Climate Change Vulnerability Index Report

Carex circinata (Coiled sedge)

Date: 17 March 2021

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G4/S1

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	0
	<3.9° F (2.2°C) warmer	100
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	0
	-0.074 to -0.096	100
	-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		Neutral
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		Greatly 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/Somewhat Increase
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		Neutral/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 four of the extant and historical occurrences of *Carex circinata* in Washington occur in areas with a projected temperature increase of < 3.9˚ F (Figure 1). One vague, historical report from Elmer ("Olympic Mountains, Clallam County") has not been included in this assessment.

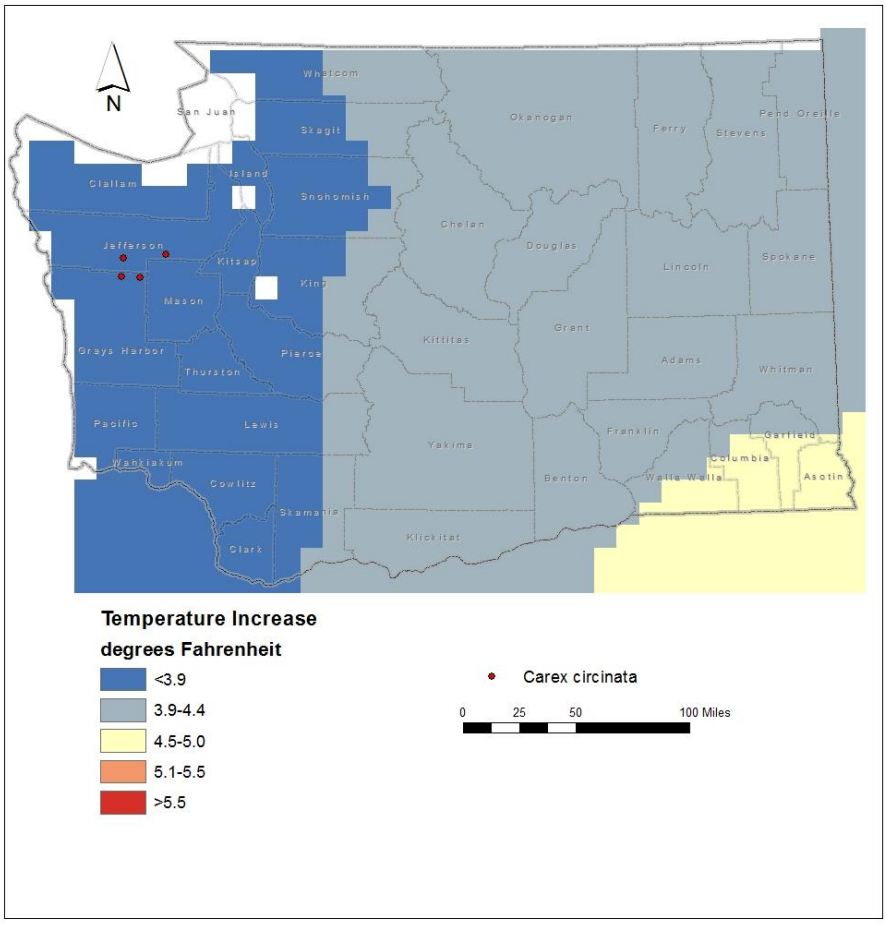

Figure 1. Exposure of *Carex circinata* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: All four of the occurrences (100%) of *Carex circinata* 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 -0.074 to -0.096 (Figure 2).

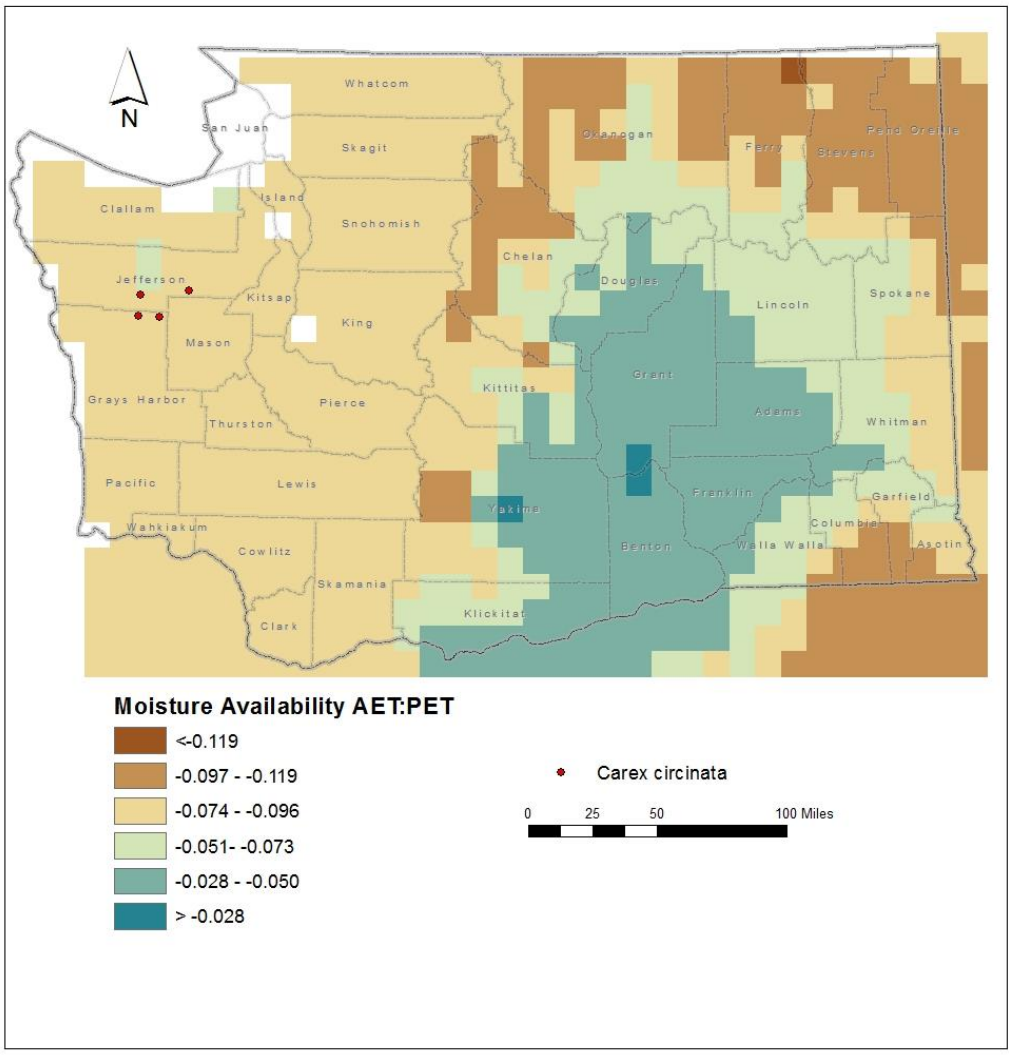

Figure 2. Exposure of *Carex circinata* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Carex circinata* are found at 3120-4700 feet (950-1430 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
Carex circinata occurs on barren, north-facing basalt cliffs, talus slopes, and moist meadows and streambanks on loamy, moss-rich soils surrounded by Alaska yellow cedar (*Callitropsis nootkatensis*), mountain hemlock (*Tsuga mertensiana*) and western hemlock (*T. heterophylla*). (Camp and Gamon 2011; Wilson et al. 2014). Some of the meadow sites appear to be former ponds that have become infilled by sediment through plant succession (WNHP records). The habitats occupied by *C. circinata* are part of the North Pacific Montane Massive Bedrock, Cliff & Talus and Temperate Pacific Subalpine-Montane Wet Meadow ecological systems (Rocchio and Crawford 2015). Populations are separated by 8-15 miles (12.5-24 km). The distribution of barren cliffs and open wet meadows is patchy within the matrix of montane to subalpine conifer forests in the southern Olympic Mountains. Forested areas provide a barrier to dispersal and potential migration of this species.

B2b. Anthropogenic barriers: Neutral.
Most of the habitat of *Carex circinata* in Washington is within Olympic National Park and the Colonel Bob Wilderness Area of Olympic National Forest in areas with limited roads or other human infrastructure to impede dispersal or migration.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.
Carex circinata produces dry, 1-seeded fruits that are lightweight and proportionally much longer than wide (Wilson et al. 2018), making them aerodynamically suitable for limited wind dispersal. Fruits might also be spread short distances by moving water and foraging animals. Average dispersal distances are probably short (<1000 m).

C2ai. Historical thermal niche: Greatly Increase.
Figure 3 depicts the distribution of *Carex circinata* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All four of the known occurrences in the state (100%) are found in areas that have experienced very small temperature variation (<37˚F/20.8˚C) during the past 50 years and are considered at greatly increased vulnerability to climate change (Young et al. 2016).

C2aii. Physiological thermal niche: Increase.
Most populations of *Carex circinata* in Washington are associated with wet meadows and wetlands associated with cold air drainage and would be vulnerable to changes in habitat quality and species composition associated with rising temperatures.

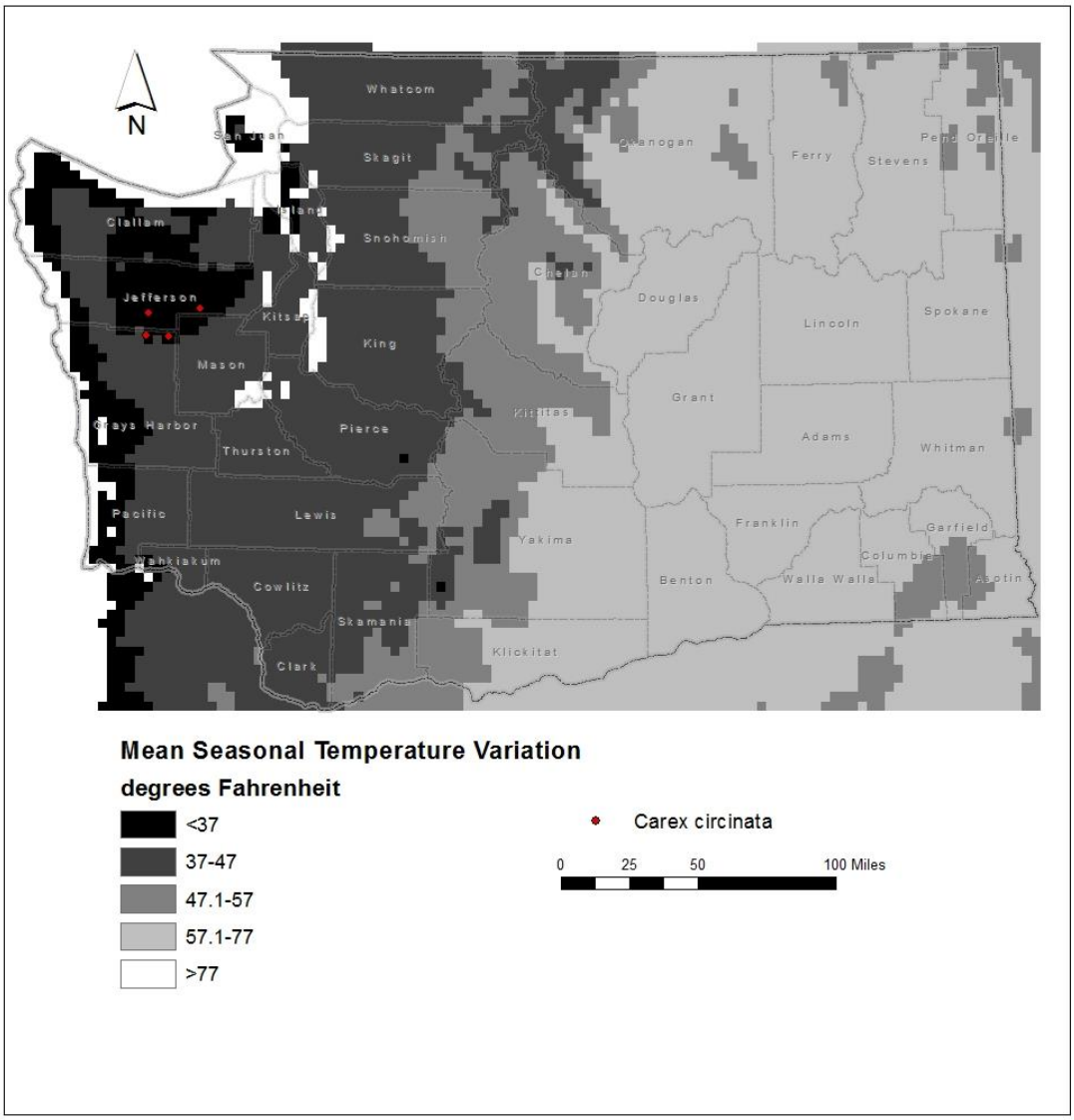

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Carex circinata* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.
All four of the known populations of *Carex circinata* in Washington (100%) are found in areas that have experienced greater than average precipitation variation in the past 50 years (>40 inches/1016 mm) (Figure 4). According to Young et al. (2016), these occurrences are neutral for climate change.

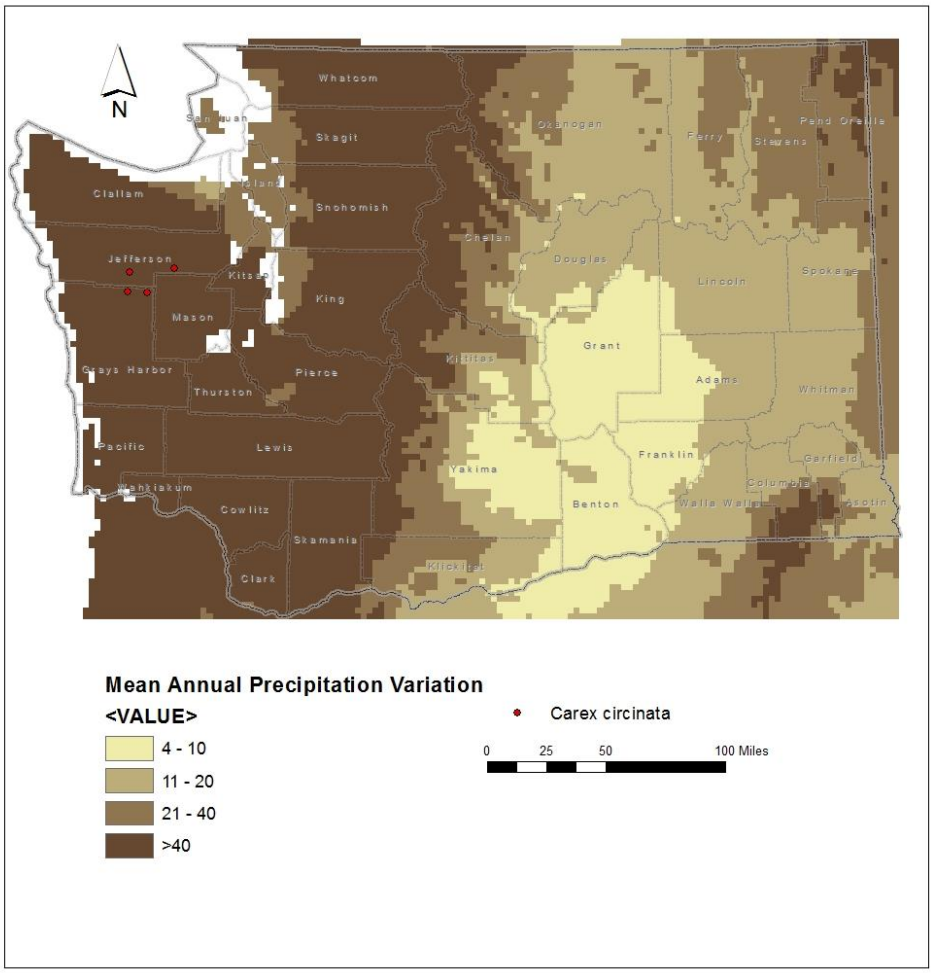

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Carex circinata* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
Populations of *Carex circinata* from wet meadows are dependent on groundwater fed by snowmelt and perennial streams. Decreases in the amount of snow and timing of its melting and increases in summer temperatures and drought that could result in permanent lowering of water tables and invasion by forest and dry meadow plant species (Rocchio and Ramm-Granberg 2017). Bedrock cliff occurrences are found in areas without a high water table and are more dependent on precipitation for moisture.

C2c. Dependence on a specific disturbance regime: Neutral.
The sparse vegetative cover in bedrock cliff populations of *Carex circinata* is maintained mostly by natural processes, such as rock fall, short growing seasons (due to long lasting snow or cold

temperatures) and poor soil development. Increased temperatures could make these sites more hospitable for establishment of competing tree, shrub, or forb species (Rocchio and Ramm-Granberg 2017). Wet meadow populations are currently not susceptible to fire or other disturbances, but could become more vulnerable if water tables are lowered due to decreased snowpack or increased summer temperature or drought (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Increase.
The populations of *Carex circinata* in Washington are found on subalpine ridgecrests and wet meadows in areas of extremely high snowfall. Reductions in the amount of snow and timing of spring melt related to climate change could result in drier conditions in summer that would lower the water table and favor invasion of forest or dry meadow species (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Neutral.
One population of *Carex circinata* is found on outcrops of pillowed basalt lava and breccia of the Crescent Formation, which occurs along the southern and eastern flank of the Olympic Mountains. Other populations (all from meadow sites) occur on Miocene-Eocene age marine sedimentary rocks that comprise the central core of the Olympics (Washington Division of Geology and Earth Resources 2016). There formations are dispersed widely in the Olympic Peninsula.

C4a. Dependence on other species to generate required habitat: Neutral/Somewhat Increase.
Rock outcrop sites are not dependent on other species to be maintained. Wet meadow sites may be enhanced by browsing by ungulates or other herbivores that contain the encroachment of woody vegetation.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
Carex circinata, like other sedge species, is entirely wind pollinated, and thus not dependent on animal pollinators.

C4d. Dependence on other species for propagule dispersal: Neutral.
Fruits are dispersed by gravity, water, or high winds. Occasionally dispersal may be abetted by animal vectors transporting fruits embedded in mud.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Grazing or disease have not been identified as significant threats to this species.

C4f. Sensitivity to competition from native or non-native species: Neutral/Somewhat Increase.
Under present conditions, competition from non-native species is minor, as few introduced plants are adapted to the barren rock outcrop and subalpine wet meadow habitat of *Carex circinata*. Reductions in the water table or increased summer drought and temperatures from climate change could result in replacement of wet meadow species by forest or dry meadow plants and increase competition for *C. circinata* (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 data are not available for Washington populations of *Carex circinata*. These occurrences are at least 200 km from their closest neighbors in Vancouver Island and southeastern British Columbia and are likely to be genetically distinct (and perhaps have lower variability) due to genetic drift or founder effects.

C5b. Genetic bottlenecks: Unknown.
Not known.

C5c. Reproductive System: Neutral.
Carex circinata is a wind-pollinated, obligate outcrosser (flowers are unisexual, with staminate flowers borne above the pistillate flowers in a single, spike-like inflorescence). The species as a whole would be expected to have at least average genetic variability. Washington populations are disjunct from those in southern British Columbia by at least 200 km and so probably have lower genetic variability or diversity due to reproductive isolation, genetic drift, or founder effects, but data are not available for confirmation.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on herbarium records in the Consortium of Pacific Northwest Herbaria website (pnwherbaria.org), *Carex circinata* has not changed its typical blooming time since the 1930s.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
Historically, the range of *Carex circinata* has been advancing northward following the retreat of glacial ice sheets, leaving behind scattered populations in the Olympic Range and mountains in British Columbia (Wilson et al. 2018). One Washington population has not been relocated since 1937 and is considered historical. Whether the population has been lost due to succession, disturbance, or 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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