Climate Change Vulnerability Index Report

Thelypodium sagittatum ssp. *sagittatum* (Arrow thelypody)

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Geographic Area: Washington Heritage Rank: G4T4/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	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	0
	-0.051 to - 0.073	80
	-0.028 to -0.050	20
	>-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		Neutral
2aii. Change in physiological thermal niche		Neutral
2bi. Changes in historical hydrological niche		Somewhat Increase
2bii. Changes in physiological hydrological niche		Increase
2c. Dependence on specific disturbance regime		Neutral
2d. Dependence on ice or snow-covered habitats		Neutral
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		Somewhat Increase
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

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 five of the known occurrences of *Thelypodium sagittatum* ssp. *sagittatum* in Washington (100%) occur in an area with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

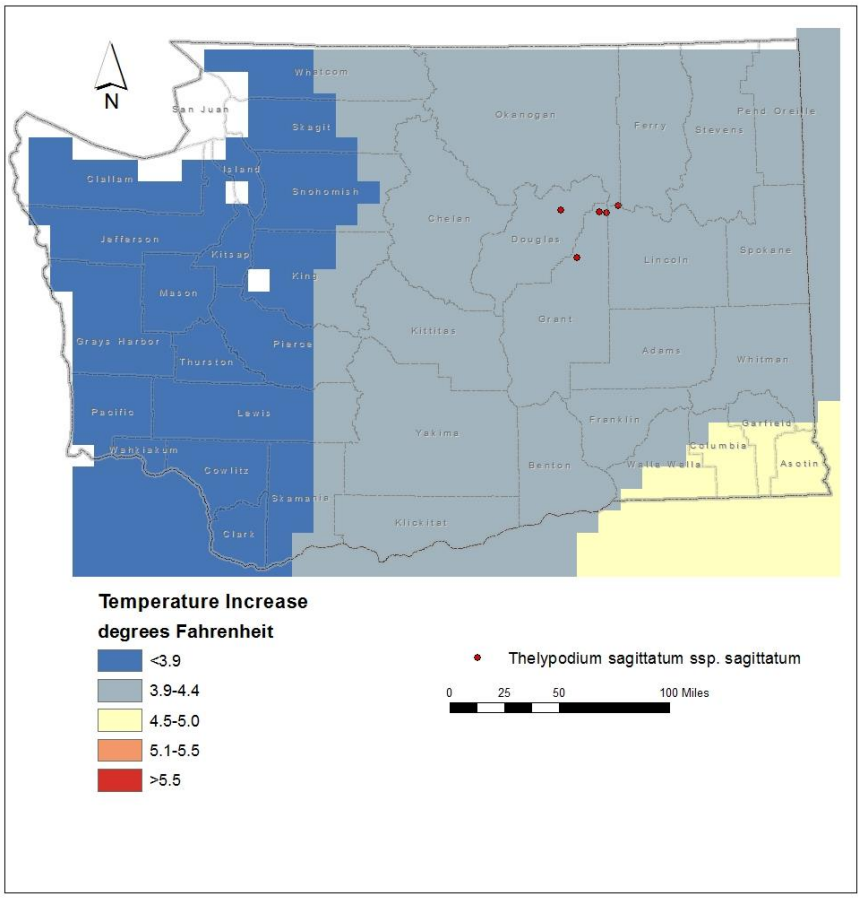

Figure 1. Exposure of *Thelypodium sagittatum* ssp. *sagittatum* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Four of the five Washington occurrence of *Thelypodium sagittatum* ssp. *sagittatum* (80%) are found in an area 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). One other population (20%) is found in an area with a projected decrease in moisture of – 0.028 to – 0.050.

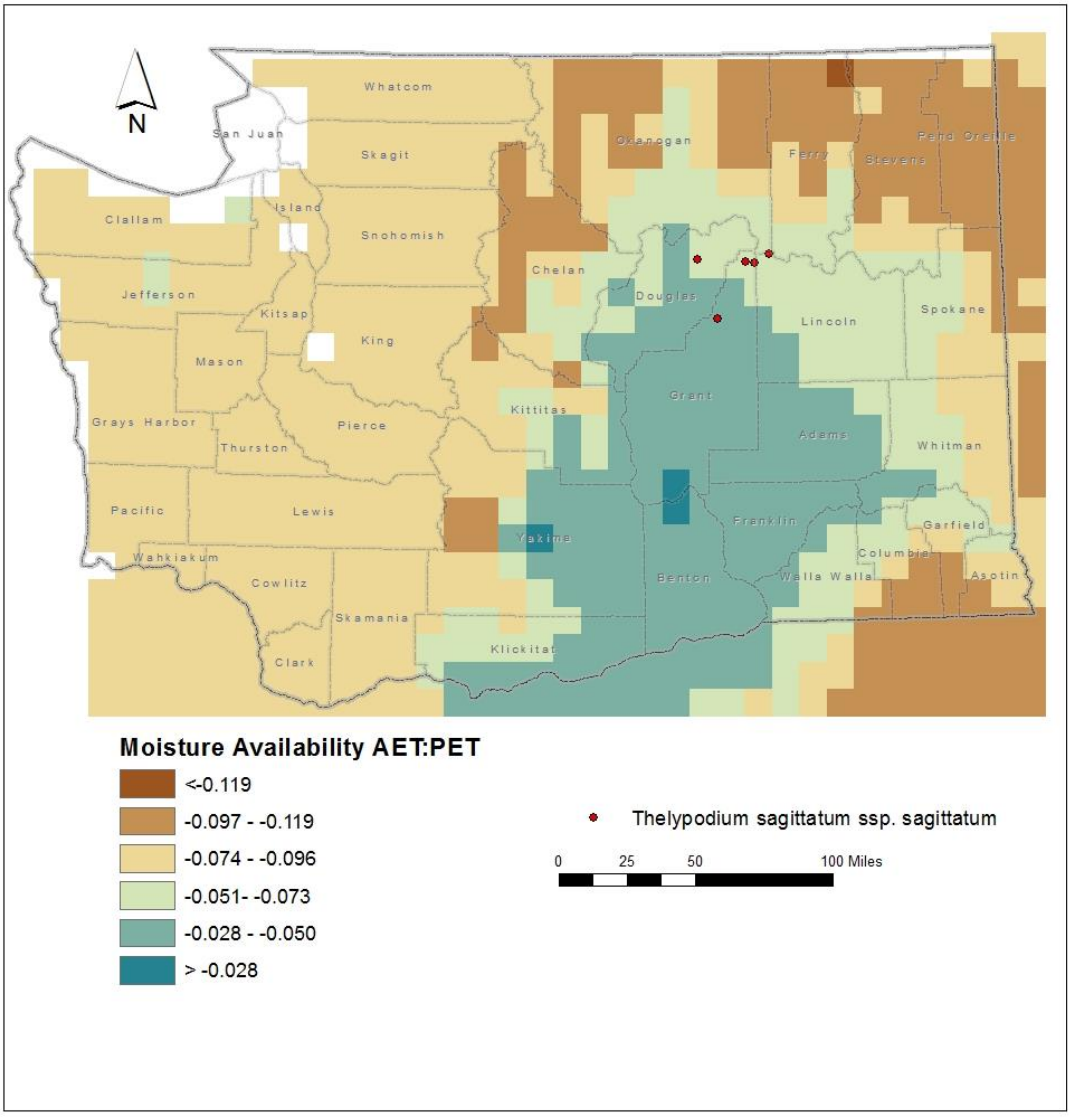

Figure 2. Exposure of *Thelypodium sagittatum* ssp. *sagittatum* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Thelypodium sagittatum* ssp. *sagittatum* are found at 1600-2300 feet (500-700 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Thelypodium sagittatum* ssp. *sagittatum* is found in shallow, alkali marshes, moist swales, and salt flats over basalt within a matrix of upland sagebrush and bunchgrass vegetation (Camp and Gamon 2011, Fertig and Kleinknecht 2020). This habitat is a component of the North American Arid West Emergent Marsh ecological system (though grading towards the Northern Columbia Plateau Basalt Pothole Ponds system) (Rocchio and Crawford 2015). Washington populations are separated by 5-37 km (3-23 miles) and occupy small areas of habitat within a matrix of unsuitable sagebrush steppe and scablands that create a barrier to dispersal.

B2b. Anthropogenic barriers: Neutral.
The range of *Thelypodium sagittatum* ssp. *sagittatum* in Washington is embedded within a matrix of natural and agricultural lands. The species is probably more isolated by natural barriers than anthropogenic ones.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.
Thelypodium sagittatum ssp. *sagittatum* produces numerous, many-seeded silique fruits per inflorescence. The fruits open along two sutures at maturity to passively release the small, un-ornamented seeds for dispersal by gravity, water, or wind. Seeds are mostly shed close to their parent, but may be able to travel 100-1000 m.

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Thelypodium sagittatum ssp. sagittatum* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All five of the extant and historical occurrences (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 risk from climate change.

C2aii. Physiological thermal niche: Neutral.
The shallow, alkali wetlands inhabited by *Thelypodium sagittatum* ssp. *sagittatum* in the Columbia Plateau of eastern Washington are not associated with cold air drainage in the growing season and not vulnerable to projected temperature increases due to climate change.

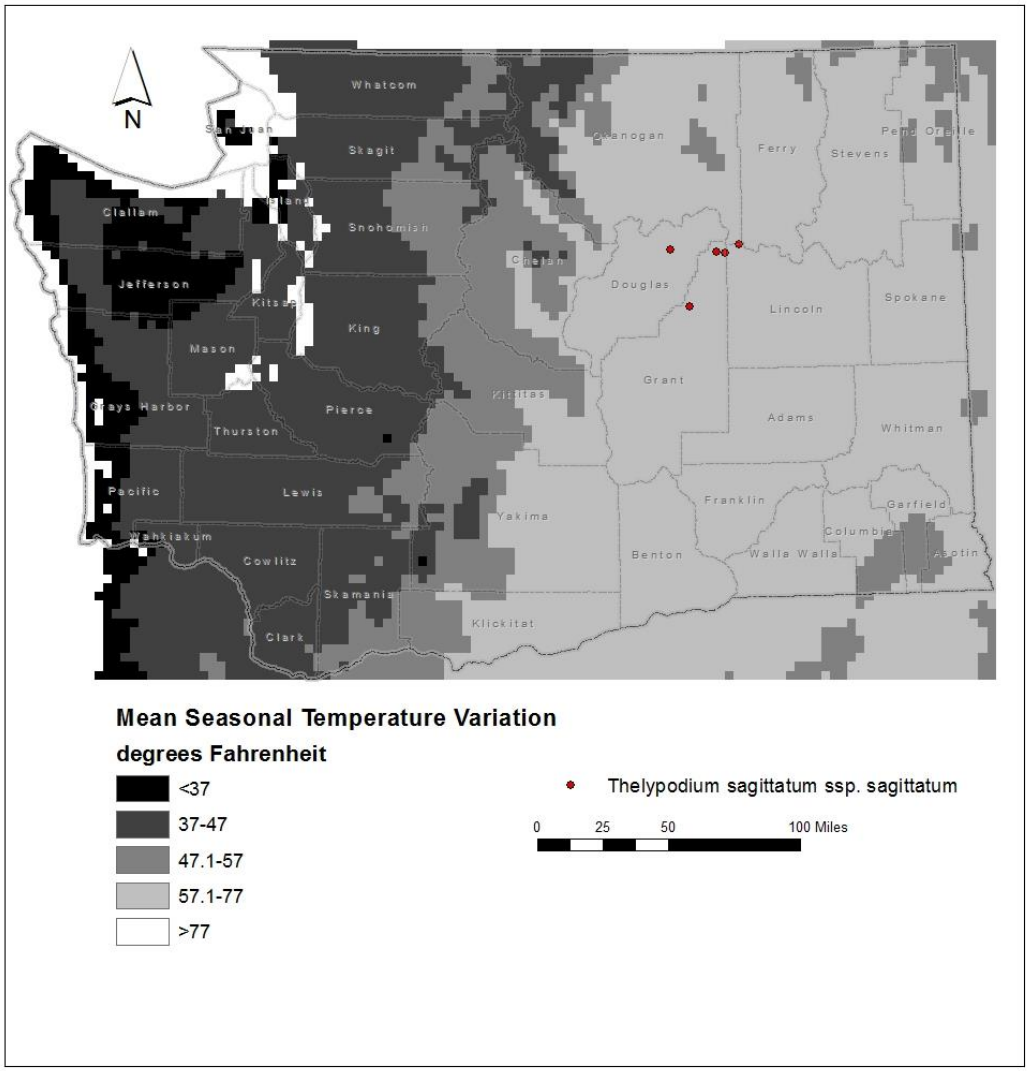

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Thelypodium sagittatum* ssp. *sagittatum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Somewhat Increase.
Four of the five populations of *Thelypodium sagittatum* ssp. *sagittatum* in Washington (80%) 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 areas are at somewhat increased vulnerability from climate change. One other occurrence is found in an area with small (4-10 inches/100-254 mm) precipitation variation in the same period and is considered at increased risk from climate change.

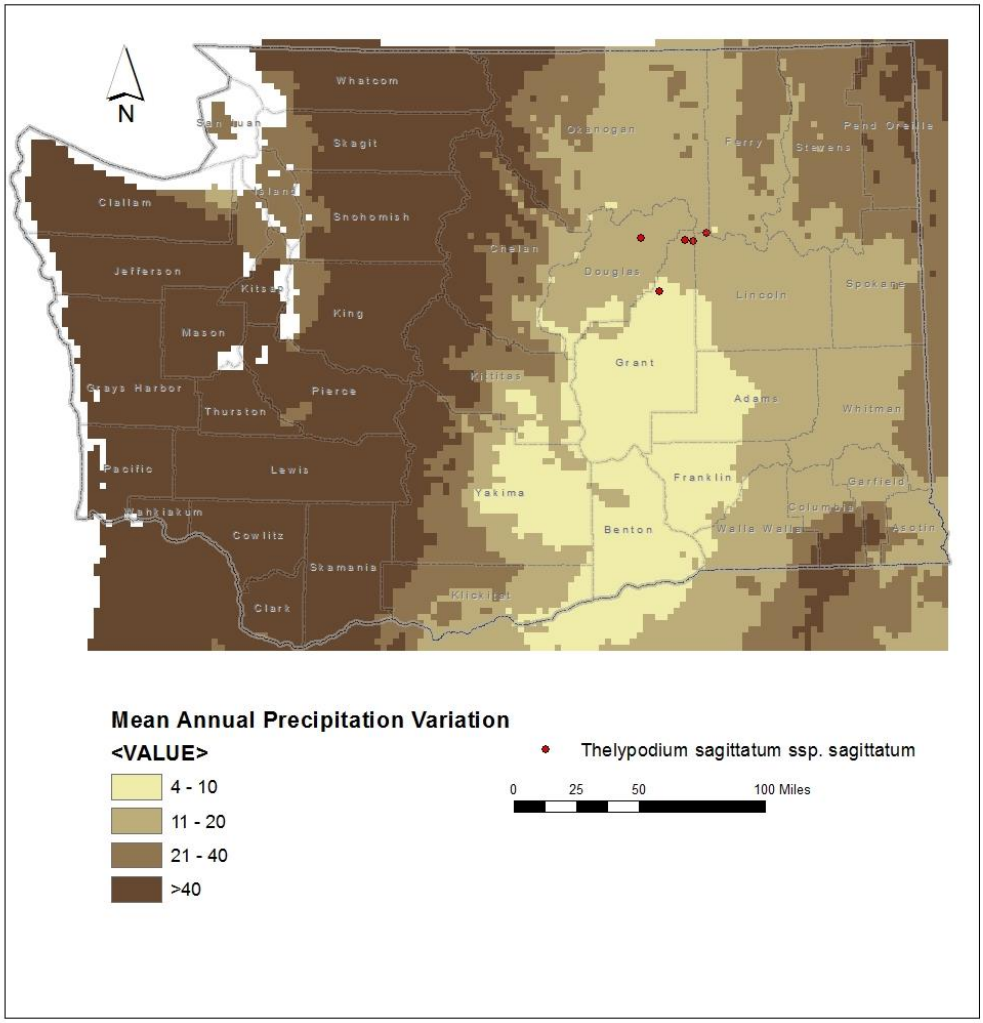

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Thelypodium sagittatum* ssp. *sagittatum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Increase.
In Washington, *Thelypodium sagittatum* ssp. *sagittatum* is found in shallow alkali depressions and other marshy meadows over basalt. These wetland areas are probably supported by rainfall, rather than groundwater. Such sites are vulnerable to changes in timing and amount of precipitation, increasing temperatures, and summer drought (Rocchio and Ramm-Granberg 2017). Marsh and pothole wetland systems are likely to convert to wet meadow communities under prolonged climate change.

C2c. Dependence on a specific disturbance regime: Neutral.
Thelypodium sagittatum ssp. *sagittatum* occurs in shallow depressions in basalt bedrock with vernal alkali wetlands surrounded by sagebrush or bunchgrass vegetation on deeper soils. The wetland communities are maintained by precipitation, seasonal drought, and soil depth and chemistry, more so than disturbances, such as fire.

C2d. Dependence on ice or snow-cover habitats: Neutral.
The range of *Thelypodium sagittatum* ssp. *sagittatum* in the Columbia Plateau in Washington has low snowfall. Drifting or late-melting snow is a supplemental source of moisture along with spring and winter rainfall.

C3. Restricted to uncommon landscape/geological features: Somewhat Increase.
In Washington, *Thelypodium sagittatum* ssp. *sagittatum* is strongly associated with shallow depressions in basalt with thin clay soil. While basalt is widespread across central and eastern Washington (and not limiting), the depressions and thin, alkali soil layers required by this species may be relatively uncommon.

C4a. Dependence on other species to generate required habitat: Neutral
The alkali marshy meadow habitat of *Thelypodium sagittatum* ssp. *sagittatum* is probably maintained primarily by natural abiotic processes.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
Like other members of the Brassicaceae, *Thelypodium sagittatum* ssp. *sagittatum* is adapted for pollination by numerous, unspecialized (generalist) species of insects such as moths, butterflies, bees, and flies. It is unlikely to be pollinator limited.

C4d. Dependence on other species for propagule dispersal: Neutral.
Seed dispersal in *Thelypodium sagittatum* ssp. *sagittatum* is entirely passive, with the small seeds spreading by wind, water, or gravity.

C4e. Sensitivity to pathogens or natural enemies: Somewhat Increase.
Impacts from pathogens are not known. This species may be threatened by livestock grazing (Camp and Gamon 2011).

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Thelypodium sagittatum ssp. *sagittatum* could be vulnerable to competition from other native or introduced plant species if its specialized vernal alkali marsh habitat became converted to wet

meadow vegetation due to changes in the timing or amount of precipitation (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.
No data are available on genetic variability for this species.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral
Thelypodium sagittatum ssp. *sagittatum* is pollinated by a variety of insects and is likely to be an outcrosser. Genetic diversity is probably average.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on flowering dates from specimens in the Consortium of Pacific Northwest herbaria website, 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 in Washington has been observed 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

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

Fertig, W. and J. Kleinknecht. 2020. Conservation status and protection needs of priority plant species in the Columbia Plateau and East Cascades ecoregions. Natural Heritage Report 2020-02. Washington natural Heritage Program, WA Department of Natural Resources, Olympia, WA. 173 pp.

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