Climate Change Vulnerability Index Report

Eriophorum viridicarinatum (Green keeled cottongrass)

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Geographic Area: Washington Heritage Rank: G5/S2

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	92
	<3.9° F (2.2°C) warmer	8
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	77
	-0.074 to - 0.096	23
	-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		Somewhat Increase
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		Neutral
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		Neutral
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: Twelve of 13 occurrences (92%) of *Eriophorum viridicarinatum* in Washington occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1). One population (8% of state total) is found in an area with a projected increase of <3.9˚ F

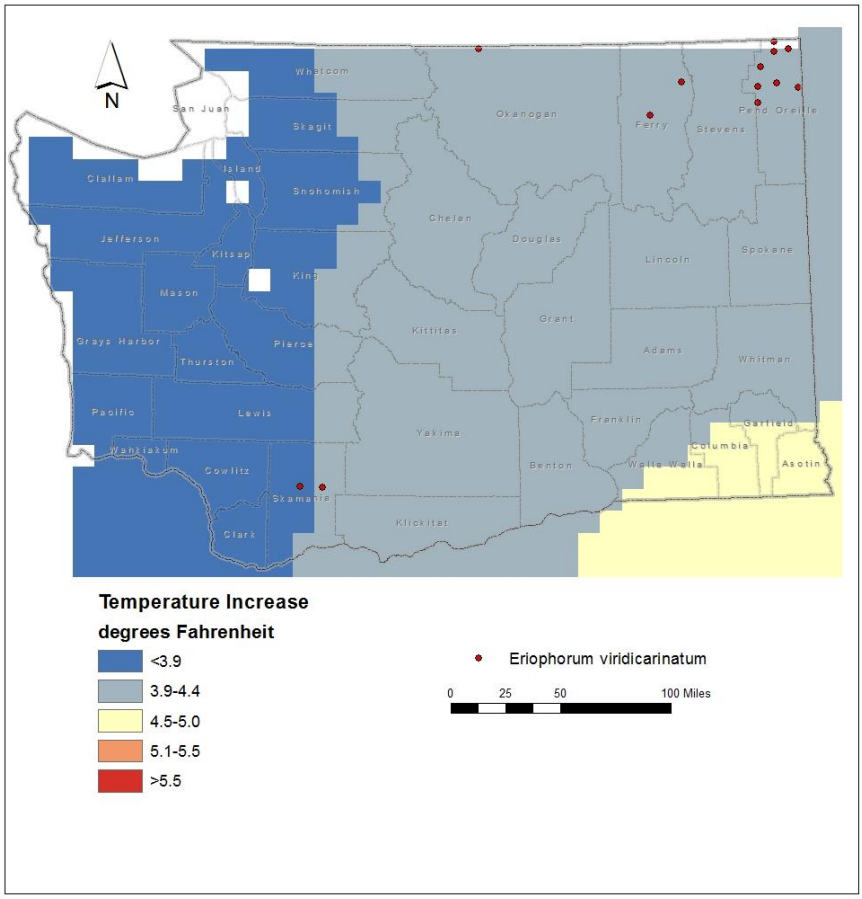

Figure 1. Exposure of *Eriophorum viridicarinatum* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Ten of the 13 Washington occurrences of *Eriophorum viridicarinatum* (77%) 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). The other 23% of occurrences are in areas with projected decrease of -0.074 to -0.096.

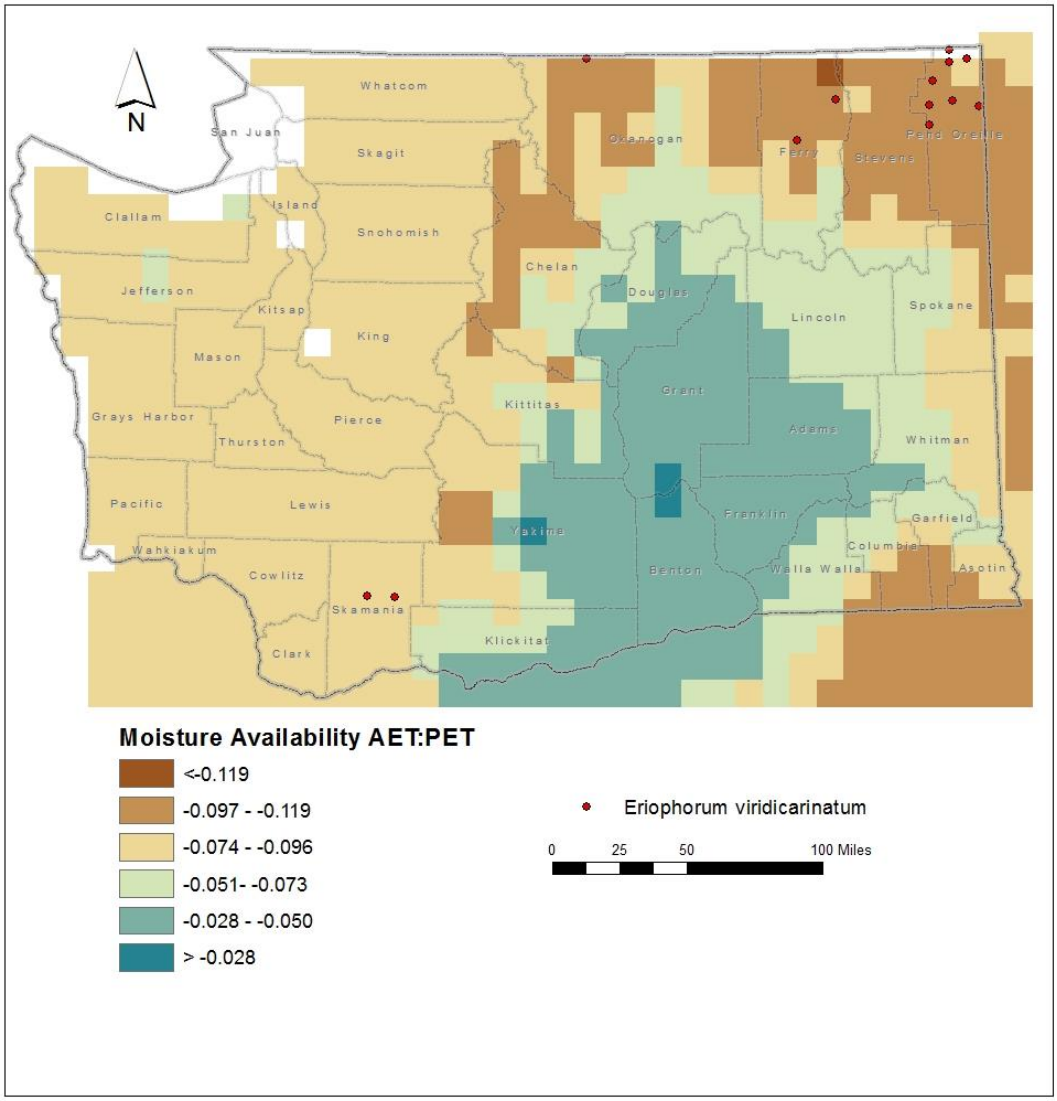

Figure 2. Exposure of *Eriophorum viridicarinatum* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Eriophorum viridicarinatum* are found at 2120-6560 feet (650-2000 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
Eriophorum viridicarinatum is an obligate wetland species found in cold calcareous fens, pond shores, and wet meadows, mostly in lower montane zones (Camp and Gamon 2011). A report from the Columbia Plateau southwest of Spokane was misidentified (Fertig and Kleinknecht 2020). Washington occurrences are part of the North Pacific Bog and Fen and Rocky Mountain Subalpine-Montane Fen ecological systems (Rocchio and Crawford 2015). Populations may be isolated from each other by 4-10 miles (7-16 km) or of unoccupied and unsuitable habitat. Large blocks of forested habitat may be a sufficient barrier to wind-dispersed pollen or seed.

B2b. Anthropogenic barriers: Neutral.
The fen habitat of *Eriophorum viridicarinatum* in Washington is already naturally fragmented and isolated, so additional habitat fragmentation by human activities is of comparatively low significance.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Neutral.
Eriophorum viridicarinatum produces small achenes associated with tufts of long, feathery bristles that aid in dispersal by wind. The fruits might also be dispersed by flowing water. Although dispersal could be constrained by forests, the fruits probably can disperse over 1 km.

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Eriophorum viridicarinatum* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Eight of the 13 known occurrences (62%) are found in areas that have experienced average temperature variation (57.1-77˚F/31.8-43.0˚C) during the last 50 years and are considered neutral in terms of climate change vulnerability (Young et al. 2016). Three populations (23%) 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. Two other occurrences (15%) are from areas that have had a small temperature variation (37-47˚F/20.8-26.3˚C) in temperature over the same period and are considered to be at increased vulnerability. The species is scored as "Neutral" in vulnerability because the majority of occurrences fall in this category.

C2aii. Physiological thermal niche: Somewhat Increase.
The montane calcareous fen and wet meadow habitat of *Eriophorum viridicarinatum* is found primarily in areas of cold air drainage and would be somewhat vulnerable to temperature increase from climate change.

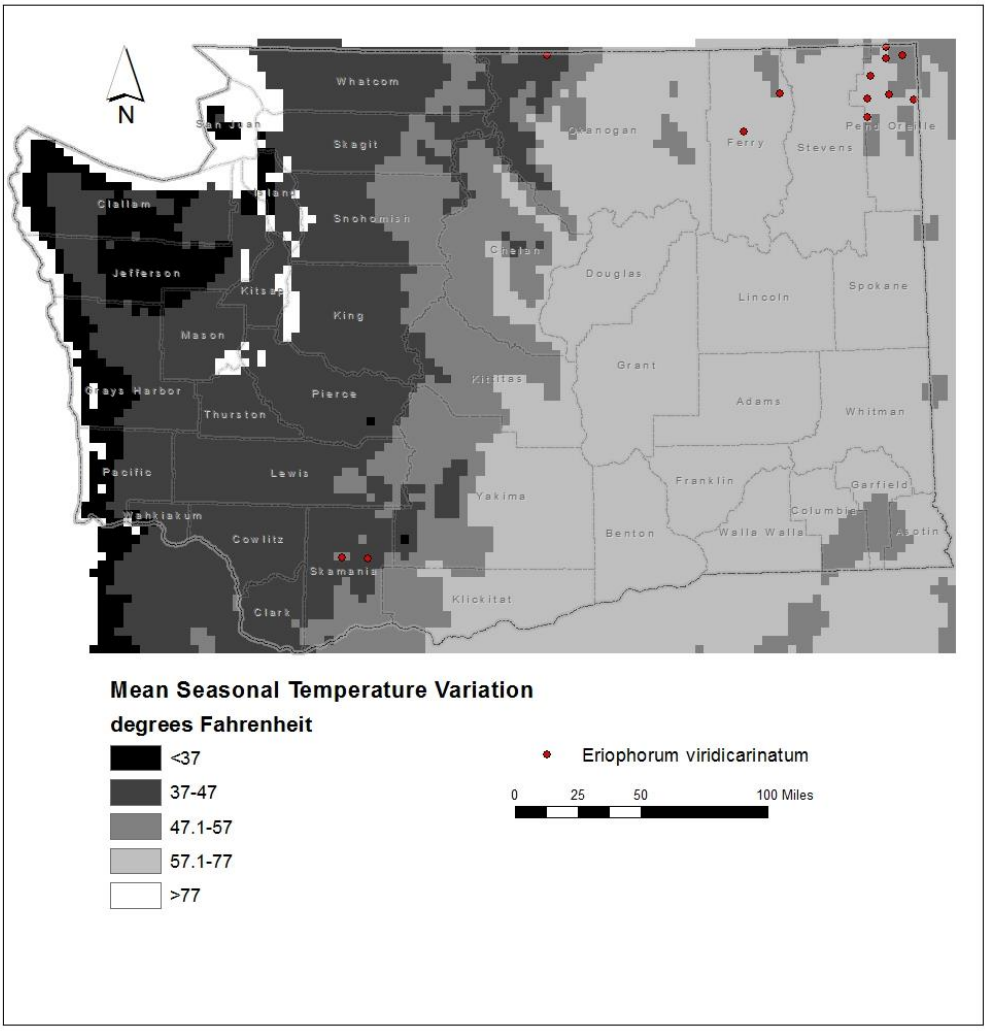

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Eriophorum viridicarinatum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.
All 13 known populations of *Eriophorum viridicarinatum* in Washington (100%) are found in areas that have experienced average of greater than 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 from climate change.

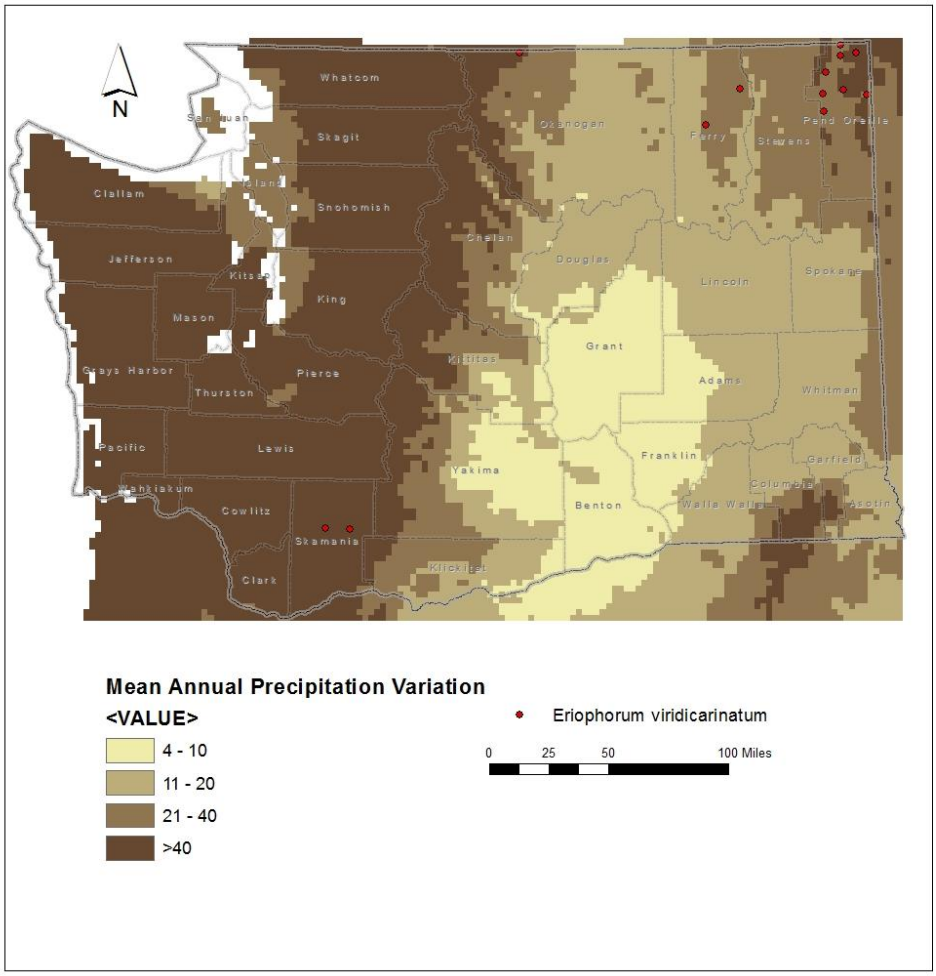

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Eriophorum viridicarinatum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Neutral.

The fen habitats of *Eriophorum viridicarinatum* are mostly associated with groundwater discharge, and in the short-term may be more resilient to reductions in available precipitations from climate change than rainwater-dependent wetlands (Rocchio and Ramm-Granberg 2017). Long-term, however, reduced snowpack and recharge of regional aquifers would make these habitats more vulnerable. For now, the score is Neutral, but long term might warrant "Somewhat Increased" (but see "Dependence on ice or snow-cover habitats" below).

C2c. Dependence on a specific disturbance regime: Neutral.
Eriophorum viridicarinatum occurs in fen and wet meadow habitats that are maintained by a high water table to prevent encroachment of forests, rather than on natural disturbance cycles. Prolonged drought that might reduce groundwater, or wildfire in surrounding forested habitat, could make these sites more prone to invasion by wetland plants adapted to less harsh environmental conditions (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Somewhat Increase.
The populations of *Eriophorum viridicarinatum* in Washington occur in fen and wet meadow habitats maintained by groundwater in regional aquifers. Ultimately, these sites are dependent on adequate winter snowfall for recharge. Reduction in winter snow accumulation could have a long term negative impact on the hydrologic conditions necessary to maintain this habitat (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Somewhat Increase.
Eriophorum viridicarinatum is found in wetland sites with basic water chemistry often associated with calcareous bedrock, which is a relatively uncommon geologic type in Washington.

C4a. Dependence on other species to generate required habitat: Neutral
The fen and wet meadow habitat occupied by *Eriophorum viridicarinatum* is maintained by natural abiotic conditions.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
Eriophorum viridicarinatum is wind-pollinated.

C4d. Dependence on other species for propagule dispersal: Neutral.
Fruits are surrounded by tufts of cottony bristles that aid in dispersal by wind.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Palatable, but not thought to be threatened by grazing from native species (livestock grazing may be a localized impact).

C4f. Sensitivity to competition from native or non-native species: Neutral.
Under present conditions, competition from non-native species is low, as few introduced plants are adapted to the harsh environmental conditions of calcareous fens. Under projected climate change, competition could increase if fen sites are converted to meadows due to a reduction in groundwater availability from prolonged drought or diminution of snow recharge (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.
There are no published studies specifically addressing the population genetics of this species.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral.
Eriophorum viridicarinatum is presumed to be an outcrosser and pollinated by wind, suggesting that rangewide genetic variability should be average. Isolated occurrences, such as those at the southern edge of its range (like Washington), might be expected to have lower overall diversity due to 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), *Eriophorum viridicarinatum* has not changed its typical blooming time since the 1890s.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
In 2009, *Eriophorum viridicarinatum* was first documented in the West Cascades ecoregion (Gifford Pinchot NF), though it is unknown whether this represents a range extension or imroved survey effort.

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.

Fertig, W. and J. Kleinknecht. 2020. Conservation status and protection needs of priority plant species in the Columbia Plateau and East Cascades ecoregions. Natural Heritage Report 2020-02. Washington Natural Heritage Program, WA Department of Natural Resources, Olympia, WA. 173 pp.

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