Climate Change Vulnerability Index Report

Eritrichium argenteum (Pale alpine forget-me-not)

Date: 10 March 2021 Synonym: *E. nanum* var. *elongatum*

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G4/S1

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	100
	<3.9° F (2.2°C) warmer	0
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	100
	-0.074 to -0.096	0
	-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		Increase
2ai Change in historical thermal niche		Somewhat 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		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		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 B: Indirect Exposure to Climate Change	
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: The single known occurrence of *Eritrichium argenteum* in Washington (100%) occurs in an area with a projected temperature increase of 3.9-4.4˚ F (Figure 1). Reports from Benton and Walla Walla counties are based on misidentifications and are excluded.

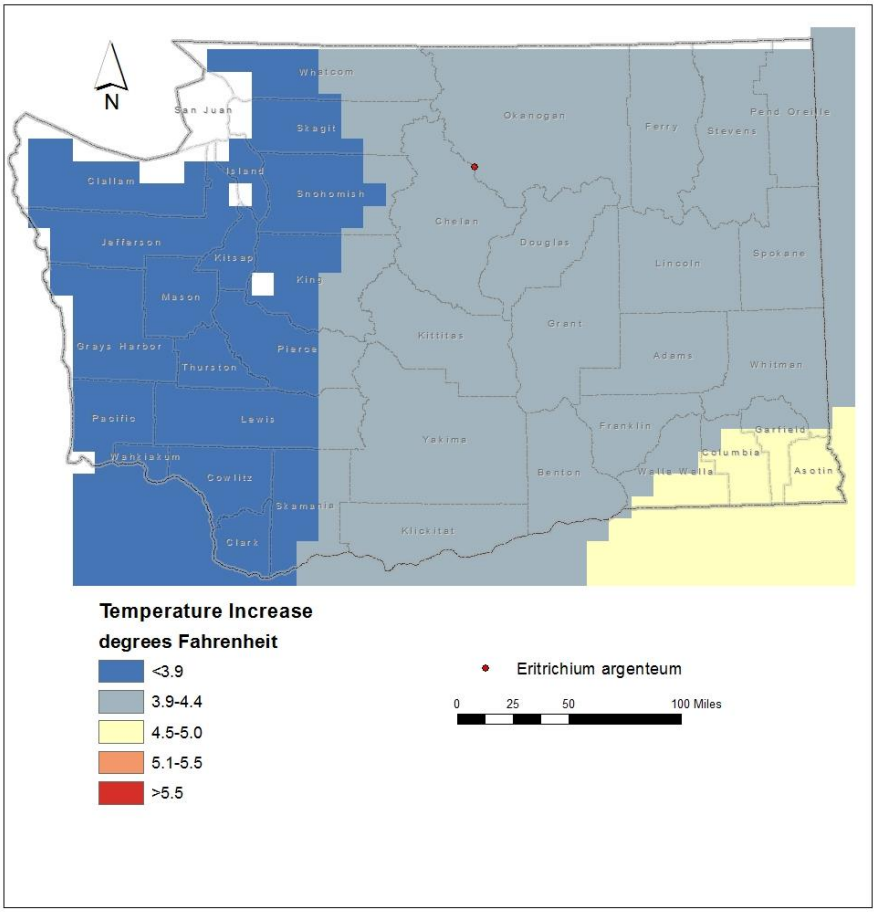

Figure 1. Exposure of *Eritrichium argenteum* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: The single occurrence of *Eritrichium argenteum* in Washington (100%) is found in an area 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).

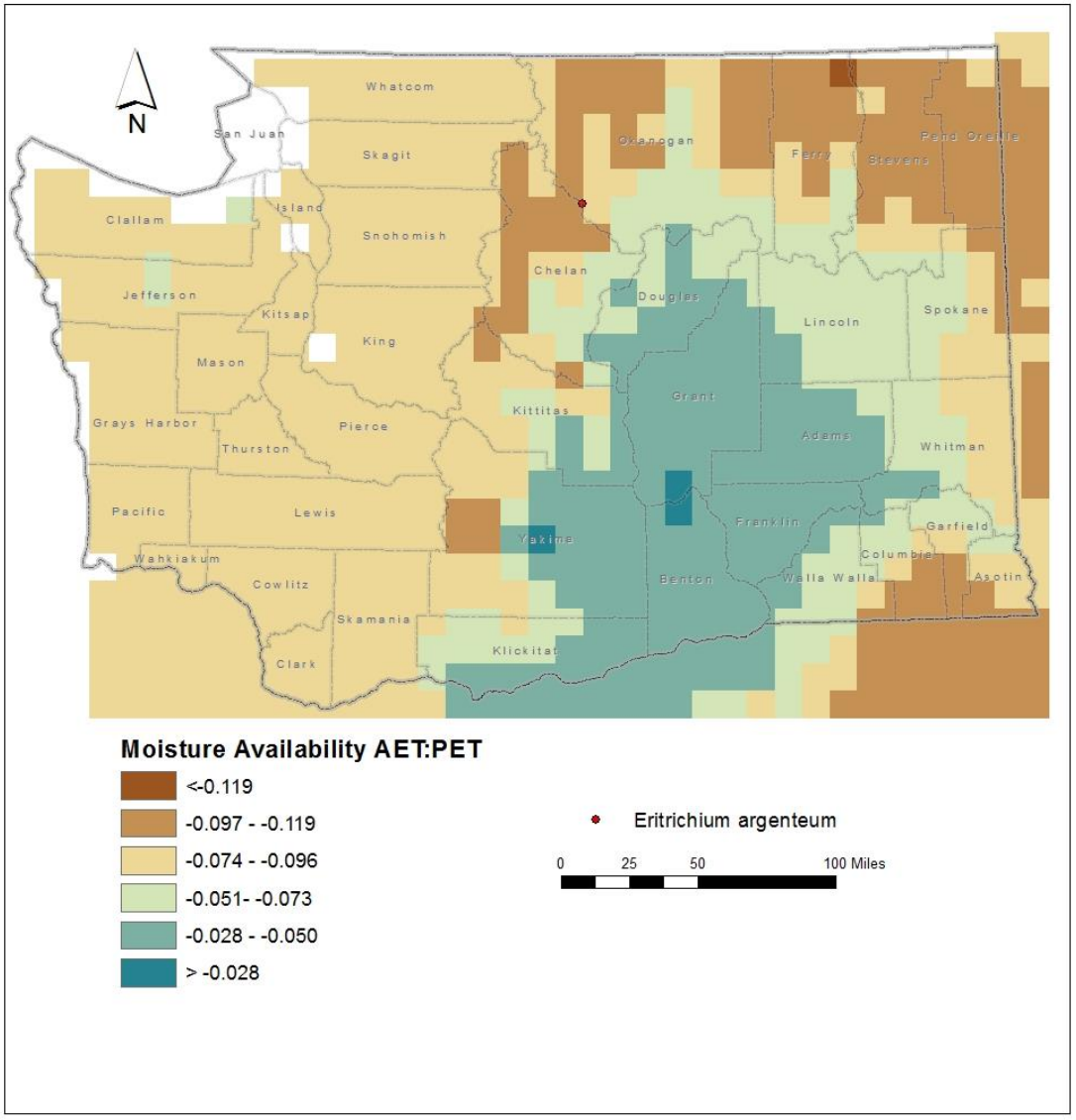

Figure 2. Exposure of *Eritrichium argenteum* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
The Washington occurrence of *Eritrichium argenteum* is found at 7300-8300 feet (2200-2600 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Increase.
Eritrichium argenteum occurs on rocky alpine slopes in a cushion plant community with dwarf, stunted shrubs (Camp and Gamon 2011; Fertig and Kleinknecht 2020). This habitat is part of the Rocky Mountain Alpine Dwarf-Shrubland, Fell-field, and Turf ecological system (Rocchio and Crawford 2015). Additional habitat may occur on high ridges of the Northern Cascades, but overall is limited in Washington. Natural barriers of unsuitable habitat at lower elevations are likely to restrict dispersal and migration to new areas under climate change.

B2b. Anthropogenic barriers: Neutral.
The alpine habitat of *Eritrichium argenteum* in Washington is restricted to the Chelan-Sawtooth Wilderness Area and is relatively unimpacted by human activities and barriers.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Increase.
Eritrichium argenteum produces one to four 1-seeded nutlets per flower. The nutlets are smooth and four-sided and lack structures to promote dispersal by wind. Genetic studies in Europe of *E. nanum* (a sister species) indicates that long distance dispersal is exceptionally rare (Stehlik et al. 2002). Dispersal probably depends on gravity and secondary movement by small mammals, and is likely to average less than 100 m.

C2ai. Historical thermal niche: Somewhat Increase.
Figure 3 depicts the distribution of *Eritrichium argenteum* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). The single state population (100%) is from an area that has experienced slightly lower than average (47.1-57˚F/26.3-31.8˚C) temperature variation during the past 50 years and is at somewhat increased vulnerability to climate change (Young et al. 2016).

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

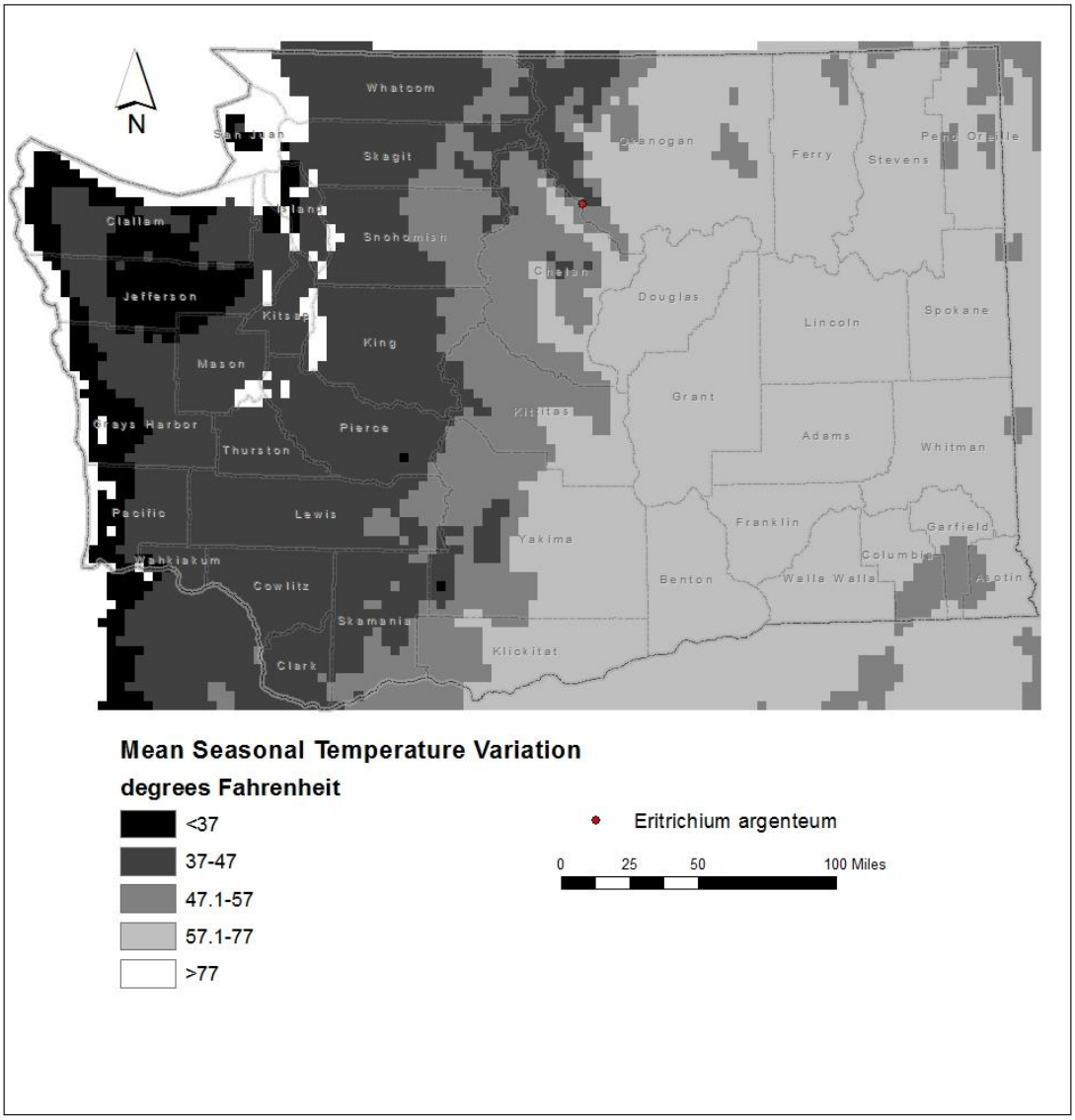

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Eritrichium argenteum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.

The single known population of *Eritrichium argenteum* in Washington is found in an area that has experienced greater than average precipitation variation in the past 50 years (>40 inches/1016 mm) (Figure 4). According to Young et al. (2016), this occurrence is at neutral vulnerability from climate change.

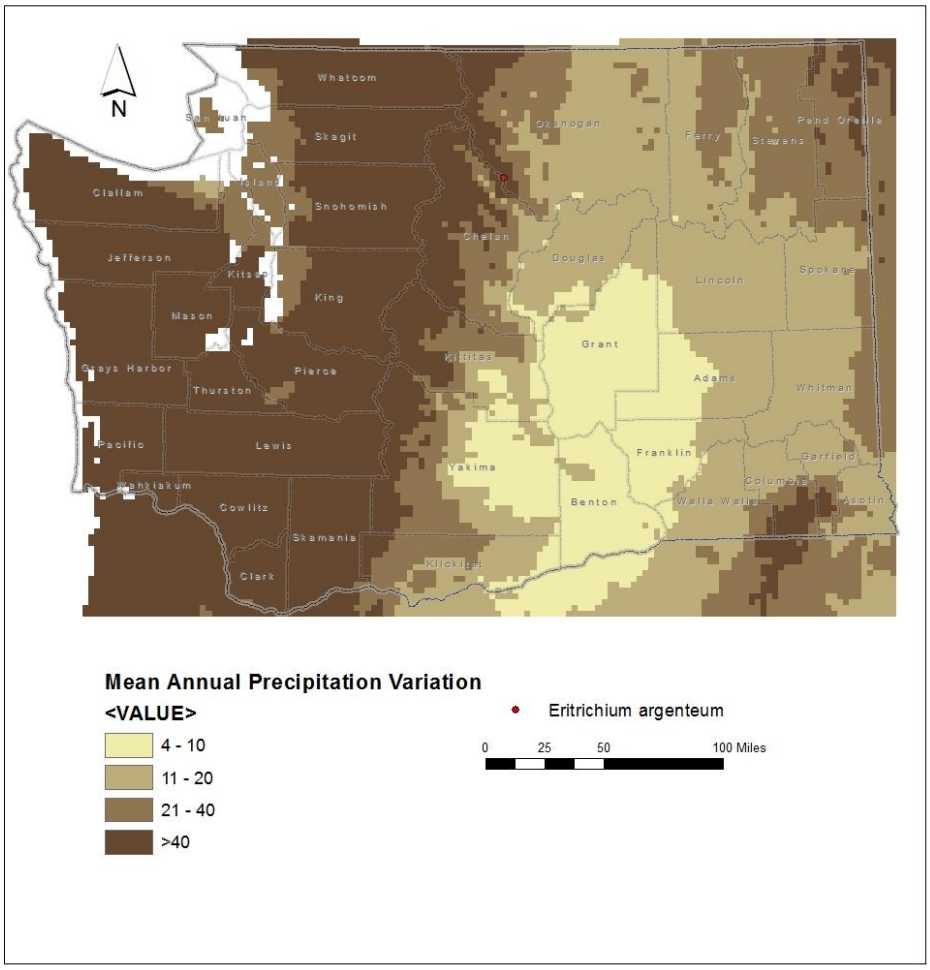

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Eritrichium argenteum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
This species is dependent on winter snow and summer precipitation for meeting its moisture needs, as it is not associated with wetlands or soils with a high water table. As such, it could be vulnerable to changes in the timing or amount of snow and rainfall (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.
Eritrichium argenteum occurs in alpine talus, scree, and turf habitats that are subject to high winds. Other than occasional rock fall, these are largely undisturbed sites at present.

C2d. Dependence on ice or snow-cover habitats: Increase.
The populations of *Eritrichium argenteum* in Washington are found on alpine ridgecrests and talus slopes/tundra associated with winter snow accumulation, though the areas may be free of snow due to evaporation or drifting during the growing season. Reduced snowpack due to climate change would decrease the amount of moisture available through runoff (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Increase.
Eritrichium argenteum is found on granite outcrops of the Oval Peak batholith, an uncommon geologic formation in the East Cascades and Okanogan Mountains of Washington (Washington Division of Geology and Earth Resources 2016).

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

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Unknown.
Studies in Europe indicate that closely related *Eritrichium nanum* is pollinated primarily by several fly species in the families Anthomyiidae and Muscidae and less commonly by bees (*Andrena* sp.) (Zoller et al. 2002). The specific pollinators of *E. argenteum* in Washington are not known.

C4d. Dependence on other species for propagule dispersal: Neutral.
The hard, nutlet fruits of *Eritrichium argenteum* lack any wings, hairs, or other structures to aid in dispersal by wind, water, or animals.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Not known, but probably not a limiting factor.

C4f. Sensitivity to competition from native or non-native species: Neutral/Somewhat Increase.
Under present conditions, competition from non-native species is minor, as few introduced plants are adapted to the harsh environmental conditions of the alpine zone. Vegetation cover is low in rocky talus slopes and fell-fields due to the paucity of germination sites and harsh climatic conditions impacting seedling survival. Under future climate change scenarios, these sites could become invaded by tree or shrub species or lower elevation forbs and grasses, resulting in increased soil accumulation, more litter, and enhanced probability of fire (Rocchio and Ramm-Granberg 2017).

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

C5a. Measured genetic variation: Unknown.
Genetic variability has not been tested in Washington material. Since the single Washington population is disjunct from occurrences in northern British Columbia, Idaho, and northeastern Oregon, it probably has a more homogeneous genome due to genetic drift or founder effects.

C5b. Genetic bottlenecks: Unknown.
Not known.

C5c. Reproductive System: Somewhat Increase.
The sister species *Eritrichium nanum* from Europe is an outcrosser with flowers that can be protandrus (stamens mature before the stigmas in the same flower) or protogynous (stigmas mature before the stamens) (Zoller et al. 2002). Genetic studies of isolated and disjunct populations in the Alps found that they were associated with genetic haplotypes, suggesting they had persisted in unglaciated refugia with minimal gene flow since the Pleistocene (Stehlik et al. 2002). Washington populations are also disjunct and likely to have reduced genetic variability due to inbreeding depression, genetic drift, or founder effects.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on observation reports from WNHP and herbarium records in the Consortium of Pacific Northwest Herbaria website (pnwherbaria.org), *Eritrichium argenteum* has not changed its typical blooming time since the 1960s.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
No major changes have been detected in the distribution of *Eritrichium argenteum* in Washington since it was first discovered in the state in the 1960.

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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