Climate Change Vulnerability Index Report

Astragalus arrectus (Palouse milkvetch)

Date: 2 September 2021

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington | Heritage Rank: G2G4/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	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	46.7
	-0.051 to - 0.073	53.3
	-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	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: All 15 confirmed occurrences of *Astragalus arrectus* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4° F (Figure 1). Erroneous or

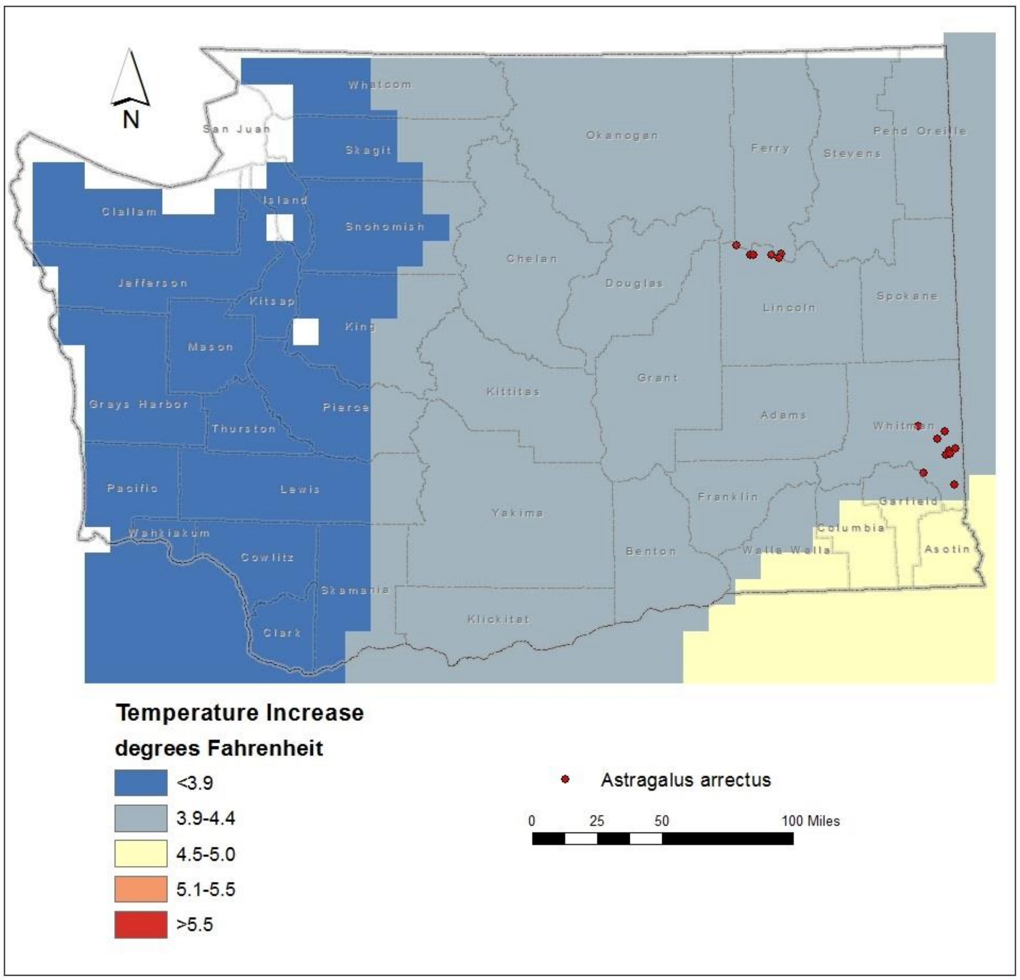

Figure 1. Exposure of *Astragalus arrectus* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

unconfirmed records from Chelan, Kittitas, and Klickitat counties (Fertig and Kleinknecht 2020) were not used in this analysis.

A2. Hamon AET:PET Moisture Metric: Eight of the 15 verified occurrences of *Astragalus arrectus* (53.3%) 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). The other 7 occurrences are from areas with a projected decrease from -0.074 to -0.096.

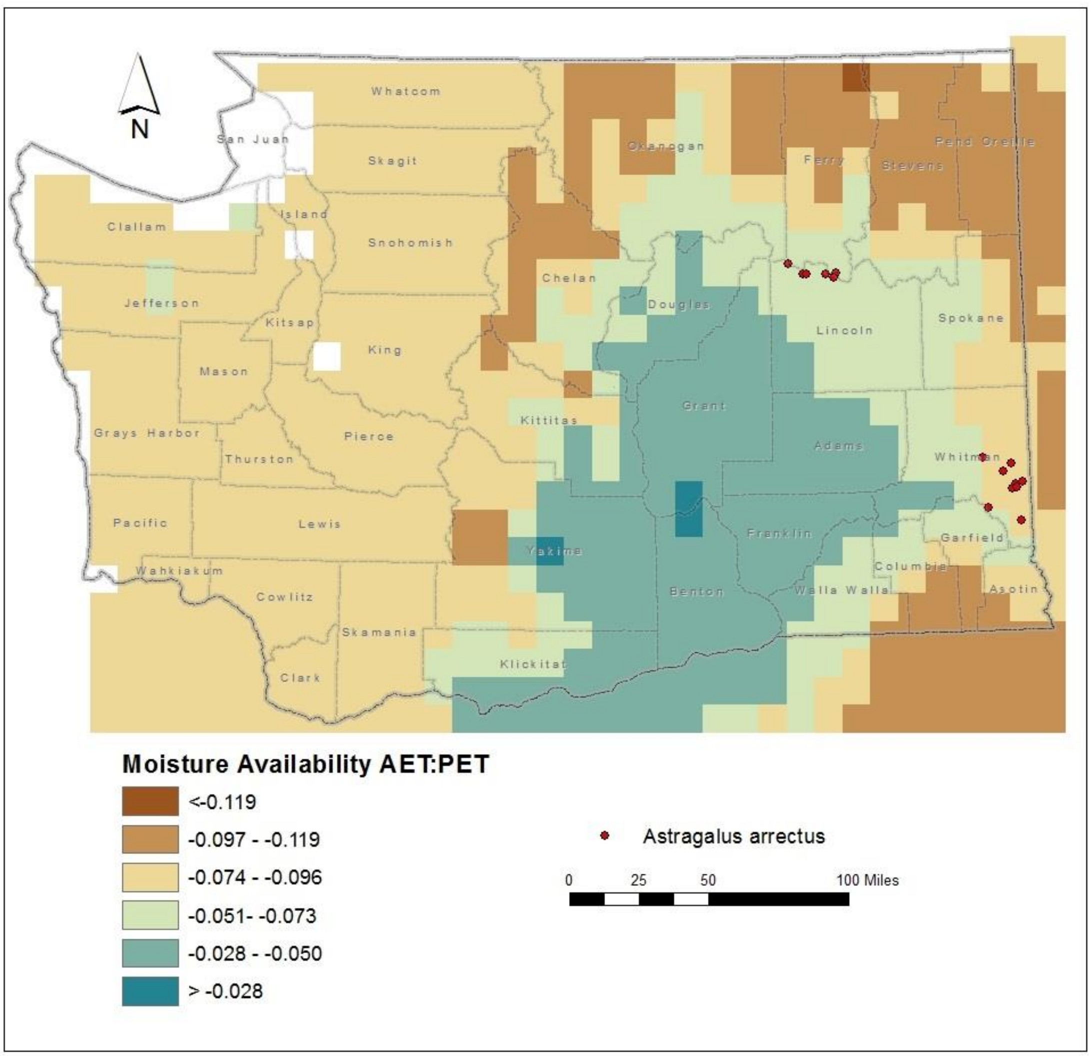

Figure 2. Exposure of *Astragalus arrectus* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
The Washington occurrences of *Astragalus arrectus* are found at 1000-2900 feet (300-880 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Astragalus arrectus* is found on grassy hillsides, sagebrush flats, river bluffs, and grassy or shrub-dominated openings in *Pinus ponderosa* and *Pseudotsuga menziesii* woods (Camp and Gamon 2011, Washington Natural Heritage Program 2021). This habitat is a component of the Columbia Basin Foothill and Canyon Dry Grassland, Columbia Basin Palouse Prairie, and Northern Rocky Mountain Ponderosa Pine Woodland and Savanna ecological systems (Rocchio and Crawford 2015). Verified populations in Washington occur in two disjunct areas along the Columbia River in northern Lincoln County and the Palouse region of southeastern Whitman County. These main population centers are separated by 84 miles (135 km). Within these areas, individual occurrences are within 1.2-9 miles (1.9-14 km) of each other. Natural barriers of unsuitable habitat are significant between the two population centers, but are less of an impediment to dispersal within the population centers.

B2b. Anthropogenic barriers: Somewhat Increase.
In Whitman County, the pre-settlement Palouse Prairie habitat of *Astragalus arrectus* has become highly fragmented in the past 150 years due to agricultural development, growth of cities and towns, and an extensive road network. These present 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 arrectus produces 15-33 flowers per inflorescence and each mature fruit can produce 18-26 seeds. The fruit pods are leathery at maturity and split open to release the seeds passively (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 distances are probably relatively short (no more than 100 m).

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Astragalus arrectus* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All 15 accepted 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 vulnerability to climate change (Young et al. 2016).

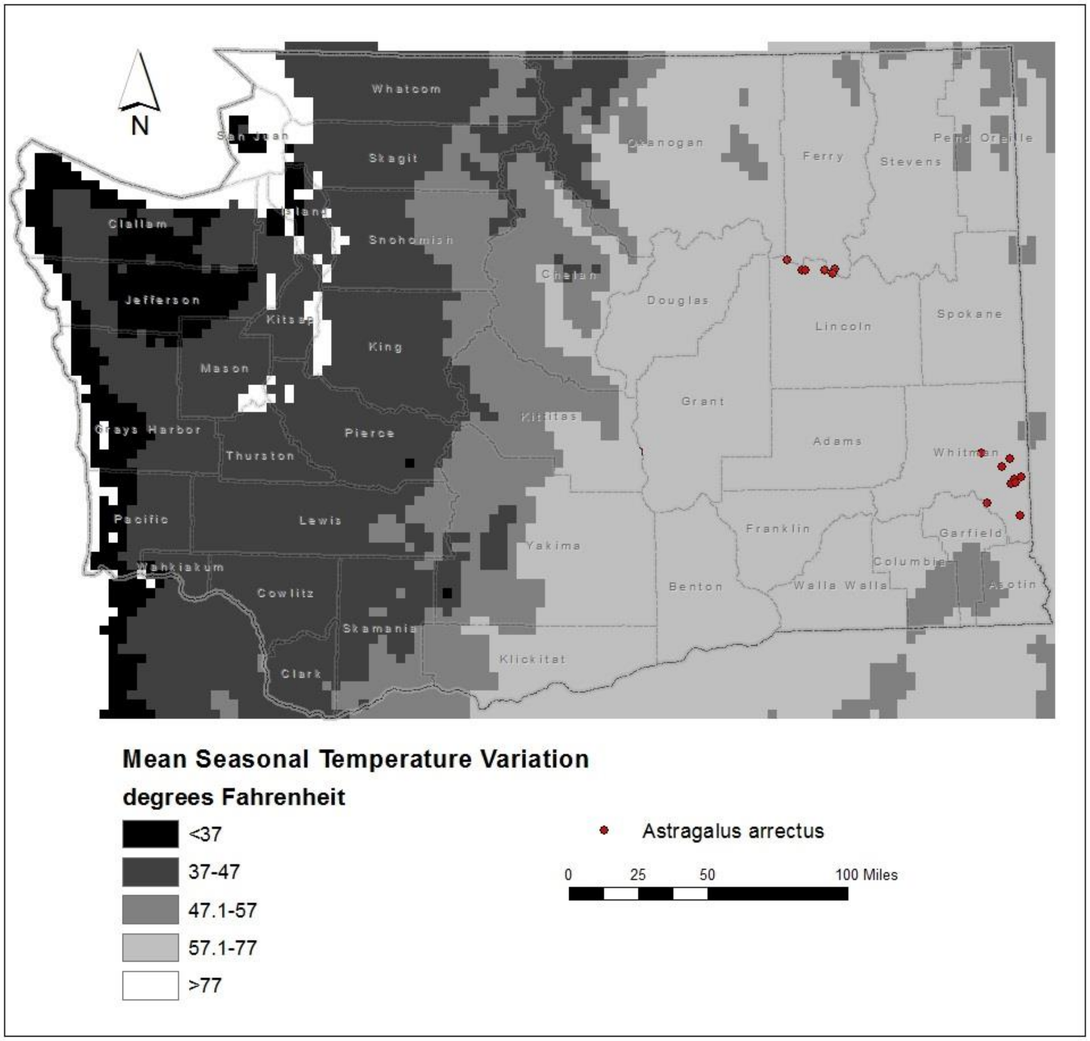

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Astragalus arrectus* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Neutral.
The grassland and open Ponderosa pine woodland habitats of *Astragalus arrectus* are not associated with cold air drainage during the growing season and would have neutral vulnerability to climate change.

C2bi. Historical hydrological niche: Somewhat Increase.
Eight of the 15 occurrences of *Astragalus arrectus* in Washington (53.3%) 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 to climate change. The other 7 occurrences (46.7%) are from areas with average precipitation variation (>20 inches/508 mm) over the same time period and are at neutral vulnerability.

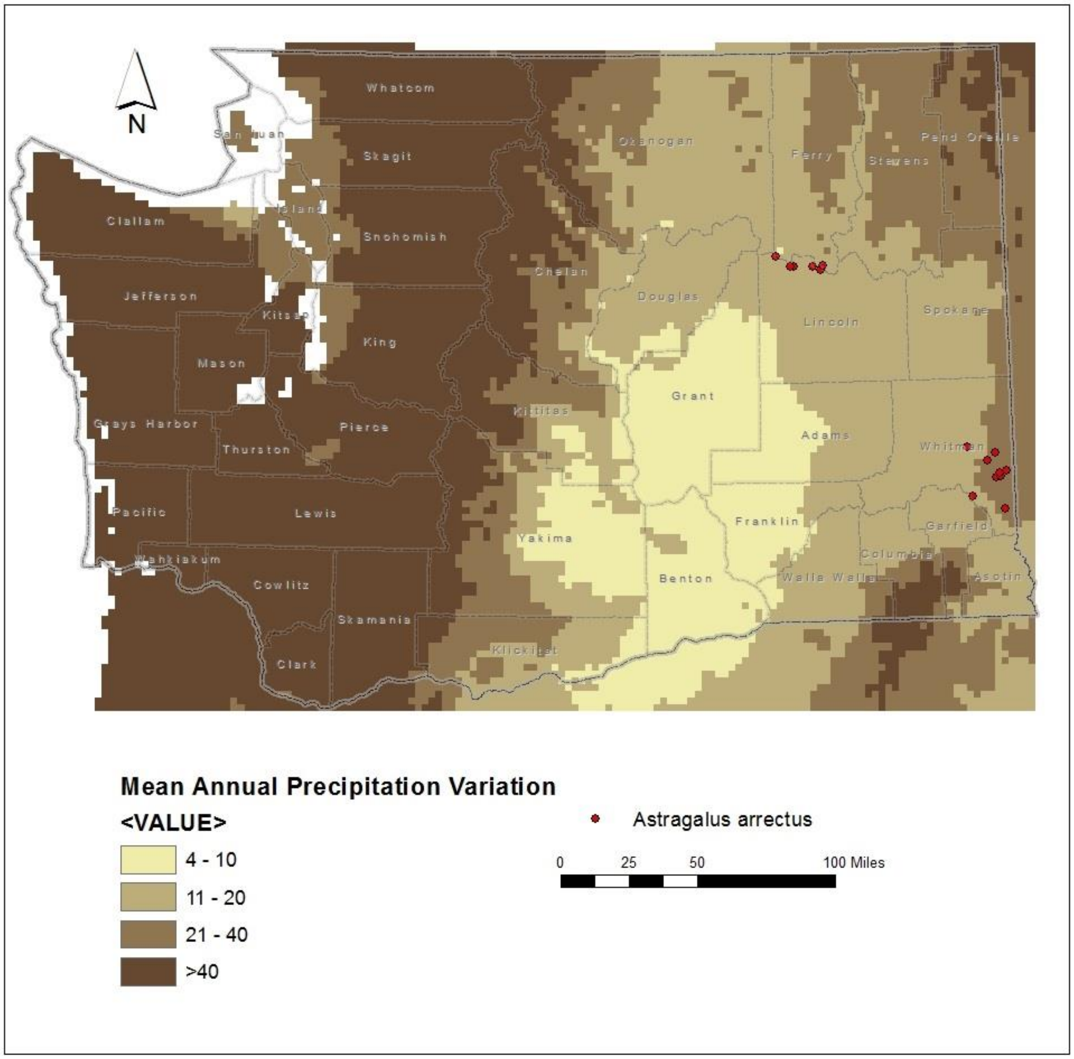

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Astragalus arrectus* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
This species is dependent 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 and Columbia Basin Palouse Prairie ecological systems are vulnerable to higher temperatures resulting in summer drought and changes in the timing or amount of precipitation (including extreme precipitation events that would accelerate erosion of steep slopes). Increased frequency and severity of fire could alter the composition of native grassland communities towards dominance by weedy annuals (Rocchio and Ramm-Granberg 2017). Northern Rocky Mountain Ponderosa Pine Woodland and Savanna sites are also vulnerable to the effects of drought on increased fire frequency or insect outbreaks that could result in a shift towards steppe vegetation (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Somewhat Increase.
Astragalus arrectus may be dependent on infrequent low-intensity wildfire to reduce encroachment from shrub species and to maintain open grassland habitat. Increased drought and reduced summer precipitation, however, could make wildfires too frequent and result in replacement of native perennial bunchgrasses with annual introduced grasses (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Neutral.
Snowpack is low over the range of *Astragalus arrectus* in the Palouse grasslands of Whitman County and along the Columbia River in Lincoln County and is a small component of the plant's annual water budget.

C3. Restricted to uncommon landscape/geological features: Neutral.
In Whitman County, *Astragalus arrectus* is primarily associated with Quaternary loess deposits, which are widespread in southeastern Washington. Occurrences in Lincoln County are found mostly on glaciolacustrine and outburst flood deposits or Grande Ronde Basalt along the Columbia River and tributary canyons (Washington Division of Geology and Earth Resources 2016). These substrates and geological features are also relatively widespread in the state.

C4a. Dependence on other species to generate required habitat: Neutral
Browsing by ungulates, rodents, and insects that impedes the spread of shrubs would help maintain the open grasslands and understory of Ponderosa pine woodlands occupied by *Astragalus arrectus,* 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 arrectus* are not known, but other *Astragalus* species are pollinated by bumblebees (*Bombus*) or other bees. A recent survey of bees of the Palouse region found higher than expected bee richness, but did not focus on pollinators of specific plant taxa (Rhoades et al. 2017).

C4d. Dependence on other species for propagule dispersal: Neutral.
The pods of *Astragalus arrectus* dehisce when dry to release seeds passively. These seeds lack wings, barbs, or hooks for dispersal by wind or animals. Dispersal distances are probably relatively short.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. Herbivory by livestock has been identified as a potential threat (Camp and Gamon 2011), although most *Astragalus* species are toxic and only utilized when other forage is not available.

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Astragalus arrectus occurs in patches of remnant grasslands and open Ponderosa pine woodlands. Adjacent areas have mostly been converted to crop agriculture. Disturbance from farming and wildfire make these areas susceptible to invasion by introduced weed species (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 arrectus* in Washington. Other species in subsection *Arrecti* have base chromosome counts of n = 11 or 12 (Spellenberg 1976). The populations along the Columbia River in Lincoln County are somewhat disjunct from the core range of the species in southeastern Washington and adjacent Idaho and might be expected to have lower genetic diversity due to founder effects or reproductive isolation.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral
Astragalus arrectus is assumed to be an outcrosser, rather than self-pollinated. Presumably, genetic variation is average rangewide, compared to other species, but no studies have been done for confirmation. Isolated occurrences, like those in Lincoln County, WA, may have lower genetic diversity.

C6. Phenological response to changing seasonal and precipitation dynamics: Somewhat Increase.
Based on herbarium records from the Consortium of Pacific Northwest herbaria website, the flowering period for *Astragalus arrectus* in Washington has shifted to earlier spring (mid April through early June) in the past 50 years, compared to early July in the late 1800s.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
Several occurrences from southeastern Washington are historical and potentially extirpated due to habitat conversion to agriculture or urbanization (Fertig and Kleinknecht 2020). Whether the range has contracted due to climate change is not known.

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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