Climate Change Vulnerability Index Report

Cypripedium parviflorum (Yellow lady's slipper)

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Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G5/S2

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	100
	<3.9° F (2.2°C) warmer	0
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	21.7
	-0.074 to - 0.096	43.5
	-0.051 to - 0.073	34.8
	-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		Neutral
2ai Change in historical thermal niche		Neutral
2aii. Change in physiological thermal niche		Somewhat Increase
2bi. Changes in historical hydrological niche		Somewhat Increase
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		Neutral
4a. Dependence on others species to generate required habitat		Neutral
4b. Dietary versatility		Not Applicable
4c. Pollinator versatility		Increase
4d. Dependence on other species for propagule dispersal		Neutral
4e. Sensitivity to pathogens or natural enemies		Somewhat Increase
4f. Sensitivity to competition from native or non-native species		Neutral
4g. Forms part of an interspecific interaction not covered above		Somewhat Increase
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: All 23 of the occurrences of *Cypripedium parviflorum* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

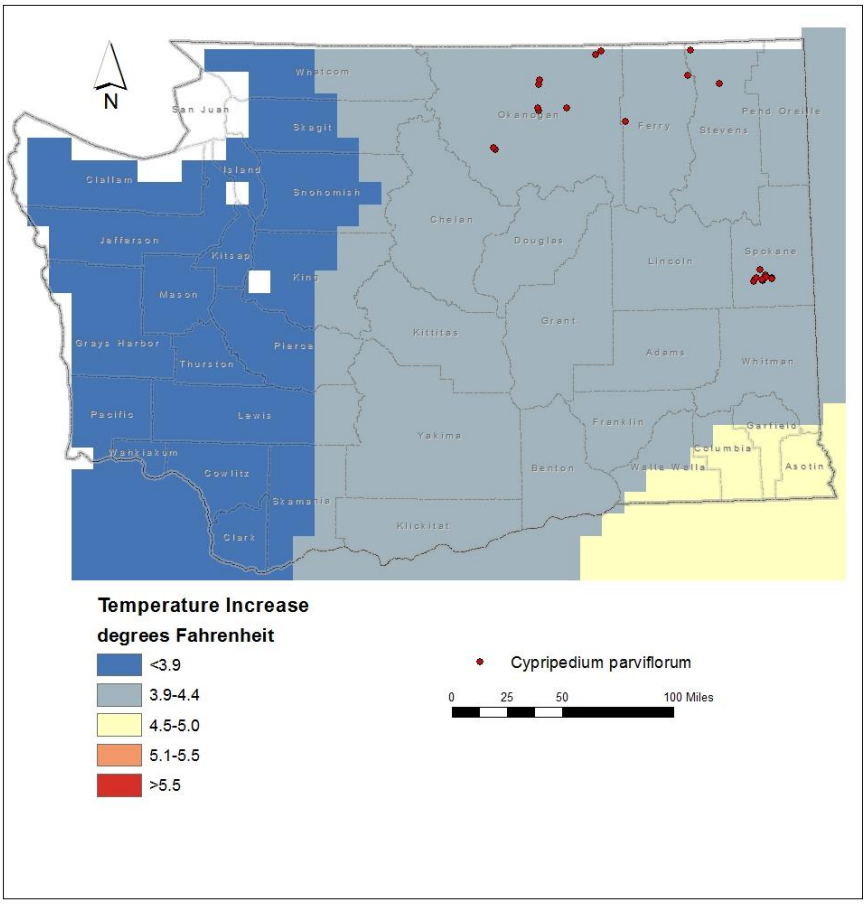

Figure 1. Exposure of *Cypripedium parviflorum* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Five of the 23 extant and historical occurrences of *Cypripedium parviflorum* (21.7%) 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 -0.097 to -0.119 (Figure 2). Ten of 23 populations (43.5%) occur in areas with a projected decrease in the range of -0.074 to -0.096. Eight other occurrences (34.8%) are from areas with a projected decrease in available moisture of -0.051 to -0.073 (Figure 2).

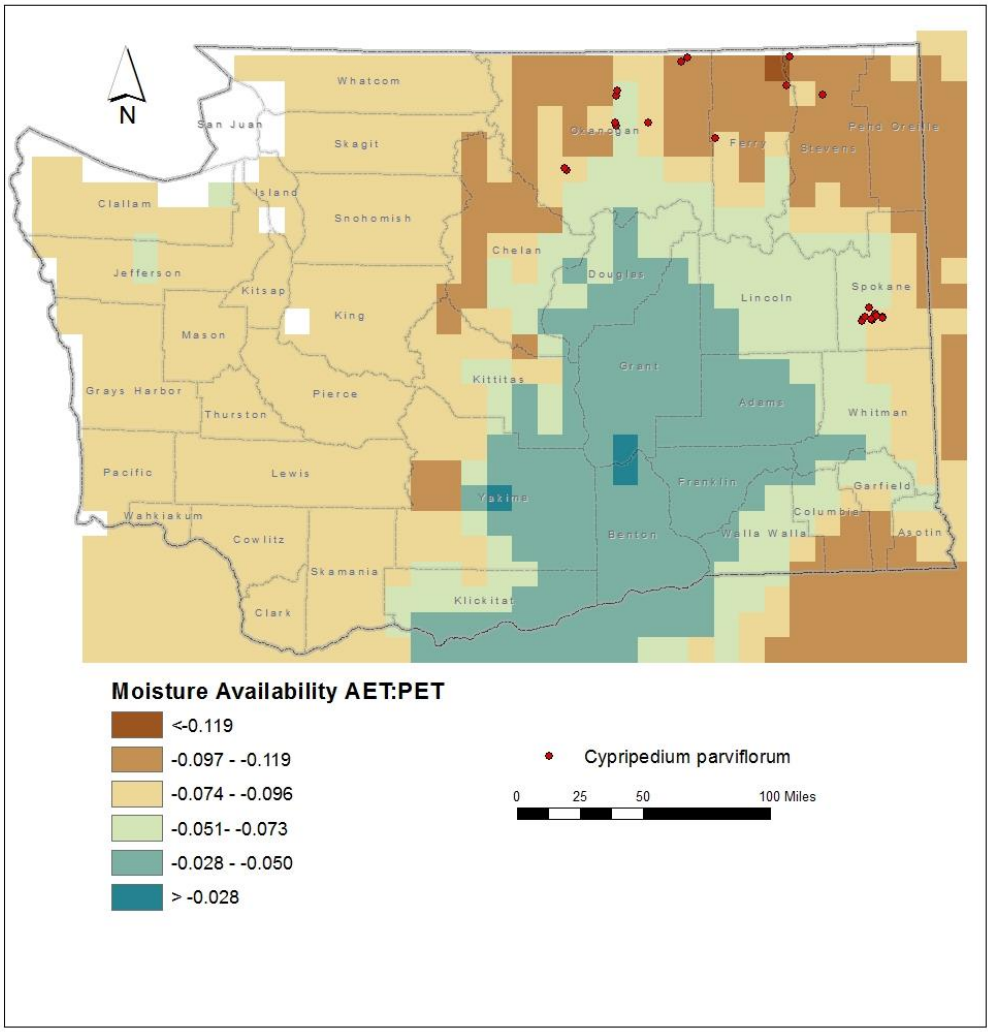

Figure 2. Exposure of *Cypripedium parviflorum* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Cypripedium parviflorum* are found at 1800-3400 feet (550-1050 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Cypripedium parviflorum* occurs in grassy areas amid shrubs along the edge of beaver ponds, perennial or ephemeral scabland ponds, marshy areas, or forested swamps (Camp and Gamon 2011, WNHP records). Some populations on the Colville National Forest occur in areas with calcareous soils. Dominant shrub and tree species in wetlands occupied by *C. parviflorum* include *Pseudotsuga menziesii, Populus tremuloides, Thuja plicata, Picea engelmannii, Pinus ponderosa, Alnus, Salix*, and *Betula* (WNHP records). The shrub/marsh and swamp forest habitat utilized by this species conforms with the Rocky Mountain Subalpine-Montane Riparian Shrubland and Northern Rocky Mountain Conifer Swamp ecological systems (Rocchio and Crawford 2015). Washington occurrences are restricted to small patches of suitable habitat separated by distances of 1-90 miles (1.5-145 km). The natural patchiness of the populations and large extent of unsuitable habitat between them creates a barrier for dispersal.

B2b. Anthropogenic barriers: Neutral.
The range of *Cypripedium parviflorum* is naturally fragmented. Human impacts on the landscape of northeastern Washington may exacerbate this condition, but overall are of less significance than 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.
Cypripedium parviflorum produces numerous, miniscule seeds within dry capsules that split open at maturity to release seed passively. Dispersal is primarily by wind and seeds can travel over 100 km (Carlson and Fulkerson 2017).

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Cypripedium parviflorum* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All 23 of the known occurrences in the state (100%) are found in areas that have experienced average (57.1-77˚F/31.8-43.0˚C) temperature variation during the past 50 years and are considered at neutral vulnerability to climate change (Young et al. 2006).

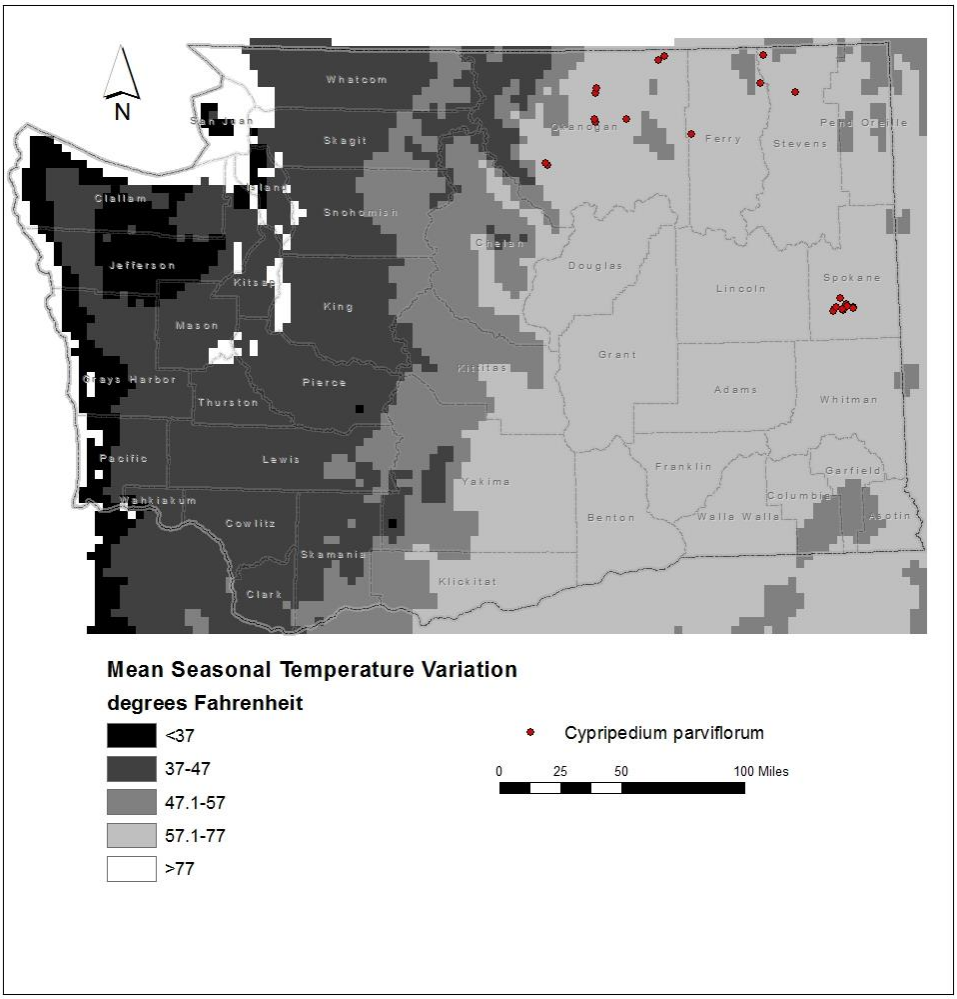

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Cypripedium parviflorum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Somewhat Increase.
Many populations of *Cypripedium parviflorum* are found in shady and cool microsites associated with swamp forests and shrubby marshlands and depressions. These sites are likely to be cold air drainages during the growing season and would have somewhat increased vulnerability to temperature changes associated with global warming.

C2bi. Historical hydrological niche: Somewhat Increase.
Twenty of the 23 populations of *Cypripedium parviflorum* in Washington (87%) are found in areas that have experienced slightly lower than average (11-20 inches/255-508 mm) precipitation variation in the past 50 years (Figure 4). According to Young et al. (2016), these occurrences are at somewhat increased vulnerability to climate change. The other three populations from northeastern Washington have experienced average or greater than average (>20 inches/508 mm) precipitation variation over the same period and are at neutral vulnerability (Figure 4).

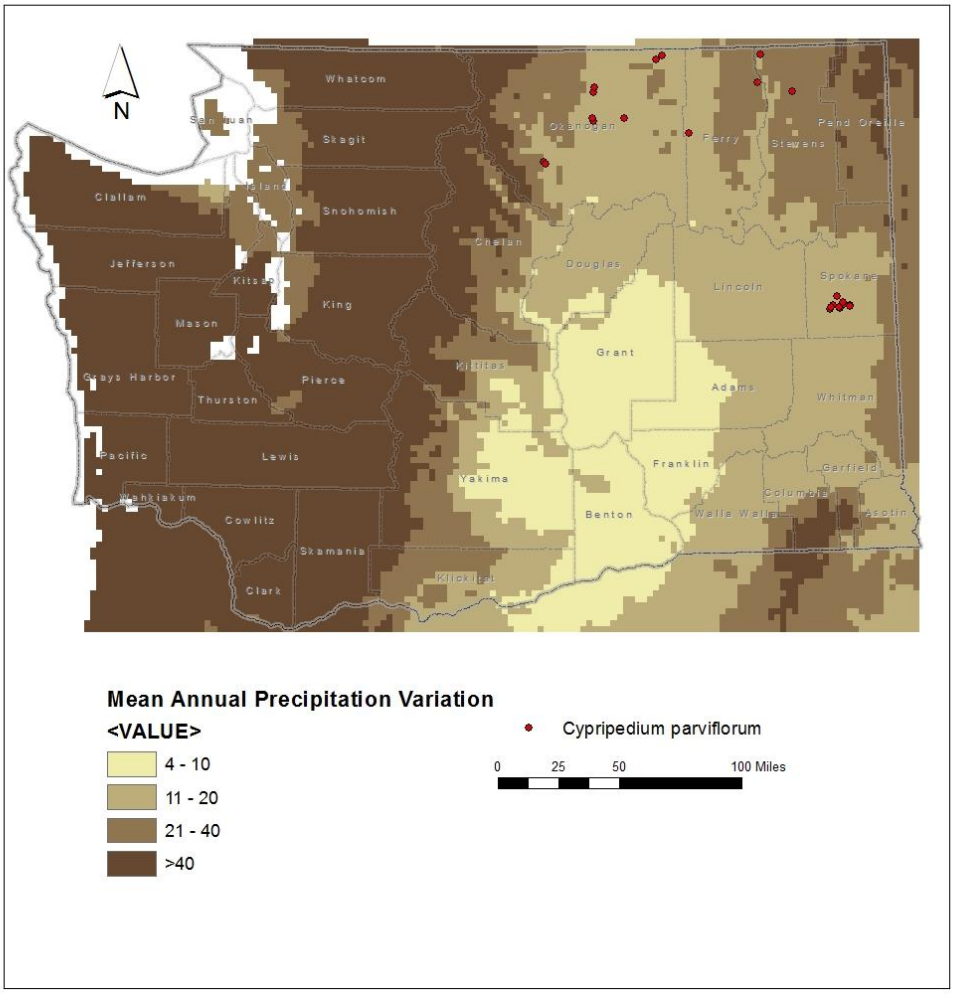

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Cypripedium parviflorum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
This species is associated with forested swamps and marshy shrublands maintained by high water tables or seasonal flooding, both of which could be negatively impacted by projected higher temperatures in the summer or earlier melting of snowpacks in the spring (Rocchio and Ramm-Granberg 2017). See "Dependence on ice or snow-cover habitats" below.

C2c. Dependence on a specific disturbance regime: Neutral.
Cypripedium parviflorum occurs in swamp forest and marshy shrubland habitats that may be subjected to flooding in spring or late winter. These high flows may be important for maintaining adequate soil moisture into the summer (Rocchio and Ramm-Granberg 2017). Otherwise, these habitats are not adapted to disturbances, such as fire or wind-throw. Increase in temperature or reduction in precipitation could make these habitats more vulnerable to drought or fire and lead to conversion to more xeric shrublands or meadows.

C2d. Dependence on ice or snow-cover habitats: Somewhat Increase.
The populations of *Cypripedium parviflorum* in Washington are found in marshy shrublands and swamp forests where high water tables are maintained in part from snowmelt. Projected future changes in temperature could negatively impact the timing of snowmelt and result in less recharge of water in the spring, making these habitats more vulnerable to summer drought (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Neutral.
Populations of *Cypripedium parviflorum* in Washington occur on a variety of substrates. In the Spokane area, most occurrences are in scoured kettle ponds in the Priest Rapids Member of the Wanapum Basalt, a common formation in eastern Washington. Elsewhere in the state, populations are found on Pleistocene glacial drift, ultramafic intrusive formations, the Metaline limestone, Tonasket gneiss, and Loomis granodiorite. The variety of substrates suggest that geological features are not limiting the distribution of this species.

C4a. Dependence on other species to generate required habitat: Neutral.
The marshy shrubland and swamp forest habitat occupied by *Cypripedium parviflorum* is maintained primarily by natural abiotic processes.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Increase.
Cypripedium parviflorum flowers are pollinated by small bees in the genus *Andraena* that are enticed to the showy slipper petal by a floral scent and then become trapped inside, able to escape only through a narrow opening at the back of the slipper below the sticky pollinaria. Bees loaded with pollen must then visit another *Cypripedium* flower and become trapped again to release their pollen load on a receptive stigma as they escape. Pollination rates and seed set are low for this and other *Cypripedium* species (Carlson and Fulkerson 2017). The complexity of pollination and few species of bees capable of being pollinators make this species have increased vulnerability to climate change.

C4d. Dependence on other species for propagule dispersal: Neutral.
The tiny seeds of *Cypripedium parviflorum* are dispersed long distances by wind and are not dependent on animals.

C4e. Sensitivity to pathogens or natural enemies: Somewhat Increase.
Impacts from pathogens are not known. This species is palatable and potentially vulnerable to grazing by livestock and other herbivores.

C4f. Sensitivity to competition from native or non-native species: Neutral.
Competition from other plant species is not identified as a significant threat to C*ypripedium parviflorum* (Camp and Gamon 2011).

C4g. Forms part of an interspecific interaction not covered above: Somewhat Increase.
Cypripedium parviflorum seeds do not contain endosperm to provide nutrition for developing seedlings, and so mycorrhizal fungi symbionts are necessary for establishment of young plants (Carlson and Fulkerson 2017). High specificity to mycorrhizal fungi has been reported for other Cypripedium species (Shefferson et al. 2005).

C5a. Measured genetic variation: Unknown.
Data are not available on the genetic diversity of this species in Washington. In the eastern United States, Wallace and Case (2000) found significant differences in genetic variation across the range of *Cypripedium parviflorum*, particularly in regions that had been glaciated. The authors suggested that a refugium may have existed within the glacial region which served as the source for new populations in the southeastern US, or the southern populations have become spatially isolated and experienced genetic drift to account for their lower genetic diversity.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral
Cypripedium parviflorum reproduces sexually and is self-incompatible. The pollination syndrome of the species is complex (as noted in Section C4c) and strongly favors outcrossing. Seeds are small and easily dispersed long distances by wind. Wallace and Case (2000) found high rates of genetic variability across the range of the species in the eastern US, consistent with high dispersal, although isolated populations also showed evidence of reduced genetic diversity through genetic drift. Genetic data are not available for Washington populations, which may have slightly lower genetic diversity than expected because the state populations are at the edge of the species' full range and could be impacted by genetic drift or founder effects.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on WNHP and Consortium of Pacific Northwest Herbaria records, 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.
The range of this species within Washington has not changed significantly in recent years.

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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