Climate Change Vulnerability Index Report

*Myosurus alopecuroides* (Foxtail mousetail)

Date: 19 November 2021 | Synonym: *Myosurus clavicaulis*

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington | Heritage Rank: G3?/S2

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 | 100 |
| | <3.9° F (2.2°C) warmer | 0 |
| 2. Hamon AET:PET moisture | < -0.119 | 0 |
| | -0.097 to -0.119 | 0 |
| | -0.074 to - 0.096 | 14.3 |
| | -0.051 to - 0.073 | 42.9 |
| | -0.028 to -0.050 | 35.7 |
| | >-0.028 | 7.1 |
| **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 |
| 2ai Change in historical thermal niche | | Neutral |
| 2aii. Change in physiological thermal niche | | Neutral/Somewhat Increase |
| 2bi. Changes in historical hydrological niche | | Somewhat Increase |
| 2bii. Changes in physiological hydrological niche | | Greatly 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 | | 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 | | 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: All 14 of the known occurrences of *Myosurus alopecuroides* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

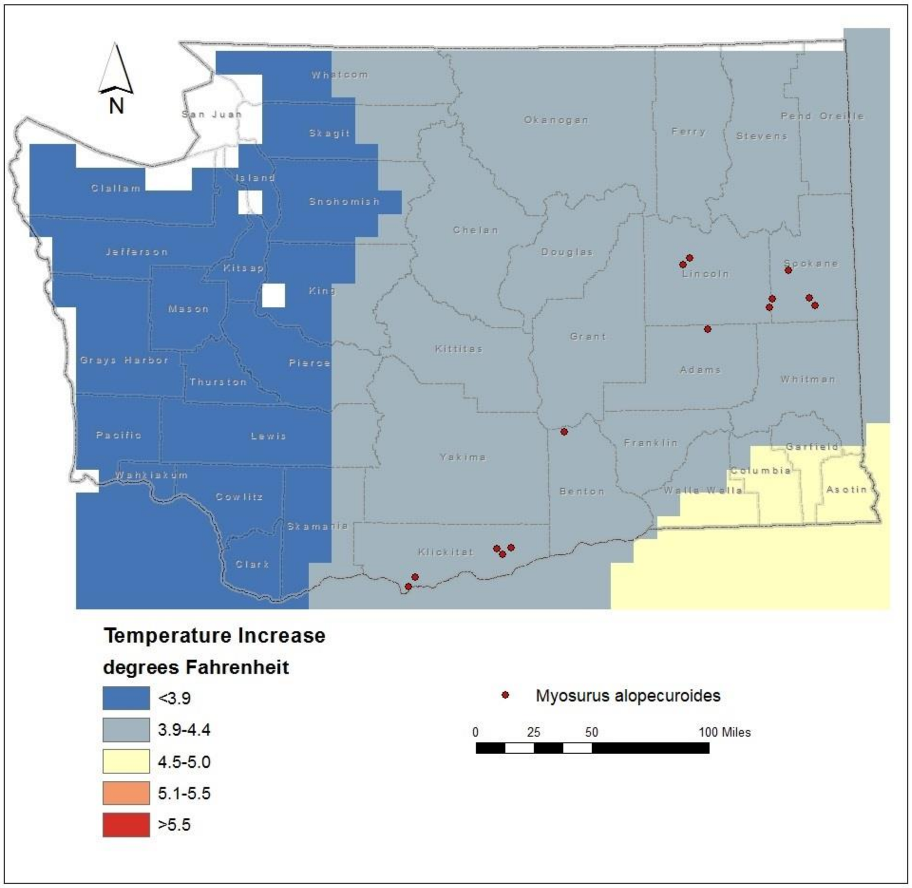


Figure 1. Exposure of *Myosurus alopecuroides* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Six of the 14 occurrences of *Myosurus alopecuroides* (42.9%) in eastern 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 -0.051 to -0.073 (Figure 2). Five occurrences from Klickitat County (35.7%) have a projected decrease of -0.028 to -0.050. Two populations from Spokane County (14.3%) are from areas with a projected decrease of -0.074 to -0.096. One occurrence (7.1%) from the central Columbia Plateau has a projected decrease of > -0.028 (Figure 2).

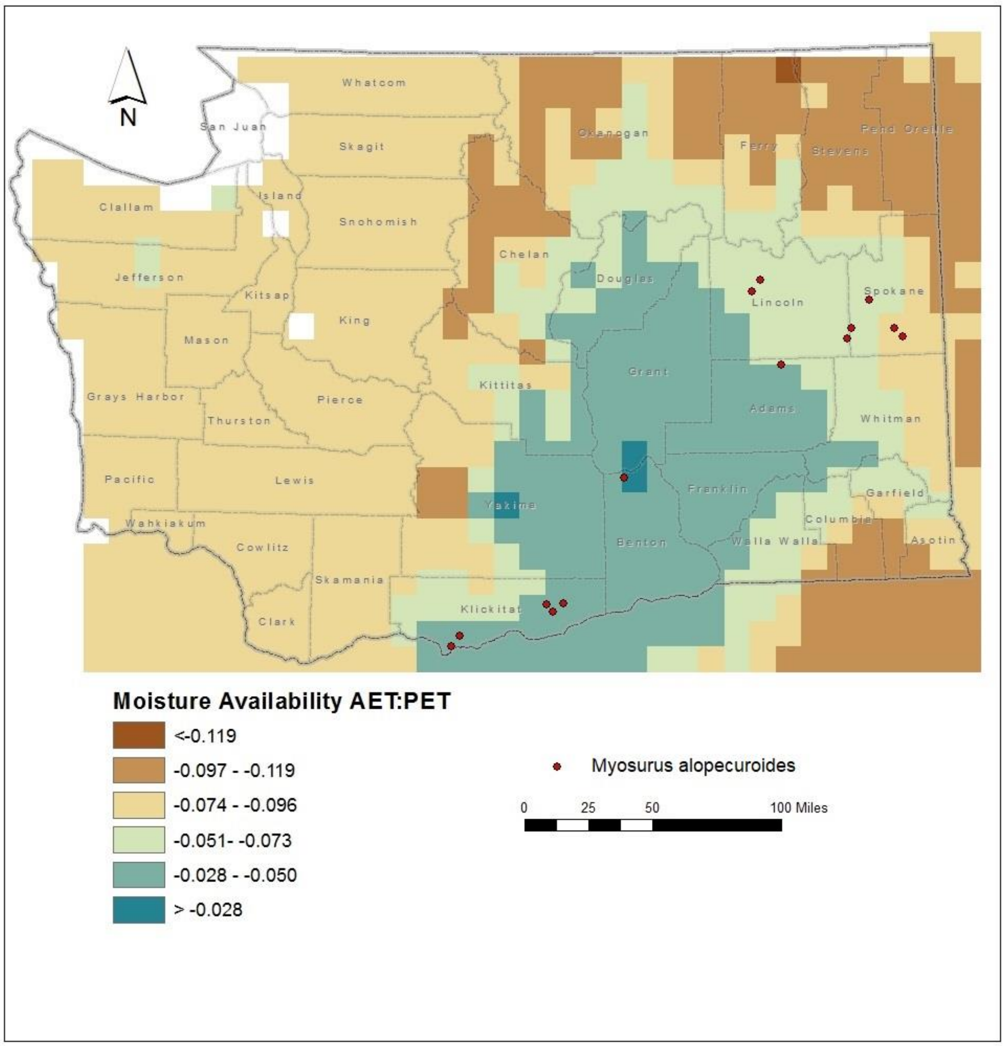


Figure 2. Exposure of *Myosurus alopecuroides* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

**Section B. Indirect Exposure to Climate Change**

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Myosurus alopecuroides* are found at 250-2500 feet (75-760 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Myosurus alopecuroides* is restricted to sparsely vegetated shallow vernal pools over clay that are flooded in spring and become dry and desiccated in summer (Camp and Gamon 2011, Washington Natural Heritage Program 2021). This habitat is part of the Columbia Plateau Vernal Pool and Modoc Basalt Flow Vernal Pool ecological systems (Rocchio and Crawford 2015). Populations are separated by 1.6-56 miles (2.3-90 km) of unoccupied and unsuitable habitat. Vernal pools are specialized landscape features embedded within a matrix of sagebrush steppe and scablands in eastern Washington that provide a barrier to dispersal.

B2b. Anthropogenic barriers: Neutral.
The vernal pool habitat of *Myosurus alopecuroides* is widely scattered and naturally sparse. Although much of the matrix landscape in which these vernal sites are embedded has been converted to agriculture, human impacts in these areas do not impose a greater impediment to migration than natural barriers.

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

**Section C: Sensitive and Adaptive Capacity**

C1. Dispersal and movements: Neutral.
*Myosurus alopecuroides* produces numerous, small, one-seeded, achene fruits that have a short, pointed beak. Fruits can become attached to mud on waterfowl or embedded in the fur or feathers of animals for long-distance transport. Carlquist (1983) notes that the related species, *Myosurus apetalus*, has a bipolar geographic range (western North America and southern Argentina) that is likely the result of long-distance dispersal mediated by migrating birds. Fruits may also disperse through water. Dispersal in *M. alopecuroides* is probably constrained by the availability of suitable habitat (other vernal pools).

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Myosurus alopecuroides* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). All 14 of the known occurrences (100%) 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).

C2aii. Physiological thermal niche: Neutral/Somewhat Increase.
The ephemeral wetland and vernal pool habitat of *Myosurus alopecuroides* is not associated with cold air drainage during the growing season. These shallow wetlands would be vulnerable to long-term persistent drought and increased temperatures during the growing season (Rocchio and Ramm-Granberg 2017).

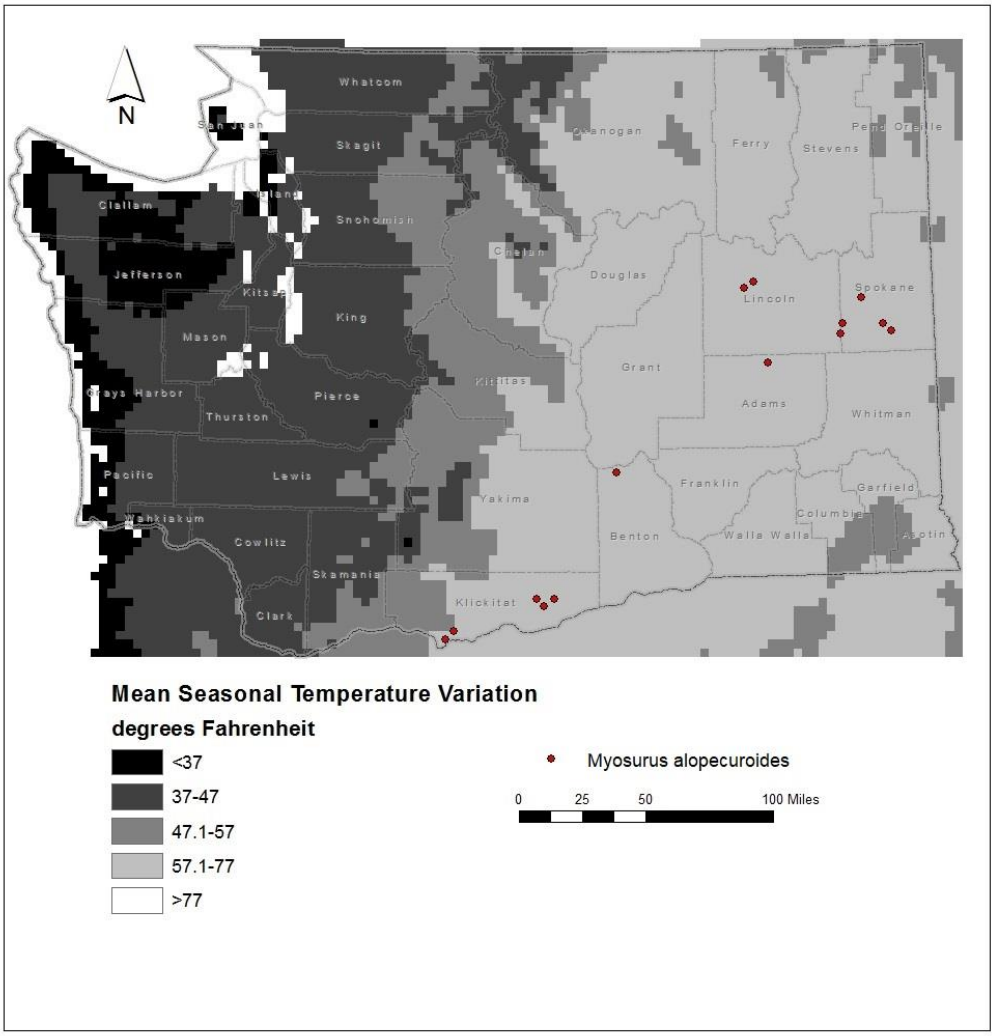


Figure 3. Historical thermal niche (exposure to past temperature variations) of *Myosurus alopecuroides* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bi. Historical hydrological niche: Somewhat Increase.
Thirteen of the 14 populations of *Myosurus alopecuroides* in Washington (92.9%) are found in areas that have experienced slightly lower than average (11-20 inches/255-508 mm) precipitation variation in the past 50 years (Figure 4). According to Young et al. (2016), these occurrences are at somewhat increased vulnerability to climate change. One population from the central Columbia Plateau is from an area with small precipitation variation (4-10 inches/100-254 mm) over the same period and is at increased risk from climate change.

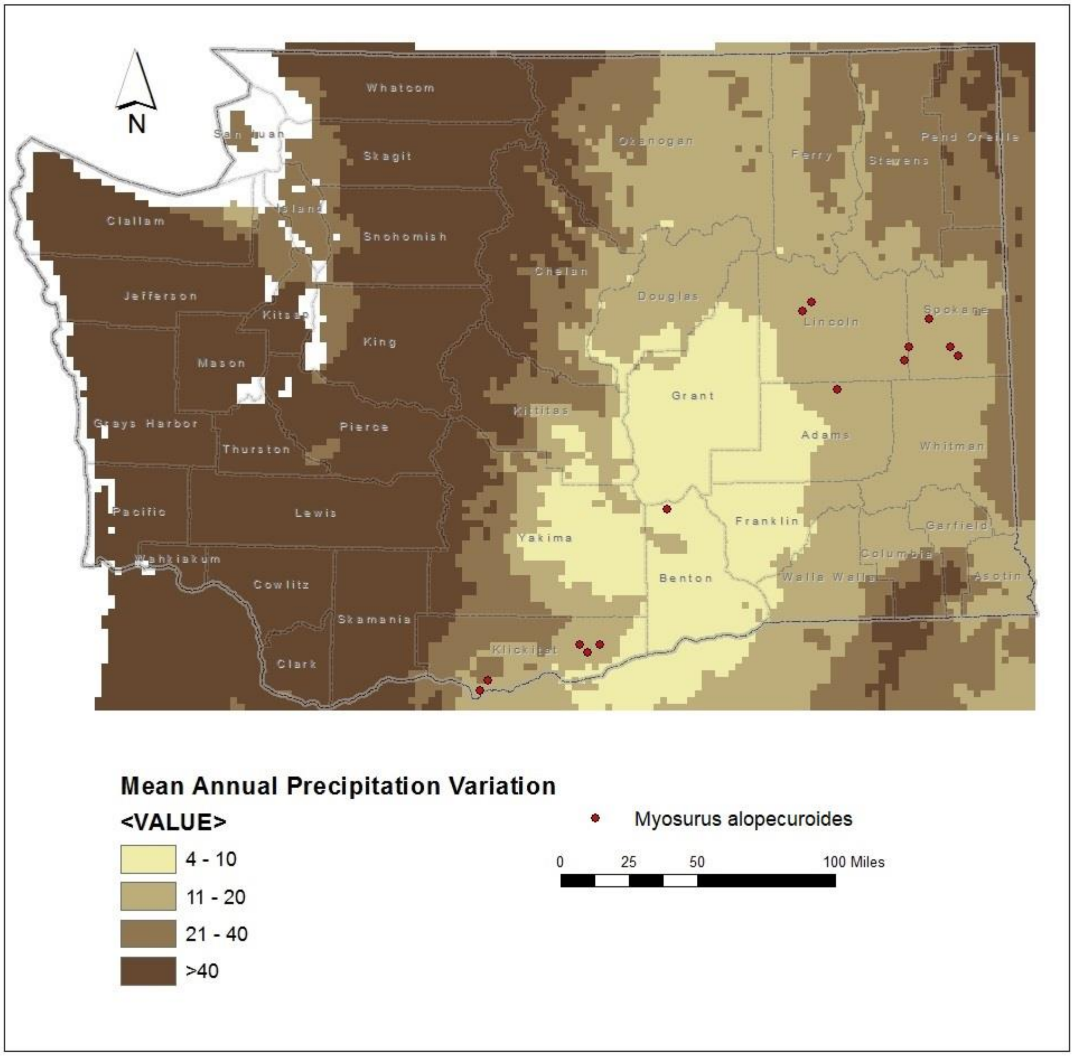


Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Myosurus alopecuroides* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Greatly Increase.
This species is strongly dependent on winter and early spring precipitation followed by summer drought to maintain its ephemeral vernal pool habitat. Under projected future climate change, winter precipitation is expected to increase, but this is likely to be offset by greater evapotranspiration from higher spring and summer temperatures (Rocchio and Ramm-Granberg 2017). Too much additional precipitation could result in permanent inundation of pools and replacement of the current flora with annuals or perennials adapted to wetter conditions. Likewise, higher rates of evapotranspiration relative to precipitation could allow

invasion by weedy upland species or conversion to drier upland plant communities (Rocchio and Ramm-Granberg 2017). Increasingly unpredictable climatic events could also be significant on this annual species that relies on a seed bank to persist through unfavorable years.

C2c. Dependence on a specific disturbance regime: Neutral.
*Myosurus alopecuroides* is not dependent on periodic disturbances to maintain its scabland and basalt tableland vernal pool habitat.

C2d. Dependence on ice or snow-cover habitats: Neutral/Somewhat Increase.
Most of the range of *Myosurus alopecuroides* in Washington is within areas with low winter snowfall, and thus drifting snow or snowmelt is a relatively minor component of the plant's annual water budget. A few populations in western Klickitat and Spokane counties are located in the transition zone towards higher elevation mountains and may receive more snow or runoff. Changes in the amount of snow or timing of its melt could affect hydrological conditions in these vernal pools (Rocchio and Ramm-Granberg 2017).

C3. Restricted to uncommon landscape/geological features: Increase.
*Myosurus alopecuroides* is restricted to shallow depressions with poor drainage in Miocene basalt beds that are deep enough to be flooded in winter and early spring, but shallow enough to become dry in late spring or summer. This species is associated with the Wanapum Basalt, which is widespread across the Columbia Plateau (Washington Division of Geology and Earth Resources 2016). Sites with the exact microsite characteristics, however, are much less widespread and may limit the ability of this species to expand its range, or constrain its response to changing hydrologic conditions due to climate change (Rocchio and Ramm-Granberg 2017).

C4a. Dependence on other species to generate required habitat: Neutral.
The vernal wetland habitat occupied by *Myosurus alopecuroides* is maintained by natural abiotic processes and geologic conditions, rather than by interactions with other species.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
*Myosurus alopecuroides* and other vernal pool species of *Myosurus* are adapted for self-pollination but also capable of out-crossing and hybridization (Stone 1959). Pollen becomes viable while flowers are still in the bud to ensure some self-fertilization. As the flower receptacle grows and elongates it can push past the reflexed sepals to expose unpollinated pistils. *Myosurus* flowers produce a small amount of nectar to attract insects that can pollinate the exposed pistils (Stone 1959). The specific pollinators of *M. alopecuroides* are not known, but based on the small size of the flowers are likely to be gnats, flies, mosquitoes, or other small Dipterans.

C4d. Dependence on other species for propagule dispersal: Neutral.
The one-seeded fruits of *Myosurus alopecuroides* may be dispersed by water, gravity, or attached to animals in mud or caught in fur or feathers by the pointed beak of the achene. *M. alopecuroides* fruits can be dispersed by a wide variety of animal species.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. The low stature of this species suggests it is not a significant forage species for most grazing animals, although flowers and fruits could be consumed by rodents or insects. Impacts from natural herbivory are probably low.

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase.
*Myosurus alopecuroides* could be sensitive to competition from other plant species (especially non-native invasive annuals) if its specialized wetland habitat were completely dried out due to climate change (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.
Data are not available on genetic diversity of *Myosurus alopecuroides* occurrences in Washington. Stone (1959) hypothesized that *M. alopecuroides* is of hybrid origin between *M. sessilis* and *M. minimus* (both 2*n* = 16) where they occur in sympatry in central California (Whittemore 1997).

C5b. Genetic bottlenecks: Unknown.
Not known.

C5c. Reproductive System: Somewhat Increase.
Genetic diversity in Washington populations of *Myosurus alopecuroides* may be lower than expected due to the prevalence of self-pollination and the hybrid origin of the species (which could reduce fecundity). Being at the northern edge of the species' range, Washington occurrences may also have lower diversity due to founder effects or genetic drift.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on herbarium records from the Consortium of Pacific Northwest herbaria website and WNHP data, *Myosurus alopecuroides* populations in Washington have not changed their flowering season since first being documented in the state in 1997 (Beck and Caplow 2006).

## Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Neutral.
No significant changes have been documented in the distribution of *Myosurus alopecuroides* in Washington in the past 30 years.

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

Beck, K.A. and F.E. Caplow. 2006. Additions to the vascular flora of Washington from a biodiversity study on the Hanford Nuclear Reservation. Madroño 53(1): 36-45.

Camp, P. and J.G. Gamon, eds. 2011. Field Guide to the Rare Plants of Washington. University of Washington Press, Seattle. 392 pp.

Carlquist, S.C. 1983. Intercontinental dispersal. Sonderbande des Naturwissenschaftlichen Vereins in Hamburg. 7: 37-47. (http://sherwincarlquist.com/pdf/Intercontinental-Dispersal_1983.pdf).

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.

Stone, D.E. 1959. A unique balanced breeding system in the vernal pool mouse-tails. Evolution 13(2): 151-174.

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

Washington Natural Heritage Program. 2021-. *Myosurus alopecuroides*. In: Field Guide to the Rare Plants of Washington. (https://fieldguide.mt.gov/wa/?species=myosurus%20alopecuroides). Accessed 19 November 2021.

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.