Climate Change Vulnerability Index Report

Cicuta bulbifera (Bulb-bearing water-hemlock)

Date: January 28, 2021

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G5/S2S3

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	82.6
	<3.9° F (2.2°C) warmer	17.4
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	73.9
	-0.074 to -0.096	26.1
	-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		Neutral/Somewhat Increase
2ai Change in historical thermal niche		Neutral
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		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		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		Somewhat Increase

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: Nineteen of the 23 known occurrences of *Cicuta bulbifera* in Washington (82.6%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1). Another four populations (17.4%) are from areas with a projected increase <3.9˚ F.

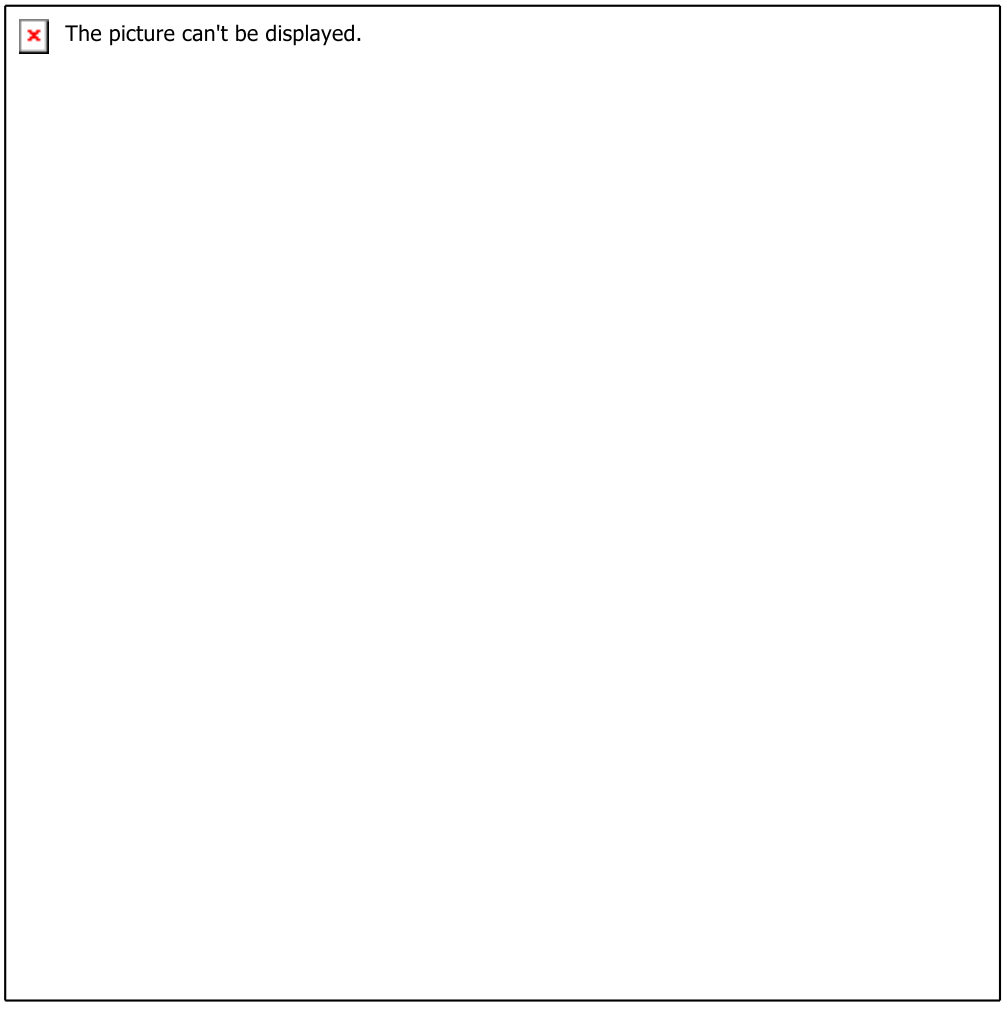

Figure 1. Exposure of *Cicuta bulbifera* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Seventeen of the 23 occurrences of *Cicuta bulbifera* (73.9%) 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). The remaining six occurrences (26.1) are in the range of -0.074 to -0.096.

Figure 2. Exposure of *Cicuta bulbifera* 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.
The Washington occurrences of *Cicuta bulbifera* are found at 20-3700 feet (6-1130 m). All of the populations (except one historical occurrence on Whidbey Island) are located well above the areas likely to be inundated by rising sea levels or impacted by increased storm surges.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Cicuta bulbifera* is found on mud, saturated mucky silt, or occasionally peat-rich soils along the margins of lakes and ponds (rarely streams) in openings surrounded by dense wetland shrub thickets or swampy coniferous forests. (Camp and Gamon 2011). Some populations are also found on floating mats of densely compacted vegetation and soil at the edge of dense *Phalaris arundinacea* and *Typha* stands (Fertig 2018). These habitats are components of the North American Arid West Emergent Marsh, North Pacific Bog and Fen, and Rocky Mountain Subalpine-Montane Fen ecological systems (Rocchio and Crawford 2015). Washington occurrences are separated by distances of 1.4-145 miles (2-235 km). Most populations are isolated by barriers of unsuitable matrix forest vegetation that are likely to impede dispersal or migration.

B2b. Anthropogenic barriers: Neutral.
The range of *Cicuta bulbifera* in Washington is primarily influenced by its dependence on widely scattered areas of specialized habitat that are naturally isolated. While the human imprint is significant in much of this area, anthropogenic factors are less likely to constrain dispersal than natural ones.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Neutral/Somewhat Increase.
Cicuta bulbifera produces small, compound umbels of white flowers which rarely mature into fruits. If present, the fruit is a schizocarp that splits into two 1-seeded segments (Lee and Downie 2006). Reproduction occurs primarily by seed-like asexual bulbils (or bulblets) produced in the axils of upper stem leaves. Fruits and bulbils are dispersed passively by water, wind, or mud encrusted on aquatic birds or mammals. Limited dispersal may also be possible from ingestion and defecation by raccoons (Hewitt and Miyanishi 1997). Average dispersal distances are probably short (<1000 meters), although longer transport would be possible by birds.

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Cicuta bulbifera* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Eighteen of the 23 known occurrences (78.3%) from Chelan, Stevens, and Pend Oreille counties are found in areas that have experienced average (57.1-77˚F/31.8-43.0˚C) temperature variation during the past 50 years and are considered at neutral vulnerability to climate change (Young et al. 2016). One occurrence from northern Stevens County near the Canadian border has experienced slightly lower than average temperature variation (47.1-57˚F/26.3-31.8˚C) during the same

period and is at somewhat increased vulnerability from climate change. Three populations from the Puget Trough have had small temperature variation (37-47˚F/20.8-26.3˚C) in the past 50 years and are at increased vulnerability. One historical population from Whidbey Island has experienced very small (<37˚F/20.8˚C) temperature variation and is at greatly increased vulnerability from climate change (Young et al. 2016).

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

C2aii. Physiological thermal niche: Increase.
Populations of *Cicuta bulbifera* from Washington are typically found along ponds or lakes in valleys that are cooler microsites than the surrounding matrix vegetation. Such areas would be at increased vulnerability from climate change.

C2bi. Historical hydrological niche: Neutral.
All 23 of the known occurrences of *Cicuta bulbifera* in Washington (100%) are found in areas that have experienced average or greater than average (>20 inches/508 mm) of precipitation variation in the past 50 years (Figure 4). According to Young et al. (2016), these areas are at neutral vulnerability to climate change.

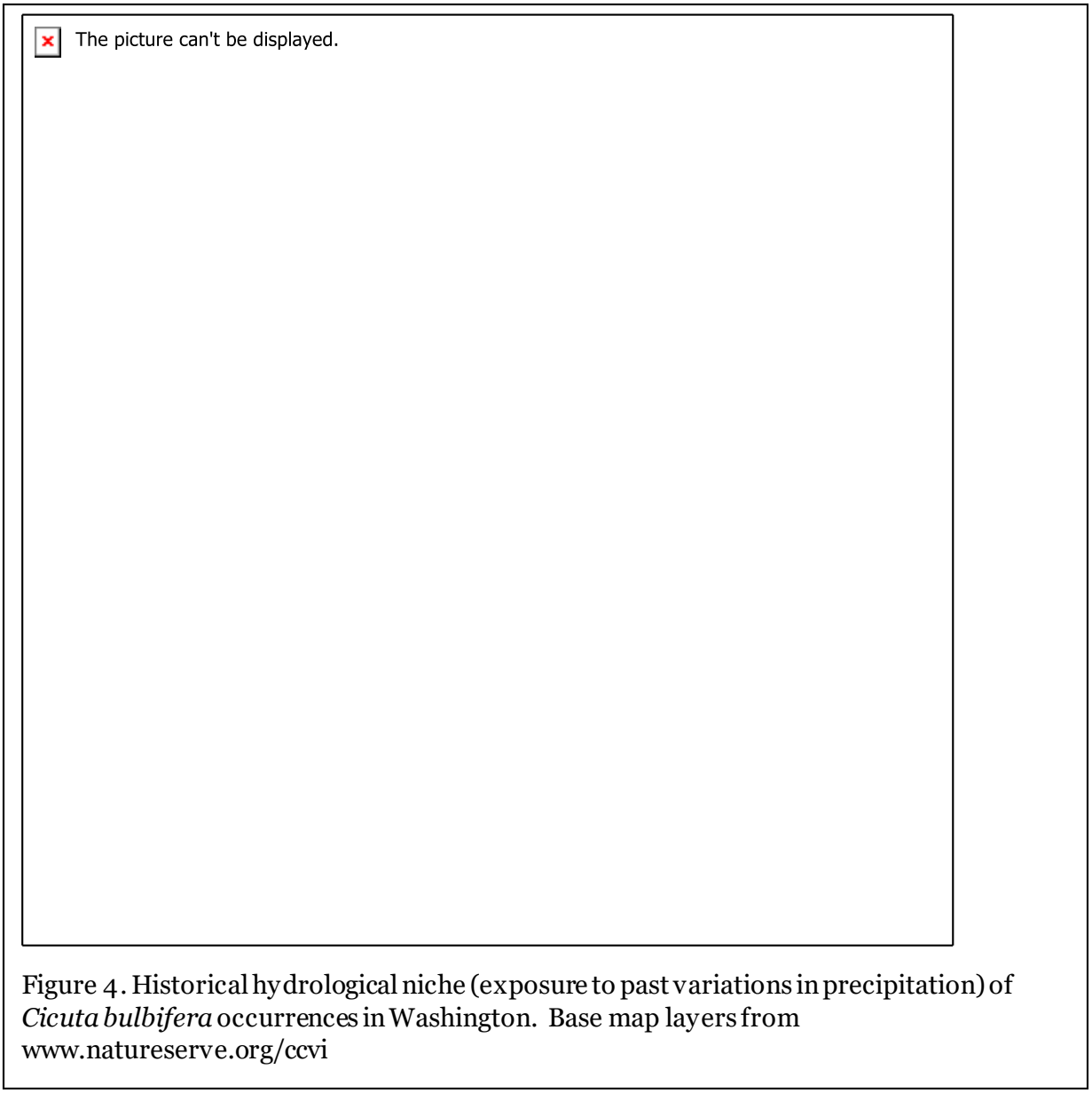

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Cicuta bulbifera* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
Most populations of *Cicuta bulbifera* in Washington are associated with muddy shores of small ponds and lakes with marsh vegetation. Sites in the North American Arid West Emergent Marsh ecological system are vulnerable to increased temperatures, decreased precipitation,

increased drought, and increased flooding that is predicted to occur due to climate change (Rocchio and Ramm-Granberg 2017). These habitats could be at risk of being converted to wet meadows. Populations associated with peatlands in the North Pacific Bog and Fen/Rocky Mountain Subalpine-Montane Fen ecological systems are more dependent on groundwater than precipitation for adequate moisture and so could be adversely affected by decreased snowpack and drops in the water table due to climate change. These sites might be at risk of being converted to forested wetlands due to tree encroachment, or have changes in water chemistry (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.
This species is not dependent on disturbance to maintain its wetland habitat

C2d. Dependence on ice or snow-cover habitats: Neutral/Somewhat Increase.
Snowpack is moderate over much of the range of *Cicuta bulbifera* in the mountains of northeastern Washington and east slopes of the Cascades. Reduced snowfall would negatively impact fen populations that are dependent on groundwater recharged by melting snow. Populations in the Puget Trough area experience low levels of snow but high amounts of winter rain.

C3. Restricted to uncommon landscape/geological features: Neutral.
In Washington, *Cicuta bulbifera* is found mostly in ponds and small lakes associated with Fraser-age (Pleistocene) glacial drift material or Holocene lacustrine deposits (Washington Division of Geology and Earth Resources 2016). These geological substrates are scattered but widespread in the Puget Trough of western Washington and the northeastern corner of the state.

C4a. Dependence on other species to generate required habitat: Neutral.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
The specific pollinators of *Cicuta bulbifera* are not known, but in general members of the Apiaceae have unspecialized flowers pollinated by a wide variety of insects. Other *Cicuta* species are reported to be pollinated by bees and flies (Mulligan and Munro 1981). Reproduction in *C. bulbifera* is predominantly by asexual bulbils, and so the species is not dependent on animal pollinators.

C4d. Dependence on other species for propagule dispersal: Neutral.
Fruits are rarely produced in *Cicuta bulbifera* due to an absence of flowers or their early abortion, which may be due to infertility from past hybridization. If present, the fruits split into two 1-seeded dry mericarps at maturity. The fruits lack barbs, bristles, wings, or other structures to aid in dispersal. Movement can occur by passive means from flowing water, or on mud attached to animals. Asexual bulbils (bulblets) are the primary reproductive/dispersal units and are fruit-like in appearance, but also lack ornamentation to facilitate transport.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Members of the genus *Cicuta* are the most poisonous group of vascular plants in North America. Of the 3-4 recognized species, *C. bulbifera* is the least virulent, but can still be toxic to livestock and other herbivores (Lee and Downie 2006). There is a report of *C. bulbifera* sprouting from

raccoon scat, suggesting that herbivory can occur and ingestion might be a means of limited dispersal (Hewitt and Miyanishi 1997).

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Several *Cicuta bulbifera* populations in western Washington are threatened by competition from invasive wetland weeds, such as reed canarygrass (*Phalaris arundinacea*) and purple loosestrife (*Lythrum salicaria*) (Fertig 2018). Occurrences in fen habitats in northeastern Washington are vulnerable to shifts in vegetation towards wet meadows or swamp forests because of potential changes in the amount of available water from precipitation and snowpack (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.
No genetic data are available for *Cicuta bulbifera* in Washington. This species is a diploid and has chromosomes intermediate in size between *C. maculata* and *C. virosa*, leading some researchers to suggest it may be of ancient hybrid origin and persisting (and spreading) primarily by asexual bulbils (Lee and Downie 2006, McNeil 2020).

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Somewhat Increase
Cicuta bulbifera is presumed to be an outcrosser, rather than self-pollinated. If the species is of hybrid origin and reproduces primarily by asexual bulbils, it would be expected to have lower than average overall genetic variability due to a reduction in outcrossing from sexual reproduction (Lee and Downie 2006).

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on herbarium records from the Consortium of Pacific Northwest herbaria website, no significant changes in the phenology of *Cicuta bulbifera* populations in Washington have been detected over the past 50 years.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
Twenty-two of the 23 occurrences in Washington are extant. Trend data are available for 13 occurrences, most of which have stable to slightly increasing numbers (Fertig 2018).

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. 2018. Rare plant survey of the Lake Terrell Wildlife Area. Natural Heritage Report 2018-08. Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia, WA. 15 pp.

Hewitt, N. and K. Miyanishi. 1997. The role of mammals in maintaining plant species richness in a floating Typha marsh in southern Ontario. Biodiversity and Conservation 6: 1085-1102.

Lee, C-S. and S.R. Downie. 2006. Phylogenetic relationships within *Cicuta* (Apiaceae tribe Oenantheae) inferred from nuclear rDNA ITS and cpDNA sequence data. Canadian Journal Botany 84: 453-468.

McNeil, R.P. 2020. *Cicuta*. pp. 93-95. In: Flora of Oregon Volume 2: Dicots A-F. Meyers, S.C., T. Jaster, K.E. Mitchell, T. Harvey, and L.K. Hardison, eds. Botanical Research Institute of Texas Press, Fort Worth, TX. 861 pp.

Mulligan, G.A. and D.B. Munro. 1981. The biology of Canadian weeds. 48. *Cicuta maculata* L., *C. douglasii* (DC.) Coult. & Rose and *C. virosa* L. Canadian Journal Plant Science 61:93-105.

Rocchio, F.J. and R.C. Crawford. 2015. Ecological systems of Washington State. A guide to identification. Natural Heritage Report 2015-04. Washington Natural Heritage Program, WA Department of Natural Resources, Olympia, WA. 384 pp.

Rocchio F.J. and T. Ramm-Granberg. 2017. Ecological System Climate Change Vulnerability Assessment. Unpublished Report to the Washington Department of Fish and Wildlife. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA.

Washington Division of Geology and Earth Resources. 2016. Surface geology, 1:100,000--GIS data, November 2016: Washington Division of Geology and Earth Resources Digital Data Series DS-18, version 3.1, previously released June 2010.
http://www.dnr.wa.gov/publications/ger_portal_surface_geology_100k.zip

Young, B.E., E. Byers, G. Hammerson, A. Frances, L. Oliver, and A. Treher. 2016. Guidelines for using the NatureServe Climate Change Vulnerability Index. Release 3.02. NatureServe, Arlington, VA. 48 pp. + app.