Climate Change Vulnerability Index Report

Salix glauca var. *villosa* (Glaucous willow)

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Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G5T5?/S1S2

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	100
	-0.074 to - 0.096	0
	-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		Neutral
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		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		Neutral
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	
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 *Salix glauca* var. *villosa* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

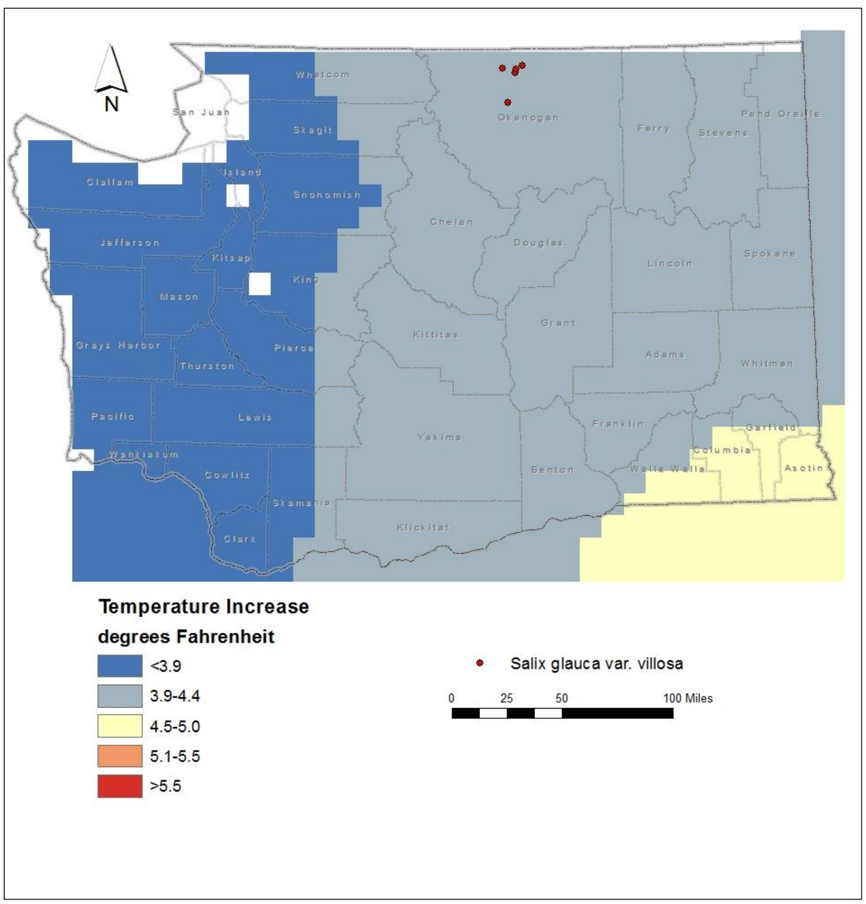

Figure 1. Exposure of *Salix glauca* var. *villosa* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: All five of the occurrences of *Salix glauca* var. *villosa* (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 -0.097 to -0.119 (Figure 2).

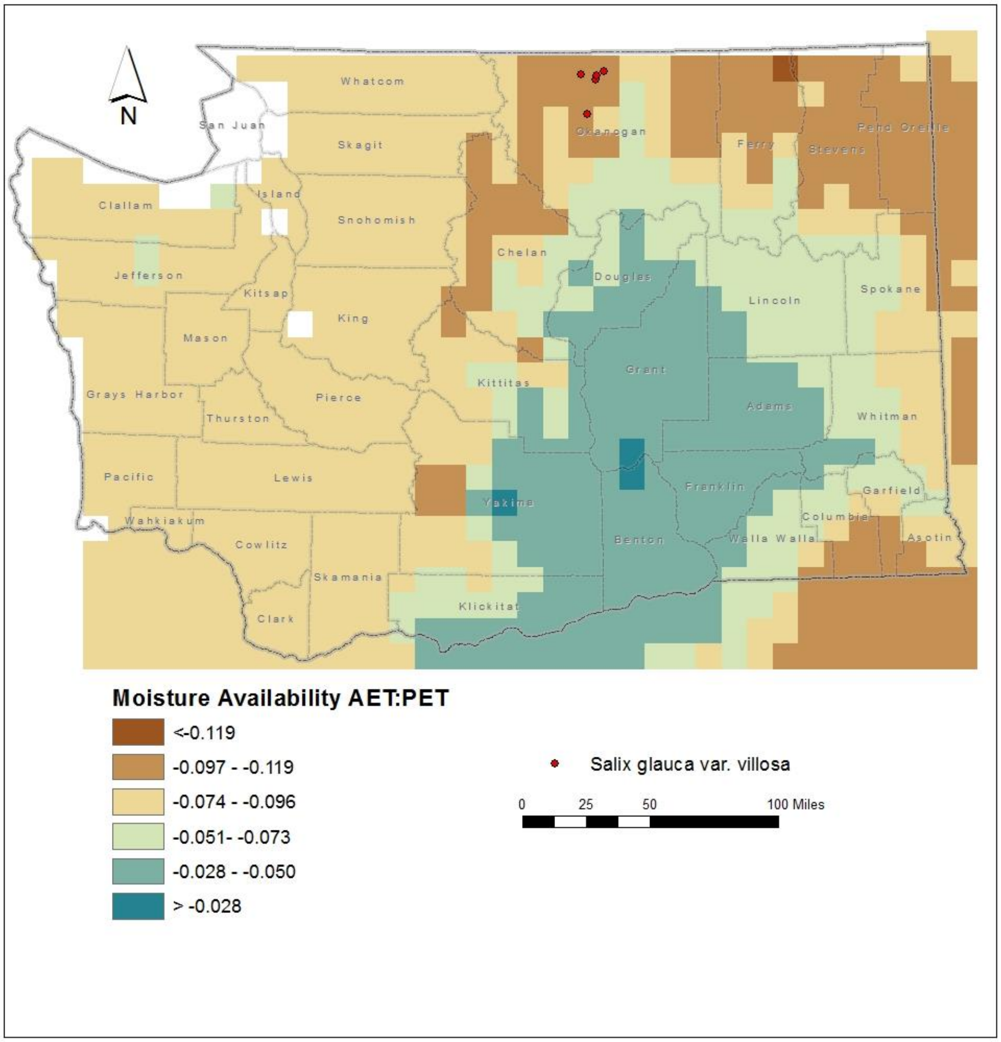

Figure 2. Exposure of *Salix glauca* var. *villosa* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Salix glauca* var. *villosa* are found at 4400-5900 feet (1340-1800 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Salix glauca* var. *villosa* occurs in a variety of habitats, including montane streamsides, shrubby wetlands, and granitic cirques near timberline (Camp and Gamon 2011, WNHP records). Lower elevation riparian sites occupied by this species correspond with the Rocky Mountain Subalpine-Montane Riparian Shrubland ecological system, while populations from rocky sites at timberline fit the Rocky Mountain Alpine Dwarf-Shrubland, Fell-Field, and Turf ecological system (Rocchio and Crawford 2015). Individual populations can occur along streams for over 5 km or be separated from other occurrences by up to 14 miles (22.3 km). Populations are found mostly in valleys and isolated from each other by low mountain ridges. These barriers may not be sufficient to completely restrict dispersal.

B2b. Anthropogenic barriers: Neutral.
The range of *Salix glauca* var. *villosa* is naturally somewhat fragmented. Human impacts on the landscape of northeastern Washington have little effect on this condition.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Neutral.
Salix glauca var. *villosa* produces numerous, many-seeded dry capsules. Seeds are small and have a tuft of wavy hairs to assist in dispersal by wind. Although average dispersal distance may be short, some seeds are capable of moving over 1 km, and so the species is not dispersal limited.

C2ai. Historical thermal niche: Somewhat Increase.
Figure 3 depicts the distribution of *Salix glauca* var. *villosa* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Four of the five known occurrences (80%) 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 risk from climate change. One other occurrence (20%) is from an area with average (57.1-77˚F/31.8-43.0˚C) temperature variation during the same period and is considered at neutral risk to climate change.

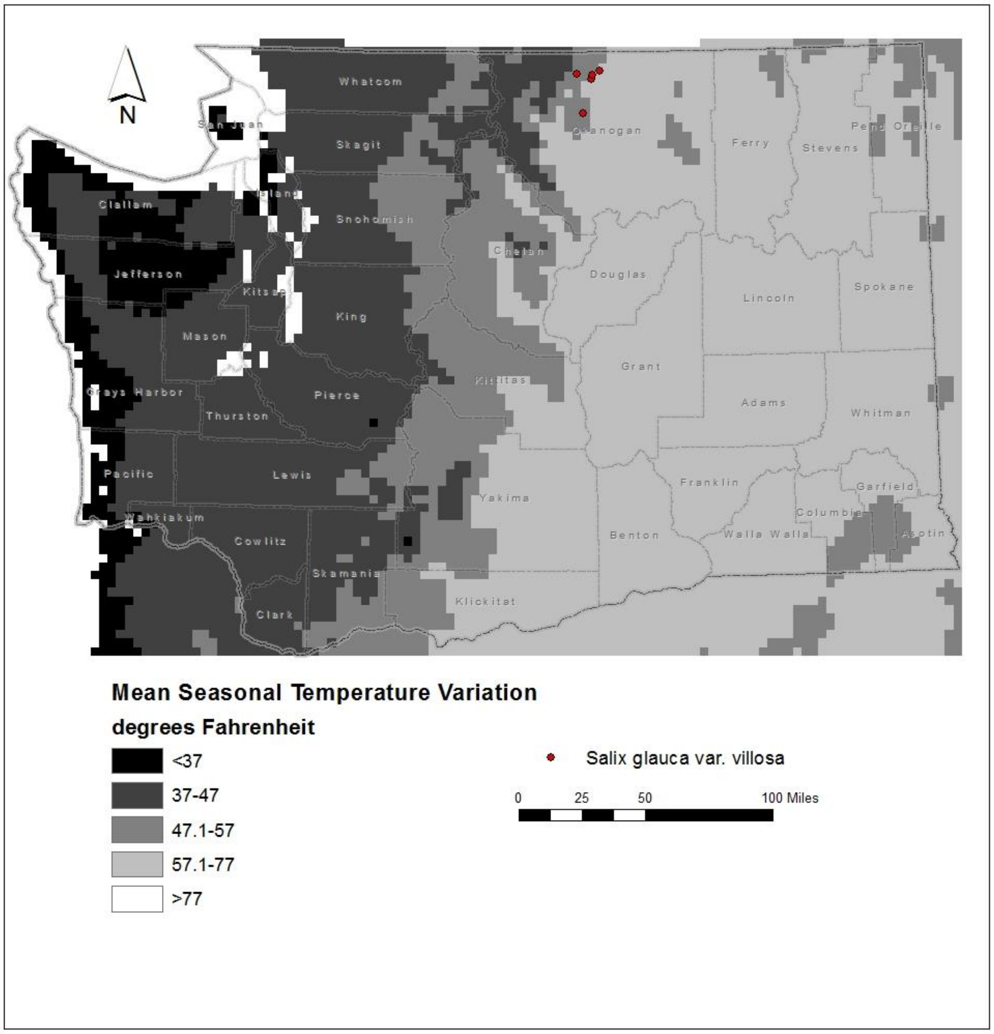

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Salix glauca* var. *villosa* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Increase.
The montane riparian shrub and timberline cirque habitat of *Salix glauca* var. *villosa* in Washington is associated with cold air drainage during the growing season and would have increased vulnerability to temperature changes associated with global warming.

C2bi. Historical hydrological niche: Neutral.
All five of the populations of *Salix glauca* var. *villosa* in Washington (100%) are found in areas that have experienced 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.

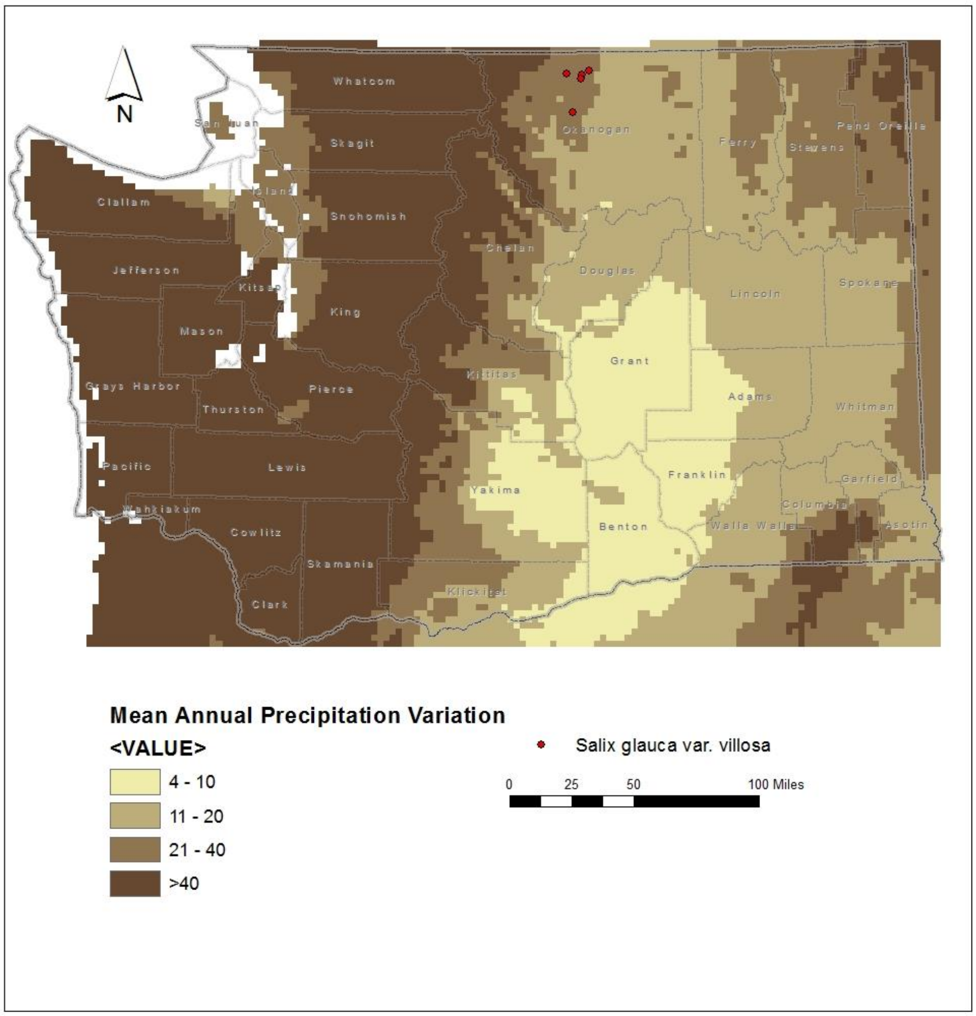

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Salix glauca* var. *villosa* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
The montane streamside habitat of *Salix glauca* var. *villosa* in Washington is largely dependent on springtime flooding due to snowmelt to maintain moisture conditions (Rocchio and Ramm-Granberg 2017). Timberline cirque habitats would be more influenced by the amount and duration of snowpack, rather than rainfall. Increased temperatures, greater likelihood of

drought, and changes in amount and timing of precipitation could alter vegetation patterns in both ecological systems and favor conversion to habitats better adapted to water stress (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.
Salix glauca var. *villosa* is not dependent on periodic disturbances to maintain its montane riparian and timberline granitic cirque habitat. The species could, however, be detrimentally affected by increased summer temperatures, drought, or decreased snowpack that might favor conversion of this habitat to forest or wet meadows, or increase fire frequency (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Increase.
The populations of *Salix glauca* var. *villosa* in Washington are found in the Okanogan Mountains of northern Washington in areas with high snowfall. The wetlands and cirque habitats occupied by this species are dependent on late-lying snowbanks for recharging groundwater or spring flooding (Rocchio and Ramm-Granberg 2017). Changes in the amount of snow or when the snow melts could lead to shifts in the dominance of herbaceous species or invasion of trees or shrubs.

C3. Restricted to uncommon landscape/geological features: Neutral
Salix glauca var. *villosa* is found mostly on gneiss-derived soils and outcrops of the Cathedral Batholith, Tiffany Mountain gneiss, and Tillman Mountain gneiss, all of which are widespread in the Okanogan region of north-central Washington.

C4a. Dependence on other species to generate required habitat: Neutral.
The wetland and cirque habitat occupied by *Salix glauca* var. *villosa* is maintained primarily by natural abiotic processes.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
Salix inflorescences lack showy petals or sepals and are capable of wind pollination. Flowers also produce nectar and floral scents to attract small insect pollinators, especially flies, bees, and butterflies.

C4d. Dependence on other species for propagule dispersal: Neutral.
Willow seeds have a tuft of wavy, silky hairs and are dispersed passively by wind.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Although willows are susceptible to rust fungi, no impacts to *Salix glauca* var. *villosa* are known. This species may be vulnerable to herbivory by beavers and livestock (Camp and Gamon 2011).

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Salix glauca var. *villosa* could be sensitive to competition from other plant species if its wetland habitat becomes drier due to drought or reduced snowpack and water recharge under future climate change (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
Salix glauca var. *villosa* is dioecious (with separate staminate and pistillate individuals) and is thus an obligate outcrosser. Pollination can occur by insects or long-distance dispersal by wind. Seed dispersal occurs by wind. The life history of this species suggests that it should have average genetic diversity across populations. The occurrences in Washington are near the edge of the species range and could have slightly lower genetic diversity due to founder effects or inbreeding depression.

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 recent changes in the distribution of this species in Washington have been detected.

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.

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.

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.