Climate Change Vulnerability Index Report

Sanicula arctopoides (Bear's-foot sanicle)

Date: 12 January 2021

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington | Heritage Rank: G5/S1

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	0
	<3.9° F (2.2°C) warmer	100
2. Hamon AET:PET moisture	< -0.119	0
	-0.097 to -0.119	0
	-0.074 to -0.096	100
	-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		Increase
2a. Distribution relative to natural barriers		Somewhat Increase
2b. Distribution relative to anthropogenic barriers		Somewhat Increase
3. Impacts from climate change mitigation		Somewhat Increase
Section C: Sensitivity and Adaptive Capacity		
1. Dispersal and movements		Neutral
2ai Change in historical thermal niche		Greatly Increase
2aii. Change in physiological thermal niche		Neutral
2bi. Changes in historical hydrological niche		Neutral
2bii. Changes in physiological hydrological niche		Somewhat Increase
2c. Dependence on specific disturbance regime		Neutral/Somewhat Increase
2d. Dependence on ice or snow-covered habitats		Neutral
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		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		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 ten of the confirmed occurrences of *Sanicula arctopoides* in Washington (100%) occur in areas with a projected temperature increase of <3.9° F (Figure 1). Two additional reports have been excluded. One is an historical record from "near Ilwaco" collected

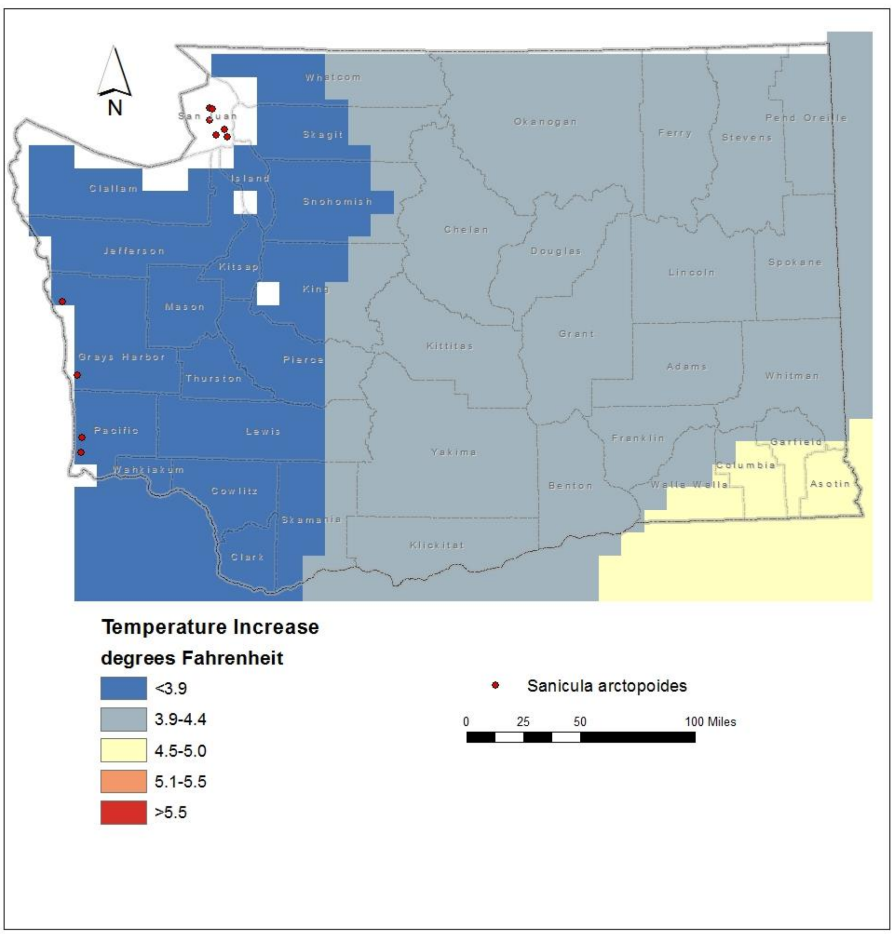

Figure 1. Exposure of *Sanicula arctopoides* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

in 1952 which has not been confirmed. The second is an iNaturalist image attributed to Cathlamet, Wahkiakum County, but with an error radius of 2500 km. (https://www.inaturalist.org/observations/21671598). The cited locality is not within the expected range of the species, and so is excluded until more precise data are available.

A2. Hamon AET:PET Moisture Metric: The ten occurrences of *Sanicula arctopoides* in Washington (100%) 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 -0.074 to -0.096 (Figure 2).

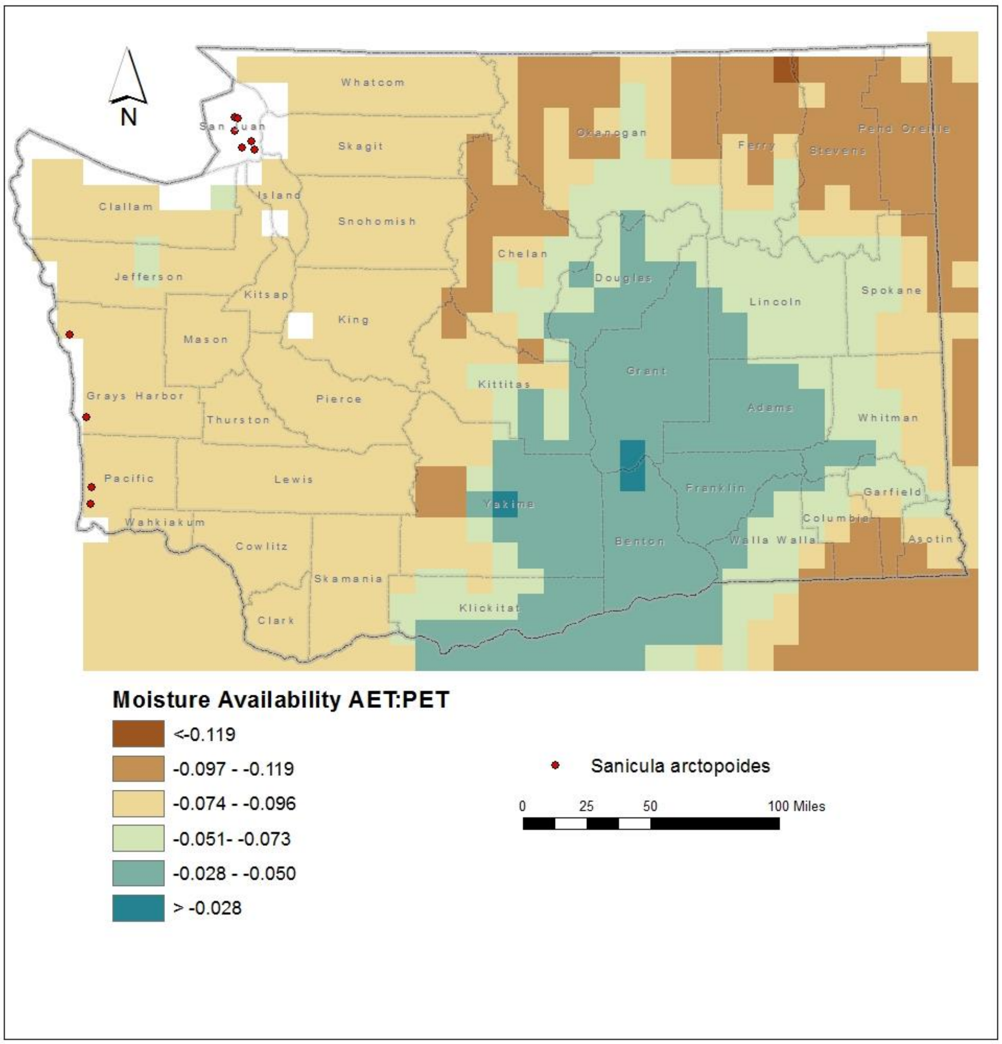

Figure 2. Exposure of *Sanicula arctopoides* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Increase.
The Washington occurrences of *Sanicula arctopoides* are found at 4-65 feet (1-20 m) and are typically within 0.5 miles (0.8 km) of the Pacific Ocean or on low-lying islands in the Salish Sea. Sea level is projected to rise by 0.5-2 m in the current century (Young et al. 2016) and could inundate at least one occurrence. At least half of the known occurrences would be impacted by storm surges or intrusions of salt water due to their proximity to the ocean and low elevation.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Sanicula arctopoides* is found mostly on coastal bluffs and grassy sand dunes near the ocean and on small islands off the coast. It has also been reported from shallow soil over bedrock and old fields at the edge of forests just above the high tide line (Camp and Gamon 2011, WNHP records). These sites conform to the North Pacific Maritime Coastal Sand Dune and Strand and North Pacific Coastal Cliff and Bluff ecological systems (Rocchio and Crawford 2015). In Canada, this species is found in Oregon white oak ecosystems on the southeast coast of Vancouver Island (COSEWIC 2015) that are analogous to the North Pacific Oak Woodland ecological system in the Puget Sound area of Washington. Individual occurrences are separated by distances of 4-100 miles (100-160 km). Potential shoreline habitat of this species is naturally patchy and occurrences may be isolated due to large blocks of unsuitable upland habitat and expanses of ocean. Migration in response to climate change will likely be somewhat limited due to these natural obstacles.

B2b. Anthropogenic barriers: Somewhat Increase.
The range of *Sanicula arctopoides* in Washington is naturally patchy, but loss of habitat has also occurred in the past 120 years due to development of shoreline sites for homes and roads. Habitat has also been lost due to efforts to manage shifting dunes and from invasion of competing vegetation. Future dispersal of this species will be constrained due to the large human footprint on coastal habitats that are already naturally fragmented.

B3. Predicted impacts of land use changes from climate change mitigation: Somewhat Increase.
The coastal bluff and shifting dune habitats of *Sanicula arctopoides* could be vulnerable to impacts from construction of sea walls or other structures to protect shoreline homes.

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Neutral.
Sanicula arctopoides produces compact umbels of dry, schizocarp fruits that split at maturity into pairs of one-seeded segments. The fruits are covered by stout, hooked bristles that catch on the fur or feathers of animals. Dried fruitstalks that break off the plant may also disperse seeds over short distances in the manner of a "tumbleweed" (COSEWIC 2015). Dispersal by birds could potentially spread fruits well over 1 km from the parent plant. Matt Fairbarns (in COSEWIC 2015), however, observed poor dispersal over short distances in seemingly suitable habitat within Canadian populations.

C2ai. Historical thermal niche: Greatly Increase.
Figure 3 depicts the distribution of *Sanicula arctopoides* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 (“historical thermal niche”). All ten occurrences (100%) are found in coastal areas that have experienced very small temperature variation (<37˚F/20.8˚C) during the past 50 years and are considered to be at greatly increased vulnerability to climate change (Young et al. 2016).

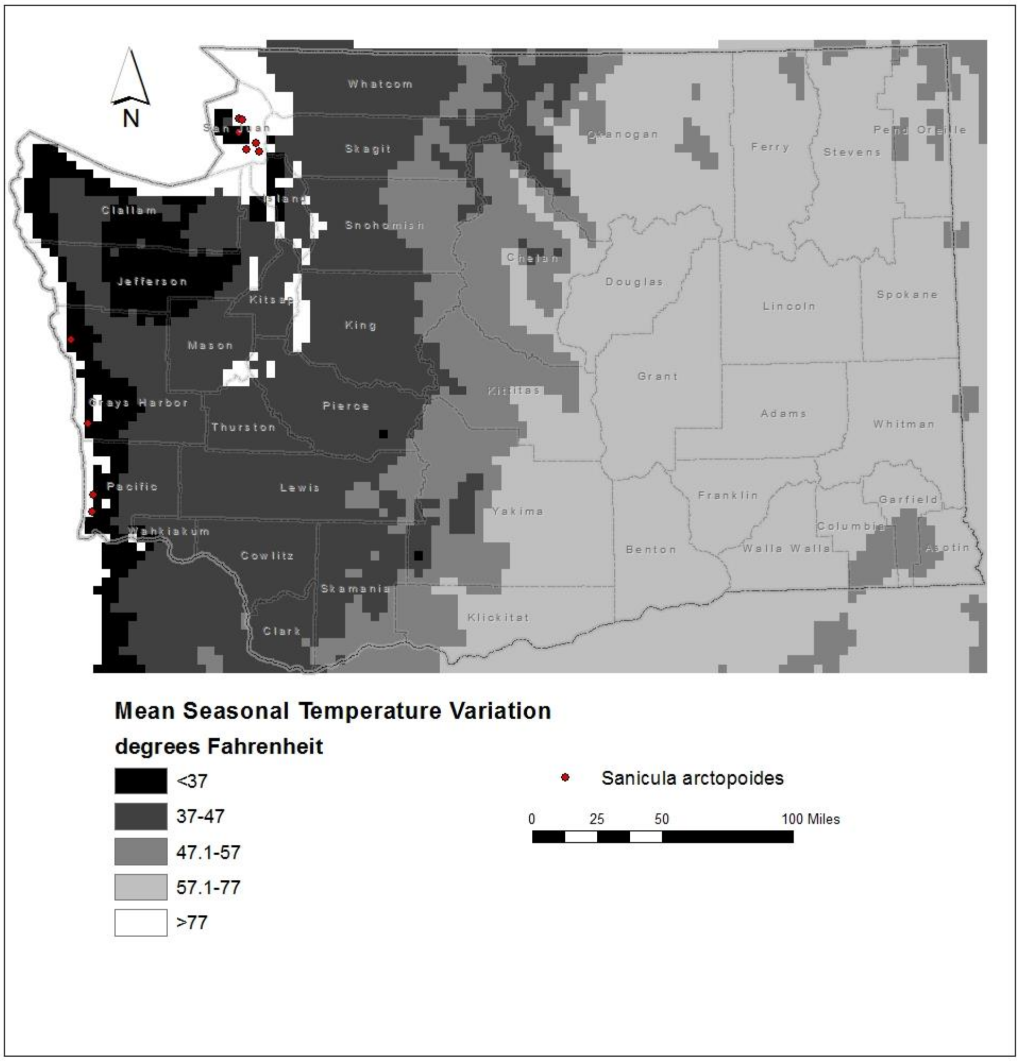

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Sanicula arctopoides* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Neutral.
The Pacific Ocean coast and San Juan Islands tend to have milder temperatures than nearby inland locations due to the moderating effect of the ocean as a heat sink. This condition has a neutral impact on climate change vulnerability.

C2bi. Historical hydrological niche: Neutral.
The six occurrences of *Sanicula arctopoides* in the San Juan Islands (60% of the state's occurrences) have experienced average (21-40 inches/533-1016 mm) precipitation variation in the past 50 years (Figure 4). The other four occurrences along the Pacific Coast (40%) have experienced greater than average precipitation variation (>40 inches/1016 mm) in the same time period. According to Young et al. (2016), all of these populations are at neutral vulnerability to climate change.

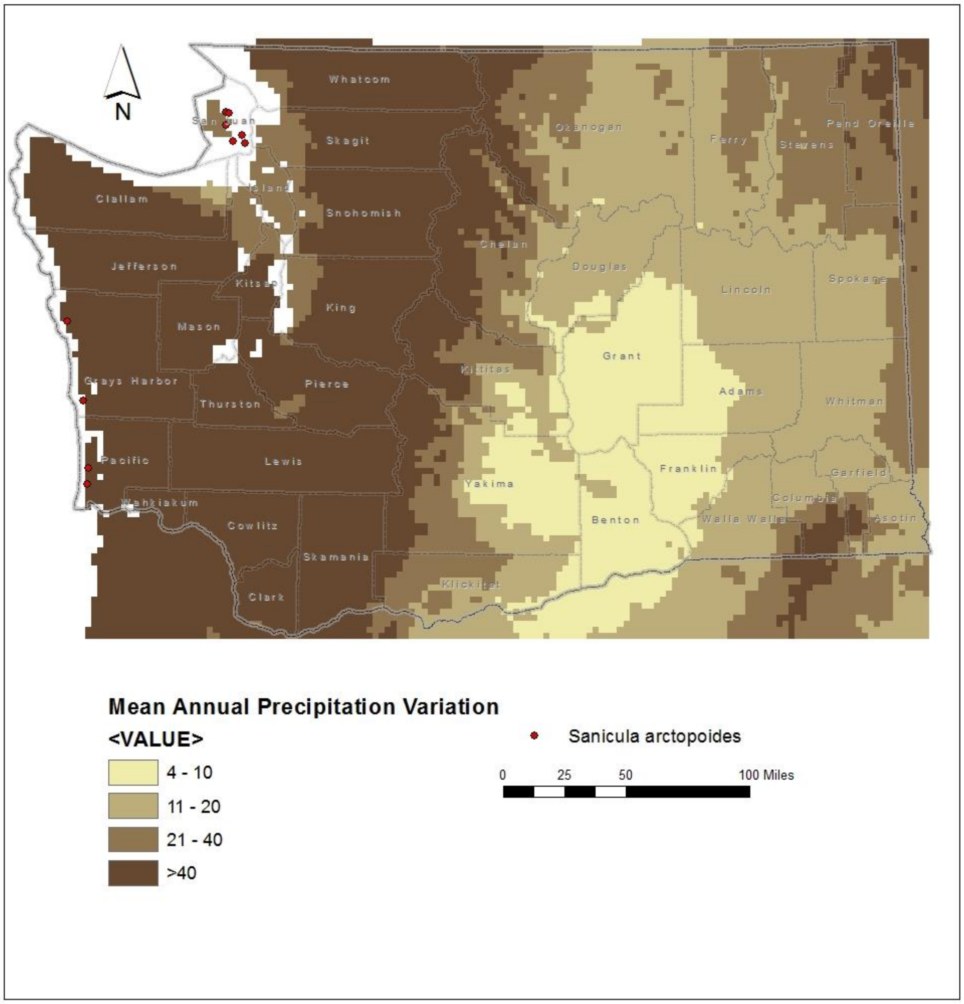

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Sanicula arctopoides* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Somewhat Increase.
This species is dependent primarily on adequate precipitation for its moisture requirements, because its habitat is typically not associated with springs or streams and soils are prone to

seasonal drought. The proximity of populations to the coast also makes them susceptible to saltwater intrusion during storm events or because of sea level rise (Rocchio and Ramm-Granberg 2017). The North Pacific Maritime Coastal Sand Dune and Strand and North Pacific Coastal Cliff and Bluff ecological systems are somewhat vulnerable to enhanced erosion from increased winter storm events. While dune sites are maintained by wind erosion, the stability of cliffs and bluffs can be decreased due to extreme weather events (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral/Somewhat Increase.
Sanicula arctopoides populations in shifting sand dune habitats along the Pacific Coast are dependent on frequent disturbance to prevent sites from becoming stabilized by meadow or woodland vegetation. Climate change may actually increase the frequency of winter storm surges and erosion that would maintain early seral conditions. These positive benefits, however, may be offset by human efforts to protect against erosion through construction (sea walls). Coastal bluff and cliff populations and those in the San Juan Islands associated with shallow soils over bedrock could be negatively impacted by increased erosion from winter storms (Rocchio and Ramm-Granberg 2017).

C2d. Dependence on ice or snow-cover habitats: Neutral.
Snowpack is low over the range of *Sanicula arctopoides* in Washington and a minimal component of its annual water budget.

C3. Restricted to uncommon landscape/geological features: Somewhat Increase.
Sanicula arctopoides is restricted to shifting sand dunes along the Pacific Coast or thin soils over basalt on maritime islands (Washington Division of Geology and Earth Resources 2016). While these rock types are not intrinsically rare, the landscape conditions under which they have formed is uncommon.

C4a. Dependence on other species to generate required habitat: Neutral.
While herbivory by ungulates, rodents, and insects can reduce invasive vegetative cover that is stabilizing dunes, frequent disturbance by wind is a more significant factor in maintaining shifting dune habitats for Pacific coast populations of *Sanicula arctopoides*.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
The specific pollinators of *Sanicula arctopoides* are poorly known in Washington. In general, members of the Apiaceae are visited by a variety of generalist pollinators, including bees, flies, and beetles.

C4d. Dependence on other species for propagule dispersal: Neutral.
The fruits of *Sanicula arctopoides* are covered in stout hooks designed to adhere to fur or feathers of a wide variety of bird or mammal species.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. Lowenberg (1994) documented that herbivory by deer early in the flowering season did not result in a loss of seed production due to compensatory flowering, but late season herbivory could reduce seed set by up to 52%. Grazing by Canada

geese is a growing threat on the Gulf Islands of Canada (COSEWIC 2015) and potentially in the San Juan archipelago in Washington (Peter Dunwiddie, personal communication 2021).

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
Populations of *Sanicula arctopoides* in shifting sand dune habitats are negatively impacted by competition from invading grassland or forest species and resulting stabilization of the dune environment.

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 *Sanicula arctopoides* in Washington.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral
Sanicula arctopoides is presumed to be an outcrosser, rather than self-pollinated. Presumably, genetic variation is average, compared to other species, but no studies have been done for confirmation.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on herbarium records from the Consortium of Pacific Northwest herbaria website and monitoring studies in Canada (COSEWIC 2015), no significant changes in the phenology of *Sanicula arctopoides* have been detected over the past 20 years.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
Abundance data are lacking for most occurrences of *Sanicula arctopoides* in Washington. At least three populations have not been relocated since 1981 and are considered historical. The only population with long term monitoring data in the state has experienced a 50% decline since 1982. Much of this decrease has been attributed to changes in vegetation cover and competition (WNHP records), rather than climate change.

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.

COSEWIC. 2015. COSEWIC assessment and status report on the Bear's-foot Sanicle *Sanicula arctopoides* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa 35 pp.

Lowenberg, G. 1994. Effects of floral herbivory on maternal reproduction in *Sanicula arctopoides* (Apiaceae). Ecology 75:359-369.

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.