Climate Change Vulnerability Index Report

Salix maccalliana (MacCalla's willow)

Date: 16 November 2021

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G5/S1

Index Result: Highly 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	66.7
	-0.074 to -0.096	0
	-0.051 to -0.073	33.3
	-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		Neutral
3. Impacts from climate change mitigation		Neutral
Section C: Sensitivity and Adaptive Capacity		
1. Dispersal and movements		Neutral
2ai Change in historical thermal niche		Neutral
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		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		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: All 3 of the known occurrences of *Salix maccalliana* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

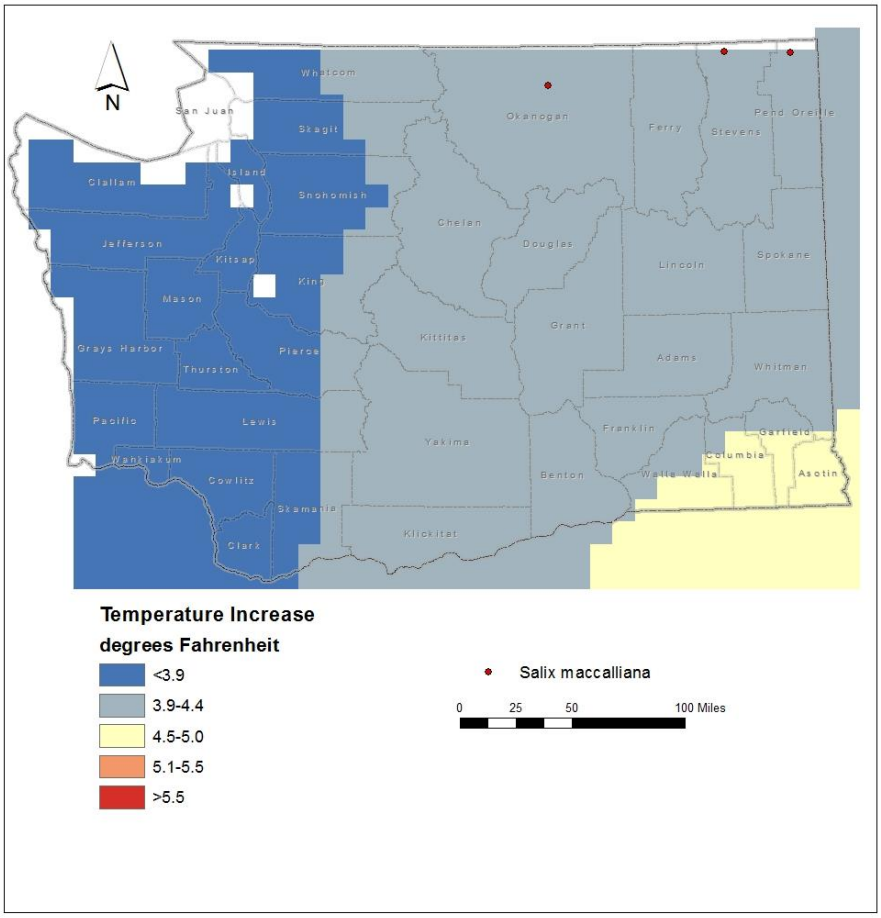

Figure 1. Exposure of *Salix maccalliana* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Two of the three occurrences (66.7%) of *Salix maccalliana* 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). One other population (33.3%) is from an area with a projected decrease of -0.051 to -0.073.

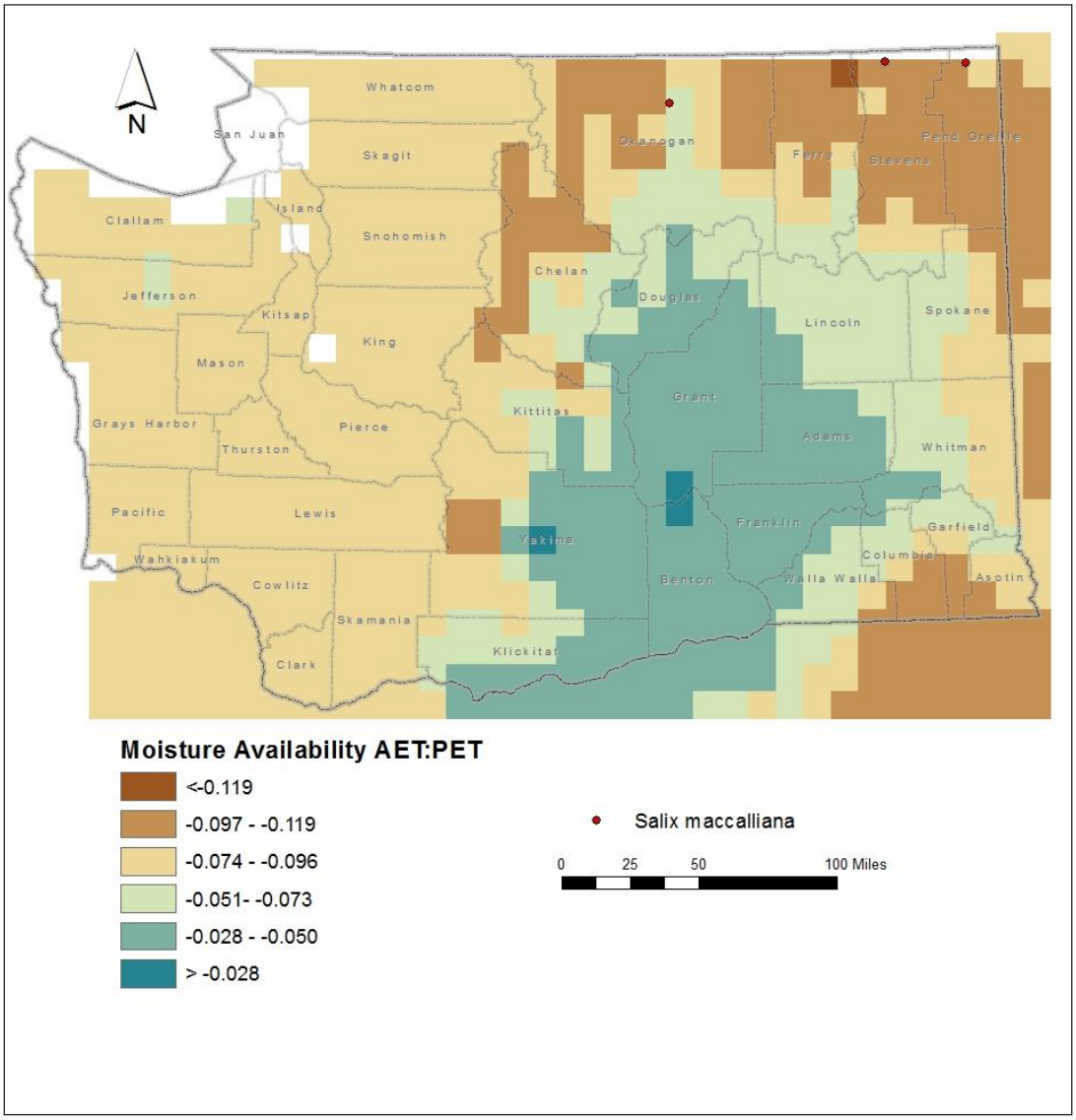

Figure 2. Exposure of *Salix maccalliana* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Salix maccalliana* are found at 1500-3000 feet (460-915 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
Salix maccalliana occurs on peaty soils of raised hummocks in fens, swamps, and marshes. At least one population is from a former cedar swamp converted to an open fen by fire (Camp and Gamon 2011; Washington Natural Heritage Program 2021). This habitat is part of the Rocky Mountain Subalpine-Montane Fen ecological system (Rocchio and Crawford 2015). Populations are separated from each other by 29-79 miles (46-127 km) of unoccupied and mostly unsuitable habitat that creates a barrier to dispersal.

B2b. Anthropogenic barriers: Neutral.
The fen habitat of *Salix maccalliana* in Washington is naturally uncommon and widely scattered within a matrix of natural and human-influenced lands. Anthropogenic activities, however, are less significant than natural impediments to dispersal.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Neutral.
Salix maccalliana produces numerous, many-seeded dry capsule fruits. Individual seeds are small and have a tuft of hairs to facilitate wind dispersal. While typical dispersal distances are probably short, some seeds are capable of moving over 1 km. Willow seeds are also able to disperse by water and can remain floating for several days (Argus 2010). Dispersal may be limited by the availability of suitable habitat for germination and survival of seedlings.

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Salix maccalliana* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All three 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. 2016).

C2aii. Physiological thermal niche: Increase.
The fen habitat of *Salix maccalliana* in Washington is associated with pockets of cold air drainage in mountain foothills and would be adversely impacted by increasing temperatures from climate change.

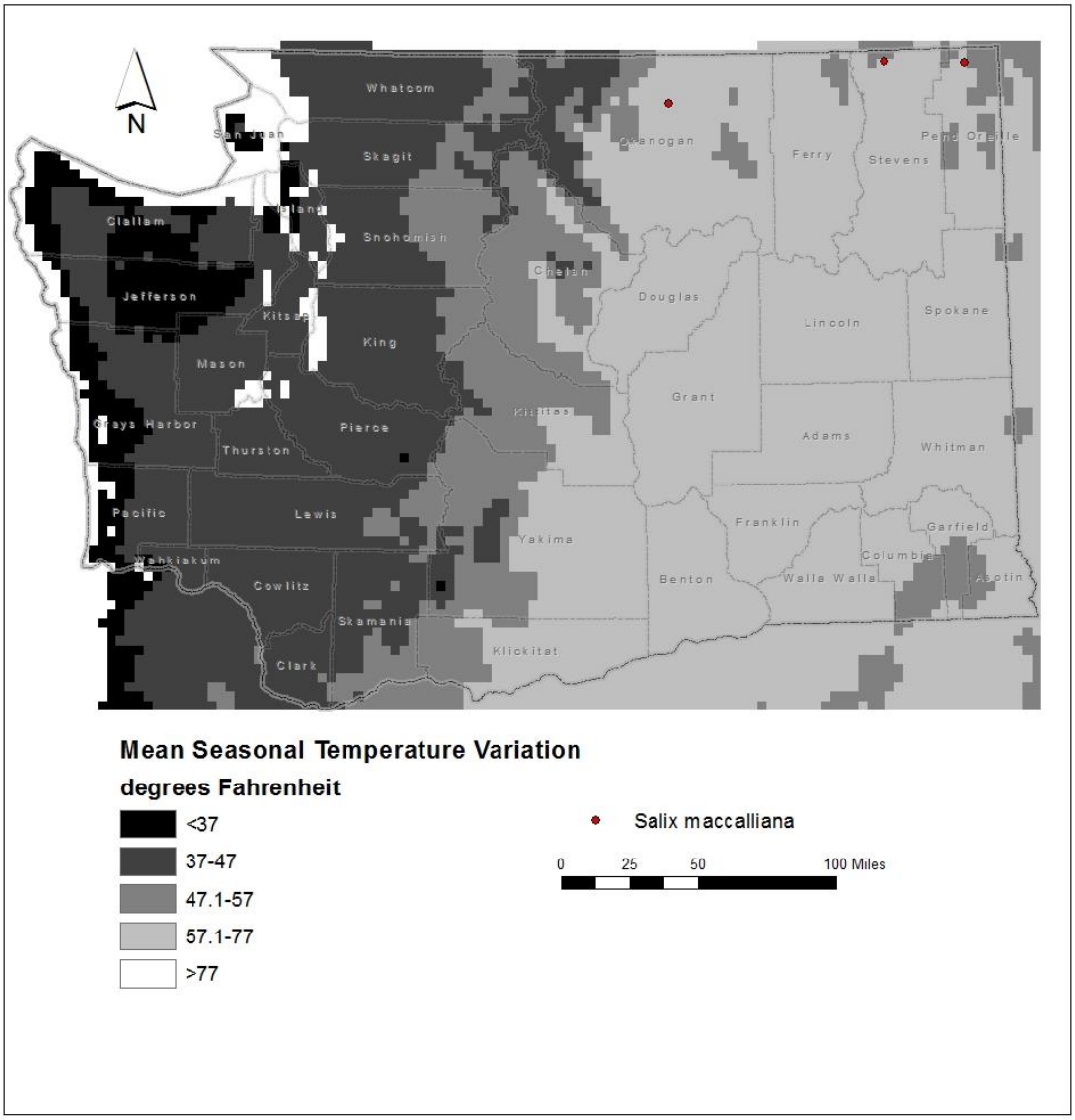

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Salix maccalliana* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.

Two of the three populations of *Salix maccalliana* in northeastern Washington (66.7%) are found in areas that have experienced average precipitation variation in the past 50 years (21-40 inches/508-1016 mm) (Figure 4). According to Young et al. (2016), these occurrences are neutral for climate change. The Okanogan County occurrence (33.3%) is from an area with slightly lower than average (11-20 inches/255-508 mm) precipitation variation over the same period and is at slightly increased risk from climate change.

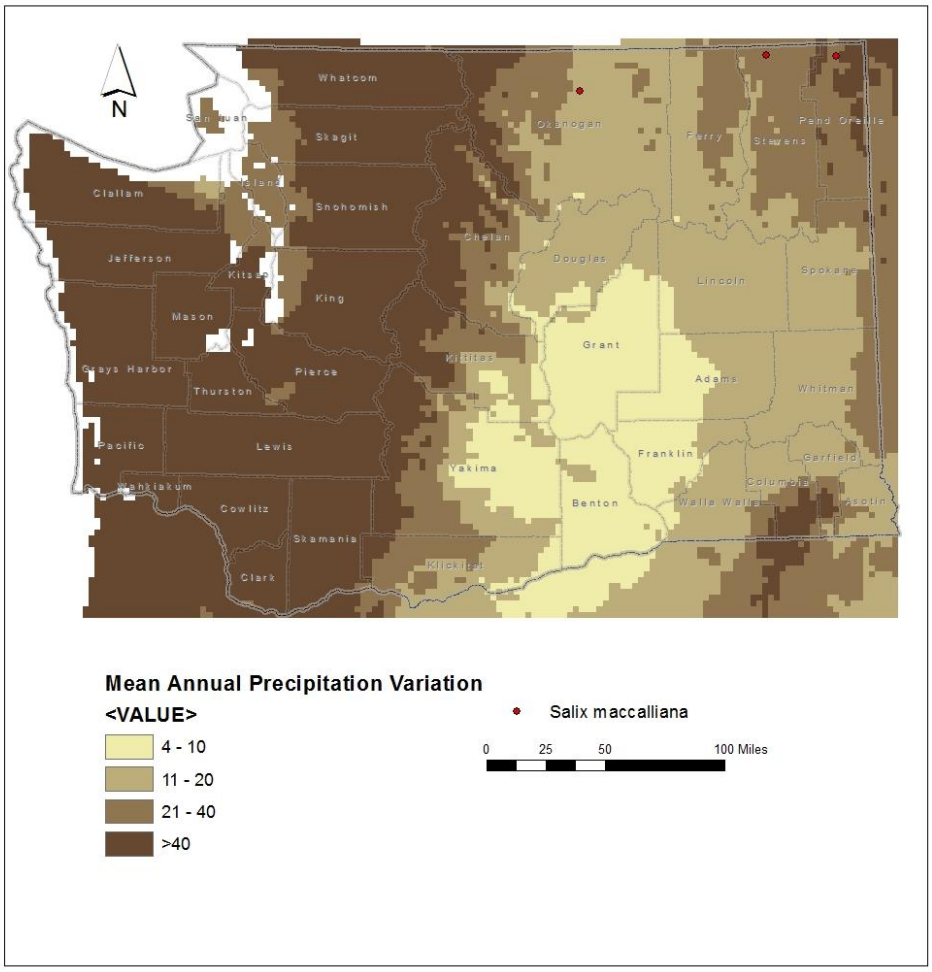

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Salix maccalliana* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
The fen habitats occupied by *Salix maccalliana* are dependent on groundwater, and thus more reliant on adequate moisture from melting snow than summer rainfall (Rocchio and Ramm-Granberg 2017). Reduction in the timing and amount of precipitation and increased temperatures and drought would make these fen sites more vulnerable to climate change (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.
Salix maccalliana is not dependent on periodic disturbances to maintain its montane peatland habitat. The species could be impacted by increased summer temperatures, drought, or reduced

snowpack that could favor conversion of fen habitats to swamp forest or wet meadows or lead to increased fire frequency (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Increase.
Salix maccalliana is found in mountainous areas of northern and northeastern Washington that receive high amounts of winter snowfall. Fen wetlands occupied by this species are dependent on groundwater recharged by melting snow (Rocchio and Ramm-Granberg 2017). Reduction in the amount of snow or timing of its melt could lead to shifts in the dominance of fen species or invasion of plants adapted to wet meadow or swamp forest environments.

C3. Restricted to uncommon landscape/geological features: Increase.
Salix maccalliana is found on Quaternary glacial drift derived from granodiorite (Loomis Pluton) or limestone (Metaline Formation) (Washington Division of Geology and Earth Resources 2016). The parent formations are of limited distribution in Washington. Landscape features associated with fens may also be sporadic, contributing to the overall rarity of the species in the state.

C4a. Dependence on other species to generate required habitat: Neutral
The fen habitat occupied by *Salix maccalliana* is maintained largely by natural abiotic conditions.

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 insect pollinators, such as flies, bees, and butterflies.

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

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Sensitivity from pathogens is not known. Willows can be important browse species for a number of native species, including ungulates, rodents, and insects. Heavy browsing is a threat to many rare willow species, but the effects on *Salix maccalliana* are poorly documented.

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Salix maccalliana could be impacted by competition from invading plant species if its fen habitat is converted to wet meadows or swamp forests due to future drought or reduced snowpack because of 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.
Genetic variability within Washington occurrences is poorly known. *Salix maccalliana* has the highest chromosome number of any species in the genus *Salix* with a $2n$ count of 190 or 228 (making it a decaploid or dodecaploid with $x = 19$) (Argus 2010). This species is probably of

hybrid origin, incorporating genomes from at least two subgenera, making it difficult to place phylogenetically (Argus 2010; Lauron-Moreau et al. 2015). Large genomes from hybridization are typically associated with high genetic diversity. Washington populations of *S. maccalliana*, are located at the southern edge of the species' overall range, and might be expected to have somewhat lower overall genetic diversity than populations at the core of its range.

C5b. Genetic bottlenecks: Unknown.
Not known.

C5c. Reproductive System: Neutral.
Salix maccalliana is an obligate outcrosser and is not limited by pollinators or dispersal, so is presumed to have average genetic variation.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on herbarium records in the Consortium of Pacific Northwest Herbaria website (pnwherbaria.org), *Salix maccalliana* has not changed its typical blooming time since the 1980s.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
No major changes have been detected in the distribution of *Salix maccalliana* in Washington since it was first documented in the state in the early 1980s.

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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