Climate Change Vulnerability Index Report

Chrysosplenium tetrandrum (Northern golden-carpet)

Date: 31 January 2020

Assessor: Walter Fertig, WA Natural Heritage Program

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	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		Somewhat Increase
2ai Change in historical thermal niche		Increase
2aii. Change in physiological thermal niche		Somewhat Increase
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		Somewhat Increase
2c. Dependence on specific disturbance regime		Somewhat Increase
2d. Dependence on ice or snow-covered habitats		Neutral/Somewhat Increase
3. Restricted to uncommon landscape/geological features		Neutral
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		Somewhat Increase

5b. Genetic bottlenecks	Unknown
5c. Reproductive system	Unknown
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 seven of the known occurrences of *Chrysosplenium tetrandrum* in Washington occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

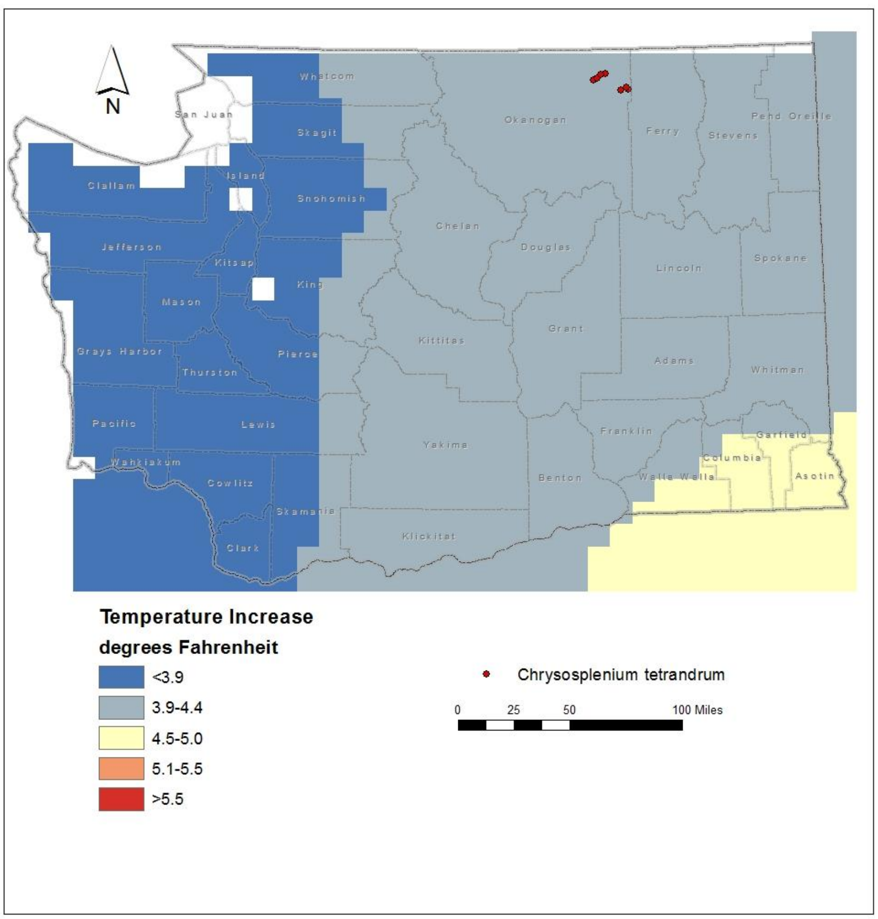

Figure 1. Exposure of *Chrysosplenium tetrandrum* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: All Washington occurrences of *Chrysosplenium tetrandrum* 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).

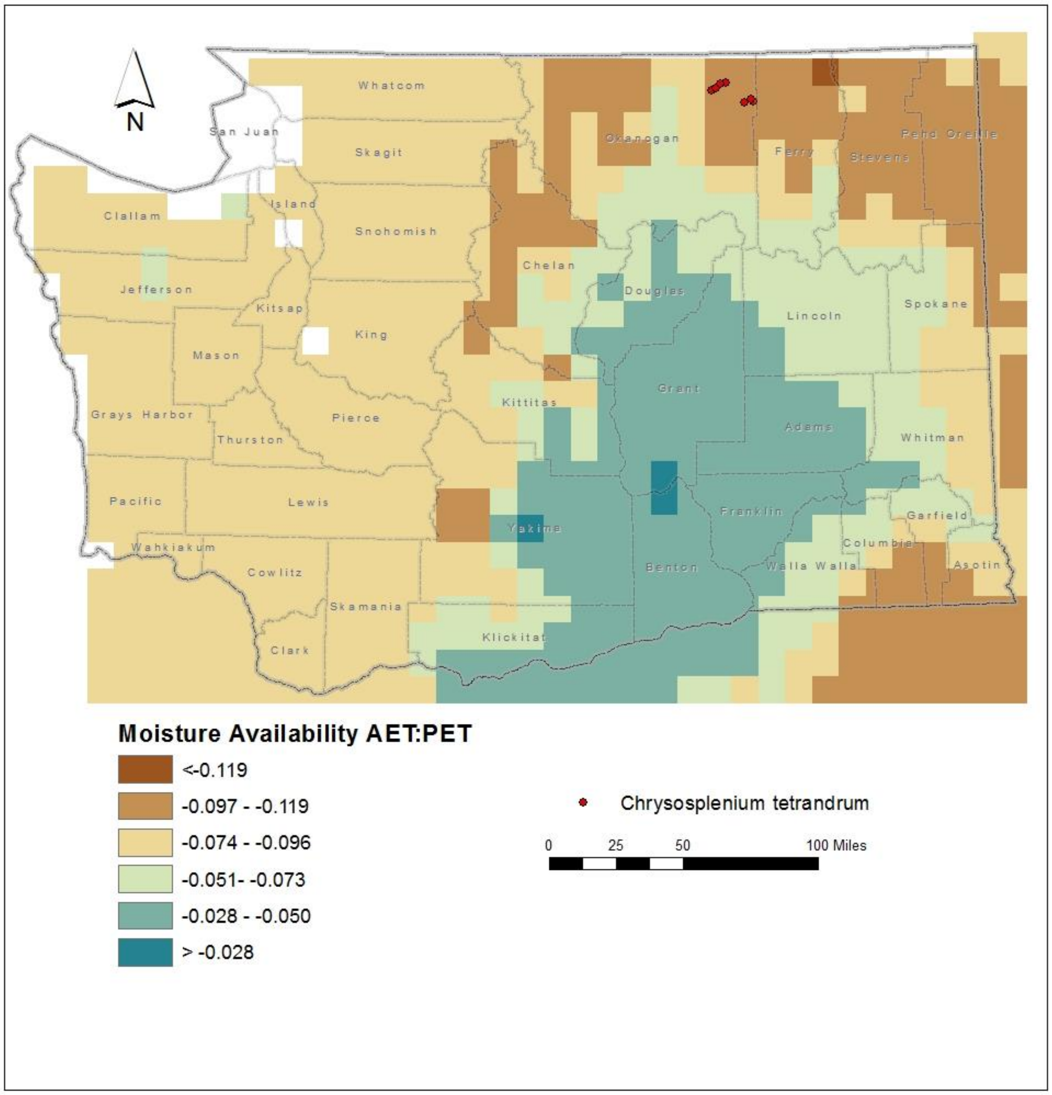

Figure 2. Exposure of *Chrysosplenium tetrandrum* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Chrysosplenium tetrandrum* are found at 3500-4600 ft (1070-1400 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Chrysosplenium tetrandrum* occurs in densely vegetated creek bottoms and seeps associated with rock crevices, wet banks, or densely vegetated stream banks associated with Douglas-fir, Engelmann spruce, and alder (Camp and Gamon 2011). These sites are part of the Rocky Mountain Subalpine-Montane Riparian Woodland and Northern Rocky Mountain Conifer Swamp ecological systems (Rocchio and Crawford 2015). Washington populations are separated by 1-11 miles (1.6-17 km) and occur within a matrix of dry upland forest habitats that may be a barrier to dispersal.

B2b. Anthropogenic barriers: Neutral.
Populations of *Chrysosplenium tetrandrum* in Washington are found in the Okanogan Plateau ecoregion at the headwaters of streams within National Forest lands, and are relatively unaffected by roads and other human barriers.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.
Chrysosplenium tetrandrum produces numerous, small, plump seeds within a cup-shaped capsule that is fully open across its top at maturity. This shape is analogous to the "splash cup" or gemmae of spore-producing liverworts, such as *Marchantia*, in which spores are dispersed by the energy of raindrops splashing on the cup. Savile (1953) observed the splash cup syndrome as a method of short-distance seed dispersal in *Chrysosplenium tetrandrum* and species of *Mitella*. Once removed from the parent plant, the seeds of *Chrysosplenium* could be secondarily relocated by small animals (insects or rodents) or by flowing water along streams. Dispersal distances are probably short under most circumstances.

C2ai. Historical thermal niche: Increase.
Figure 3 depicts the distribution of *Chrysosplenium tetrandrum* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Two of the seven known occurrences in the state 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. These populations have somewhat increased vulnerability under projected climate change (Young et al. 2016). The remaining five occurrences (71% of the state's population) are found in areas that have experienced small (37-47˚F/20.8-26.3˚C) temperature variation in the same historic time period and are at increased vulnerability to climate change. Since the majority of Washington populations are in the latter group, this factor is scored "Increase".

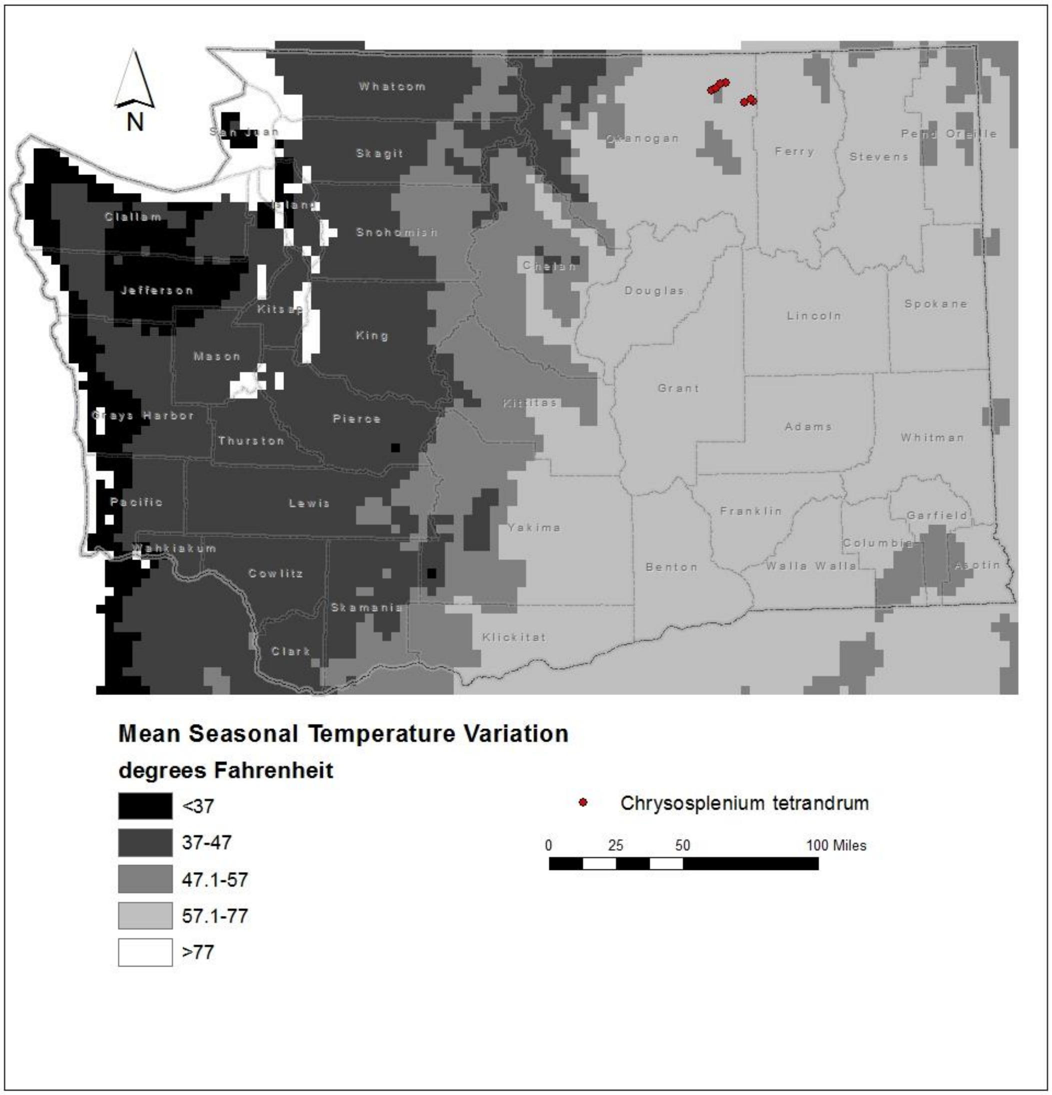

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Chrysosplenium tetrandrum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Somewhat Increase.
The montane stream habitat occupied by *Chrysosplenium tetrandrum* in Washington is associated with a moist microclimate that would be vulnerable to increased temperature and increased frequency of wildfire due to climate change Rocchio and Ramm-Granberg 2017).

C2bi. Historical hydrological niche: Neutral.
All of the known populations of *Chrysosplenium tetrandrum* in Washington are found in areas that have experienced average or greater than average (>20 inches/508 mm) precipitation

variation in the past 50 years. According to Young et al. (2016), these occurrences are Neutral in terms of risk from climate change.

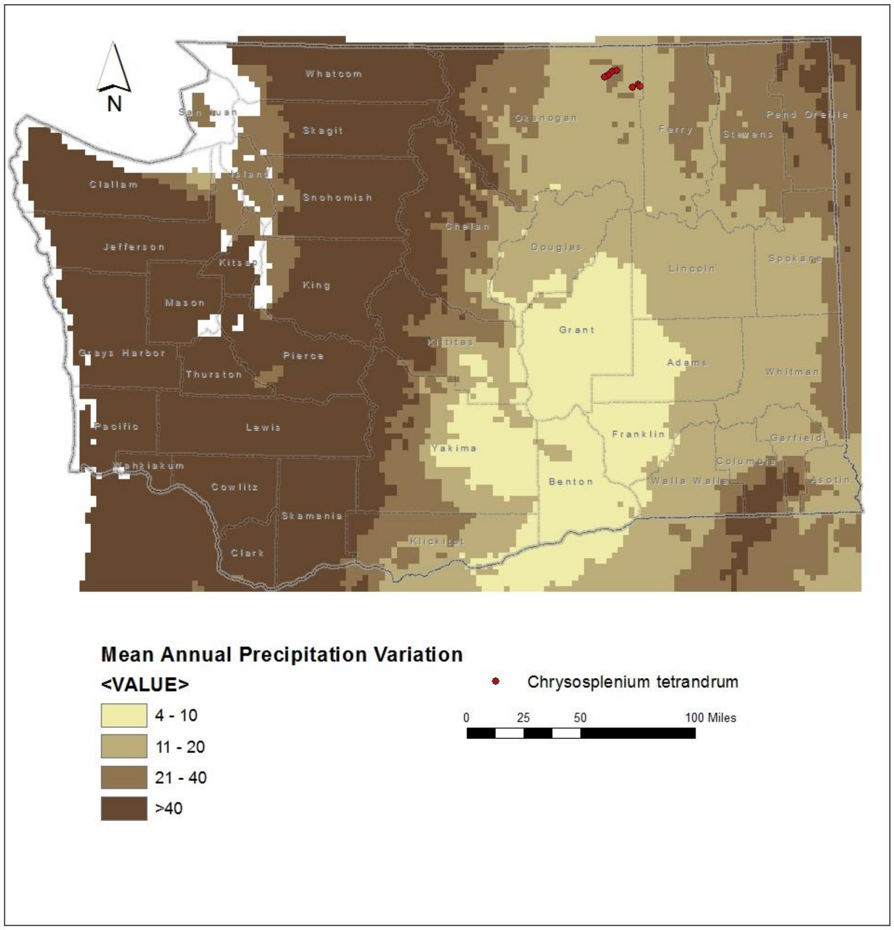

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Chrysosplenium tetrandrum* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
In Washington, this species is restricted to mossy streambanks in montane conifer forests and wet rocky seeps and thus is dependent on the continuation of adequate moisture conditions. Under climate change, the timing and amount of precipitation, amount and duration of snowpack, stream flows, and spring discharge are all likely to decrease, making these sites more vulnerable to drought and wildfire (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Somewhat Increase.
Chrysosplenium tetrandrum is not adapted to disturbance and depends on forest cover to maintain cool, shady conditions in its wetland habitat. It would be negatively impacted by increased fire frequency or drought within its montane forest wetland habitat.

C2d. Dependence on ice or snow-cover habitats: Neutral/Somewhat Increase.
Although the populations of *Chrysosplenium tetrandrum* in Washington all occur in areas of high snow accumulation, they are not directly associated with permanent snow or ice features. Reduced snowpack could affect regeneration of groundwater necessary for forested springs, and thus have a negative impact on some occurrences (Rocchio and Ramm-Granberg 2017). Across Alaska and Canada, this species is found in stream habitats in arctic and subarctic habitats and is dependent on adequate winter snow and ice cover.

C3. Restricted to uncommon landscape/geological features: Neutral
Washington populations occur on in stream drainages of low elevation mountains and are associated with the Mount Bonaparte Pluton and Klondike Mountain Formation. These geologic types are relatively widespread in the Okanogan Plateau.

C4a. Dependence on other species to generate required habitat: Neutral
The forest wetland habitat occupied by *Chrysosplenium tetrandrum* is maintained by natural climatic phenomena, and not strongly influenced by animal species.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
Chrysosplenium tetrandrum has been reported to be self-pollinated, though genetic data from Levsen and Mort (2009) suggest that some outcrossing is occurring to maintain homogenous levels of genetic diversity among Washington populations and those from British Columbia. The exact pollinator is not known, though the small size of the flowers suggest small, generalist insects such as gnats or mosquitos.

C4d. Dependence on other species for propagule dispersal: Neutral.
Dispersal of *Chrysosplenium* seeds is primarily by passive means (rain drops splashing on open capsules or gravity), abetted secondarily by flowing water or possibly by insects or rodents (Savile 1953).

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Although probably edible, the low stature of this plant suggests it is not a common food source. No natural pathogens are known.

C4f. Sensitivity to competition from native or non-native species: Neutral.
Not greatky impacted by competition from native or non-native species.

C4g. Forms part of an interspecific interaction not covered above: Neutral.
Does not require an interspecific interaction.

C5a. Measured genetic variation: Somewhat Increase.
Levsen and Mort (2009) measured low genetic differentiation and diversity across populations of *Chrysosplenium tetrandrum* sampled in Alaska, British Columbia, and Washington, suggesting that these populations arose from a recent bottleneck event or range expansion following post-Pleistocene deglaciation. Higher diversity was observed in disjunct populations in Montana and Colorado, indicating long-term isolation.

C5b. Genetic bottlenecks: Not Scored (according to Young et al. 2016, this is scored only if C5a is unknown).
There is genetic evidence of a bottleneck in Washington, British Columbia, and Alaska populations of this species (Levsen and Mort 2009).

C5c. Reproductive System: Not Scored (according to Young et al. 2016, this is scored only if C5a and C5b are unknown).
Chrysosplenium tetrandrum is primarily self-pollinated, but genetic data suggest sufficient outcrossing also occurs to maintain relatively homogenous genetic diversity across most of its range.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Changes in flowering or fruiting time for *Chrysosplenium tetrandrum* in Washington have not been observed.

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 *Chrysosplenium tetrandrum* in Washington since it was first discovered in the state in 1934.

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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