# AMERICAN BADGER

*Taxidea taxus*

The American badger is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable by the 2050s under a high (RCP 8.5) greenhouse gas scenario. The American badger is estimated to be moderately vulnerable to climate change by the 2080s under both a low and a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the American badger's estimated sensitivity to climate change. Key climate sensitivities for the American badger are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE AMERICAN BADGER'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Roads, traffic, and the presence of people have been identified as anthropogenic barriers to American badger dispersal.[1] These dispersal barriers may decrease the American badger's ability to adjust its range in response to changing climate conditions.

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

The American badger inhabits semi-desert, sagebrush, grassland, and pasture lands.[1] These areas have the potential for wind farm or solar array development, and may thus negatively affect American badger habitat.[2]

## DEPENDENCE ON DISTURBANCE EVENTS

Badger populations are typically able to avoid fires through the utilization of underground burrows.[3] However, the American badger is indirectly affected by fires via loss of prey sources. Therefore, the American badger may be negatively affected by projected increases in annual area burned,[4] if prey populations that the badger relies upon are negatively affected.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the American badger's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT

Front Page: American badger by Tony's Takes, used under CC BY-NC-ND 2.0

Back Page: American badger by Tony's Takes, used under CC BY-NC-ND 2.0

## CITATIONS

[1] Washington Wildlife Habitat Connectivity Working Group. 2010. Washington Connected Landscapes Project: Statewide Analysis. Washington Departments of Fish and Wildlife, and Transportation, Olympia, WA. www.waconnected.org.

[2] Colville Tribes staff, personal communication.

[3] Sullivan, Janet. 1996. Taxidea taxus. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: www.fs.fed.us/database/feis/animals/mammal/tata/all.html

[4] Littell, J.S., Oneil, E.E., McKenzie, D., et al. 2010. Forest Ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change, 102:139-158.

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THE CONFEDERATED TRIBES OF THE COLVILLE RESERVATION 1872

# AMERICAN BEAVER

*Castor canadensis*

The American beaver is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable by the 2050s under a high (RCP 8.5) greenhouse gas scenario. The American beaver is estimated to be moderately vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the American beaver's estimated sensitivity to climate change. Key climate sensitivities for the American beaver are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE BEAVER'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Major highways and roads have been identified as anthropogenic barriers to American beaver dispersal.[1] These dispersal barriers may decrease the American beaver's ability to adjust its range in response to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

The American beaver inhabits permanent, stable water sources. Fast moving streams, bodies of water with wave action, and areas with shifting water level or flow are unsuitable beaver habitat.[2] Projected increases in winter peak flows, and declining summer low flows[3] may negatively affect the suitability of these aquatic habitats for the American beaver.

## SENSITIVITY TO DISEASE

The American beaver is susceptible to the bacterial disease tularemia, which is transmitted by ticks, flies, and affected water. Shifts in tulameria distribution have been linked with observed climate shifts in North America.[4] Sensitivity to disease may thus increase the American beaver's vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the American beaver's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Climate Change Sensitivity Database. American Beaver (Castor canadensis).
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[4] Nakazawa, Y., Williams, R., Peterson, A.T., Mead, P., Staples, E., Gage, K.L. 2007. Climate change effects on plague and tularemeia in the United States. Vector Borne Zoonotic Dis., 7(4):529-540.

## IMAGE CREDIT

# AMERICAN MARTEN

*Martes americana*

The American marten is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5)and high (RCP 8.5) greenhouse gas scenario. The American marten is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the American marten's estimated sensitivity to climate change. Key climate sensitivities for the American marten are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT GREATLY INCREASE THE AMERICAN MARTEN'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON SNOW

The American marten is dependent on snowpack for thermal protection, foraging, and resting.[1] Projected declines in snowpack are expected to negatively affect American marten habitat.

## FACTORS THAT INCREASE THE AMERICAN MARTEN'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Major highways, towns, dam, and railroads have been identified as anthropogenic barriers to American marten dispersal.[2] These dispersal barriers may decrease the American marten's ability to adjust its range in response to changing climate conditions.

### DEPENDENCE ON DISTURBANCE EVENTS

Fire, windthrow, and forest pests and disease can all negatively affect American marten habitat. Climate change is expected to increase the frequency and intensity of fire in Washington State.[3] In addition, warmer and drier summers will stress forests, which may increase the susceptibility of forests to pests and disease. Therefore, increasing fire activity and changing risks from forest diseases and pests may negatively affect American marten habitat.

## FACTORS THAT SOMEWHAT INCREASE THE AMERICAN MARTEN'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

While the American marten is a very capable disperser, low-elevation forests, grasslands, and shrub-steppe have been identified as natural barriers to marten dispersal. Natural barriers may decrease the ability of the American marten to adjust its range in response to changing climate conditions.

### DEPENDENCE ON COOL OR COLD HABITATS

American marten inhabits regions with a typical continental climate of low annual temperatures and high levels of snowfall. Therefore, projected warming is likely to negatively affect the American marten.

### SENSITIVITY TO COMPETITION

The American marten competes with fishers. Regions with deep snow cover may give the marten a competition advantage over the fisher.[1] Therefore, projected declines in snowpack may give fisher a competitive advantage over the marten.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the American marten's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT

Front Page: American marten by USFWS, used under CC BY-NC-ND 2.0

Back Page: American marten by USFWS, used under CC BY-NC-ND 2.0

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[1] Stone, Katharine. 2010. Martes americana, American marten. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: www.fs.fed.us/database/feis/animals/mammal/maam/all.html

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# ANTELOPE BITTERBRUSH

*Purshia tridentata*

The antelope bitterbrush is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The antelope bitterbrush is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the antelope bitterbrush's estimated sensitivity to climate change. Key climate sensitivities for the antelope bitterbrush are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT GREATLY INCREASE THE ANTELOPE BITTERBRUSH'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED DISPERSAL ABILITIES

Antelope bitterbrush is dispersed by rodents. Average dispersal distance is noted between six and ten meters.[1] Species that are poor dispersers are less likely to disperse successfully in response to changing climate conditions.

## FACTORS THAT INCREASE THE ANTELOPE BITTERBRUSH'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON DISTURBANCE EVENTS

Antelope bitterbrush is very susceptible to fire kill. Within the assessment area, the bitterbrush areas that have been high-severity fires and the species has had a hard time regenerating post-fire.[2] Antelope bitterbrush in some areas may sprout after light-severity spring fire.  Projected increases in annual area burned[3] may negatively affect antelope bitterbrush.

### LIMITED DISPERSAL ABILITIES

Western redcedar seeds are wind dispersed. However, the seed's small wings limit the dispersal distance to approximately 120 meters.[2] The western redcedar's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

## CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Western redcedar are dependent on moist sites for growth.[3] Therefore, projected warming and reduce water availability may negatively affect the hydrologic suitability of western redcedar habitat.

## DEPENDENCE ON DISTURBANCE EVENTS

Western redcedar growing on wet sites within the assessment area are extremely susceptible to windthrow. While climate change is not expected to affect wind-speeds, projected increases in winter precipitation and flooding may increase the incidence of windthrow during wind storms.[3]

## SENSITIVITY TO DISEASE

Western redcedar is susceptible to numerous insects, pathogens, and pests. It is challenging to make generalizations of the responses of diseases and pests to climate change because the responses will largely be species specific. Some diseases/pests may become more widespread while others may not. For example, western redcedar is susceptible to armellaria root disease. If climate change results in a warmer and drier climate armellaria impact is projected to increase. Conversely, if climate change results in a warmer and wetter climate, the impact of armellaria is projected to remain the same.[4] Sensitivity to disease may thus increase the western redcedar's vulnerability to climate change.

## SENSITIVITY TO COMPETITION

Western redcedar is sensitive to competition from ponderosa pine.[3] Sensitivity to competition may thus increase the western redcedar's vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the antelope bitterbrush's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT



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[3] Colville Tribes staff, personal communication.
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# ARROWLEAF BALSAMROOT

*Balsamorhiza sagittata*

The arrowleaf balsamroot is estimated to be less vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The arrowleaf balsamroot is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the arrowleaf balsamroot's estimated sensitivity to climate change. Key climate sensitivities for the arrowleaf balsamroot are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT INCREASE THE ARROWLEAF BALSAMROOT'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO COMPETITION

Arrowleaf balsamroot is often outcompeted by invasive annual grass species such as cheatgrass, medusahead, Japanese broom, bulbous bluegrass.[1] Sensitivity to competition may thus increase the arrowleaf balsamroot's vulnerability to climate change.

## FACTORS THAT INCREASE THE ARROWLEAF BALSAMROOT'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

The conversion of habitat to orchard farms within the assessment area has resulted in the development of anthropogenic barriers. The orchard farms may limit the arrowleaf balsamroot's ability to adjust its range in response to changing climate conditions.[1]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the arrowleaf balsamroot's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Arrowleaf balsamroot by Dave Behr, used under CC BY-NC-ND 2.0

Back Page: Arrowleaf balsamroot by M.E. Sanseverino, used under CC BY-NC-ND 2.0

# BASIN WILDRYE

*Leymus cinereus*

The basin wildrye is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable under a high (RCP 8.5) greenhouse gas scenario. The basin wildrye is estimated to be moderately vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the basin wildrye's estimated sensitivity to climate change. Key climate sensitivities for the basin wildrye are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT INCREASE THE BASIN WILDRYE'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO COMPETITION

Basin wildrye competes with invasive annual grass species including cheatgrass, medusahead, Japanese broom, bulbous bluegrass.[1] Sensitivity to competition may thus increase the basin wildrye's vulnerability to climate change.

## FACTORS THAT SOMEWHAT INCREASE THE BASIN WILDRYE'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Agricultural land serves as an anthropogenic barrier for basin wildrye in the assessment area. This dispersal barrier may limit the basin wildrye's ability to adjust its range in response to changing climate conditions.[1]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the baisn wildrye's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Basin wildrye by Thayne Tuason, used under CC BY-NC-ND 2.0

Back Page: Basin wildrye by Matt Lavin, used under CC BY-NC-ND 2.0

# BIGHORN SHEEP

*Ovis canadensis*

The bighorn sheep is estimated to be less vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The bighorn sheep is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the bighorn sheep's estimated sensitivity to climate change. Key climate sensitivities for the bighorn sheep are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE BIGHORN SHEEP'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Roads have been identified as an anthropogenic barrier to bighorn sheep dispersal. These dispersal barriers may decrease the bighorn sheep's ability to adjust its range in response to changing climate conditions.

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

The bighorn sheep inhabits shrub steppe habitats and ridge tops (Colville Tribes staff, personal communication). These areas have the potential for wind farm or solar array development, and may thus negatively affect bighorn sheep habitat.[1]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the bighorn sheep's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Bighorn sheep by Doug Zwick, used under CC BY-NC-ND 2.0

Back Page: Bighorn sheep by Shanthanu Bhardwaj, used under CC BY-NC-ND 2.0

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Bitterroot could not be quantitatively assessed with the CCVI due to lack of species range data. For bitterroot, we qualitatively assessed the climate sensitivity within the assessment area using sensitivity factors included in the CCVI. Key climate sensitivities for bitterroot are discussed below.

## FACTORS THAT INCREASE THE BITTERROOT'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO COMPETITION

Bitterroot competes with the noxious weed sulfur cinquefoil (Potentilla recta). This noxious weed is expected to increase exponentially in the next few decades, and there is currently no known biological control.[1] Sensitivity to competition may thus increase the bitterroot's vulnerability to climate change.

## FACTORS THAT SOMEWHAT INCREASE THE BITTERROOT'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

The conversion of habitat to orchard farms within the assessment area has resulted in the development of anthropogenic barriers. The orchard farms may limit the bitterroot's ability to adjust its range in response to changing climate conditions.[1]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the bitterroot's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Bitterroot by Nicholas D., used under CC BY-NC-ND 2.0

Back Page: Bitterroot by D. Smith, used under CC BY-NC-ND 2.0

## FACTORS THAT SOMEWHAT INCREASE BLACK CAMAS'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Black camas is found within the vicinity of the Nez Pearce lands. The Columbia Plateau may serve as a barrier that limits the ability of camas to adjust its range in response to climate change.[3]

### DEPENDENCE ON DISTURBANCE EVENTS

Fire disturbance can top-kill black camas.[4] Projected increases in annual area burned[5] may negatively affect black camas.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on black camas's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

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[5] Littell, J.S., Oneil, E.E., McKenzie, D., et al. 2010. Forest Ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change, 102:139-158.

## IMAGE CREDIT

# BLACK-BACKED WOODPECKER

*Picoides arcticus*

The black-backed woodpecker is estimated to be less vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The black-backed woodpecker is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the black-backed woodpecker's estimated sensitivity to climate change. Key climate sensitivities for the black-backed woodpecker are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE BLACK-BACKED WOODPECKER'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON DISTURBANCE EVENTS

Black-backed woodpeckers in eastern Washington are often associated with recently burned stands of Douglas fir and ponderosa pine.[1] Fires also generate snags which are suitable for black-backed woodpecker nesting.[2] Models project an increase in total area burned in Washington state.[3] An increase in total area burned may initially increase suitable habitat for the woodpecker, however, the benefits of increased fire will only occur to a point. Black-backed woodpeckers are negatively affected by large scale, mega fires.[4]

### DEPENDENCE ON OTHER SPECIES FOR HABITAT

In eastern Washington, the black-backed woodpecker depends on snags in ponderosa pine and Douglas fir trees for nesting.[1,2] Dependence on another species, which may be vulnerable to climate change, for habitat generation is expected to increase a species' vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the black-backed woodpecker's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Tremblay, J. A., R. D. Dixon, V. A. Saab, P. Pyle and M. A. Patten. 2016. Black-backed Woodpecker (Picoides arcticus), version 3.0. In The Birds of North America (P. G. Rodewald, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.bkbwoo.03
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[3] Littell, J.S., Oneil, E.E., McKenzie, D., et al. 2010. Forest Ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change, 102:139-158.
[4]Colville Tribes staff, personal communication.

## IMAGE CREDIT



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# BLUE ELDERBERRY

*Sambucus nigra*

The blue elderberry could not be quantitatively assessed with the CCVI due to lack of species range data. For the blue elderberry, we qualitatively assessed the climate sensitivity within the assessment area using sensitivity factors included in the CCVI. Key climate sensitivities that enable to blue elderberry to be less vulnerable to climate change are discussed below.

## FACTORS THAT ENABLE THE BLUE ELDERBERRY TO BE LESS VULNERABLE TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

There are no significant natural barriers to blue elderberry dispersal in the assessment area. Blue elderberry seeds are dispersed by numerous bird and mammal species.[1] Birds are largely able to fly over most natural barriers within the assessment area.

### DEPENDENCE ON DISTURBANCE

Blue elderberry seeds are dispersed by numerous bird and mammal species.[1] Seeds are likely to be regurgitated or defecated at least 1km from the parent blue elderberry plant. Species that are able to disperse long distances are more likely to be able to adjust their range in response to changing climate conditions.

### DEPENDENCE ON SNOW

Blue elderberry is not directly dependent on the presence of snow or ice. Therefore, projected declines in winter snowpack are unlikely to directly negatively affect blue elderberry habitat.

### DEPENDENCE ON OTHER SPECIES FOR DISPERSAL

Seeds are dispersed by numerous bird and mammal species.[1] Dependence on another species, which may be vulnerable to climate change, for dispersal is expected to increase a species' vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the blue elderberry's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[1] Crane, M. F. 1989. Sambucus nigra subsp. cerulea. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/plants/shrub/samnig/all.html

## IMAGE CREDIT


The bluebunch wheatgrass is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable under a high (RCP 8.5) greenhouse gas scenario. The bluebunch wheatgrass is estimated to be moderately vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the bluebunch wheatgrass's estimated sensitivity to climate change. Key climate sensitivities for the bluebunch wheatgrass are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT INCREASE THE BLUEBUNCH WHEATGRASS'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO COMPETITION

Bluebunch wheatgrass competes with invasive annual grass species including cheatgrass, medusahead, Japanese broom, bulbous bluegrass.[1] Sensitivity to competition may thus increase the bluebunch wheatgrass's vulnerability to climate change.

## FACTORS THAT SOMEWHAT INCREASE THE BLUEBUNCH WHEATGRASS'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Agricultural land serves as an anthropogenic barrier for bluebunch wheatgrass in the assessment area. This dispersal barrier may limit the bluebunch wheatgrass's ability to adjust its range in response to changing climate conditions.[1]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the bluebunch wheatgrass's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Bluebunch wheatgrass by Tony Frates, used under CC BY-NC-ND 2.0

Back Page: Bluebunch wheatgrass by Matt Lavin, used under CC BY-NC-ND 2.0

# BRIDGELIP SUCKER

*Catostomus columbianus*

The bridgelip sucker is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and extremely vulnerable under a high (RCP 8.5) greenhouse gas scenario. The bridgelip sucker is estimated to be highly vulnerable to climate change by the 2080s under a low greenhouse gas scenario and extremely vulnerable under a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the bridgelip sucker's estimated sensitivity to climate change. Key climate sensitivities for the bridgelip sucker are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE BRIDGELIP SUCKER'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Bridgelip sucker inhabits lake margins, backwaters, riffles, creeks and small to medium rivers.[1] Many streams and rivers throughout the Colville assessment area have dams that could prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the bridgelip sucker's ability to adjust its range in response to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE BRIDGELIP SUCKER'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Natural barriers (e.g., waterfalls) may decrease the ability of the bridgelip sucker to adjust its range in response to changing climate conditions.[2]

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect bridgelip sucker habitat.[2]

### DEPENDENCE ON COOL OR COLD HABITATS

The bridgelip sucker is noted to inhabit lakes inhabits lake margins, backwaters, riffles, creeks and small to medium rivers with cold water.[3] Warming stream temperatures[4] may negatively affect bridgelip sucker habitat.[2]

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Bridgelip sucker summer habitat will likely decrease as summer base flows are predicted to decrease under climate change predictions.[2]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the bridgelip sucker's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability

## CITATIONS


[1] FishBase. Bridgelip sucker (Catostomus columbianus).

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## IMAGE CREDIT

Front Page: Bridgelip sucker by USGS, used under CC BY-NC-ND 2.0

Back Page: Bridgelip sucker by Museum of Comparative Zoology (Harvard).

# BROOK TROUT

*Salvelinus fontinalis*

The brook trout is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The brook trout is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the brook trout's estimated sensitivity to climate change. Key climate sensitivities for the brook trout are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE BROOK TROUT'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

The brook trout is noted to inhabit cool creeks, rivers, and lakes. While specific temperature thresholds are not described, the species is noted to prefer "cool" bodies of water.[1] Warming stream temperatures[2] will likely negatively affect brook trout habitat.

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers throughout the brook trout's range within the assessment area contain dams that could prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the brook trout's ability to adjust its range in response to changing climate conditions.

### SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids and their effects could be exacerbated with warming stream temperatures.85 Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease. Many important salmonid diseases become virulent when water temperatures reach or exceed 60-61°F.86

## FACTORS THAT SOMEWHAT INCREASE THE BROOK TROUT'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Natural barriers (e.g., waterfalls) may decrease the ability of the brook trout to adjust its range in response to changing climate conditions.[5]

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect brook trout habitat.[5]

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Brook Trout summer habitat will likely decrease as summer base flows are predicted to decrease under climate change projections.

### DEPENDENCE ON DISTURBANCE EVENTS

The survival of salmonid (i.e., salmon, trout, and char) eggs and embryos is strongly influenced by sediment deposition, water quality, and streambed scour and fill.[6] As air temperatures rise, watersheds are projected to become increasingly rain-dominant. This shift will increase the risk of winter flooding and increase sediment transport, which can negatively affect the survival of salmonid eggs. Studies have shown a negative relationship with winter flood frequency, projected to increase with climate change, and brook trout populations.[7]

### SENSITIVITY TO COMPETITION

Warming stream temperatures will enable other fish species to inhabit rivers and stream reaches that were historically too cold for them. Brown trout have been shown to be superior competitors for food at warm temperatures compared to brook trout. and brook trout populations.[7]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the brook trout's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT



## CITATIONS

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[8] Taniguchi, Y., F. J. Rahel, D. C. Novinger, and K. G. Gerow. 1998. Temperature mediation of competitive interactions among three fish species that replace each other along longitudinal stream gradients. Canadian Journal of Fisheries and Aquatic Sciences 55(8):1894-1901.

# BULL TROUT

*Salvelinus confluentus*

The bull trout is estimated to be highly vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The bull trout is estimated to be highly vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the bull trout's estimated sensitivity to climate change. Key climate sensitivities for the bull trout are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT GREATLY INCREASE THE BULL TROUT'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Bull trout require extremely cold water temperatures (45-50°F), with optimum temperatures for egg incubation ranging between 36°F and 39°F.[1] Lethal temperatures for age-0 bull trout was determined to be around 21°C and optimal temperatures for growth was approximately 13°C.[2] As stream temperatures continue to rise, the frequency with which these thresholds are exceeded, and the stream range over which they are exceeded, may increase.[3]

## FACTORS THAT INCREASE THE BULL TROUT'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers throughout bull trout range within the assessment area have dams that would prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the bull trout's ability to adjust its range in response to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Bull trout spawning habitat consists of gravel riffles in small tributary streams and lake inlet streams, which are often in close proximity to springs. Bull trout inhabit deep, cold pools; fast-flowing streams; and large, cold lakes.[1] Shifting precipitation patterns under climate change could threaten the availability of these narrowly-defined hydrological conditions. Climate change will likely result in drying stream beds, isolating patches of stream habitat.[4] Habitat loss and isolation projected by climate change could result in losses of 18-92% of thermally suitable bull trout habitat in the interior Columbia River Basin.[5]

## DEPENDENCE ON DISTURBANCE EVENTS

The survival of salmonid (i.e., salmon, trout, and char) eggs and embryos is strongly influenced by sediment deposition, water quality, and streambed scour and fill.[6] As air temperatures rise, watersheds are projected to become increasingly rain-dominant. This shift will increase the risk of winter flooding and increase sediment transport, which can negatively affect the survival of salmonid eggs.

## SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids and their effects could be exacerbated with warming stream temperatures.[7] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease.

## SENSITIVITY TO COMPETITION

Warming stream temperatures will enable other trout species to inhabit rivers and stream reaches that were historically too cold for them. The bull trout's competitive advantage as a cold-water specialist could thus decline, as warming temperatures allow competing species to disperse into its current range.[8]

## LIMITED GENETIC DIVERSITY

There is relatively little genetic variation within bull trout populations in the northwestern United States.  Species with average to high levels of genetic variation are expected to be better able to adapt to changing climate conditions.rivers and stream reaches that were historically too cold for them. The bull trout's competitive advantage as a cold-water specialist could thus decline, as warming temperatures allow competing species to disperse into its current range.[8]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the bull trout's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT

Front Page: Bull trout by USFWS, used under CC BY-NC-ND 2.0

Back Page: Bull trout by Charles R. Peterson, used under CC BY-NC-ND 2.0

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CLIMATE IMPACTS GROUP

THE CONFEDERATED TRIBES OF THE COLVILLE RESERVATION 1872

# BURBOT

*Lota lota*

The burbot is estimated to be highly vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and extremely vulnerable under a high (RCP 8.5) greenhouse gas scenario. The burbot is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the burbot's estimated sensitivity to climate change. Key climate sensitivities for the burbot are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE BURBOT'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Large hydroelectric dams act as barriers to burbot dispersal.[1] These dispersal barriers may limit the burbot's ability to adjust its range in response to changing climate conditions.

### DEPENDENCE ON COOL OR COLD HABITATS

Spawning is noted to occur between November and March in waters where temperatures are below 42.8 °F. Projected increases in stream temperatures,[2] may reduce to duration of time when stream temperatures are ideal for spawning. Additionally, burbot in the Colville assessment area are at the southern edge of their range which will increase their vulnerability to predicted climate change scenarios.[3]

## FACTORS THAT SOMEWHAT INCREASE THE BURBOT'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect burbot habitat, which includes well oxygenated, flowing waters and large deep lakes.

### SENSITIVITY TO DISEASE

Non-native warm- and coolwater species of fish, such as smallmouth bass, walleye, and northern pike, are known predators of burbot and will likely increase in abundance and distribution due to climate change.[3]

### SENSITIVITY TO COMPETITION

Burbot, walleye, and smallmouth bass have similar diets in Lake Roosevelt.[5] If walleye and smallmouth bass abundance increases with climate change, increased competition may negatively impact the burbot population.[3]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the burbot's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT



## CITATIONS

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# CANADA LYNX

*Lynx canadensis*

The Canada lynx is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5)and high (RCP 8.5) greenhouse gas scenario. The Canada lynx is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the Canada lynx's estimated sensitivity to climate change. Key climate sensitivities for the Canada lynx are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT GREATLY INCREASE THE CANADA LYNX'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON SNOW

The Canada lynx is morphologically adapted to excel in soft, deep snowpack. Projected declines in snow season length and total snowfall is likely to reduce the extent and/or quality of core lynx habitat.[1]

## FACTORS THAT INCREASE THE CANADA LYNX'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Major highways, roads, and compact snow associated with winter recreation have been identified as anthropogenic barriers to Canada lynx dispersal.[1] These dispersal barriers may decrease the Canada lynx's ability to adjust its range in response to changing climate conditions.

### DEPENDENCE ON COOL OR COLD HABITATS

The Canada lynx inhabits cold alpine areas and sub-alpine mountain forests, which are sensitive to climate change. This dependence on relatively cool or cold habitats increases the species vulnerability to climate change, as these areas are thought to be vulnerable to loss or significant reduction as a result of climate change.

## DEPENDENCE ON DISTURBANCE EVENTS

Climate change is projected to increase summer drought severity, area burned by wildfire, and pest and disease dynamics.[1] These disturbance events may negatively affect forest habitat used by the Canada lynx.

## DIETARY VERSATILITY

In winter, the Canada lynx exclusively preys upon snowshoe hare.[2] Species that are unable to switch between different food types are more likely to be negatively affected by climate change.

# FACTORS THAT SOMEWHAT INCREASE THE CANADA LYNX'S VULNERABILITY TO CLIMATE CHANGE:

## OCCURRENCE OF NATURAL BARRIERS

While the Canada lynx is a very capable disperser, large lakes and high topographic relief have been identified as natural barriers to lynx dispersal.[1] Natural barriers may decrease the ability of the Canada lynx to adjust its range in response to changing climate conditions.

## SENSITIVITY TO COMPETITION

Bobcats have been identified as competitors of the Canada lynx.[2] Sensitivity to competition may thus increase the Canada lynx's vulnerability to climate change.

## LIMITED GENETIC DIVERSITY

Low levels of genetic variation have been documented in populations at the periphery of the Canada lynx range, which includes the Washington's Cascade population.[3] Species with low levels of genetic variation are expected to be less able to adapt to changing climate conditions.

# FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the Canada lynx's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

# IMAGE CREDIT

Front Page: Canada lynx by Denis-Carl Rbidoux, used under CC BY-NC-ND 2.0

Back Page: Canada lynx by Eric Kilby, used under CC BY-NC-ND 2.0

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# CEANOTHUS

*Ceanothus velutinus*

The ceanothus is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable under a high (RCP 8.5) greenhouse gas scenario. The ceanothus is estimated to be moderately vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the ceanothus's estimated sensitivity to climate change. Key climate sensitivities for the ceanothus are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT GREATLY INCREASE THE CEANOTHUS'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED DISPERSAL ABILITIES

After ceanothus seeds ripen they are ejected from the containing pods.[1] The seeds generally remain where they fall (close to the parent plant) unless they are carried further distances by small animals.[1] The species' poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE CEANOTHUS'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Plantation forests are likely to reduce the amount of quality ceanothus habitat due to stand initiation.[2]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the ceanothus's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[2] Colville Tribes staff, personal communication.

## IMAGE CREDIT

# CHINOOK FALL RUN

*Oncorhynchus tshawytscha*

The Chinook (fall run) is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The Chinook (fall run) is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the Chinook's (fall run) estimated sensitivity to climate change. Key climate sensitivities for the Chinook (fall run) are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE CHINOOK'S (FALL RUN) VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Chinook salmon inhabit deep, cold pools prior to spawning. Water temperatures exceeding 48-50°F may reduce survival of Chinook salmon embryos and alevins.[1] Additionally, migration delays and blockages can form when stream temperatures exceed 69.8°F and can contribute to reproductive failure. As stream temperatures continue to rise, the frequency with which these thresholds are exceeded and total river miles affected may increase. Although fall run Chinook do not enter the Upper Columbia until mid-late Sept and October, they arrive in the estuary in and begin migrating in the lower Columbia during August when rising temperatures may exceed their suitability thresholds.[2]

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers throughout bull trout range within the assessment area have dams that would prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the bull trout's ability to adjust its range in response to changing climate conditions.

### DIET VERSATILITY

Chinook salmon are planktivores and insectivores as juveniles in freshwater then shift to feeding on squid, shrimp, and small fish in the ocean.[3] Haskell et al. (2017)[4] illustrate how subyearling Chinook can alternate between food sources to mitigate metabolic challenges associated with increased water temperature. Species that can readily switch between different food sources are less likely to be negatively affected by climate change. However, juvenile salmon and their food abundance (anchovy, herring, etc.) suffered during warmer ocean conditions due to lower productivity.[2]

## SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids, and their effects could be exacerbated with warming stream temperatures.[5] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease.

# FACTORS THAT SOMEWHAT INCREASE THE CHINOOK'S (FALL RUN) VULNERABILITY TO CLIMATE CHANGE:

## SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect Chinook salmon habitat.[2]

## CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Large, deep, pools offer important holding habitat for Chinook salmon prior to spawning. While sufficient flows are required to ensure incubating embryos receive sufficient oxygenation, extreme low or high flows can destroy embryos and fry residing within the streambed.[6] Shifting precipitation patterns under climate change could threaten these sensitive hydrological conditions.

## SENSITIVITY TO COMPETITION

Chinook salmon compete with other resident fish species which may increase in abundance with increasing temperatures.[2]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the Chinook's (fall run) sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT



## CITATIONS

[1] Richter, K., Kolmes, S.A. 2005. Maximum Temperature Limits for Chinook, Coho, and Chum Salmon, and Steelhead Trout in the Pacific Northwest. Reviews in Fisheries Science. 13(1): 23-49, doi: 10.1080/10641260590885861

[2] Colville Tribes staff, personal communication.

[3] NatureServe Explorer. Chinook salmon (Oncorhynchus tshawystscha).

[4] Haskell, C. A., D. A. Beauchamp, and S. M. Bollens. 2017. Linking functional response and bioenergetics to estimate juvenile salmon growth in a reservoir food web. PLOS ONE 12(10):e0185933.

[5] Crozier, L. 2015. Impacts of climate change on salmon of the Pacific Northwest: A review of the scientific literature published in 2014. Fish Ecology Division, Northwest Fisheries Science Center. NOAA. https://www.nwfsc.noaa.gov/assets/11/8473_07312017_171438_Crozier.2015-BiOp-Lit-Rev-Salmon-Climate-2014.pdf

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# CHINOOK SPRING RUN

*Oncorhynchus tshawytscha*

The Chinook (spring run) is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The Chinook (spring run) is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the Chinook's (spring run) estimated sensitivity to climate change. Key climate sensitivities for the Chinook (spring run) are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT GREATLY INCREASE THE CHINOOK'S (SPRING RUN) VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Chinook salmon prefer to inhabit deep, cold pools prior to spawning. However, many tributaries in the Upper Columbia are deficient in this habitat due to naturally warm climate, low summer flows, and reduced habitat complexity (fewer large log jams).[1] Water temperatures exceeding 48-50°F may reduce survival of Chinook salmon embryos and alevins.[2] Additionally, migration delays and blockages can form when stream temperatures exceed 69.8°F and can contribute to reproductive failure. As stream temperatures continue to rise, especially in the tributary streams in which spring Chinook spawn, the frequency with which these thresholds are exceeded and total river miles affected may increase, effectively eliminating large stretches of previously suitable habitat.[1]

## FACTORS THAT INCREASE THE CHINOOK'S (SPRING RUN) VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers throughout spring Chinook salmon range within the assessment area have dams that would prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These barriers may decrease the ability of spring Chinook runs to adjust their range in response to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Large, deep, pools offer important holding habitat for Chinook salmon prior to spawning. While sufficient flows are required to ensure incubating embryos receive sufficient oxygenation, extreme low or high flows can destroy embryos and fry residing within the streambed.[3] Shifting precipitation patterns under climate change could threaten these sensitive hydrological conditions.

## DIET VERSATILITY

Chinook salmon are planktivores and insectivores as juveniles in freshwater then shift to feeding on squid, shrimp, and small fish in the ocean.[4] Haskell et al. (2017)[5] illustrate how subyearling Chinook can alternate between food sources to mitigate metabolic challenges associated with increased water temperature. Species that can readily switch between different food sources are less likely to be negatively affected by climate change. However, juvenile salmon and their food abundance (anchovy, herring, etc.) suffered during warmer ocean conditions due to lower productivity.[1]

## SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids, and their effects could be exacerbated with warming stream temperatures.[6] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease.

## LIMITED GENETIC DIVERSITY

Populations of Chinook salmon in the interior Columbia River basin have lower genetic diversity and population size when compared to ocean-type Chinook.[7] The effective population size of some spring runs have been estimated to be as low as 30 (i.e., Entiat Hatchery).[7] Genetic diversity of Chinook salmon has decreased when comparing contemporary samples to ancient samples in the Columbia and Snake rivers.[8] Species with average to high levels of genetic variation are expected to be more likely to adapt to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the Chinook's (spring run) sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT



## CITATIONS

[1] Colville Tribes staff, personal communication.

[2] Richter, K., Kolmes, S.A. 2005. Maximum Temperature Limits for Chinook, Coho, and Chum Salmon, and Steelhead Trout in the Pacific Northwest. Reviews in Fisheries Science. 13(1): 23-49, doi: 10.1080/10641260590885861

[3] Raleigh, R.F., Miller, W.J., Nelson, P.C. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S Fish Wildl. Serv. Biol. Rep. 82(10.122). 64 pp.

[4] NatureServe Explorer. Chinook salmon (Oncorhynchus tshawystscha).

[5] Haskell, C. A., D. A. Beauchamp, and S. M. Bollens. 2017. Linking functional response and bioenergetics to estimate juvenile salmon growth in a reservoir food web. PLOS ONE 12(10):e0185933.

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# CHINOOK SUMMER RUN

*Oncorhynchus tshawytscha*

The Chinook (summer run) is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The Chinook (summer run) is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the Chinook's (summer run) estimated sensitivity to climate change. Key climate sensitivities for the Chinook (summer run) are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE CHINOOK'S (SUMMER RUN) VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Chinook salmon inhabit deep, cold pools prior to spawning. Water temperatures exceeding 48-50°F may reduce survival of Chinook salmon embryos and alevins.[1] Additionally, migration delays and blockages can form when stream temperatures exceed 69.8°F and can contribute to reproductive failure. As stream temperatures continue to rise, the frequency with which these thresholds are exceeded and total river miles affected may increase. Upper Columbia summer Chinook arrive at their natal tributaries from late-June until late-August, in many years they must hold in the Columbia River for weeks or a month before temperatures are low enough to finish their migration. If climate change results in longer or more intense thermal barriers then survival during pre-spawn holding will likely decrease.[2]

### OCCURRENCE OF MAN-MADE BARRIERS

Dams on the Columbia River are likely to serve as anthropogenic barriers to summer run Chinook dispersal. These dispersal barriers may limit the chinook salmon's ability to adjust its range in response to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Large, deep, pools offer important holding habitat for Chinook salmon prior to spawning. While sufficient flows are required to ensure incubating embryos receive sufficient oxygenation, extreme low or high flows can destroy embryos and fry residing within the streambed.[3] Shifting precipitation patterns under climate change could threaten these sensitive hydrological conditions.

## DIET VERSATILITY

Chinook salmon are planktivores and insectivores as juveniles in freshwater then shift to feeding on squid, shrimp, and small fish in the ocean.[4] Haskell et al. (2017)[5] illustrate how subyearling Chinook can alternate between food sources to mitigate metabolic challenges associated with increased water temperature. Species that can readily switch between different food sources are less likely to be negatively affected by climate change. However, juvenile salmon and their food abundance (anchovy, herring, etc.) suffered during warmer ocean conditions due to lower productivity.[2]

## SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids, and their effects could be exacerbated with warming stream temperatures.[6] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease.

# FACTORS THAT SOMEWHAT INCREASE THE CHINOOK'S (SUMMER RUN) VULNERABILITY TO CLIMATE CHANGE:

## LIMITED GENETIC DIVERSITY

A population of summer run Chinook salmon in the interior Columbia River basin has effective population size of approximately 1,175 (i.e., the Methow River population), which is lower than other populations of Chinook salmon in the Columbia River basin.[7] Genetic diversity of Chinook salmon has decreased when comparing contemporary samples to ancient samples in the Columbia and Snake rivers.[7] Species with average to high levels of genetic variation are expected to be better able to adapt to changing climate conditions.

# FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the Chinook's (summer run) sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

# IMAGE CREDIT



# CITATIONS

[1] Richter, K., Kolmes, S.A. 2005. Maximum Temperature Limits for Chinook, Coho, and Chum Salmon, and Steelhead Trout in the Pacific Northwest. Reviews in Fisheries Science. 13(1): 23-49, doi: 10.1080/10641260590885861

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[3] Raleigh, R.F., Miller, W.J., Nelson, P.C. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S Fish Wildl. Serv. Biol. Rep. 82(10.122). 64 pp.

[4] NatureServe Explorer. Chinook salmon (Oncorhynchus tshawystscha).

[5] Haskell, C. A., D. A. Beauchamp, and S. M. Bollens. 2017. Linking functional response and bioenergetics to estimate juvenile salmon growth in a reservoir food web. PLOS ONE 12(10):e0185933.

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# COLUMBIA SPOTTED FROG

*Rana luteiventris*

The Columbia spotted frog is estimated to be highly vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and extremely vulnerable under a high (RCP 8.5) greenhouse gas scenario. The Columbia spotted frog is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the Columbia spotted frog's estimated sensitivity to climate change. Key climate sensitivities for the Columbia spotted frog are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE COLUMBIA SPOTTED FROG'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO DISEASE

Introduced trout, char, and amphibian species including brook trout, cutthroat trout, rainbow trout, and bullfrogs are predators of tadpoles and juvenile Columbia spotted frogs.[1] Projected increases in stream temperatures[2] will facilitate the spread of trout and char to stream and rivers that have historically been too cold for these species.

### LIMITED GENETIC VARIATION

Low levels of within population genetic variation have been observed in Columbia spotted frog populations in Oregon.[3] Species with average to high levels of genetic variation are expected to be better able to adapt to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABLITY

The Columbia spotted frog is a highly aquatic species dependent on permanent or ephemeral sites for breeding.[1] Therefore, projected warming and reduce water availability may negatively affect the hydrologic suitability of Columbia spotted frog habitat.

## FACTORS THAT SOMEWHAT INCREASE THE COLUMBIA SPOTTED FROG'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

The Columbia spotted frog inhabits areas with close proximity to permanent water sources. Therefore, stretches of the landscape without consistent water sources (i.e., wetlands, streams, ponds, or lakes) may serve as natural dispersal barriers for the frog. Natural barriers may decrease the ability of the Columbia spotted frog to adjust its range in response to changing climate conditions.

### OCCURRENCE OF MAN-MADE BARRIERS

Roads are often a source of mortality for the Columbia spotted frog and can also serve as anthropogenic barriers to dispersal.[1] These dispersal barriers may limit the Columbia spotted frog's ability to adjust its range in response to changing climate conditions.

### LIMITED DISPERSAL ABILITIES

The Columbia spotted frog has mediocre dispersal abilities. In central Idaho populations, the Columbia spotted frog has been documented dispersing up to 3,300 ft. (1 km) between breeding and summer sites, however females are typically found 1,600 ft. (0.5 km) between the two sites.[4] The mediocre dispersal abilities of the Columbia spotted frog decreases the likelihood that the species will be able to adjust its range in response to changing climate conditions.

### DEPENDENCE ON DISTURBANCE EVENTS

The Columbia spotted frog is sensitive to drought conditions due to its dependence on permanent water sources.[5] Projected declines in summer precipitation and increasing summer temperatures are likely to negatively affect Columbia spotted frog habitat.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the Columbia spotted frog's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT

Front Page: Columbia spotted frog by USFWS, used under CC BY-NC-ND 2.0

Back Page: Columbia spotted frog by Charles Peterson, used under CC BY-NC-ND 2.0

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[1] AmphibiaWeb. Columbia spotted frog (Rana luteiventris).

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[4] NatureServe Explorer. Columbia spotted frog (Rana luteiventris).

[5] Colville Tribes staff, personal communication.

# COMMON LOON

*Gavia immer*

The common loon is estimated to be less vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The common loon is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the common loon's estimated sensitivity to climate change. Key climate sensitivities that enable to common loon to be less vulnerable to climate change are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT ENABLE THE COMMON LOON TO BE LESS VULNERABLE TO CLIMATE CHANGE:

### DISPERSAL ABILITIES

Common loons have excellent dispersal abilities and are able to migrate long-distances.[1] The loon's excellent dispersal ability increases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

### DEPENDENCE ON COOL OR COLD HABITATS

The common loon is adapted to a wide range of temperature regimes and are therefore unlikely to be directly negatively affected by warming temperatures.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Common loons are not dependent on a specific hydrological niche. While the species is dependent on large lakes and reservoirs,[1] it is unlikely that climate change will alter the hydrologic suitability of common loon habitat.

### DIET VERSATILITY

The common loon consumes a wide variety of fish and crustaceans.[1] Species that can readily switch between different food sources are less likely to be negatively affected by climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the common loon's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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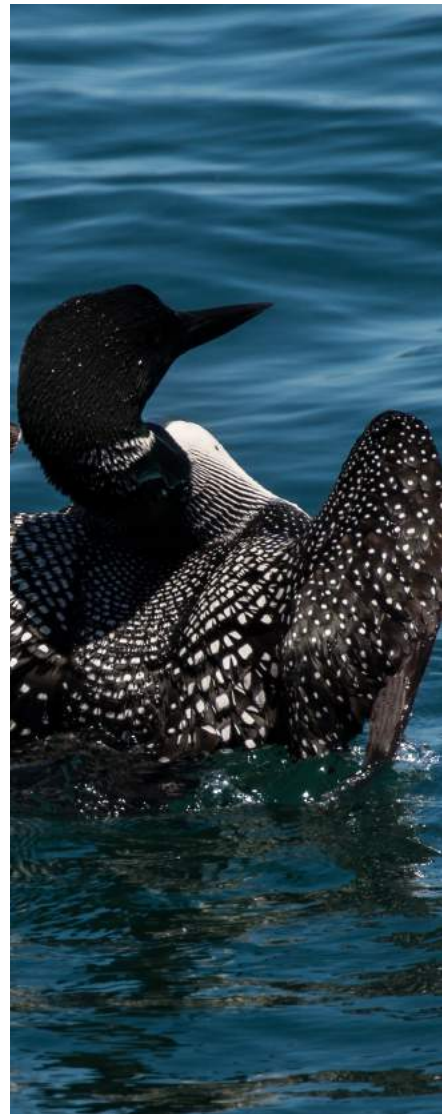

## IMAGE CREDIT

Front Page: Common loon by USFWS, used under CC BY-NC-ND 2.0

Back Page: Common loon by Jim Gain, used under CC BY-NC-ND 2.0

# DEVIL'S CLUB

*Oplopanax horridus*

The Devil's club is estimated to be less vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The Devil's club is estimated to be less vulnerable to climate change by the 2080s under a low scenario and moderately vulnerbale under a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the Devil's club's estimated sensitivity to climate change. Key climate sensitivities for the Devil's club are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT INCREASE THE DEVIL'S CLUB'S VULNERABILITY TO CLIMATE CHANGE:

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Devil's club is dependent on damp or moist sites for growth.[1] Therefore, projected warming and reduce water availability may negatively affect the hydrologic suitability of Devil's club habitat.

## FACTORS THAT MAY SOMEWHAT INCREASE THE DEVIL'S CLUB'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON DISTURBANCE EVENTS

Devil's club is killed by fire.[2] Because devil's club is an understory plant, recovery is likely faster than a species that would likely be exposed to higher fire intensities.[2] Projected increases in annual area burned[3] may negatively affect devil's club.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the Devil's club's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

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## IMAGE CREDIT

# DOUGLAS FIR

*Pseudotsuga menziesii var. glauca*

Douglas fir could not be quantitatively assessed with the CCVI due to lack of species range data. For Douglas fir, we qualitatively assessed the climate sensitivity within the assessment area using sensitivity factors included in the CCVI. Key climate sensitivities for Douglas fir are discussed below.

## FACTORS THAT SOMEWHAT INCREASE THE DOUGLAS FIR'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED DISPERSAL ABILITIES

Douglas fir seeds are primarily wind-dispersed, although small mammals are also Douglas fir seed dispersers.[1] It is noted that most seeds fall within 100 m of the parent plant. The Douglas fir's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

### DEPENDENCE ON DISTURBANCE EVENTS

Crown fires are frequently kill Douglas fir stands over large areas.[1] Douglas fir seeds perish when fire temperatures exceed 140 °F. Projected increases in annual area burned[2] will likely negatively affect Douglas fir stands in the assessment area.

### SENSITIVITY TO COMPETITION

Douglas fir is expected to be outcompeted by ponderosa pine, a species that is likely to do better under warmer and drier conditions.[3]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on Douglas fir's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[3] Colville Tribes staff, personal communication.


## IMAGE CREDIT

Front Page: Douglas fir by Brent Miller, used under CC BY-NC-ND 2.0

Back Page: Douglas fir by J. Maughn, used under CC BY-NC-ND 2.0

# ELK

*Cervus canadensis nelsoni*

The elk could not be quantitatively assessed with the CCVI due to lack of species range data. For the elk, we qualitatively assessed the climate sensitivity within the assessment area using sensitivity factors included in the CCVI. Key climate sensitivities for the elk are discussed below.

## FACTORS THAT SOMEWHAT INCREASE THE ELK'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Roads and active logging sites have been identified as anthropogenic barriers to elk dispersal.[1] These dispersal barriers may decrease the elk's ability to adjust its range in response to changing climate conditions.

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Elk inhabits sagebrush-steppe habitat. Sagebrush-steppe habitats are often considered suitable sites for wind farm or solar array development. Renewable energy development in sagebrush-steppe has the potential to negatively affect elk habitat.[2]

### LIMITED GENETIC VARIATION

Low levels of mitochondrial DNA variation have been observed within North American elk populations.[3] Species with low levels of genetic variation are expected to be less able to adapt to changing climatic conditions.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the elk's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[1] Innes, Robin J. 2011. Cervus elaphus. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: www.fs.fed.us/database/feis/mammal/ceel/all.html [2018, April 11].

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## IMAGE CREDIT

# FERNLEAF BISCUITROOT

*Lomatium dissectum*

The fernleaf biscuitroot is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and highly vulnerable under a high (RCP 8.5) greenhouse gas scenario. The fernleaf biscuitroot is estimated to be highly vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the fernleaf biscuitroot's estimated sensitivity to climate change. Key climate sensitivities for the fernleaf biscuitroot are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |

## FACTORS THAT INCREASE THE FERNLEAF BISCUITROOT'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO COMPETITION

Fearnleaf biscuitroot competes with the noxious weed sulfur cinquefoil (Potentilla recta). This noxious weed is expected to increase exponentially in the next few decades, and there is currently no known biological control.[1]

## FACTORS THAT SOMEWHAT INCREASE THE FERNLEAF BISCUITROOT'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE ON NATURAL BARRIERS

The biscuitroot is found within the vicinity of the Nez Pearce lands. The Columbia Plateau may serve as a barrier that limits the dispersal of the biscuitroot.[1]

### OCCURRENCE OF MAN-MADE BARRIERS

The conversion of habitat to orchard farms within the assessment area has resulted in the development of anthropogenic barriers. The orchard farms may limit the fernleaf biscuitroot's ability to adjust its range in response to changing climate conditions.[1]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the fernleaf biscuitroot's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.

## IMAGE CREDIT

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the foamberry's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.

## IMAGE CREDIT

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Back Page: Foamberry by NPS, used under CC BY-NC-ND 2.0

# GOLDEN EAGLE

*Aquila chrysaetos*

The golden eagle is estimated to be less vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The golden eagle is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the golden eagle's estimated sensitivity to climate change. Key climate sensitivities for the golden eagle are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE GOLDEN EAGLE'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

The golden eagle uses areas of land with large open spaces. These open pockets of land within the assessment area are often considered potential suitable sites for wind turbine development. Wind energy development in these open pockets of land has the potential to negatively affect golden eagle habitat, and may result in injury or mortality.[1,2]

### SENSITIVITY TO DISEASE

Disease is not currently considered a concern for golden eagles, however, West Nile virus is an emerging disease of potential concern for the species. In the western United States, the golden eagle resides in semiarid landscapes with low mosquito (the vector for West Nile transmission) prevalence.[3] Shifting precipitation patterns under climate change could alter mosquito prevalence in the project area, potentially increasing the species exposure to the virus. Sensitivity to disease may thus increase the golden eagle's vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the golden eagle's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

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## IMAGE CREDIT

Front Page: Golden eagle by David Illig, used under CC BY-NC-ND 2.0

Back Page: Golden eagle by USFWS, used under CC BY-NC-ND 2.0

# GREAT GRAY OWL

*Strix nebulosa*

The great gray owl is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable by the 2050s under a high (RCP 8.5) greenhouse gas scenario.  The great gray owl is estimated to be less vulnerable to climate change by the 2080s under a low greenhouse gas scenario and moderately vulnerable under a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the great gray owl's estimated sensitivity to climate change. Key climate sensitivities for the great gray owl are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE GREAT GRAY OWL'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON DISTURBANCE EVENTS

The availability of great gray owl nesting and perching sites are significantly affected by forest disturbance events including fire, succession, and disease.[1] Projected increases in annual area burned,[2] may initially reduce nesting and perching sites for the great gray owl.

### DEPENDENCE ON OTHER SPECIES FOR HABITAT

Great gray owls frequently use abandoned raptor nests as nesting sites.[3] Dependence on another species, which may be vulnerable to climate change, for habitat generation is expected to increase a species' vulnerability to climate change.

## GENETIC BOTTLENECKS IN RECENT HISTORY

Pacific Northwest great gray owl populations have undergone recent population bottlenecks.[4] Evidence of genetic bottlenecks can be used to infer reductions in species-level genetic variation that could potentially impede a species ability to adapt to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the great gray owl's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Ulev, Elena D. 2007. Strix nebulosa. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: www.fs.fed.us/database/feis/animals/bird/stne/all.html

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## IMAGE CREDIT


The grizzly bear is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable by the 2050s under a high (RCP 8.5) greenhouse gas scenario. The grizzly bear is estimated to be moderately vulnerable to climate change by the 2080s under both a low and a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the grizzly bear's estimated sensitivity to climate change. Key climate sensitivities for the grizzly bear are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT INCREASE THE GRIZZLY BEAR'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Highways and roads have been identified as anthropogenic barriers to grizzly bear dispersal.[1] These dispersal barriers may decrease grizzly bear's ability to adjust its range in response to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE GRIZZLY BEAR'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED GENETIC VARIATION

Low levels of genetic diversity have been documented in populations of grizzly bears along the southern limit of the species distribution.[2] Species with average to high levels of genetic diversity are expected to be better able to adapt to changing climate conditions.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the grizzly bear's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Roever, C.L., Boyce, M.S., Stenhouse, G.B. 2010. Grizzly bear movements relative to roads: application of step selection functions. Ecography 33:1113-1122.
[2] Paetkau, D., Waits, L.P., Clarkson, P.L., Craighead, L., Vyse, E., Ward, E., Strokeck, C. 1998. Variation in genetic diversity across the range of North American brown bears. Conservation Biology 12: 418-429.

## IMAGE CREDIT

# IDAHO FESCUE

*Festuca idahoensis*

The Idaho fescue is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and highly vulnerable under a high (RCP 8.5) greenhouse gas scenario. The Idaho fescue is estimated to be highly vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the Idaho fescue's estimated sensitivity to climate change. Key climate sensitivities for the Idaho fescue are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |

## FACTORS THAT INCREASE THE IDAHO FESCUE'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED DISPERSAL ABILITIES

Idaho fescue seed dispersal is limited to the immediate vicinity of the parent plant.[1] The Idaho fescue's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

### SENSITIVITY TO COMPETITION

Idaho fescue competes with invasive annual grass species including cheatgrass, medusahead, Japanese broom, bulbous bluegrass.[2] Sensitivity to competition may thus increase the Idaho fescue's vulnerability to climate change.

## FACTORS THAT SOMEWHAT INCREASE THE IDAHO FESCUE'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE ON MAN-MADE BARRIERS

Agricultural land serves as an anthropogenic barrier for Idaho fescue in the assessment area. This dispersal barrier may limit the Idaho fescue's ability to adjust its range in response to changing climate conditions.[2]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the Idaho fescue's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS


[1] Zouhar, Kristin L. 2000. Festuca idahoensis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us /database/feis/plants/graminoid/fesida/all.html

[2] Colville Tribes staff, personal communication.


## IMAGE CREDIT

# KOKANEE SALMON

*Oncorhynchus nerka*

The kokanee salmon is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The kokanee salmon is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the kokanee salmon's estimated sensitivity to climate change. Key climate sensitivities for the kokanee salmon are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE KOKANEE SALMON'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers throughout kokanee salmon range within the assessment area have dams that would prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change.[1] These dispersal barriers may limit the kokanee salmon's ability to adjust its range in response to changing climate conditions.

### SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids, and their effects could be exacerbated with warming stream temperatures.[2] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease.

## FACTORS THAT SOMEWHAT INCREASE THE KOKANEE SALMON'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Waterfalls act as natural barriers to kokanee dispersal.[1] Natural barriers may decrease the ability of kokanee to adjust its range in response to changing climate conditions.

## SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect kokanee habitat.[1]

## DEPENDENCE ON COOL OR COLD HABITATS

Kokanee salmon are noted as being very sensitive to water temperatures.[3] Schools of kokanee school in lakes at specific depths that correspond to ideal temperature regimes. As water temperatures continue to rise,[4] the frequency with which water temperature thresholds are exceeded may increase. However, well oxygenated thermoclines may continue to provide habitat with suitable temperatures.[1]

## CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Many stocks of Pacific salmon, including kokanee salmon, have evolved to spawn during fall months when water temperatures are colder and stream flows are low.[5] The wide range of observed spawning dates may make them more resilient to climate change. However, projected changes in the timing and volume of seasonal streamflow[6] may negatively affect some kokanee populations.

## DEPENDENCE ON DISTURBANCE EVENTS

The survival of salmonid (i.e., salmon, trout, and char) eggs and embryos is strongly influenced by sediment deposition, shifts in water quality, and streambed scour and fill.[7] As air temperatures rise, watersheds are projected to become increasingly rain-dominant. This shift will increase the risk of winter flooding and sediment transport, which can negatively affect the survival of salmonid eggs.

## SENSITIVITY TO COMPETITION

Competition from warm water, zooplanktivore fish species will likely increase.[1]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the kokanee salmon's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT

Front Page: Kokanee salmon by Kate Ware used under CC BY-NC-ND 2.0

Back Page: Kokanee salmon by Jcookfisher, used under CC BY-NC-ND 2.0

## CITATIONS


[1] Colville Tribes staff, personal communication.

[2] Crozier, L. 2015. Impacts of climate change on salmon of the Pacific Northwest: A review of the scientific literature published in 2014. Fish Ecology Division, Northwest Fisheries Science Center. NOAA. https://www.nwfsc.noaa.gov/assets/11/8473_07312017_171438_Crozier.2015-BiOp-Lit-Rev-Salmon-Climate-2014.pdf

[3] Montana Field Guide. Kokanee Salmon (Oncorhynchus nerka).

[4] Isaak, D.J., Wollrab, S., Horan, D., Chandler, G. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980-2009 and implications for salmonid fishes. Climatic Change 113: 499-524.

[5] Sauter, S.T., McMillan, J., Dunham, J. 2001. Salmonid behavior and water temperature. EPA, Prepared as Part of Region 10 Temperature Water Quality Criteria Guidance Development Project. 38 pp.

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# LODGEPOLE PINE

*Pinus contorta*

The lodgepole pine is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and moderately vulnerable under a high (RCP 8.5) greenhouse gas scenario. The lodgepole pine is estimated to be moderately vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the lodgepole pine's estimated sensitivity to climate change. Key climate sensitivities for the lodgepole pine are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT INCREASE THE LODGEPOLE PINE'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED DISPERSAL ABILITIES

Lodgepole pine seeds are primarily wind-dispersed, although water runoff and small mammals are also lodgepole seed dispersers.[1] Most seeds fall within 200 ft. (60 m) of the parent plant. The lodgepole pine's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE LODGEPOLE PINE'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

The lodgepole pine occurs at higher elevations in the assessment with colder temperatures.[2] Projected warming may negatively affect lodgepole pine habitat within the assessment area.

## SENSITIVITY TO DISEASE

The mountain pine beetle is noted as the most serious insect pest that affects the lodgepole pine.[1] The beetle is often associated with killing most of the large diameter trees within a stand.[1] The amount of forest susceptible to mountain pine beetle is projected to increase early in the 21st century (warming temperatures enable mountain beetles to reach high elevation forests), and then decrease by the late 21st century as temperatures exceed the mountain pine beetle's thermal optimum.[3]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the lodgepole pine's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Anderson, Michelle D. 2003. Pinus contorta var. latifolia. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/plants/tree/pinconl/all.html

[2] Colville Tribes staff, personal communication.

[3] Bentz B.J., Régnière J., Fettig C.J. Hansen E.M., Hayes J.L., Hicke J.A. et al. 2010. Climate change and bark beetles of the western United States and Canada: direct and indirect effects. BioScience 60, 602–613.

## IMAGE CREDIT

# MOOSE

*Alces alces*

The moose is estimated to be highly vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and extremely vulnerable under a high (RCP 8.5) greenhouse gas scenario. The moose is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the moose's estimated sensitivity to climate change. Key climate sensitivities for the moose are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE MOOSE'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Moose are physiologically adapted to cold climates and are sensitive to heat stress when temperatures exceed -5°C in winter and +14°C in summer.[1] Therefore, projected warming is likely to negatively affect the moose.

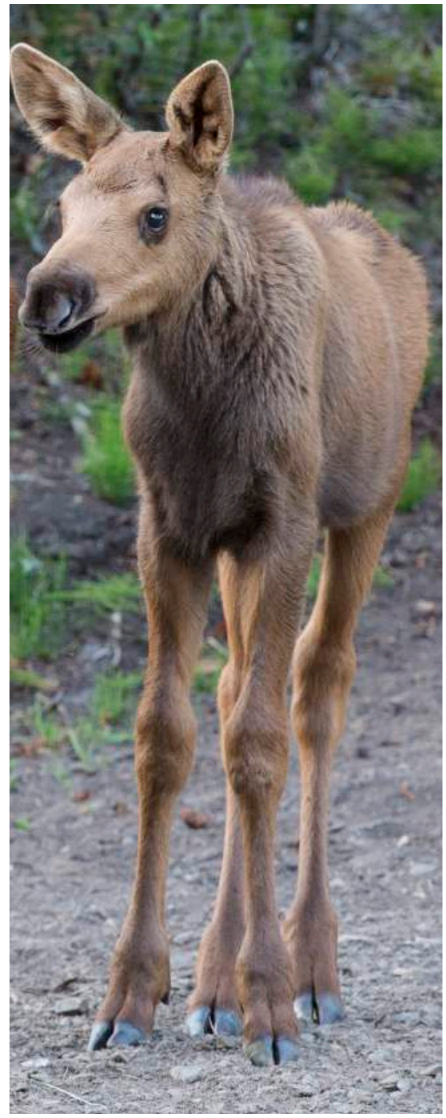
## FACTORS THAT SOMEWHAT INCREASE THE MOOSE'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Roads, cities, and wildlife fences have been identified as anthropogenic barriers to moose dispersal.[1] These dispersal barriers may decrease the moose's ability to adjust its range in response to changing climate conditions.

## CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Riparian and palustrian habitat are critical for moose throughout their range.[2] These quality or extent of these habitat types may be reduced under climate change.



## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the moose's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Climate Change Sensitivity Database. Moose (Alces alces).
[2] Colville Tribes staff, personal communication.
[3] NatureServe Explorer. Moose (Alces alces).

## IMAGE CREDIT

# MOREL MUSHROOM

*Morchella esculenta*

The morel mushroom could not be quantitatively assessed with the CCVI due to lack of species range data. For the morel mushroom, we qualitatively assessed the climate sensitivity within the assessment area using sensitivity factors included in the CCVI. Key climate sensitivities for morel mushroom are discussed below.

## FACTORS THAT SOMEWHAT INCREASE THE MOREL MUSHROOM'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED DISPERSAL ABILITIES

Yellow morel colonies have been observed to effectively outbreed over distances between 300 and 3000 feet.[1] The morel mushroom's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on morel mushroom's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Pilz, David; McLain, Rebecca; Alexander, Susan; Villarreal-Ruiz, Luis; Berch, Shannon; Wurtz, Tricia L.; Parks, Catherine G.; McFarlane, Erika; Baker, Blaze; Molina, Randy; Smith, Jane E. 2007. Ecology and management of morels harvested from the forests of western North America. Gen. Tech. Rep. PNW-GTR-710. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 161 p.

## IMAGE CREDIT

# MOUNTAIN WHITEFISH

*Prosopium williamsoni*

The mountain whitefish is estimated to be highly vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and extremely vulnerable under a high (RCP 8.5) greenhouse gas scenario. The mountain whitefish is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the mountain whitefish's estimated sensitivity to climate change. Key climate sensitivities for the mountain whitefish are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE MOUNTAIN WHITEFISH'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers throughout mountain whitefish range within the assessment area have dams that would prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the mountain whitefish's ability to adjust its range in response to changing climate conditions.

### SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids and their effects could be exacerbated with warming stream temperatures.[1] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease.

## WHAT INCREASE THE MOUNTAIN WHITEFISH'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Natural barriers (e.g., waterfalls) may decrease the ability of the mountain whitefish to adjust its range in response to changing climate conditions.[2]

### OCCURRENCE OF MAN-MADE BARRIERS

Roads are often a source of mortality for the Columbia spotted frog and can also serve as anthropogenic barriers to dispersal.[5] These dispersal barriers may limit the Columbia spotted frog's ability to adjust its range in response to changing climate conditions.

### LIMITED DISPERSAL ABILITIES

The Columbia spotted frog has mediocre dispersal abilities. In central Idaho populations, the Columbia spotted frog has been documented dispersing up to 3,300 ft. (1 km) between breeding and summer sites, however females are typically found 1,600 ft. (0.5 km) between the two sites.[4] The mediocre dispersal abilities of the Columbia spotted frog decreases the likelihood that the species will be able to adjust its range in response to changing climate conditions.

### DEPENDENCE ON DISTURBANCE EVENTS

The Columbia spotted frog inhabits areas with close proximity to permanent water sources.[4] Projected declines in summer precipitation and increasing summer temperatures are likely to negatively affect Columbia spotted frog habitat.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the mountain whitefish's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Crozier, L. 2015. Impacts of climate change on salmon of the Pacific Northwest: A review of the scientific literature published in 2014. Fish Ecology Division, Northwest Fisheries Science Center. NOAA. https://www.nwfsc.noaa.gov/assets/11/8473_07312017_171438_Crozier.2015-BiOp-Lit-Rev-Salmon-Climate-2014.pdf

[2] Colville Tribes staff, personal communication.

[1] AmphibiaWeb. Columbia spotted frog (Rana luteiventris).

[2] Isaak, D.J., Wollrab, S., Horan, D., Chandler, G. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980-2009 and implications for salmonid fishes. Climatic Change 113: 499-524.

[3] Funk, C.W., Blouin, M.S., Corn, P.S., Mazell, B.A., Pilliod, D.S., Amish, S., Allendorf, F.W. 2005. Population structure of Columbia spotted frogs (Rana luteiventris) is strongly affected by the landscape. Molecular Ecology 14: 483-496.

[4] NatureServe Explorer. Columbia spotted frog (Rana luteiventris).

[5] AmphibiaWeb. Columbia spotted frog (Rana luteiventris).

## IMAGE CREDIT

# MULE DEER

*Odocoileus hemionus*

The mule deer is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5)and high (RCP 8.5) greenhouse gas scenario. The mule deer is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the mule deer's estimated sensitivity to climate change. Key climate sensitivities for the mule deer are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE MULE DEER'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

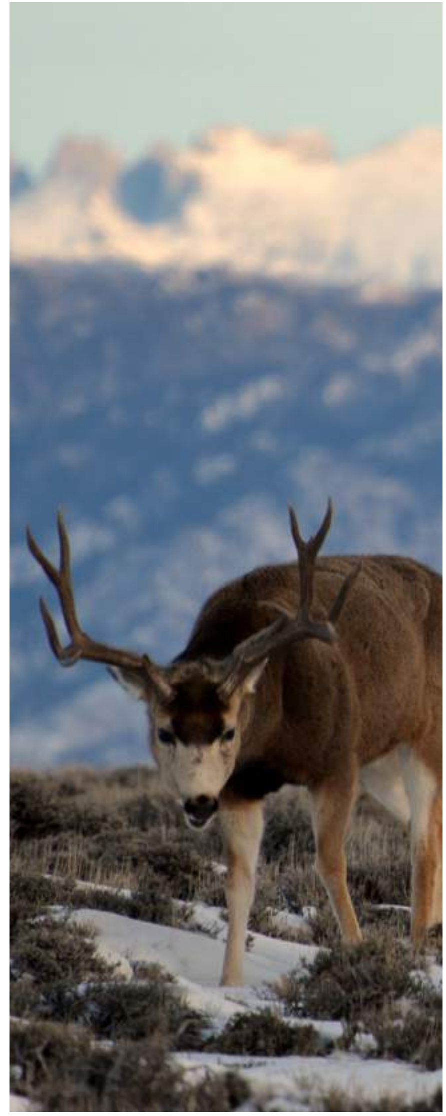
Fences, urban and suburban areas, and rural housing developments have all been identified as anthropogenic barriers to mule deer dispersal.[1] These dispersal barriers may decrease the mule deer's ability to adjust its range in response to changing climate conditions.

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

The mule deer inhabits sagebrush-steppe habitat. Sagebrush-steppe habitats are potential sites for wind farm or solar array development, and may thus negatively affect mule deer habitat.[2]

## SENSITIVITY TO DISEASE

There are many bacterial diseases and parasites that infect mule deer and may cause mortality. For example, bluetongue virus (BT) is transmitted to mule deer by biting gnats.[3] Typically, BT is most prevalent in deer populations during the summer months when hot and dry conditions are advantageous for the gnats. Increasing incidence of drought and warming temperatures may benefit gnat populations and increase the window of opportunity for outbreaks of BT in mule deer populations. Sensitivity to disease may thus increase the mule deer's vulnerability to climate change.



## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the mule deer's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability

## CITATIONS

[1] Wakeling, B.F., J.W. Gagnon, D.D. Olson, D.W. Lutz, T.W. Keegan, J.M. Shannon, A. Holland, A. Lindbloom, and C. Schroeder. 2015. Mule Deer and Movement Barriers. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies, U.S.A.
[2] Colville Tribes staff, personal communication.
[3] Hoff, G.L., and D.M. Hoff. 1976. Bluetongue and epizootic hemorrhagic disease: A review of these diseases in non-domestic artiodactyles. Journal of Zoo Animal Medicine 7:26–30.

## IMAGE CREDIT

# NORTHERN PIKE

*Esox lucius*

The northern pike is estimated to be lesss vulnerable to climate change by the 2050s under a both low (RCP 4.5) and high (RCP 8.5) greenhouse gas scneario. The northern pike is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the northern pike's estimated sensitivity to climate change. Key climate sensitivities for the northern pike are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT INCREASE THE NORTHERN PIKE'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Northern pike inhabit clear lakes, quiet pools and backwater of creeks and small to large rivers.[1] Many streams and rivers throughout the Colville assessment area have dams that could prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the northern pike's ability to adjust its range in response to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE NORTHERN PIKE'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect northern pike habitat.[2]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the northern pike's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] FishBase. Northern pike (Esox Lucius).
[2] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Northern pike by Kat Daned, used under CC BY-NC-ND 2.0

Back Page: Northern pike by Miguel Sanchez Mateos Paniagua, used under CC BY-NC-ND 2.0

# NORTHERN PIKEMINNOW

*Ptychocheilus oregonensis*

The northern pikeminnow is estimated to be lesss vulnerable to climate change by the 2050s under a both low (RCP 4.5) and high (RCP 8.5) greenhouse gas scneario. The northern pikeminnow is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the northern pikeminnow's estimated sensitivity to climate change. Key climate sensitivities for the northern pikeminnow are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT INCREASE THE NORTHERN PIKEMINNOW'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

The northern pikeminnow inhabits lakes, pools, and rivers. margins, backwaters.[1] Many streams and rivers throughout the Colville assessment area have dams that could prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the northern pikeminnow's ability to adjust its range in response to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE NORTHERN PIKEMINNOW'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect northern pikeminnow habitat.[2]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the northern pikeminnow's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] FishBase. Northern pikeminnow (Ptychocheilus oregonensis).
[2] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Northern pikeminnow by Tim Loh, used under CC BY-NC-ND 2.0

Back Page: Northern pikeminnow by USGS, used under CC BY-NC-ND 2.0

# PACIFIC LAMPREY

*Lampetra tridentata*

The pacific lamprey is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and extremely vulnerable under a high (RCP 8.5) greenhouse gas scenario. The pacific lamprey is estimated to be highly vulnerable to climate change by the 2080s under a low scenario and extremely vulnerable under a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the pacific lamprey's estimated sensitivity to climate change. Key climate sensitivities for the pacific lamprey are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT GREATLY INCREASE THE PACIFIC LAMPREY'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Spawning is noted to occur between May and June and occurs in water temperatures between 50 and 59 °F (20 and 15 °C). As stream temperatures continue to rise,[1] the frequency with which these thresholds are exceeded, and the stream range over which they are exceeded, may increase. Additionally, warmer water can negatively impact Pacific lamprey by causing testicular atrophy and prespawn mortality.[2] Bayer et al. 2000[3] states that mortality rates for early life stages of Pacific lamprey increase substantially when water temperatures reach 22°C.

## FACTORS THAT INCREASE THE PACIFIC LAMPREY'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Anadromous Pacific lamprey populations reside in marine waters for most of their life. Resident freshwater populations reside in lakes, rivers, and creeks.[4] The species return to natal streams to spawn. Many streams and rivers throughout the Colville assessment area have dams that could prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the Pacific lamprey's ability to adjust its range in response to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE PACIFIC LAMPREY'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect Pacific lamprey habitat.[5]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the pacific lamprey's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Isaak, D.J., Wollrab, S., Horan, D., Chandler, G. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980-2009 and implications for salmonid fishes. Climatic Change 113: 499-524.

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[4] FishBase. Pacific Lamprey (Lampetra tridentada).

[5] Colville Tribes staff, personal communication.

## IMAGE CREDIT

# PACIFIC YEW

*Taxus brevifolia*

The pacific yew is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and moderately vulnerable under a high (RCP 8.5) greenhouse gas scenario. The pacific yew is estimated to be moderately vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the pacific yew's estimated sensitivity to climate change. Key climate sensitivities for the pacific yew are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE PACIFIC YEW'S VULNERABILITY TO CLIMATE CHANGE:

### CHANGES IN STREAMFLOW OR WATER AVAILABILITY

The Pacific yew is dependent on moist sites for growth.[1] Therefore, projected warming and reduce water availability may negatively affect the hydrologic suitability of Pacific yew habitat.

### DEPENDENCE ON DISTURBANCE EVENTS

The thin bark of the Pacific yew leaves the species highly susceptible to heat damage. For example, the Pacific yew is often killed even after small ground fires. As a result of this sensitivity, the species often occurs on sites with long fire-free intervals.[2] Projected increases in annual area burned[3] may negatively affect the Pacific yew.

## SENSITIVITY TO COMPETITION

Pacific yew is a shade-tolerant species and is often outcompeted during gap phase replacement[2] by ponderosa pine within the assessment area.[1]

# FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the pacific yew's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

# CITATIONS


[1] Colville Tribes staff, personal communication.
[2] Tirmenstein, D. A. 1990. Taxus brevifolia. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us/database/feis/plants/tree/taxbre/all.html
[3] Isaak, D.J., Wollrab, S., Horan, D., Chandler, G. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980-2009 and implications for salmonid fishes. Climatic Change 113: 499-524.


## IMAGE CREDIT

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the painted turtle's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

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[3] Gervais, J., Rosenberg, D., Barnes, S., Puchy, C., Stewart, E. 2009. Conservation assessment for the western painted turtle in Oregon (Chrysemys picta bellii). Version 1.1., Sponsored by: U.S.D.I. Bureau of Land Management and Fish and Wildlife Serve, U.S.D.A. Forest Service Region 6, Oregon Department of Fish and Wildlife, City of Portland.

## IMAGE CREDIT

Front Page: Painted turtle by John Clare, used under CC BY-NC-ND 2.0

Back Page: Painted turtle by John Clare, used under CC BY-NC-ND 2.0

# PAPER BIRCH

*Betula papyrifera*

The paper birch is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable under a high (RCP 8.5) greenhouse gas scenario. The paper birch is estimated to be less vulnerable to climate change by the 2080s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable under a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the paper birch's estimated sensitivity to climate change. Key climate sensitivities for the paper birch are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT INCREASE THE PAPER BIRCH'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED DISPERSAL ABILITIES

The paper birch is primarily wind-dispersed.[1] Seeds typically fall 30-61 meters (100-200 ft.) feet from the parent plant. The paper birch's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE PAPER BIRCH'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Paper birch grows in a wide variety of climates ranging from boreal to humid.[2] Projected increases in temperature[3] are unlikely to negatively affect paper birch.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the paper birch's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

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[3] Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2013. Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.

## IMAGE CREDIT

# PONDEROSA PINE

*Pinus ponderosa*

The ponderosa pine is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and highly vulnerable under a high (RCP 8.5) greenhouse gas scenario. The ponderosa pine is estimated to be highly vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the ponderosa pine's estimated sensitivity to climate change. Key climate sensitivities for the ponderosa pine are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE PONDEROSA PINE'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO DISEASE

Ponderosa pine are estimated to be affected by approximately 200 insect species. These infestations can decrease seed and seedling production, reforestation failures, and productivity reductions.[1] Ponderosa pine is also noted as being affected by many diseases, including root diseases, trunk decays, and needle and twig blights. Projected increases in temperature and declines in summer precipitation are expected to stress forests and increase tree susceptibility to insect infestations and pathogens.[2]

### OCCURRENCE ON MAN-MADE BARRIERS

Agricultural land and developed areas within the assessment area serve as natural barriers for ponderosa pine in the assessment area. These dispersal barriers may limit the ponderosa pine's ability to adjust its range in response to changing climate conditions.

## DEPENDENCE ON DISTURBANCE EVENTS

Fire is an important part of the ponderosa pine's ecology. The species has thick bark and an open crown structure which facilitates post-fire survival.[1] While projected increases in annual area burned may initially facilitate establishment of ponderosa pine seeds,[3] there will likely be a threshold where the area of land burned will out-weight the successional advantage of establishing after a fire.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the ponderosa pine's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Habeck, R. J. 1992. Pinus ponderosa var. benthamiana, P. p. var. ponderosa. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/plants/tree/pinponp.all.html

[2] Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2013. Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.

[3] Isaak, D.J., Wollrab, S., Horan, D., Chandler, G. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980-2009 and implications for salmonid fishes. Climatic Change 113: 499-524.

## IMAGE CREDIT

# PRONGHORN ANTELOPE

*Antilocapra americana*

The pronghorn antelope is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable by the 2050s under a high (RCP 8.5) greenhouse gas scenario. The pronghorn antelope is estimated to be moderately vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the pronghorn antelope's estimated sensitivity to climate change. Key climate sensitivities for the pronghorn antelope are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT INCREASE THE ANTELOPE'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Roads and fences have been identified as anthropogenic barriers to pronghorn antelope dispersal.[1] These dispersal barriers may decrease the pronghorn antelope's ability to adjust its range in response to changing climate conditions.

### LIMITED GENETIC DIVERSITY

Pronghorn antelope populations have expressed lower levels of genetic diversity.[2] Species with low levels of genetic diversity are expected to be less able to adapt to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE ANTELOPE'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION

The pronghorn antelope inhabits sagebrush-steppe habitat. Sagebrush-steppe habitats are often considered suitable sites for wind farm or solar array development, and may thus negatively affect pronghorn antelope habitat.[1]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the pronghorn antelope's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.
[2] Lee, T.E., Bickham J.W., Scott, D.M. 1994. Mitochondrial DNA and allozyme analysis of North American pronghorn populations. The Journal of Wildlife Management 58: 307-318.

## IMAGE CREDIT


The quaking aspen is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and moderately vulnerable under a high (RCP 8.5) greenhouse gas scenario. The quaking aspen is estimated to be moderately vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the quaking aspen's estimated sensitivity to climate change. Key climate sensitivities for the quaking aspen are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE QUAKING ASPEN'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

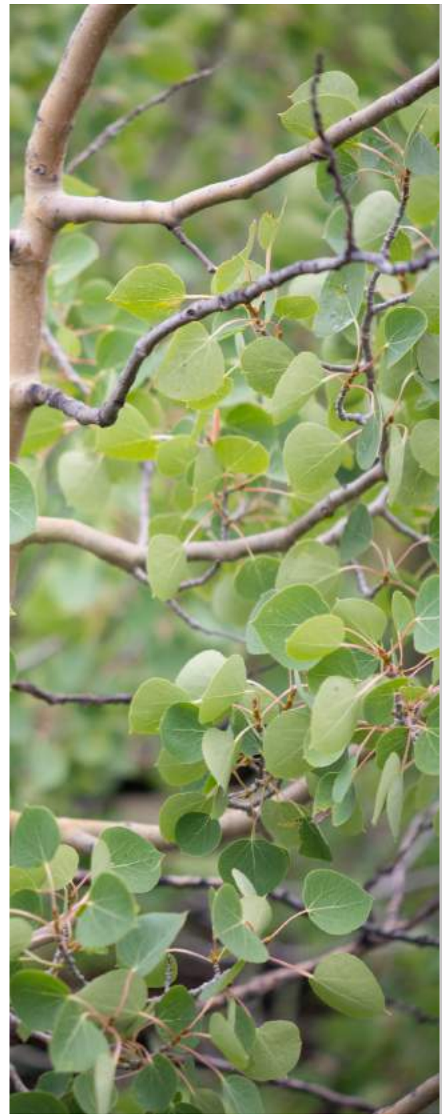
Quaking aspen are found in high elevation areas and northern latitudes that often include low seasonal temperatures and short growing seasons.[1] Projected increases in temperature and growing season length could negatively affect quaking aspen.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Quaking aspen is generally found in regions where annual precipitation is greater than evapotranspiration,[2] and are dependent on moist sites for growth.[3] Therefore, projected warming and reduce water availability may negatively affect the hydrologic suitability of quaking aspen habitat.

## DEPENDENCE ON DISTURBANCE EVENTS

Droughts may increase the susceptibility of quaking aspen to canker infections. Drier, warmer, climate conditions may favor invasion of gypsy moths –a known pest of quaking aspen – in the western United States.[4] Sensitivity to disease and pests may thus increase the quaking aspen's vulnerability to climate change.



## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the quaking aspen's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS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[3] Colville Tribes staff, personal communication.
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## IMAGE CREDIT



CLIMATE IMPACTS GROUP

THE CONFEDERATED TRIBES OF THE COLVILLE RESERVATION 1872

# REDBAND TROUT

*Oncorhynchus mykiss gairdneri*

The redband trout is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The redband trout is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the redband trout's estimated sensitivity to climate change. Key climate sensitivities for the redband trout are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE REDBAND TROUT'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

While redband trout have often been considered more tolerant of warmer water temperatures than other salmonid species, recent research suggests that the thermal tolerances of redband trout populations in southeastern Oregon differ only slightly from other salmonids. It could therefore be concluded that the redband trout is not uniquely tolerant of warm water temperatures compared to other salmonids.[1] Thus, rising stream temperatures under climate change could negatively affect redband trout populations.

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers within the assessment area have dams that prevent redband trout access to more suitable, cooler habitat if their present habitat becomes too warm. These dispersal barriers may limit the redband trout's ability to adjust its range in response to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

During winter, redband trout inhabit cold, deep pools in mountain streams. During summer, redband trout inhabit low-gradient, medium-elevation stream reaches with pools, which are critical spawning habitat. Redband trout also inhabit higher gradient channels with riffles or areas with boulder and cobbles. Shifting precipitation patterns under climate change could alter the suitability of these habitats for redband trout.

### SENSITIVITY TO DISEASE

Warming stream temperatures may intensify mortality from fish pathogens. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids and these effects could be exacerbated with warming stream temperatures.[3] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease. Many important salmonid diseases become virulent when water temperatures reach 60-61°F.[4]

## FACTORS THAT SOMEWHAT INCREASE THE REDBAND TROUT'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Natural barriers (e.g., waterfalls) will decrease the ability of redband trout to adjust its range in response to changing climate conditions.[5]

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect redband rainbow trout habitat.[5]

### DEPENDENCE ON DISTURBANCE EVENTS

The survival of salmonid (i.e., salmon, trout, and char) eggs and embryos is strongly influenced by sediment deposition, water quality, and streambed scour and fill.[6] As air temperatures rise, watersheds are projected to become increasingly rain-dominant. This shift will increase the risk of winter flooding and sediment transport, which can negatively affect the survival of salmonid eggs.

### SENSITIVITY TO COMPETITION

Redband trout compete with resident brook trout, which are fish-eaters and known to prey on young salmonids. It is estimated that there have been at least 35 non-native fish species introduced to the redband trout range within the Columbia River Basin. Climate change may influence the success of redband trout as it competes for resources.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the redband trout's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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FishBase. Brook trout (Salvelinus fontinalis).
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# SCOULER'S WILLOW

*Salix scouleriana*

The Scouler's willow is estimated to be less vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The Scouler's willow is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the Scouler's willow's estimated sensitivity to climate change. Key climate sensitivities for the Scouler's willow are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE SCOULER'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIONS

Plantation forests are likely to reduce the amount of quality Scouler's willow habitat due to stand initiation.[1]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the Scouler's willow's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Scouler's willow by Matt Lavin, used under CC BY-NC-ND 2.0

Back Page: Scouler's willow by Matt Lavin, used under CC BY-NC-ND 2.0

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the service berry's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[2] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Service berry by USFWS, used under CC BY-NC-ND 2.0

Back Page: Service berry by Andrey Zharkikh, used under CC BY-NC-ND 2.0

# SHARP-TAILED GROUSE

*Tympanuchus phasianellus*

The sharp-tailed grouse is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and highly vulnerable by the 2050s under a high (RCP 8.5) greenhouse gas scenario.  The sharp-tailed grouse is estimated to be highly vulnerable to climate change by the 2080s under a low greenhouse gas scenario and extremely vulnerable under a high scenario. This ranking reflects both projected future changes in climate as well as the sharp-tailed grouse's estimated sensitivity to climate change. Key climate sensitivities for the sharp-tailed grouse are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE SHARP-TAILED GROUSE'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Roads and barbed wire fences serve as anthropogenic barriers to sharp-tailed grouse dispersal.[1,2] These dispersal barriers may limit the sharp-tailed grouse's ability to adjust its range in response to changing climate conditions.

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

The sharp-tailed inhabits sagebrush habitat. These areas have the potential for wind farm or solar array development, and may thus negatively affect sharp-tailed grouse habitat.[1]

## LIMITED GENETIC DIVERSITY

Genetic diversity in a population of Washington Columbian sharp-tailed grouse has been observed to be lower than a population in Idaho.[3] Species with average to high levels of genetic diversity are expected to be better able to adapt to changing climate conditions.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the sharp-tailed grouse's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT

Front Page: Sharp-tailed grouse by USFWS, used under CC BY-NC-ND 2.0

Back Page: Sharp-tailed grouse by David A. Mitchell, used under CC BY-NC-ND 2.0

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CLIMATE IMPACTS GROUP

THE CONFEDERATED TRIBES OF THE COLVILLE RESERVATION 1872

# SMALLMOUTH BASS

*Micropterus dolomieu*

The smallmouth bass is estimated to be lesss vulnerable to climate change by the 2050s under a both low (RCP 4.5) and high (RCP 8.5) greenhouse gas scneario. The smallmouth bass is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the smallmouth bass's estimated sensitivity to climate change. Key climate sensitivities for the smallmouth bass are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT INCREASE THE SMALLMOUTH BASS'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Smallmouth bass inhabit shallow rocky regions of lakes, flowing river pools, flowing streams.[1] Many streams and rivers throughout the Colville assessment area have dams that could prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the ability of the smallmouth bass to adjust its range in response to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE SMALLMOUTH BASS'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect smallmouth bass habitat.[2]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the smallmouth bass's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] FishBase. Smallmouth bass (Micropterus dolomieu).
[2] Colville Tribes staff, personal communication.

## IMAGE CREDIT

# SOCKEYE SALMON

*Oncorhynchus nerka*

The sockeye salmon is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The sockeye salmon is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the sockeye salmon's estimated sensitivity to climate change. Key climate sensitivities for the sockeye salmon are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |

## FACTORS THAT GREATLY INCREASE THE SOCKEYE SALMON'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

The preferred spawning temperature range for sockeye salmon is 36.1°F to 46.4°F.[1] As stream temperatures continue to rise,[2] the frequency with which these thresholds are exceeded and total river miles affected may increase. Additionally, sockeye arrive at tributary mouths (Wenatchee and Okanogan) in early-July when temperatures are rising quickly. In most years a large proportion of the Sockeye run is delayed from entering the Okanogan River due to high temperatures. Earlier onset or later breakdown of the thermal barrier could significantly affect long-term persistence. The Columbia River generally has a hospital thermal regime for migration and pre-spawn holding; however, in 2015 the Columbia River was warmed to several degrees above normal and there were catastrophic losses of Sockeye all throughout the migration.[3]

## FACTORS THAT INCREASE THE SOCKEYE SALMON'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers throughout sockeye salmon range within the assessment area have dams that act as barriers to sockeye movement (particularly upstream of Chief Joseph and Grand Coulee dams). These man-made barriers may limit the sockeye salmon's ability to adjust its range response to changing climate conditions.[3]

### DIET VERSATILIY

In the freshwater, young sockeye salmon primarily feed on crustacean zooplankton. As adults in the ocean, sockeye salmon generally feed on pelagic crustaceans and plankton.[4] Because sockeye salmon diets are generally limited, they are more likely to be negatively affected by climate change. Moreover, salmon have suffered as lower productivity in the ocean, as a result of warming waters, limited food availability.[3]

### SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids, and their effects could be exacerbated with warming stream temperatures.[5] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease.

## FACTORS THAT SOMEWHAT INCREASE THE SOCKEYE SALMON'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Natural barriers (e.g., waterfalls) will decrease the ability of the sockeye salmon to adjust their range in response to changing climate conditions.[3]

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect sockeye salmon habitat.[3]

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Many stocks of Pacific salmon, including sockeye salmon, have evolved to spawn during fall months when water temperatures are colder and stream flows are low.[6] Projected changes in the timing and volume of seasonal streamflow[7] may negatively affect sockeye salmon populations.

### DEPENDENCE ON DISTURBANCE EVENTS

The survival of salmonid (i.e., salmon, trout, and char) eggs and embryos is strongly influenced by sediment deposition, shifts in water quality, and streambed scour and fill.[8] As air temperatures rise, watersheds are projected to become increasingly rain-dominant. This shift will increase the risk of winter flooding and sediment transport, which can negatively affect the survival of salmonid eggs.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the sockeye salmon's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS


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[2] Isaak, D.J., Wollrab, S., Horan, D., Chandler, G. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980-2009 and implications for salmonid fishes. Climatic Change 113: 499-524.

[3] Colville Tribes staff, personal communication.

[4] Quinn, T. P. 2005. The behavior and ecology of Pacific salmon and trout. University of Washington Press, Seattle.

[5] Crozier, L. 2015. Impacts of climate change on salmon of the Pacific Northwest: A review of the scientific literature published in 2014. Fish Ecology Division, Northwest Fisheries Science Center. NOAA. https://www.nwfsc.noaa.gov/assets/11/8473_07312017_171438_Crozier.2015-BiOp-Lit-Rev-Salmon-Climate-2014.pdf

[6] Sauter, S.T., McMillan, J., Dunham, J. 2001. Salmonid behavior and water temperature. EPA, Prepared as Part of Region 10 Temperature Water Quality Criteria Guidance Development Project. 38 pp.

[7] Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2013. Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.

[8] DeVries, P. 1997. Riverine salmonid egg burial depths: review of published data and implications for scour studies. Can. J. Fish Aquat. Sci. 54: 1685-1698.


## IMAGE CREDIT

# STEELHEAD SUMMER RUN

*Oncorhynchus mykiss*

The steelhead (summer run) is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The steelhead (summer run) is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the steelhead's (summer run) estimated sensitivity to climate change. Key climate sensitivities for the steelhead (summer run) are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT GREATLY INCREASE THE STEELHEAD'S (SUMMER RUN) VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

It has been indicated that 10°C is the preferred steelhead egg hatching temperature. Optimal growth for juvenile steelhead occurs in the range of 14°C to 15°C. 21°C is the temperature which blocks adult steelhead migration. It is recommended that daily maximum temperatures remain below 19° to 20°C to prevent directly lethal conditions to steelhead.[1] As stream temperatures continue to rise,[2] the frequency with which these thresholds are exceeded, and the stream range over which they are exceeded, may increase.

## FACTORS THAT INCREASE THE STEELHEAD'S (SUMMER RUN) VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers throughout steelhead range within the assessment area have dams and culverts that would prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the steelhead's ability to adjust its range in response to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Steelhead are often found in cool clear lakes and cool swift streams with silt-free substrate. In streams, deep low velocity pools are important wintering habitats.[3] Projected change in seasonal streamflow and precipitation[4] may alter some of the streamflow dynamics and erosion and sediment transport in the region.

## DIET VERSATILITY

Steelhead consume a variety of aquatic and terrestrial invertebrates along with small fish species.[5] Species that can readily switch between different food sources are less likely to be negatively affected by climate change, at least in the freshwater lifestages. However, low productivity ocean cycles can affect all of their food, even if they are feeding from multiple taxonomic groups. Dietary diversity is not likely to ameliorate the effects of low ocean productivity because it will reduce productivity of all food sources.[6]

## SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids, and their effects could be exacerbated with warming stream temperatures.[7] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease.

## LIMITED GENETIC DIVERSITY

Genetic variation is very limited in the Upper Columbia steelhead populations. Species with average to high levels of genetic variation are expected to be better able to adapt to changing climate conditions.

## SENSITIVITY TO COMPETITION

Chinook salmon compete with other resident fish species which may increase in abundance with increasing temperatures.[2]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the steelhead's (summer run) sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT

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Back Page: Steelhead by Fungus Guy, used under CC BY-NC-ND 3.0

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[3] NatureServe Explorer. Steelhead (Oncorhynchus mykiss).

[4] Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2013. Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.

[5] FishBase. Steelhead (Oncorhynchus mykiss).

[6] Colville Tribes staff, personal communication.

[7] Crozier, L. 2015. Impacts of climate change on salmon of the Pacific Northwest: A review of the scientific literature published in 2014. Fish Ecology Division, Northwest Fisheries Science Center. NOAA. https://www.nwfsc.noaa.gov/assets/11/8473_07312017_171438_Crozier.2015-BiOp-Lit-Rev-Salmon-Climate-2014.pdf

[8] UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia spring Chinook salmon and steelhead recovery plan. Wenatchee, Washington.

# THINLEAF HUCKLEBERRY

*Vaccinium membranaceum*

The thinleaf huckleberry is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and highly vulnerable under a high (RCP 8.5) greenhouse gas scenario. The thinleaf huckleberry is estimated to be highly vulnerable to climate change by the 2080s under a low greenhouse gas scenario and extremely vulnerable under a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the thinleaf huckleberry's estimated sensitivity to climate change. Key climate sensitivities for the thinleaf huckleberry are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE THINLEAF HUCKLEBERRY'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Thinleaf huckleberry are associated with cold subalpine forests at mid- and high-elevation zones within the assessment area. Projected warming may negatively affect thinleaf huckleberry habitat within the assessment area.[1]

## FACTORS THAT SOMEWHAT INCREASE THE THINLEAF HUCKELEBERRY'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE MITIGATION ACTIVITIES

Plantation forests are likely to reduce the amount of quality thinleaf huckleberry habitat due to stand initiation.[1]

### DEPENDENCE ON SNOW

Thinleaf huckleberry are found at higher elevations within the assessment area and are often associated with snow cover during the winter months.[1] Therefore, projected declines in winter snowpack may negatively affect thinleaf huckleberry habitat.

## FACTORS THAT SOMEWHAT INCREASE THE THINLEAF HUCKLEBERRY'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO DISEASE

Thinleaf huckleberry within the assessment area has been affected by a rust fungus and an unidentified "spongey" substance. Projected warming and reduced moisture availability may stress the huckleberry, limiting the species ability to mount an effective immune response.[1]

### REPRODUCTIVE SYSTEM

Thinleaf huckleberry is able to reproduce vegetatively and via seed dispersal.[2] Vegetative reproduction has been noted of particular importance to the thinleaf huckleberry. In plants, genetic variation is linked to reproductive system. Species that reproduce vegetatively are assumed to have lower levels of genetic variation. Species with average to high levels of genetic diversity are expected to be better able to adapt to changing climate conditions.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the thinleaf huckleberry's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS


[1] Colville Tribes staff, personal communication.
[2] Simonin, Kevin A. 2000. Vaccinium membranaceum. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: www.fs.fed.us/database/feis/plants/shrub/vacmem/all.html


## IMAGE CREDIT

# TIGER SALAMANDER

*Ambystoma tigrinum*

The tiger salamander is estimated to be highly vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and extremely vulnerable under a high (RCP 8.5) greenhouse gas scenario. The tiger salamander is estimated to be highly vulnerable to climate change by the 2080s under low greenhouse gas scenario and extremely vulnerable under a high greenhouse gas scneario. This ranking reflects both projected future changes in climate as well as the tiger salamander's estimated sensitivity to climate change. Key climate sensitivities for the tiger salamander are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE TIGER SALAMANDERS'S VULNERABILITY TO CLIMATE CHANGE:

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Both annual and seasonal variations in precipitation can result in ponds or wetlands drying prior to metamorphosis of salamander larvae.[1] Projected increases in temperature and projected declines in moisture availability may result in wetlands drier out earlier in the year or for longer periods.

## FACTORS THAT SOMEWHAT INCREASE THE TIGER SALAMANDERS'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Wide, fast-moving rivers act as natural barriers to tiger salamander dispersal.[1] Natural barriers may decrease the ability of the tiger salamander to adjust its range in response to changing climate conditions.

### OCCURRENCE OF MAN-MADE BARRIERS

Roads, housing, commercial development, railroads, power transmission lines, and irrigation canals can all serve as anthropogenic barriers to dispersal for the tiger salamander. These dispersal barriers may limit the tiger salamander's ability to adjust its range in response to changing climate conditions.

## LIMITED DISPERSAL ABILITIES

Tiger salamanders are relatively poor dispersers. Dispersal events typically occur after metamorphosis between wetlands and upland sites, and rarely exceed 200 m.[3] The poor dispersal ability of the tiger salamander decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

## DEPENDENCE ON DISTURBANCE EVENTS

The tiger salamander is sensitive to drought conditions due to its dependence on habitats with close proximity to water sources, including wetlands.[1] Projected declines in summer precipitation and increasing summer temperatures are likely to negatively affect tiger salamander habitat.

## DEPENDENCE ON OTHER SPECIES FOR HABITAT

The tiger salamander uses the burrows of the Great Basin pocket mouse and pocket gophers as underground refugia. The salamander is able to construct its own burrow if mouse and gopher burrows are unavailable. Dependence on another species, which may be vulnerable to climate change, for habitat generation is expected to increase a species' vulnerability to climate change.

## DSENSITIVITY TO DISEASE

A pathogenic chytrid fungus (Batrachochytrium dendrobatidis), which has been associated with the frog population declines in North America, have recently been observed in tiger salamander populations.[4] Sensitivity to disease may thus increase the tiger salamander's vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the tiger salamander's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT



## CITATIONS

[1] Washington Wildlife Habitat Connectivity Working Group (WHCWG). 2012. Washington Connected Landscapes Project: Analysis of the Columbia Plateau Ecoregion. Washington's Department of Fish and Wildlife, and Department of Transportation, Olympia, WA.
[2] NatureServe Explorer. Tiger salamander (Ambystoma tigrinum)
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# TULE

*Schoenoplectus acutus*

Tule could not be quantitatively assessed with the CCVI due to lack of species range data. For tule, we qualitatively assessed the climate sensitivity within the assessment area using sensitivity factors included in the CCVI. Key climate sensitivities for tule are discussed below.

## FACTORS THAT INCREASE TULE'S VULNERABILITY TO CLIMATE CHANGE:

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Tule inhabits marshes, swamps, seeps, washes, floodplains, and in wet meadows. The species requires sites with saturated soils or standing water for the majority of the year.[1] Projected declines in summer streamflow,[2] may reduce the availability of suitable habitat for tule in summer.

### SENSITIVITY TO COMPETITION

Tule competes with invasive phragmites which displace native tule habitat.[3] Sensitivity to competition may thus increase the tule's vulnerability to climate change.

## FACTORS THAT MAY SOMEWHAT INCREASE THE TULE'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

The draining of tule habitat and conversion to agricultural land and orchard farms has resulted in the development of anthropogenic barriers within the assessment area. These barriers may limit the tule's ability to adjust its range in response to changing climate conditions.[3]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on tule's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[1] Esser, Lora L. 1995. Schoenoplectus acutus. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us/database/feis/plants/graminoid/schacu/all.html

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[3] Colville Tribes staff, personal communication.

## IMAGE CREDIT

Front Page: Tule by Nick Varvel, used under CC BY-NC-ND 2.0

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# WALLEYE

*Sander vitreus*

The walleye is estimated to be les vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scneario. The walleye is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the walleye's estimated sensitivity to climate change. Key climate sensitivities for the walleye are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT INCREASE THE WALLEYE'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Walleye inhabit lakes, pools, backwaters, and runs of medium to large rivers.[1] Many streams and rivers throughout the Colville assessment area have dams that could prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the walleye's ability to adjust its range in response to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE WALLEYE'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect walleye habitat.[2]

## CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Walleye populations are known to be sensitive to water level fluctuation which will likely be altered under climate change scenarios.[2]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the walleye's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability

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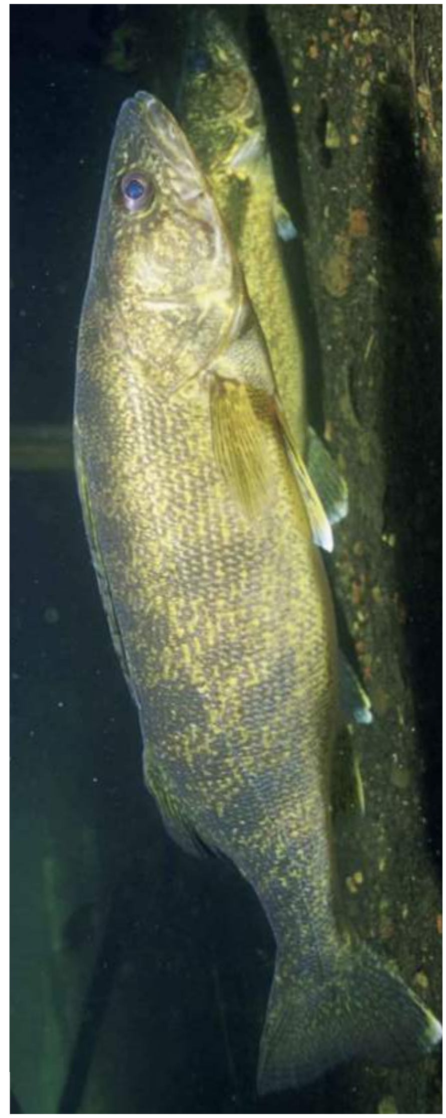
[1] FishBase. Walleye (Sander vitreus).

[2] Colville Tribes staff, personal communication.



## IMAGE CREDIT


The wapato could not be quantitatively assessed with the CCVI due to lack of species range data. For the wapato, we qualitatively assessed the climate sensitivity within the assessment area using sensitivity factors included in the CCVI. Key climate sensitivities for the wapato are discussed below.

## FACTORS THAT INCREASE THE WAPATO'S VULNERABILITY TO CLIMATE CHANGE:

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Wetland wapato is an obligate wetland species found in both marshes and wetlands with shallow water levels.[1] Projected declines in summer streamflow,[2] may reduce the availability of suitable habitat in summer months for the wetland wapato.

## FACTORS THAT MAY SOMEWHAT INCREASE THE DEVIL'S CLUB'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Wapato is found within the vicinity of the Nez Pearce lands. The Columbia Plateau may serve as a barrier that limits the ability of wapato to adjust its range in response to climate change.[3]

### OCCURRENCE OF MAN-MADE BARRIERS

The draining of wapato habitat and conversion to agricultural land and orchard farms has resulted in the development of anthropogenic barriers within the assessment area. These barriers may limit the wapato's ability to adjust its range in response to changing climate conditions.[3]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the wapato's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[1] Invasive Species Compendium. Sagittaria latifolia. https://www.cabi.org/isc/datasheet/109160
[2] Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2013. Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.
[3] Colville Tribes staff, personal communication.


## IMAGE CREDIT

# WATER BIRCH

*Betula occidentalis*

The water birch is estimated to be less vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The water birch is estimated to be less vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the water birch's estimated sensitivity to climate change. Key climate sensitivities for the water birch are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE WATER BIRCH'S VULNERABILITY TO CLIMATE CHANGE:

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Water birch is a riparian species that inhabits sites adjacent to streams and also inhabits wet swales, marshes, ravines, bogs, or moist open woods. These habitats typically have water tables at or near the soil surface throughout summer.[1] Projected declines in summer streamflow,[2] may reduce the availability of suitable habitat for the water birch.

### DEPENDENCE ON DISTURBANCE EVENTS

While the water birch is able to tolerate inundation for several months, studies have suggested that water birch growth and abundance are higher on sites that are flooded for shorter durations.[1] Projected increases in the frequency of winter flooding[2] may negatively affect water birch habitat.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the water birch's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Gucker, Corey. 2012. Betula occidentalis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us /database/feis/plants/tree/betocc/all.html
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## IMAGE CREDIT

# WESTERN LARCH

*Larix occidentalis*

The western larch is estimated to be moderately vulnerable to climate change by the 2050s under both a low (RCP 4.5) greenhouse gas scenario and highly vulnerable under a high (RCP 8.5) greenhouse gas scenario. The western larch is estimated to be highly vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the western larch's estimated sensitivity to climate change. Key climate sensitivities for the western larch are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |

## FACTORS THAT GREATLY INCREASE THE WESTERN LARCH'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED DISPERSAL ABILITIES

Western larch seeds are wind-dispersed and most seeds fall within 100 m of the parent plant.[1] In addition, the western larch only bears a cone crop every five to seven years which severely limits the species ability to move across the landscape.[2] The western larch's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE WESTERN LARCH'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Western larch occupy relatively cool climate zones where the average annual temperature is 45 degrees F.[1] In Washington, the western larch establishes on sites between 2,000-5500 ft.[1] Projected warming[3] may negatively affect western larch habitat.

### SENSITIVITY TO DISEASE

Dwarf mistletoe is considered the most significant parasite that affects the western larch.[1] Warming temperatures and changes in precipitation (increasing or decreasing) may increase damage from dwarf mistletoe.[1,4] Sensitivity to dwarf mistletoe may thus increase the western larch's vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the western larch's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[1] Scher, Janette S. 2002. Larix occidentalis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us/database/feis/plants/tree/larlya/all.html

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## IMAGE CREDIT

Front Page: Western larch by sunrisesoup, used under CC BY-NC-ND 2.0

Back Page: Western larch by karen_hine, used under CC BY-NC-ND 2.0

# WESTERN PEARLSHELL

*Margaritifera falcata*

The western pearlshell mussel could not be quantitatively assessed with the CCVI due to lack of species range data. For the western pearlshell, we qualitatively assessed the climate sensitivity within the assessment area using sensitivity factors included in the CCVI. Key climate sensitivities for the western pearlshell are discussed below.

## FACTORS THAT GREATLY INCREASE THE WESTERN PEARLSHELL'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

The western pearlshell mussel is known to inhabit cool and cold streams.[1] One observation noted that glochida packets typically occur in water temperatures of 56.3 degrees F (13.5 degrees C). As stream temperatures continue to rise,[2] the frequency with which these thresholds are exceeded, and the stream range over which they are exceeded, may increase.

## FACTORS THAT INCREASE THE WESTERN PEARLSHELL'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Western pearlshell mussels inhabit cold streams with low to moderate gradients.[1] Dams and non-fish-friendly culverts may act as anthropogenic barriers to mussel dispersal. These dispersal barriers may limit the western pearlshell mussel's ability to adjust its range in response to changing climate conditions.

### CHANGES IN STREAMFLOW OR WATER AVAILABILITY

The mussels often inhabit streams with large boulders that limit scour from streamflow.[1] Projected increases in winter peak flows may increase streambed scour and negatively affect mussel habitat. Summer habitat will also likely be lost as baseflows decrease and mussel beds dry up.[3]

### DEPENDENCE ON DISTURBANCE EVENTS

Western pearlshell mussel are susceptible to flood scouring and increased sedimentation that will likely be influenced by climate change.[3]

### DEPENDENCE ON OTHER SPECIES FOR DISPERSAL

The western pearlshell mussel depends on salmonid species for dispersal.[3] Dependence on another species, which may be vulnerable to climate change, for dispersal is expected to increase a species' vulnerability to climate change.

## FACTORS THAT SOMEWHAT INCREASE THE WESTERN PEARLSHELL'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

Climate change mitigation actions, such as new hydropower projects, may affect western pearlshell mussel habitat.[3]

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the western pearlshell's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[1] Western Pearlshell — Margaritifera falcata. Montana Field Guide. Montana Natural Heritage Program. Retrieved on April 17, 2018, from http://FieldGuide.mt.gov/speciesDetail.aspx?elcode=IMBIV27020

[2] Isaak, D.J., Wollrab, S., Horan, D., Chandler, G. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980-2009 and implications for salmonid fishes. Climatic Change 113: 499-524.

[3] Colville Tribes staff, personal communication.

## IMAGE CREDIT

# WESTERN REDCEDAR

*Thuja plicata*

The western redcedar is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The western redcedar is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the western redcedar's estimated sensitivity to climate change. Key climate sensitivities for the western redcedar are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE WESTERN REDCEDAR'S VULNERABILITY TO CLIMATE CHANGE:

### LIMITED GENETIC DIVERSITY

Western redcedar has one of the lowest levels of genetic diversity among conifers. Species with low levels of genetic diversity are expected to be less able to adapt to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE WESTERN REDCEDAR'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Agricultural land within the assessment area may limit to ability of the western redcedar to disperse into cool forests north of the assessment area. These dispersal barriers may limit the western redcedar's ability to adjust its range in response to changing climate conditions.

### LIMITED DISPERSAL ABILITIES

Western redcedar seeds are wind dispersed. However, the seed's small wings limit the dispersal distance to approximately 120 meters.[2] The western redcedar's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

## CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Western redcedar are dependent on moist sites for growth.[3] Therefore, projected warming and reduce water availability may negatively affect the hydrologic suitability of western redcedar habitat.

## DEPENDENCE ON DISTURBANCE EVENTS

Western redcedar growing on wet sites within the assessment area are extremely susceptible to windthrow. While climate change is not expected to affect wind-speeds, projected increases in winter precipitation and flooding may increase the incidence of windthrow during wind storms.[3]

## SENSITIVITY TO DISEASE

Western redcedar is susceptible to numerous insects, pathogens, and pests. It is challenging to make generalizations of the responses of diseases and pests to climate change because the responses will largely be species specific. Some diseases/pests may become more widespread while others may not. For example, western redcedar is susceptible to armellaria root disease. If climate change results in a warmer and drier climate armellaria impact is projected to increase. Conversely, if climate change results in a warmer and wetter climate, the impact of armellaria is projected to remain the same.[4] Sensitivity to disease may thus increase the western redcedar's vulnerability to climate change.

## SENSITIVITY TO COMPETITION

Western redcedar is sensitive to competition from ponderosa pine.[3] Sensitivity to competition may thus increase the western redcedar's vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the western redcedar's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[3] Colville Tribes staff, personal communication.

[4] Sturrock, R. N.; Frankel, S. J.; Brown, A. V.; Hennon, P. E.; Kliejunas, J. T.; Lewis, K. J.; Worrall, J. J., and Woods, A. J. 2011. Climate change and forest diseases. Plant Pathology 60:133-149.

# WESTERN SPRING BEAUTY

*Claytonia lanceolata*

Western spring beauty could not be quantitatively assessed with the CCVI due to lack of species range data. For the Indian potato, we qualitatively assessed the climate sensitivity within the assessment area using sensitivity factors included in the CCVI. Key climate sensitivities for the Indian potato are discussed below.

## FACTORS THAT INCREASE THE WESTERN SPRING BEAUTY'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

The draining of western spring beauty habitat and conversion to agricultural land and orchard farms has resulted in the development of anthropogenic barriers within the assessment area.[1] These barriers may limit the western spring beauty's ability to adjust its range in response to changing climate conditions.

### LIMITED DISPERSAL ABILITY

Western spring beauty seeds are dispersed via explosive dehiscence, are unlikely to travel significant distances from the parent plant. The Indian potato's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Western spring beauty is typically found on moist sites.[2] Projected declines in summer streamflow,[3] may reduce the availability of suitable habitat in summer months for the western spring beauty.

### DEPENDENCE ON DISTURBANCE EVENTS

Western spring beauty seeds are stored in the soil and germinate post-fire.[2] While projected increases in annual area burned[4] may initially benefit these berry species, there is likely a limit to the beneficial effects of increasing annual area burned.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the western spring beauty's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

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## IMAGE CREDIT

# WESTERN TOAD

*Anaxyrus boreas*

The western toad is estimated to be highly vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The western toad is estimated to be highly vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the western toad's estimated sensitivity to climate change. Key climate sensitivities for the western toad are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |

## FACTORS THAT INCREASE THE WESTERN TOAD'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

The western toad has been identified as a species that is highly sensitive to development. Roads and urban areas have been identified as anthropogenic barriers to western toad dispersal.[1] These dispersal barriers may limit the western toad's ability to adjust its range in response to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Breeding sites include ponds, small lakes, streams, pools, and ditches with stagnant or extremely slow-moving water.[2] Projected warming will likely increase evapotranspiration and may shorten the wet season of small pools and ditches, and may lead to mis-matches between when metamorphosis occurs and when these bodies of water are present.

### SENSITIVITY TO DISEASE

A pathogenic chytrid fungus (Batrachochytrium dendrobatidis) is partially responsible for widespread declines of western toad populations in North America.[3] Sensitivity to disease may thus increase the western toad's vulnerability to climate change.

## FACTORS THAT SOMEWHAT INCREASE THE WESTERN TOAD'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

The western toad inhabits areas with close proximity to permanent water sources.[4] Therefore, stretches of the landscape without consistent water sources (i.e., wetlands, streams, ponds, or lakes) may serve as natural dispersal barriers for the toad. Natural barriers may decrease the ability of the western toad to adjust its range in response to changing climate conditions.

### DEPENDENCE ON DISTURBANCE EVENTS

The western toad is sensitive to drought conditions during the larvae/ metamorphosis life-cycle stage.[2] Projected warming and declining summer precipitation are expected to reduce the number of sites available for breeding.

### DEPENDENCE ON OTHER SPECIES FOR HABITAT

Western toads use gopher and ground squirrel burrows as retreats during cold weather when temperatures dip below 3°C.[2] Dependence on another species, which may be vulnerable to climate change, for habitat generation is expected to increase a species' vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the western toad's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https:// cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability

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[3] Environment and Climate Change Canada. 2016. Management Plan for the Western Toad (Anaxyrus boreas) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment and Climate Change Canada, Ottawa. iv + 38 pp.

[4] Colville Tribes staff, personal communication.


## IMAGE CREDIT

# WESTSLOPE CUTTHROAT TROUT

*Oncorhynchus clarkii lewisi*

The westslope cutthroat trout is estimated to be extremely vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The westslope cutthroat trout is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the westslope cutthroat trout's estimated sensitivity to climate change. Key climate sensitivities for the westslope cutthroat trout are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT INCREASE THE CUTTHROAT TROUT'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON COOL OR COLD HABITATS

Populations of westslope cutthroat trout spawn in water temperatures of 50 °F (10 °C).[1] As stream temperatures continue to rise,[2] the frequency with which these thresholds are exceeded, and the stream range over which they are exceeded, may increase. Projected declines in cutthroat populations are strongly associated with increases in temperature.[3]

### OCCURRENCE OF MAN-MADE BARRIERS

Many streams and rivers throughout the Colville assessment area have dams that could prevent access to suitable habitat if the present occupied habitat became too warm as a result of climate change. These dispersal barriers may limit the westslope cutthroat trout's ability to adjust its range in response to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Populations of westslope cutthroat trout spawn in streams during spring when water temperatures are cold and water flows are high with spring run-off.[1] Projected advances in the time of snowmelt[4] may cause flooding associated with snowmelt to shift earlier in the year. This may result in a mismatch between when late winter/spring floods occur and when the westslope cutthroat trout spawns.

### DEPENDENCE ON DISTURBANCE EVENTS

The survival of salmonid (i.e., salmon, trout, and char) eggs and embryos is strongly influenced by sediment deposition, water quality, and streambed scour and fill.[5] As air temperatures rise, watersheds are projected to become increasingly rain-dominant. This shift will increase the risk of winter flooding and increase sediment transport, which can negatively affect the survival of salmonid eggs. Cutthroat populations show a weak negative relationship with winter high flow frequency.[3]

## SENSITIVITY TO DISEASE

Warming stream temperatures may increase mortality caused by fish pathogens and diseases. Vibrio and Ceratomyxa shasta are two infections known to negatively affect salmonids and their effects could be exacerbated with warming stream temperatures.[6] Increasing water temperatures can stress salmonids, reducing their ability to mount an effective immune response to disease.

# FACTORS THAT SOMEWHAT INCREASE THE CUTTHROAT TROUT'S VULNERABILITY TO CLIMATE CHANGE:

## SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

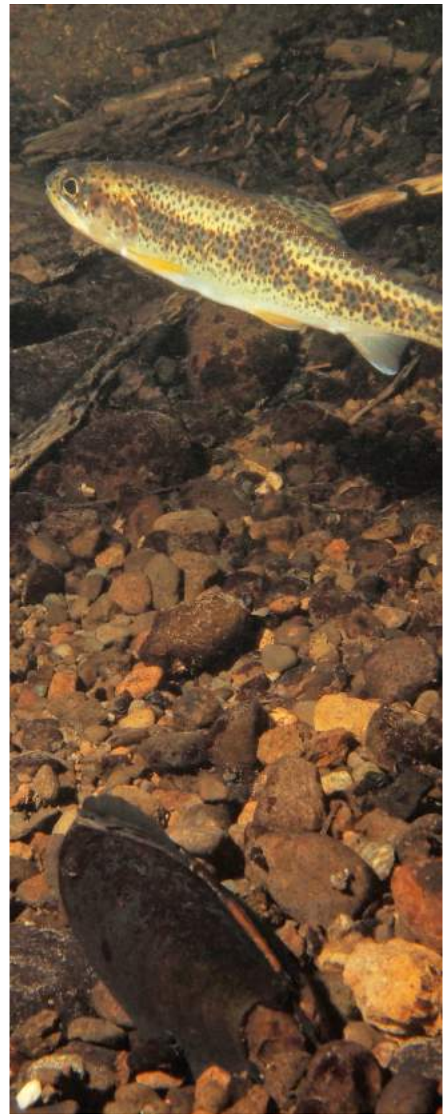
Climate change mitigation actions, such as new hydropower projects, may affect westslope cutthroat trout habitat.[7]

## OCCURRENCE OF NATURAL BARRIERS

Natural barriers (e.g., waterfalls) will decrease the ability of westslope cutthroat trout to adjust its range in response to changing climate conditions.[7]

## SENSITIVITY TO COMPETITION

Redband trout compete with resident brook trout, which are fish-eaters and known to prey on young salmonids. It is estimated that there have been at least 35 non-native fish species introduced to the redband trout range within the Columbia River Basin. Climate change may influence the success of redband trout as it competes for resources.



# FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the westslope cutthroat trout's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

# IMAGE CREDIT

Front Page: Westslope cutthroat trout by Vlad Karpinskiy, used under CC BY-NC-ND 2.0

Back Page: Westslope cutthroat trout by USFWS, used under CC BY-NC-ND 2.0

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[1] Westslope Cutthroat Trout — Oncorhynchus clarkii lewisi. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on November 26, 2017, from http://FieldGuide.mt.gov/speciesDetail.aspx?elcode=AFCHA02088

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[5] DeVries, P. 1997. Riverine salmonid egg burial depths: review of published data and implications for scour studies. Can. J. Fish Aquat. Sci. 54: 1685-1698.

[6] Crozier, L. 2015. Impacts of climate change on salmon of the Pacific Northwest: A review of the scientific literature published in 2014. Fish Ecology Division, Northwest Fisheries Science Center. NOAA. https://www.nwfsc.noaa.gov/assets/11/8473_07312017_171438_Crozier.2015-BiOp-Lit-Rev-Salmon-Climate-2014.pdf

[7] Colville Tribes staff, personal communication.

# WHITE STURGEON

*Acipenser transmontanus*

The white sturgeon is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scneario and highly vulnerable under a high (RCP 8.5) greenhouse gas scenario. The white sturgeon is estimated to be highly vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the white sturgeon's estimated sensitivity to climate change. Key climate sensitivities for the white sturgeon are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |

## FACTORS THAT INCREASE THE WHITE STURGEON'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Large hydroelectric dams in the Columbia River basin will pose fish passage issues for fish residing in the assessment area. Culverts can also serve as anthropogenic barriers for fish passage. These dispersal barriers may limit the white sturgeon's ability to adjust its range in response to changing climate conditions.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Associations between river discharge during the spawning season and spawning intensity (i.e., number of eggs) were drawn for the lower Columbia River. Years with extremely low flow during spawning may reduce the effectiveness of sturgeon spawning.[1]

## FACTORS THAT SOMEWHAT INCREASE THE WHITE STURGEON'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

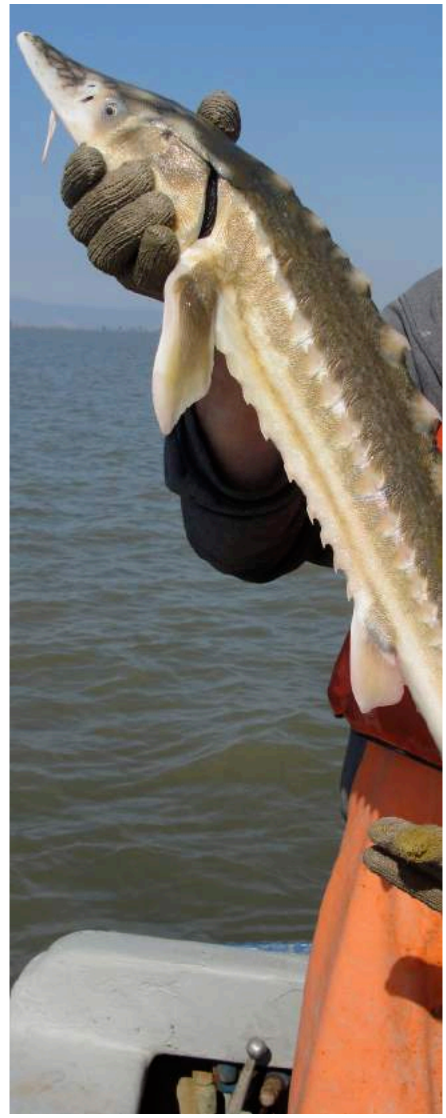
Climate change mitigation actions, such as new hydropower projects, may affect white sturgeon habitat, which includes the bottom of large, cold rivers.[2]

### DEPENDENCE ON COOL OR COLD HABITATS

Spawning has been observed to typically occur in water temperatures between 50 °F and 64.4 °F. Projected increases in stream temperatures,[3] may reduce the duration of time when stream temperatures are ideal for spawning and incubation. Low survival of white sturgeon eggs has been observed at temperatures greater than 18°C,[4] but Golder (2010)[3] observed relatively high survival up to 22°C.

### LIMITED GENETIC DIVERSITY

Genetic diversity in white sturgeon populations in the Upper Columbia have been described as low.[6] Species with low levels of genetic diversity are expected to be less able to adapt to changing climate conditions, compared with species with high levels of genetic variation.



## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the white sturgeon's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[3] Isaak, D.J., Wollrab, S., Horan, D., Chandler, G. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980-2009 and implications for salmonid fishes. Climatic Change 113: 499-524.

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## IMAGE CREDIT

# WHITE-HEADED WOODPECKER

*Leuconotopicus albolarvatus*

The white-headed woodpecker is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and highly vulnerable by the 2050s under a high (RCP 8.5) greenhouse gas scenario. The white-headed woodpecker is estimated to be highly vulnerable to climate change by the 2080s under a low greenhouse gas scenario and extremely vulnerable under a high scenario. This ranking reflects both projected future changes in climate as well as the white-headed woodpecker's estimated sensitivity to climate change. Key climate sensitivities for the white-headed woodpecker are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Less Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE WHITE-HEADED WOODPECKER'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON DISTURBANCE EVENTS

White-headed woodpeckers are a relatively fire-tolerant species as they depend on forest fire for the development of burned forest with residual snags and stumps for nesting cavities.[1] However, white-headed woodpeckers are negatively affected by large scale, mega fires.[2] Climate change is expected to increase the frequency and intensity of fire in western Washington,[3] which may negatively affect white-headed woodpecker habitat.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the white-headed woodpecker's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

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[2] Colville Tribes staff, personal communication.

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## IMAGE CREDIT

# WHITE-TAILED DEER

*Odocoileus virginianus*

The white-tailed deer is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and highly vulnerable by the 2050s under a high (RCP 8.5) greenhouse gas scenario. The white-tailed deer is estimated to be highly vulnerable to climate change by the 2080s under both a low and a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the white-tailed deer's estimated sensitivity to climate change. Key climate sensitivities for the white-tailed deer are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE WHITE-TAILED DEER'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Roads have been identified an anthropogenic barrier to white-tailed deer dispersal. These dispersal barriers may decrease the white-tailed deer's ability to adjust its range in response to changing climate conditions.

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

The white-tailed deer inhabits sagebrush-steppe habitat. Sagebrush-steppe habitats are often considered suitable sites for wind farm or solar array development. Renewable energy development in sagebrush-steppe has the potential to negatively affect white-tailed deer habitat.[1]

## SENSITIVITY TO DISEASE

White-tailed deer are susceptible to bluetongue virus (BT).[1] BT is transmitted to deer by biting gnats.[2] Typically, BT is most prevalent in deer populations during the summer months when hot and dry conditions are advantageous for the gnats. Increasing incidence of drought and warming temperatures may benefit gnat populations and increase the window of opportunity for outbreaks of BT in mule deer populations. Sensitivity to disease may thus increase the white-tailed deer's vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the white-tailed deer's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT

Front Page: White-tailed deer by Tony's Takes, used under CC BY-NC-ND 2.0

Back Page: White-tailed deeer by Tony's Takes, used under CC BY-NC-ND 2.0

## CITATIONS


[1] Colville Tribes staff, personal communication.
[2] Hoff, G.L., and D.M. Hoff. 1976. Bluetongue and epizootic hemorrhagic disease: A review of these diseases in non-domestic artiodactyles. Journal of Zoo Animal Medicine 7:26–30.

# WHITE-TAILED JACKRABBIT

*Lepus townsendii*

The white-tailed jackrabbit is estimated to be moderately vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and highly vulnerable under a high (RCP 8.5) greenhouse gas scenario. The white-tailed jackrabbit is estimated to be highly vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the white-tailed jackrabbit's estimated sensitivity to climate change. Key climate sensitivities for the white-tailed jackrabbit are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Moderately Vulnerable |
| | RCP 8.5 | Highly Vulnerable |
| 2080s | RCP 4.5 | Highly Vulnerable |
| | RCP 8.5 | Highly Vulnerable |

## FACTORS THAT INCREASE THE WHITE-TAILED JACKRABBITS'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF MAN-MADE BARRIERS

Major highways and roads have been identified as anthropogenic barriers to white-tailed jackrabbit dispersal, and also contribute to jackrabbit mortality.[1] These dispersal barriers may decrease the white-tailed jackrabbit's ability to adjust its range in response to changing climate conditions.

## FACTORS THAT SOMEWHAT INCREASE THE WHITE-TAILED JACKRABBITS'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE CHANGE MITIGATION ACTIVITIES

The white-tailed jackrabbit inhabits sagebrush-steppe habitat. Sagebrush-steppe habitats are often considered suitable sites for wind farm or solar array development. Renewable energy development in sagebrush-steppe has the potential to negatively affect white-tailed jackrabbit habitat.[2]

## DEPENDENCE ON OTHER SPECIES FOR HABITAT

White-tailed jackrabbits will either use a ground depression or an abandoned burrow for a nesting site.[3] Dependence on another species, which may be vulnerable to climate change, for habitat generation is expected to increase a species' vulnerability to climate change.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the golden eagle's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## IMAGE CREDIT

Front Page: White-tailed jackrabbit by USFWS, used under CC BY-NC-ND 2.0

Back Page: White-tailed jackrabbit by USFWS, used under CC BY-NC-ND 2.0

## CITATIONS


[1] Washington Wildlife Habitat Connectivity Working Group. 2010. Washington Connected Landscapes Project: Statewide Analysis. Washington Departments of Fish and Wildlife, and Transportation, Olympia, WA. www.waconnected.org.

[2] Colville Tribes staff, personal communication.

[3] NatureServe Explorer. White-tailed jackrabbit (Lepus townsendii)

# WHITEBARK PINE

*Pinus albicaulis*

The whitebark pine is estimated to be moderately vulnerable to climate change by the 2050s under both a low (RCP 4.5) and high (RCP 8.5) greenhouse gas scenario. The whitebark pine is estimated to be extremely vulnerable to climate change by the 2080s under both a low and high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the whitebark pine's estimated sensitivity to climate change. Key climate sensitivities for the whitebark pine are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |
| 2080s | RCP 4.5 | Extremely Vulnerable |
| | RCP 8.5 | Extremely Vulnerable |

## FACTORS THAT GREATLY INCREASE THE WHITEBARK PINE'S VULNERABILITY TO CLIMATE CHANGE:

### OCCURRENCE OF NATURAL BARRIERS

Whitebark pine is found in the highest elevation zones within the assessment area and is therefore unable to disperse to colder, higher elevation areas.[1] This will decrease the ability of the whitebark pine to adjust its range in response to changing climate conditions.

### LIMITED DISPERSAL ABILITIES

Whitebark pine seeds are primarily wind-dispersed, although small mammals also disperse whitebark seed.[2] Most seeds fall within 100 m of the parent plant. In addition, the whitebark pine does not produce a seed crop annually which severely limits the species ability to move across the landscape.[1] The whitebark pine's poor dispersal ability decreases the likelihood that the species will be able to adjust its range to keep pace with shifting climate conditions.

### DEPENDENCE ON COOL OR COLD HABITATS

In eastern Washington, whitebark pine is a high-elevation species found on mountain peaks and ridges (>6000 ft.) and is associated with cooler or cold temperatures.[2] Projected warming[3] may negatively affect whitebark pine habitat within the assessment area.[1]

## FACTORS THAT INCREASE THE WHITEBARK PINE'S VULNERABILITY TO CLIMATE CHANGE:

### DEPENDENCE ON SNOW

Whitebark pine frequently inhabits sites with snow cover during the winter months.[1,2] Projected declines in snowpack[3] will likely negatively affect whitebark pine habitat.

### DEPENDENCE ON DISTURBANCE EVENTS

Infrequent, stand-replacing fires and smaller, patchy fires are considered an important part of the whitebark pine's ecology.[2] However, the 2015 fire season decimated large whitebark pine population in the assessment area. The whitebark pine are unable to regenerate from the mega-fires the region has experienced over the past decade.[1] Projected increases in annual area burned[4] may negatively affect whitebark pine populations within the assessment area.

### DEPENDENCE ON OTHER SPECIES FOR DISPERSAL

Whitebark pine seeds are cached by the Clark's nutcracker. This is the primary method of dispersal for the whitebark pine.[2] Dependence on another species, which may be vulnerable to climate change, for dispersal is expected to increase a species' vulnerability to climate change.

### SENSITIVITY TO COMPETITION

Whitebark pine currently competes with the lodgepole pine, a species that is likely to be better able to tolerate the projected increase in annual area burned.[1]

## FACTORS THAT SOMEWHAT INCREASE THE WHITEBARK PINE'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO DISEASE

The mountain pine beetle is noted as the most serious insect pest to the whitebark pine.[2] The amount of forest susceptible to mountain pine beetle is projected to increase early in the 21st century (warming temperatures enable mountain beetles to reach high elevation forests), and then decrease by the late 21st century as temperatures exceed the mountain pine beetle's thermal optimum.[5]

### LIMITED GENETIC VARIATION

Whitebark pine between population diversity is noted as being extremely low within the assessment area.[1] Species with average to high levels of genetic diversity are expected to be better able to adapt to changing climate conditions.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the whitebark pine's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

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[5] Bentz B.J., Régnière J., Fettig C.J. Hansen E.M., Hayes J.L., Hicke J.A. et al. 2010. Climate change and bark beetles of the western United States and Canada: direct and indirect effects. BioScience 60, 602–613.

# WOOD'S ROSE

*Rosa woodsii*

The Wood's rose is estimated to be less vulnerable to climate change by the 2050s under a low (RCP 4.5) greenhouse gas scenario and moderately vulnerable under a high (RCP 8.5) greenhouse gas scenario. The Wood's rose is estimated to be less vulnerable to climate change by the 2080s under a low scenario and moderately vulnerable under a high greenhouse gas scenario. This ranking reflects both projected future changes in climate as well as the Wood's rose's estimated sensitivity to climate change. Key climate sensitivities for the Wood's rose are discussed below.

| | | |
|---|---|---|
| 2050s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |
| 2080s | RCP 4.5 | Less Vulnerable |
| | RCP 8.5 | Moderately Vulnerable |

## FACTORS THAT SOMEWHAT INCREASE THE WESTERN LARCH'S VULNERABILITY TO CLIMATE CHANGE:

### SENSITIVITY TO CLIMATE MITIGATION ACTIVITIES

Plantation forests are likely to reduce the amount of quality Wood's rose habitat due to stand initiation.[1]

### DEPENDENCE ON COOL OR COLD HABITATS

While Wood's rose is adapted to a broad range of temperature regimes the species seeds do require cold stratification to germinate.[1] Projected increases in air temperature[2] may negatively affect the species seeds ability to germinate.

### CHANGES IN STREAMFLOW AND WATER AVAILABILITY

Wood's rose is dependent on moist sites for growth.[1] Therefore, projected warming and reduce water availability may negatively affect the hydrologic suitability of Wood's rose habitat.

## FOR MORE INFORMATION

This fact sheet is a product of the Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. For more information on the Wood's rose's sensitivity and vulnerability to climate change or to find out more about the overall assessment results please reference the report or contact the University of Washington Climate Impacts Group (https://cig.uw.edu; cig@uw.edu).

Krosby, M. and H. Morgan. 2018. Colville Tribes' Natural Resources Climate Change Vulnerability Assessment. Climate Impacts Group, University of Washington.

## CITATIONS

[1] Colville Tribes staff, personal communication.
[2] Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2013. Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.

## IMAGE CREDIT