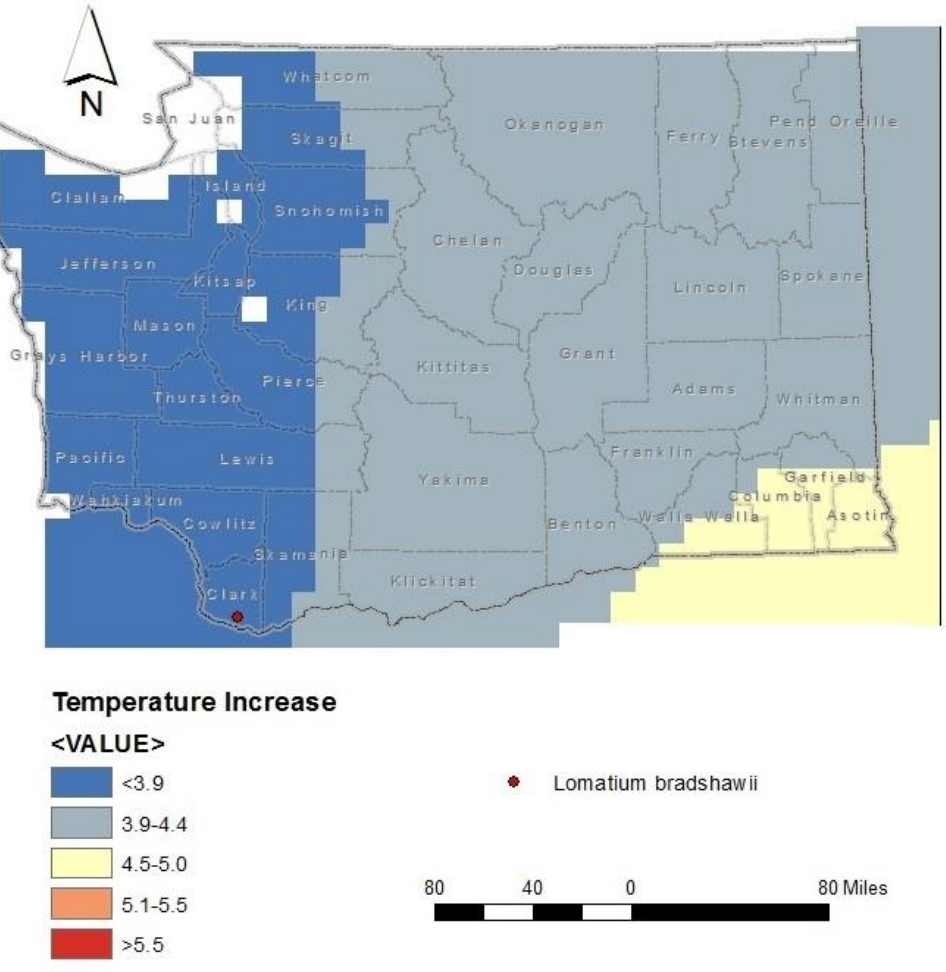

Figure 1. Exposure of *Lomatium bradshawii* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: The single occurrence of *Lomatium bradshawii* in Washington is found in an area with a predicted decrease in available moisture between -0.074 and – 0.096 (Figure 2).

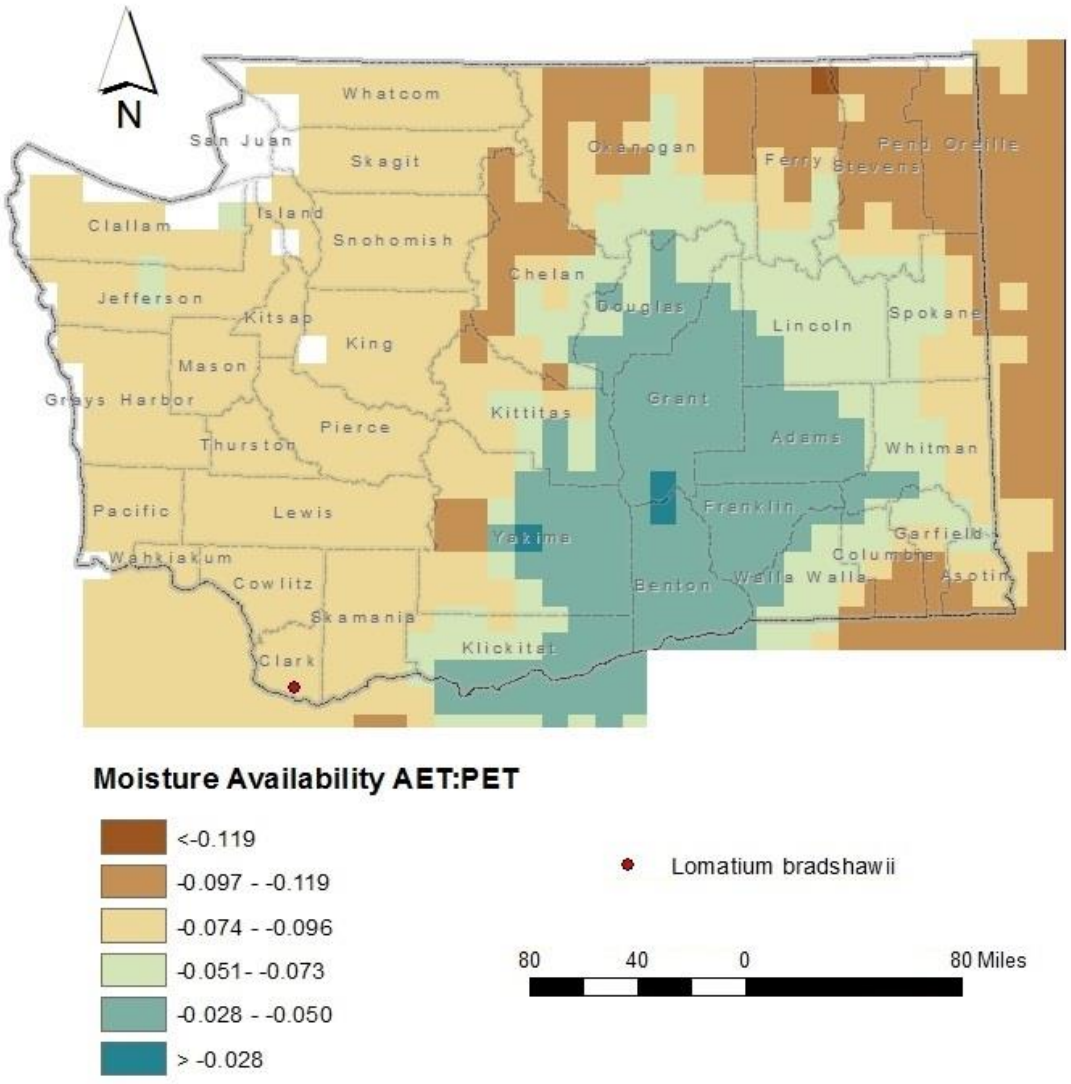

Figure 2. Exposure of *Lomatium bradshawii* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
The entire range of *Lomatium bradshawii* in Washington is at an elevation of 56m (185 ft) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Neutral.
In Washington, *Lomatium bradshawii* is found in seasonally flooded prairies and grasslands dominated by *Deschampsia cespitosa* in a narrow hydrologic ecotone between dry uplands and wet creek banks (Camp and Gamon 2011; Fertig 2019; Rush and Gamon 1999). This habitat occurs within a matrix of drier grasslands, oak woodlands, agricultural fields, and urban and suburban development. Historically, there was a moderate amount of connectivity between potential habitat sites following riparian corridors.

B2b. Anthropogenic barriers: Somewhat Increase.
Most of the likely historical habitat for *Lomatium bradshawii* in the southern Puget Trough in Washington has been converted to agriculture or urban/suburban development. As a result, areas of potential habitat for this species are highly fragmented and the matrix vegetation and less conducive for migration.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.
Lomatium bradshawii fruits are dry, 1-seeded and have a prominent raised wing-like margin, which would suggest that dispersal could be facilitated by wind. Kagan (1980) observed that dispersal was very limited, with many fruits traveling no more than 1 meter from their parent. Studies of other *Lomatium* species have also documented surprisingly short dispersal distances, which may account for the unusually high degree of local endemism in the genus (Marsico and Hellman 2009).

C2ai. Historical thermal niche: Increase.
The single occurrence of *L. bradshawii* in Washington is found on the west side of the Cascades in an area with increased vulnerability for temperature variation (Figure 3).

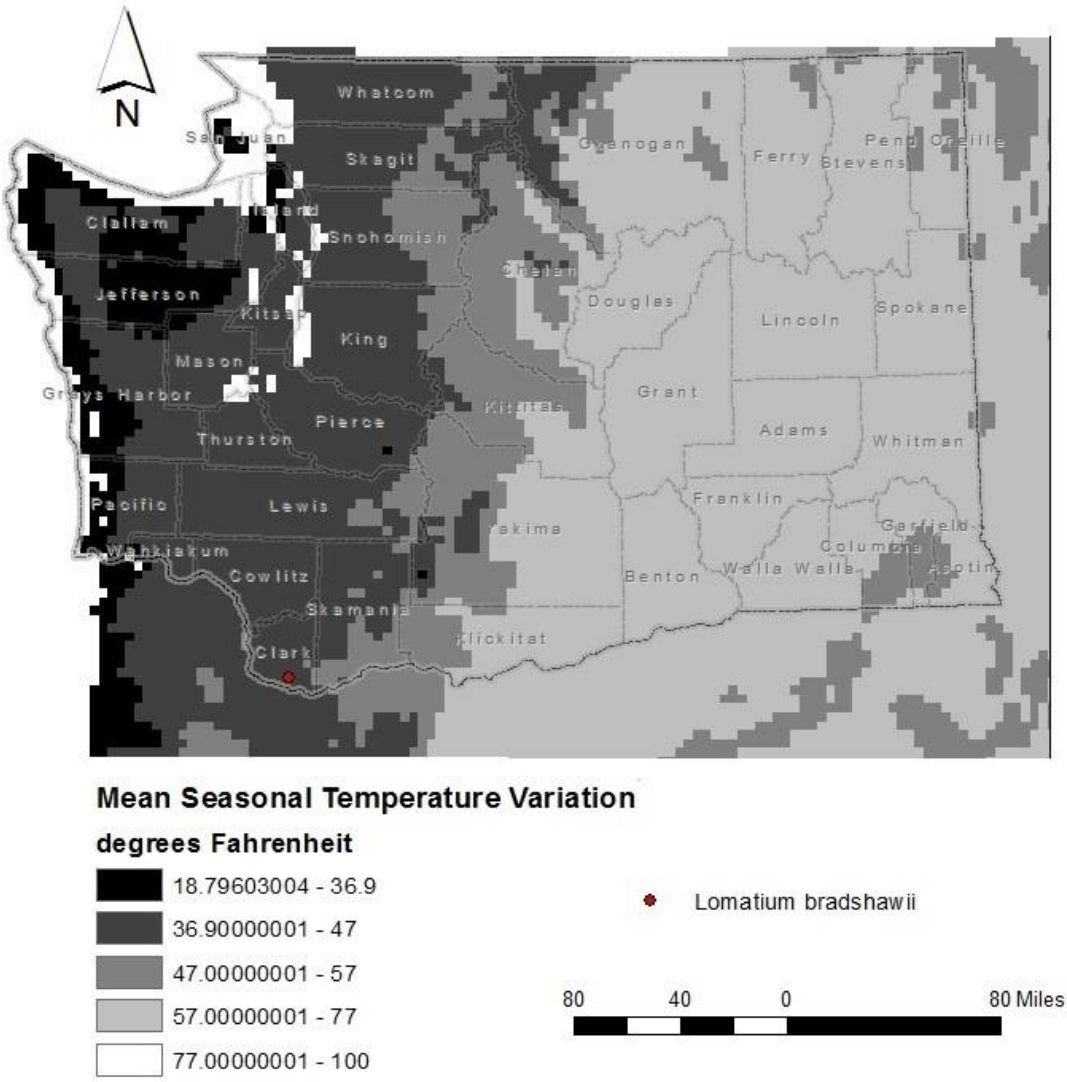

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Lomatium bradshawii* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Neutral.
The *Lomatium bradshawii* occurrence in Washington is found in a broad wetland valley that may be slightly cooler than the surrounding uplands, though not sufficiently different to make the site more vulnerable to projected climate change.

C2bi. Historical hydrological niche: Neutral.
The Washington occurrence of *Lomatium bradshawii* (Figure 4) is found in an area with more than 40 inches of mean annual precipitation variation. This is considered "Neutral" under the CCVI guidelines Young et al. 2016).

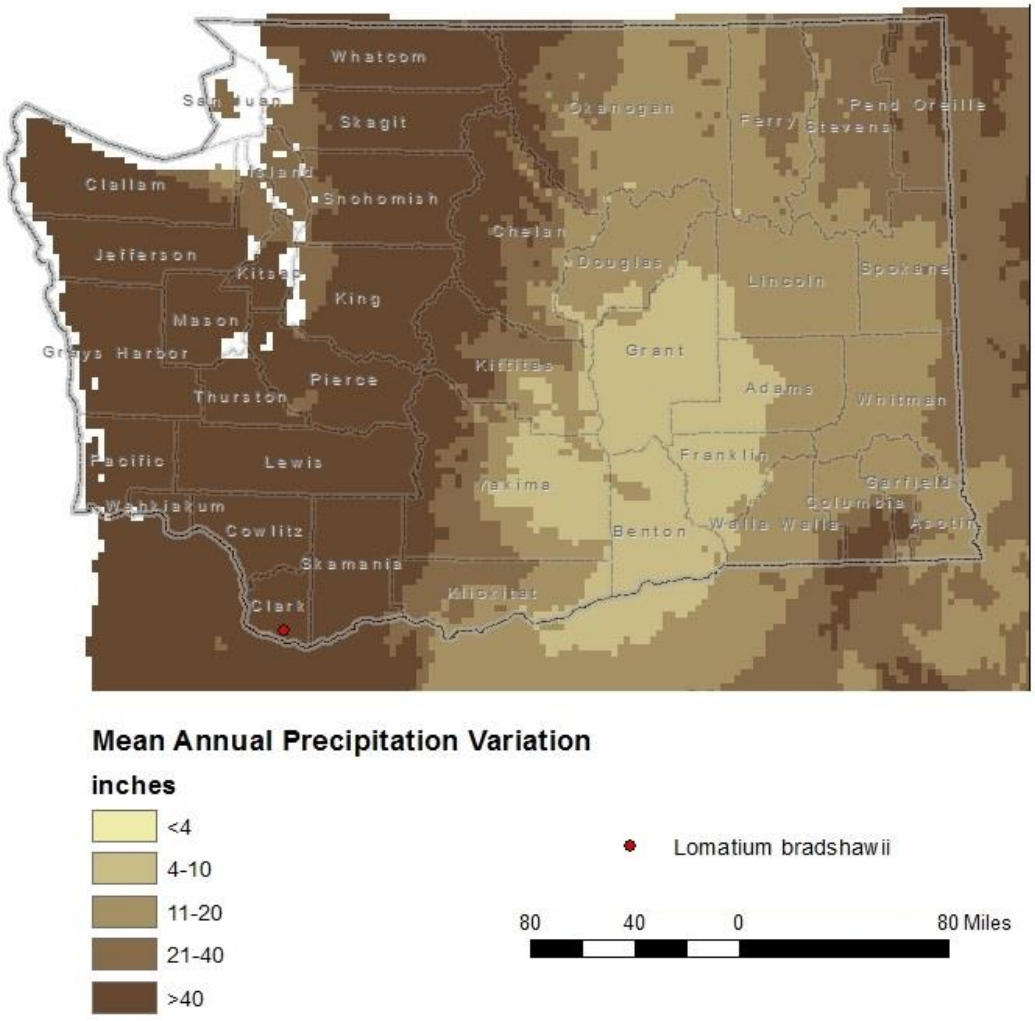

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Loamtium bradshawii* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Increase.
Lomatium bradshawii is dependent on wet prairie habitats with poorly drained clay soils that are seasonally flooded (though not in the growing season) (Wentworth 1996). This relatively narrow ecological niche is vulnerable to significant changes in hydrological patterns.

C2c. Dependence on a specific disturbance regime: Somewhat Increase.
Lomatium bradshawii responds positively to low intensity fire through increased growth and density, at least in the first 1-3 years after disturbance (Pendergass et al. 1999). Periodic disturbance may be necessary to maintain habitat conditions suitable for this species (USFWS 2010). The absence of disturbance and resulting competition from other vegetation is one of the important threats to *L. bradshawii* (Fertig 2019; USFWS 2010).

C2d. Dependence on ice or snow-cover habitats: Neutral.
The single *Lomatium bradshawii* occurrence in Washington is at a low enough elevation where snow and ice are minor contributors to overall precipitation.

C3. Restricted to uncommon landscape/geological features: Neutral.
Although the Washington occurrence of *Lomatium bradshawii* is restricted to an alluvial clay loam soil type (Wentworth 1996), this does not qualify as an uncommon geologic substrate according to CCVI guidance from Young et al. (2016).

C4a. Dependence on other species to generate required habitat: Neutral.
The wet meadow habitats occupied by *Lomatium bradshawii* in Washington were produced by natural geologic phenomena, and not a consequence of ecosystem engineering by other organisms.

C4b. Dietary versatility: Not applicable for plants.

C4c. Pollinator versatility: Neutral.
A pollinator exclusion study in Oregon by Kaye and Kirkland (1994) found that *Lomatium bradshawii* requires insects for pollination. At least 38 different insect species have been documented visiting *L. bradshawii* flowers in the Willamette Valley. The majority of these potential pollinators are solitary bees (*Andrena* sp., Halictidae), syrphid flies, or other flies (Diptera) (Kaye and Kirkland 1994). The diversity of potential pollinators suggests that reproduction in *L. bradshawii* is not pollinator limited.

C4d. Dependence on other species for propagule dispersal: Neutral.
Fruit dispersal appears to be limited to passive means (Kagan 1980), rather than by animals.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
The Washington occurrence has been impacted by vole herbivory (Wentworth 1996). Browsing by cattle and deer have also been reported. Kagan (1980) reported evidence of damage by spittle bugs and aphids and parasitism by a fungus. The overall impact of herbivory and pathogens is probably low.

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
One of the major threats to *Lomatium bradshawii* in Washington is invasion of its wet prairie habitat by introduced weeds and upland trees and shrubs. Controlled burns and herbicide treatment have been effective in reducing these threats for short periods of time, but need to be repeated every 3 years or so (Pendergrass et al. 1999; Ramm-Granberg and Rocchio 2018).

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

C5a. Measured genetic variation: Neutral.
Based on AFLP markers, Gitzendanner (1998) documented high levels of genetic diversity in most populations of *Lomatium bradshawii*.

C5b. Genetic bottlenecks: Unknown.
Although the range of *Lomatium bradshawii* has contracted due to habitat loss in the past century, it is unknown whether there has been a significant bottleneck in the past 500 years reducing the total size of the population to less than 1000 individuals required to score this factor (Young et al. 2016).

C5c. Reproductive System: Neutral.
Lomatium bradshawii has relatively high genetic diversity and has been documented to require insect pollinators for fruit set (Kaye and Kirkland 1994), seemingly refuting the report of potential self-compatibility by Kagan (1980) based on a small sample size. The reproductive system of *L. bradshawii* promotes outcrossing through andromonoeicy (the formation of separate staminate and bisexual hermaphroditic flowers) and protogyny (the earlier maturation of stigmas and styles than stamens in hermaphroditic flowers) (Kagan 1980; Kaye and Kirkland 1994; USFWS 2010).

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

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Unknown.
Trend data in Washington have been ambiguous, in part due to the difficulty in accurately estimating population numbers due to the extremely high density of plants in some areas and the difficulty in differentiating between individuals. Population size has ranged from 70,411 based on ocular estimates (Wentworth 1996) to 22 million based on extrapolation from plot data in especially dense patches. Arnett and Goldner (2017) estimated the total number to be 8.7-12.8 million based on more random sampling. Wilderman (2019) has been monitoring populations on Lacamas Natural Area preserve from 1998-2019 and documented a longterm decline (Fertig 2019). Data specifically linking population trends to climate change are lacking.

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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