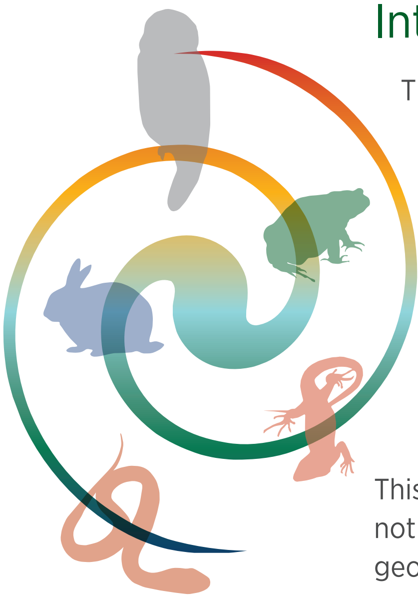
How Will Climate Change Affect Riparian Freshwater Systems and Species in Washington?

Washington Department of FISH and WILDLIFE



Introduction

This summary represents an initial evaluation of climate change vulnerability for riparian systems and associated species based on expert input and information in the scientific literature. In this context, climate change vulnerability is a function of the sensitivity of a particular resource to climate changes and its exposure to those changes. The aim of this document is to summarize the climatic factors riparian systems and species are sensitive to, the projected changes for those factors, and potential impacts to systems and species. This document also provides an overview of management actions that could be implemented to help reduce vulnerabilities and impacts.

This initial evaluation focused on the terrestrial ecological systems, and did not include the fish species that use aquatic and riparian systems in the same geography.

Exposure: How much of a change in climate a system or species is likely to experience

Sensitivity: Whether and how a system or species is likely to be affected by a given change in climate

Vulnerability

V = E+S / 2

This assessment also included confidence rankings. Confidence reflects the sureness experts had in a given ranking and was based on the extent and quality of reference material and information.

Riparian Freshwater System Description[1]

Riparian freshwater systems are found throughout Washington, and are generally dominated by woody riparian vegetation and, in some cases, herbaceous emergent plants. Many of these systems are linear due to their association with rivers and streams, and all are dependent on surface- and groundwater hydrology, including streamflow and seasonal flooding. Current non-climate stressors are varied and include dams and water diversions, development, agriculture, grazing, roads, and logging.

[1] Information in this section comes from: (1) Washington Department of Fish and Wildlife. 2015. Washington's State Wildlife Action Plan: 2015 Update. Washington Department of Fish and Wildlife, Olympia, Washington, USA; and (2) Rocchio, F.J. and R.C. Crawford. 2015. Ecological Systems of Washington State: A Guide to Identification. Washington State Department of Natural Resources. Report 2015-04. 397 pp.

Fact sheet developed by EcoAdapt.

This summary covers the following riparian freshwater systems:

Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland.

This widespread system occurs on streambanks and river floodplains in lower montane and foothill areas of the Northern Rocky Mountains, and can be dominated by both deciduous and coniferous trees and shrubs. Human land use and management activities (e.g., development, agriculture, reservoirs and dams, roads, grazing, logging) have fragmented and degraded this habitat, reducing connectivity and contributing to altered hydrology, invasive species establishment, and changes in riparian plant communities, impacting the structure, function, and integrity of this system. Closely associated species include the mountain quail, sharp-tailed grouse, Preble's shrew, northern leopard frog, Rocky Mountain tailed frog, and meadow fritillary.

Columbia Basin Foothill Riparian Woodland and Shrubland.

This system is associated with permanent, intermittent, and ephemeral streams in the Columbia Basin, and is dominated by woody riparian species such as cottonwood (Populus spp.). The removal of woody vegetation for fuel and building materials and conversion of riparian areas for agricultural purposes have led to dramatic declines in the extent of this system, and livestock grazing continues to degrade the remaining areas. In addition, cottonwood stands have been reduced in some areas where altered stream hydrology (e.g., by dams and water withdrawals) limits regeneration. Closely associated species include the sharp-tailed grouse, ring-necked snake, sharp-tailed snake, northern leopard frog, Rocky Mountain tailed frog, Columbia clubtail, Columbia Oregonian, Mad River mountainsnail, Mann's mollusk-eating ground beetle, and white-belted ringtail.

North Pacific Lowland Riparian Forest and Shrubland.

This system occurs in lower elevations throughout the Pacific Northwest, but is concentrated in western Washington. Riparian forests and tall shrublands are typically linear and found on low alluvial floodplains confined by valleys or inlets and along rivers and streams. It is likely that half the historical extent of this system has been lost, and remaining areas are degraded by human land use and management activities such as dams and water diversions, roads, logging, and grazing; this has resulted in altered stream hydrology, channel incision, invasive species establishment, and changes in riparian plant communities. Closely associated species include the Columbian white-tailed deer, Cascade torrent salamander, Dunn's salamander, Oregon spotted frog, brown juga, three-band juga, and Puget Oregonian.

Temperate Pacific Freshwater Emergent Marsh.

This system occurs at all elevations in western Washington, but is most common in lowland areas. These permanently or semi-permanently flooded wetlands are dominated by herbaceous plants, and have experienced significant declines due to development, agriculture, grazing, logging, roads, and water management, as well as the loss of beavers. Remaining areas are heavily fragmented and degraded by excessive nutrient inputs, invasive species, and changes in hydrology. Closely associated species include the peregrine falcon, cinnamon teal, western pond turtle, tiger salamander, and Oregon spotted frog.

Rocky Mountain Subalpine-Montane Riparian Woodland.

This relatively common system occurs at higher elevations, and is comprised of seasonally-flooded forest areas that are generally associated with narrow valleys and canyons with cold air drainage. The connectivity of this system has been reduced by human land use in adjacent upland areas, and reservoirs, water diversions, roads, and other development can lead to vegetation loss and/or shifts in species composition. This system has no closely associated species; generally associated species include the gray wolf, grizzly bear, caribou, hoary bat, silver-haired bat, Townsend's western big-eared bat, wolverine, harlequin duck, Columbia spotted frog, western toad, and Morrison's bumblebee.

North Pacific Bog and Fen.

This system occurs in coastal and lowland areas of western Washington, and is characterized by peat substrates. Vegetation typically is dominated by conifers and a variety of shrub and herbaceous species, including sphagnum moss. Many bogs and fens have been lost due to land use conversion to development or agriculture, and remaining peatlands have been isolated and degraded by roads, logging, grazing, and peat mining. Closely associated species include the Beller's ground beetle, Hatch's click beetle, and Makah copper.

The extent of most riparian freshwater systems has declined significantly, and the majority of remaining areas have been fragmented or degraded due to land use conversion and human activities that contribute to impacts such as altered hydrology, vegetation removal, nutrient loading, and erosion. Climate change is likely to exacerbate the impacts of these non-climate stressors on riparian freshwater systems, potentially leading to further habitat degradation and loss.

Key Climate Sensitivities and Impacts:
Riparian Freshwater Systems[2]

Overall, riparian freshwater systems are sensitive to climatic factors that reduce and/or alter hydrology and moisture availability, such as changes in precipitation and soil moisture, temperature, drought, snowpack, streamflow, and flooding regimes. Riparian vegetation is adapted to high levels of soil moisture, and drier conditions are likely to contribute to shifts in species composition towards drought-adapted species, as well as declines in plant germination and growth. Similarly, reduced streamflow and changes in the frequency and magnitude of seasonal flooding events may alter vegetation composition, establishment, and succession, resulting in the loss of disturbance-adapted plants and shifts toward annual species and younger overall age classes; shifts in the timing of flood events may affect regeneration success of species that adapted the timing of seed dispersal or germination to coincide with historic streamflow patterns. Sensitivity to wildfire varies among riparian freshwater systems, but typically younger riparian stands are more vulnerable to damage and/or tree mortality, and successful recovery is dependent upon adequate soil moisture. More frequent and/or severe wildfires driven by increased drought may alter age class and species composition, as well as succession in riparian plant communities. Bogs and fens are unique in that they are typically dependent on groundwater sources and/or surface runoff (e.g., precipitation and snowmelt) for their water source; under increasingly dry conditions, peat substrates begin to decompose and upland plant encroachment may increase, resulting in reduced area or loss of the system. Sensitivity rankings for riparian freshwater systems include:

Northern Rocky Mountain Lower Montane Riparian Woodland & Shrubland	Mod-High Sensitivity	High Confidence
Columbia Basin Foothill Riparian Woodland and Shrubland	Mod-High Sensitivity	High Confidence
North Pacific Lowland Riparian Forest and Shrubland[3]	Mod Sensitivity	Mod Confidence
Temperate Pacific Freshwater Emergent Marsh	Mod Sensitivity	Mod Confidence
Rocky Mountain Subalpine-Montane Riparian Woodland	High Sensitivity	High Confidence
North Pacific Bog and Fen	Mod-High Sensitivity	Mod Confidence

Key Climate Sensitivities and Impacts:
Riparian Freshwater Associated Species

In riparian freshwater systems, reduced habitat and prey/forage availability drives overall species sensitivity to climate change. Warmer, drier conditions caused by shifts in precipitation patterns, reduced snowpack, earlier snowmelt, drought, and increased air and water temperatures are likely to alter the hydrology of riparian freshwater systems, reducing streamflow and moisture availability and increasing winter floods. These impacts will contribute to declines in habitat extent, quality, and connectivity in riparian freshwater systems, adversely impacting closely and generally associated species. **For example:**

- Warmer, drier conditions are likely to reduce prey availability (e.g., insects) for the **hoary bat**, **Preble's shrew**, and **silver-haired bat**, as well as suitable habitat for species that utilize riparian habitats associated

[2] Information on system and species sensitivity, exposure, and overall vulnerability can be found in the WDFW Climate Vulnerability spreadsheet. Sensitivity of riparian systems to climatic factors was assessed by evaluating whether each system occurs in a relatively narrow climatic zone and/or whether it experiences large changes in structure or composition in response to relatively small changes in a given climate or climate-driven factor (e.g., temperature, drought).

[3] For those systems with moderate confidence evaluations, managers may want to target monitoring or data collection efforts that help increase understanding of potential impacts of climate. Higher confidence evaluations can provide greater clarity as to what management actions may be most effective in reducing vulnerabilities and increasing resilience of these systems.

with forest, riparian, and grassland systems (e.g., **caribou**, **Preble's shrew**, **sharp-tailed grouse**, **Columbia spotted frog**, **Cope's giant salamander**, **northern leopard frog**, **Oregon spotted frog**, **Rocky Mountain tailed frog**, **sharp-tailed snake**).

- Reductions in aquatic and riparian habitats will likely negatively impact many amphibians and invertebrates, including the **tiger salamander**, **Van Dyke's salamander**, and **Mann's mollusk-eating ground beetle**, which depend on habitat characteristics such as large woody debris, leaf litter, shading, and talus to provide cool, damp areas.
- Low stream flows may degrade and/or reduce available habitat for **Cope's giant salamander**, the **western toad**, and the **white-belted ringtail** and desiccate eggs and larvae of the **Columbian clubtail**.
- Flooding and associated scour/sedimentation may reduce breeding sites and/or suitable habitat for the **Cascade torrent salamander**, **Cope's giant salamander**, **Rocky Mountain tailed frog**, **western toad**, and **Columbia clubtail**, and alter breeding and forage habitats for the **Harlequin duck**, and removal of riparian vegetation during floods or wildfires reduces available habitat for the **white-belted ringtail**.
- Loss of wetland and pond breeding habitat and reductions in herbaceous riparian vegetation used as non-breeding habitat could significantly affect **northern leopard frogs** and **Oregon spotted frogs**, and warmer temperatures may increase predation on frogs.
- Loss of peat and changes in bog vegetation could reduce habitat and alter food availability for the **Beller's ground beetle**, **Hatch's click beetle**, and **Makah copper**.
- Altered fire regimes could eliminate suitable habitat for **mountain quail** and **western gray squirrel** and reduce roosting and foraging opportunities for the **silver-haired bat** and **hoary bat**. Increasing fire frequencies may expand overall habitat area available for the **mardon skipper**, but could also lead to increased mortality and subsequent population declines.
- Increased insect and disease outbreaks in forests could benefit the **silver-haired bat** by providing more snags for roosting.

Other possible climate impacts on riparian freshwater associated species include:

- Prolonged wet weather in the spring increases chick mortality in the **sharp-tailed grouse**, and increased flooding could reduce breeding success for the **cinnamon teal**.
- Warmer, drier conditions will favor the expansion of deer, elk, and moose by increasing overwinter

Sensitivity rankings for riparian freshwater species include[4]:

Mammals

Species	Sensitivity	Confidence
Caribou *(Rangifer tarandus)*	High Sensitivity	High Confidence
Hoary Bat *(Lasiurus cinereus)*	High Sensitivity	Mod Confidence
Preble's Shrew *(Sorex preblei)*	Mod Sensitivity	Mod Confidence
Silver-haired Bat *(Lasionycteris noctivagans)*	High Sensitivity	High Confidence
Western Gray Squirrel *(Sciurus griseus)*	Mod-High Sensitivity	Mod Confidence

Birds

Species	Sensitivity	Confidence
Cinnamon Teal *(Anas cyanoptera)*	Mod Sensitivity	Low Confidence
Harlequin Duck *(Histrionicus histrionicus)*	Mod-High Sensitivity	Low Confidence
Mountain Quail *(Oreortyx pictus)*	Mod Sensitivity	Mod Confidence
Sharp-tailed Grouse *(Tympanuchus phasianellus)*	Mod Sensitivity	Mod Confidence

[4] Sensitivities and impacts are described for closely associated species with moderate or higher sensitivity rankings and moderate-high to high sensitivity rankings for generally associated species. Closely associated species are used to describe those which are depending on these systems for one or more stages of their life cycle.

Vulnerability assessment methodology developed by EcoAdapt.

Amphibians & Reptiles

Species	Sensitivity	Confidence
Cascade Torrent Salamander *(Rhyacotriton cascadae)*	Mod-High Sensitivity	Mod Confidence
Columbia Spotted Frog *(Rana luteiventris)*	Mod-High Sensitivity	Mod Confidence
Cope's Giant Salamander *(Dicamptodon copei)*	Mod-High Sensitivity	Mod Confidence
Northern Leopard Frog *(Rana pipiens)*	Mod-High Sensitivity	Mod Confidence
Oregon Spotted Frog *(Rana pretiosa)*	Mod-High Sensitivity	Mod Confidence
Rocky Mountain Tailed Frog *(Ascaphus montanus)*	Mod-High Sensitivity	Mod Confidence
Sharp-tailed Snake *(Contia tenuis)*	Mod Sensitivity	Low Confidence
Tiger Salamander *(Ambystoma tigrinum)*	Mod Sensitivity	Mod Confidence
Van Dyke's Salamander *(Plethodon vandykei)*	High Sensitivity	Mod Confidence
Western Toad *(Anaxyrus boreas)*	Mod-High Sensitivity	Mod Confidence

Invertebrates

Species	Sensitivity	Confidence
Beller's Ground Beetle *(Agonum belleri)*	Mod Sensitivity	Mod Confidence
Columbia Clubtail *(Gomphus lynnae)*	Mod-High Sensitivity	High Confidence
Hatch's Click Beetle *(Eanus hatchii)*	Mod-High Sensitivity	High Confidence
Makah Copper *(Lycaena mariposa charlottensis)*	Mod-High Sensitivity	Mod Confidence
Mann's Mollusk-eating Ground Beetle *(Scaphinotus mannii)*	Mod Sensitivity	Low Confidence
Mardon Skipper *(Polites mardon)*	Mod-High Sensitivity	Mod Confidence
Taylor's Checkerspot *(Euphydryas editha taylori)*	Mod-High Sensitivity	High Confidence
White-belted ringtail *(Erpetogomphus compositus)*	Mod-High Sensitivity	Low Confidence

Projected Future **Climate Exposure**[5]

Under projected future climate conditions, riparian freshwater habitats and species will likely be exposed to shifts in hydrology resulting from changes in precipitation, increased drought, snowpack reductions, and earlier snowmelt, as well as changes in factors that affect vegetation growth and mortality, such as temperature, soil moisture, wildfire, and insect/disease outbreaks. Precipitation and soil moisture projections for the state are highly variable, with some areas projected to get drier and others wetter. Seasonal patterns are more certain, and it is likely that summers will be drier and fall, winter, and spring will be wetter. Precipitation intensity may increase and a greater proportion of precipitation may fall as rain rather than snow, which can contribute to large flooding events, especially in rain-dominated and transient basins. Reduced snowpack and shifts towards earlier timing of snowmelt and runoff (by as much as 3-4 weeks) will contribute to changes in streamflow, which is likely to decline in the summer and increase in the winter. Air temperature is projected to increase in all seasons, with summers experiencing the most rapid warming. Increases in air temperature are projected to drive reduced soil moisture and increase the risk of drought, even with potential increases in winter precipitation.

Summer streamflows are likely to decline due to warmer, drier conditions, but flows may increase in other seasons, especially if winter precipitation increases. Reductions in snowpack and earlier snowmelt will also contribute to altered river and stream hydrology. Drier summers will increase drought risk, and are likely to lead to declines in soil moisture and increases in wildfire frequency and severity.

[5] Information in this section comes from (1) Washington Department of Fish and Wildlife. 2015. Washington's State Wildlife Action Plan: 2015 Update, Appendix C. Washington Department of Fish and Wildlife, Olympia, Washington, USA; (2) Hamlet AF, Mote PW, Clark MP, Lettenmaier DP. 2007. Twentieth-century trends in runoff, evapotranspiration, and soil moisture in the western United States. Journal of Climate 20:1468–1486; (3) Knowles N, Dettinger MD, Cayan DR. 2006. Trends in snowfall versus rainfall in the western United States. Journal of Climate 19:4545–4559; and (4) Stewart IT, Cayan DR, Dettinger MD. 2005. Changes toward earlier streamflow timing across western North America. Journal of Climate18:1136–1155.

Climate Change
Vulnerability Assessment

Low High
Moderate-High Vulnerability

Mod Confidence

Looking together at sensitivity and exposure, the riparian freshwater systems evaluated in this assessment exhibit overall moderate-high vulnerability (moderate confidence) to climate changes including shifts in precipitation and soil moisture, reduced snowpack and earlier snowmelt, increased air and water temperatures, lower summer streamflows, drought, and altered flooding regimes. Shifts in precipitation and soil moisture will likely affect the distribution and species composition of riparian vegetation, and changes in streamflow and flooding may alter patterns of vegetation recruitment and succession. Drought and wildfire may drive large-scale mortality, and vegetation recovery from disturbances may be reduced where drier conditions limit adequate soil moisture for seedling recruitment and growth. Marshes, bogs, and fens are not closely associated with rivers and streams, and so may be more vulnerable to changes in precipitation and surface runoff. Many of the species closely associated with freshwater riparian systems are dependent on seasonal periods of high or low stream flows for breeding and/or utilize cool, moist microsites provided by riparian vegetation and woody debris. Changes in hydrology that impact streamflow, flooding, and riparian vegetation structure and composition are likely to reduce habitat availability and quality for these species, as well as alter prey/forage availability. Some species are also dependent on adjacent upland habitats for part of their life cycle, and these species may be additionally vulnerable to climate impacts in riparian, grassland, and forest habitats.

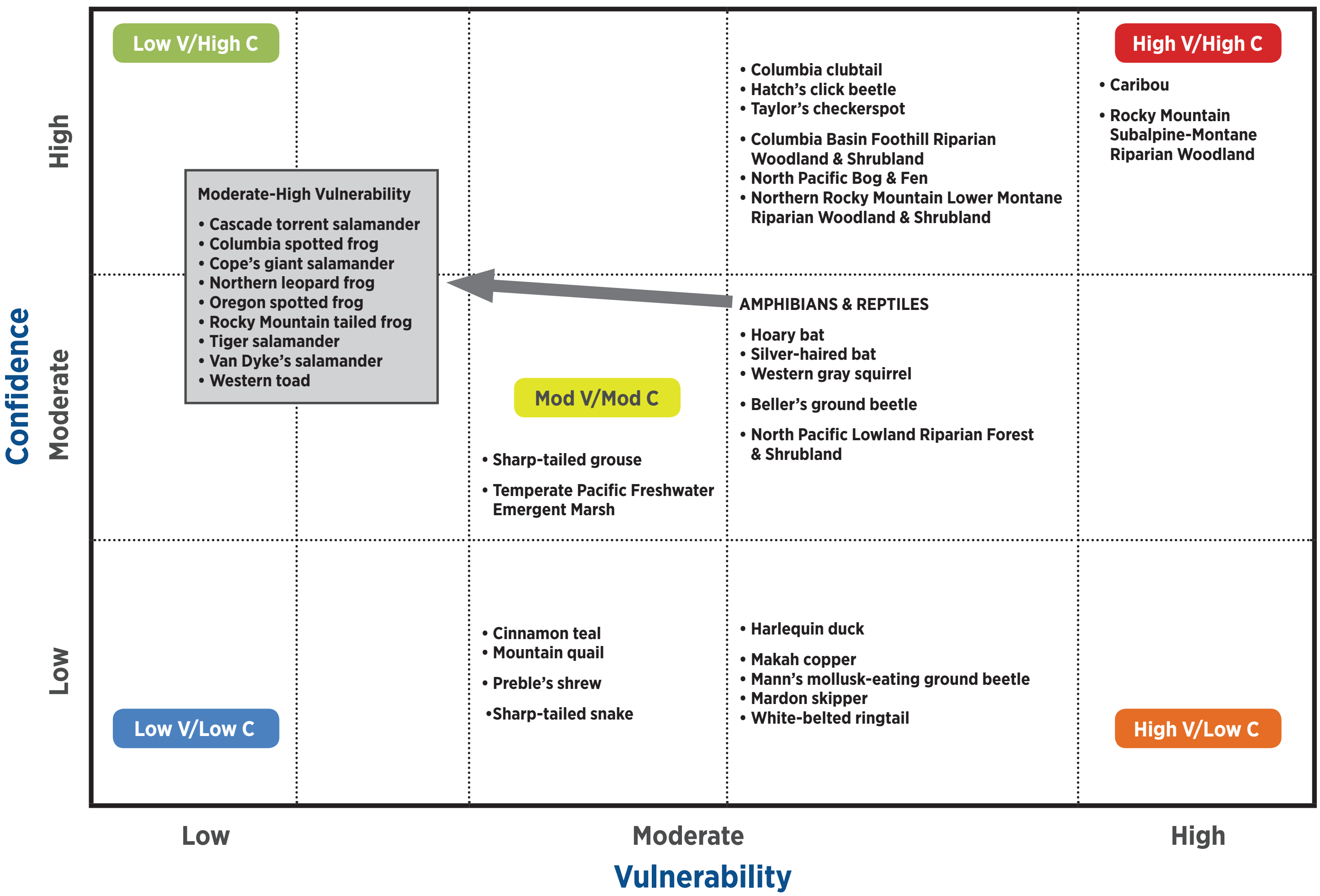
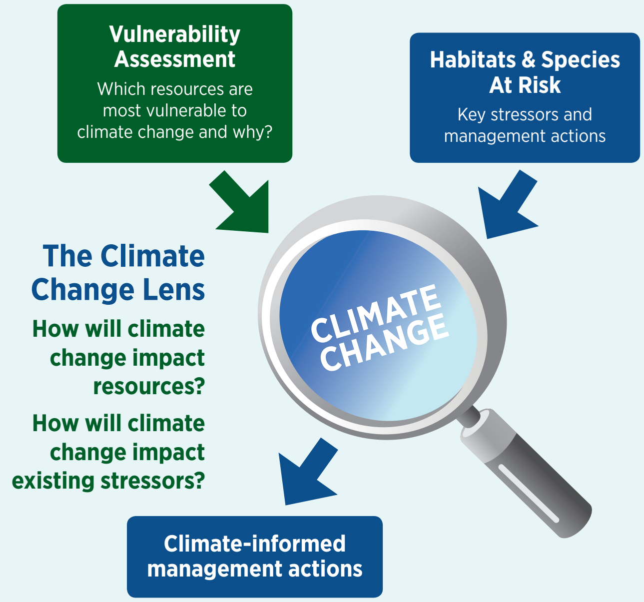


Figure 1. Vulnerability and confidence rankings plotted for riparian systems and species. Those systems and species with high vulnerability to climate change and high confidence are located in the upper right; those systems and species with low vulnerability to climate change and low confidence are located in the bottom left. Figure created by EcoAdapt.

Adapting to

Climate Change



Climate change adaptation strategies attempt to reduce the negative impacts of, or take advantage of opportunities presented by, climate change. To begin identifying adaptation options, it's helpful to consider the management actions proposed or currently underway and think about them in the context of climate change. For example, how may climate change affect the success of a given action (i.e., does it present a new or unexpected challenge)? Alternatively, does the action help to minimize climate vulnerabilities, making it a priority for implementation? Adding this climate 'lens' to what is already being done helps to mainstream adaptation into current decision-making frameworks.

There are five basic types of adaptation strategies; resistance, resilience, transition, knowledge, and collaboration. Managers can select adaptation strategies that best suit a given situation (e.g., long-term management plan vs. on-the-ground project), although they are encouraged to consider both near- or short-term options (e.g., resistance, resilience) as well as those more suitable in the long-term (e.g., transition). Additionally, managers can use the confidence evaluations from this vulnerability assessment to identify where more research or monitoring is needed. For example, the sensitivity of the sharp-tailed snake was evaluated as moderate, but the confidence in that ranking was low due to a lack of data and information on how oviposition sites may be influenced by soil moisture patterns, as well as uncertainty about whether this species could switch to an alternate prey base. A knowledge-gathering adaptation strategy to address this issue could be to collect data on typical oviposition sites in order to determine whether sites are linked with environmental factors likely to be affected by climate change (e.g., soil moisture). The table below presents a suite of adaptation options that resource managers could consider implementing for riparian habitats and species.

With riparian freshwater systems

Shifts in precipitation, reduced snowpack and earlier snowmelt, drought, and altered streamflows

Can modify the hydrology as well as vegetation composition and structure of these systems

Which causes reductions or changes in habitat extent, quality, and connectivity

Affecting forage and prey availability

And reproductive success of species that depend on these systems

To sustain resources into the future, conservation actions and strategies must take into account future climatic conditions and consider multiple stressors and broad geographic scales.

What are the types of adaptation strategies?

Resistance strategies: Prevent the effects of climate change from affecting a resource. *Near-term approach*

Resilience strategies: Buffer against climate change impacts by avoiding the effects of or recovering from changes. *Near- to mid-term approach*

Transition strategies: Intentionally accommodate change and adaptively respond to variable conditions. *Long-term approach*

Knowledge strategies: Gather information about climate impacts and/or management effectiveness in addressing climate change challenges. *Near- to long-term approach*

Collaboration strategies: Coordinate efforts and capacity across landscapes and agencies. *Near- to long-term approach*

Adaptation strategies for riparian freshwater systems and species

ADAPTATION CATEGORY	ADAPTATION STRATEGIES
RESISTANCE	• Protect groundwater sources (e.g., seeps and springs) from potential development and degradation • Reduce water withdrawals from streams (e.g., agricultural/irrigation, municipal, industrial) • Manage livestock grazing to reduce impacts on riparian vegetation and channels • Decrease erosion and sediment delivery from roads
RESILIENCE	• Restore natural stream hydrology to reduce vulnerability to projected climate changes • Identify and restore degraded riparian habitat to shade streams and provide floodwater storage • Restore floodplain connections to improve lateral connectivity with streams
TRANSITION	• Identify and protect climate refugia and focus species conservation activities within these areas • Facilitate change to desired species assemblages and/or species adapted to future conditions
KNOWLEDGE	• Monitor species at risk of decline under future climate conditions • Increase knowledge of groundwater resources • Determine response of streams and connected lakes and reservoirs to projected changes in climate • Monitor, model, and conduct research and adaptive management to support adaptation actions and evaluate effectiveness
COLLABORATION	• Increase partnerships to facilitate the protection of riparian freshwater systems • Communicate with other agencies and organizations about projects and coordinate on-the-ground activities (e.g., erosion control) • Leverage resources (e.g., funding, partnerships) and priorities across jurisdictional and political boundaries to implement landscape-scale adaptation strategies

For more information about this project or other WDFW climate change initiatives, please visit **wdfw.wa.gov/conservation/climate_change** or contact Lynn Helbrecht at **lynn.helbrecht@dfw.wa.gov** or **(360) 902-2238**

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