Climate Change Vulnerability Index Report

Anemone patens var. *multifida* (Pasqueflower)

Date: 3 March 2021 Synonym: *Pulsatilla nuttalliana*

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington Heritage Rank: G5T5/S1

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	100
	-0.074 to -0.096	0
	-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		Somewhat Increase
3. Impacts from climate change mitigation		Neutral
Section C: Sensitivity and Adaptive Capacity		
1. Dispersal and movements		Increase
2ai Change in historical thermal niche		Somewhat 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		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/Somewhat Increase
4b. Dietary versatility		Not Applicable
4c. Pollinator versatility		Unknown
4d. Dependence on other species for propagule dispersal		Neutral
4e. Sensitivity to pathogens or natural enemies		Somewhat Increase
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
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 4 of the accepted extant and historical occurrences of *Anemone patens* var. *multifida* in Washington (100%) occur in areas with a projected temperature increase of 3.9-

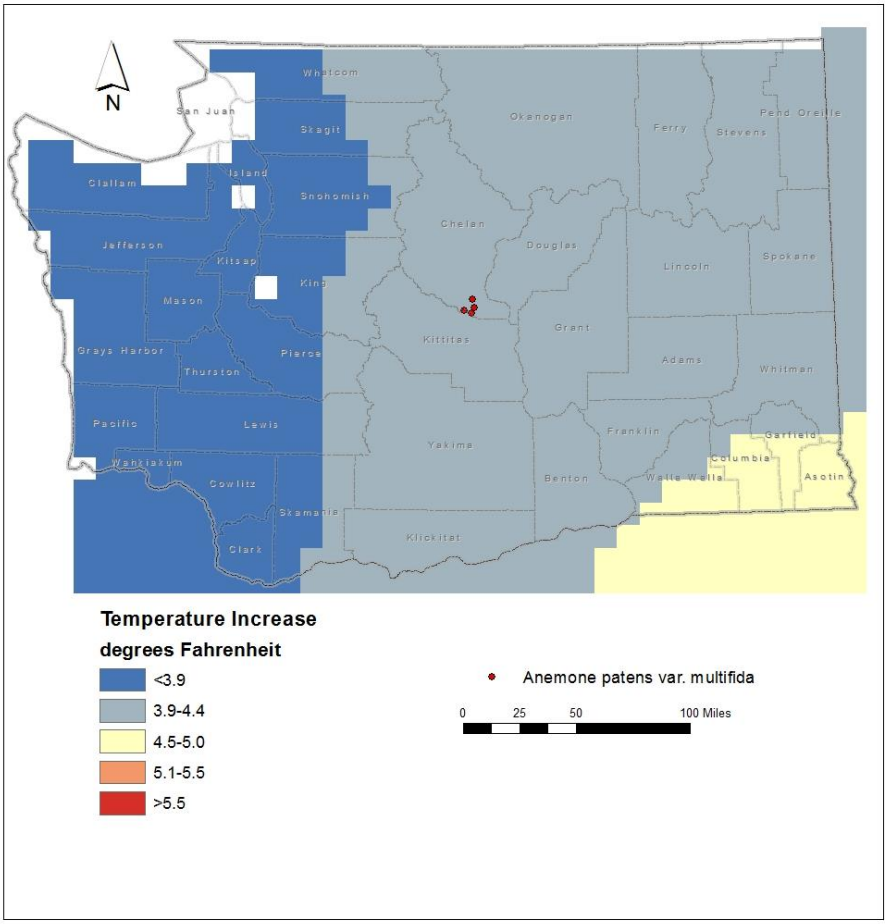

Figure 1. Exposure of *Anemone patens* var. *multifida* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

4.4 ° F (Figure 1). Previous reports from Okanogan and Whatcom County are based on misidentifications (Fertig and Kleinknecht 2020) and are excluded from this analysis.

A2. Hamon AET:PET Moisture Metric: The four occurrences (100%) of *Anemone patens* var. *multifida* 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).

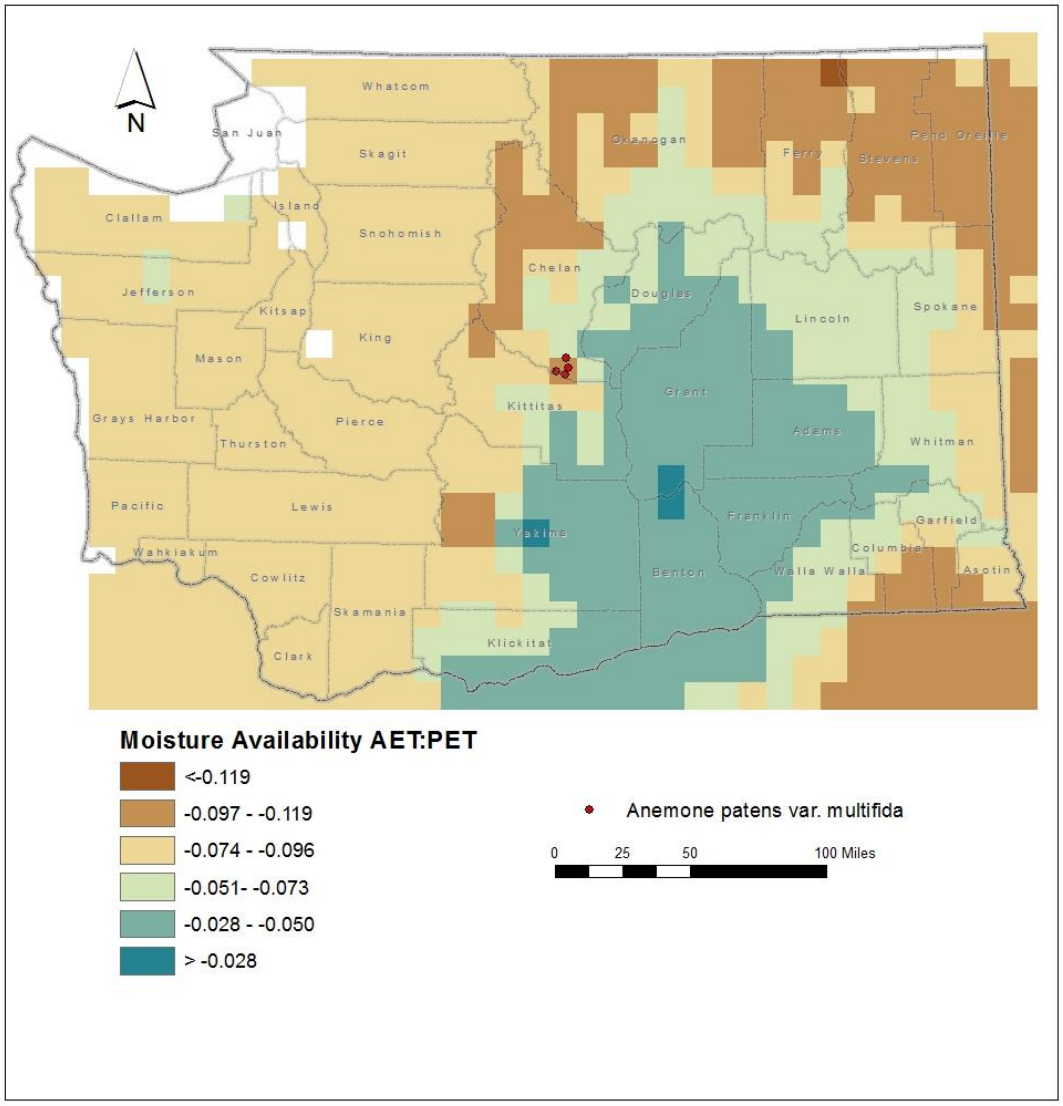

Figure 2. Exposure of *Anemone patens* var. *multifida* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Anemone patens* var. *multifida* are found at 3360-6600 feet (1025-2010 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Anemone patens* var. *multifida* occurs primarily on rocky basalt or sandstone talus slopes and meadows bordered by montane forests of *Pinus ponderosa* and *Pseudotsuga menziesii*. Reports from alpine habitats (Camp and Gamon 2011) were based on misidentifications. This species' habitat is part of the Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest ecological system (Rocchio and Crawford 2015). Populations are only 2.4-3.8 air miles (4-6 km) apart, but separated by canyons with unoccupied and unsuitable habitat. The proximity of the sites allows for some gene exchange between them. Topographic barriers could present a hurdle for migration of this species northward under projected climate change scenarios.

B2b. Anthropogenic barriers: Somewhat Increase.
The montane to subalpine ridge habitat of *Anemone patens* var. *multifida* in Washington is bisected by natural barriers (canyons and unsuitable forest habitat) and by human infrastructure, such as roads, agricultural fields, timber harvest areas, and rural inhabitations. Both natural and anthropogenic barriers are likely to constrain future migration.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Increase.
Anemone patens var. *multifida* produces ball-like heads of nut-like achene fruits, each surmounted by a feathery style that helps disperse the individual achenes by wind. In theory, fruits could be dispersed over long distances, but studies in Germany found that 90% of fruits dispersed in the immediate vicinity of the maternal plant and only 0.05% were carried more than 100m away, perhaps abetted by secondary dispersal by insects carrying fruits once they landed on the ground (Röder and Kiehl 2006).

C2ai. Historical thermal niche: Somewhat Increase.
Figure 3 depicts the distribution of *Anemone patens* var. *multifida* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All four of the known occurrences in the state (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 (Young et al. 2016).

C2aii. Physiological thermal niche: Somewhat Increase.
The montane talus meadow and forest habitat of *Anemone patens* var. *multifida* is within cold air drainages on mountain slopes and would have somewhat increased vulnerability to warming temperatures from climate change.

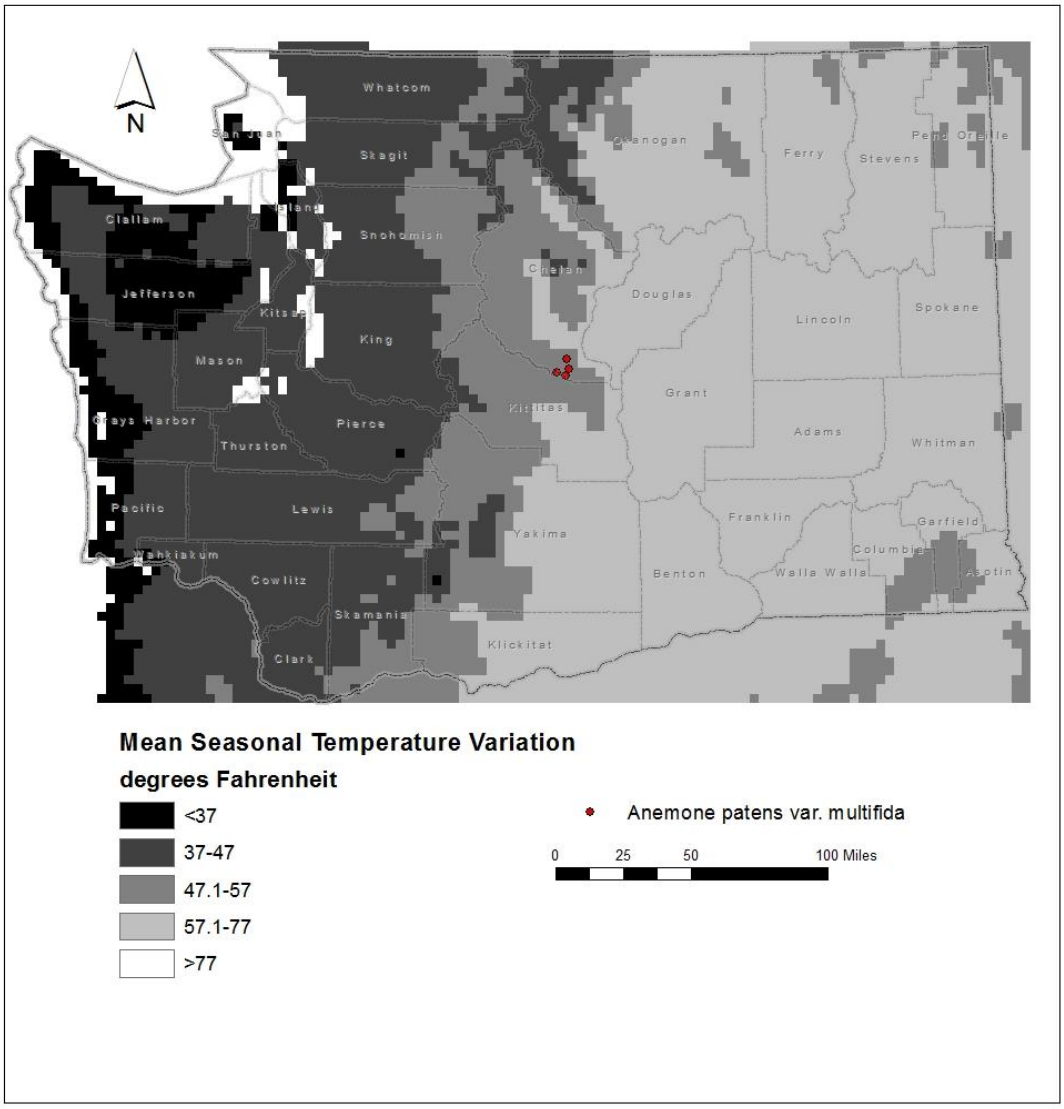

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Anemone patens* var. *multifida* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Neutral.

All of the known populations of *Anemone patens* var. *multifida* in Washington (100%) are found in areas that have experienced average precipitation variation in the past 50 years (20 -40 inches/508-1016 mm) (Figure 4). According to Young et al. (2016), these occurrences are neutral for climate change.

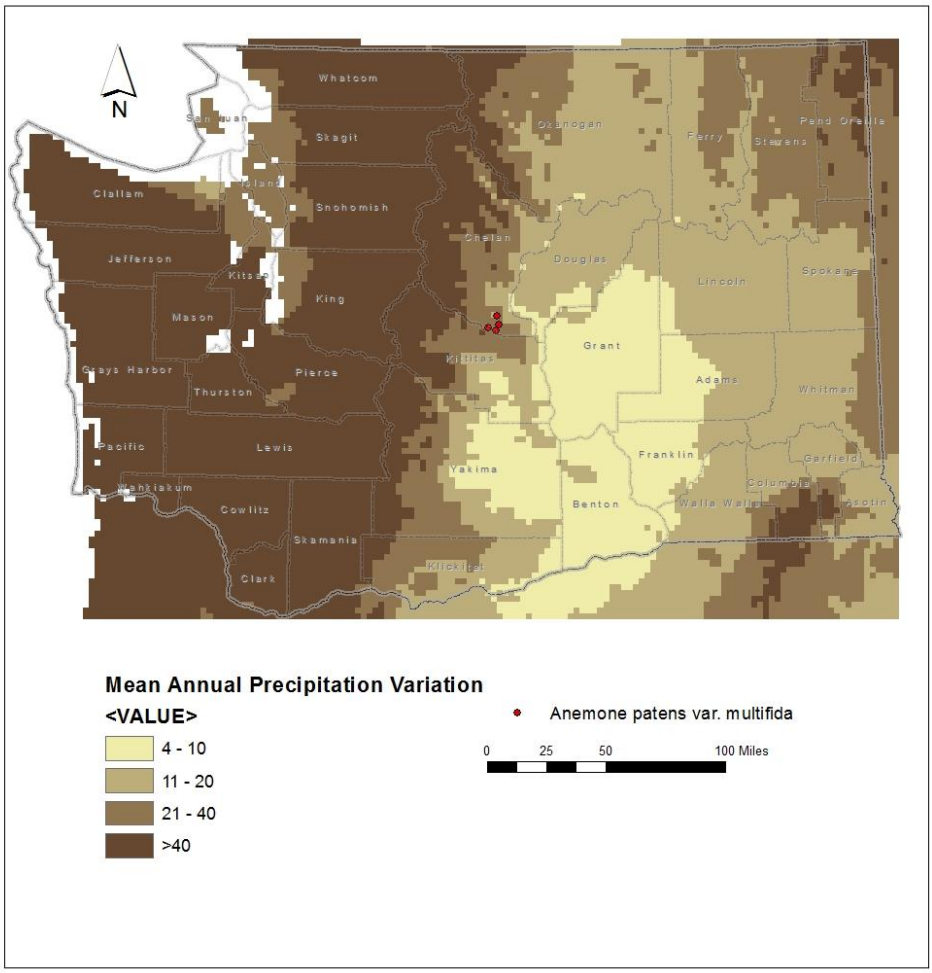

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Anemone patens* var. *multifida* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
This species relies on winter snow and summer precipitation for the majority of its annual water budget. Changes in the duration and amount of snowpack and amount of summer precipitation, coupled with increased temperatures, are likely to make the montane meadow/forest ecotone habitat of *Anemone patens* var. *multifida* more prone to drought and wildfire, favoring conversion to drier grasslands (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.
Under future climate change scenarios, montane meadow/forest habitats are likely to become drier and more prone to wildfire and outbreaks of mountain pine beetle. This increase in

disturbance could favor the shift to drier grasslands and invasion of non-native weedy species (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Somewhat Increase.
Populations of *Anemone patens* var. *multifida* in Washington are found in montane areas of the Eastern Cascades with moderate to high snowfall. Rocky meadow areas occupied by this species may have reduced snow cover due to wind or drifting, allowing this species to flower earlier than other native forbs (Bock and Peterson 1975). Reductions in the amount of snowpack or in the timing of melting due to increased temperatures in the future could impact meadow/conifer forest ecotone communities through reductions in available moisture or increased fire frequency or severity (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Somewhat Increase.
Anemone patens var. *multifida* is associated with the Tertiary Swauk Formation and Quaternary landslide deposits. The Swauk Formation consists of interbedded sandstone and mudstone deposited as stream outwash and is found primarily in the Wenatchee Mountains (Washington Division of Geology and Earth Resources 2016).

C4a. Dependence on other species to generate required habitat: Neutral/Somewhat Increase.
The montane talus and meadow habitat occupied by *Anemone patens* var. *multifida* is maintained largely by natural abiotic conditions, such as fire, snow deposition, and drought, but vegetation density and height may also be controlled by herbivory of native ungulates, rodents, and insects.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Unknown.
In Colorado, Bock and Peterson (1975) observed pollination of *Anemone patens* var. *multifida* by honeybees (*Apis mellifera*), andrenid bees (*Andrena* spp.), bumblebees (*Bombus* spp.) and syrphid flies. The precise pollinators in Washington are not known.

C4d. Dependence on other species for propagule dispersal: Neutral.
The achene fruits of *Anemone patens* var. *multifida* have a persistent, feathery style to aid in dispersal by wind. Secondary dispersal by insects may be important for spreading seed once it lands on the ground.

C4e. Sensitivity to pathogens or natural enemies: Somewhat Increase.
Populations may be threatened by livestock grazing (Fertig and Kleinknecht 2020), although studies in Europe suggest that grazing and other management activities to maintain meadow and forest edge habitats are necessary for long-term persistence of the species (Szczecińska et al. 2016).

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Studies in Alberta found that *Anemone patens* var. *multifida* experienced a negative population growth rate in prairie habitats that became dominated by introduced smooth brome (*Bromus inermis*) but increased over time in native prairie (Williams and Crone 2006). In Europe, where *A. patens* var. *patens* is endangered, populations are declining due to increased competition

with perennial grasses and mosses in places where cattle grazing has been removed and strict fire control policies have been enacted (Szczecińska et al. 2016).

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

C5a. Measured genetic variation: Somewhat Increase.
Washington populations of *Anemone patens* var. *multifida* are disjunct by 250 miles (400 km) from their nearest congeners in southeastern British Columbia. The Washington occurrences are probably genetically distinct from other populations in the Rocky Mountains due to inbreeding, genetic drift, or founder effects. Research in central Europe has shown that widely isolated populations of *A. patens* have reduced genetic diversity and high levels of inbreeding, which is likely a factor in its steep decline (Szczecińska et al. 2016). Genetic data are currently not available for Washington populations.

C5b. Genetic bottlenecks: Unknown.
Not known.

C5c. Reproductive System: Neutral.
Anemone patens var. *multifida* produces large, open, showy flowers that are pollinated by a variety of early spring generalist bees and syrphid flies. Flowers are protogynous (with stigmas being receptive before pollen is shed) to promote outcrossing, but is also capable of selfing if pollinators are unavailable. Seed germination rates are comparable under out-crossing and selfing (Bock and Peterson 1975).

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on herbarium records in the Consortium of Pacific Northwest Herbaria website (pnwherbaria.org), *Anemone patens* var. *multifida* has not changed its typical blooming time in the past 50 years.

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 *Anemone patens* var. *multifida* in Washington since it was first documented in the state in 1925.

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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