Climate Change Vulnerability Index Report

Astragalus arthurii (Arthur's milkvetch)

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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	100
	3.9-4.4° F (2.2-2.4°C) warmer	0
	<3.9° F (2.2°C) warmer	0
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	15.8
	-0.074 to - 0.096	84.2
	-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		Somewhat Increase
3. Impacts from climate change mitigation		Neutral
Section C: Sensitivity and Adaptive Capacity		
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		Somewhat Increase
2c. Dependence on specific disturbance regime		Somewhat Increase
2d. Dependence on ice or snow-covered habitats		Neutral
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

6. Phenological response to changing seasonal and precipitation dynamics	Neutral
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: The 19 extant and historical occurrences of *Astragalus arthurii* in Washington (100%) occur in an area with a projected temperature increase of 4.5-5.0˚ F (Figure 1).

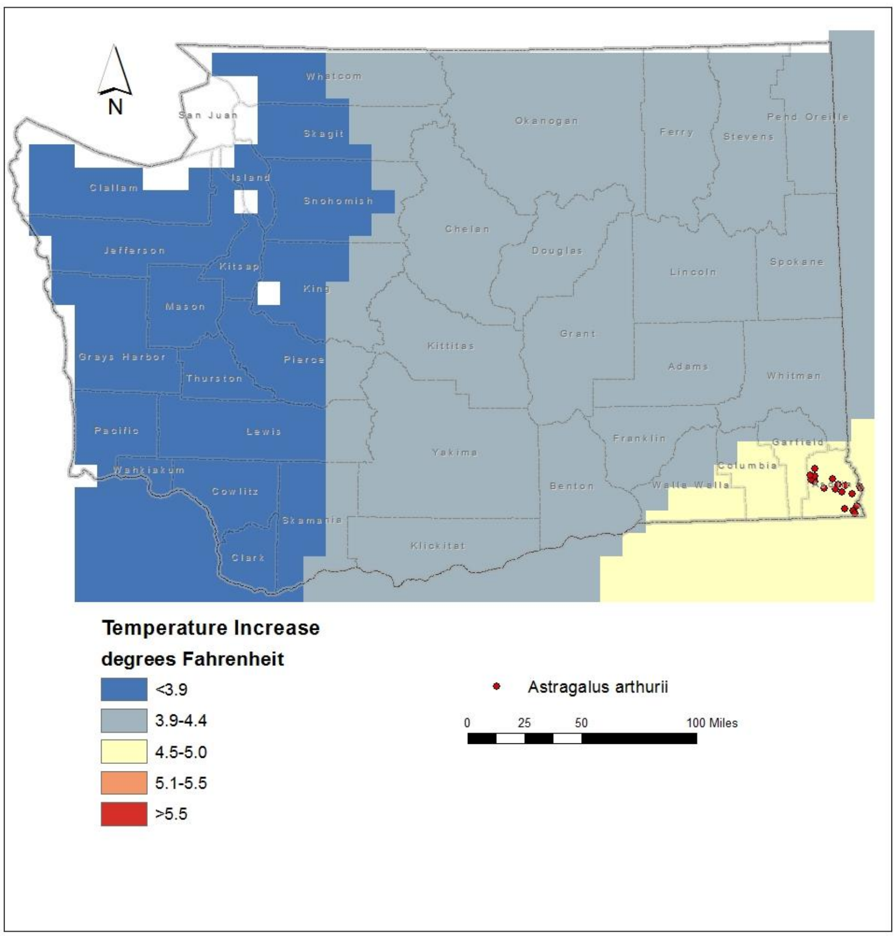

Figure 1. Exposure of *Astragalus arthurii* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Sixteen of the 19 occurrences of *Astragalus arthurii* (84.2%) in Washington 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 -0.074 to -0.096 (Figure 2). The other three occurrences (15.8%) are from areas with a projected decrease in available moisture of -0.097 to -0.119.

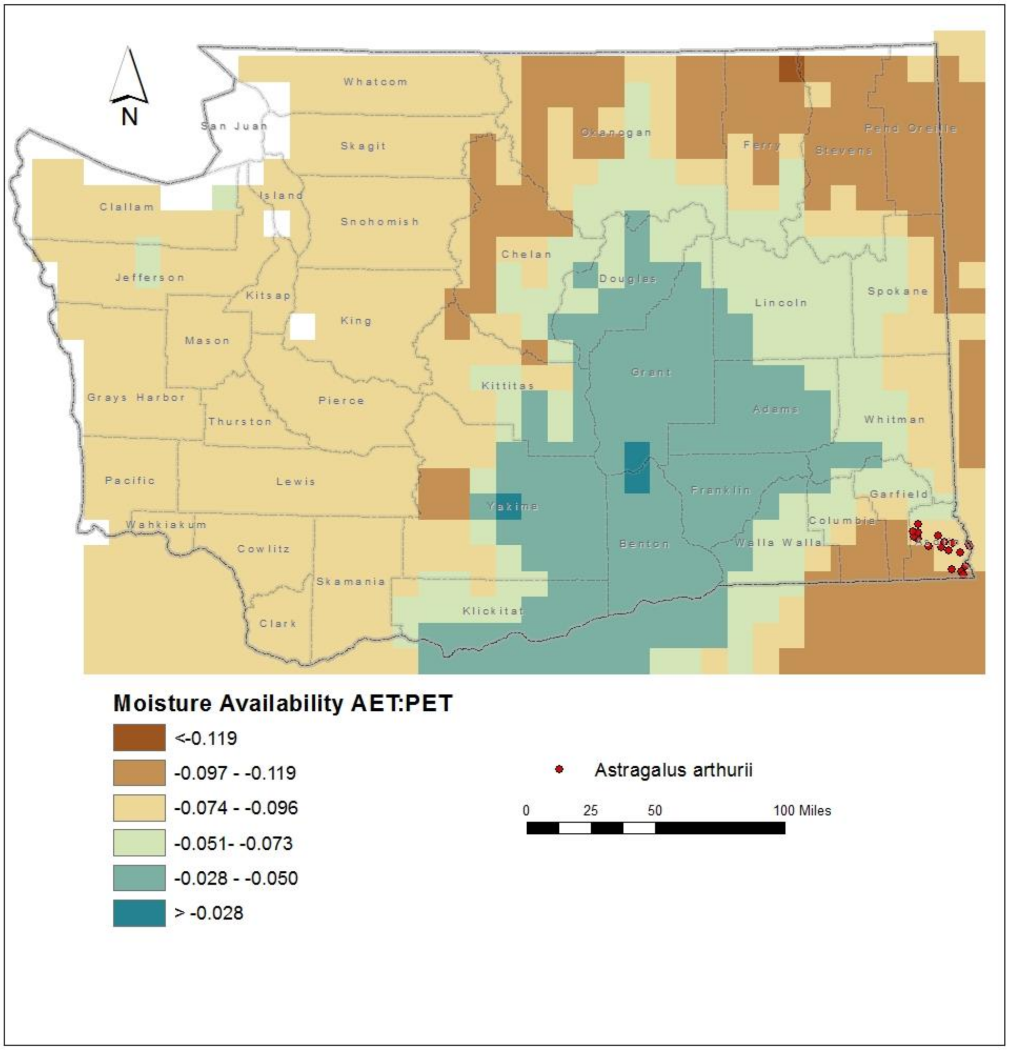

Figure 2. Exposure of *Astragalus arthurii* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
The Washington occurrences of *Astragalus arthurii* are found at 800-3900 feet (245-1200 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Astragalus arthurii* is found on dry grassy hills and rocky meadows on basalt dominated by bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*) and Sandberg bluegrass (*Poa secunda*) (Camp and Gamon 2011; Fertig and Kleinknecht 2020). This habitat is a component of the Columbia Basin Foothill and Canyon Dry Grassland ecological system (Rocchio and Crawford 2015). Washington populations occur mostly on ridges and are separated from other populations by distances of 1-6.6 miles (1.9-11 km). The intervening unoccupied valley bottom habitat creates a barrier to dispersal or migration.

B2b. Anthropogenic barriers: Somewhat Increase.
The range of *Astragalus arthurii* in Washington is bisected by roads and agricultural fields that form a barrier to dispersal.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.
Astragalus arthurii produces 5-20 flowers per inflorescence and each mature fruit contains 18-30 seeds that are released passively by dehiscence of the legume pod (Barneby 1964). The seeds do not possess any wings, barbs, or hooks to promote dispersal by wind or animals. Dispersal is primarily by gravity and perhaps secondarily by insects or rodents, but the total distance is probably relatively short (no more than 100 m).

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Astragalus arthurii* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Twelve of the 19 occurrences (63.2%) 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. 2016). The other 7 occurrences (36.8%) are from areas with slightly lower than average (47.1-57˚F/26.3-31.8˚C) temperature variation and are at somewhat increased risk from climate change Young et al. 2016).

C2aii. Physiological thermal niche: Neutral.
The Columbia Basin Foothill and Canyon Dry Grassland habitat of *Astragalus arthurii* is not associated with cold air drainage during the growing season and would have neutral vulnerability to climate change.

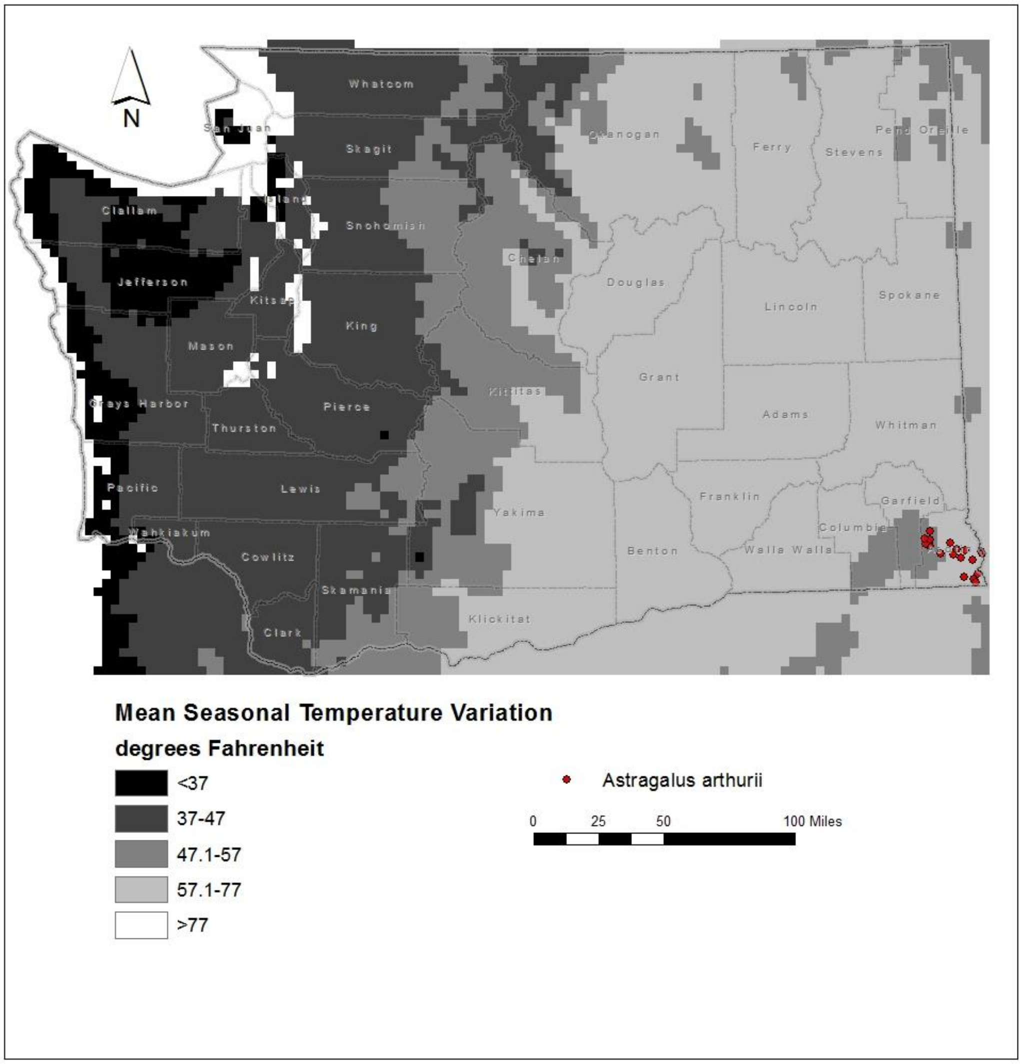

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Astragalus arthurii* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Somewhat Increase.
Eleven of the 19 occurrence of *Astragalus arthurii* in Washington (57.9%) are found in areas that have experienced slightly lower than average (11-20 inches/255-508 mm) of precipitation variation in the past 50 years (Figure 4). According to Young et al. (2016), these areas are at somewhat increased vulnerability to climate change. Eight other populations occur in areas with average precipitation variation (21-40 inches/508-1016 mm) over the same period and are at neutral vulnerability to climate change.

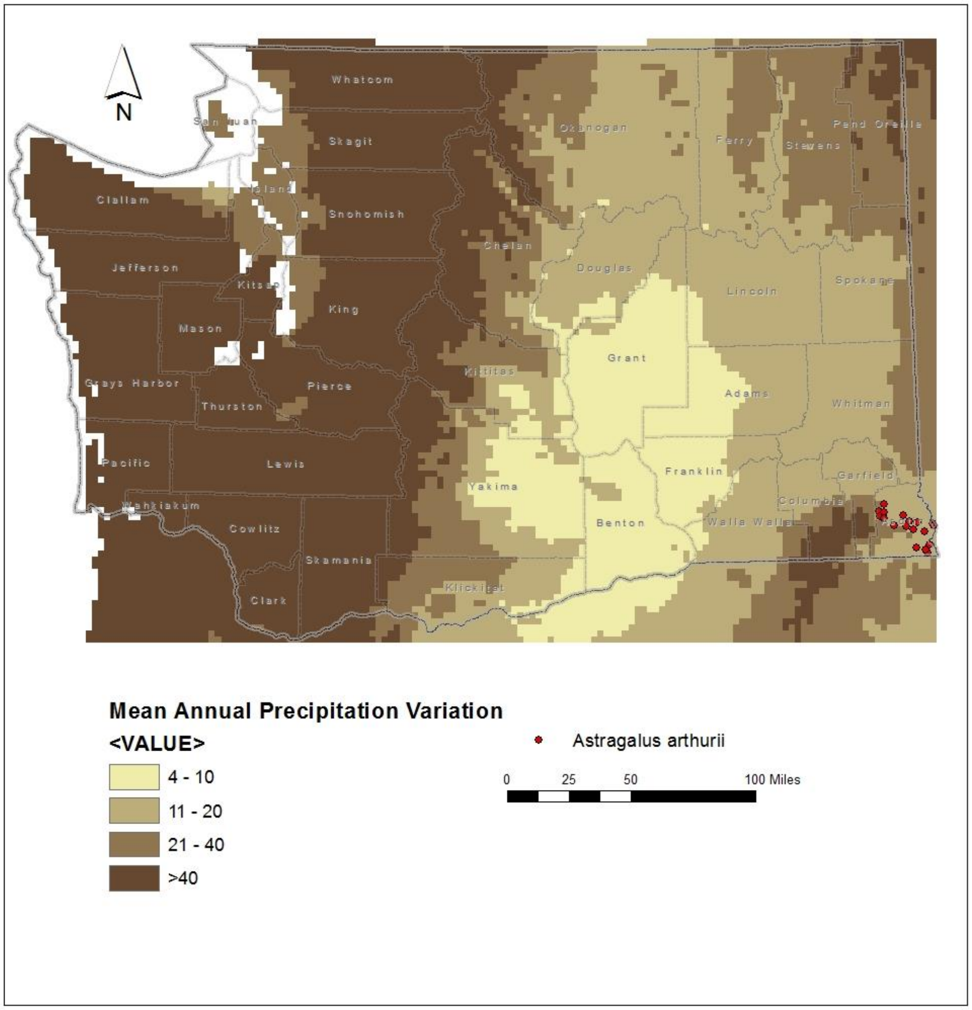

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Astragalus arthurii* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
This species is dependent primarily on adequate precipitation for its moisture requirements, because its habitat is typically not associated with springs, streams, or a high water table. The Columbia Basin Foothills and Canyon Dry Grassland ecological system is vulnerable to changes in the timing or amount of precipitation, including extreme precipitation events that could accelerate erosion of steep slopes. Changes in precipitation, coupled with increases in temperature, could result in more frequent and severe drought and an increase in fire frequency (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Somewhat Increase.
Astragalus arthurii is dependent on infrequent wildfire to reduce encroachment from less fire-adapted shrub species and to maintain open grassland habitat. Natural fire frequency is thought to be less than 20 years (Rocchio and Crawford 2015). Increased drought and reduced summer precipitation, however, might make wildfires too frequent and result in replacement of native perennial bunchgrass with annual introduced grasses (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Neutral.
Snowpack is relatively low over the range of *Astragalus arthurii* in the eastern foothills of the Blue Mountains in southeastern Washington and a small component of its annual water budget.

C3. Restricted to uncommon landscape/geological features: Neutral.
Astragalus arthurii is found on outcrops of the Saddle Mountain and Grande Ronde basalts, which are widespread in the Blue Mountains and elsewhere in eastern Washington (Washington Division of Geology and Earth Resources 2016).

C4a. Dependence on other species to generate required habitat: Neutral.
Browsing by ungulates, rodents, and insects that would impede shrub cover would help maintain the rocky grasslands occupied by *Astragalus arthurii,* although drought and infrequent fire probably are more significant.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Unknown.
The specific pollinators of *Astragalus arthurii* are not known, but other *Astragalus* species are usually pollinated by bees.

C4d. Dependence on other species for propagule dispersal: Neutral.
The fruits of *Astragalus arthurii* dehisce when dry to release seeds passively. These seeds lack wings, barbs, or hooks for dispersal by wind or animals.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. Most *Astragalus* species are unpalatable or toxic to herbivores due to the presence of indolizidine alkaloids, aliphatic nitro compounds, or selenium in their tissues (Rios and Waterman 1997). Although some populations of *A. arthurii* are found in areas grazed by cattle and horses (Camp and Gamon 2011), herbivory is probably not a significant threat (Fertig and Kleinknecht 2020).

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Astragalus arthurii occurs in grassland slopes that burn infrequently. Under projected future climate change, these areas will be more prone to drought and increased frequency of wildfires, which in turn could lead to increased competition with non-native annual weeds (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 genetic data are available for *Astragalus arthurii* in Washington. Head (1957) reported the chromosome number of *A. arthurii* to be $2n = 24$.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral.
Astragalus arthurii is presumed to be an outcrosser, rather than self-pollinated. Presumably, genetic variation is average, compared to other species, but no studies have been done for confirmation.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on herbarium records from the Consortium of Pacific Northwest herbaria website, no significant changes in the phenology of *Astragalus arthurii* populations in Washington have been detected over the past 90 years.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
Four of the 19 occurrences of *Astragalus arthurii* in Washington are historical and have not been relocated since 1981 (Fertig and Kleinknecht 2020). These populations are mostly on private lands that could be impacted by development, conversion to agriculture, or herbicides (Camp and Gamon 2011). No occurrences are known to be directly lost due to impacts from recent 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

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