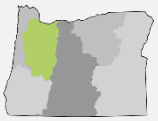


WILLAMETTE

REGION 3

Observed & Projected Climate Changes

Air & Water Temperature

Observed

Annual Air

- Average temperature in Oregon was warmer than normal in 18 of the last 23 water years (as of 2022).
- Mean annual temperatures have increased by about 1.2-1.5°C (2.2-2.7°F) since 1895.

Seasonal Air

- Summer, fall, and winter temperatures have each increased by about 1.4°C (2.5°F) since 1895; spring temperatures have increased by about 0.7°C (1.3°F).

Extreme Heat

- Increasing number of extremely warm days (e.g., Salem: 17.1 days >90°F (32°C) from 1951-2020; 37 days from 2021-2022).
- Increasing number of extremely warm nights in Portland; no significant change for Salem, Eugene.

Streams

- Long-term temperature monitoring sites in the McKenzie River basin (downstream of large dams and reservoirs) show little evidence of warming trends during late summer months in comparison to nearby free-flowing reaches.

Projected by 2100

Annual Air

- +2°C (3.6°F) to +6.0°C (10.8°F).

Seasonal Air

- Largest temperature increase is projected during summer (+6°C/10.8°F), followed by fall (+5°C/9°F), and then spring and winter (+4°C/7.2°F).
- Portland's Dec/Jan temperature patterns are projected to be similar to those currently experienced in Mar.
- Projected increases in summer mean maximum daily temperature - Eugene: 28°C (82°F) in 2020s; 31.3°C (88°F) by 2050s.
- Projected increases in winter mean maximum daily temperature - Eugene: 10°C (50°F) in 2020s; 12.2°C (54°F) by 2050s.

Extreme Heat

- Longer, more frequent, and more intense extreme heat events.
- Increase in the annual number of days >90°F (32°C) by mid-century (+13 to +21 days) compared to 1971-2000.
  - Eugene: 19 days in 2020s; 38 days by 2050s.
  - Portland: 14 days in 2020s; 31 days by 2050s.
- Increased frequency & magnitude of days with an extreme heat index (temperature + humidity).

Streams

- Outside of regulated reaches, temperature increases are projected to be relatively uniform except for small increases in streams at the highest elevations.
- +2.2°C (4°F) for mean August stream temperature.

Precipitation & Drought

Observed

Annual	• Overall, Oregon's precipitation is below average in 17 of the last 23 water years (as of 2022). • No long-term trend in annual precipitation within the region.
Seasonal	• Spring precipitation has increased in the past century.
Snowpack	• No significant change in April 1 snow-water equivalent (SWE) since 1980. • Annual peak SWE has decreased significantly with a simultaneous increase in rain-on-snow events.
Drought	• Persistent and severe droughts have occurred in Oregon since 2000. • Increased drought severity from 1987-2013 compared to 1960-1986.

Projected by 2100

Annual	• Generally, no change or minimal increase.
Seasonal	• Slight increase in winter precipitation (Dec-Feb) and less precipitation during the growing season (Apr-Oct).
Extreme Precipitation	• Increased intensity of atmospheric rivers. • Increased number of days with an atmospheric river present.
Snowpack	• Complete loss of snowpack in the lower and mid-elevations; significant declines at higher elevations. • Average snow residence time is expected to decline by about 8-10 weeks relative to current conditions.

Drought	• Increased frequency and duration of drought.
	• Increased probability of more extreme droughts than those observed in the past century.
	• Annual number of dry days:
	  ○ Eugene: 133 days in 1990s; 140 days by 2050.
	  ○ Portland: 135 days in 1990s; 141 days by 2050.
	• Climatic water deficit (CWD; a measure of drought stress) is projected to increase, with the largest percentage change above 1,500 m (4,921 ft).

Hydrology & Sea Level Rise

Observed

Streamflows	• Across the Pacific Northwest, a higher fraction of the total annual flow occurs earlier in the year, and summer flows have been decreasing.

Projected by 2100

Streamflows	• Lower elevation catchments (rain-dominant) will be less affected than higher elevation catchments; smaller streams in lower elevations do not show major peak-flow increases. • Peak flow increases projected in mid to higher elevations and in main tributaries with the expansion of rain-on-snow events and greater contribution of winter rain to floods. • Increased frequency and magnitude of floods due to more intense rainfall and shifts from snow to rain. • In areas where snow is not a large contributor to streamflow, small decreases in low flows are expected. • Greatest declines in low flows occur in High Cascade streams and some of the larger tributary rivers (e.g., Sandy River, Middle Fork Willamette River, Santiam River). • Summer flows are projected to decline by 38-58%. • Overall, summer water availability indicates less streamflow for extended periods.

Disturbances

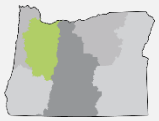
Projected by 2100

Wildfire	• Increased suitability for large wildfires for the western Cascades; highest suitability in the southeastern part of the region (Willamette National Forest).
	• Increased fire activity and frequency.
	• Uncertainty regarding fire severity; some studies suggest an increase in burn severity while others project either no change or potential reductions in fire severity.
	• Increased number of high fire danger days in summer and fall.
	  ○ Eugene: 12 days in 2020s; 16 days by 2050s.
	  ○ Portland: 15 days in 2020s; 20 days by 2050s.

Insects & Pathogens	• Increased pathogen activity in areas with drought-stressed host species. • Altitudinal and latitudinal range expansion of some forest pathogens. • Warmer winters and hotter droughts may enable some insects to increase reproductive rates and move into previously unsuitable habitat. • Increased tree mortality from insects and pathogens as trees are exposed to more stress associated with growing-season drought.
Invasive Plants	• Altered distribution and spread of nonnative plant species. • Warm, dry sites with increased topographic exposure may be particularly susceptible to nonnative species.

Information from the following references and the citations therein:

1. Halofsky, J.E., D.L. Peterson, and R.A. Gravenmier, eds. 2022. Climate change vulnerability and adaptation in the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest. Gen. Tech. Rep. PNW-GTR-1001. U.S. Dept of Ag., Forest Service, Pacific Northwest Research Station. 469 p.
2. Dalton, M. and E. Fleishman, eds. 2021. Fifth Oregon Climate Assessment. Oregon Climate Change Research Institute, Oregon State University. 183 p.
3. Fleishman, E., ed. 2023. Sixth Oregon Climate Assessment. Oregon Climate Change Research Institute, Oregon State University. 248 p.
4. Department of Land Conservation and Development. 2023. Climate Change Vulnerability Assessment Workshops, Regional Climate Change Projections Fact Sheets. https://www.oregon.gov/lcd/CL/Pages/Vulnerability-Assessment.aspx



WILLAMETTE

REGION 3 Observed & Projected Changes for Habitats & Fish Species

Habitats

Cold Forests / Subalpine

credit: Chris Glantz, ODOT

- Likely that cold forests will be more sensitive to warming at their lower elevation limits as moist-forest species may expand into these places.
- As snowpack decreases, cold-forest species may be able to establish at treeline (assuming sufficient soil is available).
- Increased fire frequency and extent at high elevations would lead to mortality of cold forest species as they have low fire resistance; fire could also limit establishment in reburns.
- In general, soil moisture stress will reduce overall vigor and growth of subalpine tree species.

Moist Forests

credit: BLM

- Fire- and drought-intolerant species (e.g., western hemlock, Pacific silver fir, western redcedar) likely to decrease in abundance, particularly on drier sites as a result of drought stress.
- Lower elevation areas that are currently in the western hemlock zone likely to transition to mixed forest types, with increased hardwood component; western hemlock zone may shift upward into areas historically in the Pacific silver fir zone.
- Increasing fire frequency in lower elevation forests likely to favor hardwoods.
- Increased productivity due to increased growing season length, adequate moisture levels, and increased atmospheric CO_2; however, moisture may become limiting for tree establishment and growth on drier sites.
- In general, projections suggest that climatically suitable area for Pacific silver fir forests will not change much with warming temperatures.
- Dominant species in middle elevations (i.e., noble fir, Pacific silver fir) may be sensitive to replacement by species from lower elevations (i.e., Douglas-fir), although the former species may find suitable habitat where they can migrate to higher elevations.

Woodlands

credit: AirHaake

- Projected expansion of woodland types with hotter and drier conditions (e.g., upslope expansion and in areas along the eastern margins of the Willamette Valley).
- Increased fire frequency could reduce conifer encroachment, favoring the development of relatively open oak woodlands.
- Lower elevation areas along the western Cascades are projected to transition from moist coniferous forest to warm mixed forest and subtropical forest, suggesting future conditions will be conducive to hardwoods (e.g., oak, bigleaf maple, Pacific madrone).
- Fire exclusion and nonnative annual grass species may limit the capacity of oak woodlands to adapt to changing conditions.

Meadows


credit: BLM

- Warming temperatures, decreased snowpack, and increasing CO_2 may facilitate woody vegetation growth, resulting in loss of meadows.
- Subalpine meadow losses have been observed during the late 20th century and are likely to continue.
- Large patches of high-severity fire could restore some aspects of meadow vegetation, but this is dependent on the persistence of native species following tree encroachment; fire may also increase exposure to nonnative plant invasions.

Riparian


credit: Kris Arnold

- Increasing temperature and evapotranspiration as well as decreasing summer streamflows could lead to drying and increased drought sensitivity in some riparian areas; this could decrease the extent of the riparian zone and/or result in shifts in riparian plant composition.
- Increased winter flooding, erosion, and sedimentation.

Wetlands & Groundwater-Dependent Ecosystems (GDE)


credit: Rick Obst

- Reduced water during summer could potentially reduce the duration and depth of standing water and increase water temperatures, affecting local distribution and abundance of associated plants and wildlife (i.e., amphibians).
- Reduced snowpack will likely shorten the length of time aquifer recharge can occur, leading to faster runoff, less recharge, and less groundwater to support GDEs.
- Some GDEs may decrease in size or dry out in summer.
- In some cases, slowly infiltrating precipitation that includes rain and snow could recharge groundwater aquifers as effectively as seasonal snowmelt runoff.
- Ephemeral wetlands at higher elevations are expected to be highly sensitive to warming conditions; wetlands at lower elevations will be vulnerable to increasing water demands.

Fish Species

Steelhead Trout


credit: Greg Shields, cc

- Warming temperatures could lead to a change in life history expression, with a loss of steelhead life history forms and an increase in inland rainbow trout forms because of a faster growth rate.
- Juveniles that rear in steep channels are vulnerable to more frequent or larger disturbances associated with wildfires and debris flows or floods and scour.
- Lower flows and warmer temperatures place additional stress on steelhead, which could increase pre-spawn mortality rates, impair spawning ability, or reduce the viability of eggs and embryos.

Coastal Cutthroat Trout


credit: Bureau of Environmental Services.

- Returning adults (of sea-run form) and juveniles located farther down the river network may be subject to increased river temperatures.
- Potential increased susceptibility to wildfire and lower summer flows for freshwater forms using stream reaches further up.
- Downstream displacement of headwater-rearing fish, with increased exposure to warmer stream temperatures and potential for intensified biological interactions with native and nonnative species found lower in the watershed.

Pacific Lamprey


credit: USFWS

- Increased risk of mortality for embryonic and newly-hatched Pacific lamprey due to water temperatures exceeding 20°C (68°F) in summer.
- Increases in water temperature can also affect survival of larval rearing fishes, timing or number of individuals as they metamorphose into ocean-going life stage, or lead to premature migration of juvenile lamprey (which could expose them to saltwater before they have made necessary physiological changes).

Bull Trout


credit: Aubree Benson USFS

- By the end of the century, only 4% of streams in the Upper Willamette core area are projected to remain within the optimal thermal range for bull trout; the area is also projected to see an increase in stream length experiencing high flow events.
- Increasing water temperatures can affect spawning distribution and abundance and early rearing.
- Populations exposed to high temperatures and frequent winter flooding may have lower genetic diversity.

Coho Salmon


credit: USGS

- Warming water temperatures can accelerate egg incubation rates in winter or spring and potentially desynchronize the developmental phenology of juveniles from the temporal availability of seasonal habitats.
- Resident juvenile life stages are likely to be impacted by long-term summer flow declines and temperature increases, which can result in habitat loss and reduced population sizes due to increased competition for food and space.

Chinook Salmon


credit: Greg Morgan, BLM

- The Upper Willamette Middle Fork population is projected to experience an increase in stream length experiencing high flows.
- Spring Chinook in the region are projected to experience warmer water temperatures, especially in the Middle Fork Willamette River.
- Highly variable flow and temperature regimes in April and May can affect smolt migration (e.g., high flows and water temperatures can narrow migration window while cool temperatures and minimal flows can delay migration).
- Holding adults are vulnerable to higher summer water temperatures.
- Reduced availability of coldwater refuges in late summer and early fall.
- Altered behavior, physiology, and growth due to warmer water temperatures.

Information from the following references and the citations therein:

1. Halofsky, J.E., D.L. Peterson, and R.A. Gravenmier, eds. 2022. Climate change vulnerability and adaptation in the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest. Gen. Tech. Rep. PNW-GTR-1001. U.S. Dept of Ag., Forest Service, Pacific Northwest Research Station. 469 p.