

## Climate Change Vulnerability Index Report

*Arabis olympica* (Olympic rockcress)

Date: 18 October 2021

Synonym: *A. furcata* var. *olympica*

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington

Heritage Rank: GH/SH

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	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: Indirect Exposure to Climate Change		Effect on Vulnerability
1. Sea level rise		Neutral
2a. Distribution relative to natural barriers		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		Greatly Increase
2aii. Change in physiological thermal niche		Increase
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		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		Unknown
4d. Dependence on other species for propagule dispersal		Neutral
4e. Sensitivity to pathogens or natural enemies		Unknown
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		Increase

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

**Section A: Exposure to Local Climate Change**

A1. Temperature: The six historical occurrences of *Arabis olympica* in Washington (100%) are found in areas with a projected temperature increase of < 3.9 ° F (Figure 1).

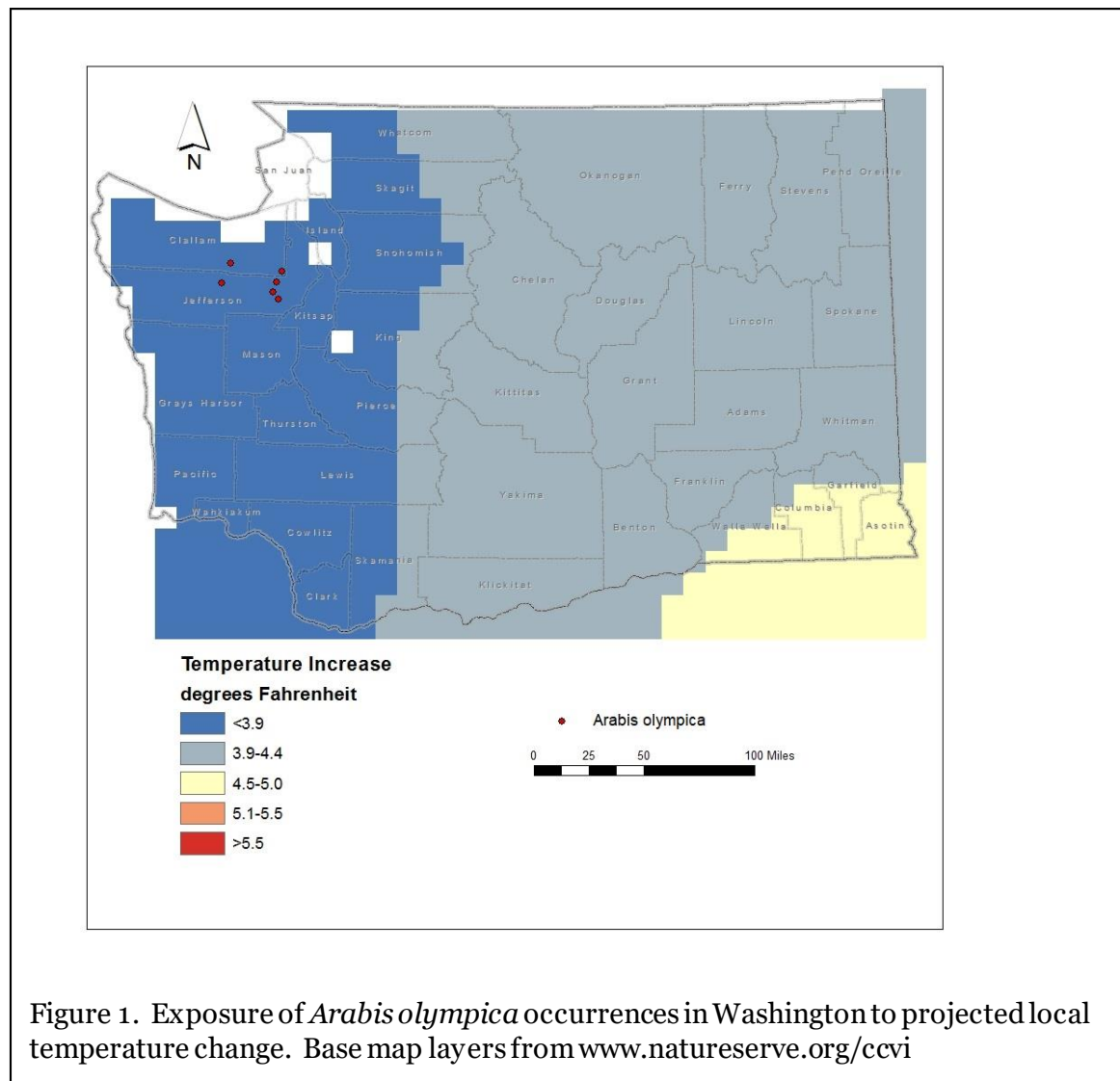


Figure 1. Exposure of *Arabis olympica* occurrences in Washington to projected local temperature change. Base map layers from [www.natureserve.org/ccvi](http://www.natureserve.org/ccvi)

A2. Hamon AET:PET Moisture Metric: All six historical occurrences of *Arabis olympica* (100%) 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).

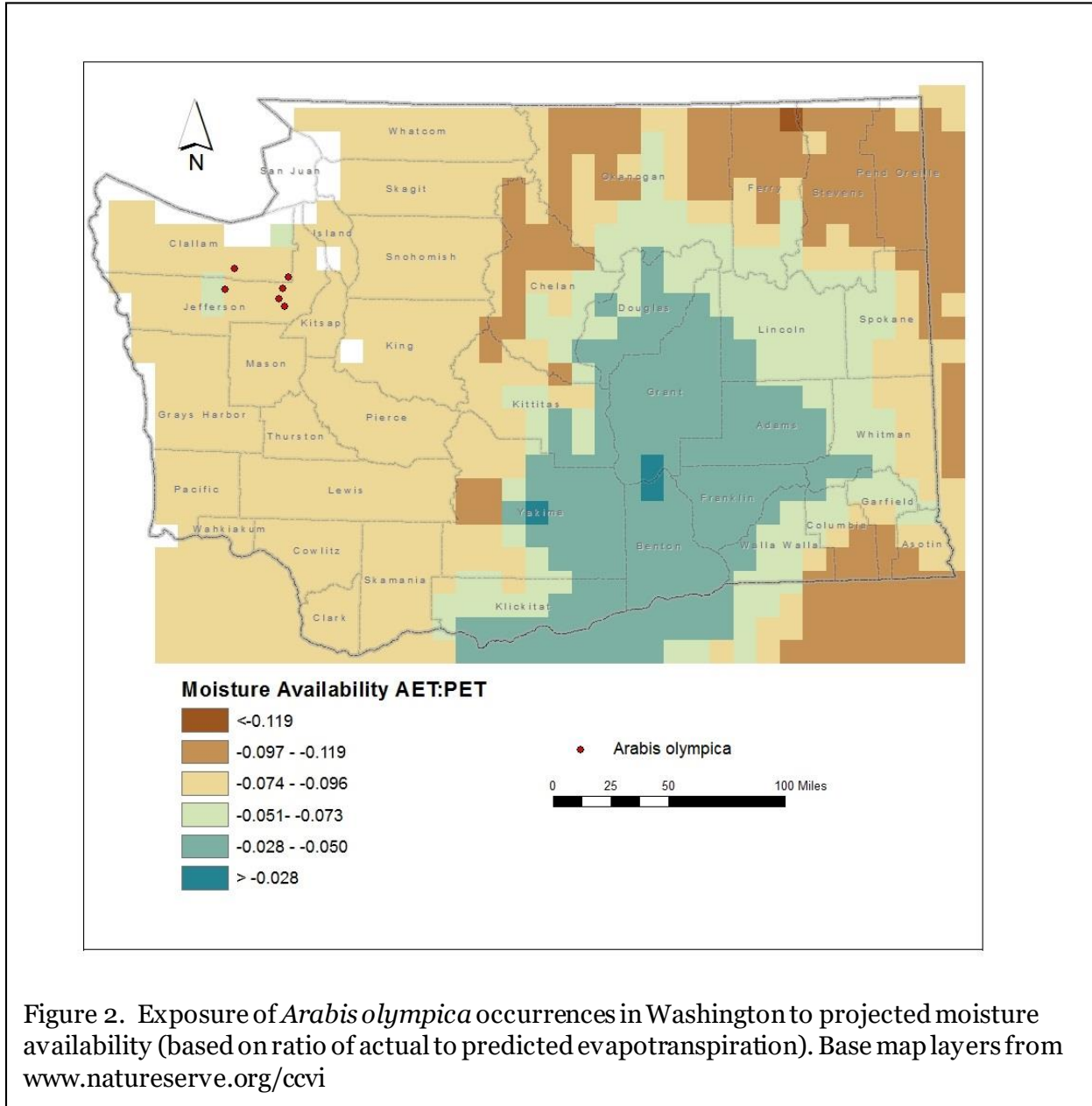


Figure 2. Exposure of *Arabis olympica* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from [www.natureserve.org/ccvi](http://www.natureserve.org/ccvi)

## Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.

The Washington occurrences of *Arabis olympica* are found at 3000-4495 feet (915-1370 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Increase.

*Arabis olympica* is endemic to the northeastern Olympic Range in Washington, where it is found in subalpine to alpine dry rocky meadows and turf areas amid rock outcrops (Buckingham et al. 1995; Fertig 2020; Washington Natural Heritage Program 2021). These habitats are a component of the North Pacific Alpine & Subalpine Dry Grassland and North Pacific Dry & Mesic Alpine Dwarf-Shrubland, Fell-Field & Meadow ecological systems (Rocchio and Crawford 2015). The entire global range of *A. olympica* is restricted to an area of 20 x 30 miles (33 x 46 km). Individual occurrences are separated by 5.5-20 miles (9-32 km) and occur on ridge systems isolated by deep valleys and unsuitable forested habitat. The Olympic Range is also disjunct from other alpine mountain ranges north and east of the Salish Sea/Puget Sound, making potential migration more difficult.

B2b. Anthropogenic barriers: Neutral.

The range of *Arabis olympica* is primarily at or above treeline in Olympic National Park and The Brothers and Buckhorn wilderness areas of Olympic National Forest. These sites have some hiking trails but otherwise the human footprint is negligible and does not present an additional barrier to dispersal.

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

### **Section C: Sensitive and Adaptive Capacity**

C1. Dispersal and movements: Somewhat Increase.

*Arabis olympica* produces numerous, small, flattened seeds with a narrow wing within a dry, dehiscent fruit (Al-Shehbaz 2010). Seeds are released passively and may spread by gravity or strong winds. Dispersal distances are probably moderate (about 1000 m).

C2ai. Historical thermal niche: Greatly Increase.

Figure 3 depicts the distribution of *Arabis olympica* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 (“historical thermal niche”). Five of the six occurrences (83.3%) are found in areas that have experienced very small (<37 °F/20.8 °C) temperature variation during the past 50 years and are considered at greatly increased vulnerability to climate change (Young et al. 2016). One other occurrence (16.7%) is from an area with small (37-47 °F/20.8-26.3 °C) temperature variation over the same period and is at increased vulnerability to climate change.

C2aii. Physiological thermal niche: Increase.

The range of *Arabis olympica* is restricted to alpine and subalpine areas exposed to high winds and cold winter temperatures. These areas are projected to become warmer due to climate change (Rocchio and Ramm-Granberg 2017).

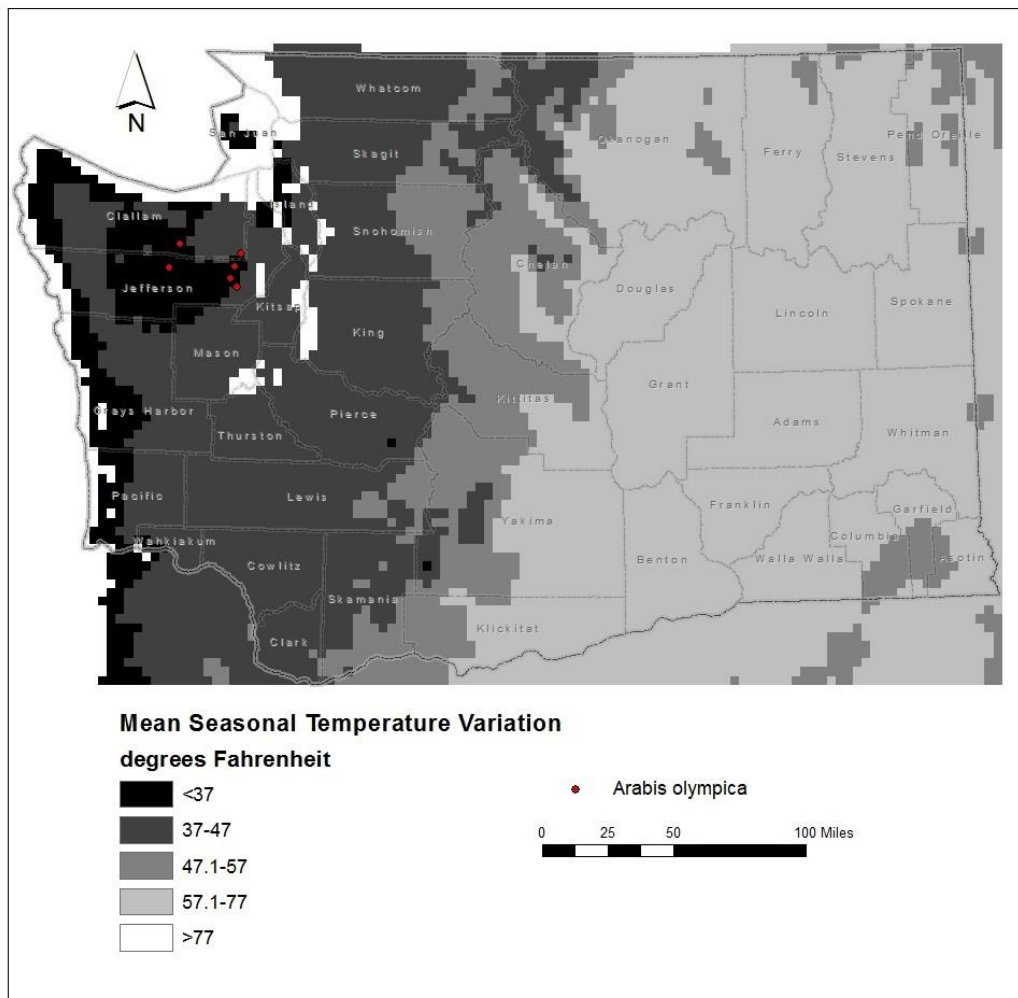


Figure 3. Historical thermal niche (exposure to past temperature variations) of *Arabis olympica* occurrences in Washington. Base map layers from [www.natureserve.org/ccvi](http://www.natureserve.org/ccvi)

C2bi. Historical hydrological niche: Neutral.

All six of the historical occurrences of *Arabis olympica* in Washington (100%) are found in areas that have experienced greater than average (>40 inches/1016 mm) of precipitation variation in the past 50 years (Figure 4). According to Young et al. (2016), these areas are at neutral vulnerability to climate change.

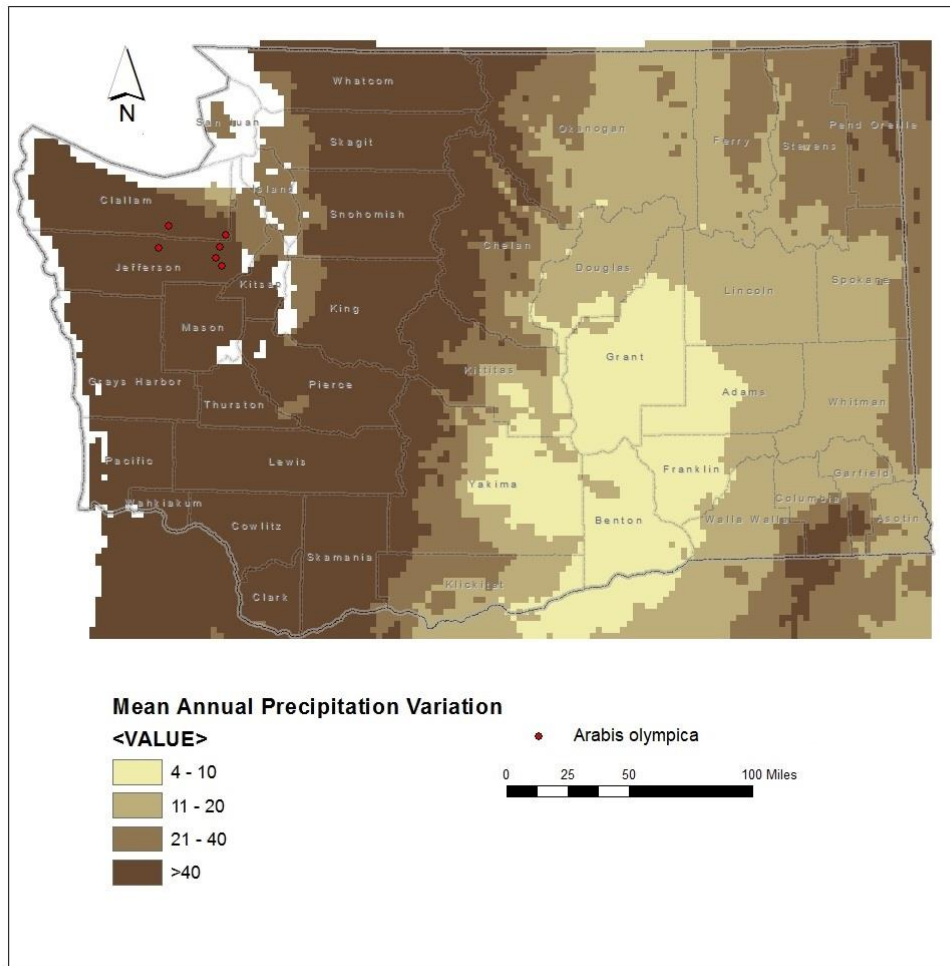


Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Arabis olympica* occurrences in Washington. Base map layers from [www.natureserve.org/cvvi](http://www.natureserve.org/cvvi)

C2bii. Physiological hydrological niche: Somewhat Increase.

*Arabis olympica* occurs primarily in dry to moist alpine or subalpine meadows or rocky areas that are dependent on adequate snowmelt or summer precipitation for their moisture requirements. Increased temperatures from climate change are likely to alter the timing of snowmelt, leading to earlier runoff (Rocchio and Ramm-Granberg 2017). The amount and timing of summer precipitation is also likely to change, making these habitats drier and more vulnerable to invasion by lower elevation dry meadow species.

C2c. Dependence on a specific disturbance regime: Neutral.

The open, alpine to subalpine, meadow and rock outcrop habitat of *Arabis olympica* is maintained by a short growing season, high winds, and late-lying snow that prevent tree species from becoming established. Increased temperatures and changes in precipitation patterns could result in shifts in vegetation towards forest or drier meadow species and make these areas more vulnerable to wildfire (Rocchio and Ramm-Granberg 2017).

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

The Olympic Mountains average over 10 meters (400 inches) of snow. The alpine and subalpine areas inhabited by *Arabis olympica* are on open ridges or slopes where snow may be exposed to wind and sun and less likely to accumulate late into the summer, making the local microenvironment drier than surrounding areas. Changes in the amount of snow, or timing of its melting (Rocchio and Ramm-Granberg 2017), will likely have an important impact on the persistence of this species.

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

*Arabis olympica* is found primarily on outcrops of the Eocene-age Crescent Formation, a basalt layer found mostly along the eastern and northern rim of the Olympic Range. One occurrence is associated with Oligocene-Miocene marine sediments (Washington Division of Geology and Earth Resources 2016).

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

The open alpine-subalpine meadow and rocky ridge habitat of *Arabis olympica* is mostly maintained by abiotic processes, such as snow distribution and how it is influenced by wind and melting temperatures, rather than by other species.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Unknown.

The specific pollinators of *Arabis olympica* are not known. Other *Arabis* and related *Boechea* species are pollinated by a variety of insects, including honey bees (*Apis*), solitary bees (*Bombus*), bee flies (*Bombylius*), butterflies, and wasps (Hamilton and Mitchell-Olds 1994).

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

The fruits of *Arabis olympica* dehisce when dry to release seeds passively by gravity or wind. The seeds are flat and have narrow wings to facilitate dispersal by wind. Secondary transport by animals may occur, but probably is insignificant.

C4e. Sensitivity to pathogens or natural enemies: Unknown.

Impacts from pathogens are not documented. *Arabis olympica* may be susceptible to herbivory by insects, rodents, or hoofed animals, including introduced mountain goats (*Oreamnos americanus*), but impacts are poorly documented.

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

*Arabis olympica* occurs mostly in dry alpine or subalpine meadows or rocky ridges. Under projected future climate change, these sites are likely to be warmer and have a longer growing season (Rocchio and Ramm-Granberg 2017), which may allow subalpine species to expand their

range or increase the cover of other alpine competitors. Herbivory or trampling by introduced mountain goats is a threat to many Olympic alpine plant species (Schreiner et al. 1994).

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

C5a. Measured genetic variation: Unknown.

Basic information on the ploidy level or population genetics of *Arabis olympica* are not known (Koch et al. 2010), although the species is inferred to be closely related to *Arabis furcata* based on morphological traits (Al-Shehbaz 2010, Rollins 1941).

C5b. Genetic bottlenecks: Unknown.

During the Pleistocene, populations of *Arabis olympica* could have been restricted to unglaciated refugia and had limited gene exchange with other populations or increased inbreeding.

C5c. Reproductive System: Increase.

According to Al-Shehbaz (2010), the few available herbarium specimens of *Arabis olympica* all have immature seeds. While this could be a factor of under-sampling, it might also reflect reproductive bottlenecks related to past hybridization, poor pollination success, or severe inbreeding. Species of *Arabis* and *Boechea* (formerly included in *Arabis*) exhibit a wide variety of breeding systems, including obligate outcrossing, limited autogamy (selfing), and apomixis (producing seed without fertilization) (Rollins 1941). Research is needed on the reproductive system and ploidy of *Arabis olympica* to determine whether these are factors in its rarity.

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

Based on Washington Natural Heritage Program data, no significant changes in the phenology of *Arabis olympica* populations have been detected.

## **Section D: Documented or Modeled Response to Climate Change**

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

No populations of *Arabis olympica* have been observed since 1980 and attempts to relocate two historical occurrences in 2015 and 2016 were unsuccessful. Many historical records have vague locality details, and this species is small and cryptic, so it can be easy to overlook. Populations may also be in significant decline, and its range has become more constricted. Wershow and DeChaine (2018) did not include this species in their study of climate change impacts on alpine endemics of the Olympic Range, in part because they were unable to relocate any populations (Wershow notes from Rare Care survey in 2016).

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

Wershow and DeChaine (2018) modeled the projected future habitat of five Olympic alpine endemics that overlap the range of *Arabis olympica* and found that 85-99% of their current habitat would no longer be suitable by 2080 due to rising temperatures and reduced moisture availability.



D3. Overlap of modeled future (2050) range with current range: Neutral.  
Based on the projected future range of other alpine endemic plants found in similar habitats in the Olympic Mountains (Wershow and Dechaine 2018), the range of *Arabis olympica* is expected to contract rather than shift in distribution.

D4. Occurrence of protected areas in modeled future (2050) distribution: Neutral.  
Despite the likely contraction of potential suitable habitat due to climate change, the entire range of *Arabis olympica* will still be restricted to Olympic National Park.

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