Climate Change Vulnerability Index Report

Erythranthe pulsiferae (Pulsifer's monkeyflower)

Date: 20 October 2021 Synonym: *Mimulus pulsiferae*

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G4?/S2

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	90
	<3.9° F (2.2°C) warmer	10
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	10
	-0.074 to -0.096	30
	-0.051 to -0.073	50
	-0.028 to -0.050	10
	>-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		Neutral/Somewhat Increase
2ai Change in historical thermal niche		Somewhat Increase
2aii. Change in physiological thermal niche		Somewhat Increase
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		Increase
2c. Dependence on specific disturbance regime		Somewhat Increase
2d. Dependence on ice or snow-covered habitats		Neutral/Somewhat Increase
3. Restricted to uncommon landscape/geological features		Neutral
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		Unknown

5b. Genetic bottlenecks	Unknown
5c. Reproductive system	Neutral/Somewhat 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: Nine of the 10 extant and historical occurrences of *Erythranthe pulsiferae* in Washington (90%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1). This includes one disjunct and historical population from Okanogan County that needs

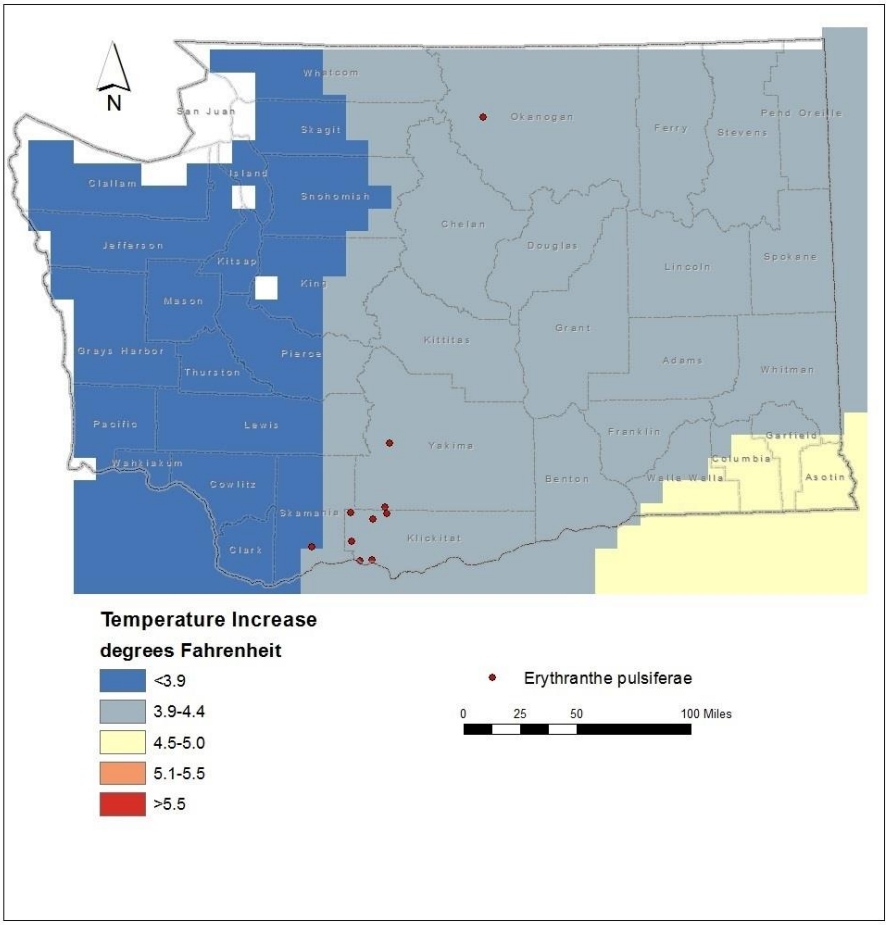

Figure 1. Exposure of *Erythranthe pulsiferae* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

confirmation. One other occurrence (10%) from the Columbia River is from an area with a projected temperature of <3.9˚ F (Figure 1).

A2. Hamon AET:PET Moisture Metric: Five of the 10 occurrences (50%) of *Erythranthe pulsiferae* 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 -0.051 to -0.073 (Figure 2). Three occurrences (30%) are in areas with a projected decrease of -0.074 to -0.096. One historical population (10%) is from an area with a predicted decrease of -0.097 to -0.119. One other occurrence (10%) is from an area with a projected decrease of -0.028 to -0.050 (Figure 2).

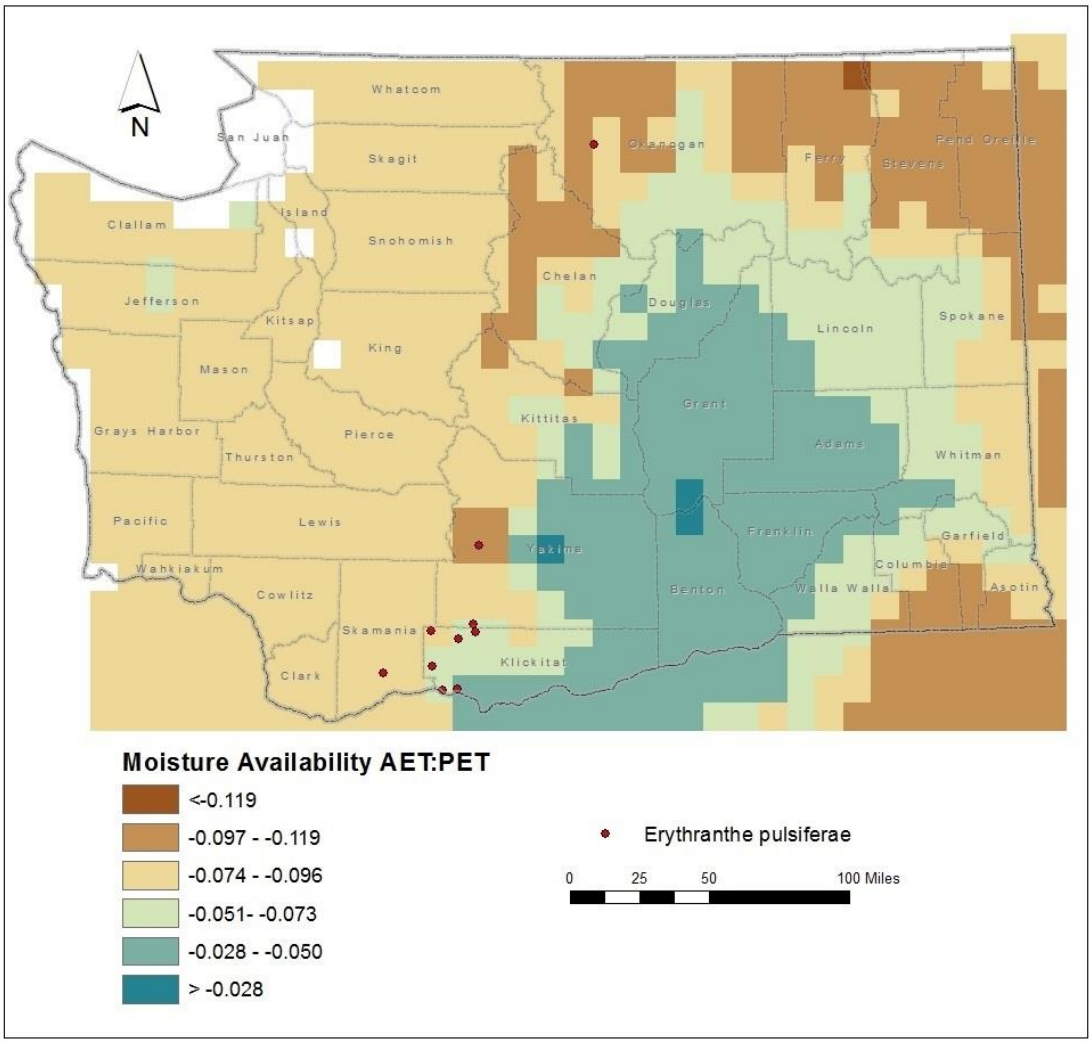

Figure 2. Exposure of *Erythranthe pulsiferae* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Erythranthe pulsiferae* are found at 1580-4000 feet (480-1220 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
Erythranthe pulsiferae occurs primarily in seasonally wet or moist meadows, gravelly streambanks, or openings in ponderosa pine (*Pinus ponderosa*), Oregon white oak (*Quercus garryana*) or Douglas-fir (*Pseudotsuga menziesii*) woods (Camp and Gamon 2011, Washington Natural Heritage Program 2021). This habitat is part of the Rocky Mountain Alpine-Montane Wet Meadow and Temperate Pacific Subalpine-Montane Wet Meadow ecological systems (Rocchio and Crawford 2015). Populations may be isolated from each other by 3.1-148 miles (5.1-238 km) of unsuitable habitat that presents a barrier to dispersal. (This distance is reduced to 26 miles [44 km] if the historical and questionable population from Okanogan County is excluded.)

B2b. Anthropogenic barriers: Neutral.
The historical range of *Erythranthe pulsiferae* in Washington is strongly influenced by roads, cities, farmland, rangeland, and other large-scale anthropogenic influences, but dispersal may be more limited by available habitat and natural barriers.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Neutral/Somewhat Increase.
Erythranthe pulsiferae produces dry capsules that split open at maturity to passively release numerous, small seeds that lack any ornamentation (feathery hairs, barbs, hooks) to facilitate dispersal by wind or animal vectors. Dispersal may be by gravity, strong winds, flowing water, or secondary transport by insects or rodents caching seeds. Most seeds probably fall within a short range of their parent, but some could stick to mud on waterfowl and be transported longer distances.

C2ai. Historical thermal niche: Somewhat Increase.
Figure 3 depicts the distribution of *Erythranthe pulsiferae* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Seven of the 10 known occurrences in the state (70%) 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 vulnerability to climate change (Young et al. 2016). The three other occurrences (30%) are from areas that have had average variation (57.1-77˚F/31.8-43.0˚C) in temperature over the same period and are at neutral vulnerability to climate change.

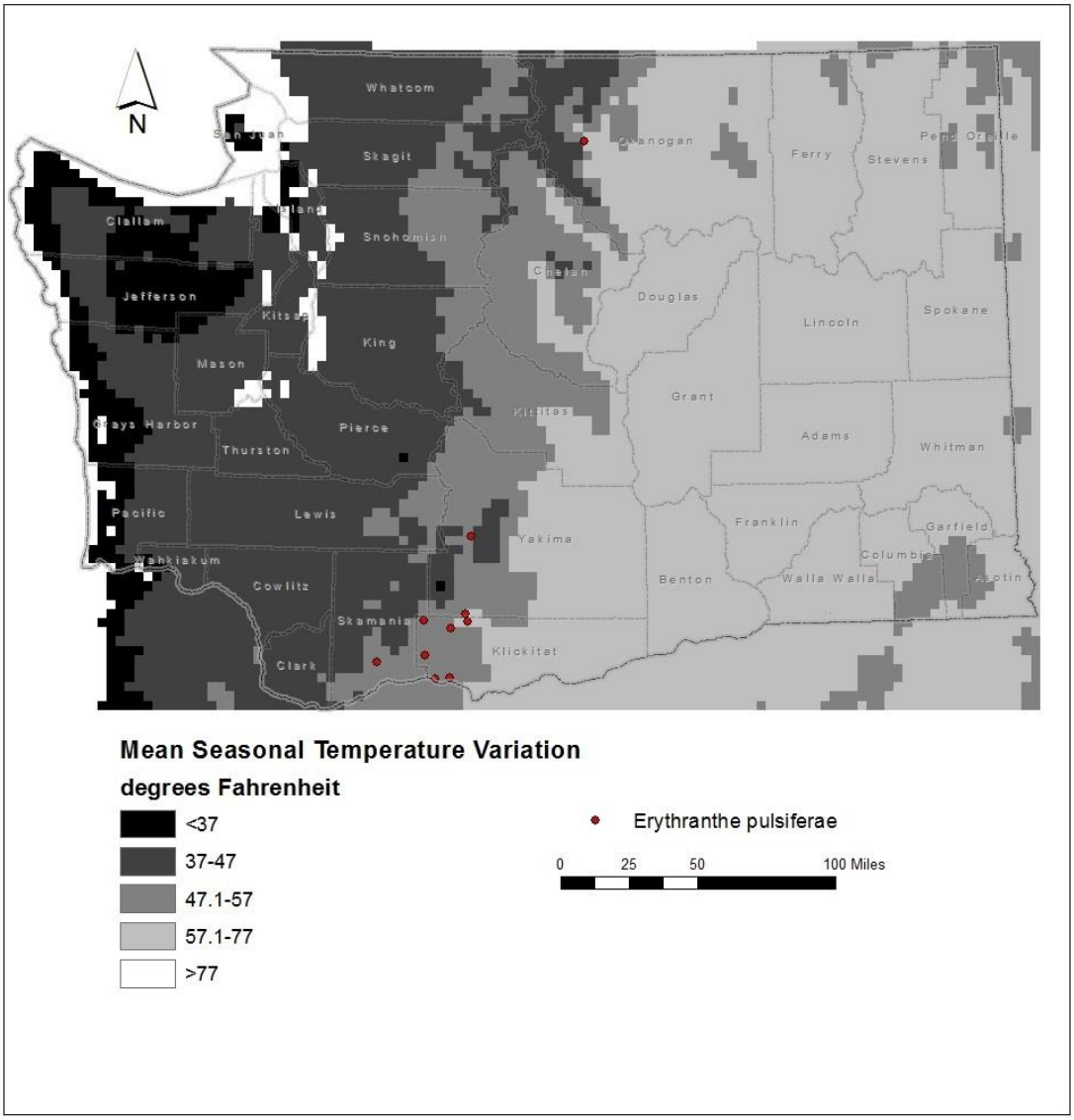

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Erythranthe pulsiferae* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Somewhat Increase.
The seasonally moist meadows, rocky streambanks, or forest openings occupied by *Erythranthe pulsiferae* are found primarily in narrow drainage bottoms subject to cold air drainage. These habitats could be adversely impacted by predicted warming temperatures from climate change.

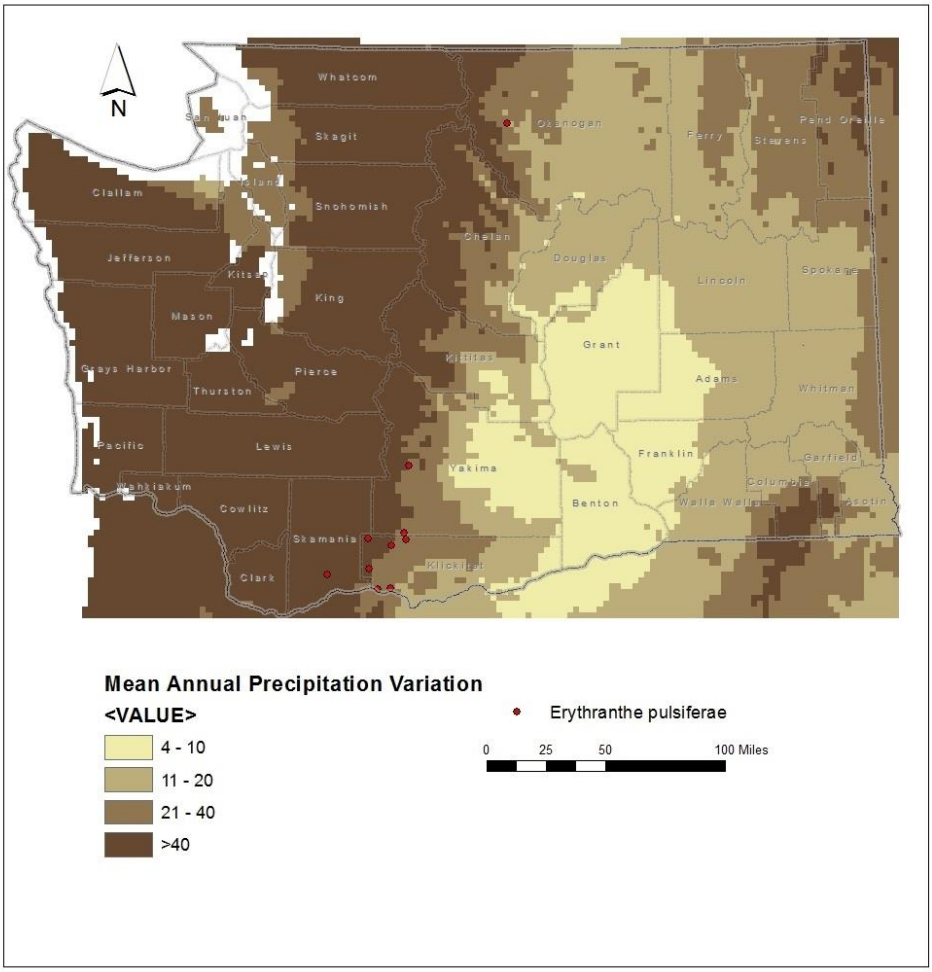

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Erythranthe pulsiferae* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.
All 10 of the extant and historical populations of *Erythranthe pulsiferae* in Washington (100%) are found in areas that have experienced average or greater than average precipitation variation in the past 50 years (>20 inches/508 mm) (Figure 4). According to Young et al. (2016), these occurrences are neutral for climate change.

C2bii. Physiological hydrological niche: Increase.
Erythranthe pulsiferae occurs in seasonally wet meadows, rocky streambanks, and openings in conifer forests and relies on late-lying snow, high water tables, or adequate spring and summer precipitation to maintain necessary moisture levels. Under projected climate change, these habitats are likely to have increased summer temperatures, more variability in the amount and timing of rainfall, changes in the amount and timing of snowmelt, reduced soil moisture, and

higher risk of wildfire (Rocchio and Ramm-Granberg 2017). These changes could shift existing moist meadow or forest habitat to drier meadows inhabited by a new suite of plant species.

C2c. Dependence on a specific disturbance regime: Somewhat Increase.
Erythranthe pulsiferae occurs wet meadows and openings in conifer forests. Meadow sites may be maintained by adequate moisture from melting snow and groundwater recharge or summer precipitation. Landform patterns (depressions) are important in retaining moisture on the landscape. Populations in forest openings may rely on periodic low-intensity fire or wind-throw to create or maintain these conditions. The frequency or magnitude of these disturbances could increase under warming conditions (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Neutral/Somewhat Increase.
The populations of *Erythranthe pulsiferae* in Washington are found in low elevation mountain and foothill valleys or drainages that receive low to moderate amounts of snow. Patterns of snow deposition (such as drifting in low-lying areas) may be important to augment the annual water budget for some occurrences. Changes in the amount or timing of snowmelt could have a negative impact on the recharge of groundwater (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Neutral.
Erythranthe pulsiferae occurs primarily on Quaternary alluvium and basalts derived from the Wanapum and Grande Ronde formations (Washington Division of Geology and Earth Resources 2016). These substrates occur widely in eastern Washington. Local topographic relief, such as depressions, may be an important microhabitat feature for this species, but are also widespread on the landscape.

C4a. Dependence on other species to generate required habitat: Neutral
The wet meadow, streamside, and forest habitat occupied by *Erythranthe pulsiferae* is maintained largely by natural abiotic conditions.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Unknown.
The specific pollinators of *Erythranthe pulsiferae* are not known. Yellow-flowered species of *Erythranthe* (formerly *Mimulus*) with large flowers are primarily pollinated by various species of bees, mostly from the genus *Bombus* or *Apis* (Bodbyl Roels and Kelly 2011). Smaller-flowered *Erythranthe* species (like *E. pulsiferae*) may be insect pollinated and autogamous (capable of self pollination) (Meinke 1992).

C4d. Dependence on other species for propagule dispersal: Neutral.
Seeds of *Erythranthe pulsiferae* may be dispersed by gravity, strong winds, flowing water, or in mud on waterfowl.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. This species is probably not negatively impacted by herbivory.

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
The lower montane wet meadow, rocky streamside, and conifer forest habitats of *Erythranthe pulsiferae* are potentially impacted by competition from introduced plant species today, and will continue to be affected under warming or drying conditions in the future, especially if these result in conversion of sites to drier meadows (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 research on *Erythranthe pulsiferae* has focused primarily on assessing its taxonomic relationships with other *Erythranthe* species and not its population-level genetic differentiation. Whittall (1999) found that *E. pulsiferae* is more closely related to other species of the *E. moschata* complex centered in the Sierra Nevada of California than morphologically similar species endemic to the Columbia or Snake rivers (such as *E. washingtonensis*, *E. patula*, and *E. ampliata*).

C5b. Genetic bottlenecks: Unknown.
Not known.

C5c. Reproductive System: Neutral/Somewhat Increase.
The flowers of *Erythranthe pulsiferae* have paired anthers located at the same level as the stigma, allowing for self-pollination (autogamy) (Nesom 2012). Selfing generally results in lower overall genetic diversity within populations, but can increase diversity between populations. Washington populations are at the northern edge of its range and are more likely to have lower overall genetic diversity due to inbreeding or founder effects.

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), *Erythranthe pulsiferae* may be flowering earlier (late April-late May) than it did in the 1880s-1930s (June-July or September).

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
The range of *Erythranthe pulsiferae* within Washington has thought to have contracted significantly since the 1930s based on the historical populations reported from southeast Washington in the Columbia Plateau ecoregion (Fertig and Kleinknecht 2020). Recent inspection of the herbarium records that were the basis of these reports indicates that these were misidentifications. One historical occurrence in Okanogan County also needs confirmation. If it is also erroneous, the range of this species remains largely the same as it was historically.

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

Bodbyl Roels, S.A. and J.K. Kelly. 2011. Rapid evolution caused by pollinator loss in *Mimulus guttatus*. Evolution: International Journal of Organic Evolution 65(9): 2541-2552.

Camp, P. and J.G. Gamon, eds. 2011. Field Guide to the Rare Plants of Washington. University of Washington Press, Seattle. 392 pp.

Meinke, R.J. 1992. Systematic and reproductive studies of Mimulus (Scrophulariaceae) in the Pacific Northwest: Implications for conservation biology. PhD thesis, Oregon State University, Corvallis, OR. 151 pp.

Rocchio, F.J. and R.C. Crawford. 2015. Ecological systems of Washington State. A guide to identification. Natural Heritage Report 2015-04. Washington Natural Heritage Program, WA Department of Natural Resources, Olympia, WA. 384 pp.

Rocchio F.J. and T. Ramm-Granberg. 2017. Ecological System Climate Change Vulnerability Assessment. Unpublished Report to the Washington Department of Fish and Wildlife. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

Washington Division of Geology and Earth Resources. 2016. Surface geology, 1:100,000 --GIS data, November 2016: Washington Division of Geology and Earth Resources Digital Data Series DS-18, version 3.1, previously released June 2010. http://www.dnr.wa.gov/publications/ger_portal_surface_geology_100k.zip

Washington Natural Heritage Program. 2021-. *Erythranthe pulsiferae*. In: Field Guide to the Rare Plants of Washington. (https://fieldguide.mt.gov/wa/?species=erythranthe%20pulsiferae). Accessed 20 October 2021.

Whittall, J.B. 1999. A molecular phylogeny for the *Mimulus moschatus* alliance (Scrophulariaceae) and its conservation implications. Master's thesis, Oregon State University, Corvallis, OR. 87 pp.

Young, B.E., E. Byers, G. Hammerson, A. Frances, L. Oliver, and A. Treher. 2016. Guidelines for using the NatureServe Climate Change Vulnerability Index. Release 3.02. NatureServe, Arlington, VA. 48 pp. + app.