Climate Change Vulnerability Index Report

Hackelia taylorii (Taylor's stickseed)

Date: 11 February 2020

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington

Heritage Rank: G2/S2

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	50
	-0.074 to - 0.096	50
	-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		Somewhat Increase
2aii. Change in physiological thermal niche		Increase
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		Neutral
2c. Dependence on specific disturbance regime		Somewhat Increase
2d. Dependence on ice or snow-covered habitats		Increase
3. Restricted to uncommon landscape/geological features		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		Somewhat Increase
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		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 *Hackelia taylorii* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

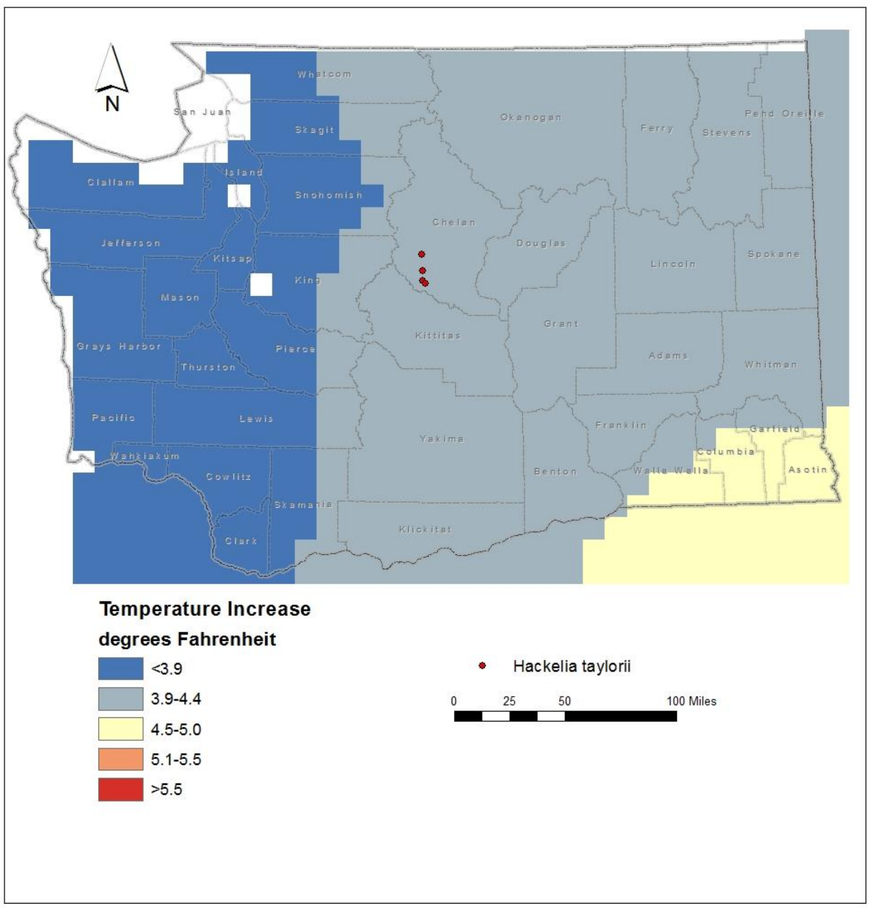

Figure 1. Exposure of *Hackelia taylorii* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Two of the four Washington occurrences of *Hackelia taylorii* (50%) 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 50% of occurrences are in areas with projected decrease of -0.074 to -0.096.

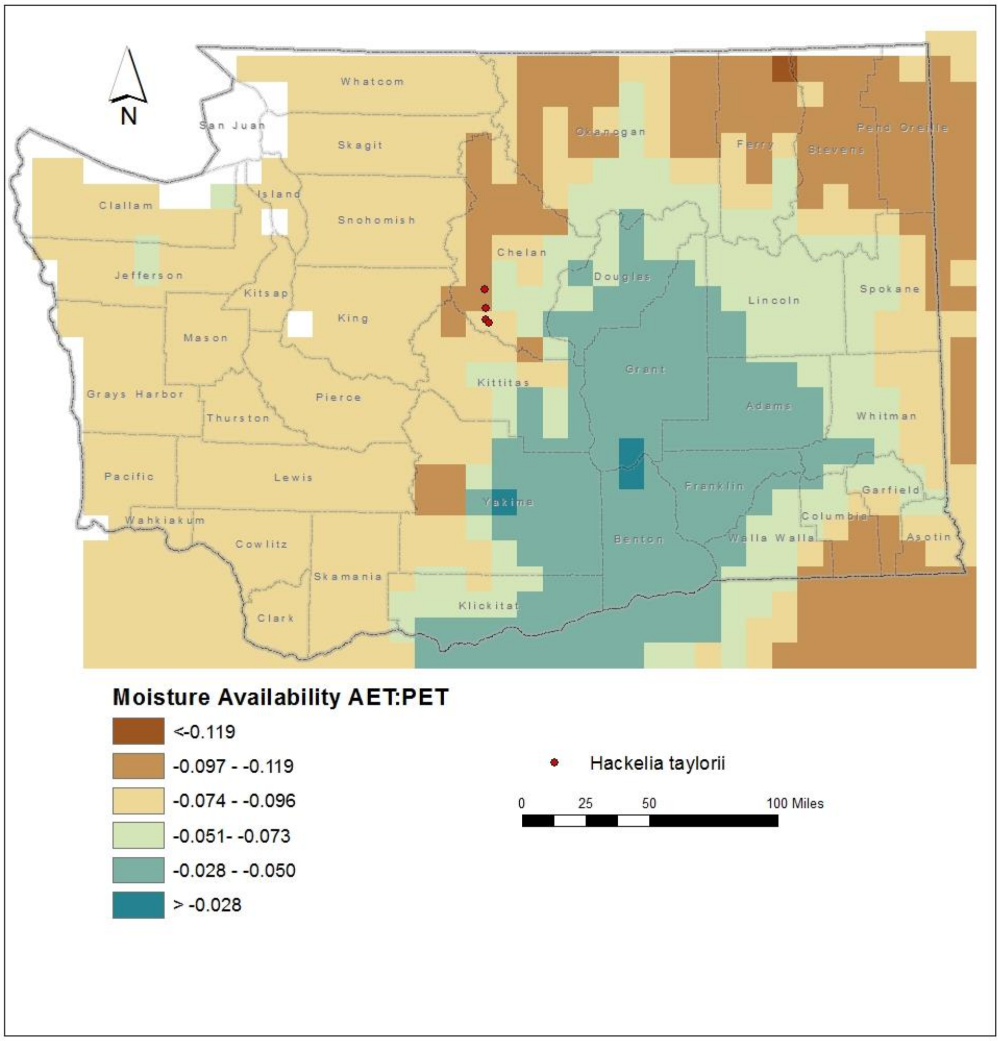

Figure 2. Exposure of *Hackelia taylorii* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Hackelia taylorii* are found at 5900-7550 feet (1800-2300 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Hackelia taylorii* is found on steep, unstable, sparsely vegetated, subalpine to alpine sandy-gravely talus slopes derived from the Mount Stuart batholith (an intrusive gabbro, granite, and quartz diorite) (Camp and Gamon 2011, Fertig 2020, Harrod et al. 2013). This habitat is part of the Rocky Mountain Alpine Bedrock and Scree ecological system (Rocchio and Crawford 2015). Individual populations occupy small areas and are separated from each other by 2-12 km (1.25-7.3 miles) of mostly unsuitable habitat. The natural heterogeneity of suitable habitat and its presence within a matrix of unsuitable environments creates a natural barrier to pollen and seed dispersal.

B2b. Anthropogenic barriers: Neutral.
The subalpine to alpine talus and cliff habitat of *Hackelia taylorii* in Washington is naturally dissected; human stressors that are dominant in more accessible lowland sites are far less prevalent here (Rocchio and Ramm-Granberg 2017).

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.
Hackelia taylorii produces 1-seeded nutlets with a rim of marginal prickles that facilitate dispersal on the fur or feathers of animals. These fruits could potentially travel more than 1 km if stuck to an animal. Observations of the closely related *Hackelia venusta* (which has similar fruits), suggest that most fruits are dropped close to the parent plant and may move downhill due to rock slides or erosion (Gamon 1997). Actual dispersal distance is probably less than 1 km in *H. taylorii*.

C2ai. Historical thermal niche: Somewhat Increase.
Figure 3 depicts the distribution of *Hackelia taylorii* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All of the known occurrences (100%) 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.

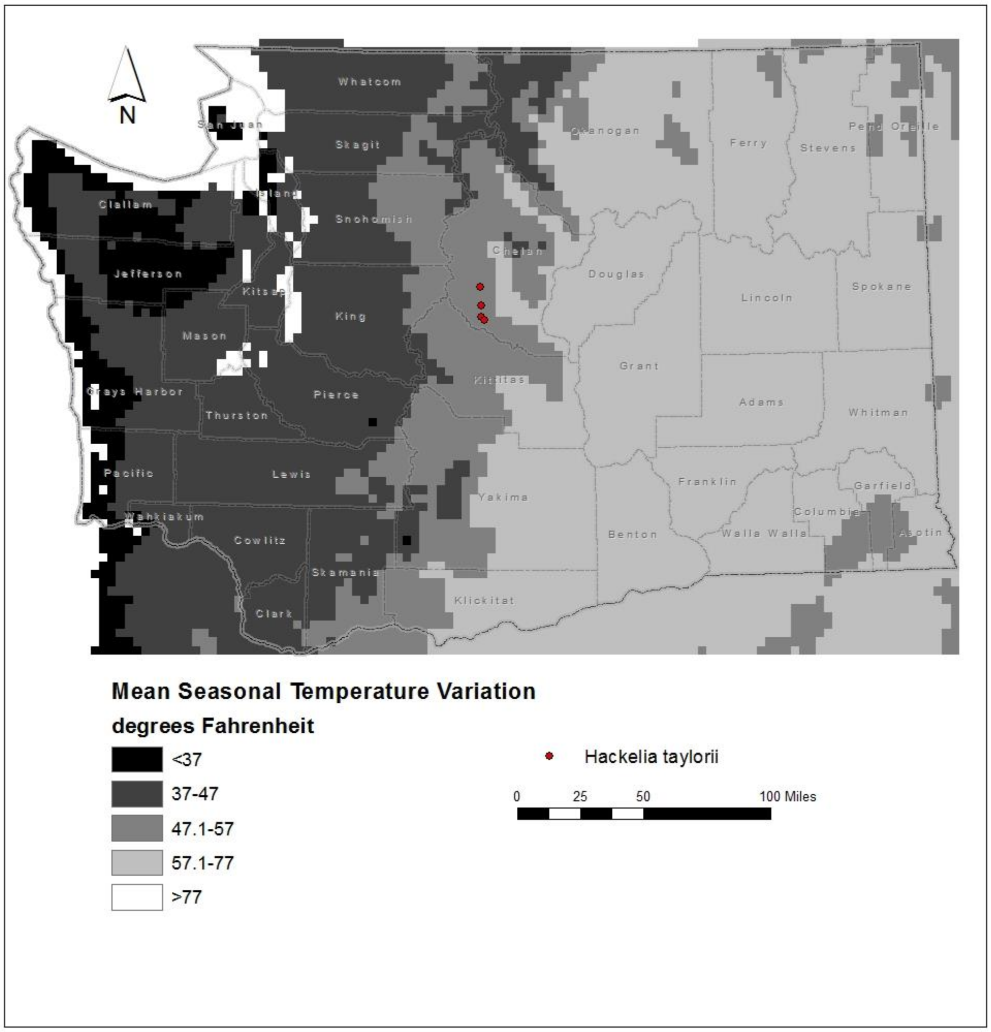

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Hackelia taylorii* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Increase.
The subalpine to alpine talus and cliff habitat of *Hackelia taylorii* is associated with cold temperatures during the growing season would have increased vulnerability to climate change.

C2bi. Historical hydrological niche: Neutral.
All four of the known populations of *Hackelia taylorii* in Washington (100%) are found in areas that have experienced average or 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.

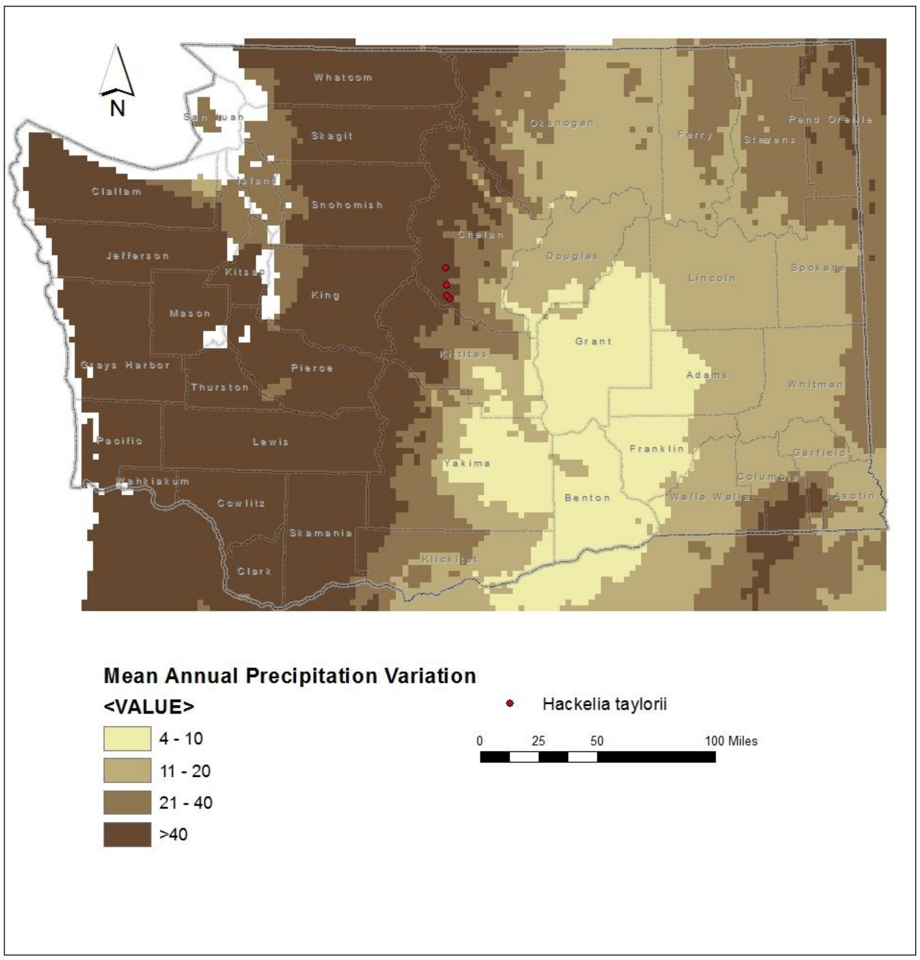

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Hackelia taylorii* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Neutral.
The subalpine to alpine rock talus and cliff habitat of *Hackelia taylorii* is not strongly associated with wetland habitats and scored as neutral (but see "Dependence on ice or snow-cover habitats" below).

C2c. Dependence on a specific disturbance regime: Somewhat Increase.
Hackelia taylorii is found in unstable talus slopes and cliffs prone to rock fall. Arnett (2014) noted that one occurrence was nearly eliminated due to a large landslide. This sort of disturbance helps reduce competing vegetation cover. Under projected climate change, rock slide areas would become warmer and could potentially support more vegetation, ultimately creating more soil to stabilize slopes and alter the community structure to a subalpine turf community (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Increase.
The populations of *Hackelia taylorii* in Washington occur at high elevations in the subalpine and alpine zone and are largely dependent on precipitation or late-lying snowbanks for soil moisture. Increased summer temperatures or drought resulting from projected climate change would reduce the amount of moisture available during the growing season (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Increase.
Hackelia taylorii is restricted to the Mount Stuart batholith, an intrusive gabbro, granite, and quartz diorite (Fertig 2020) and is found predominantly on steep slopes or cliffs.

C4a. Dependence on other species to generate required habitat: Neutral
The rock talus and cliff habitat occupied by *Hackelia taylorii* is maintained by natural abiotic processes.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
Hackelia venusta, the closest relative to *H. taylorii*, is capable of self pollination and outcrossing (Taylor 2008). The primary pollinators of *H. venusta* are generalist bees *Andrena nigrocaerulea* and *Protosmia rubifloris* and flies (*Eulonchus* and *Nicocles*) (Taylor 2008). These, or similar species, may also be the pollinators of *Hackelia taylorii*.

C4d. Dependence on other species for propagule dispersal: Somewhat Increase.
Hackelia taylori is dependent on small mammals or birds for long-distance dispersal.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known and the species does not appear to be significantly affected by herbivory.

C4f. Sensitivity to competition from native or non-native species: Neutral.
Hackelia taylorii occurs in areas that are sparsely vegetated and has few native or introduced competitors under the current climate regime. Projected climate change could make its habitat more conducive for lower elevation meadow species to invade (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.
Hipkins et al. (2003) investigated isozyme variation between white and blue-flowered populations of *Hackelia venusta* (the blue-flowered phase is now recognized as *H. taylorii*) and related *Hackelia* species from Washington. They found average levels of genetic variability within the white-flowered ("true") *H. venusta* and somewhat lower variability in blue-flowered *H. taylorii* compared to *H. diffusa*, a more common species of central Washington. Hipkins et al. (2003) and Wendling and DeChaine (2011) found that isozyme and molecular ITS data did not show significant genetic differentiation between white and blue-flowered forms of *H. venusta*, though the two taxa are morphologically distinct and occur in different habitats (Harrod et al. 2013).

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral
Hackelia taylorii is presumed to be an outcrosser and pollinated by numerous species of bees and flies, suggesting that genetic variability should be average rangewide.

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 change has been detected to date.

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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