Climate Change Vulnerability Index Report

*Veronica dissecta* ssp. *lanuginosa* (Woolly kittentails)

Date: 30 September 2021 Synonym: *Synthyris lanuginosa*

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G4T2/S2

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 | 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: 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 | | Greatly 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 | | 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 | | Somewhat Increase |
| 4g. Forms part of an interspecific interaction not covered above | | Neutral |
| 5a. Measured genetic diversity | | Somewhat Increase |
| 5b. Genetic bottlenecks | | Neutral |
| 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 | Somewhat Increase |
| D2. Modeled future (2050) change in population or range size | Increase |
| D3. Overlap of modeled future (2050) range with current range | Neutral |
| D4. Occurrence of protected areas in modeled future (2050) distribution | Neutral |

## Section A: Exposure to Local Climate Change

A1. Temperature: All ten of the occurrences of *Veronica dissecta* ssp. *lanuginosa* in Washington (100%) are found in areas with a projected temperature increase of < 3.9˚ F (Figure 1).

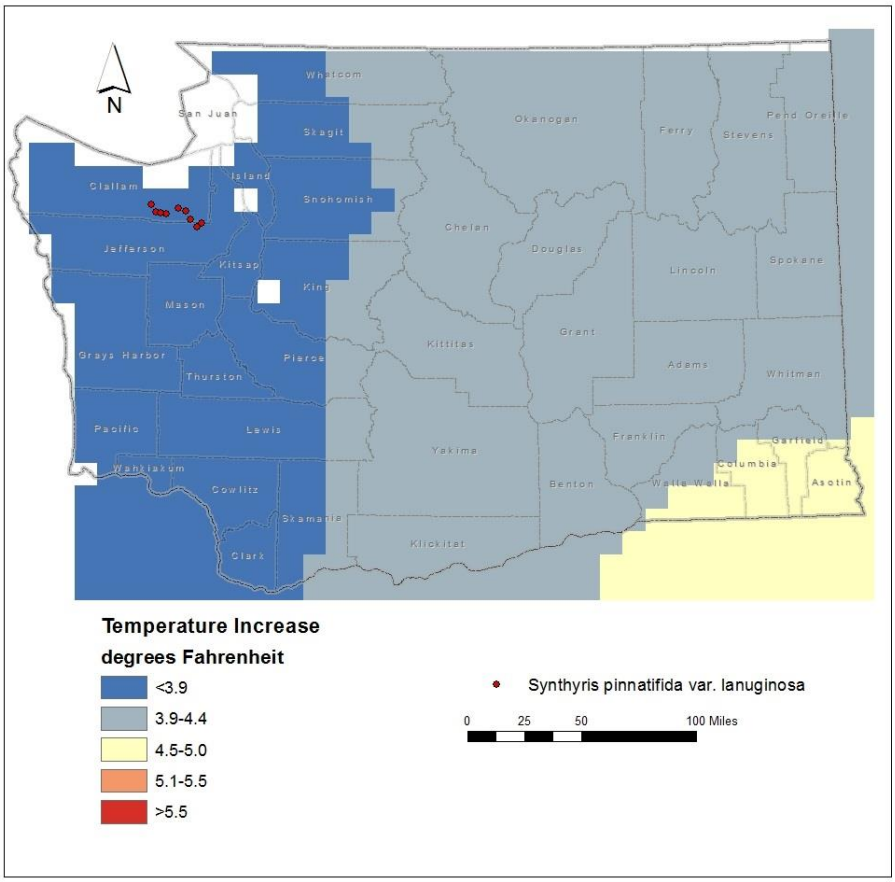


Figure 1. Exposure of *Veronica dissecta* ssp. *lanuginosa* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: The ten occurrences of *Veronica dissecta* ssp. *lanuginosa* (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).

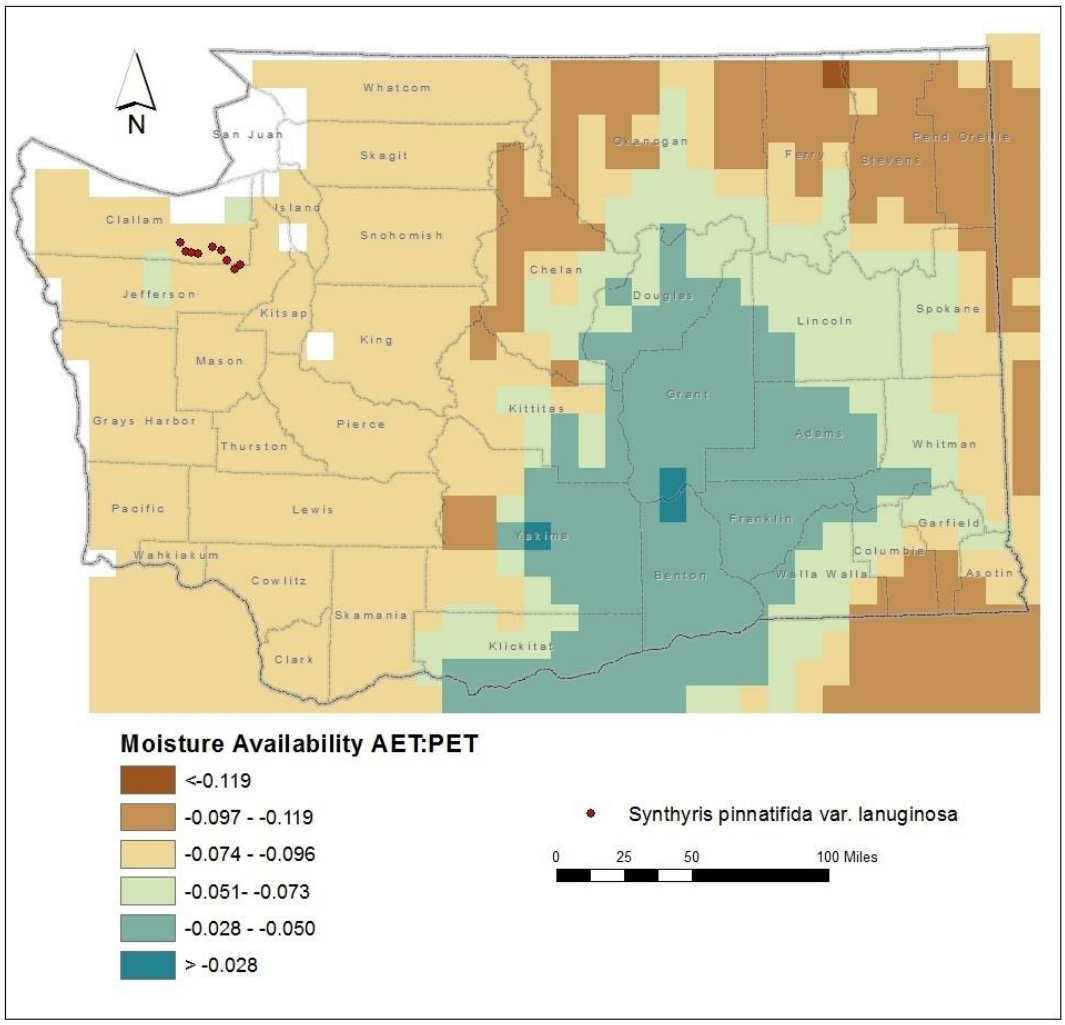


Figure 2. Exposure of *Veronica dissecta* ssp. *lanuginosa* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

## Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
The Washington occurrences of *Veronica dissecta* ssp. *lanuginosa* are found at 4640-6900 feet (1415-2100 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Increase.
*Veronica dissecta* ssp. *lanuginosa* is endemic to the northeastern Olympic Range in Washington, where it is found in alpine cushion plant communities on south or southwest-facing rocky meadows, exposed fell-fields, or talus slopes (Camp and Gamon 2011; Wershow and DeChaine 2018). These habitats are a component of the North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-Field and Meadow ecological system (Rocchio and Crawford 2015). The entire range of this taxon is restricted to an area of 6 x 21 miles (10 x 33 km) (Washington Natural Heritage Program 2021). Individual occurrences are naturally separated by valleys between alpine ridges, which create a barrier to local dispersal and gene flow (Marlowe and Hufford 2008). The isolation of the Olympic Range also constrains potential migration to other alpine mountain ranges north and east of the Salish Sea/Puget Sound in Washington or British Columbia.

B2b. Anthropogenic barriers: Neutral.
The range of *Veronica dissecta* ssp. *lanuginosa* in Washington is primarily above treeline in Olympic National Park and Olympic National Forest. These areas have some hiking trails but the overall human footprint is small and does not present a significant 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.
*Veronica dissecta* ssp. *lanuginosa* plants produce 10-30 flowers per raceme, with each fruit containing 10-16 seeds (Hufford 2019). At maturity, the dry fruit capsules split open to release seeds passively. The seeds lack wings, hooks, barbs, or other structures to facilitate dispersal by animals or wind. Average dispersal distances are probably relatively short (well under 100 m), though longer transport is possible from high winds.

C2ai. Historical thermal niche: Greatly Increase.
Figure 3 depicts the distribution of *Veronica dissecta* ssp. *lanuginosa* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Seven of the 10 known occurrences (70%) are found in areas that have experienced very small (<37˚F/20.8˚C) temperature variation during the past 50 years and are considered at greatly increased vulnerability to climate change (Young et al. 2016). Three other occurrences (30%) are from areas with small (37-47˚F/20.8-26.3˚C) temperature variation over the same time period and are at increased vulnerability to climate change.

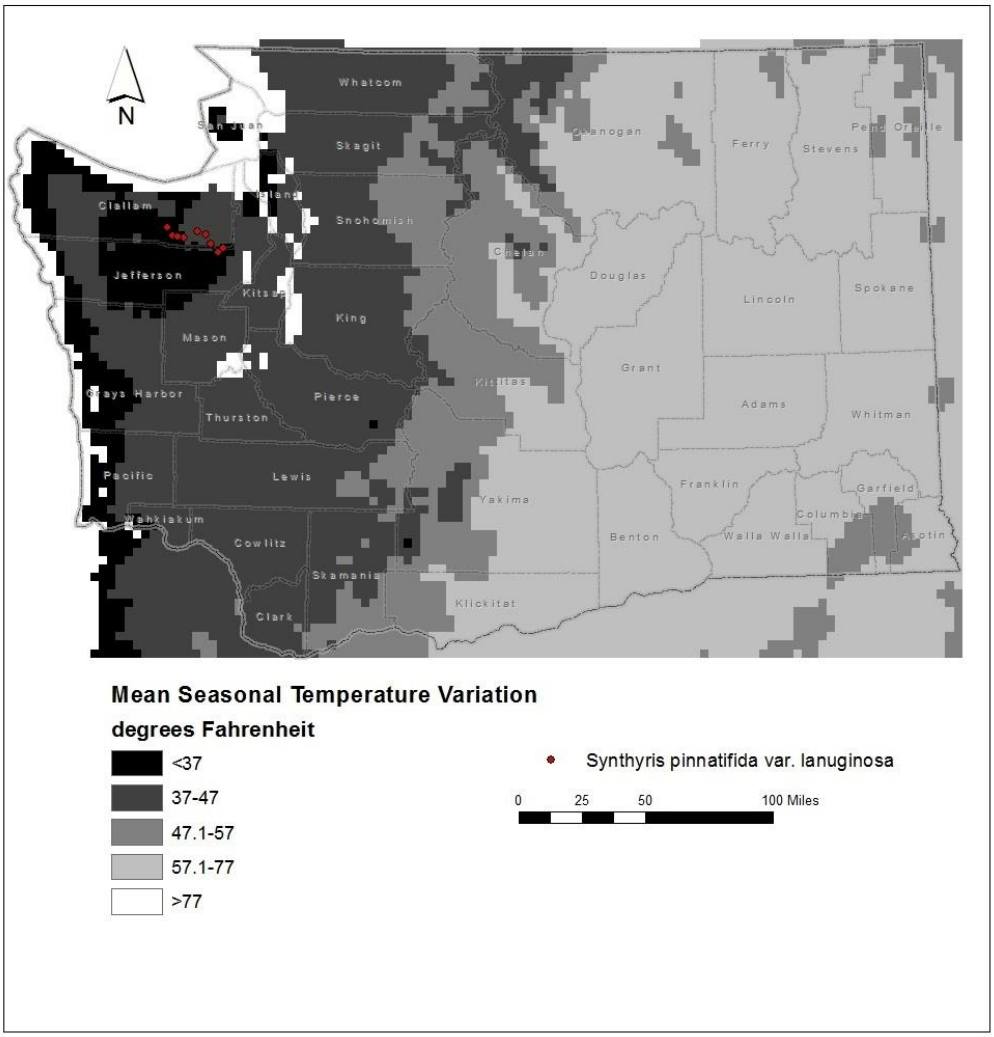


Figure 3. Historical thermal niche (exposure to past temperature variations) of *Veronica dissecta* ssp. *lanuginosa* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Increase.

The range of *Veronica dissecta* ssp. *lanuginosa* is restricted to alpine areas exposed to high winds and cold winter temperatures. Most populations occur on southerly slopes that provide a warmer microclimate than other exposures. Increased temperatures could extend the growing season (Rocchio and Ramm-Granberg 2017), but might also put this species under increased moisture stress. A prolonged growing season could favor other plant species expanding into the habitat of *V. dissecta* ssp. *lanuginosa* and lead to increased competition for space and resources.

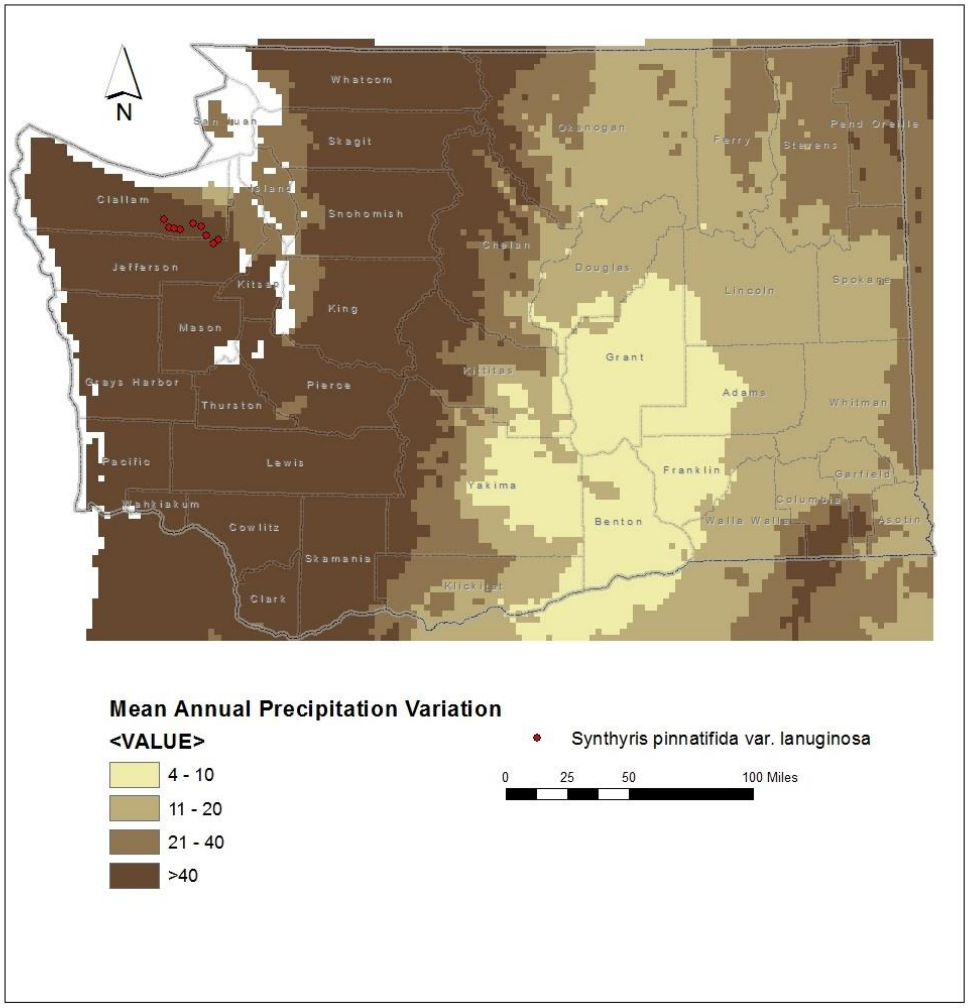


Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Veronica dissecta* ssp. *lanuginosa* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.
All ten of the occurrences of *Veronica dissecta* ssp. *lanuginosa* 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 areas are at neutral vulnerability to climate change.

C2bii. Physiological hydrological niche: Somewhat Increase.
*Veronica dissecta* ssp. *lanuginosa* occurs primarily on exposed south facing rocky slopes that are not associated with perennial streams or a high water table. The species depends on winter snowfall and summer precipitation for its water needs. Snowpacks are likely to be thinner on the wind-exposed slopes occupied by *V. dissecta* ssp. *lanuginosa* than on more protected slopes.

With climate change, the amount of snow may be reduced, or it will melt sooner in the spring. Increased temperatures from climate change are likely to change the timing of snowmelt, leading to earlier runoff (Rocchio and Ramm-Granberg 2017). Changes in the timing or amount of summer precipitation could also impact survival and reproduction of this species and favor competing plants adapted to drier conditions.

C2c. Dependence on a specific disturbance regime: Neutral.
The alpine cushion plant and fell-field habitat of *Veronica dissecta* ssp. *lanuginosa* is maintained by natural, abiotic processes (mostly climate-related) rather than periodic disturbances, such as fire or drought.

C2d. Dependence on ice or snow-cover habitats: Somewhat Increase.
The Olympic Mountains average over 10 meters (400 inches) of snow. The alpine areas inhabited by *Veronica dissecta* ssp. *lanuginosa* are on open or steep slopes where snow is more exposed to wind and sun and less likely to accumulate late into the summer, making the local microenvironment drier than surrounding areas. Reductions in the amount of snow, or changes in the timing of snowmelt could make alpine cushion plant and fell-field habitats drier in the future and more prone to invasion by plants from lower elevations (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Increase.
*Veronica dissecta* ssp. *lanuginosa* is restricted to alpine exposures of Oligocene and Eocene-age marine sediments (including thin bedded sandstones and shales) found in a semi-circular arc along the east side of the Olympic Mountains (Washington Division of Geology and Earth Resources 2016). Under future climate change, the amount of suitable substrate will become even more reduced as growing conditions become restricted to only the highest peaks in the northeast corner of the Olympics (Wershow and DeChaine 2018).

C4a. Dependence on other species to generate required habitat: Neutral.
The alpine cushion plant and fell-field habitat of *Veronica dissecta* ssp. *lanuginosa* is maintained mostly by natural factors, such as low temperatures, high precipitation, southerly exposures, and high winds erosion, rather than activities of animal species.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Unknown.
The specific pollinators of *Veronica dissecta* ssp. *lanuginosa* are not known. Related *Synthyris* species (now placed in *Veronica*) are pollinated by halictid bees (Hufford and McMahon 2004).

C4d. Dependence on other species for propagule dispersal: Neutral.
The fruits of *Veronica dissecta* ssp. *lanuginosa* dehisce when dry to release seeds passively by gravity or wind. These seeds lack wings, barbs, or hooks for dispersal by wind or animals.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. Introduced mountain goats (*Oreamnos americanus*) have been reported grazing on *Veronica dissecta* ssp. *lanuginosa* at one site. Herbivory by other animals is not well documented.

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
*Veronica dissecta* ssp. *lanuginosa* occurs mostly in alpine cushion plant and fell-field communities which are likely to become warmer, drier, and have a longer growing season under projected climate change (Wershow and DeChaine 2018). These changes could facilitate spread of lower elevation plants into alpine habitats and increase competition for resources and space (Rocchio and Ramm-Granberg 2017). Herbivory or trampling by introduced mountain goats may be a potential threat (Schreiner et al. 1994).

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

C5a. Measured genetic variation: Somewhat Increase.
Marlowe and Hufford (2008) found relatively limited genetic diversity in *Veronica dissecta* ssp. *lanuginosa* (cited as *Synthyris lanuginosa* in their study) compared to its sister taxa, *Veronica canbyi* and *V. dissecta* (ssp. *dissecta*) from the northern Rocky Mountains of Montana and Idaho. The absence of shared haplotypes between *V. dissecta* ssp. *lanuginosa* and its closest relatives suggests that the event that isolated ssp. *lanuginosa* was not recent. A phylogeographic analysis of the *dissecta*-clade suggests that ssp. *lanuginosa* diverged approximately 7.55 million years ago (10.99-4.59 mya) through allopatric speciation (Hooker 2018).

C5b. Genetic bottlenecks: Neutral.
Small populations of *Veronica dissecta* ssp. *lanuginosa* may have been restricted to unglaciated refugia within the Olympic Mountains during the Pleistocene and subjected to genetic bottlenecks (Buckinhgam et al. 1995). Inter-population genetic variability was found to be greater than intra-population diversity by Marlowe and Hufford (2008).

C5c. Reproductive System: Neutral.
*Veronica dissecta* ssp. *lanuginosa* is primarily an out-crosser, but is capable of self-pollination if bees first visit older flowers near the base of the inflorescence that are functionally staminate and then work their way up the flower stalk to pollinate younger flowers that are functionally pistillate (protogynous) (Hufford and McMahon 2004).

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on Washington Natural Heritage Program data, no significant changes in the phenology of *Veronica dissecta* ssp. *lanuginosa* populations have been detected over the past 90 years.

**Section D: Documented or Modeled Response to Climate Change**

D1. Documented response to recent climate change: Somewhat Increase.
Two occurrences of *Veronica dissecta* ssp. *lanuginosa* from Hurricane Ridge and Mount Angeles have not been relocated in more than 40 years and may be extirpated. The loss of these populations (both from the northwestern edge of its range) suggest that the overall range is contracting. Whether this is due primarily to climate change or is influenced by local events (trampling, over-collection, or herbivory) is not known. Both of these sites are well-visited within Olympic National Park, increasing the likelihood of impacts and detection (if the species was still present).

D2. Modeled future (2050) change in population or range size: Increase.
Wershow and DeChaine (2018) modeled the current and future distribution of *Veronica dissecta* ssp. *lanuginosa* and four other alpine endemics of the Olympic Range based on herbarium data, field sampling, and various environmental predictors, such as elevation, slope angle, aspect, topographic position, solar radiation, temperature and precipitation. *Veronica dissecta* ssp. *lanuginosa* had the most restricted predicted range and narrowest ecological niche of any species in the assessment and was projected to have a 99% reduction in its range, collapsing to the Mount Constance area.

D3. Overlap of modeled future (2050) range with current range: Neutral.
Based on its modeled future distribution under climate change, the range of *Veronica dissecta* ssp. *lanuginosa* is expected to contract by 99%, rather than shift in distribution to new, currently unoccupied habitat (Wershow and DeChaine 2018).

D4. Occurrence of protected areas in modeled future (2050) distribution: Neutral.
Despite the likely contraction of potential suitable habitat due to climate change, the entire range of *Veronica dissecta* ssp. *lanuginosa* will still be restricted to Olympic National Park and the Buckhorn Wilderness Area of Olympic National Forest.

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