Climate Change Vulnerability Index Report

Polemonium viscosum (Sticky sky-pilot)

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Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G5/S2

Index Result: Extremely 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	69.2
	-0.074 to -0.096	30.8
	-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		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		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		Increase
4a. Dependence on others species to generate required habitat		Neutral
4b. Dietary versatility		Not Applicable
4c. Pollinator versatility		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		Neutral/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	Somewhat Increase
6. Phenological response to changing seasonal and precipitation dynamics	Neutral
Section D: Documented or Modeled Response	
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: All 13 extant and historical occurrences of *Polemonium viscosum* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

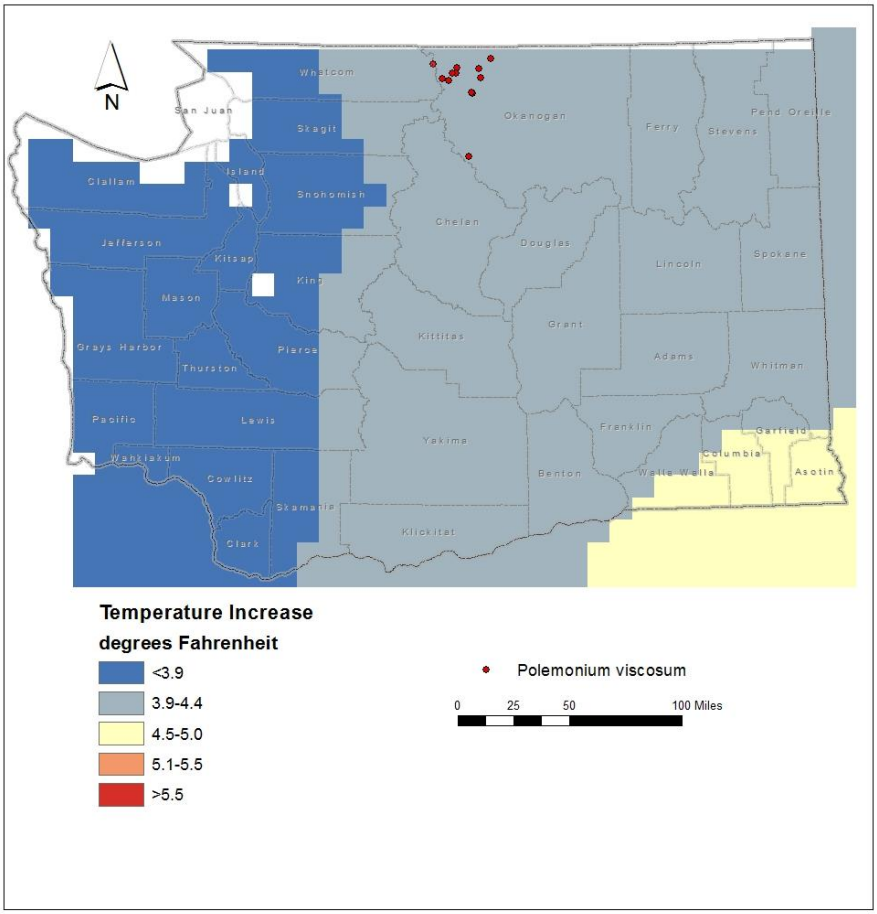

Figure 1. Exposure of *Polemonium viscosum* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Nine of the 13 occurrences (69.2%) of *Polemonium viscosum* 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 -0.097 to -0.119 (Figure 2). Four other populations (30.8%) are from areas with a projected decrease of -0.074 to -0.096.

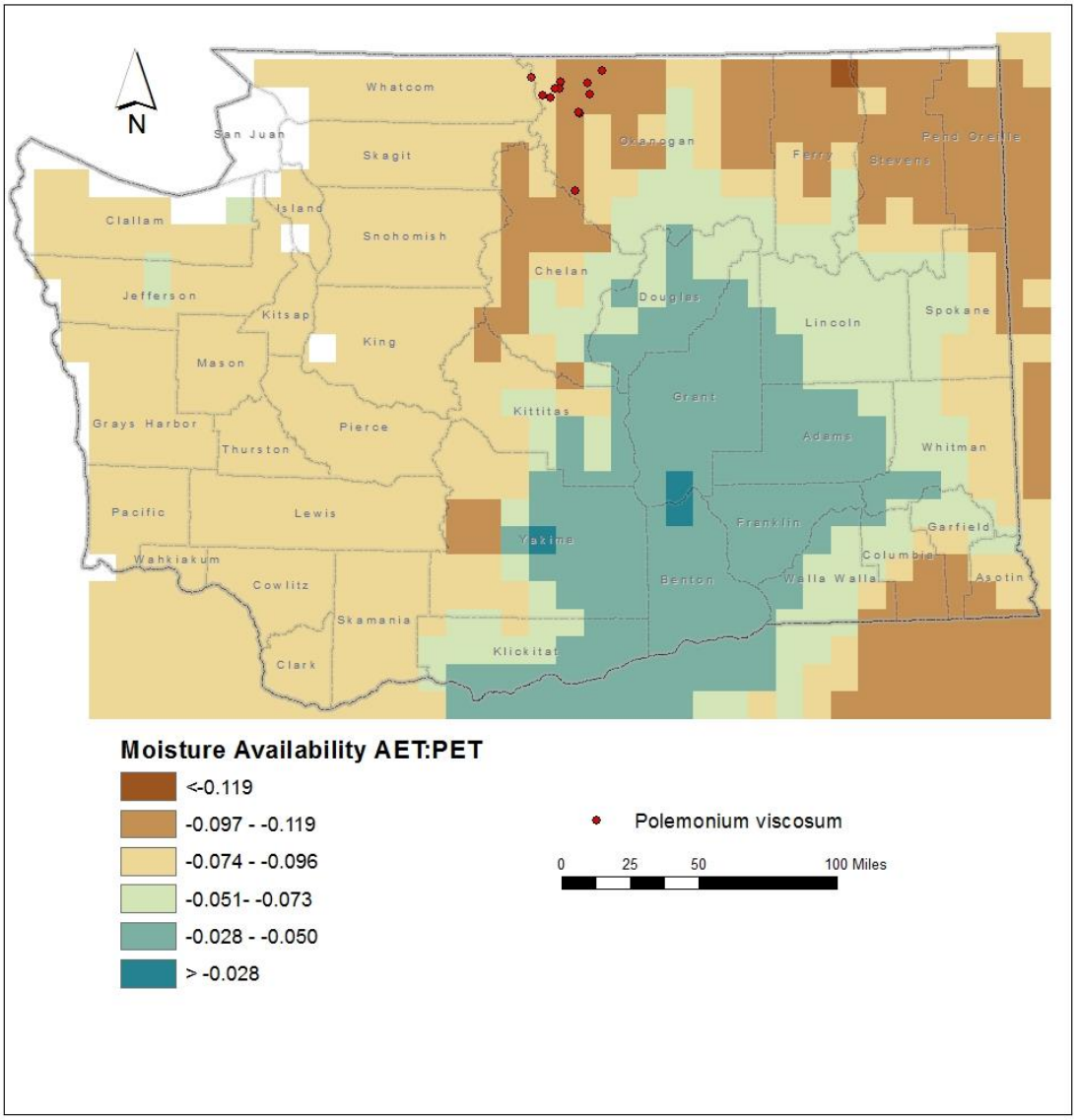

Figure 2. Exposure of *Polemonium viscosum* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Polemonium viscosum* are found at 6350-8200 feet (1935-2500 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
Polemonium viscosum occurs in crevices and protected microsites in alpine talus, fellfield, and sandy-gravelly slopes, often below recently melted snow (Camp and Gamon 2011; Washington Natural Heritage Program 2021). This habitat is part of the Rocky Mountain Alpine Bedrock and Scree ecological system (Rocchio and Crawford 2015). Populations are found on separate ridges or peaks isolated by 1.3-28 miles (2.5-45 km) of unoccupied and unsuitable habitat. The natural heterogeneity of available habitat forms a barrier to dispersal and future migration.

B2b. Anthropogenic barriers: Neutral.
Eight populations of *Polemonium viscosum* in Washington are found in wilderness areas with a minimal human footprint. The alpine summits inhabited by the species are surrounded by anthropogenic infrastructure in adjacent lowlands, but these areas are already a natural 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: Increase.
Polemonium viscosum produces 2-12 seeds in dry capsule fruits that split open at maturity to passively release the seed (Newport 1989). The seeds are dispersed primarily by gravity and perhaps secondarily by animals. Average dispersal distances are probably small (<100 meters).

C2ai. Historical thermal niche: Increase.
Figure 3 depicts the distribution of *Polemonium viscosum* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All 13 of the known occurrences in the state (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).

C2aii. Physiological thermal niche: Greatly Increase.
The alpine talus habitat of *Polemonium viscosum* is entirely within a cold climate zone during the flowering season and highly vulnerable to temperature increase from climate change.

C2bi. Historical hydrological niche: Neutral.
All of the known populations of *Polemonium viscosum* 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.

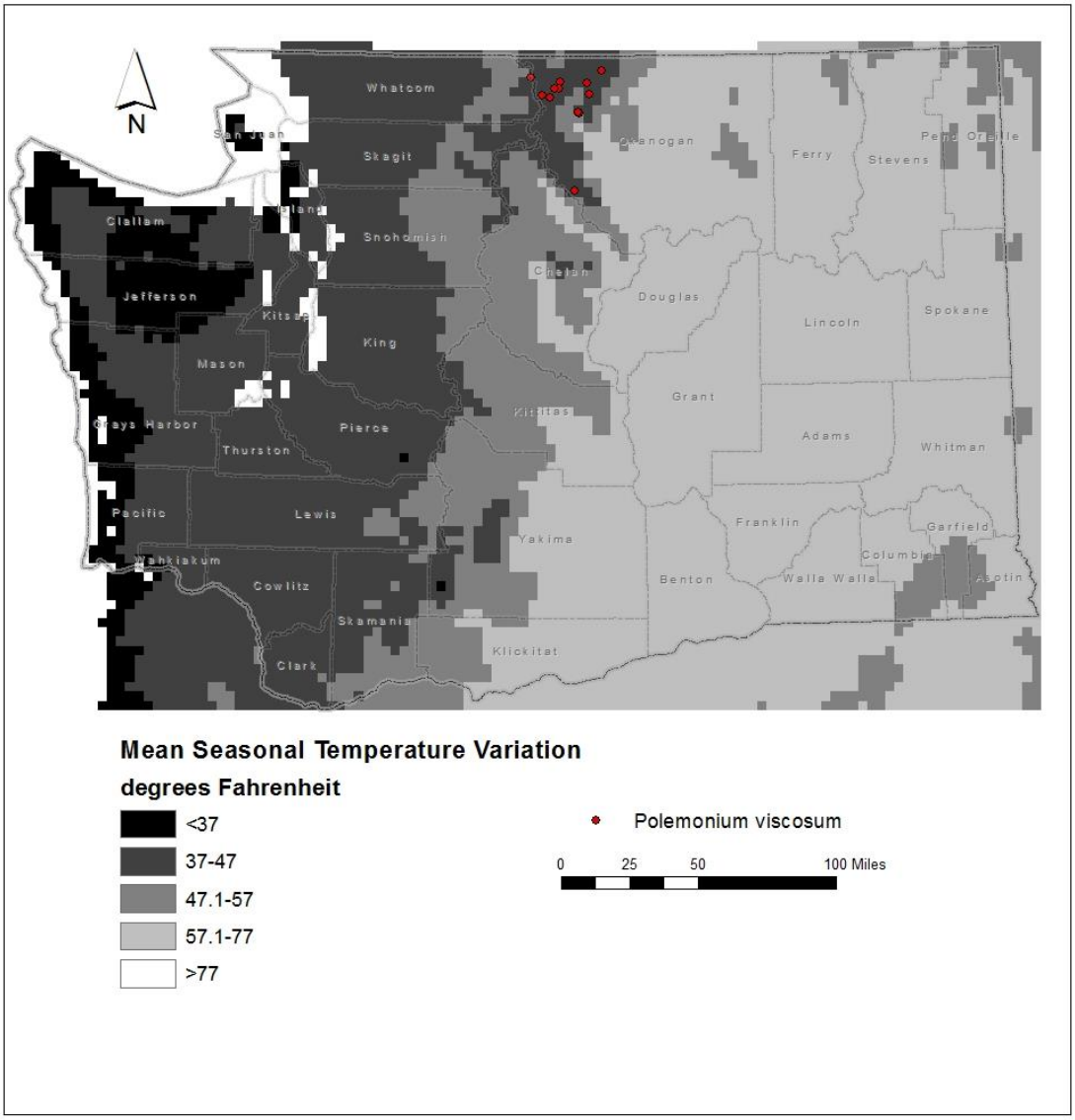

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Polemonium viscosum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
This species is dependent on winter snow and summer precipitation for meeting its moisture needs, as populations are not associated with perennial wetlands or soils with a high water table. It could be vulnerable to changes in the timing or amount of snow and rainfall and earlier snowmelt related to warming temperatures (Rocchio and Ramm-Granberg 2017). Increased temperatures would extend the growing season and accelerate soil formation, allowing for increased vegetation cover and long-term displacement of existing species with those adapted to meadow conditions.

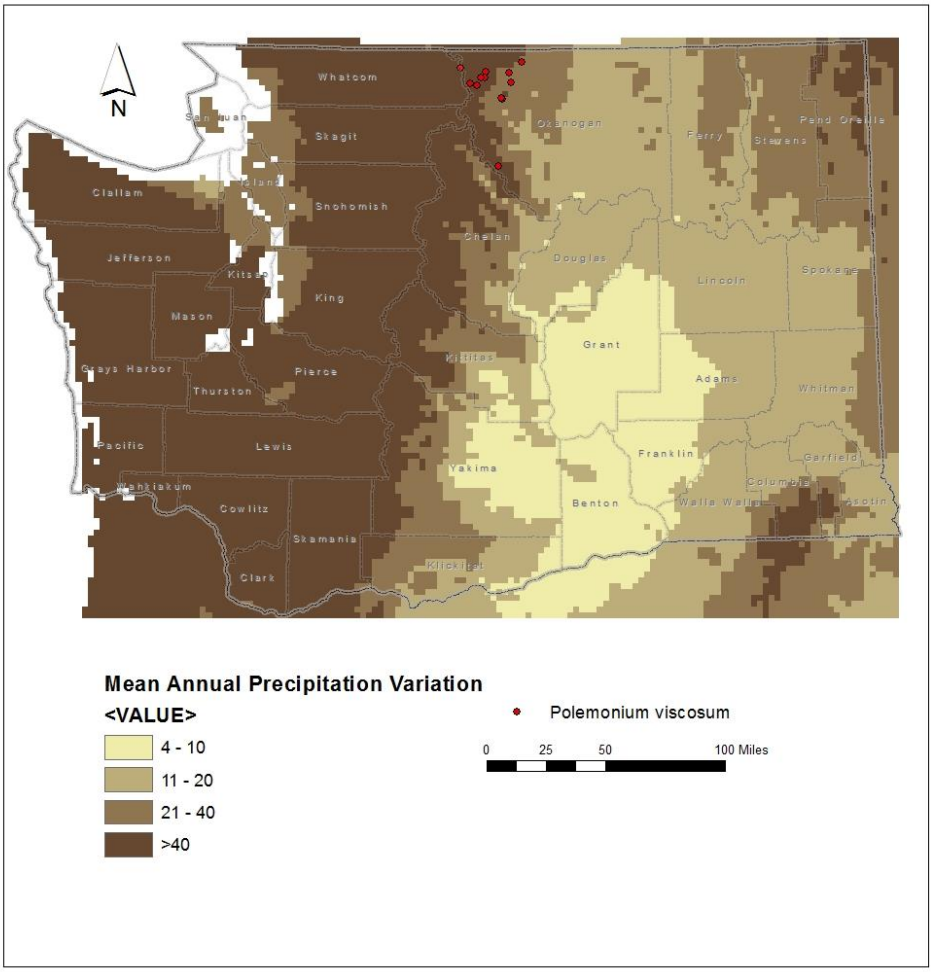

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Polemonium viscosum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2c. Dependence on a specific disturbance regime: Neutral.
Polemonium viscosum occurs in alpine talus and rock outcrop habitats that are subjected to high winds. Other than occasional rock fall, these sites are largely undisturbed at present.

C2d. Dependence on ice or snow-cover habitats: Increase.
Populations of *Polemonium viscosum* in Washington are found on alpine talus slopes and ridgecrests associated with high winter snow accumulation. Reduced snowpack due to climate change, or changes in the timing of snowmelt, would decrease the amount of moisture available through runoff (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Increase.
Polemonium viscosum is found primarily on outcrops of Cretaceous marine sedimentary rock (including the Winthrop Sandstone, Goat Creek, and Harts Pass formations) or intrusions of Eocene granodiorite and Paleocene tonalite (Oval Peak batholith) (Washington Division of Geology and Earth Resources 2016). These formations occupy a limited area in western Okanogan County south of the Canadian border and may account for the small range of *P. viscosum* in Washington.

C4a. Dependence on other species to generate required habitat: Neutral.
The alpine talus habitat occupied by *Polemonium viscosum* is maintained largely by natural abiotic conditions.

C4b. Dietary versatility: Not applicable for plants.

C4c. Pollinator versatility: Increase.
Polemonium viscosum has large, tubular, purple to blue flowers that attract a variety of insect pollinators, including bumblebees (*Bombus*), solitary bees, syrphid flies, anthomyiid flies, and muscid flies (Galen 1985). Bumblebees, however, are the most effective pollinators due to their size and faithfulness to visiting *Polemonium* flowers, whereas other insect species are more generalist pollinators with low floral fidelity. Studies in Colorado have found that the golden-belted bumblebee (*Bombus kirbiellus*) is the primary pollinator of *P. viscosum*. In Washington, *B. kirbiellus* is ranked S1 (critically imperiled), which may factor into the rarity of *P. viscosum* in the state (NatureServe 2021).

Polemonium viscosum is noteworthy in producing flowers with two distinct odors (either in different individuals or on the same plant). Sweet-smelling flowers preferentially attract bumblebees, while skunky-smelling flowers (with the odor produced by sticky glands on the sepals) function to deter herbivory by ants, which can cause damage to stigmas and ovaries and reduce seed set (Galen and Cuba 2007, Galen and Kevan 1983).

C4d. Dependence on other species for propagule dispersal: Neutral.
Seeds of *Polemonium viscosum* are released passively through the dehiscence of dry fruit capsules and rely on gravity or high winds for dispersal (although secondary movement by foraging animals may also occur).

C4e. Sensitivity to pathogens or natural enemies: Somewhat Increase.
Impacts from pathogens are not known. Overall herbivory on the sticky-glandular foliage appears to be low. Floral damage by nectar-feeding ants can result in significant reductions in seed production (Galen 1983) and has resulted in the evolution of different flower shapes and scents in *Polemonium viscosum* in response (Galen 1985).

C4f. Sensitivity to competition from native or non-native species: Neutral/Somewhat Increase.
The harsh growing conditions and few sites for seedling establishment keep vegetation cover low in the alpine talus and fellfield habitat occupied by *Polemonium viscosum*. Competition with invasive non-native plants is also minimal. Under projected climate change, competition with native and introduced plant species could increase if lower elevation species are able to expand their range due to milder and longer growing seasons or increased soil development (Rocchio and Ramm-Granberg 2017).

C4g. Forms part of an interspecific interaction not covered above: Neutral.
Does not require an interspecific interaction, other than pollinators.

C5a. Measured genetic variation: Unknown.
In Colorado, Galen et al. (1991) found genetic differentiation and morphologic differences at two ends of a population cline, suggesting local adaptation was important in creating ecotypic variation. Similar studies have not been done in Washington. Based on the isolation of Washington populations, it is likely that they have lower overall genetic diversity than occurrences from the central and southern Rocky Mountains.

C5b. Genetic bottlenecks: Unknown.
Washington populations of *Polemonium viscosum* are geographically isolated from the core of the species' range in the central and southern Rocky Mountains (northeast Oregon to southwest Montana, south to northern Arizona and New Mexico). If Washington occurrences arose via long distance dispersal, they would be expected to have lower genetic diversity due to founder effects or inbreeding.

C5c. Reproductive System: Somewhat Increase.
Polemonium viscosum is an obligate outcrosser with little self-compatibility (Galen and Kevan 1980). These characteristics are associated with normal genetic variability. The isolated populations in Washington probably have reduced genetic diversity, however, due to genetic drift or founder effects.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on herbarium specimens in the Consortium of Pacific Northwest Herbaria website (pnwherbaria.org) and WNHP records, the flowering period of *Polemonium viscosum* has not changed significantly in the last 100 years.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Unknown.
Two occurrences of *Polemonium viscosum* in Washington are historical (not relocated in the last 40 years). Whether this potential range contraction is due to climate change is not known.

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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