Climate Change Vulnerability Index Report

Nicotiana attenuata (Coyote tobacco)

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Geographic Area: Washington Heritage Rank: G4/S2

Index Result: Less 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	0
	-0.074 to - 0.096	2.6
	-0.051 to - 0.073	15.4
	-0.028 to -0.050	79.4
	>-0.028	2.6
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		Neutral
2aii. Change in physiological thermal niche		Neutral
2bi. Changes in historical hydrological niche		Somewhat Increase
2bii. Changes in physiological hydrological niche		Neutral
2c. Dependence on specific disturbance regime		Neutral
2d. Dependence on ice or snow-covered habitats		Neutral
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/Neutral
4g. Forms part of an interspecific interaction not covered above		Neutral
5a. Measured genetic diversity		Neutral
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	Somewhat Increase
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 39 of the extant and historical occurrences of *Nicotiana attenuata* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

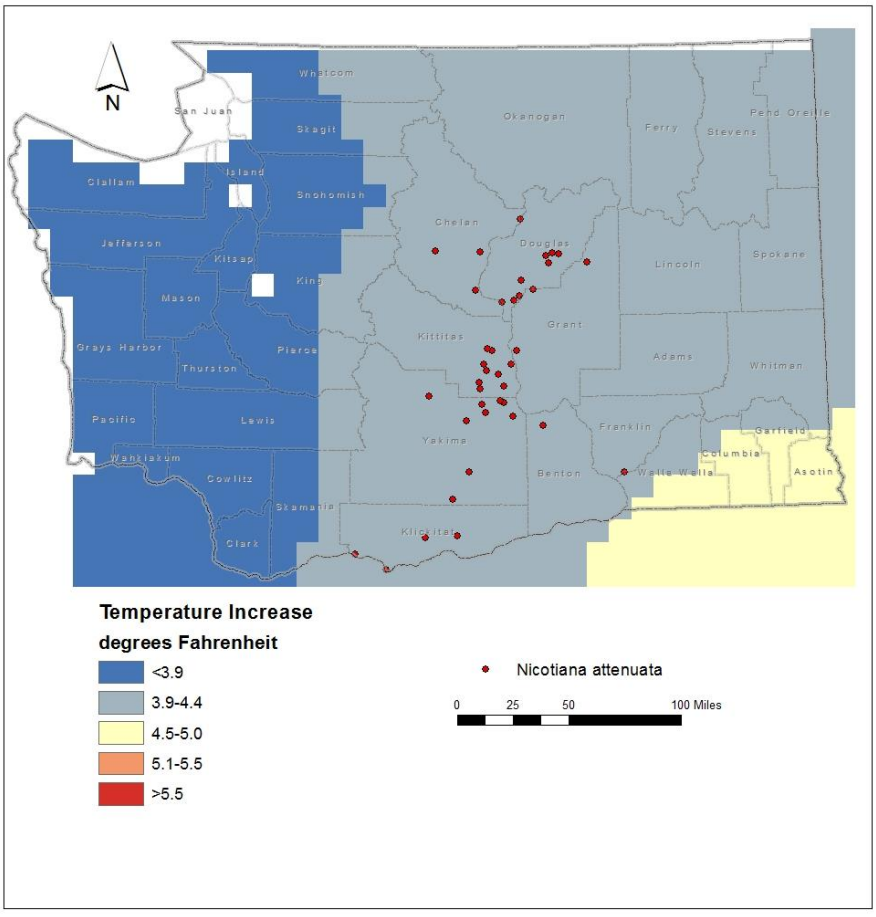

Figure 1. Exposure of *Nicotiana attenuata* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Thirty-one of the 39 occurrences of *Nicotiana attenuata* (79.4%) 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 --0.028 to -0.050 (Figure 2). Six populations (15.4%) are from areas with a projected decrease in the range of -0.051 to -0.073. One occurrence (2.6%) is from an area with a predicted decrease in the range of -0.074 to -0.096 and one other (2.6%) has a projected decrease of > -0.028 (Figure 2).

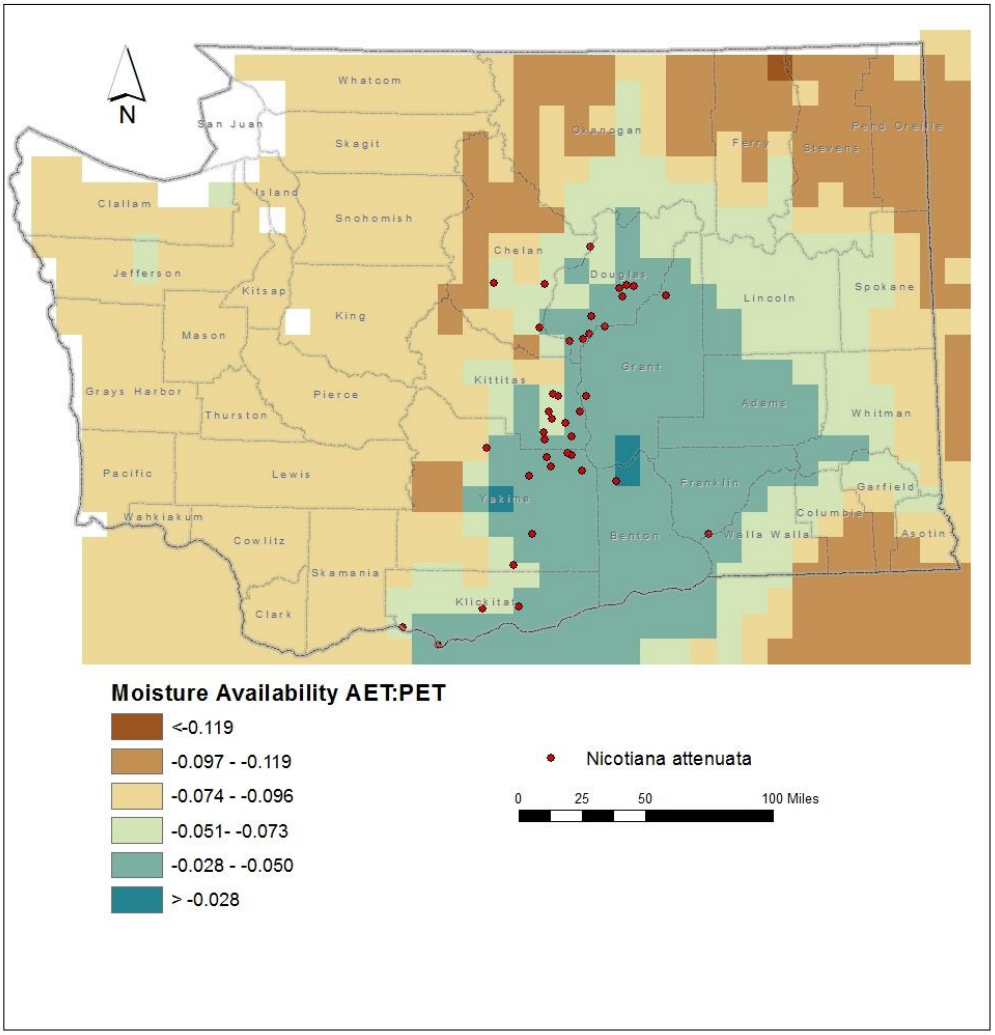

Figure 2. Exposure of *Nicotiana attenuata* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Nicotiana attenuata* are found at 320-2640 feet (100-800 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Nicotiana attenuata* occurs in open or disturbed areas within big sagebrush (*Artemisia tridentata*) communities on sandy bottoms, rocky washes, or roadsides (Camp and Gamon 2011, Fertig and Kleinknecht 2020). This species is strongly associated with fire and may remain abundant up to three years following wildfire, and then persist for 30-150 years in the seedbank until the next fire (Preston and Baldwin 1999). The habitat occupied by *N. attenuata* conforms with the Inter-Mountain Basins Wash and Inter-Mountain Basins Big Sagebrush Steppe ecological systems (Rocchio and Crawford 2015). Washington populations often consist of a series of subpopulations separated by less than 0.1 miles. Other populations may be up to 22 miles (35 km) apart. Potential habitat for this species is relatively widespread in central Washington but fragmented by natural and anthropogenic barriers. Of the two, natural barriers may be more important, as anthropogenic disturbances may actually increase habitat along disturbed roadsides (areas that historically would not have been suitable).

B2b. Anthropogenic barriers: Neutral.
The range of *Nicotiana attenuata* is naturally fragmented. Human impacts on the landscape of have contributed to this condition, but overall may be of less significance because anthropogenic disturbances have created open conditions along roadsides favorable to this early seral species.

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

Section C: Sensitive and Adaptive Capacity

C1. Dispersal and movements: Somewhat Increase.
Nicotiana attenuata produces numerous small, unornamented seeds in dry fruit capsules that split open to release the seeds passively by wind or gravity. Dispersal distances are probably variable, with most seed landing near the parent plant, and some seed traveling 100-1000m. Once dispersed, long-term seed dormancy and persistence of the seedbank may be critical for establishing populations after wildfire (Preston and Baldwin 1999).

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Nicotiana attenuata* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Thirty-four of the 39 occurrences (87.2%) 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). Five other populations (12.8%) have had slightly lower than average (47.1-57˚F/26.3-31.8˚C) temperature variation during the same period and are considered at somewhat increased vulnerability to climate change.

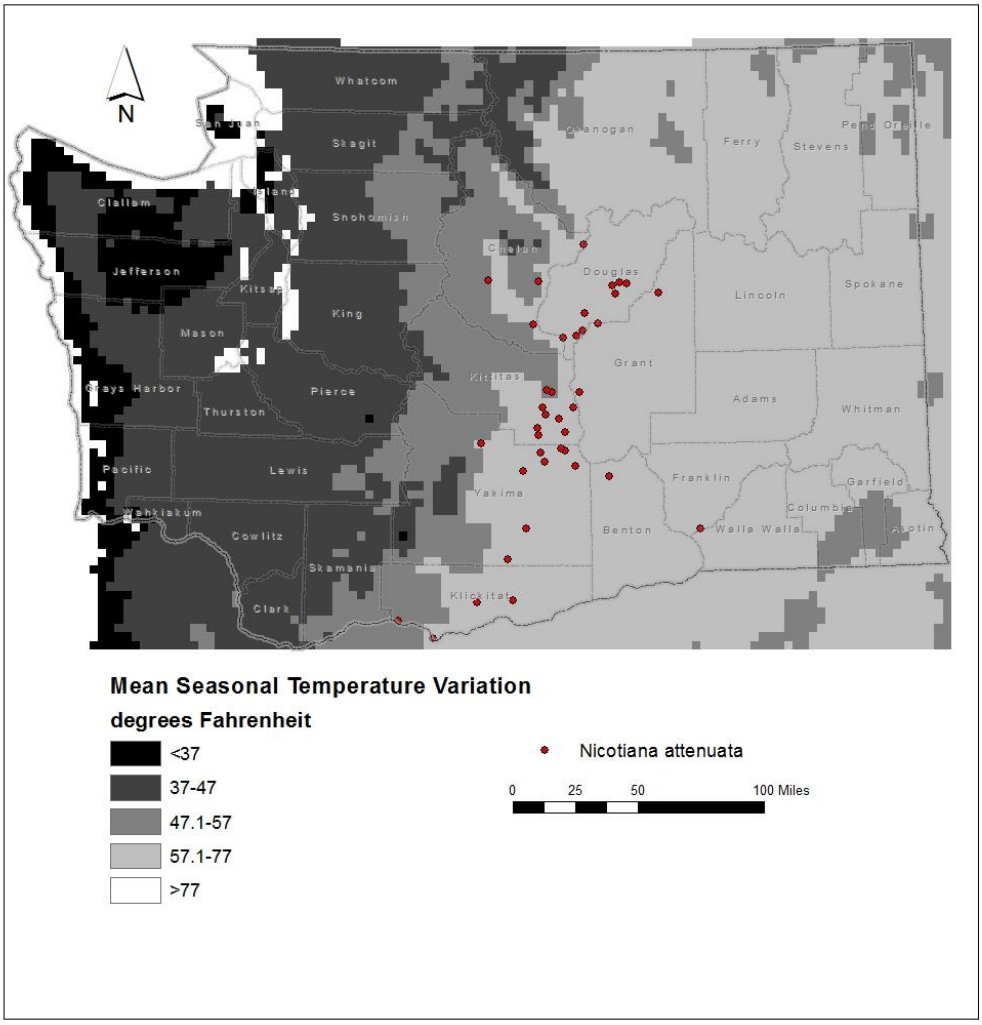

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Nicotiana attenuata* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Neutral.
The disturbed sagebrush habitat of *Nicotiana attenuata* in central Washington is not associated with cold air drainage during the growing season and would have neutral vulnerability to climate change.

C2bi. Historical hydrological niche: Somewhat Increase.
Twenty-three of the 39 populations of *Nicotiana attenuata* in Washington (59%) 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. Thirteen populations (33.3%) have experienced small (4-10 inches/100-254 mm) precipitation variation over the same period and are at increased vulnerability (Figure 4). Three other occurrences (7.7%) have experienced average (>20 inches/508 mm) precipitation variation and are at neutral vulnerability.

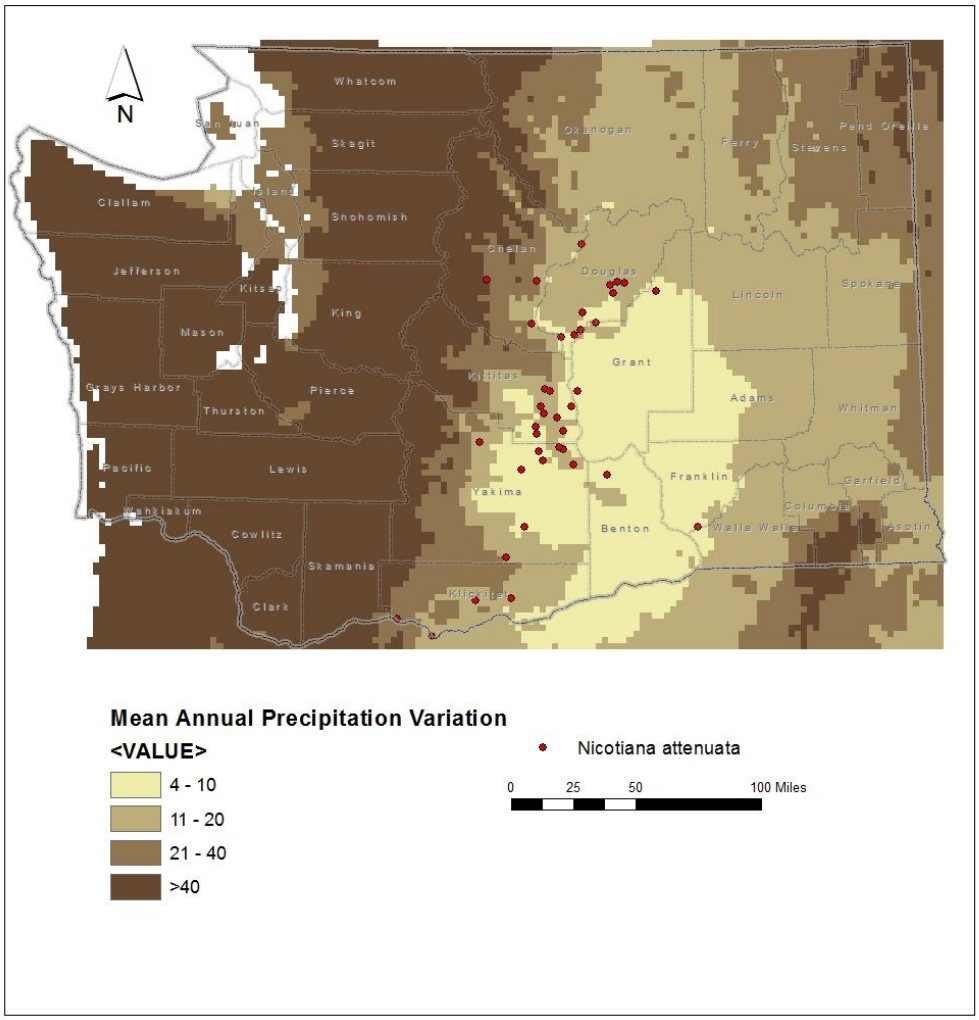

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Nicotiana attenuata* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Neutral.
Nicotiana attenuata populations occur in disturbed openings in Big sagebrush steppe and seasonally dry wash bottoms. These areas are dependent on spring and summer precipitation and could be impacted by changes in the timing and amount of rainfall and higher temperatures, which in turn could make the habitats more prone to wildfire (Rocchio and Ramm-Granberg 2017). As *N. attenuata* is adapted to wildfire for seed germination and short-term abundance (before leaving more seed in the seedbank for future disturbances; Preston and Baldwin 1999), this species might actually benefit from projected climate change.

C2c. Dependence on a specific disturbance regime: Neutral.
Nicotiana attenuata is positively associated with periodic wildfires to create suitable open habitat and requires chemicals in smoke to break seed dormancy (Preston and Baldwin 1999). In the absence of climate change, reduction in the frequency of fire would be considered a negative impact on this species. Increased drought and higher temperatures, however, are likely to increase the frequency of wildfire and could open up additional habitat for *N. attenuata*, provided there is a seedbank available in or near burned areas (augmentation by seeding might be beneficial in some areas as a conservation measure).

C2d. Dependence on ice or snow-cover habitats: Neutral.
Snowpack is low in the areas occupied by *Nicotiana attenuata*.

C3. Restricted to uncommon landscape/geological features: Neutral.
Populations of *Nicotiana attenuata* occur primarily on outcrops of the Grande Ronde and Wanapum basalt and Quaternary alluvium, both common geologic formations in central Washington.

C4a. Dependence on other species to generate required habitat: Neutral.
The disturbed, open sagebrush habitat occupied by *Nicotiana attenuata* is maintained by natural abiotic processes (primarily fire), rather than by interactions with other species.

C4b. Dietary versatility: Not applicable for plants

C4c. Pollinator versatility: Neutral.
Nicotiana attenuata is self-fertile and is primarily self-pollinated, but it can also be pollinated by hawkmoths in the genera *Hyles* and *Manduca* (Sime and Baldwin 2003), which promotes out-crossing and increases genetic diversity.

C4d. Dependence on other species for propagule dispersal: Neutral.
Seed dispersal in *Nicotiana attenuata* is probably by wind, gravity, or other passive means. The species is not dependent on animals for dispersal.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. *Nicotiana attenuata* is consumed by at least 20 different herbivores, but the degree of herbivory varies depending on the plant's ability to rapidly produce anti-herbivory compounds, such as nicotine (Baldwin 2001).

C4f. Sensitivity to competition from native or non-native species: Somewhat Increase/Neutral.
Nicotiana attenuata is most abundant in areas that are frequently disturbed by wildfire or human impacts, such as blading roads (Baldwin 2001; Fertig and Kleinknect 2020). In the absence of disturbance, it is quickly outcompeted by other native or introduced plant species, and may become absent from a site within three years (Preston and Baldwin 1999). Increased drought and higher temperatures due to climate change is likely to increase disturbances such as fire, which would potentially counteract effects of secondary succession (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: Neutral.
Data are not available on the genetic diversity of this species in Washington. Studies elsewhere in western North America have found relatively low genetic variation between populations (populations are homogeneous), but high genetic divergence within populations (Bahulikar et al. 2004). The authors attribute this to multiple generations of seeds being available in the seed bank and strong natural selection on cohorts of germinating plants following wildfire.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral
Nicotiana attenuata is primarily a selfer, but 3-24% of seed can be produced from pollination by hawkmoths (Sime and Baldwin 2003).

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on WNHP and Consortium of Pacific Northwest Herbaria records, the flowering season of this species has not changed significantly since records were first available in the late 19th Century.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Somewhat Increase.
The range of *Nicotiana attenuata* has contracted since the mid-20th Century, with populations in the foothills of the East Cascades and in southeastern Washington no longer extant (Gamon and Camp 2011; WNHP records, Consortium of Pacific Northwest Herbaria records).

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

Bahulikar, R.A., D. Stanculescu, C.A. Preston, and I.T. Baldwin. 2004. ISSR and AFLP analysis of the temporal and spatial population structure of the post-fire annual, *Nicotiana attenuata*, in SW Utah. BMC Ecology 4, 12 (2004). https://doi.org/10.1186/1472-6785-4-12.

Baldwin, I.T. 2001. An ecologically motivated analysis of plant-herbivore interactions in native tobacco. Plant Physiology 127:1449-1458.

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. and J. Kleinknecht. 2020. Conservation status and protection needs of priority plant species in the Columbia Plateau and East Cascades ecoregions. Natural Heritage Report 2020-02. Washington Natural Heritage Program, WA Department of Natural Resources, Olympia, WA. 173 pp.

Preston, C.A. and I.T. Baldwin. 1999. Positive and negative signals regulate germination in the post-fire annual, *Nicotiana attenuata*. Ecology 80(2): 481-494.

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.

Sime, K.R. and I.T. Baldwin. 2003. Opportunistic out-crossing in *Nicotiana attenuata* (Solanaceae), a predominantly self-fertilizing native tobacco. BMC Ecology 3, 6 (2003). https://doi.org/10/1186/1472-6785-3-6.

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.