Climate Change Vulnerability Index Report

Pediocactus nigrispinus (Snowball cactus)

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Geographic Area: Washington Heritage Rank: G4/S2

Index Result: Moderately 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	5.55
	-0.051 to - 0.073	5.55
	-0.028 to -0.050	88.9
	>-0.028	0
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		Increase
2bii. Changes in physiological hydrological niche		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/Somewhat Increase
4e. Sensitivity to pathogens or natural enemies		Neutral
4f. Sensitivity to competition from native or non-native species		Neutral
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	
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 36 of the occurrences of *Pediocactus nigrispinus* in Washington (100%) occur in areas with a projected temperature increase of 3.9-4.4˚ F (Figure 1).

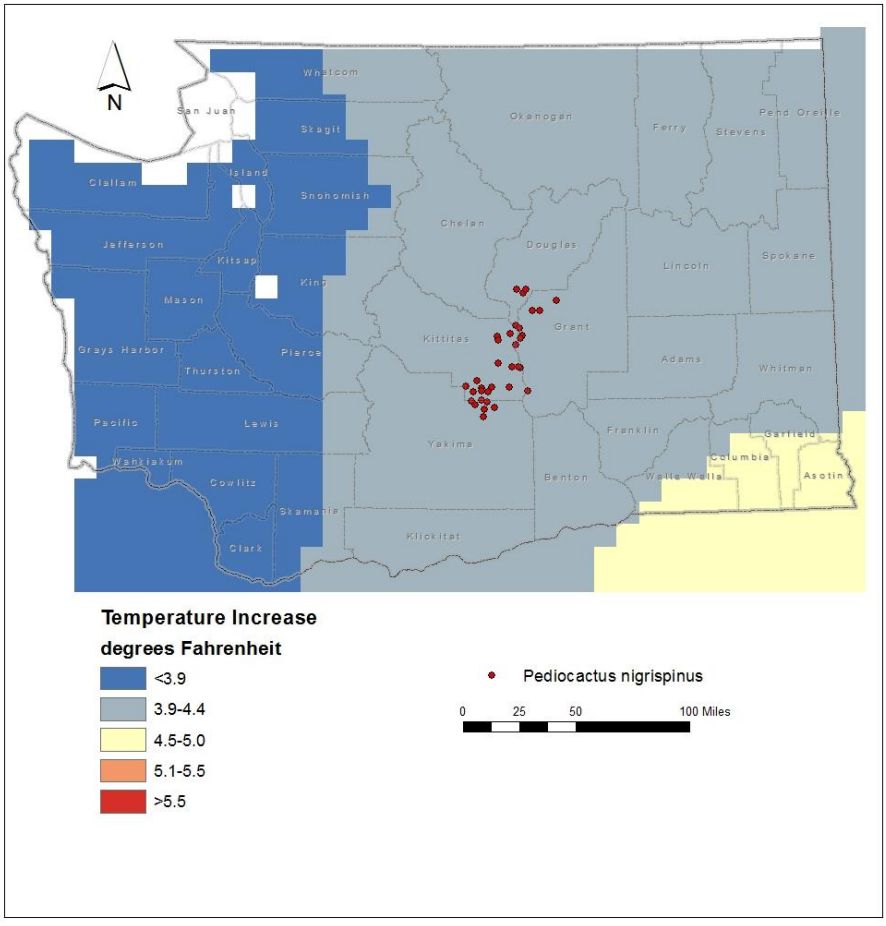

Figure 1. Exposure of *Pediocactus nigrispinus* occurrences in Washington to projected local temperature change. Base map layers from www.natureserve.org/ccvi

A2. Hamon AET:PET Moisture Metric: Thirty-two of the 36 occurrences of *Pediocactus nigrispinus* (88.9%) 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 -0.028 to -0.050 (Figure 2). Two populations (5.55%) are from areas with a projected decrease in the range of -0.051 to -0.073 and two others (5.55%) are from areas with a predicted decrease of -0.074 to -0.096 (Figure 2).

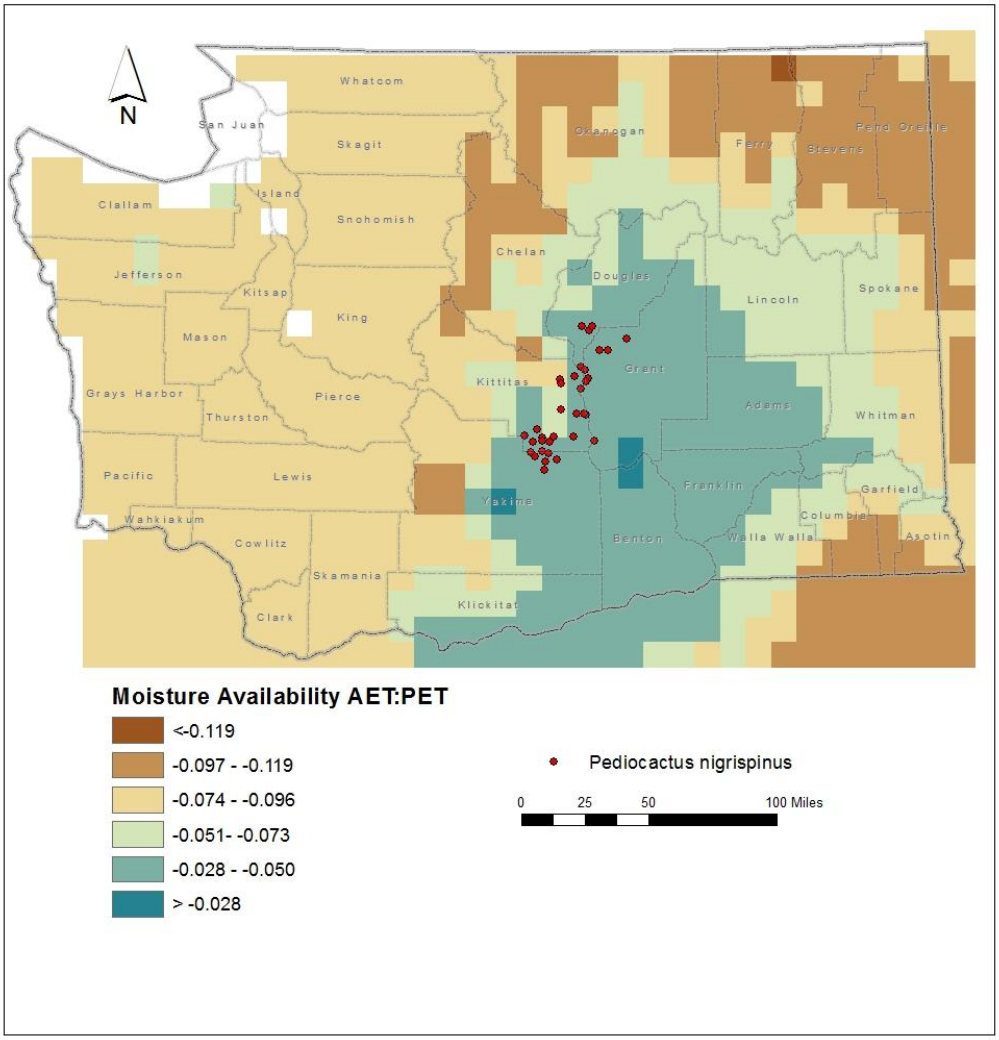

Figure 2. Exposure of *Pediocactus nigrispinus* occurrences in Washington to projected moisture availability (based on ratio of actual to predicted evapotranspiration). Base map layers from www.natureserve.org/ccvi

Section B. Indirect Exposure to Climate Change

B1. Exposure to sea level rise: Neutral.
Washington occurrences of *Pediocactus nigrispinus* are found at 600-4000 feet (200-1200 m) and would not be inundated by projected sea level rise.

B2a. Natural barriers: Somewhat Increase.
In Washington, *Pediocactus nigrispinus* occurs on basalt outcrops and slopes in scabland areas with thin soil or gravelly lithosols. These sites are usually dominated by *Artemisia rigida* or *Artemisia tridentata* with *Eriogonum thymoides, Poa secunda*, and *Pseudoroegneria spicata* (Bockelman 2020, Fertig and Kleinknecht 2020, WNHP 2005). This habitat conforms with the Columbia Plateau Scabland Shrubland ecological system (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 8 miles (13 km) apart. The areas occupied by this species are isolated primarily by natural barriers.

B2b. Anthropogenic barriers: Neutral.
The range of *Pediocactus nigrispinus* is naturally fragmented. Human impacts on the landscape of central Washington have contributed to this condition, but overall are of less significance 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: Somewhat Increase.
Pediocactus nigrispinus produces berry-like fruits with multiple small seeds that are released passively as the fruit dries at maturity. Ants have been observed transporting seeds and storing them underground (Bockelmann 2020). Dispersal distances are probably relatively short (100-1000 m at most).

C2ai. Historical thermal niche: Neutral.
Figure 3 depicts the distribution of *Pediocactus nigrispinus* in Washington relative to mean seasonal temperature variation for the period from 1951-2006 ("historical thermal niche"). Thirty-four of the 36 occurrences (94.4%) 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). Two other populations (5.6%) 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.

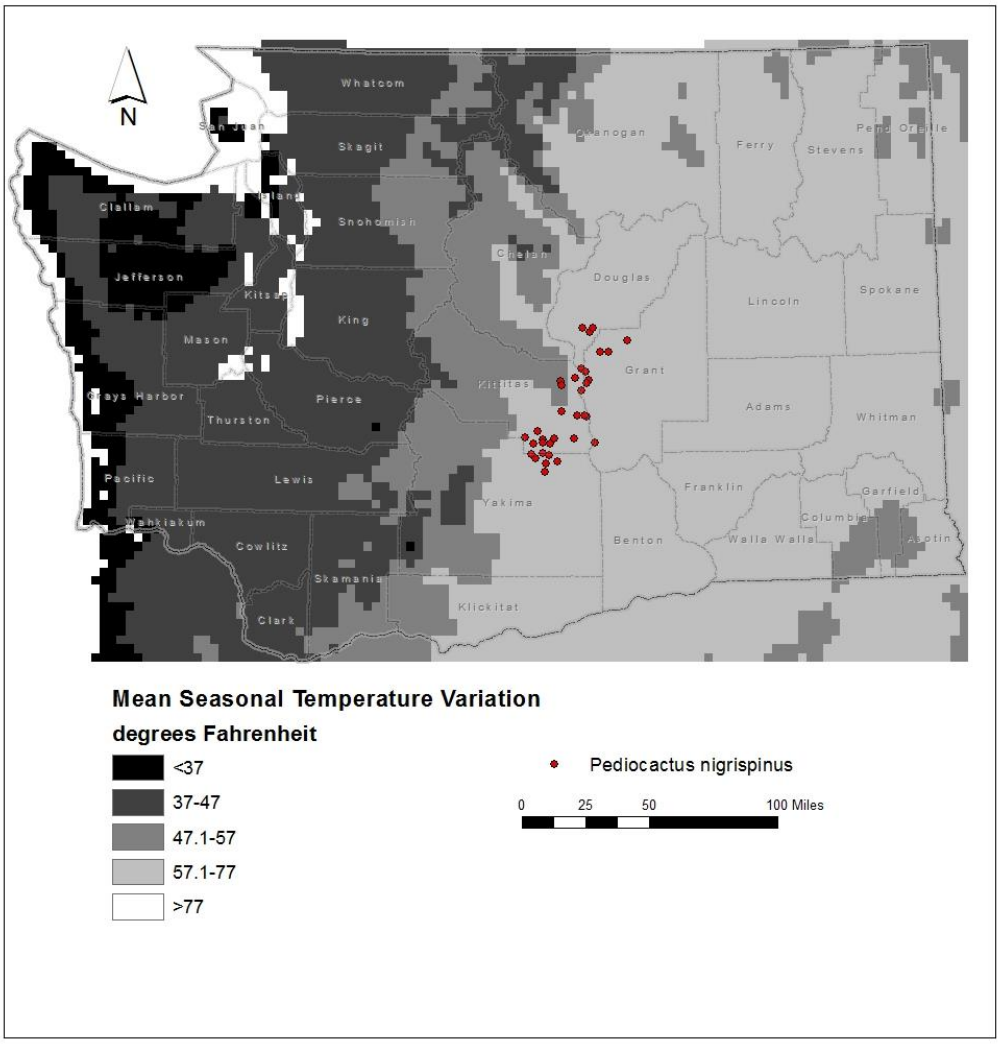

Figure 3. Historical thermal niche (exposure to past temperature variations) of *Pediocactus nigrispinus* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2aii. Physiological thermal niche: Neutral.

The basalt ridge and sagebrush steppe habitat of *Pediocactus nigrispinus* is not associated with cold air drainage during the growing season and would have neutral vulnerability to climate change.

C2bi. Historical hydrological niche: Increase.
Twenty-five of the 36 populations of *Pediocactus nigrispinus* in Washington (69.4%) are found in areas that have experienced small (4-10 inches/100-254 mm) precipitation variation in the past 50 years (Figure 4). According to Young et al. (2016), these occurrences are at increased vulnerability to climate change. Nine other populations (25%) have experienced slightly lower than average (11-20 inches/255-508 mm) precipitation variation over the same period and are at somewhat increased vulnerability (Figure 4), while two occurrences (5.6%) have experienced average (>20 inches/508 mm) precipitation variation and are at neutral vulnerability.

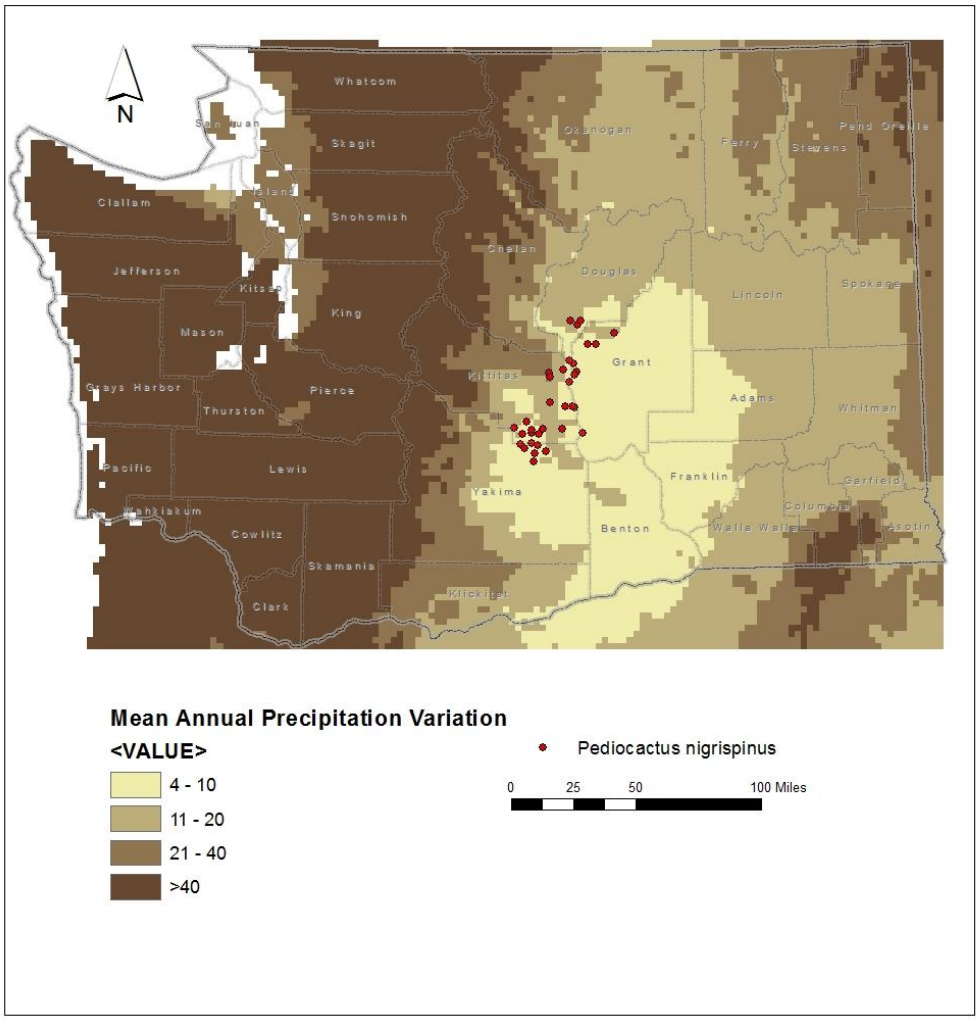

Figure 4. Historical hydrological niche (exposure to past variations in precipitation) of *Pediocactus nigrispinus* occurrences in Washington. Base map layers from www.natureserve.org/ccvi

C2bii. Physiological hydrological niche: Increase.
Pediocactus nigrispinus populations occur on scabland lithosol ridges and slopes in areas without springs, streams, or a high water table. These sites are dependent on winter snow and fall and spring precipitation for a large proportion of their yearly water budget. Changes in the timing of snowmelt or the amount of precipitation could make these sites drier in the future and subject to displacement by lichens or invasive annuals (Rocchio and Ramm-Granberg 2017).

C2c. Dependence on a specific disturbance regime: Neutral.
Pediocactus nigrispinus occurs in areas that are sparsely vegetated due to shallow soils, freeze-thaw, and summer drought. These areas are not dependent on episodic disturbances, such as wildfire, for perpetuation.

C2d. Dependence on ice or snow-cover habitats: Neutral/Somewhat Increase.
Bockelman (2020) notes that *Pediocactus nigrispinus* tends to be most abundant in areas where winter snowdrifts are present and provide supplemental moisture in the spring after they melt. Overall, snow cover is low in this plant's habitat in central Washington.

C3. Restricted to uncommon landscape/geological features: Neutral.
Pediocactus nigrispinus occurs primarily on outcrops of the Miocene-age Grande Ronde and Wanapum basalt, Quaternary alluvium, and Pleistocene Lake Missoula flood deposits, all of which are common geologic formations in central Washington.

C4a. Dependence on other species to generate required habitat: Neutral.
The scabland shrubland habitat occupied by *Pediocactus nigrispinus* 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.
Pediocactus nigrispinus is pollinated primarily by small sweat bees (Bockelman 2020). The large flowers with numerous stamens are unspecialized and could potentially be pollinated by many insect species.

C4d. Dependence on other species for propagule dispersal: Neutral/Somewhat Increase.
Dried fruits of *Pediocactus nigrispinus* split open at maturity to release numerous small seeds. Dispersal can be augmented by ants, which carry seeds to their underground nests for food (some seeds are not eaten and become planted by the ants) (Bockelman 2020). Seed may also be transported passively by wind or gravity.

C4e. Sensitivity to pathogens or natural enemies: Neutral.
Impacts from pathogens are not known. This species is not vulnerable to herbivory, but could be impacted by trampling.

C4f. Sensitivity to competition from native or non-native species: Neutral.
Pediocactus nigrispinus occurs in sparsely vegetated lithosol ridges and slopes with low cover or competition from other plant species. Climate change and increased fire frequency could shift the species composition towards invasive annual species (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 the genetic diversity of this species in Washington.

C5b. Genetic bottlenecks: Unknown.

C5c. Reproductive System: Neutral
Pediocactus nigrispinus is probably an obligate outcrosser and likely to have moderate amounts of genetic diversity. Washington populations are isolated from those in Oregon and Idaho and might be expected to be diverging genetically.

C6. Phenological response to changing seasonal and precipitation dynamics: Neutral.
Based on WNHP and Consortium of Pacific Northwest Herbaria records, no changes have been detected in phenology in recent years.

Section D: Documented or Modeled Response to Climate Change

D1. Documented response to recent climate change: Somewhat Increase.
The range of *Pediocactus nigrispinus* has contracted, with three disjunct occurrences from south-central Yakima County not being relocated for more than 40 years and possibly extirpated. Whether this absence is due to climate change, local exploitation, or is an artifact of incomplete survey is not known.

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

Bockelman, R. 2020. *Pediocactus nigrispinus* – Washington's only ball cactus. Douglasia 44(1): 2.

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.

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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.