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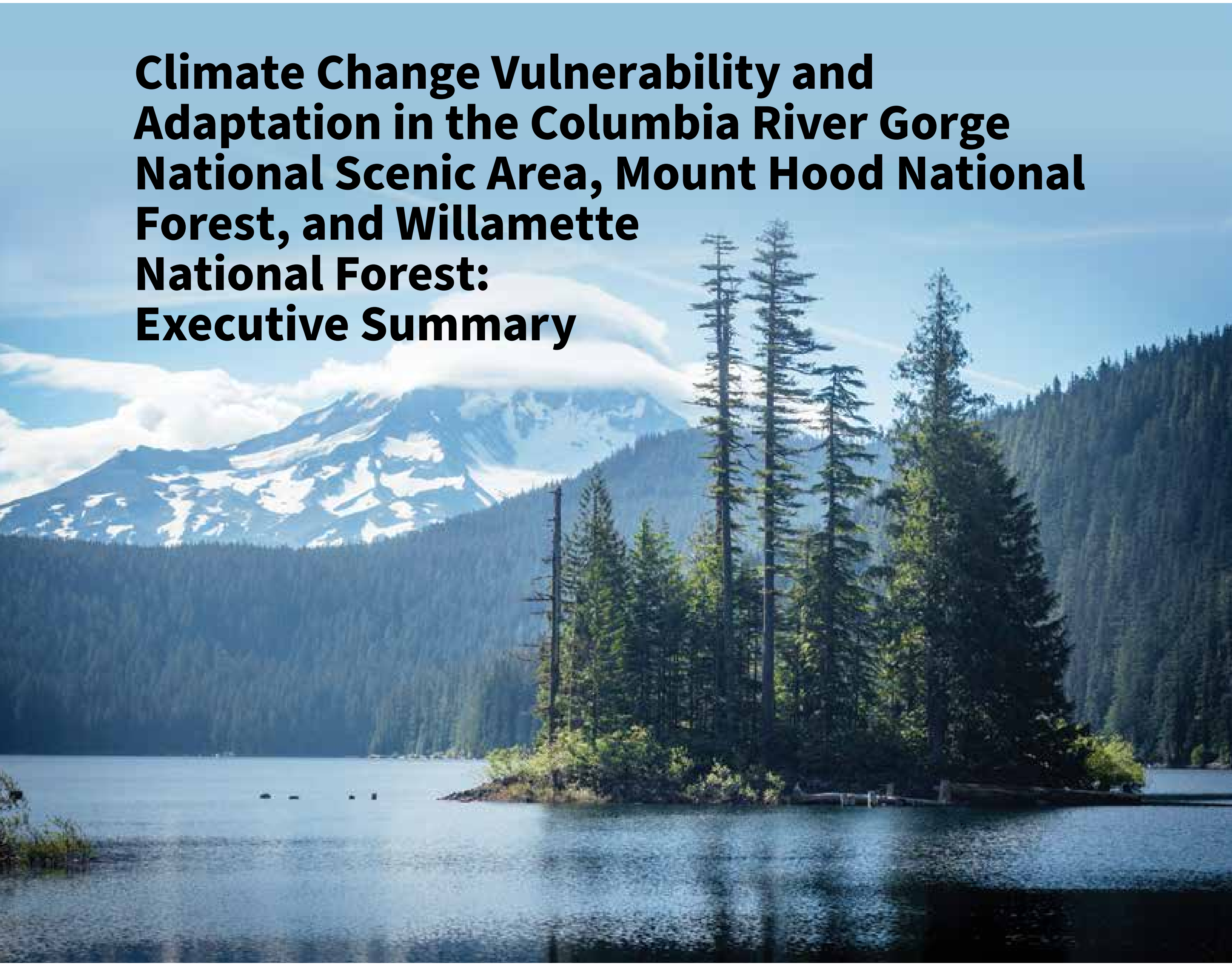
Climate Change Vulnerability and Adaptation in the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest: Executive Summary



Introduction

The following summary highlights key points from the climate change vulnerability assessment for the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest (Halofsky et al. 2022). The vulnerability assessment was developed by a science-management adaptation partnership involving managers from these national forest units, staff from the U.S. Department of Agriculture Forest Service's Pacific Northwest Region, scientists, and representatives from other organizations (hereafter referred to as CMWAP). The vulnerability assessment summarizes projected changes in climate and assesses effects on natural resources in these three national forest units located primarily in north-central Oregon, with a small portion of land in southern Washington. CMWAP participants worked together to identify locally relevant adaptation options, which are summarized in the report.

Historical and Future Climate

- The CMWAP assessment area has an annual mean temperature of around 7 °C (45 °F), but there is considerable variability because of its wide elevation range and the Cascade Range's effect on regional air masses. Temperatures vary seasonally, with winter minimums commonly falling below freezing and summer maximums reaching 20 °C (68 °F) or higher (fig. 1).
- The region has a Mediterranean precipitation pattern in which 70 percent of annual precipitation occurs from November to March, with a distinct dry season in the summer (fig. 1).
- The average annual temperature within the CMWAP assessment area has increased by 1.2–1.4 °C (2.2–2.5 °F) since 1895.
- Compared to observed historical temperature, mean annual temperature is projected to increase about 4.5 °C (8 °F) by the end of the 21st century (2070–2099) under a high greenhouse gas emissions scenario (RCP[1] 8.5) (fig. 2).
- Climate projections generally show either no change or a negligible increase in annual precipitation. They also show a shift towards slightly more winter precipitation (December–February) and slightly less precipitation during the already dry growing season (April–October).
- In general, climate variability within and between years is likely to continue and potentially increase.

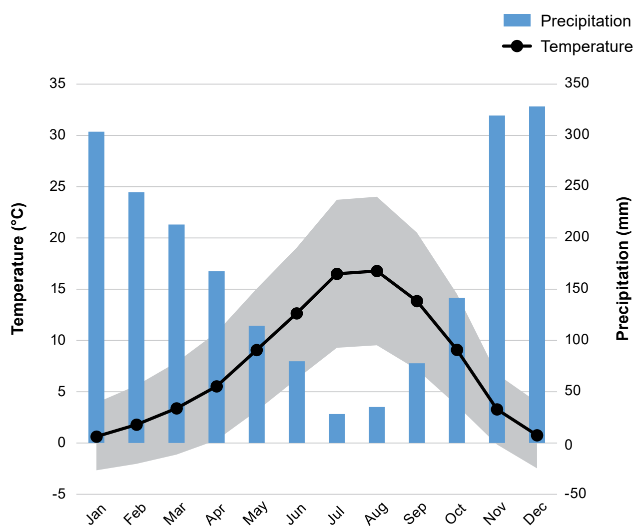


Figure 1—Mean monthly temperature and precipitation for 1970–1999 in the Columbia River Gorge National Scenic Area and Mount Hood and Willamette National Forests Adaptation Partnership assessment area from the parameter-elevation regressions on independent slopes model (PRISM) dataset. PRISM uses point data, a digital elevation model, and other spatial datasets to generate gridded estimates of climatic parameters at multiple timescales. The mean monthly minimum and maximum temperatures are represented by the shaded area, with the mean monthly temperature identified by the black line.

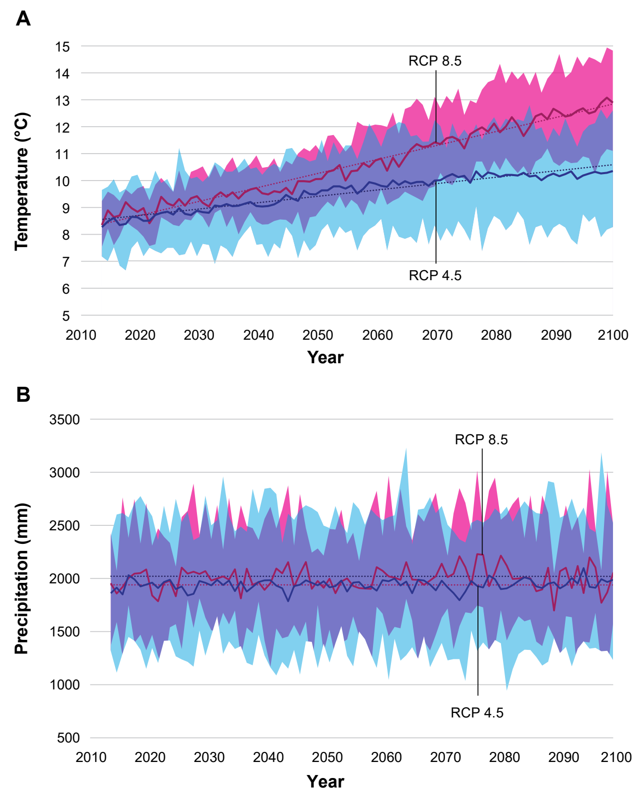


Figure 2—Comparison of RCP 4.5 and 8.5 climate change scenarios for the Columbia River Gorge National Scenic Area and Mount Hood and Willamette National Forests Adaptation Partnership assessment area through the end of the 21st century for projected (A) annual temperature and (B) annual precipitation. The model averages (red and blue lines) project warmer temperatures regardless of scenario through at least mid-century, whereas there is no discernible trend for precipitation.

[1] RCP = representative concentration pathway. Different RCP scenarios are used in climate modeling to project the trajectory of greenhouse gas emissions and their combined effect with other factors that influence the amount of heat that enters and leaves the Earth's atmosphere. RCP 4.5 represents a future with significant reduction in global greenhouse gas emissions and climate stabilization by 2100. RCP 8.5 represents a future with no climate change mitigation, high population growth, and continued increase in greenhouse gas emissions through 2100.

Water Resources and Infrastructure

- Climate change is likely to cause more winter precipitation as rain and less as snow (fig. 3), earlier snowmelt, and receding glaciers, leading to higher peak flows (fig. 4) and declines in summer baseflows.
- The permeable volcanic rocks of the High Cascades slow groundwater recessions and may dampen climate change effects on streamflow.
- Changing hydrology due to variability in timing and amounts of precipitation within and between years will affect water quality, water availability, soils, and vegetation. Aging trail and road networks, especially older culverts, will be vulnerable to damage.

Adaptation Options

- Use climate-informed streamflow projections to aid decisions on structure type and sizing at stream crossings as well as decisions about travel management and restoration.
- Disconnect road ditch lines from streams during project work to reduce sediment delivery.
- Use instream restoration techniques (e.g., adding wood to streams) to improve hydrologic connectivity in floodplains and increase water storage capacity.
- Reintroduce or support populations of American beaver (*Castor canadensis*) to slow water movement and increase water storage.

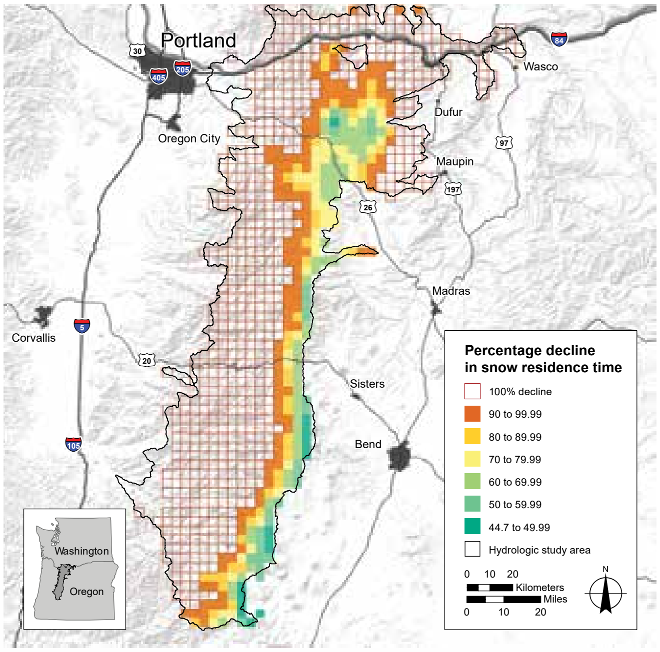


Figure 3—Projected percentage change in snow residence time between a historical period (1975–2005) and the 2080s (2071–2090) under RCP 8.5. From National Forest Climate Change Maps (https://www.fs.usda.gov/rm/boise/AWAE/projects/national-forest-climate-change-maps.html).

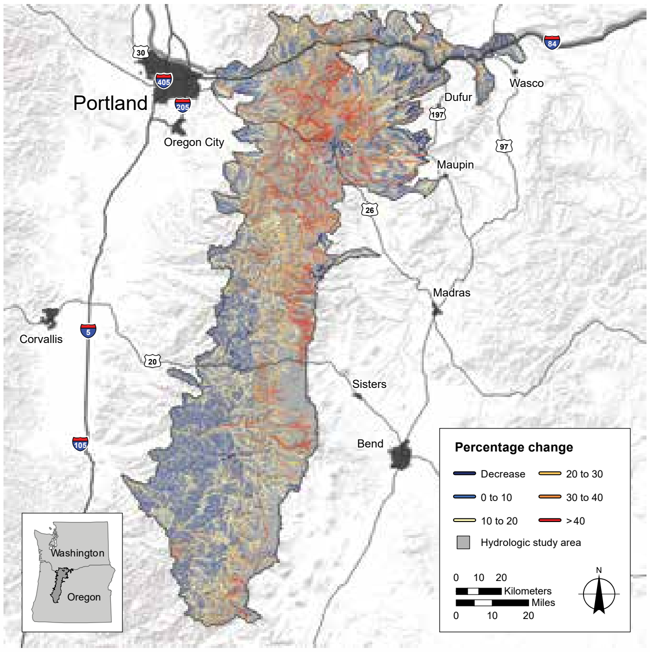


Figure 4—Projected percentage increase in peak flows between a historical period (1970–1999) and the 2080s (2070–2099) under the A1B emission scenario, based on variable infiltration capacity hydrologic modeling. Areas of low groundwater recession may be overestimated.

Fisheries and Aquatic Habitat

- Decreased summer streamflows (22 to 43 percent in the 2040s and 38 to 58 percent in the 2080s) and warmer water temperature (table 1) will reduce habitat amount and quality for coldwater fish species, especially at lower elevations.
- Changes in timing and amount of flow and temperature can affect habitat, survival, and outmigration for spring-spawning species. Disturbance of redds and displacement of newly hatched fry by increased winter and spring flows are potential vulnerabilities.
- Fall-spawning species are sensitive to flow and temperature changes in every season.

Adaptation Options

- Adaptation strategies include conserving existing habitats and restoring degraded habitats.
  - Increase connectivity to maximize coldwater refugia.
  - Reestablish natural processes (e.g., fire, sedimentation, streamflow).
  - Reduce impacts of invasive species.
  - Leverage partnerships to expand efforts across boundaries.
- Adaptation tactics include collaborative and educational activities.
  - Implement watershed-scale restoration projects with partners.
  - Coordinate monitoring between agencies.
  - Increase education and outreach to stakeholders and water users.

Vegetation

- Higher air temperature, through its influence on soil moisture and plant stress, is expected to cause gradual changes in the abundance and distribution of vegetation species (fig. 5).
- Drought-tolerant species will likely have the competitive edge, leading to changes in composition relative to current species mixes or a transition to a different vegetation type (table 2).
- Ecological disturbance, mostly through increased occurrence of wildfire, will be the primary facilitator of vegetation change. Future forest landscapes may be dominated by younger age classes and smaller trees (fig. 6).

Adaptation Options

- Maintain spatial diversity to minimize high-severity fire extent and help increase resilience to fire, drought, and insects, thus supporting functional ecosystems.
- Reduce stand density in forests to decrease inter-tree competition and drought stress, thus increasing tree growth and vigor.
- Implement fuel treatments in forests to help reduce stand-replacement fires.
- Map current and potential plant communities of concern (e.g., mixed oak/pine refugia) as well as invasives, then prioritize areas for treatment and protection.
- Favor drought-tolerant genotypes and species during management activities to help increase survival following disturbances.
- Plan for more winter flooding and drier soils in summer in wetland, riparian, and groundwater-dependent habitats.

Table 1—Projected change in the proportion of streams with mean temperatures less than 17 °C (62.5 °F) in August for focal fish species habitats

Species	Historical (2000s)	Future (2040s)	Future (2080s)
	- - - - - - - - - - - - - - - -	*Percent*	- - - - - - - - - - - - - - - -
Summer steelhead (*Oncorhynchus mykiss*)	73	67	58
Winter steelhead (*O. mykiss*)	86	75	58
Redband trout (*O. mykiss*)	91	86	81
Coastal cutthroat trout (*O. clarkii*)	94	91	82
Pacific lamprey (*Entosphenus tridentatus*)	41	38	34
Bull trout (*Salvelinus confluentus*)	72	68	58
Coho salmon (*O. kisutch*)	52	46	38
Spring chinook salmon (*O. tshawytscha*)	84	77	65
Fall chinook salmon (*O. tshawytscha*)	40	28	12
Chum salmon (*O. keta*)	13	6	1

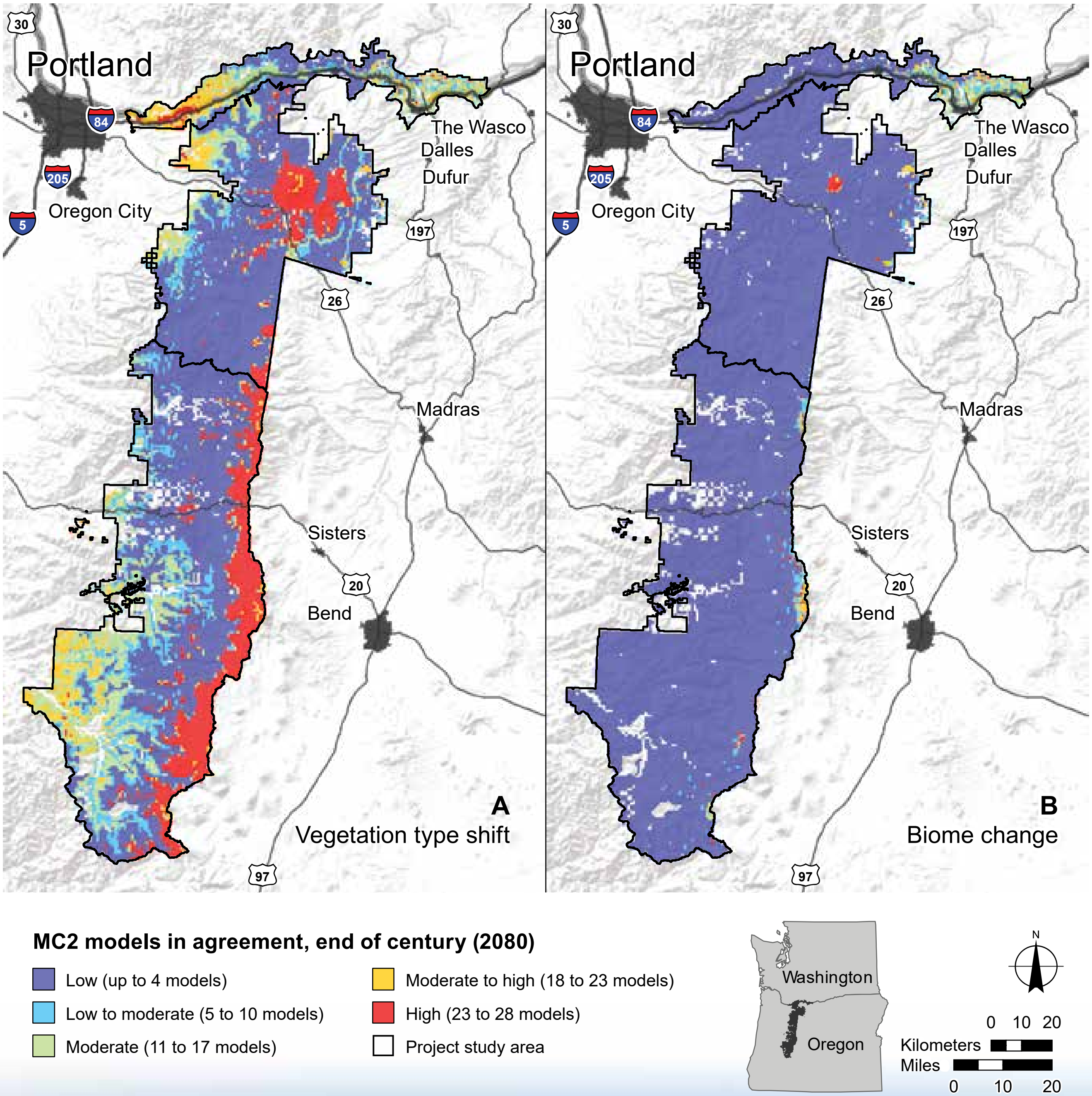


Figure 5—Agreement in simulations of vegetation change from the MC2 dynamic global vegetation model (among 28 climate scenarios) at the end of the century (2080) for (A) simulated change in vegetation type and (B) simulated change in biome (e.g., forest to woodland or shrubland to grassland).

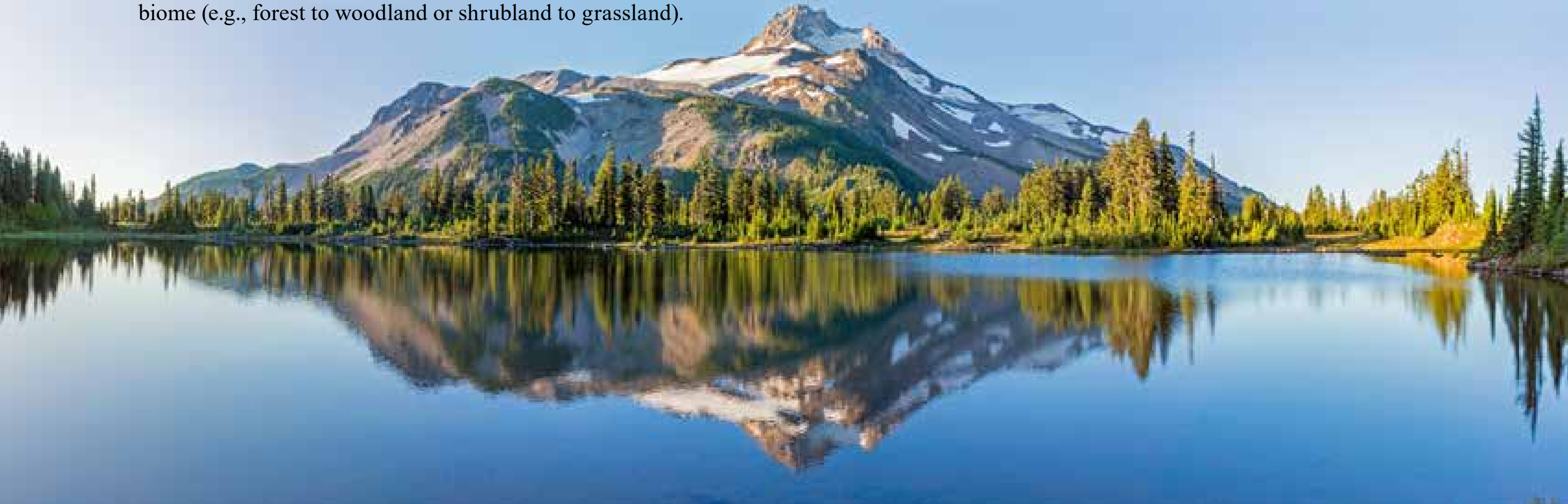


Table 2—Summary of key vulnerabilities by forests type in the Columbia River Gorge National Scenic Area and Mount Hood and Willamette National Forests Adaptation Partnership assessment area

Forest type	Key vulnerabilities
Moist forest	Dominance of Douglas-fir (*Pseudotsuga menziesii*) is likely to continue with fire- and drought-intolerant western hemlock (*Tsuga heterophylla*), Pacific silver fir (*Abies amabilis*), and western redcedar (*Thuja plicata*) possibly decreasing, which could reduce stand density and canopy layering. Increased fire frequency may favor hardwoods in lower elevations. Productivity could increase from longer growing seasons and higher CO_2 levels but may be offset by water deficits at drier sites.
Cold forests	Decreases in subalpine fir (*A. lasiocarpa*), mountain hemlock (*Tsuga mertensiana),* and Engelmann spruce (*Picea engelmannii*) are projected through competition with lower elevation species. Wildfire may lead to large-scale mortality and regeneration failure. Expansion of mountain pine beetle (*Dendroctonus ponderosae*) would compound ongoing stress from pathogens like white pine blister rust (*Cronartium ribicola*) in whitebark pine (*Pinus albicaulis*).
Dry forests	Dry forests and woodlands are likely to maintain their current distribution, but increased exposure to fire may affect composition and structure. Ponderosa pine (*P. ponderosa*) may shift to higher elevations becoming more dominant relative to Douglas-fir and white fir (*A. concolor*). Growth may decrease and mortality may increase in some cases through interactions among drought, insects, and perhaps other disturbances. Drought stress and higher fire frequency may cause a transition to woodlands or shrublands in the driest locations.
Special habitats	Oak woodlands are already reduced and fragmented. More frequent fire may benefit them but increase invasive annual grasses. Tree encroachment from snowpack declines will reduce meadow area. Large fires may restore some meadows by killing recently established trees. Riparian areas may decrease in extent, and their plant communities may change through increasing drought sensitivity, higher evapotranspiration, and lower summer streamflows.

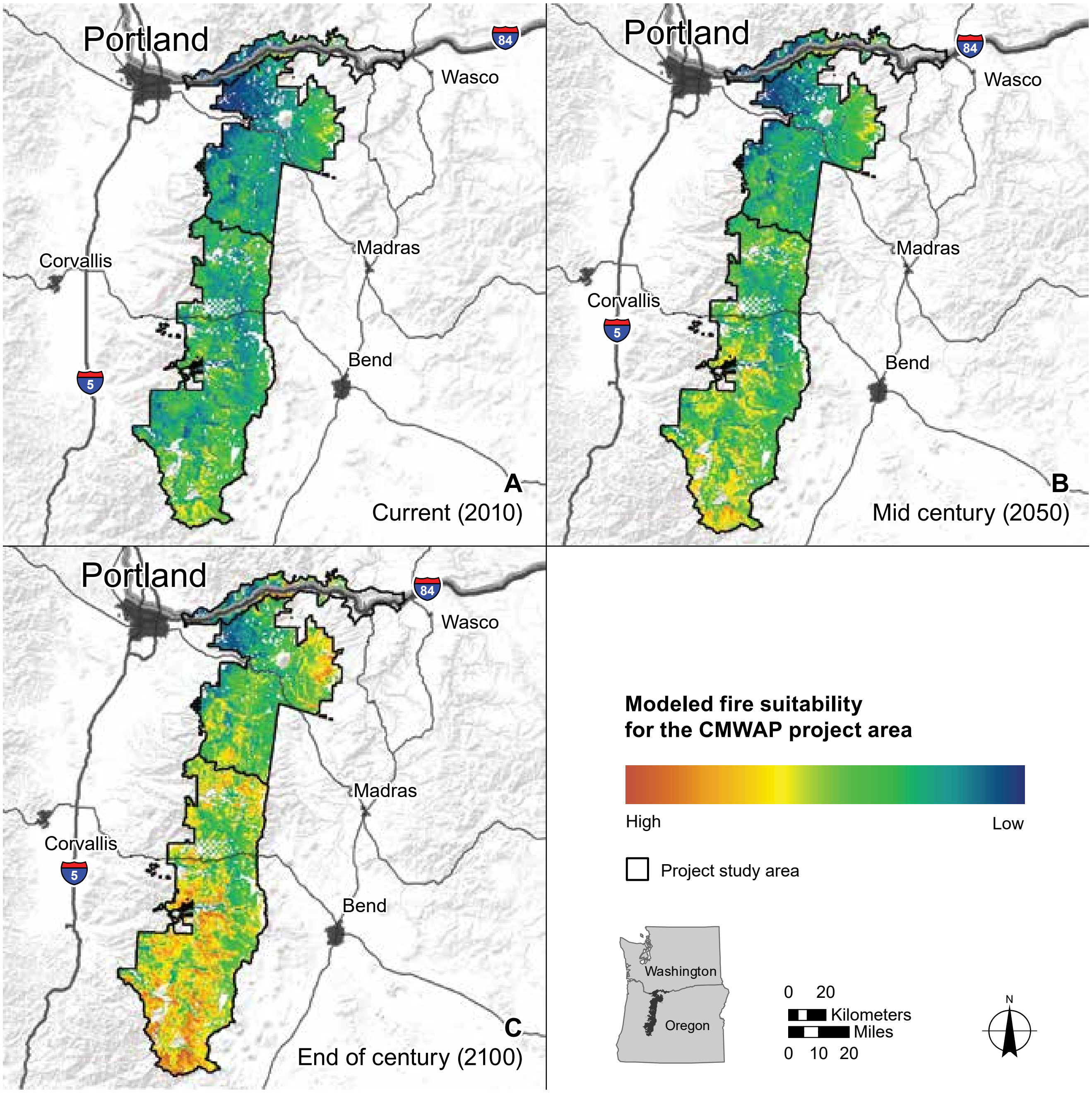


Figure 6—Modeled environmental suitability for large forest fires in the Columbia River Gorge National Scenic Area and Mount Hood and Willamette National Forests Adaptation Partnership (CMWAP) assessment area (A) under current climate and projected future climate, and (B) at the middle of the century, and (C) at the end of the century, both as projected under the RCP 8.5 emission scenario.

Wildlife

- Ecosystem responses to climate change will affect animal species through altered food availability, competition, predator-prey dynamics, and availability of key habitat features (table 3).
- Despite the flexibility and adaptive capacity of many species, widespread shifts in animal ranges and local extirpation of some species may result from climate change and other stressors.

Adaptation Options

- Increase habitat connectivity at large spatial scales, especially across different land ownerships, to enhance persistence of mobile species.
- Coordinate the mapping and surveying of habitats where connectivity is sensitive to repeat disturbances and of distributions of species that could potentially repopulate disturbance-affected areas.
- Enhance resilience of late-successional habitat by increasing the heterogeneity of forest structure at multiple spatial scales.
- Use adaptation approaches to restore hydrologic function and connectivity for water and fish that are also beneficial to wildlife.

Table 3—Summary of climate change effects on focal wildlife habitat types

Focal habitat	Effects
Oak woodlands	Increased fire frequency may favor oaks, but currently fragmented habitats hinder dispersal and maintenance of metapopulations as local habitats are extirpated. Example fauna: western gray squirrel (*Sciurus griseus*), woodpeckers that use acorns, rare butterflies.
Conifer forests—western hemlock	Future habitat will be determined by the interplay between disturbance, management, and regeneration. Old-forest conditions will be a limiting factor. Fragmentation reduces dispersal capability, and mismatches could occur between thermal suitability and key shelter features. Example fauna: northern spotted owl (*Strix occidentails caurina*), red tree vole (*Arborimus longicaudus*), northern flying squirrels (*Glaucomys sabrinus*), snag roosting bats.
Conifer forests—Pacific silver fir	Lower elevation areas may transition to western hemlock. Isolated patches may limit dispersal. Subnivean (snow-based) habitats are sensitive to loss depending on disturbance and the presence of large trees and wood. Example fauna: American marten (*Martes americana*), many bird species.
Subalpine forests	Already isolated and stressed by recreational use and forest pathogens (e.g., white pine blister rust), further isolation and contraction of habitat patches is likely. Example fauna: all subalpine-associated species.
East-side forests/mixed woodlands	Remnant old-growth ponderosa pine/mixed-conifer may be lost to wildfire, and drought may limit reestablishment of forest habitat. Already scarce riparian habitats will decline. Example fauna: old-growth-associated species, mollusks, amphibians.
Shrub, grass, and rock	Effects will vary depending on location. These habitats are sensitive to shifting wildfire return intervals. Grass communities (e.g., in forests and alpine meadows) reliant on certain soil-moisture conditions could decline with more frequent drought. Example fauna: riparian-associated snails that rely on talus.
Early-seral habitat	Early-seral forest is expected to increase as fire frequency increases. The exposed nature of early-seral forests will cause fauna to experience more direct changes in temperature and moisture. Example fauna: butterflies with specific hosts, fauna sensitive to phenological mismatches.
Riparian, wetlands, and water	Heat budgets for water bodies are complex, making fine-scale projections uncertain. Peak temperature and low flows are aquatic stressors that may cooccur more frequently, favoring invasive species. Habitat presence and size could decrease with less snow. Example fauna: cold-water-associated species.

Recreation

- Summer recreation will benefit from a longer period of suitable weather, especially during spring and autumn shoulder seasons.
- Snow-based recreation will be negatively affected by less and more transient snow, especially at lower elevations (fig. 7).
- Hunting may be sensitive to temperature and timing of snow, while fishing will be sensitive to changes in streamflows and stream temperatures.
- Water-based recreation will be sensitive to lower water levels during drought years. However, demand for water-based recreation may increase with warmer temperatures.
- Forest product gathering may also be somewhat sensitive because of changes in the distribution and abundance of items.

Adaptation Options

- Redirect recreational use to optimize opportunities and protect areas vulnerable to damage to help maintain a high-quality recreational experience.
- Adjust capacity and availability of sites based on variable weather conditions from year to year.
- Identify areas of heavy use and adjust resources or consider dispersing access to other areas.
- Seasonally restrict access in some cases, especially when snow melts early making roads and trails vulnerable.
- Increase flexibility in the seasonality of staffing, permitting, and concessionaire contracts to respond to altered demands and opportunities in the future.

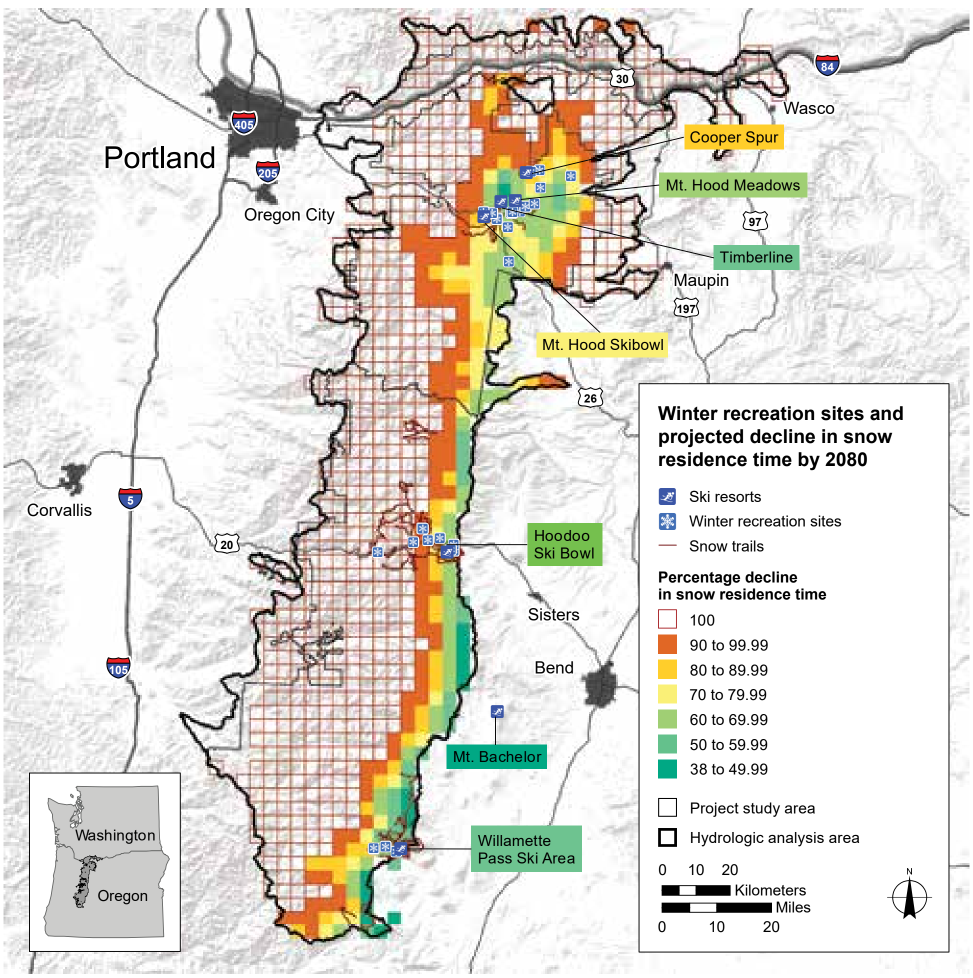


Figure 7—Snow-based recreation sites and decline in snow residence time in the Columbia River Gorge National Scenic Area and Mount Hood and Willamette National Forests Adaptation Partnership assessment area. Sites are indicated by blue boxes with snowflakes, overlaid on percentage decline in snow residence time. The six labeled ski areas are those for which the Pacific Northwest Ski Area Association collects annual visitation data. Ski area label colors match the percentage decline in snow residence time for their location, as shown in the legend.

Ecosystem Services

- Climate change may affect cultural resources, including "first foods," such as huckleberries (*Vaccinium* spp.) and salmon, that are valued by American Indian tribes.
- Impacts of higher temperatures and disturbances on forest structure and growth will affect timber supply, carbon sequestration, and special forest product availability (table 4).
- Warming could affect insect pollinator physiology and behavior, creating potential phenological mismatches in insect emergence and timing of flowering.
- Changes in plant species composition and productivity will affect livestock forage.
- The ability of forests to sequester carbon will likely decrease if a warmer climate increases physiological stress in trees and increases the frequency and extent of disturbances.

Adaptation Options

- Reduce nonclimate stressors and apply restoration practices in locations where production of first foods can be enhanced, thus improving the sustainability of cultural resources.
- Implement stand density management that supports forest health, thus improving the sustainability of forest products.
- Reduce surface fuels in forests and wildland-urban interfaces, which will prevent high-intensity wildfires and benefit the long-term stability of carbon.
- Protect pollinator habitat, maintain species diversity, and increase agency and public awareness about the importance of pollinators.
- Manage public expectations for landscape change and disturbance to facilitate long-term adjustment to new conditions.

Table 4—Summary of metrics describing selected ecosystem services in Mount Hood National Forest (MTH), Willamette National Forest (WIL), and Columbia River Gorge National Scenic Area (CRG)

UNIT	Ecosystem service	Grazing[a]	Timber volume[b]	Nontimber forest products[c]				Carbon stock[d]	Recreation[e]	Water supply[f]
				Christmas trees	Mushrooms	Nontimber wood/firewood	Decorative and craft plants			
	Area (× 1000 ha)	*Animal unit months*	*Million board feet sold*	*Permits*	*Gallons*	*Million board feet sold*	*Beargrass, salal, limbs, boughs, etc. in pounds*	*Metric tons per ha*	*Visits × 1,000*	*Millions of cubic meters*
MTH	411	1,807	27	3,432	3,270	6.4	669,484	348	2,945	5287
WIL	684	none	74.3	3,973	11,985	4.7	1,001,592	403	1,589	9935
CRG	118	117	0.2	none	none	0.09	none	326	3,238	414

AUM = animal unit month; ha = hectares.

Graphics used are public domain; tent graphic designed by Brgfx/http://www.freepick.com; water drop graphic from http://www.vexels.com.

[a] From U.S. Forest Service INFRA inventory data for fiscal year 2017.

[b] Timber volume is the 2013–2018 annual average reported by the U.S. Forest Service Pacific Northwest Region.

[c] Nontimber forest products metrics are annual averages for 2013–2018, as reported by the U.S. Forest Service Pacific Northwest Region.

[d] Carbon stocks are for 2013, as reported in USDA FS (2015).

[e] From U.S. Forest Service National Visitor Use Monitoring (NVUM) program (CRG and MTH data from 2016, WIL data from 2017). NVUM data only covers national forest lands and does not fully capture the Columbia River Gorge National Scenic Area, which hosts recreation opportunities and infrastructure on state and private ownerships.

[f] Estimate of mean annual renewable water supply is for the period 1981–2010 from Brown et al. (2016).

For More Information

Halofsky, J.E.; Peterson, D.L.; Gravenmier, R.A., 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. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 469 p. https://doi.org/10.2737/PNW-GTR-1001.

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Cover photo: View of the Bull Run Watershed, Bull Run Lake, and Mount Hood, located on Mount Hood National Forest. Photo credit: Portland Water Bureau.

All other photos Adobe Stock.

Abstract

Hoyer, Robert; Timberlake, Thomas; compilers. 2023. Climate change vulnerability and adaptation in the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest: executive summary. Misc. Pub. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 11 p.

This is the executive summary for the report, *Climate Change Vulnerability and Adaptation in the Columbia River Gorge National Scenic Area, Mount Hood National Forest, and Willamette National Forest*, by Halofsky et al. (2022, PNW-GTR-1001). The vulnerability and adaptation assessment was conducted by a science-management partnership comprising of the three U.S. Department of Agriculture Forest Service units, Forest Service scientists, and other organizations. The partnership assessed the vulnerability of natural resources to climate change and developed adaptation options that minimize negative impacts and facilitate ecosystem transition to a warmer climate.

Keywords: Adaptation, aquatic ecosystems, climate change, climate-smart management, ecosystem services, fisheries, hydrology, infrastructure, recreation, science-management partnership, terrestrial ecosystems, vegetation, wildfire, wildlife.

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