Climate Change Vulnerability Index Report

Castilleja cryptantha (Obscure paintbrush)

Date: 27 September 2021

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington | Heritage Rank: G2G3/S2S3

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	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		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/Somewhat Increase
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		Neutral
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	Increase
6. Phenological response to changing seasonal and precipitation dynamics	Somewhat Increase
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: All 22 of the occurrences of *Castilleja cryptantha* in Washington (100%) are from areas with a projected temperature increase of 3.9-4.4° F (Figure 1).

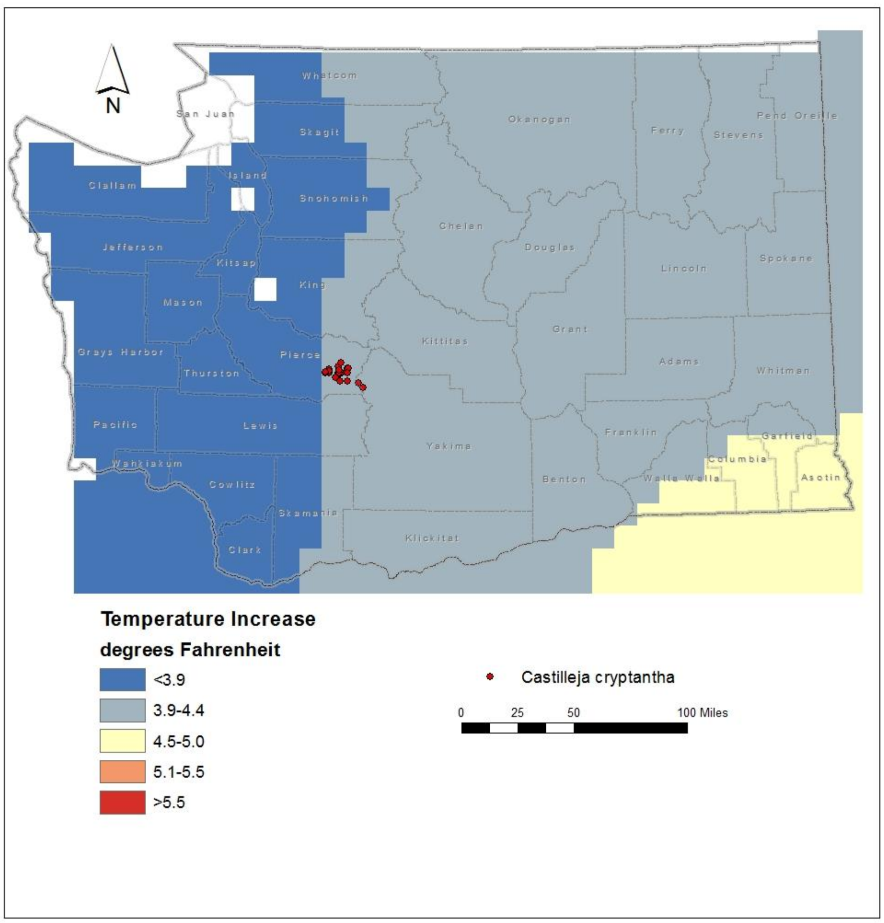

Figure 1. Exposure of *Castilleja cryptantha* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: The 22 occurrences of *Castilleja cryptantha* in Washington (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).

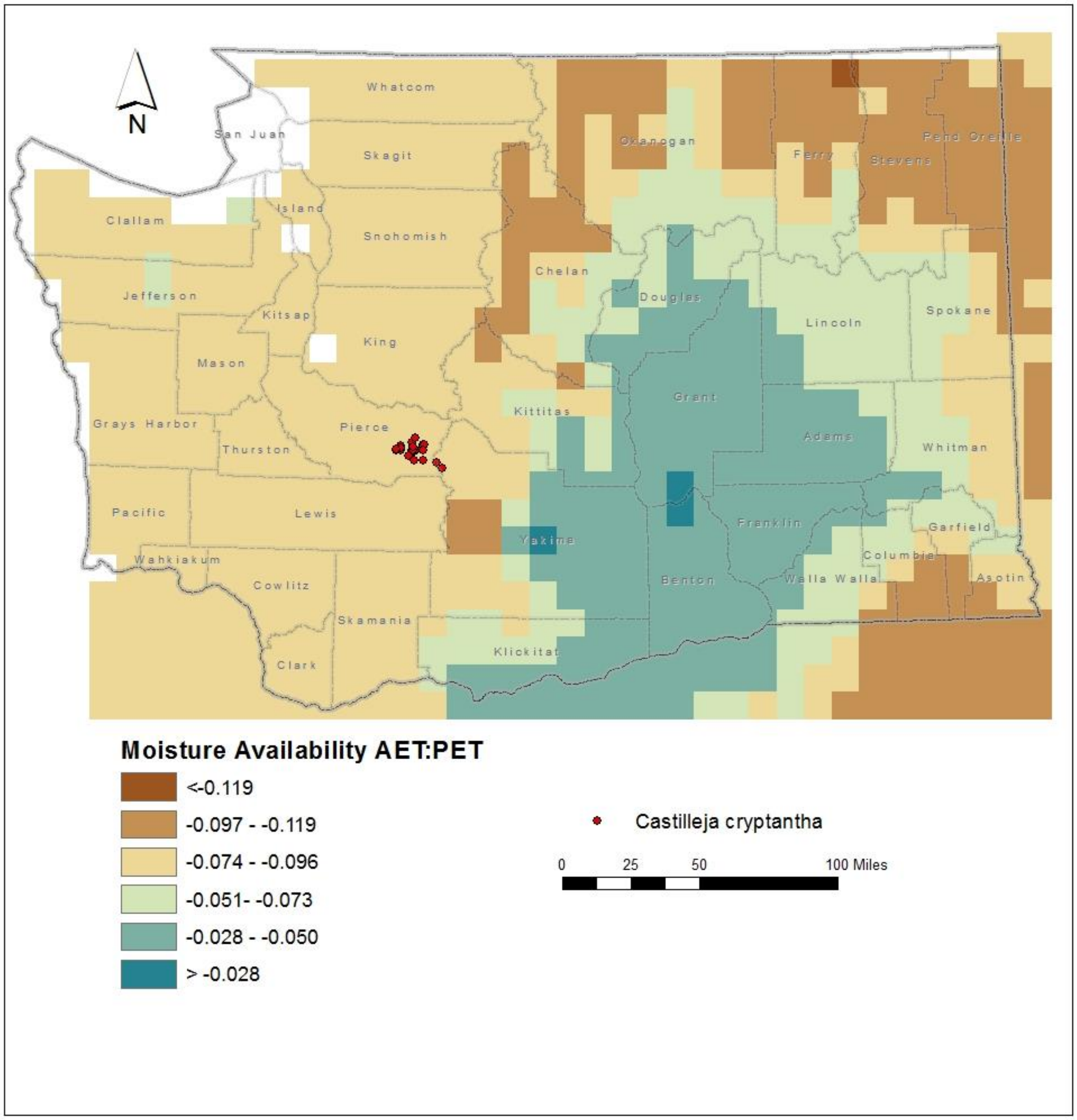

Figure 2. Exposure of *Castilleja cryptantha* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Castilleja cryptantha* are found at 4860-6760 feet (1480-2060 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
Castilleja cryptantha occurs in grassy subalpine meadow flats and the edges of small alpine lakes and stream channels with poorly developed soils and dense cover of low shrubs and sedges (Camp and Gamon 2011, Egger et al. 2019). This habitat is part of the Northern Rocky Mountain Subalpine-Upper Montane Grassland ecological system (Rocchio and Crawford 2015). Populations are separated by 0.5-4.6 miles (0.6-7.4 km) of unoccupied valley habitat, which provides a barrier to propagule dispersal.

B2b. Anthropogenic barriers: Neutral.
The range of *Castilleja cryptantha* in Mount Rainier National Park is partially bisected by paved roads that are mostly located in unoccupied or unsuitable habitat. Most of the habitat of this species is not impacted directly by human infrastructure.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Increase.
Castilleja cryptantha produces numerous, small seeds within a dry capsule fruit that splits open at maturity. Seeds are passively dispersed by gravity, high winds, or secondarily by foraging animals. The seeds lack hooks, barbs, wings, or feathery structures to aid with dispersal. Average dispersal distances are probably short (less than 100 m).

C2ai. Historical thermal niche: Increase.
Figure 3 depicts the distribution of *Castilleja cryptantha* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Nineteen of the 22 known occurrences in the state (86.4%) 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). Two occurrences on the east side of the Cascades crest are from areas with slightly lower than average (47.1-57˚F/26.3-31.8˚C) temperature variation during the same period and are considered at somewhat increased vulnerability. One population on the slopes of Mount Rainier is from an area with very small temperature variation (<37˚F/20.8˚C) over the last 50 years and is considered at greatly increased risk from climate change (Young et al. 2016).

C2aii. Physiological thermal niche: Greatly Increase.
The subalpine meadow and streamside habitat of *Castilleja cryptantha* is entirely within a cold climate zone during the flowering season and highly vulnerable to temperature increase from climate change.

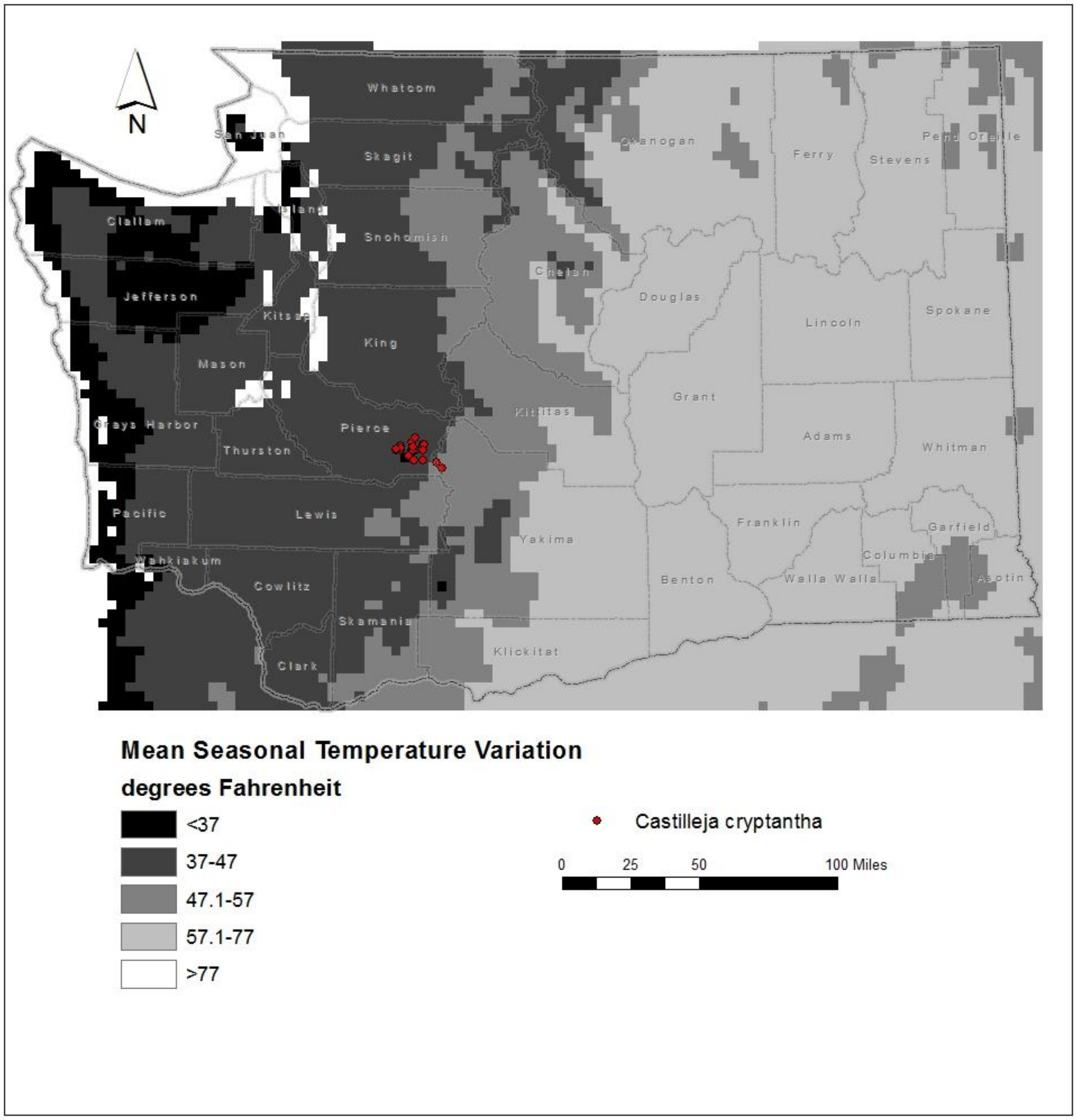

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Castilleja cryptantha* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.
All of the known populations of *Castilleja cryptantha* 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.

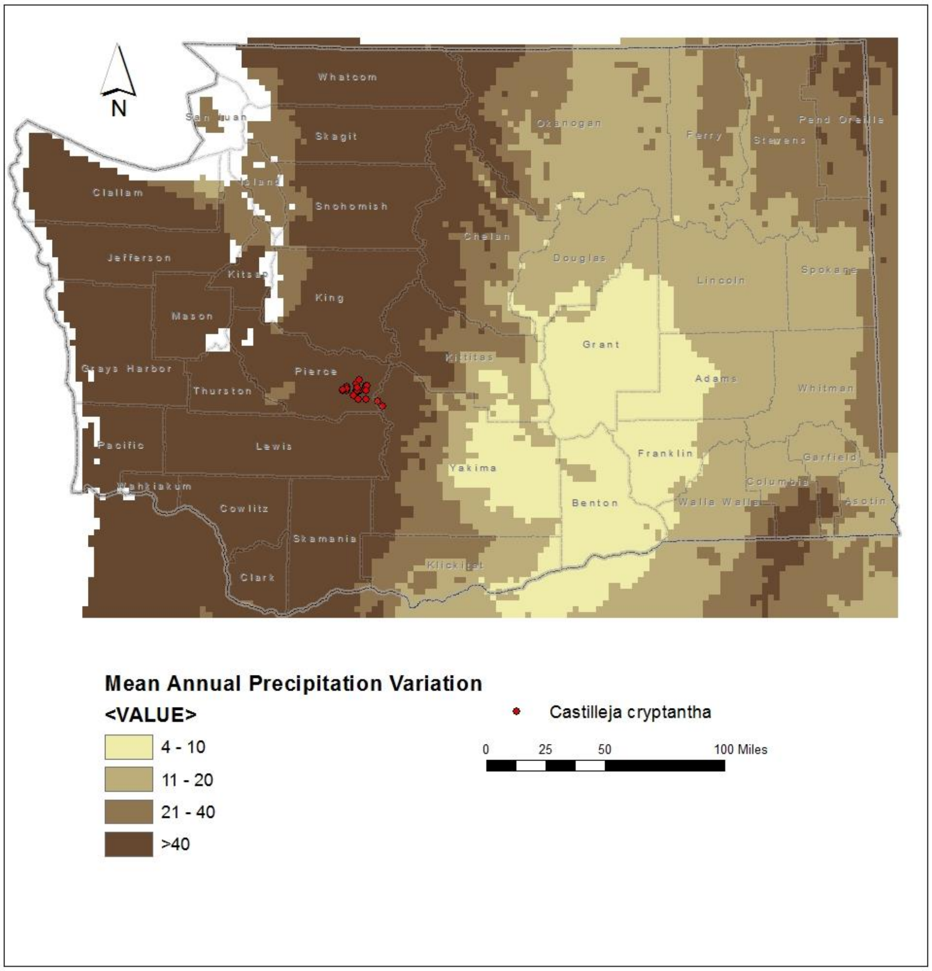

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Castilleja cryptantha* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
The subalpine meadow and streamside habitat of *Castilleja cryptantha* is dependent on adequate amounts of winter snow and spring/summer rainfall. Changes in the amount of snowfall, the timing of snow melt, the amount and timing of rainfall, or increased drought (from higher summer temperatures) could have negative impacts on moist meadow sites and result in conversion to drier grasslands (Rocchio and Ramm-Granberg 2017). Invasion of meadow sites by conifers could be countered by drier conditions or increased vulnerability to wildfire.

C2c. Dependence on a specific disturbance regime: Neutral/Somewhat Increase.
Castilleja cryptantha occurs in subalpine meadow and streamside habitats that are dominated by shrubs and herbaceous plants. These habitats are largely maintained by precipitation and

edaphic factors, more than natural disturbance patterns. Under future climate change scenarios, these sites could become more susceptible to wildfire associated with drought or higher temperatures (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Somewhat Increase.
The populations of *Castilleja cryptantha* in Washington are found in subalpine meadows and along the margins of small lakes and streams in areas with high winter snow accumulation. Reductions in the amount of snowpack or timing of snow melt, could shift vegetation composition towards plants adapted to drier meadows (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Increase.
Castilleja cryptantha is found primarily on pumice and volcaniclastic rocks of the Oligocene Ohanapecosh Formation. Populations also occur on Quaternary age Mount Rainier andesite and Holocene glacial till (Washington Division of Geology and Earth Resources 2016). These outcrops are largely found in the vicinity of Mount Rainier, and may account for the small geographic extent of the species.

C4a. Dependence on other species to generate required habitat: Neutral.
The subalpine meadow and brushy streamside habitat of *Castilleja cryptantha* is maintained largely by natural abiotic conditions.

C4b. Dietary versatility: Not applicable for plants.

C4c. Pollinator versatility: Neutral.
Unlike most paintbrush species, *Castilleja cryptantha* is predominantly self-pollinated (Duffield 1972; Egger et al. 2019). Duffield (1972) conducted experiments with caged plants at Mount Rainier and observed high fruit production in *C. cryptantha* when pollinators were excluded. This species has stigmas that barely exceed the anthers and never project beyond the corolla or calyx, as in cross-pollinated *Castilleja* species (Duffield 1972; Egger et al. 2019). Since it is not dependent on other species for pollination, *C. cryptantha* has neutral vulnerability to pollinator loss related to climate change.

C4d. Dependence on other species for propagule dispersal: Neutral.
The dry capsule fruits of *Castilleja cryptantha* split open at maturity to passively release numerous small seeds that spread primarily by gravity or wind.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Camp and Gamon (2011) suggested this species might be impacted by elk trampling. Threats from pathogens or herbivory have not been reported.

C4f. Sensitivity to competition from native or non-native species: Neutral.
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 high in the subalpine meadow and streamside habitat occupied by *Castilleja cryptantha*. Under projected climate change, the composition of these habitats might shift towards species adapted to drier conditions, but overall cover is not likely to be affected (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.
Egger (2015) reported a chromosome count of $n = 12$ for *Castilleja cryptantha*. Overall genetic diversity is not known, but is probably lower than expected due to its self-pollination breeding system (see section C5c below).

C5b. Genetic bottlenecks: Unknown.
Not known.

C5c. Reproductive System: Increase.
Castilleja cryptantha apparently reproduces mostly by self-pollination (Duffield 1972, Egger et al. 2019). As a result, the species is likely to have very low genetic diversity, making it more vulnerable to impacts of rapidly changing climate (Young et al. 2016).

C6. Phenological response to changing seasonal and precipitation dynamics: Somewhat Increase.
Based on herbarium records in the Consortium of Pacific Northwest Herbaria website (pnwherbaria.org), the flowering period of *Castilleja cryptantha* now starts in late June, rather than July to late August in older records. Reports of flowering in May are based on misidentified specimens.

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 *Castilleja cryptantha* in Washington since it was first discovered in the state in the 1902.

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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