Climate Change Vulnerability Index Report

Arcteranthis cooleyae (Cooley's buttercup)

Date: 25 October 2021 Synonym: *Ranunculus cooleyae*

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G5/S1

Index Result: Moderately 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	25
	<3.9° F (2.2°C) warmer	75
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		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		Somewhat Increase/Increase
2ai Change in historical thermal niche		Somewhat 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		Somewhat 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		Neutral
4f. Sensitivity to competition from native or non-native species		Neutral
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: Documented or Modeled Response	
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: Three of the four occurrences of *Arcteranthis cooleyae* in Washington (75%) occur in areas with a projected temperature increase of <3.9˚ F (Figure 1). One other population (25%) is from an area with a projected temperature increase of 3.9-4.4˚ F.

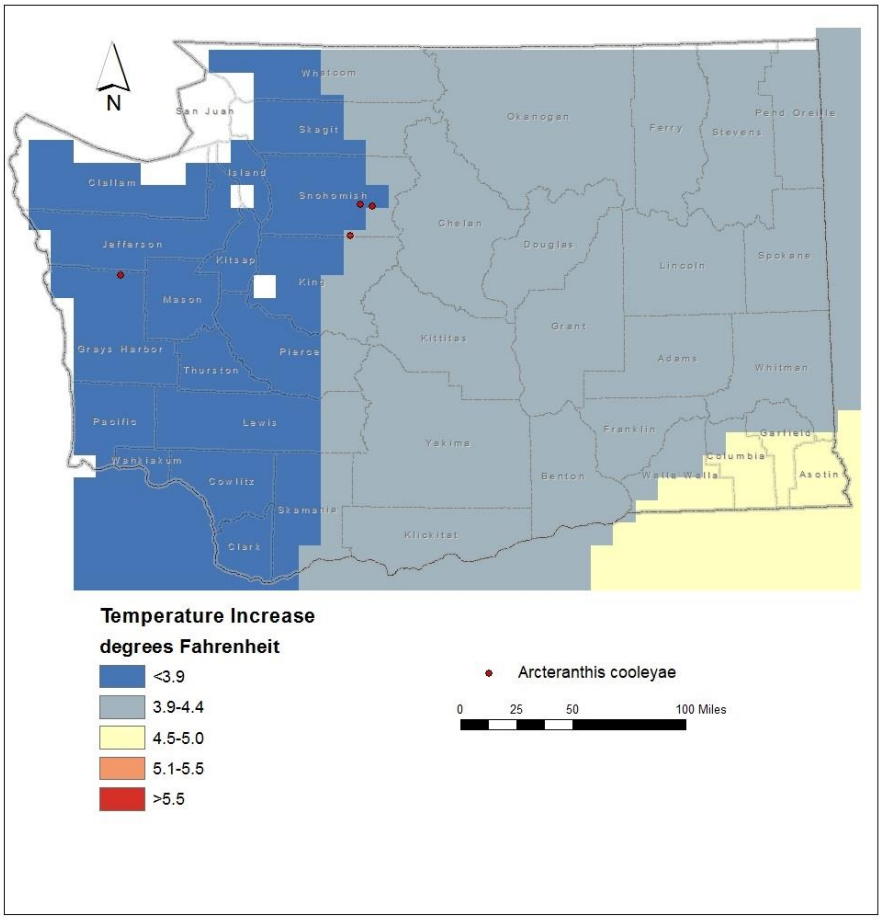

Figure 1. Exposure of *Arcteranthis cooleyae* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: All of the known Washington occurrences of *Arcteranthis cooleyae* (100%) 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).

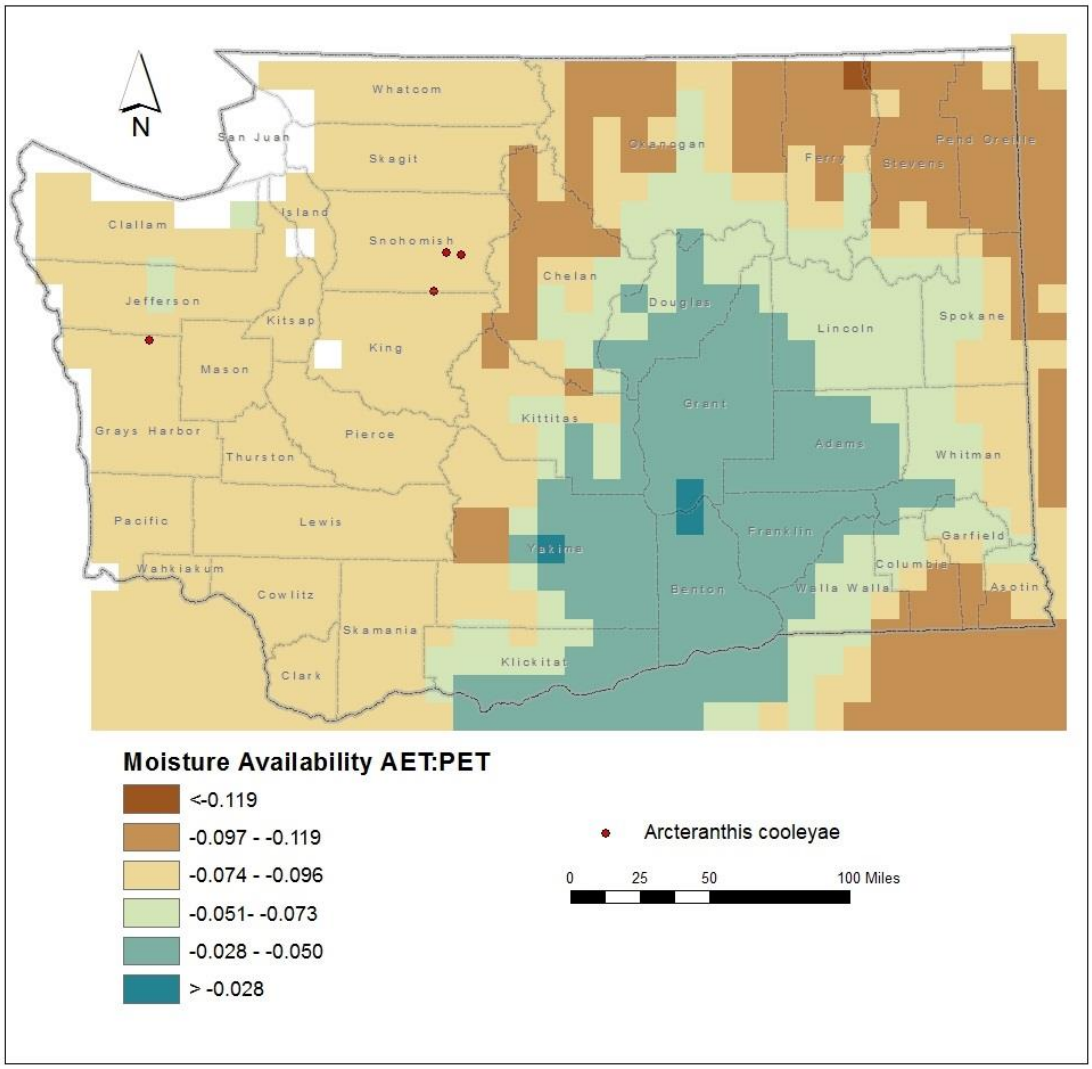

Figure 2. Exposure of *Arcteranthis cooleyae* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Arcteranthis cooleyae* are found at 2500-6000 feet (760-1830 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Arcteranthis cooleyae* is found at the base of cliffs on talus or fine gravel and sand, or on stream outlets and the edges of receding snowbanks, often on shady, north-facing slopes (Camp and Gamon 2011, Washington Natural Heritage Program 2021). This habitat is a component of the North Pacific Alpine & Subalpine Bedrock & Scree ecological system (Rocchio and Crawford 2015). Individual populations are separated by 5-14.5 miles (7.6-23 km) in the North Cascades, with one disjunct population in the Olympic Range isolated by 103 miles (166 km). Large areas of unsuitable habitat exist between occurrences and dispersal is restricted by natural barriers.

B2b. Anthropogenic barriers: Neutral.
The range of *Arcteranthis cooleyae* in Washington is restricted to National Forest lands surrounded by human infrastructure, including roads, cities, and areas managed for silviculture or agriculture. Natural barriers, however, are more significant obstacles to dispersal than anthropogenic ones.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase/Increase.
Each flower of *Arcteranthis cooleyae* produces a ball-like cluster of 70-100 one-seeded achenes. Each achene has a persistent, hooked beak that can potentially latch on to animals for long distance dispersal. Scherff et al. (1994) found that dispersal of another beaked-fruited alpine buttercup (*Ranunculus adoneus*) averaged only 15-25 cm from the parent plant based on gravity and secondary dispersal by animals. Average dispersal distances for *A. cooleyae* may be similarly short, but with infrequent long-distance transport possible by birds or large-bodied mammals.

C2ai. Historical thermal niche: Somewhat Increase.
Figure 3 depicts the distribution of *Arcteranthis cooleyae* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Two of the four known occurrences (50%) are found in areas that have experienced slightly lower than average (47.1-57˚F/26.3-31.8˚C) temperature variation during the past 50 years and are considered at somewhat increased risk from climate change (Young et al. 2016). One population (25%) is from an area with small temperature variation (37-47˚F/20.8-26.3˚C) over the same period and is at increased risk from climate change. One other occurrence in the Olympic Range (25%) is from an area with very small (>37˚F/20.8˚C) temperature variation during the last 50 years and is at greatly increased risk from climate change (Young et al. 2016).

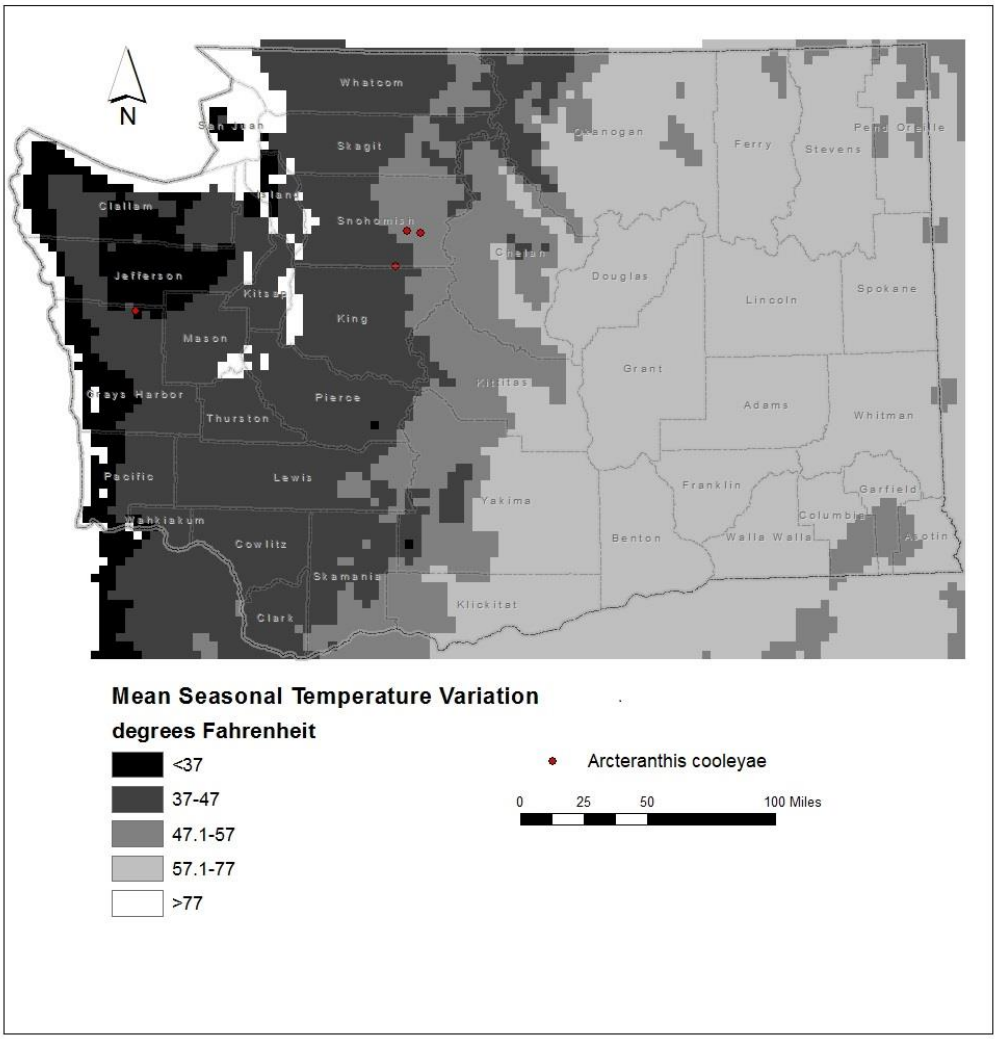

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Arcteranthis cooleyae* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Increase.
In Washington, populations of *Arcteranthis cooleyae* are associated with subalpine, north-facing cliffs and talus slopes that are often shaded and in cold-air drainages. Under projected climate change, these cool microsites are likely to become warmer.

C2bi. Historical hydrological niche: Neutral.
All populations of *Arcteranthis cooleyae* in Washington (100%) are found in areas that have experienced greater than average (>40 inches/1016 mm) precipitation variation in the past 50 years (Figure 4). According to Young et al. (2016), these occurrences are at neutral vulnerability from climate change.

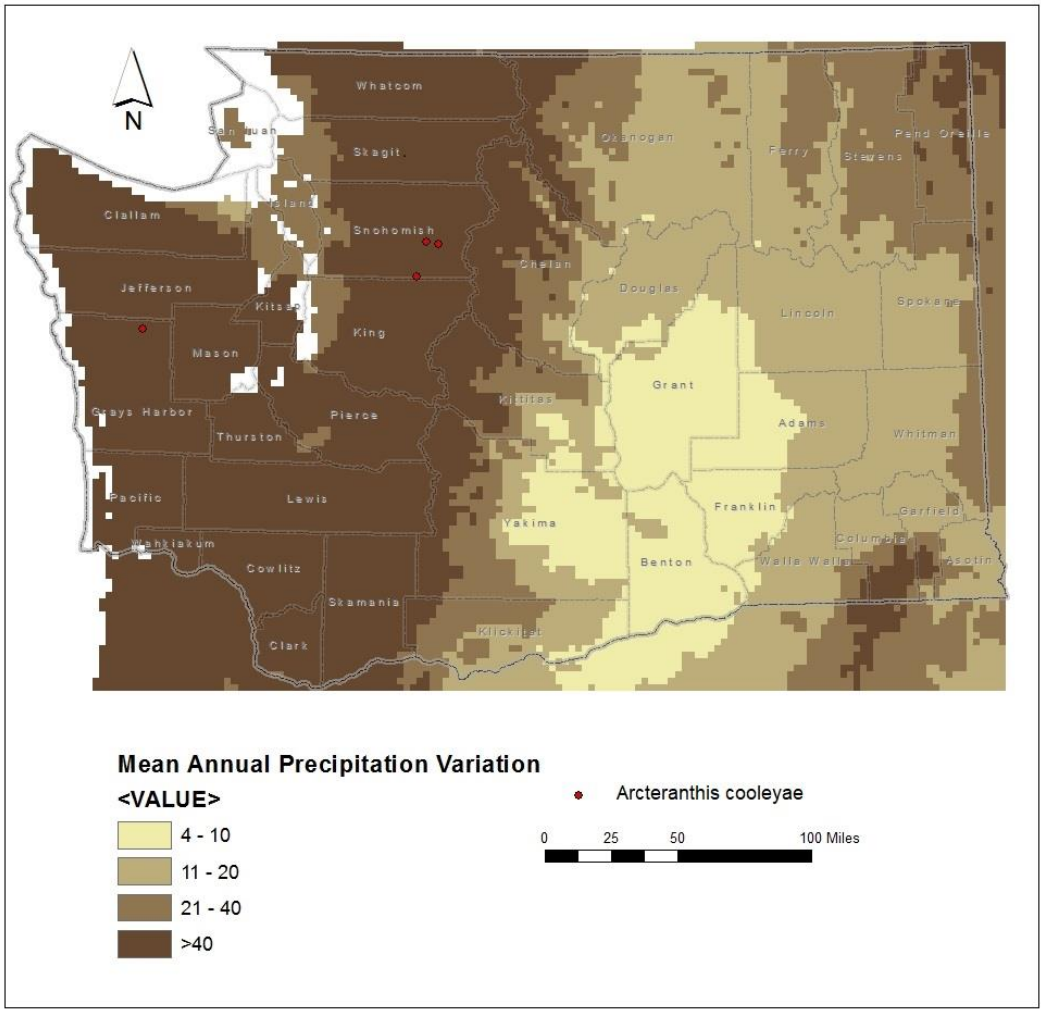

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Arcteranthis cooleyae* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
This species occurs in shady cliff and talus sites that are not associated with perennial water sources or a high water table. *Arcteranthis cooleyae* is dependent on adequate winter snow and spring/summer rainfall for its moisture needs. Changes in the timing or amount of precipitation or snowmelt due to climate change and higher temperatures could extend the growing season and result in more soil development, making these barren cliff sites more suitable for forest vegetation (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.
Arcteranthis cooleyae occurs on barren cliffs and talus slopes that are maintained by natural weathering processes and facilitated by cool climatic conditions and high winds that reduce soil formation and keep plant density low. Additional periodic disturbances are not required to maintain this habitat.

C2d. Dependence on ice or snow-cover habitats: Somewhat Increase.
The populations of *Arcteranthis cooleyae* in Washington occur in area of high snow accumulation. Reduction in the amount of snow, conversion of snow to rain, or changes in the timing of snowmelt would potentially alter the amount of moisture available for this species under projected climate change (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Somewhat Increase.
In the Olympic Mountains, *Arcteranthis cooleyae* is restricted to basalts of the Eocene-age Crescent Formation that rings the southern, eastern, and northeastern core of the range. Populations from the Cascades are associated with the Eocene volcanic Barlow Pass Formation and the Index Batholith (Washington Division of Geology and Earth Resources 2016). None of these geologic formations is particularly widespread in Washington, which may contribute to the rarity of *A. cooleyae* in the state.

C4a. Dependence on other species to generate required habitat: Neutral
The habitat occupied by *Arcteranthis cooleyae* is maintained by natural abiotic processes rather than by interactions with other species.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Unknown.
The specific pollinators of *Arcteranthis cooleyae* in Washington are poorly known. Like other buttercups (*Ranunculus* and segregate genera *Beckwithia*, *Ficaria*, and *Halerpestes*) the cup-like flowers and ample nectar reward of *A. cooleyae* flowers probably attract a variety of generalist pollinators, which might include bees, butterflies, and flies.

C4d. Dependence on other species for propagule dispersal: Neutral.
Arcteranthis cooleyae produces numerous 1-seeded fruits (achenes) that have a small hook at the tip. Dispersal is primarily passive (gravity), but fruits can be secondarily moved by seed-caching animals or if the hooks get attached to fur or feathers. It is not dependent on a single animal species for dispersal.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. Due to its remote cliff habitat, *Arcteranthis cooleyae* receives minimal impacts from livestock or ungulate grazing, though it could be consumed by insects or rodents. Overall impacts appear to be low.

C4f. Sensitivity to competition from native or non-native species: Neutral.
Rocky microsites occupied by *Arcteranthis cooleyae* are not especially vulnerable to competition from other native or introduced plant species.

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

C5a. Measured genetic variation: Unknown.
No data are available on genetic variability of Washington populations of *Arcteranthis cooleyae*. Recent genetic and morphologic studies indicate that *Arcteranthis* is more closely related to *Trautvetteria caroliniensis* than to other species of *Ranunculus*, in which it was once included (Emadzade et al. 2010).

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral.
Arcteranthis cooleyae produces perfect flowers and is presumed to be an out-crosser with normal levels of genetic variation across all populations. Washington occurrences are at the extreme southern end of the species' range and might be expected to have lower overall genetic diversity due to inbreeding or founder effects.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on flowering dates from specimens in the Consortium of Pacific Northwest herbaria website, no major changes have been detected in phenology in recent years.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
Although one population of *Arcteranthis cooleyae* has not been relocated since the early 1960s, the range of the species in the state has not decreased significantly.

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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