Climate Change Vulnerability Index Report

*Swertia perennis* (Swertia)

Date: 10 March 2020

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** | **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 | 66.7 |
| | <3.9° F (2.2°C) warmer | 33.3 |
| 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** | | **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** | | |
| 1. Dispersal and movements | | Somewhat 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 | | Neutral |
| 4d. Dependence on other species for propagule dispersal | | Neutral |
| 4e. Sensitivity to pathogens or natural enemies | | Unknown |
| 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** | |
| 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: Two of the three occurrences of *Swertia perennis* in Washington (66.7%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1). One other populations (33.3%) is form an area with a projected temperature increase of < 3.9˚ F.

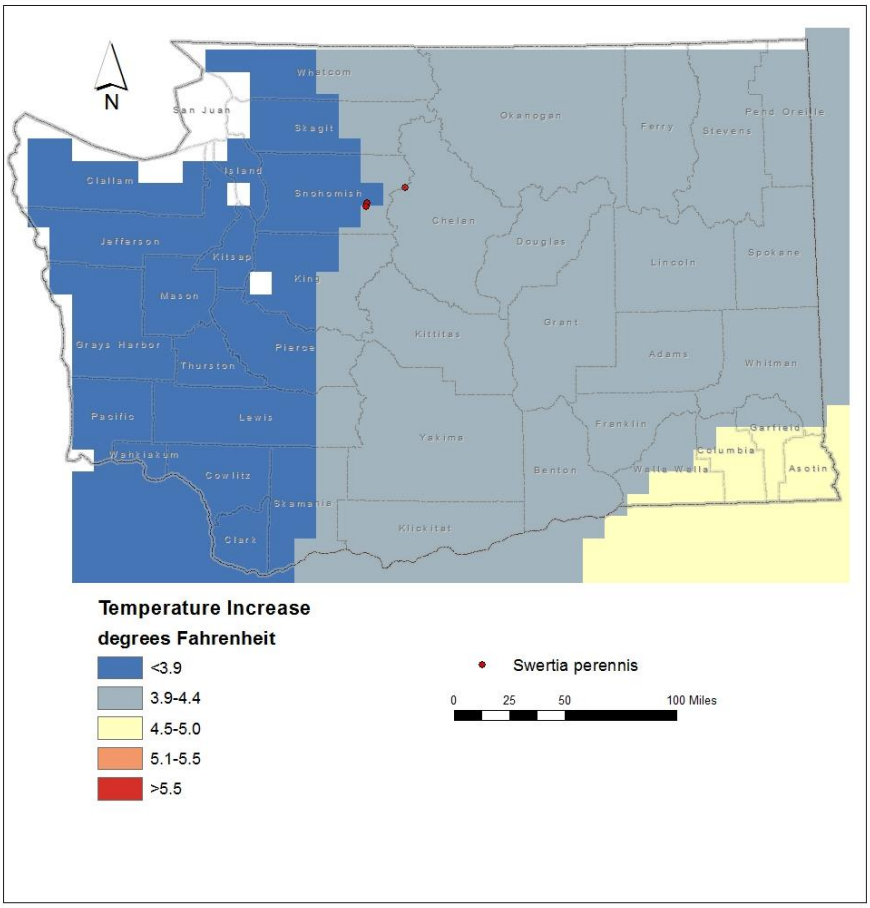


Figure 1. Exposure of *Swertia perennis* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: All three of the occurrences of *Swertia perennis* (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).

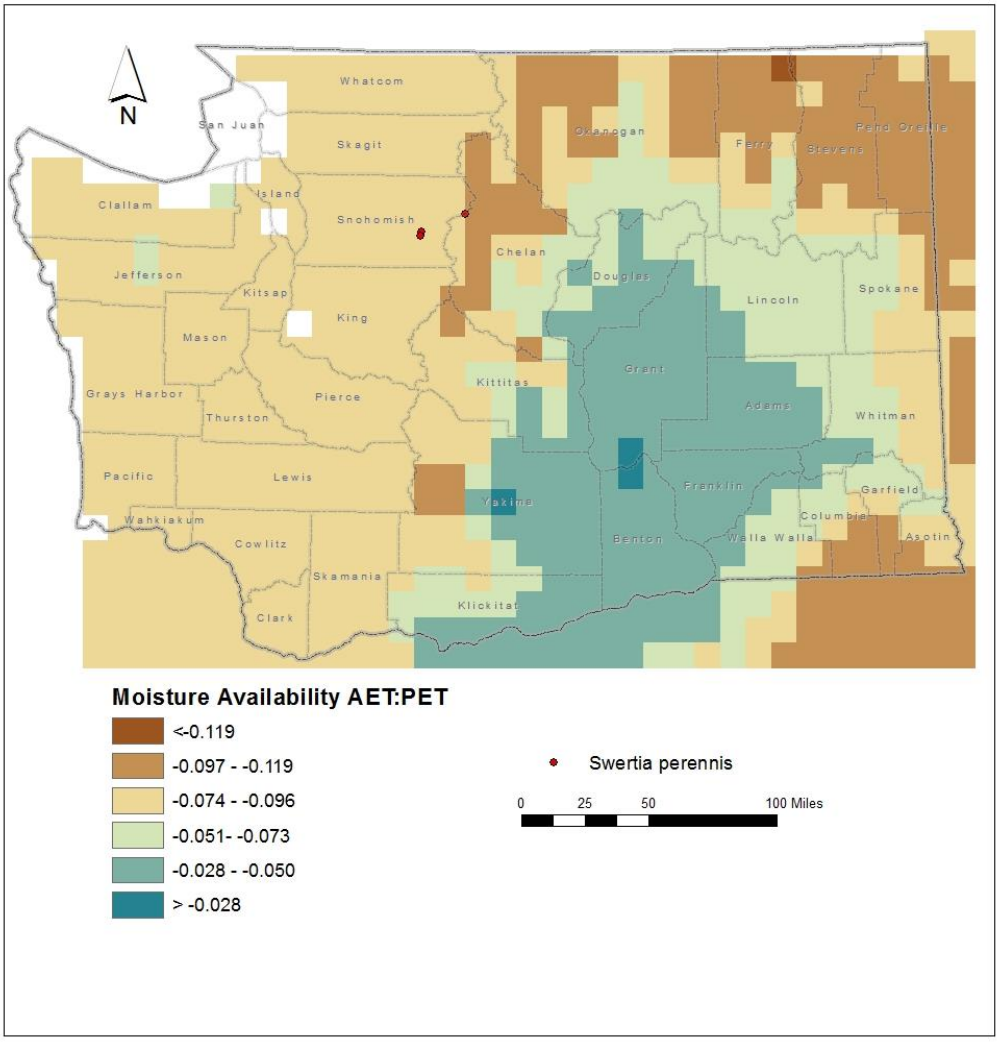


Figure 2. Exposure of *Swertia perennis* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

## Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Swertia perennis* are found at 4000-5680 feet (1220-1730 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Swertia perennis* occurs in montane to subalpine moist meadows and streambanks (WNHP 2005). Populations are found in gravelly swales where extra water may accumulate (WNHP records). This habitat is probably a component of the Temperate Pacific Subalpine-Montane Wet Meadow ecological system (Rocchio and Crawford 2015). Elsewhere in its range (Rocky Mountain states and across boreal Canada and Eurasia), *S. perennis* is often found in bogs, wet meadows, and streambanks in mountains (Cronquist et al. 1984) and populations tend to be discontinuous and patchy (Urbaniak et al. 2018). Washington occurrences are restricted to small patches of suitable habitat separated by distances of 2-19 miles (3-30 km). The natural patchiness of the populations and large extents of unsuitable habitat between forests and dry meadows and valleys probably create a barrier to dispersal.

B2b. Anthropogenic barriers: Neutral.
The range of *Swertia perennis* is naturally somewhat fragmented. Human impacts on the landscape of the Cascade crest where this species occurs have been moderate. In Europe, however, centuries of conversion and development of fen wetlands has greatly increased the fragmentation of populations (Leinert et al. 2002).

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

## Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.
*Swertia perennis* produces dry capsules containing as many as 50 flat, wing-margined seeds (Lienert et al. 2002). The seeds are dispersed passively by dehiscence of the mature capsule, but may be able to spread further by wind or water. Lienert et al. (2002) found that dispersal distances between patches of *S. perennis* in Switzerland were less than 1000 m.

C2ai. Historical thermal niche: Somewhat Increase.
Figure 3 depicts the distribution of *Swertia perennis* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All three of the occurrences in the state (100%) 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. 2006).

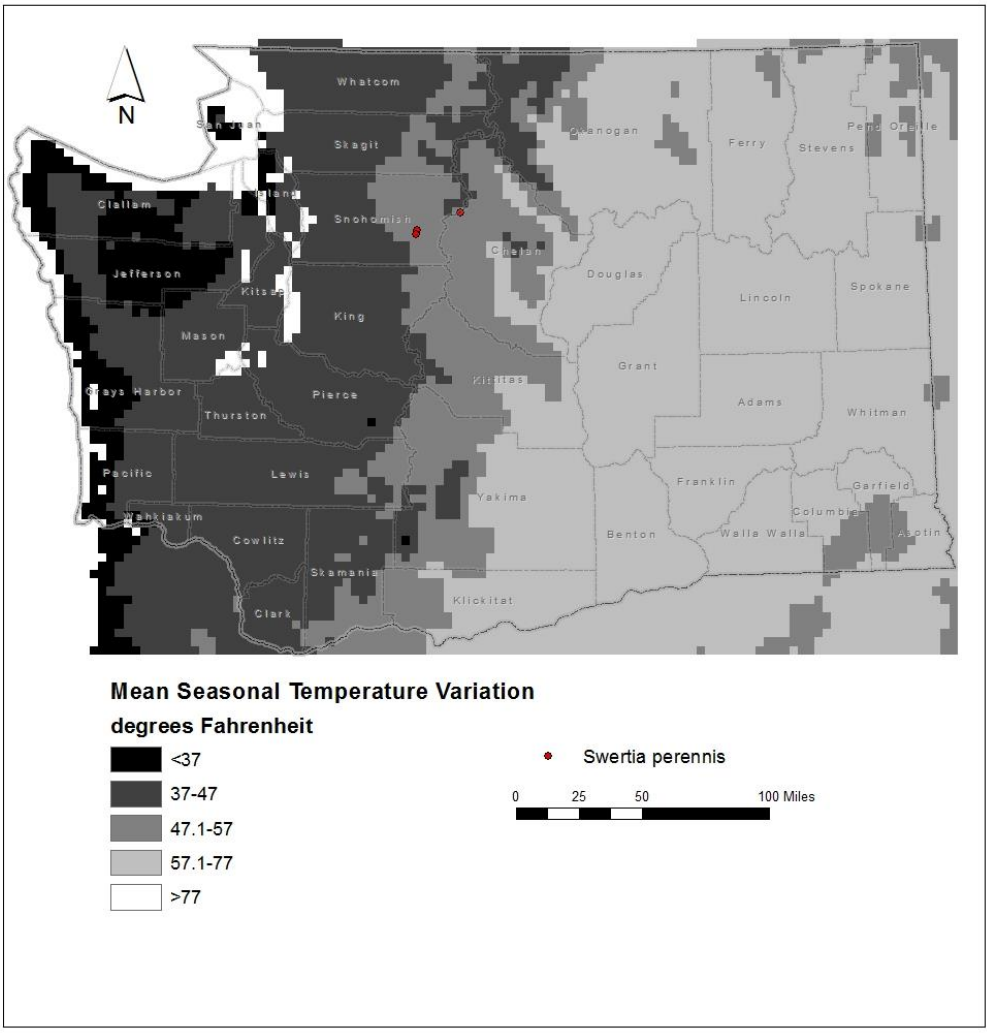


Figure 3. Historical thermal niche (exposure to past temperature variations) of *Swertia perennis* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Increase.
The montane to subalpine wet meadow habitat of *Swertia perennis* may be associated with cold air drainages during the growing season and would have increased vulnerability to temperature changes associated with global warming.

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

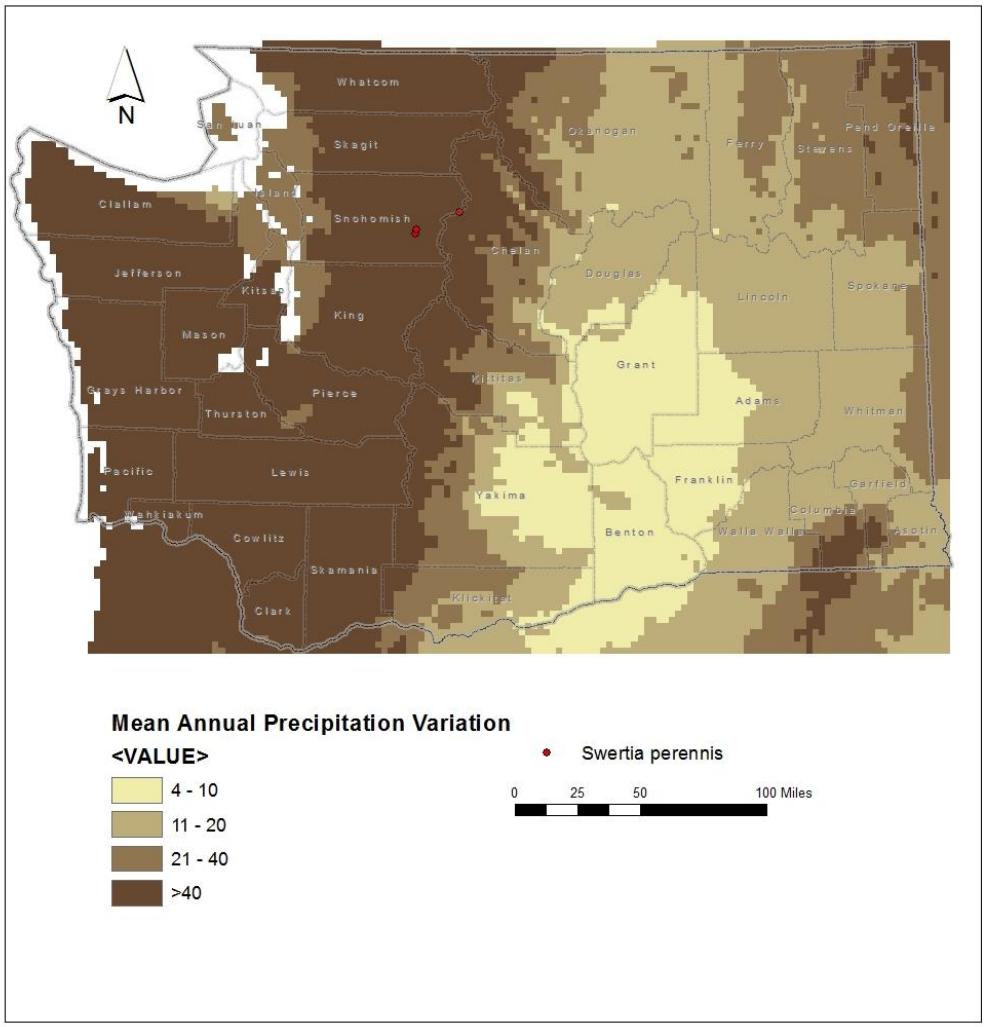


Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Swertia perennis* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
This species is associated with wet meadows that may be fed by groundwater or augmented by spring and summer precipitation. In Washington, *Swertia perennis* populations tend to be associated with shallow, gravelly swales that may accumulate more runoff than surrounding areas (WNHP records). Groundwater-derived wet meadows would be more affected by changes

in the amount and timing of melt of snowpack (see C2d below). Montane wet meadows in Washington may be augmented by surface flow and rainfall, and thus vulnerable to changes in the timing and amount of precipitation during the growing season (Rocchio and Ramm-Granberg 2017). Such changes could hasten the conversion of wet meadows to less mesic plant communities or increase the likelihood for invasion by forests or increased wildfire.

C2c. Dependence on a specific disturbance regime: Neutral.
*Swertia perennis* occurs in montane to subalpine wet meadow habitats that are maintained by high water tables that restrict the invasion of forest trees and exclude herbaceous plants adapted to drier conditions. Under future climate change scenarios, these areas 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).

C2d. Dependence on ice or snow-cover habitats: Somewhat Increase.
The populations of *Swertia perennis* in Washington are found in wet meadows in the montane and subalpine zones that are associated with relatively deep and slow-melting snow. Groundwater recharge from snow is an important source of moisture during the growing season and reductions in the amount of snow or timing of melt could result in long term shifts in vegetation composition of these sites, favoring forests or drier meadows (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Somewhat Increase.
Populations of *Swertia perennis* in Washington occur on a variety of substrates, including mica-quartz of the Napeequa unit of the Chelan Mountains terrane, granodioirite of the Grotto batholith, and Quaternary volcanic talus. These populations may also be restricted to swale-like depressions and avalanche tracks that accumulate extra moisture. These geology types and landforms are somewhat uncommon in the Cascade Range, and so this factor is scored as Somewhat Increase rather than neutral.

C4a. Dependence on other species to generate required habitat: Neutral.
The montane and subalpine wet meadow habitat of *Swertia perennis* is maintained primarily by natural abiotic processes.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
*Swertia perennis* flowers are pollinated by a wide variety of insects, including beetles, butterflies, syrphid flies, bees, and wasps Leinert et al. 2002).

C4d. Dependence on other species for propagule dispersal: Neutral.
The seeds of *Swertia perennis* are winged and dispersed by wind or water, rather than by animals.

C4e. Sensitivity to pathogens or natural enemies: Unknown.
Impacts from pathogens are not known. This species is probably not impacted by grazing, but little information is available.

C4f. Sensitivity to competition from native or non-native species: Neutral.
Competition with other species is probably low at present. In the future, as the montane wet meadow habitat of *Swertia perennis* becomes drier due to increased temperatures or changes in the seasonality of precipitation, this species could be more vulnerable to competition with trees or other herbs adapted to forest or dry meadow habitats (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.
Data are not available on the genetic diversity of this species in Washington.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral
*Swertia perennis* is an outcrosser and reproduces sexually by seed. Lienert et al. (2002) and Urbaniak et al. (2018) found high levels of genetic diversity across populations in Europe, suggesting that gene flow has been occurring, at least in the recent past. Small and isolated occurrences in Europe did have reduced genetic variability (Lienert et al. 2002). Populations in Washington are at the southern edge of the species range in northwestern North America and probably have lower genetic diversity than populations in the Rocky Mountains due to inbreeding or founder effects.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
No 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.
No changes in the distribution of this species have been noted due to climate change.

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

Cronquist, A., A.H. Holmgren, N.H. Holmgren, J.L. Reveal, and P.K. Holmgren. 1984. Volume Four Subclass Asteridae (except Asteraceae). Intermountain Flora, Vascular Plants of the Intermountain West, U.S.A. New York Botanical garden, Bronx, NY. 573 pp.

Lienert, J., M. Fischer, J. Schneller, and M. Diemer. 2002. Isozyme variability of the wetland specialist *Swertia perennis* (Gentianaceae) in relation to habitat size, isolation, and plant fitness. American Journal of Botany 89(5); 801-811.

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.

Urbaniak, J., P. Kwiatkowski, and P. Pawlikowski. 2018. Phylogeography of *Swertia perennis* in Europe based on cpDNA markers. PeerJ. 6:e5512. (doi: 10.7717/peerj.5512).

[WNHP] Washington Natural Heritage Program. 2005. Field Guide to Washington's Rare Plants. Washington Natural Heritage Program, WA Department of Natural Resources and Bureau of Land Management.

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.