**Climate Change Vulnerability Index Report**

*Pediocactus nigrispinus* (Snowball cactus)

Date: 18 April 2020

Assessor: Walter Fertig, WA Natural Heritage Program

Geographic Area: Washington

Heritage Rank: G4/S2

Index Result: Moderately Vulnerable

Confidence: Very High

### Climate Change Vulnerability Index Scores

<table>
<thead>
<tr>
<th>Section A</th>
<th>Severity</th>
<th>Scope (% of range)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Temperature Severity</strong></td>
<td>&gt;6.0° F (3.3°C) warmer</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5.6-6.0° F (3.2-3.3°C) warmer</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5.0-5.5° F (2.8-3.1°C) warmer</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4.5-5.0° F (2.5-2.7°C) warmer</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3.9-4.4° F (2.2-2.4°C) warmer</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>&lt;3.9° F (2.2°C) warmer</td>
<td>0</td>
</tr>
<tr>
<td><strong>2. Hamon AET:PET moisture</strong></td>
<td>&lt; -0.119</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>-0.097 to -0.119</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>-0.074 to -0.096</td>
<td>5.55</td>
</tr>
<tr>
<td></td>
<td>-0.051 to - 0.073</td>
<td>5.55</td>
</tr>
<tr>
<td></td>
<td>-0.028 to -0.050</td>
<td>88.9</td>
</tr>
<tr>
<td></td>
<td>&gt;=-0.028</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section B</th>
<th>Effect on Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Sea level rise</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>2a. Distribution relative to natural barriers</strong></td>
<td>Somewhat Increase</td>
</tr>
<tr>
<td><strong>2b. Distribution relative to anthropogenic barriers</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>3. Impacts from climate change mitigation</strong></td>
<td>Neutral</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section C</th>
<th>Effect on Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Dispersal and movements</strong></td>
<td>Somewhat Increase</td>
</tr>
<tr>
<td><strong>2ai. Change in historical thermal niche</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>2a(ii). Change in physiological thermal niche</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>2bi. Changes in historical hydrological niche</strong></td>
<td>Increase</td>
</tr>
<tr>
<td><strong>2bii. Changes in physiological hydrological niche</strong></td>
<td>Increase</td>
</tr>
<tr>
<td><strong>2c. Dependence on specific disturbance regime</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>2d. Dependence on ice or snow-covered habitats</strong></td>
<td>Neutral/Somewhat Increase</td>
</tr>
<tr>
<td><strong>3. Restricted to uncommon landscape/geological features</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>4a. Dependence on others species to generate required habitat</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>4b. Dietary versatility</strong></td>
<td>Not Applicable</td>
</tr>
<tr>
<td><strong>4c. Pollinator versatility</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>4d. Dependence on other species for propagule dispersal</strong></td>
<td>Neutral/Somewhat Increase</td>
</tr>
<tr>
<td><strong>4e. Sensitivity to pathogens or natural enemies</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>4f. Sensitivity to competition from native or non-native species</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>4g. Forms part of an interspecific interaction not covered above</strong></td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>5a. Measured genetic diversity</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>5b. Genetic bottlenecks</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>5c. Reproductive system</strong></td>
<td>Neutral</td>
</tr>
</tbody>
</table>
### 6. Phenological response to changing seasonal and precipitation dynamics

| 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 D

**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).

---

![Temperature increase map](https://www.natureserve.org/ccvi)

**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

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

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.

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).

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.
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.


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.

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.

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


