Climate Change Vulnerability Index Report

Carex heteroneura (Smooth-fruited sedge)

Date: 14 September 2021

Synonym: *C. heteroneura* var. *epapillosa*, *C. epapillosa*

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington

Heritage Rank: G5/S2S3

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	91.7
	-0.074 to -0.096	8.3
	-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		Neutral
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		Somewhat Increase
2aii. Change in physiological thermal niche		Increase
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		Increase
2c. Dependence on specific disturbance regime		Neutral
2d. Dependence on ice or snow-covered habitats		Somewhat 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	Somewhat Increase
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/Somewhat Increase
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 24 of the occurrences of *Carex heteroneura* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

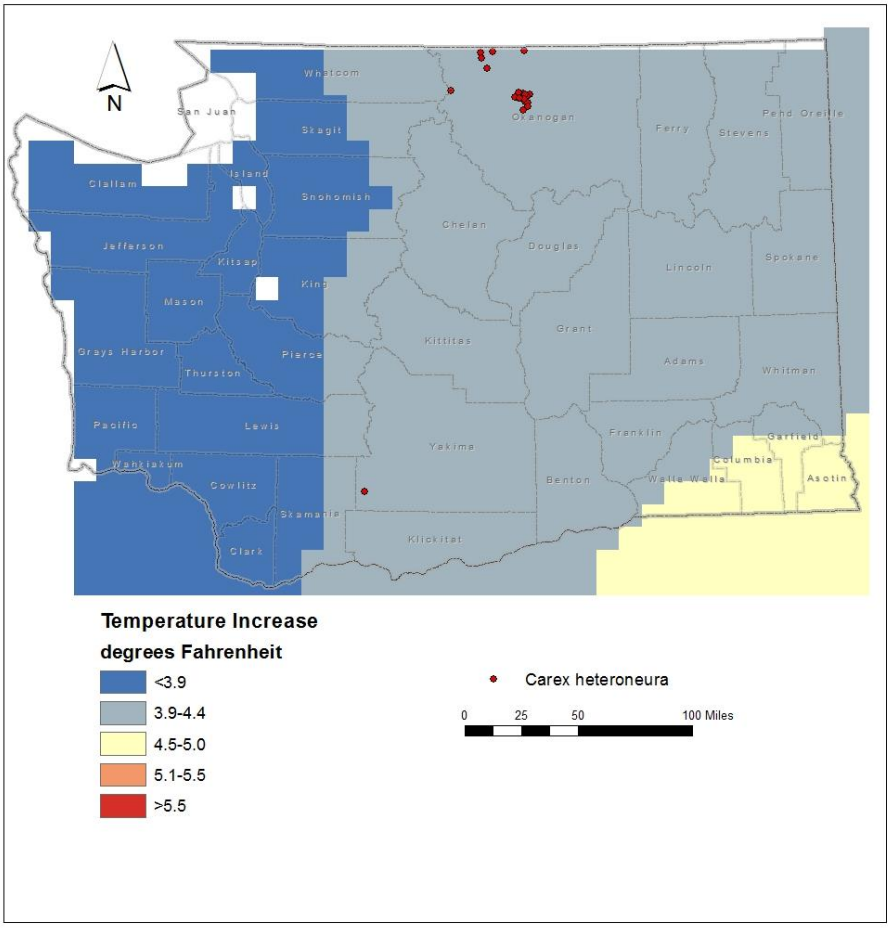

Figure 1. Exposure of *Carex heteroneura* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Twenty-two of the 24 occurrences (91.7%) of *Carex heteroneura* 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). Two other populations (8.3%) are from areas with a projected decrease of -0.074 to -0.096.

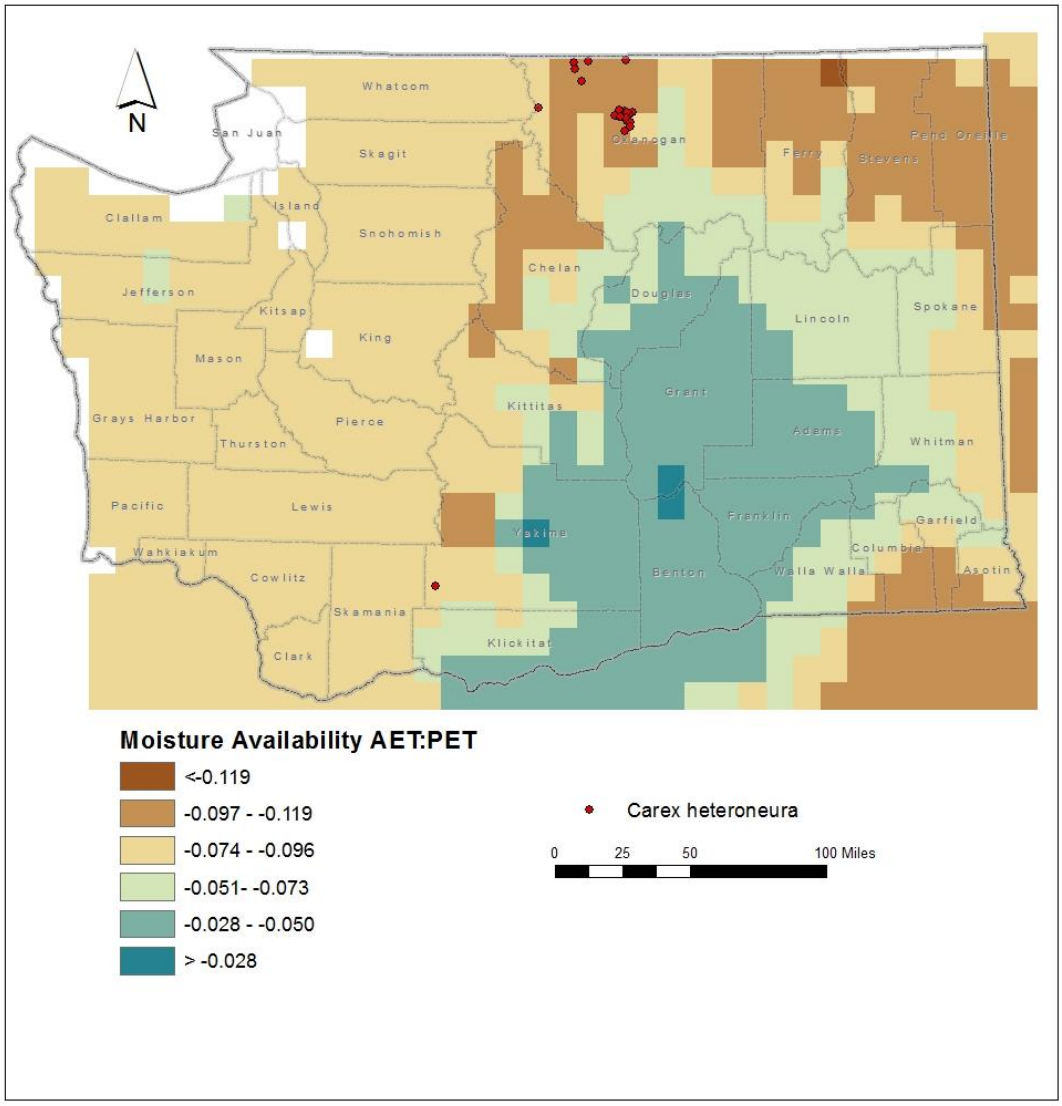

Figure 2. Exposure of *Carex heteroneura* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Carex heteroneura* are found at 5300-7900 feet (1615-2405 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Neutral.
Carex heteroneura occurs primarily in moist to mesic subalpine meadows and margins of streams, lakes, and seeps. It may also be associated with steep, rocky talus slopes (Camp and Gamon 2011; Washington Natural Heritage Program 2021). This habitat is part of the Rocky Mountain Alpine-Montane Wet Meadow ecological system (Rocchio and Crawford 2015). Most populations in the mountains of northern Washington are found within 0.6-18.5 miles (1-30 km) of each other, but a disjunct (and historical) occurrence in the Mount Adams area is separated by 180 miles (288 km). Natural barriers include mountain ridges and valleys, but are probably a minor impediment to dispersal in northern Washington. The isolated Yakima County population is separated by unoccupied and unsuitable habitat.

B2b. Anthropogenic barriers: Neutral.
Much of the subalpine habitat of *Carex heteroneura* in Washington is found along drainages in wilderness areas or backcountry sites with relatively few anthropogenic features aside from limited areas with trails, roads, and logging. Human-induced barriers are relatively minor.

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 heteroneura produces 1-seeded dry fruits contained within winged sac-like perigynia that are passively dispersed by gravity, water, or high winds, mostly within a short distance of the parent plant (< 1000 m). Under rare circumstances, the perigynia are capable of longer-distance dispersal, which may account for disjunct occurrences, such as at Mount Adams (Biek and McDougall 2007).

C2ai. Historical thermal niche: Somewhat Increase.
Figure 3 depicts the distribution of *Carex heteroneura* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Eighteen of the 24 known occurrences in the state (75%) 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 vulnerability to climate change (Young et al. 2016). The six other occurrences (25%) are from areas that have had a small variation (37-47˚F/20.8-26.3˚C) in temperature over the same period and are at increased vulnerability to climate change.

C2aii. Physiological thermal niche: Increase.
The subalpine meadow, streamside, and talus habitat of *Carex heteroneura* occurs in areas with cold air drainage in the flowering season and is vulnerable to temperature increases from climate change.

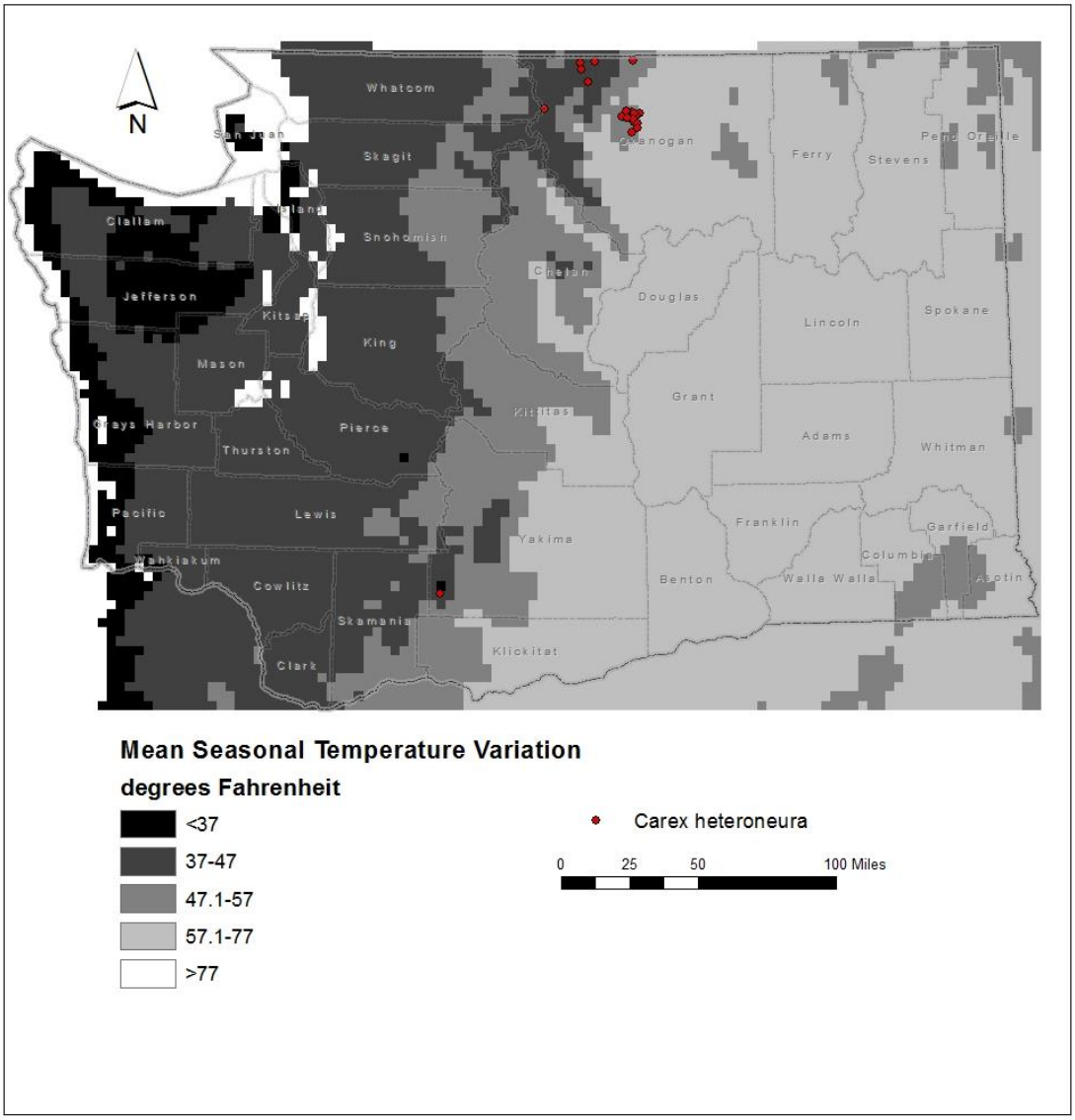

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Carex heteroneura* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.
All of the known populations of *Carex heteroneura* in Washington (100%) are found in areas that have experienced average or greater than average precipitation variation in the past 50 years (>20 inches/508 mm) (Figure 4). According to Young et al. (2016), these occurrences are neutral for climate change.

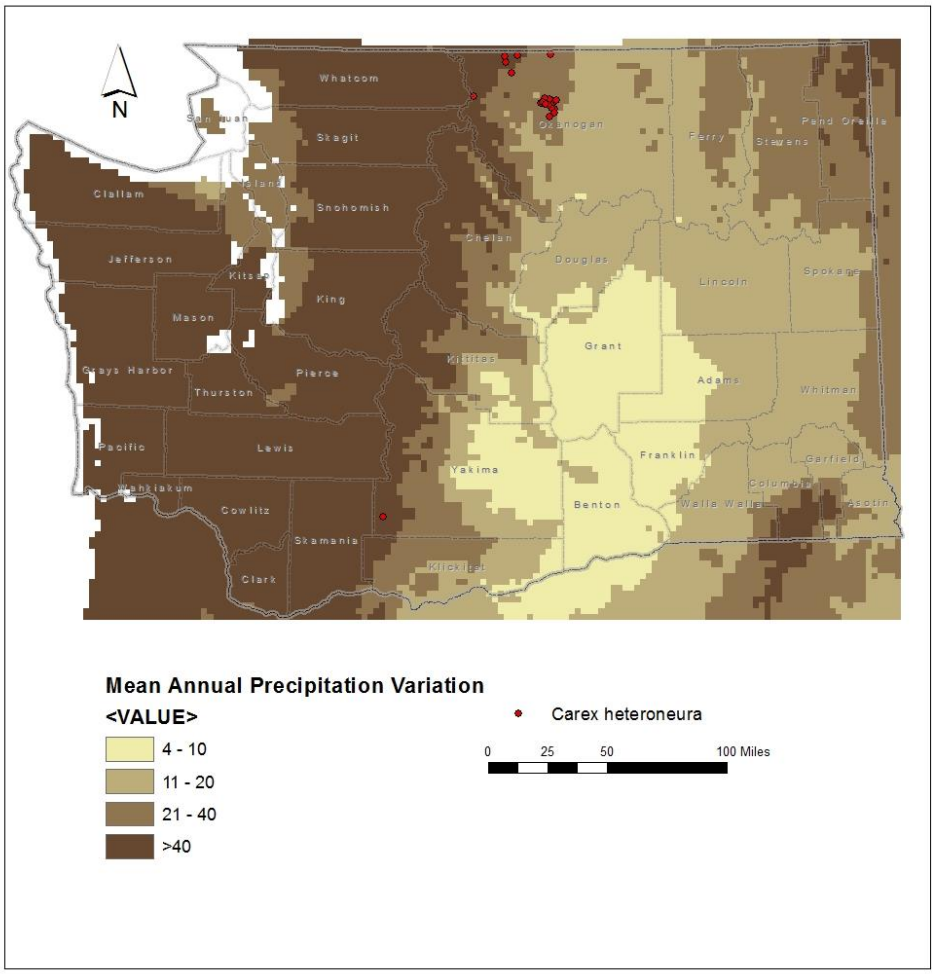

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Carex heteroneura* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Increase.
Habitats occupied by *Carex heteroneura* in the Rocky Mountain Alpine-Montane Wet Meadow ecological system are highly vulnerable to changes in the amount of snowpack, timing of snowmelt, changes in timing and amount of summer precipitation, increased summer temperatures and drought, and reduction in stream flows or depth to groundwater from projected climate change (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.
Carex heteroneura occurs in subalpine wet meadows, streamsides, and talus slopes that are maintained primarily from groundwater discharge and snowmelt, rather than natural

disturbances (Rocchio and Crawford 2015). Under projected climate change, these areas could become drier and more fire-prone in the future (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Somewhat Increase.
The populations of *Carex heteroneura* in Washington are found in subalpine wet meadows, streamsides, and talus areas fed by groundwater or snowmelt. Reduction in the amount or timing of snowmelt could alter the species composition in these communities, favoring plant taxa adapted to drier conditions (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Somewhat Increase.
Carex heteroneura is found on a variety of geologic substrates, including the Tiffany Mountain gneiss, Doe Mountain tonalite, marine sediments of the Hart's Pass Formation, and other gneiss and tonalite formations. In the Mount Adams area, it was historically found on andesite (Washington Division of Geology and Earth Resources 2016). Many of these geologic types are relatively uncommon in northern Washington.

C4a. Dependence on other species to generate required habitat: Neutral.
The subalpine wet meadow, streamside, and talus habitat occupied by *Carex heteroneura* is maintained largely by natural abiotic conditions, although influenced by browsing and grazing.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
Carex species are entirely wind pollinated.

C4d. Dependence on other species for propagule dispersal: Neutral.
Dispersal of fruits is predominantly passive by gravity or high winds. Secondary dispersal over short distances may occur by insects or rodents.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. This species could be impacted by grazing, though other graminoids are probably preferred forage.

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Under present conditions, competition from non-native species is minor, as few introduced plants are adapted to the harsh environmental conditions of the subalpine zone. Under projected climate change, competition could increase as wet meadows become drier and species composition shifts (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: Somewhat Increase.
No information is available on genetic diversity of Washington occurrences. Wilson et al. (2008) suggest that the high degree of local variability in floral morphology (which has resulted in a complicated taxonomic history) may be a result of the lack of gene flow between different mountain ranges. Washington populations of *Carex heteroneura* are near the northern edge of

the species range and are somewhat isolated from those in British Columbia and Oregon, which could result in reduced genetic variability due to inbreeding or founder effects.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral.
As a wind-pollinated, obligate out-crosser, *Carex heteroneura* would be expected to have reasonably high genetic variability. Washington populations are found near the edge of its global range, so are likely to possess lower levels of genetic diversity due to inbreeding or founder effects.

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 heteroneura* has not changed its typical blooming time.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral/Somewhat Increase.
The disjunct occurrence in the Mount Adams area has not been relocated since 1906 and may be extirpated. As a consequence, the extent of this species' range in Washington has contracted. Whether this is due to habitat loss, over-grazing, 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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