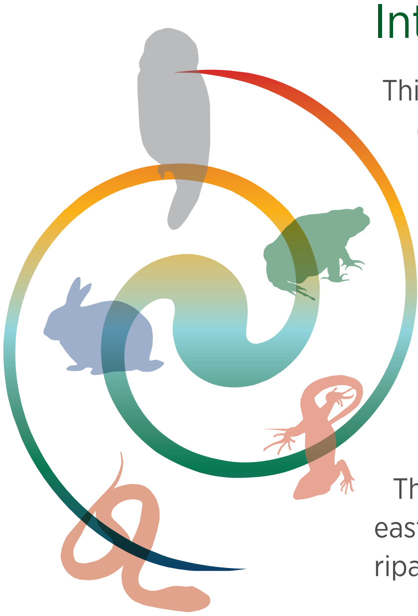
Washington Department of FISH and WILDLIFE

How Will Climate Change Affect East-Side Forest Systems and Species in Washington?



Introduction

This summary represents an initial evaluation of climate change vulnerability for east-side forest 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 east-side forest 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 within east-side forests, 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.

East-Side Forest System Description[1]

East-side forest systems generally occur in interior eastern Washington, ranging from foothills to montane and subalpine areas. They typically feature coniferous canopy components and a shrub, grass, or forb understory, with understory composition and cover being influenced by canopy cover, soil conditions, and moisture. Historically portions of these forests featured more open, low density forest structure and high landscape heterogeneity maintained by higher frequency, lower severity fire. Current non-climate stressors include fire suppression, timber harvest, excessive grazing, roads, urban and agricultural development, recreation, and forest pathogens and insects, all of which are contributing to altered fire regimes and shifts in forest structure, species composition, and distribution.

[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 east-side forest systems:

Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest.

This widespread matrix coniferous forest system, dominated by ponderosa pine, Douglas fir, and other seral species, is found from 1500-6300 feet on eastern slopes of the Cascades, Okanogan Highlands, Northern Rocky Mountains, and Blue Mountains. The ecological integrity of this system is threatened by fire suppression, timber management and harvest, excessive grazing, roads, and forest pathogens and insects, which have altered natural fire regimes, forest structure, and species composition, including almost eliminating late-seral, low density stands. Closely associated species include the Rocky Mountain tailed frog, flammulated owl, golden eagle, great gray owl, mountain quail, pygmy nuthatch, white-headed woodpecker, lynx, western gray squirrel, California mountain kingsnake, and sharp-tailed snake.

Northern Rocky Mountain Mesic Montane Mixed Conifer Forest.

This forest system, dominated by western hemlock and western red-cedar, occurs in the Rocky Mountains of eastern Washington at elevations between 2500-6000 feet. Eastern Washington represents the edge of this system's distribution, so it is typically found in moist and cool microsites. Fire suppression, timber management and harvest, roads, and forest pathogens and insects, have altered forest structure and fire regimes, degrading ecological integrity. Closely associated species include the Rocky Mountain tailed frog, flammulated owl, mountain quail, and woodland caribou.

Northern Rocky Mountain Ponderosa Pine Woodland and Savanna.

This matrix system, dominated by ponderosa pine, occurs on the driest conifer-supporting sites in the Pacific Northwest, including the foothills of the eastern Cascades, Blue Mountains, Okanogan Highlands, and the Columbia Basin. Fire suppression, roads, and forest pathogens and insects have degraded the ecological integrity of this system by altering natural fire regimes. Altered fire regimes, along with past excessive grazing, have contributed to a denser, closed-canopy forest structure and altered vegetative composition. Closely associated species include the flammulated owl, mountain quail, pygmy nuthatch, white-headed woodpecker, western gray squirrel, California Mountain kingsnake, ring-necked snake, sharp-tailed snake, Chelan mountainsnail, and mardon skipper.

Northern Rocky Mountain Subalpine Woodland and Parkland.

This large, high elevation patch system occurs in the east Cascades, the eastern portion of the north Cascades, the northeastern Olympic Mountains, and Washington's northern Rocky Mountains. Harsh site conditions create a mosaic of herb- or dwarf shrub-dominated openings, stunted tree clumps, and open woodland; tree components include whitebark pine, subalpine fir, and subalpine larch. Fire suppression and blister rust have altered forest structure, composition, and fire regimes. Excessive livestock grazing and intensive recreation can further degrade ecological integrity by causing surface soil disturbance. Closely associated species include the Cascade red fox and western bumblebee.

East Cascades Oak-Ponderosa Pine Forest and Woodland.

This restricted matrix ecological system, dominated by Garry oak, ponderosa pine, and Douglas fir occurs near lower treeline (1509-6299 feet) in the eastern Cascade foothills within 40 miles of the Columbia River Gorge. The ecological integrity of this system has been degraded by fire suppression, excessive grazing, timber harvest, and forest pathogens and insects, which have contributed to shifts in canopy cover, stand density, and fire regimes. Additionally, urban and agricultural development have fragmented habitat. Closely associated species include the Lewis' woodpecker, pygmy nuthatch, western gray squirrel, California mountain kingsnake, ring-necked snake, sharp-tailed snake and the western pond turtle.

Many east-side forest systems have been impacted by fire suppression, timber harvest, excessive grazing, and forest pathogens and insects. Climate change is likely to exacerbate the impacts of these non-climate stressors on east-side forests, potentially contributing to additional fire regime changes and altered forest structure and distribution and species composition.

Key Climate Sensitivities and Impacts:

East-Side Forest Systems[2]

Overall, east-side forest systems exhibit sensitivity to altered fire regimes, changes in soil moisture, insect and disease outbreaks. Altered fire regimes could have variable impacts on east-side forests. More frequent, low severity fire may promote a return to more open stand structure with reduced competition, and promote heterogeneous landscape conditions by creating new opportunities for species establishment and habitat expansion. However, many east-side forests currently feature altered forest structure (including higher tree density, more fire-intolerant species, and more ladder fuels), which increase the likelihood of stand-replacing fire, subsequently driving further alterations in forest stand age, structure, and species composition, and reducing landscape heterogeneity. Frequent re-burning may also undermine forest establishment by reducing seed sources and soil moisture and increasing soil temperature. East-side forests are also sensitive to soil moisture changes as a result of drought, precipitation changes, and/or reduced snowpack; changes in soil moisture may alter east-side forest system species composition, forest structure, and distribution. For example, reduced soil moisture may enhance old growth mortality, cause habitat contraction away from driest areas, and/or cause type conversion to more dry-adapted ecological systems. East-side forests are also sensitive to increased insect and disease outbreaks and associated tree mortality. Sensitivity rankings for east-side forest systems include:

Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	Mod-High Sensitivity	Mod Confidence
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	Mod-High Sensitivity	Mod Confidence
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	Mod-High Sensitivity	High Confidence
Northern Rocky Mountain Subalpine Woodland and Parkland[3]	Mod Sensitivity	Mod Confidence
East Cascades Oak-Ponderosa Pine Forest and Woodland	Mod-High Sensitivity	Mod Confidence

Key Climate Sensitivities and Impacts:

East-Side Forest Associated Species

In east-side forest systems, habitat specialization drives overall species sensitivity to climate changes. Altered fire regimes, changes in soil moisture, insect outbreaks, and tree pathogens that reduce the extent, quality, structure, composition, and connectivity of east-side forest habitats will likely have adverse impacts on associated species. **For example:**

- Shifts toward younger-age forest stands may reduce habitat quality and availability for **caribou** and **lynx**, which depend on old-growth habitats for forage, hunting, nesting, and reproduction.
- Increased forest density and forest encroachment into higher elevation parkland, meadow and grassland areas could reduce optimal habitat for the **Cascade red fox**, **mardon skipper**, and **western bumblebee**.

[2] Information on system and species sensitivity, exposure, and overall vulnerability can be found in the WDFW Climate Vulnerability spreadsheet. Sensitivity of east-side forest 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.

- Reductions in east-side forest habitat availability could adversely affect the **great gray owl**, **mountain quail**, **white-headed woodpecker**, **sharp-tailed snake**, and **Rocky Mountain tailed frog**, as well as prey availability for the **golden eagle**.
- Altered disturbance regimes (i.e. fire, insect and disease outbreaks) could decrease or degrade suitable habitat for **mountain quail**, **western gray squirrel**, **northern spotted owl**, and **spruce grouse**, 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.
- Warmer, drier conditions leading to loss of peat land, wetlands, ponds, and other aquatic habitat, as well as changes in vegetation, could negatively impact the **northern bog lemming**, **Columbia spotted frog**, **Oregon spotted frog**, **western toad**, **Cascades needlefly**, ***Psychoglypha***, **Rainier roachfly**, and ***Rhyacophilia***.
- Warming temperatures and declines in snowpack could lead to reduced habitat availability and quality, prey caching success, and dispersal for the **wolverine**.

Other possible climate impacts on east-side forest associated species include:

- Warmer, drier conditions could affect insect availability and reduce drinking sources for the **hoary bat** and **silver-haired bat**, and limit the time periods for movement across terrestrial habitats for the **Columbia spotted frog**.
- Wildfire may extirpate existing populations of non-mobile species, such as the **western bumblebee** and **mardon skipper**.
- Reduced snowpack and earlier snowmelt are likely to alter competition and prey dynamics for **lynx** and the **Cascade red fox**, and competition and predation dynamics for **caribou**.
- Reduced snowpack, earlier snowmelt, and warmer temperatures are likely to disrupt **western bumblebee** and mardon skipper life cycles, potentially causing phenology asynchrony with key forage plants. Earlier snowmelt could also result in phenological mismatch with **harlequin duck** breeding ecology.
- Reduced snowpack and shifts from snow to rain are likely to negatively impact the **pika**, which requires a moderate amount of snowpack for insulation during winter months.
- Warmer temperatures may increase disease risk for **western gray squirrels**, have physiological impacts on the **great gray owl**, and alter reproduction timing for **tiger salamanders**, while changes in precipitation may affect the **Columbia spotted frog** through alterations in breeding timing, egg survival, and prey availability.

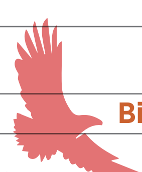
Wildfire can temporarily reduce availability of east-side forest habitats, but it plays an important role in creating mature, open forests preferred by many east-side forest species.

Sensitivity rankings for east-side forest species include[4]:

Mammals

Species	Sensitivity	Confidence
Cascade Red Fox (Vulpes vulpes cascadensis)	Mod-High Sensitivity	Mod Confidence
Caribou *(Rangifer tarandus)*	High Sensitivity	High Confidence
Hoary Bat *(Lasiurus cinereus)*	High Sensitivity	Mod Confidence
Northern Bog Lemming *(Synaptomys borealis)*	Mod-High Sensitivity	Mod Confidence
Lynx *(Lynx canadensis)*	High Sensitivity	High Confidence
Pika *(Ochotona princips)*	High Sensitivity	High Confidence
Silver-haired Bat *(Lasionycteris noctivagans)*	High Sensitivity	High Confidence
Western Gray Squirrel *(Sciurus griseus)*	Mod-High Sensitivity	Mod Confidence
Wolverine *(Gulo gulo)*	High Sensitivity	High Confidence

Birds



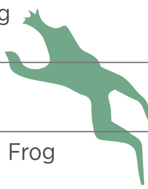
Species	Sensitivity	Confidence
Golden Eagle (Aquila chrysaetos)	Mod Sensitivity	High Confidence

[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.

Species	Sensitivity	Confidence
Great Gray Owl (*Strix nebulosa*)	Mod Sensitivity	Low Confidence
Harlequin Duck (*Histrionicus histrionicus*)	Mod-High Sensitivity	Low Confidence
Mountain Quail (*Oreortyx pictus*)	Mod Sensitivity	Mod Confidence
Northern Spotted Owl (*Strix occidentalis caurina*)	Mod-High Sensitivity	Mod Confidence
Pygmy Nuthatch (*Sitta pygmaea*)	Mod Sensitivity	Mod Confidence
Spruce Grouse (*Falcipennis canadensis*)	Mod-High Sensitivity	High Confidence
White-Headed Woodpecker (*Picoides albolarvatus*)	Mod-High Sensitivity	Mod Confidence

Amphibians & Reptiles

Species	Sensitivity	Confidence
California Mountain Kingsnake (*Lampropeltis zonata*)	Mod-High Sensitivity	Low Confidence
Columbia Spotted Frog (*Rana luteiventris*)	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*)	High Sensitivity	Mod Confidence
Western Toad (Anaxyrus boreas)	Mod-High Sensitivity	Mod Confidence



Invertebrates

Species	Sensitivity	Confidence
Caddisfly (*Psychoglypha browni*)	Mod-High Sensitivity	Mod Confidence
Caddisfly (*Rhyacophilia vetina*)	High Sensitivity	Mod Confidence
Cascades Needlefly (*Megaleuctra kincaidi*)	Mod-High Sensitivity	Mod Confidence
Mardon Skipper (*Polites mardon*)	Mod-High Sensitivity	Mod Confidence
Rainier Roachfly (*Soliperla fenderi*)	Mod-High Sensitivity	High Confidence
Wenatchee Forestfly (*Malenka wenatchee*)	Mod Sensitivity	Low Confidence
Western Bumblebee (*Bombus occidentalis*)	Mod-High Sensitivity	Mod Confidence

Vulnerability assessment methodology developed by EcoAdapt.

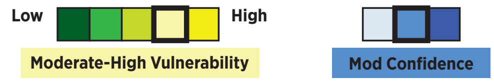
Projected Future
Climate Exposure[5]

Under projected future climate conditions, east-side forest systems and species will likely be exposed to increased wildfire risk (frequency and intensity), warmer temperatures, increased drought risk, precipitation changes, and decreased snowpack and soil moisture by the end of the century. Air temperature is projected to increase in all seasons, with summers experiencing the most rapid warming. Increases in air temperature are projected to increase drought risk, particularly in summer, even with potential increases in winter precipitation. Air temperature increases are also likely to increase insect outbreaks by allowing range expansions to higher elevations, accelerating reproductive cycles, and allowing earlier arrival or emergence. Increased wildfire frequency, intensity, severity, and total area burned are also projected for the region due to warmer temperatures. Precipitation projections for the state are highly variable; there is greatest certainty regarding seasonal precipitation patterns, with summers projected to get drier. Snowpack is projected to continue declining, with greatest losses at lower elevations, and many previously snow-dominant basins in eastern Washington are projected to transition to rain-dominant. Precipitation changes and snowpack reductions are likely to contribute to soil moisture declines in many areas supporting east-side forest systems, including the East Cascades, Okanogan Highlands, Northern Rocky Mountains, and the Blue Mountains.

Temperature is projected to increase in all seasons, in all scenarios. In general, summers are likely to get drier and have greater drought risk, and winter snowpack is projected to decline. Changes in fire frequency and total area burned are also projected for the state.

[5] Information in this section comes from: (1) Littell, J.S., E.E. Oneil, D. McKenzie, J.A. Hicke, J.A. Lutz, R.A. Norheim, and M.M. Elsner. 2010. Forest ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change, 102, 129-158; (2) Bell, D.M., J.B. Bradford, and W.K. Lauenroth. 2013. Early indicators of change: divergent climate envelopes between tree life stages imply range shifts in the western United States. Global Ecoloy and Biogeography, 23, 168-180; and (3) 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.

Climate Change
Vulnerability Assessment



Looking together at sensitivity and exposure, the east-side forest systems evaluated in this assessment exhibit overall moderate-high vulnerability (moderate to high confidence) to climate changes including altered fire regimes; declining soil moisture due to shifts in precipitation, increased drought, and reduced snowpack; and increased insect outbreaks. Altered fire regimes are likely to affect overall stand structure, species composition, and tree regeneration. A return to higher frequency, lower severity fires could benefit these forest types, while increased frequency of stand replacing fires could cause loss of remnant old growth and open structure forest, further reducing landscape heterogeneity. Fire suppression practices, roads, and livestock grazing have increased east-side forest vulnerability to altered wildfire regimes by changing recent fire frequency and behavior and creating denser, more closed-canopy forests with more fine fuel continuity and ladder fuels. Altered forest structure as a result of these non-climate stressors also increases forest vulnerability to soil moisture declines, insect outbreaks, and pathogen incidence and severity. Reduced soil moisture may alter distribution and composition of east-side forest systems, including potential type conversion to shrub systems if conditions become too arid. Insect outbreaks and increases in forest pathogen incidence and severity may increase tree mortality and cause shifts in tree dominance. Many of the species associated with east-side forests exhibit vulnerability to climatic factors that alter forest habitat extent, quality, structure, and connectivity. Additionally, east-side forest species are often vulnerable to changes in temperature, which can impact phenology, physiology, prey availability, and nesting success. Some east-side forest species are also sensitive to reduced snowpack and earlier snowmelt, which can alter predator, prey, and competition dynamics, as well as insect life cycles.

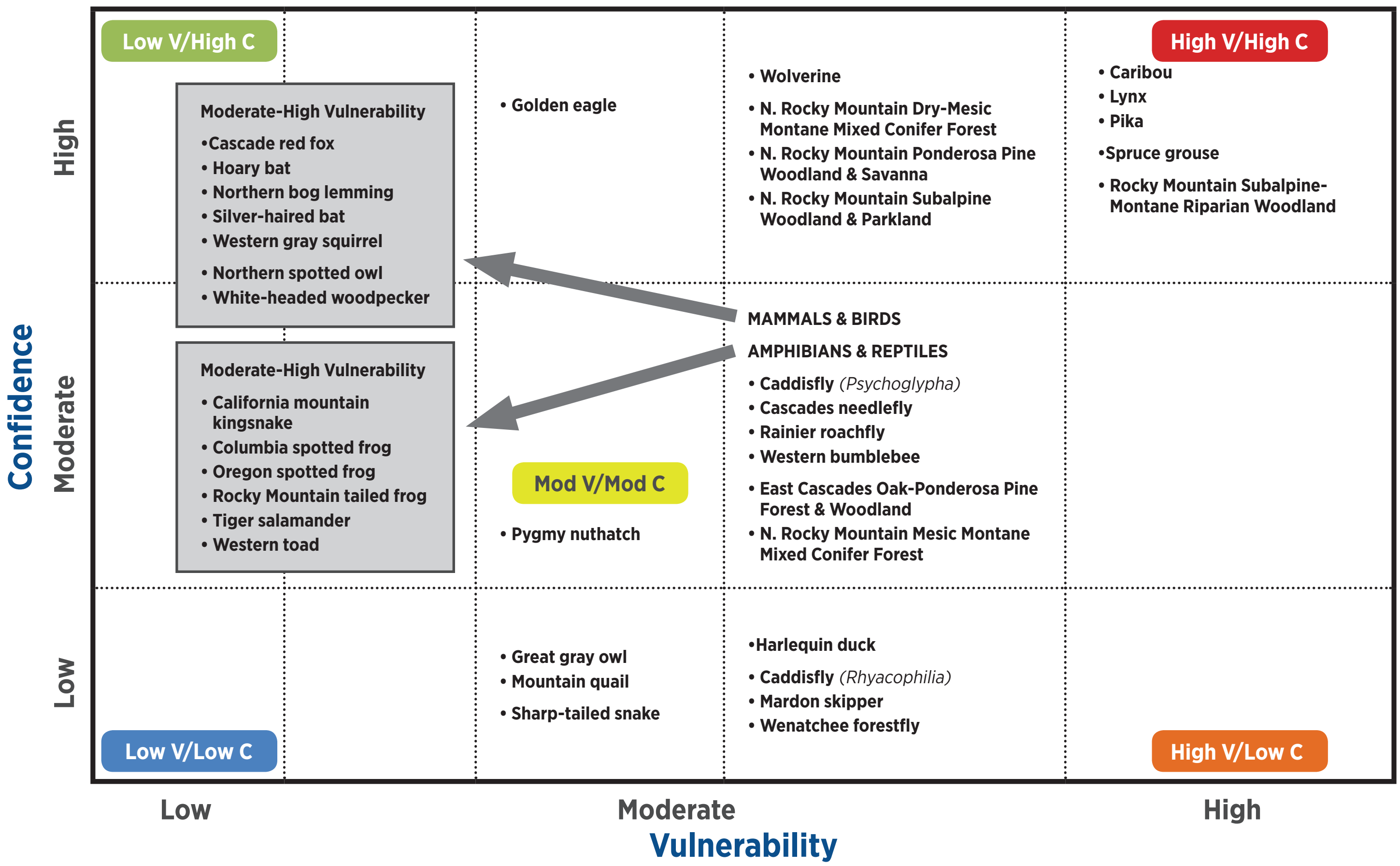
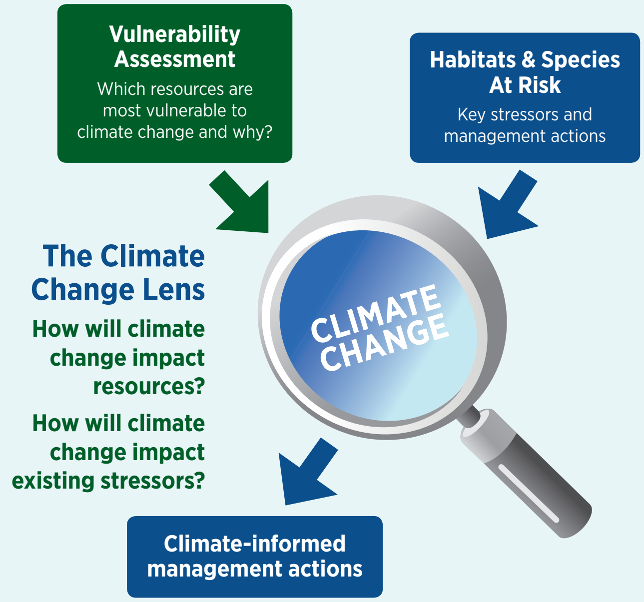


Figure 1. Vulnerability and confidence rankings plotted for east-side forest systems and species. Those systems and species with high vulnerability to climate change and high confidence are located in the upper right; those systems and species with low vulnerability to climate change and low confidence 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 California mountain kingsnake was evaluated as moderate, but the confidence in that ranking was low due to a lack of data and information on whether changing soil moisture conditions will impact reproduction, snake physiology, or preferred prey availability. A knowledge-gathering adaptation strategy to address this issue could be to monitor existing populations in order to determine whether reproduction, physiological condition, or prey availability is 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 east-side forest habitats and species.

With east-side forest systems

Altered fire regimes, reduced soil moisture, and increased insect and disease outbreaks

Can alter forest structure, distribution, and species composition

Which causes reductions or changes in habitat extent and quality

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 east-side forest systems and species

ADAPTATION CATEGORY	ADAPTATION STRATEGIES
RESISTANCE	• Prevent stand-replacing wildfire • Prevent invasive species establishment and spread
RESILIENCE	• Use prescribed fire or thinning to reduce forest density and promote structural diversity and fire-tolerant species • Promote legacy trees for forest regeneration and wildlife habitat • Reduce the impact of existing non-climate stressors
TRANSITION	• Maintain, create, and/or protect refugia • Facilitate change to desired species assemblages and/or species adapted to future conditions • Develop or increase seed collections to increase genetic diversity
KNOWLEDGE	• Monitor, model, and conduct research to improve understanding of climate changes and impacts on species and habitats • Monitor, model, and conduct research and adaptive management to support adaptation actions and evaluate effectiveness
COLLABORATION	• Communicate with other agencies and organizations about projects and coordinate on-the-ground activities (e.g., seed collection) • 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**

Fact sheet developed by EcoAdapt.