Climate Change Vulnerability Index Report

Polemonium carneum (Great polemonium)

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Geographic Area: Washington Heritage Rank: G4/S2

Index Result: Less 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		Somewhat Increase/Neutral
2b. Distribution relative to anthropogenic barriers		Somewhat Increase/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		Neutral
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		Neutral
2c. Dependence on specific disturbance regime		Somewhat Increase/Neutral
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		Unknown
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	
D1. Documented response to recent climate change	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 17 occurrences of *Polemonium carneum* in Washington (100%) occur in areas with a projected temperature increase of < 3.9˚ F (Figure 1).

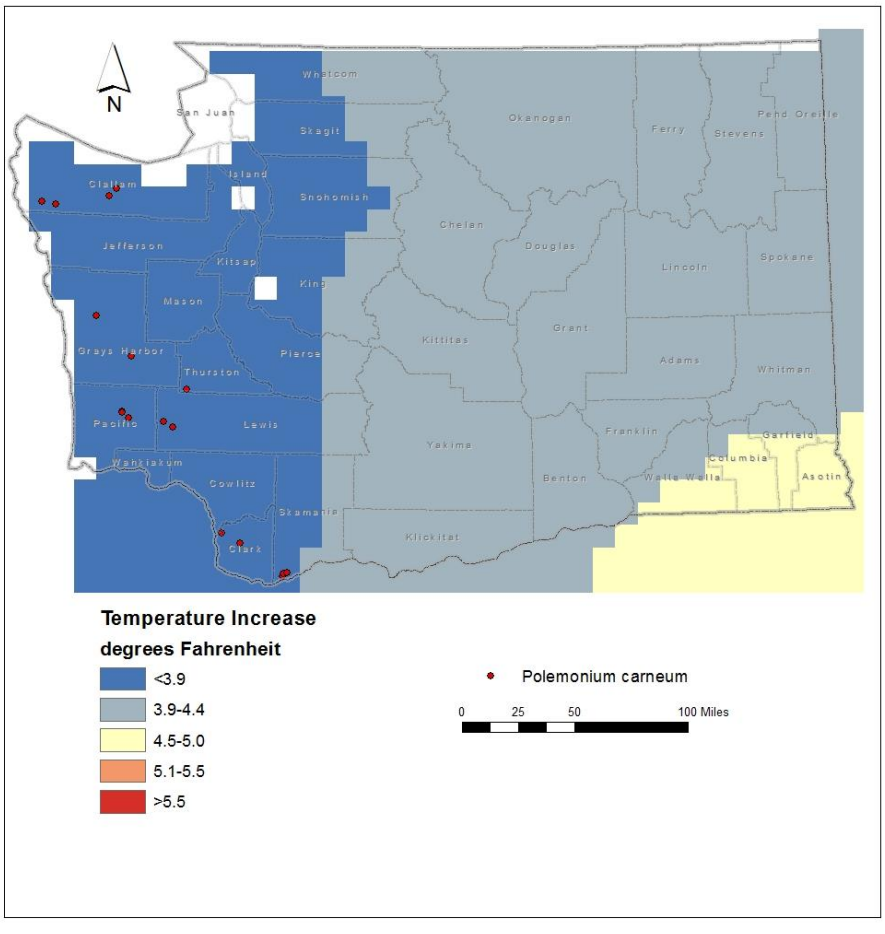

Figure 1. Exposure of *Polemonium carneum* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

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

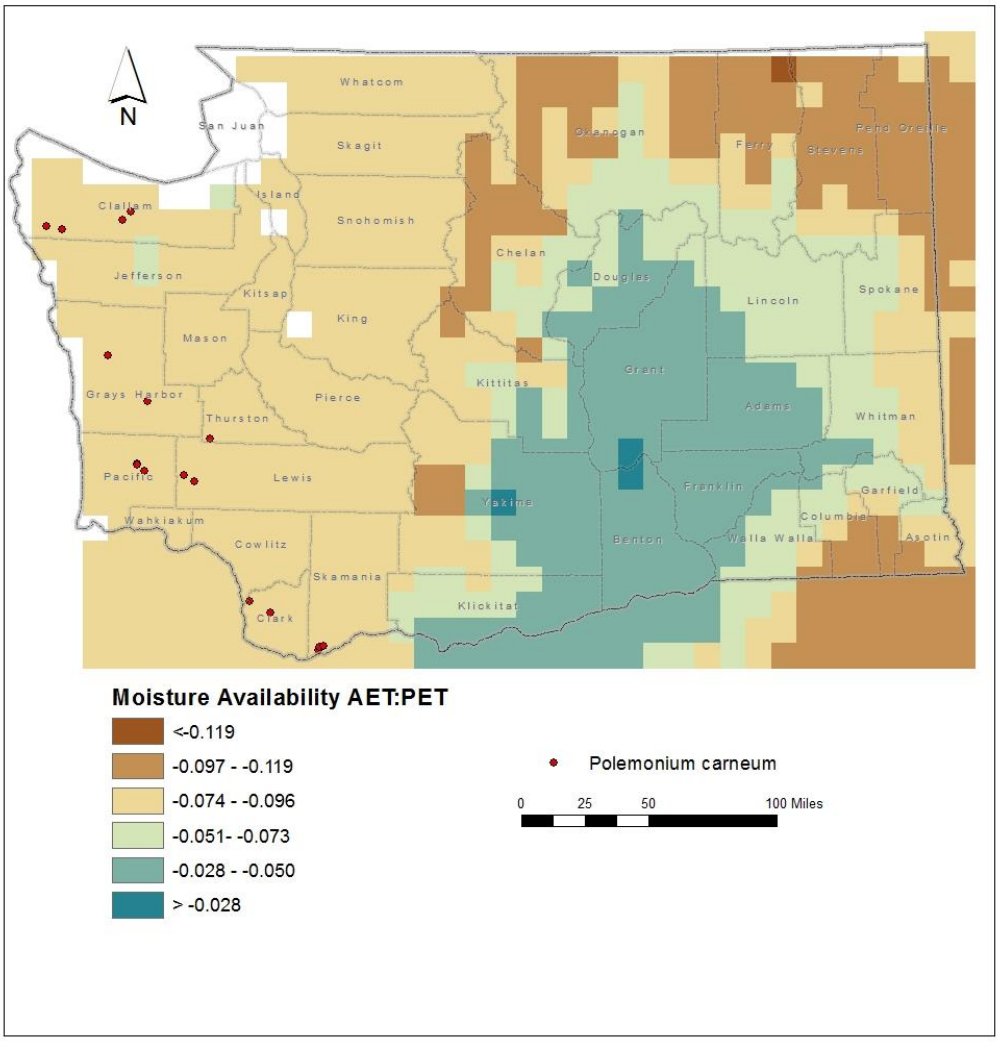

Figure 2. Exposure of *Polemonium carneum* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Polemonium carneum* are found at 150-2000 feet (50-600 m) and would not be inundated by projected sea level rise. Some occurrences in Oregon on the Pacific Coast would be impacted by rising sea levels.

B2a. Natural barriers: Somewhat Increase/Neutral.
In Washington, *Polemonium carneum* is found in open areas in moist forests of Douglas-fir, meadows, and fencerows and in the ecotone between forests and prairies (Camp and Gamon 2011; WNHP records). These habitats probably represent early seral communities within disturbed North Pacific Dry Douglas-fir Forest and Woodland or North Pacific Maritime Dry-Mesic Douglas-fir-Western hemlock forest ecological systems or prairie/bald stands in the North Pacific Herbaceous Bald and Bluff and Willamette Valley Upland Prairie and Savanna ecological systems being invaded by Douglas-fir (Rocchio and Crawford 2015). Washington occurrences are separated by 2.5-52 miles (4-84 km). Patches of suitable habitat occur sporadically within a matrix of lowland forest, remnant prairie, and anthropogenic (agricultural, rural, and urban) environments. Barriers to gene flow are probably equally influenced by natural and human barriers.

B2b. Anthropogenic barriers: Somewhat Increase/Neutral
The range of *Polemonium carneum* in Washington is largely embedded within a matrix of second-growth natural habitats and human-modified landscapes, with gene flow equally restricted by natural and anthropogenic processes.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.
Polemonium carneum produces dry, capsule fruits with numerous seeds that are released passively. *Polemonium* seeds become mucilaginous and sticky when wet, so can be dispersed by animals, such as waterfowl. Dispersal distances are poorly known for *P. carneum*, but are likely in the range of 100-1000m.

C2ai. Historical thermal niche: Increase.
Figure 3 depicts the distribution of *Polemonium carneum* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Ten of the 17 known occurrences (58.8%) 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). Three occurrences (17.7%) are from areas with very small (<37˚F/20.8˚C) temperature variation over the same period and are at greatly increased vulnerability to climate change. Four other populations are found in areas with slightly lower than average (47.1-57˚F/26.3-31.8˚C) temperature variation over the past 50 years and would be at somewhat increased vulnerability to climate change (Fgure 3, Young et al. 2016).

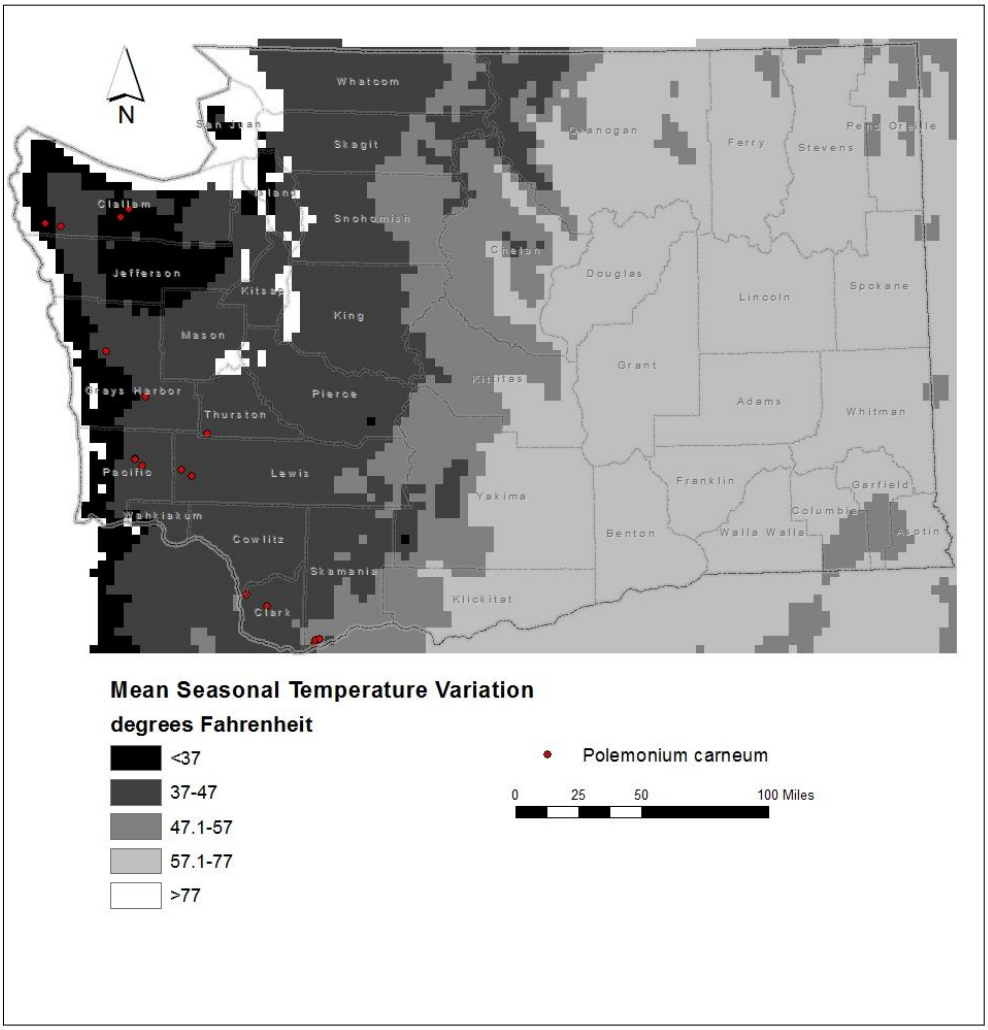

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Polemonium carneum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Neutral.
The open forest and meadow ecotone habitat of *Polemonium carneum* is not associated with cold air drainage during the growing season and would have neutral vulnerability to climate change.

C2bi. Historical hydrological niche: Neutral.
All 17 of the populations of *Polemonium carneum* 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.

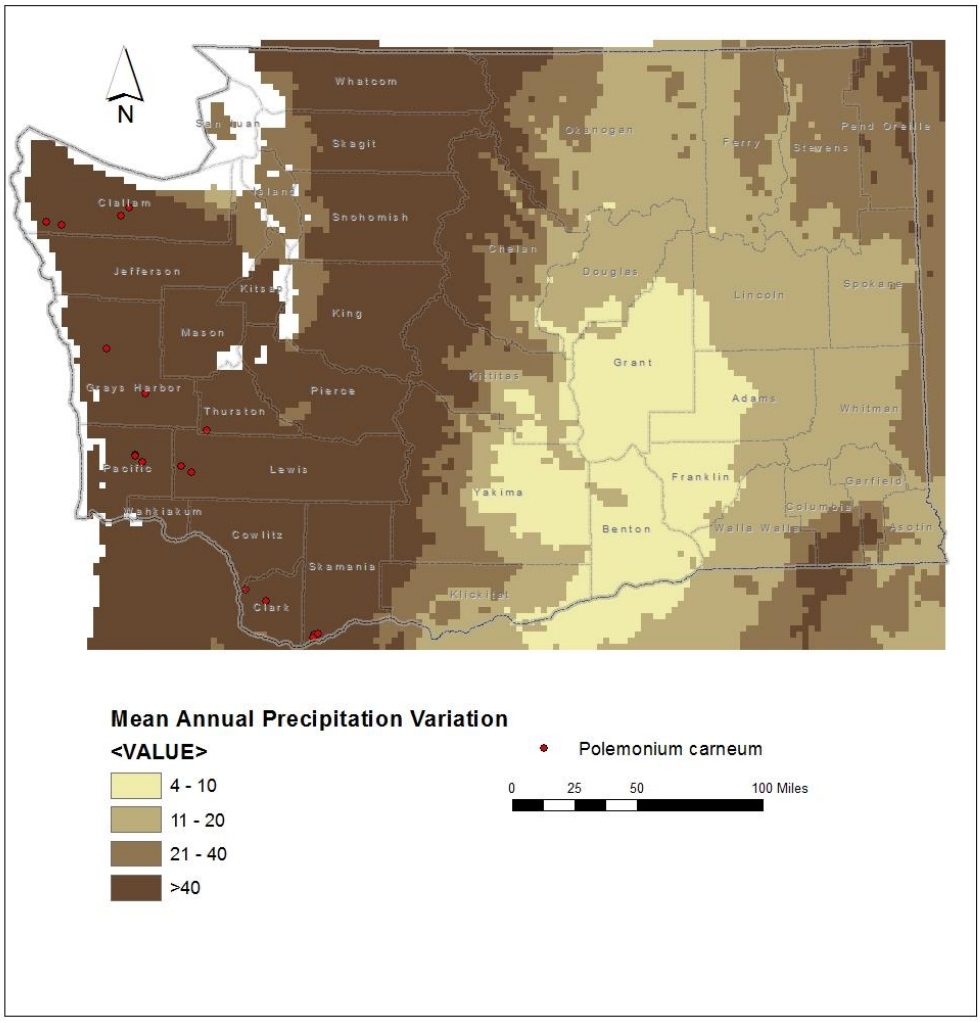

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Polemonium carneum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Neutral.
This species is found in sites where moisture from precipitation is typically not limiting. Reduced precipitation and increased temperatures could make its habitats more at risk from wildfire under projected climate change scenarios (Rocchio and Ramm-Granberg 2017).

Increased fire could actually benefit *Polemonium carneum* in creating or maintaining meadow or forest ecotone conditions.

C2c. Dependence on a specific disturbance regime: Somewhat Increase/Neutral.
Polemonium carneum is dependent on periodic disturbances, such as high winds or low intensity wildfire to maintain its open meadow or early seral habitat. Increased temperatures and decreased precipitation projected from climate change are likely to increase the frequency and intensity of wildfires and wind-throw (Rocchio and Ramm-Granberg 2017), which could benefit this species by favoring grasslands over forests. Reduced soil moisture, however, could impact herbaceous plants, like *P. carneum*, and increased disturbance could result in greater competition from invasive non-native plants.

C2d. Dependence on ice or snow-cover habitats: Neutral.
The populations of *Polemonium carneum* in Washington occur primarily in areas of moderate winter snowfall. Populations associated with North Pacific herbaceous balds in the Olympic Peninsula could be impacted by reduced snow accumulation or changes in snowmelt patterns (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Neutral.
Polemonium carneum is found on a variety of geological substrates in western Washington, including Eocene marine sediments, Quaternary alluvium and glacial till, and various post-glacial flood deposits. These formations are all widespread in this part of the state.

C4a. Dependence on other species to generate required habitat: Neutral
The habitat occupied by *Polemonium carneum* is maintained primarily by natural abiotic processes, especially wind and fire.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Unknown.
Polemonium carneum is an outcrosser and is insect pollinated (Worley et al. 2009). The exact pollinators are not known. Related species of *Polemonium* with large flowers are pollinated by bumblebees in the genus *Bombus* (Zimmerman 1980).

C4d. Dependence on other species for propagule dispersal: Neutral.
Polemonium carneum seeds are released passively when the dry capsule fruits are mature and split open. The seeds become mucilaginous and sticky when wettened, and can potentially be transported long distance in muddy soil stuck to birds.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. This species may be vulnerable to livestock grazing (Camp and Gamon 2011), but effects of grazing by native species is not known.

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
The habitat of *Polemonium carneum* is in meadows and prairie areas bordered by Douglas-fir forests and is vulnerable to invasion by trees in the absence of periodic disturbance, such as fire or wind-throw. Climate change is likely to increase fire frequency and intensity, which could

reduce tree cover but make sites prone to invasion and competition by invasive non-native species (Rocchio and Ramm-Granberg 2017).

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

C5a. Measured genetic variation: Unknown.
Genetic data are not available from Washington. A study comparing genetic diversity among 18 taxa in the genus *Polemonium* (Worley et al. 2009) found that *P. carneum* had a higher degree of genetic variability than all but three species.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral
Polemonium carneum produces showy, insect-pollinated flowers and is an obligate outcrosser (Worley et al. 2009). It is likely to have average genetic variability based on these life history traits.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on records from the Consortium of Pacific Northwest Herbaria, the phenology of this species has not changed significantly since it was first documented in Washington in the 1890s.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Somewhat Increase.
Eight of the 17 occurrences of *Polemonium carneum* in Washington have not been relocated since 1980 and are considered historical. These populations may be locally extirpated due to changes in habitat condition from vegetation succession or climate change.

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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