Climate Change Vulnerability Index Report

Salix candida (Hoary willow)

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Geographic Area: Washington Heritage Rank: G5/S1

Index Result: Highly 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		Neutral
2aii. Change in physiological thermal niche		Greatly 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		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		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 four of the known occurrences of *Salix candida* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

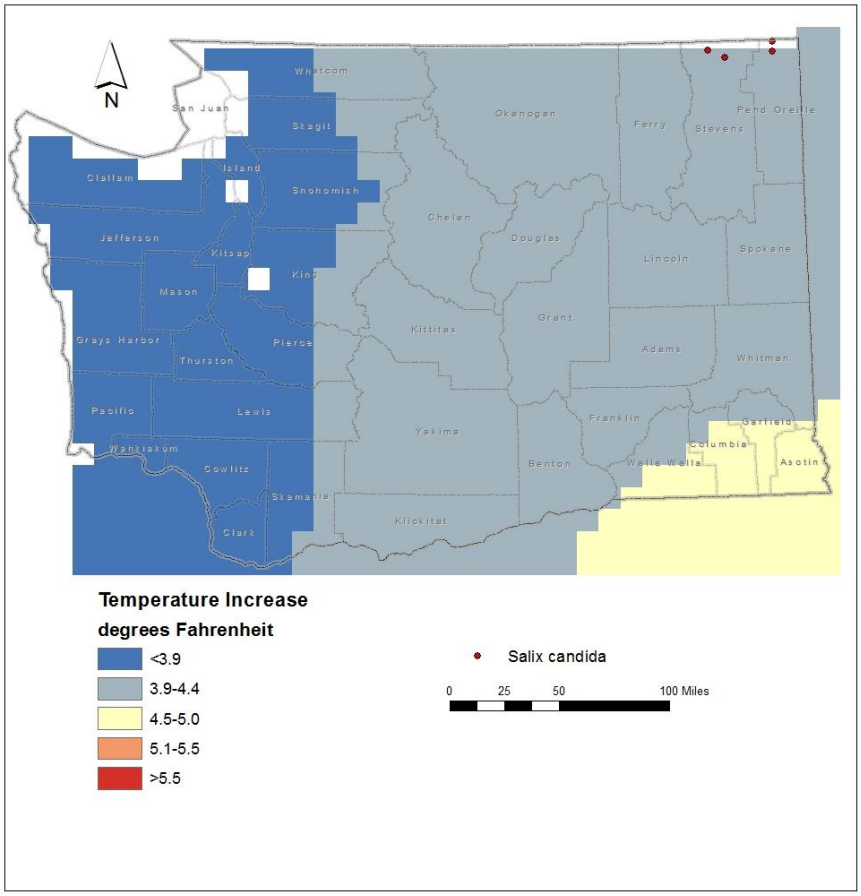

Figure 1. Exposure of *Salix candida* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: All four of the occurrences of *Salix candida* (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).

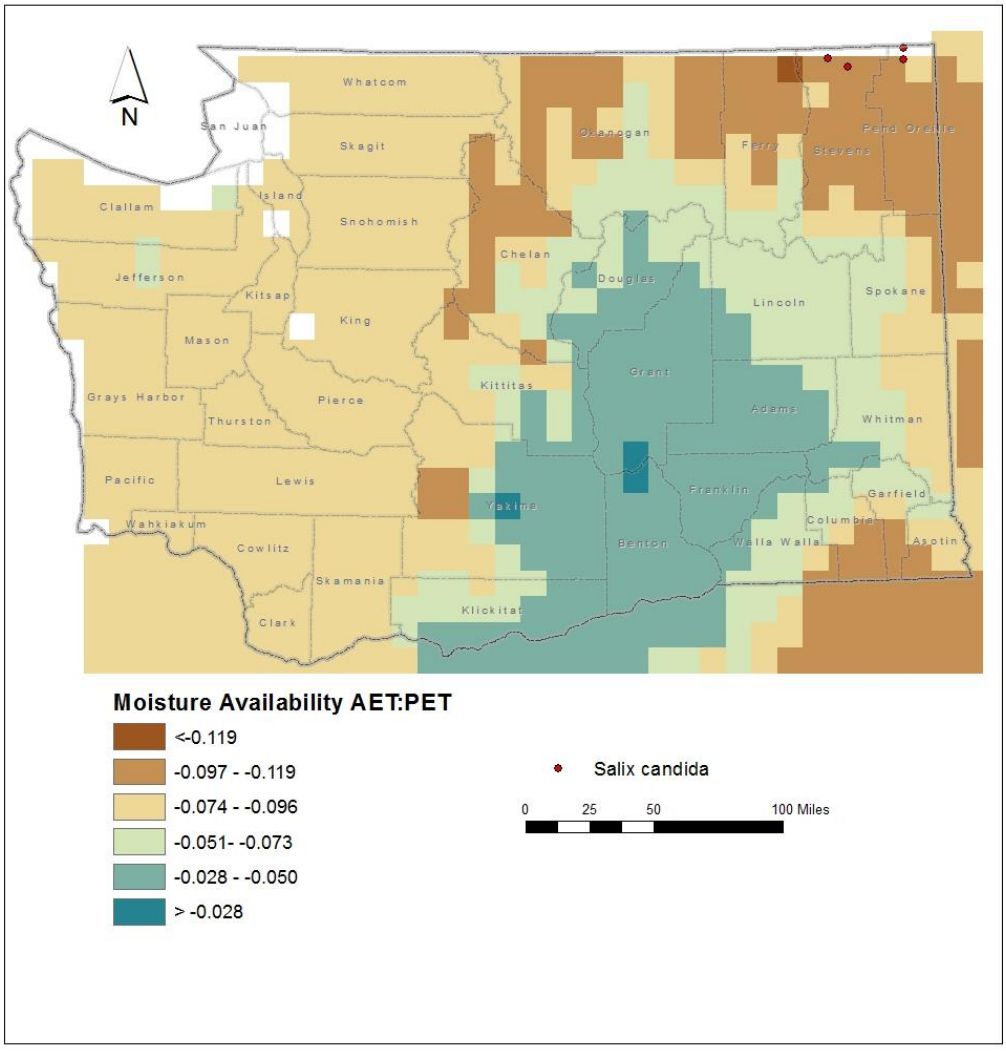

Figure 2. Exposure of *Salix candida* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Salix candida* are found at 2000-2950 feet (600-900 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Salix candida* is found in fens and willow carrs associated with peat and limestone soils on undulating or hummocky terrain, sometimes surrounding small ponds (Camp and Gamon 2011; WNHP records). Rangewide, it is usually found in nutrient-rich fens with high mineral content and alkaline pH (Decker 2006). In Washington, *S. candida* habitat is a component of the Rocky Mountain Subalpine-Montane Fen ecological system (Rocchio and Crawford 2015). Individual populations occupy sites as small as 0.5-3 acres and are separated by 6.5-35 km (4-22 miles). These specialized habitats are naturally isolated from each other with mostly unsuitable habitat in-between.

B2b. Anthropogenic barriers: Neutral.
The range of *Salix candida* is naturally 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 candida 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: Neutral.
Figure 3 depicts the distribution of *Salix candida* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All four of the known 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 to climate change.

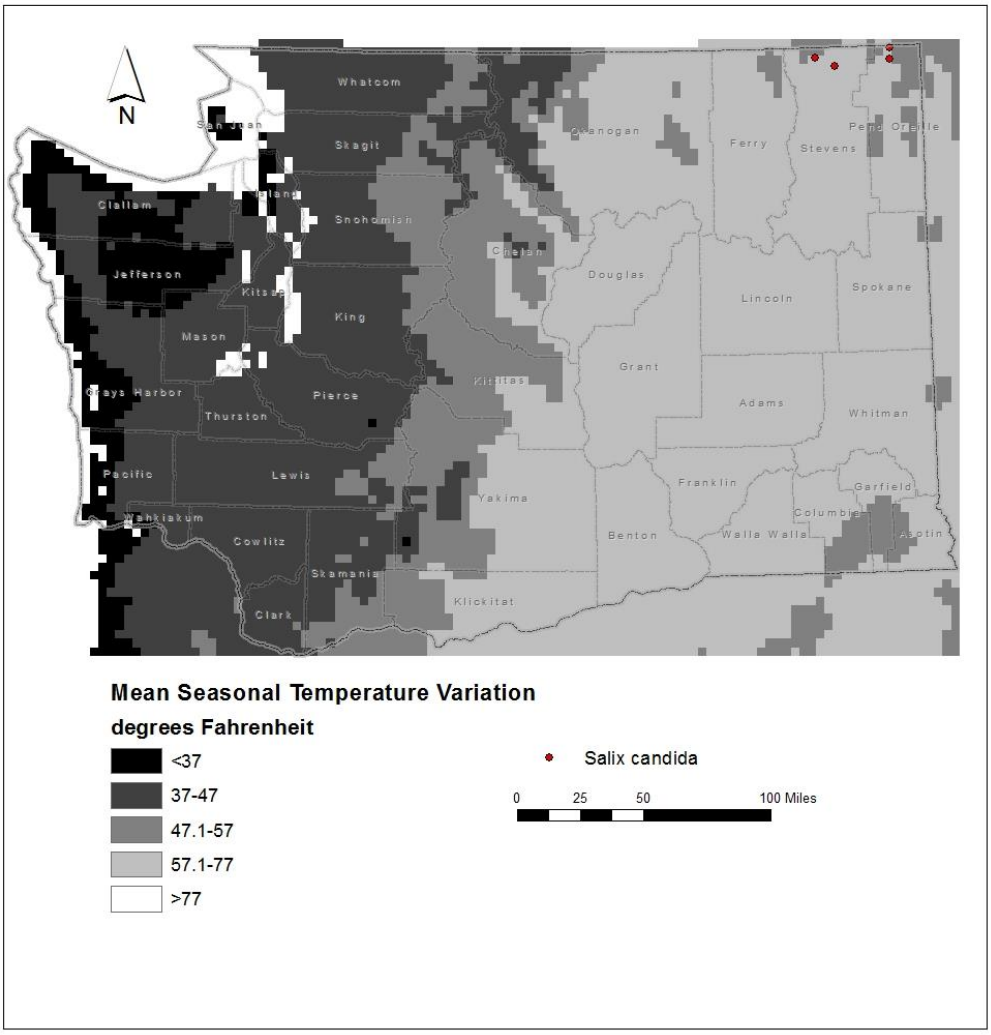

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Salix candida* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Greatly Increase.
The fen habitat of *Salix candida* is associated with cold air drainage during the growing season and would have greatly increased vulnerability to temperature changes associated with global warming.

C2bi. Historical hydrological niche: Neutral.
All four of the populations of *Salix candida* 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.

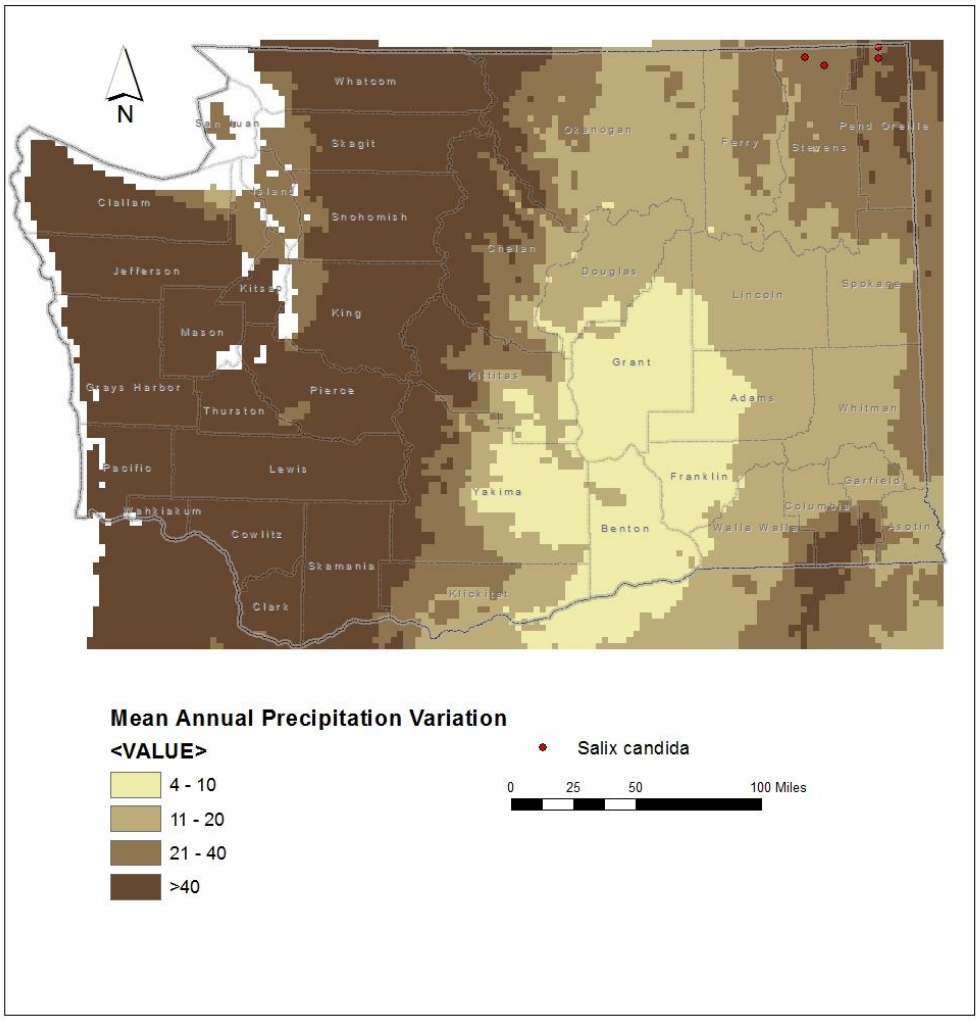

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Salix candida* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
The calcareous fen habitat of *Salix candida* in Washington is largely dependent on groundwater, although fens associated with ponds may also have some connection with surface water (Rocchio and Ramm-Granberg 2017). Groundwater-fed wetlands are more reliant on adequate snowpack (see C2d below), but reduction in the timing and amount of precipitation and

increased drought would make these sites more vulnerable to climate change (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.
Salix candida is not dependent on periodic disturbances to maintain its fen or wet meadow 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 meadows, or increase fire frequency (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Increase.
The populations of *Salix candida* in Washington are found in the mountains of northeast Washington in areas with high snowfall. The fen wetlands occupied by this species are dependent on late-lying snowbanks for recharging groundwater (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: Somewhat Increase.
Salix candida is found mostly on glacial drift deposits or spoils derived from the Metaline Formation, a limestone and dolomite formation found sporadically in northeastern Washington.

C4a. Dependence on other species to generate required habitat: Neutral.
The wetland habitat occupied by *Salix candida* 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 (Decker 2006).

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 candida* are known (Decker 2006). Hoary willow is reported as being heavily browsed in some wetlands (Decker 2006), and often is browsed before fruiting catkins can mature at sites in Wyoming (Fertig 1998). Once established, however, plants are long-lived and capable of re-sprouting following herbivory (Decker 2006).

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Salix candida could be sensitive to competition from other plant species if its specialized wetland habitat became drier due to drought or reduced snowpacks 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 candida 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.

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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.