

Climate Change Vulnerability Index Report
Pedicularis rainierensis (Mt. Rainier lousewort)

Date: 14 April 2020

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington

Heritage Rank: G2G3/S2S3

Index Result: Highly 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	76.5
	<3.9° F (2.2°C) warmer	23.5
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		Somewhat Increase
2b. Distribution relative to anthropogenic barriers		Neutral
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		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		Neutral/Somewhat Increase
4d. Dependence on other species for propagule dispersal		Neutral
4e. Sensitivity to pathogens or natural enemies		Somewhat Increase
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	Somewhat Increase
Section D	
D1. Documented response to recent climate change	Neutral
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: Thirteen of the 17 occurrences of *Pedicularis rainierensis* in Washington (76.5%) occur in areas with a projected temperature increase of 3.9-4.4° F (Figure 1). Four other occurrences (23.5%) are from areas with a projected temperature increase <3.9° F.

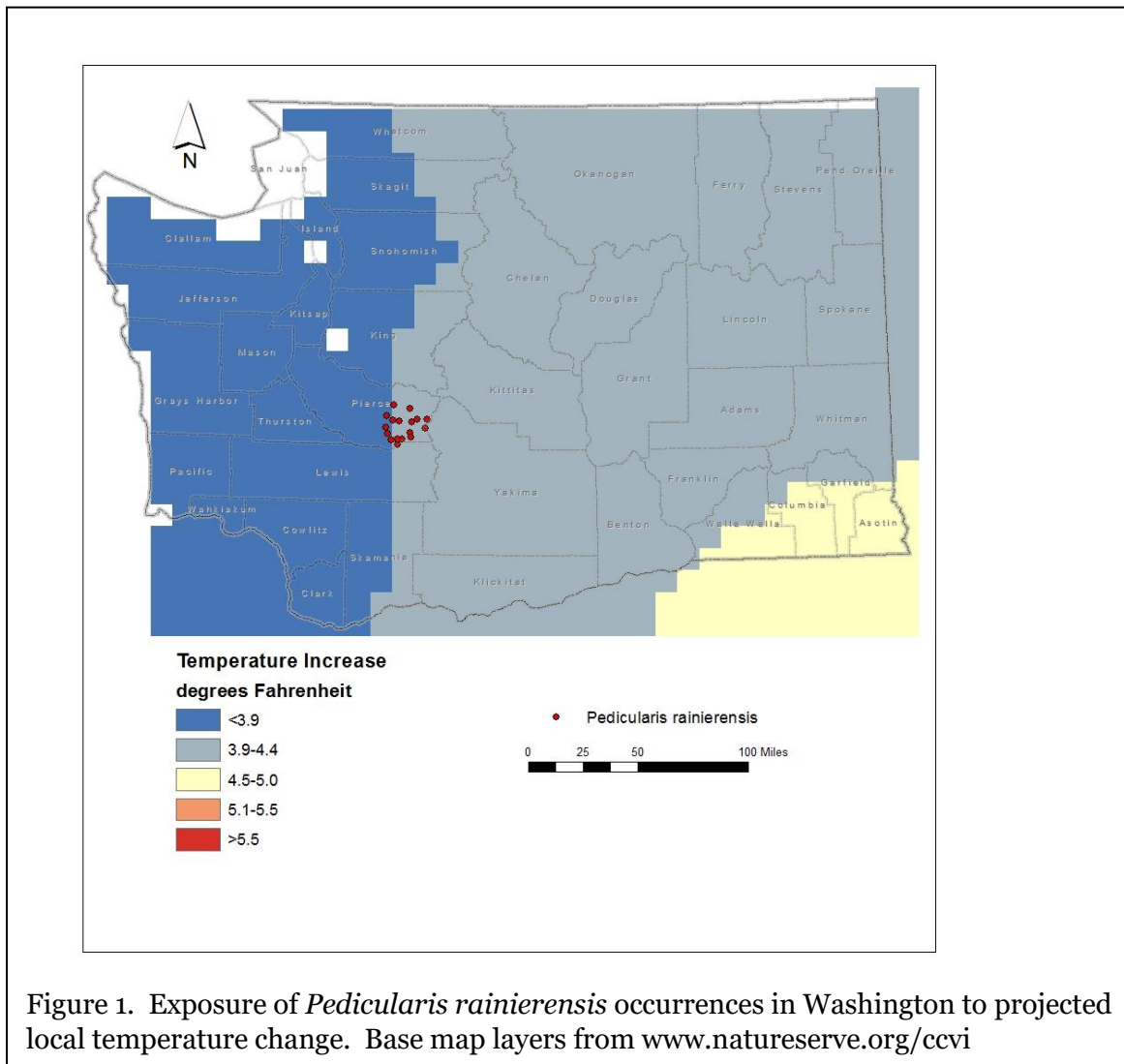


Figure 1. Exposure of *Pedicularis rainierensis* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: All 17 of the occurrences of *Pedicularis rainierensis* (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).

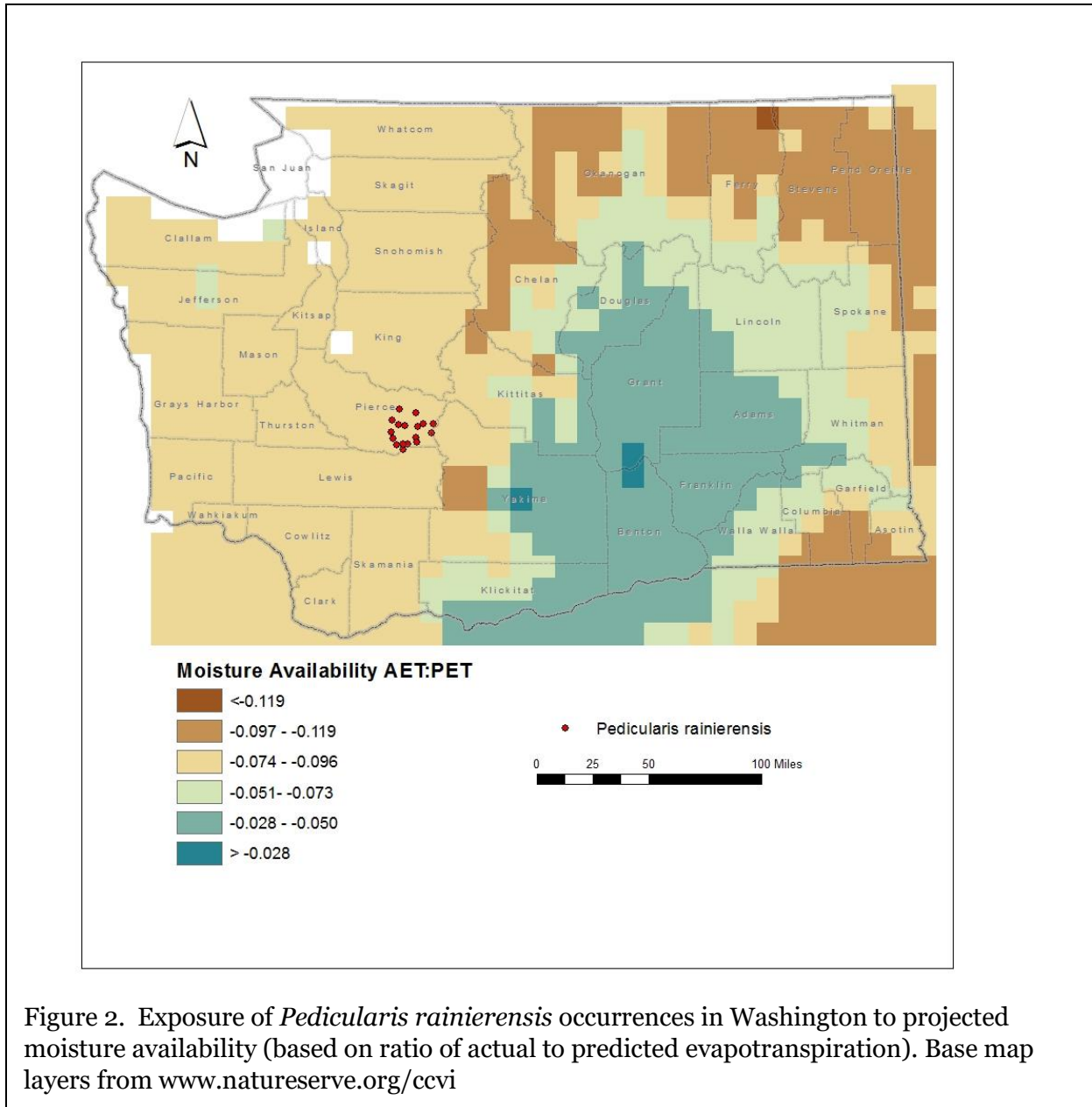


Figure 2. Exposure of *Pedicularis rainierensis* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.

Washington occurrences of *Pedicularis rainierensis* are found at 4800-6800 feet (1400-2100 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.

In Washington, *Pedicularis rainierensis* is found in subalpine or alpine moist meadows, rocky slopes, and openings in Subalpine fir and Mountain hemlock forests on deep loam, moist talus, or gravel on the slopes of Mount Rainier (Camp and Gamon 2011, Fertig and Kleinknecht 2020). This habitat most closely matches the North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-Field and Meadow ecological system (Rocchio and Crawford 2015). Washington occurrences often consist of a series of subpopulations separated by less than 0.1 miles. Other populations may be up to 6 miles (8.4 km) apart. Patches of suitable habitat are separated by extensive areas of subalpine forest and steep valleys that present a barrier to gene flow.

B2b. Anthropogenic barriers: Neutral.

The entire range of *Pedicularis rainierensis* is restricted to the slopes of Mount Rainier and vicinity. This area has few permanent anthropogenic barriers 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.

Pedicularis rainierensis produces dry, capsule fruits containing 20-25 small seeds that are dispersed passively by wind or gravity. Average distances may be relatively short, but a small fraction of seed could disperse over 100 meters.

C2ai. Historical thermal niche: Increase.

Figure 3 depicts the distribution of *Pedicularis rainierensis* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 (“historical thermal niche”). All 17 of the known occurrences (100%) are found in areas that have experienced small (37-47°F/20.8-26.3°C) temperature variation during the past 50 years and are considered at increased vulnerability to climate change (Young et al. 2016).

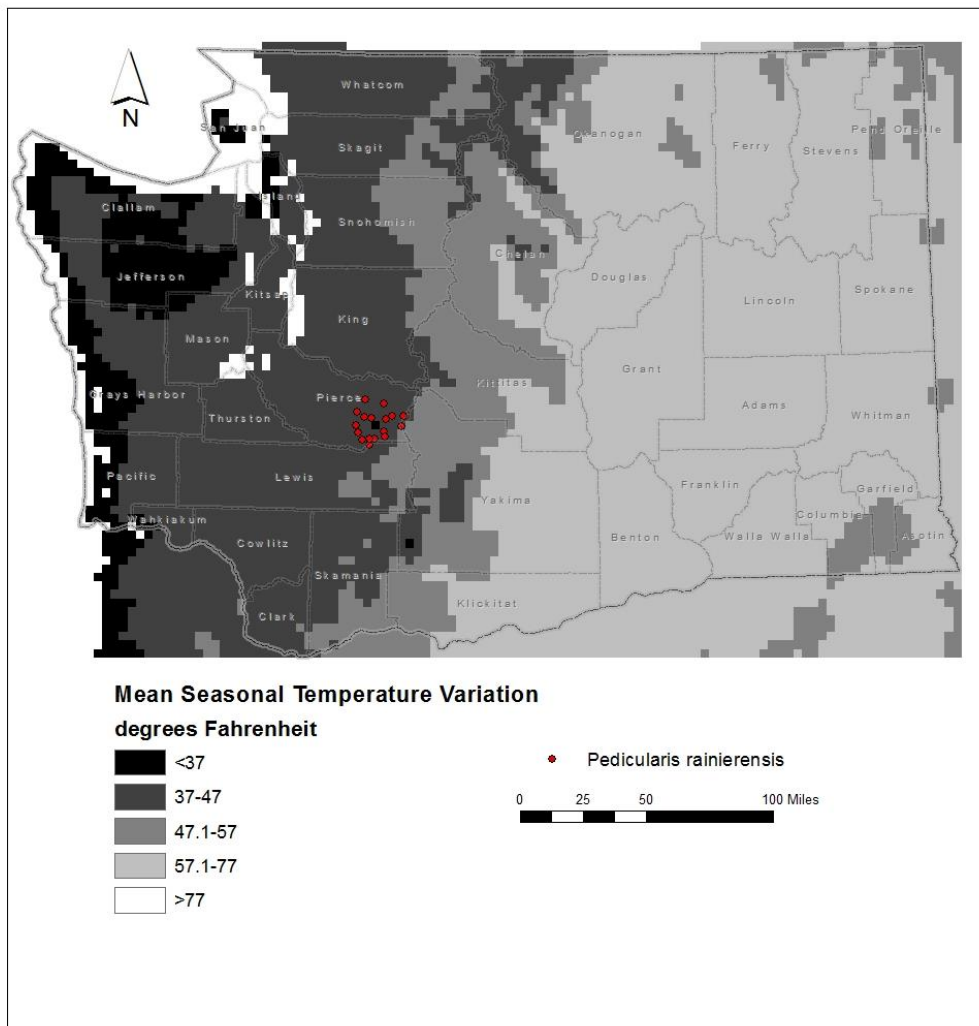


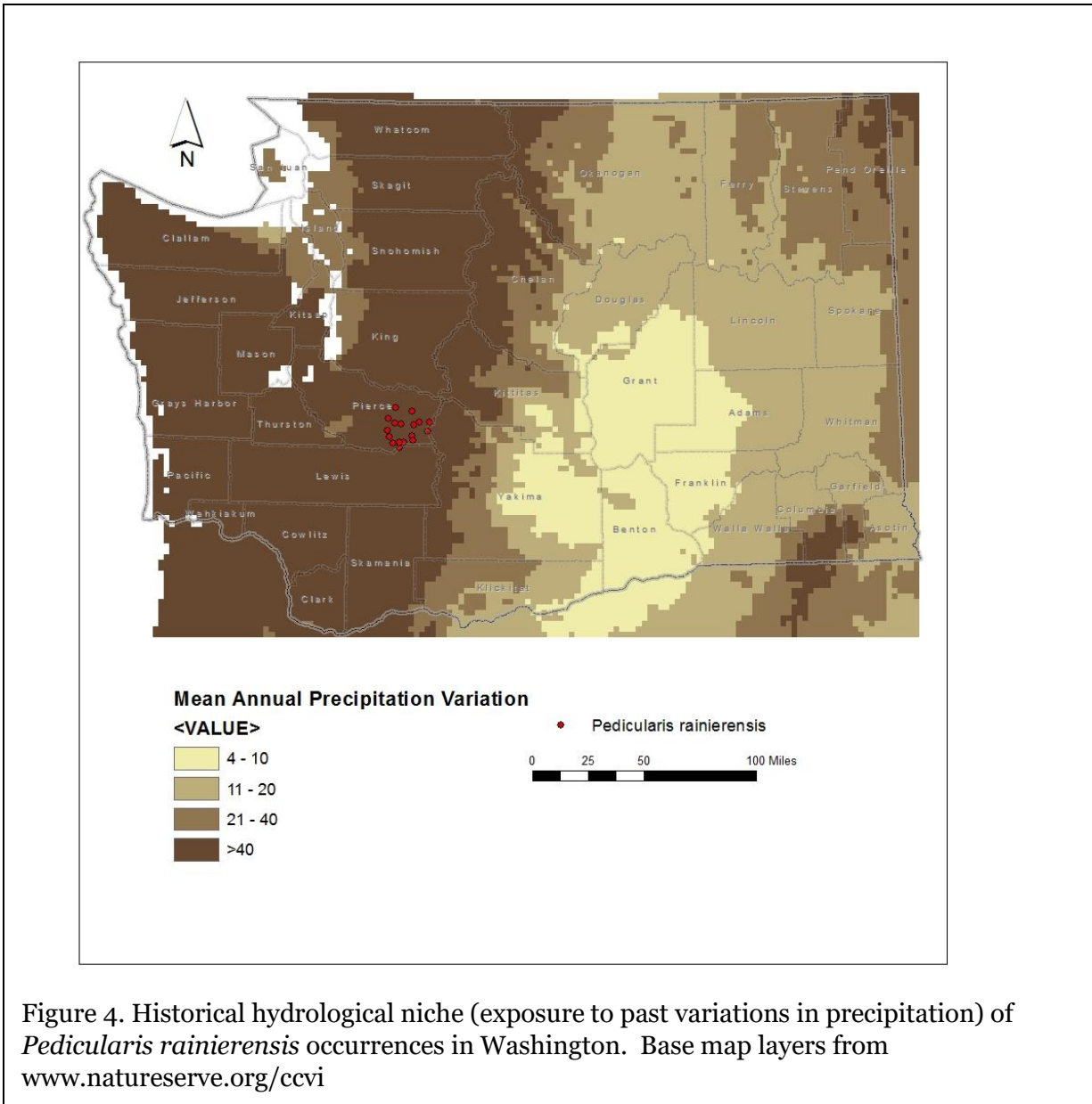
Figure 3. Historical thermal niche (exposure to past temperature variations) of *Pedicularis rainierensis* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2a.ii. Physiological thermal niche: Increase.

The subalpine/alpine meadow habitat of *Pedicularis rainierensis* is associated with cold air drainage during the growing season and would have increased vulnerability to temperature changes from climate change.

C2bi. Historical hydrological niche: Neutral.

All 17 of the populations of *Pedicularis rainierensis* in Washington (100%) are found in areas that have experienced greater than average (>20 inches/508 mm) of precipitation variation in the past 50 years (Figure 4). According to Young et al. (2016), these occurrences are at neutral vulnerability from climate change.



C2bii. Physiological hydrological niche: Somewhat Increase.

This species is dependent on adequate growing season moisture from melting snow and summer precipitation. Hotter temperatures and reductions in the amount and timing of summer rainfall and reduction in the amount of snowfall or the timing of snowmelt could disrupt growth and flowering of alpine and subalpine plant species or make mesic meadow sites more vulnerable to

displacement by conifer forest or drier meadows (Rocchio and Ramm-Granberg 2017). See also “Dependence of ice or snow-cover habitats below.

C2c. Dependence on a specific disturbance regime: Neutral.

Pedicularis rainierensis is not dependent on periodic disturbances to maintain its subalpine/alpine mesic meadow habitat.

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

The populations of *Pedicularis rainierensis* in Washington occur at the subalpine/alpine ecotone in moist meadows on the slopes of Mount Rainier. These sites are highly dependent on moisture from late-lying snowbanks (Rocchio and Ramm-Granberg 2017). Changes in the amount of snow or the timing of snow melt could lead to shifts in the dominance of herbaceous species or invasion of trees or shrubs.

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

Pedicularis rainierensis is restricted to high elevation outcrops of Quaternary andesite, Holocene debris flows, and Miocene and Oligocene-age andesite and rhyolite deposits on the slopes of Mount Rainier. Similar deposits are found on Mount Adams but are otherwise not extensive in Washington.

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

The habitat occupied by *Pedicularis rainierensis* is maintained primarily by natural abiotic processes.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral/Somewhat Increase.

Macior (1973) observed five different bumblebee (*Bombus*) species pollinating *Pedicularis rainierensis*, although the majority of pollination was conducted by just three species (*Bombus bifarius*, *B. melanopygus*, and *B. occidentalis*). Pollination was done primarily by worker bees found inverted within the galea beak of the corolla or rarely by queens or workers collecting nectar and pollen in flight. Hummingbirds are also attracted to *P. rainierensis* for nectar (Macior 1973). Bee foraging behavior and fidelity to a particular *Pedicularis* species and differences in the timing of flowering traditionally helped prevent hybridization among the six native taxa of *Pedicularis* on Mount Rainier (Adams 1983, Macior 1973). More recently, hybrids between *P. rainierensis* and *P. bracteosa* have been found on Mount Rainier as the range of *P. bracteosa* has begun to move higher upslope (Fertig and Kleinknecht 2020). The long-term persistence of native *Bombus* species in light of climate change is poorly known.

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

Seeds are released passively by wind when the dry capsule fruits are mature and split open.

C4e. Sensitivity to pathogens or natural enemies: Somewhat Increase.

Disease, trampling, and grazing by elk and marmots have been identified as potential threats (Camp and Gamon 2011, Fertig and Kleinknecht 2020).

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase. *Pedicularis rainierensis* may be hybridizing with *P. bracteosa* where the two species now overlap on Mount Rainier and barriers to pollen exchange due to timing of flowering or pollinator behavior break down (Adams 1983, Macior 1973). Climate change is likely to increase competition from meadow species or invasive trees and shrubs if subalpine/alpine wet meadow sites become drier or have reduced snowpack (Rocchio and Ramm-Granberg 2017).

C4g. Forms part of an interspecific interaction not covered above: Neutral. Mulvey and Hansen (2011) found no evidence that *Pedicularis rainierensis* is a potential telial host for white pine blister rust (*Cronartium ribicola*) in whitebark pine in Mount Rainier National Park.

C5a. Measured genetic variation: Unknown. Genetic data are not available.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral *Pedicularis rainierensis* produces showy, insect-pollinated flowers and is an obligate outcrosser (Macior 1973). It is likely to have average genetic variability based on these life history parameters.

C6. Phenological response to changing seasonal and precipitation dynamics: Somewhat Increase. Macior (1973) reported the flowering season for *Pedicularis rainierensis* at his study sites on Mount Rainier to be from July 22 to August 10. Since 1973, this species has been documented to flower as early as June 23 and as late as August 16 (Consortium of Pacific Northwest Herbaria database records).

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral. No significant changes have been documented.

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

References

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