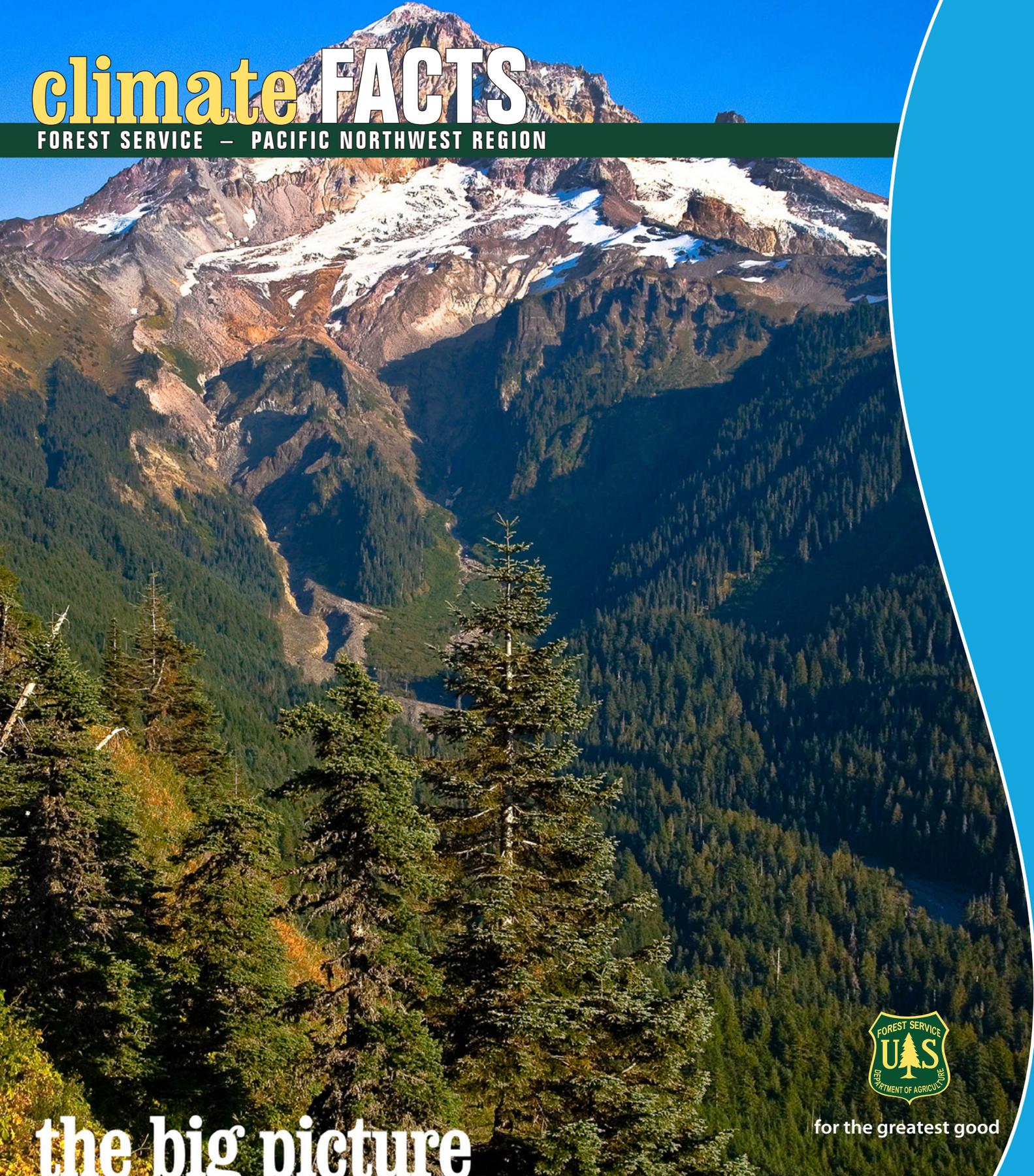




United States  
Department of  
Agriculture

# climate FACTS

FOREST SERVICE — PACIFIC NORTHWEST REGION



for the greatest good

## the big picture

# PACIFIC NORTHWEST FORESTS

## What is Climate Change?

In order to understand climate change, it is important to understand the difference between weather and climate. Weather describes the conditions of the atmosphere (e.g., temperature, precipitation, humidity, and cloudiness) over a short period of time (minutes to months) in a particular area. Climate, on the other hand, is the long-term (30 years or more) average of weather conditions in a given region. Put simply, climate is what you expect, and weather is what you get. While weather can be difficult to predict, climate is driven by factors that scientists understand relatively well. Scientists use their understanding of climate to develop complex Global Climate Models that can closely reproduce historical climate conditions and make projections about what future climate may be like.

The past century has seen an increasing trend in global average temperature. This trend is linked to the continuing rise in atmospheric concentrations of greenhouse gases (GHG) like carbon dioxide (CO<sub>2</sub>). GHGs absorb heat energy reflected from the earth's surface, then re-radiate it back to the Earth's surface. The warming trend is expected to continue through the next century, with the magnitude of warming primarily contingent on the amount GHG emitted by humans in the future.<sup>1</sup>

## What does it mean for the Pacific Northwest?

Climate change has the potential to alter the landscapes of the Pacific Northwest (PNW). A warmer climate will affect valued resources managed by the Forest Service in Region 6.

- Reduced snowpack and earlier melting alters the streamflow dynamics of many river systems.<sup>2</sup>
- Increased water temperature in streams affect habitat suitability for sensitive aquatic species.<sup>2</sup>
- Sea-level rise puts important coastal features at risk from erosion and inundation.<sup>2</sup>
- Warmer temperatures, and changing stressors and disturbance patterns lead to changes in composition and structure of forest, shrubland, and grassland ecosystems.<sup>2</sup>
- These biophysical effects lead to socioeconomic consequences for inhabitants of the Pacific Northwest.<sup>3</sup>

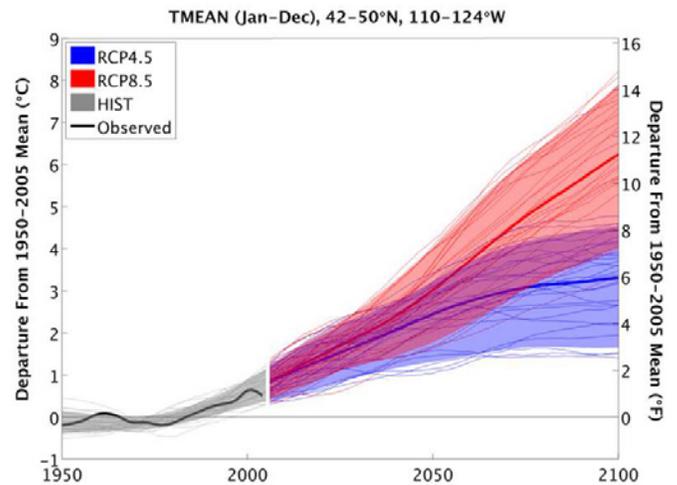


Figure 1: Observed annual average temperature change (1950–2011) and simulated annual average temperature change (1950–2100) for a selection of climate models under a high emission scenario (red shading) and a moderate scenario (blue shading). Thin lines represent individual models with the thicker lines representing the multi-model average (Mote et al., 2013).<sup>5</sup>

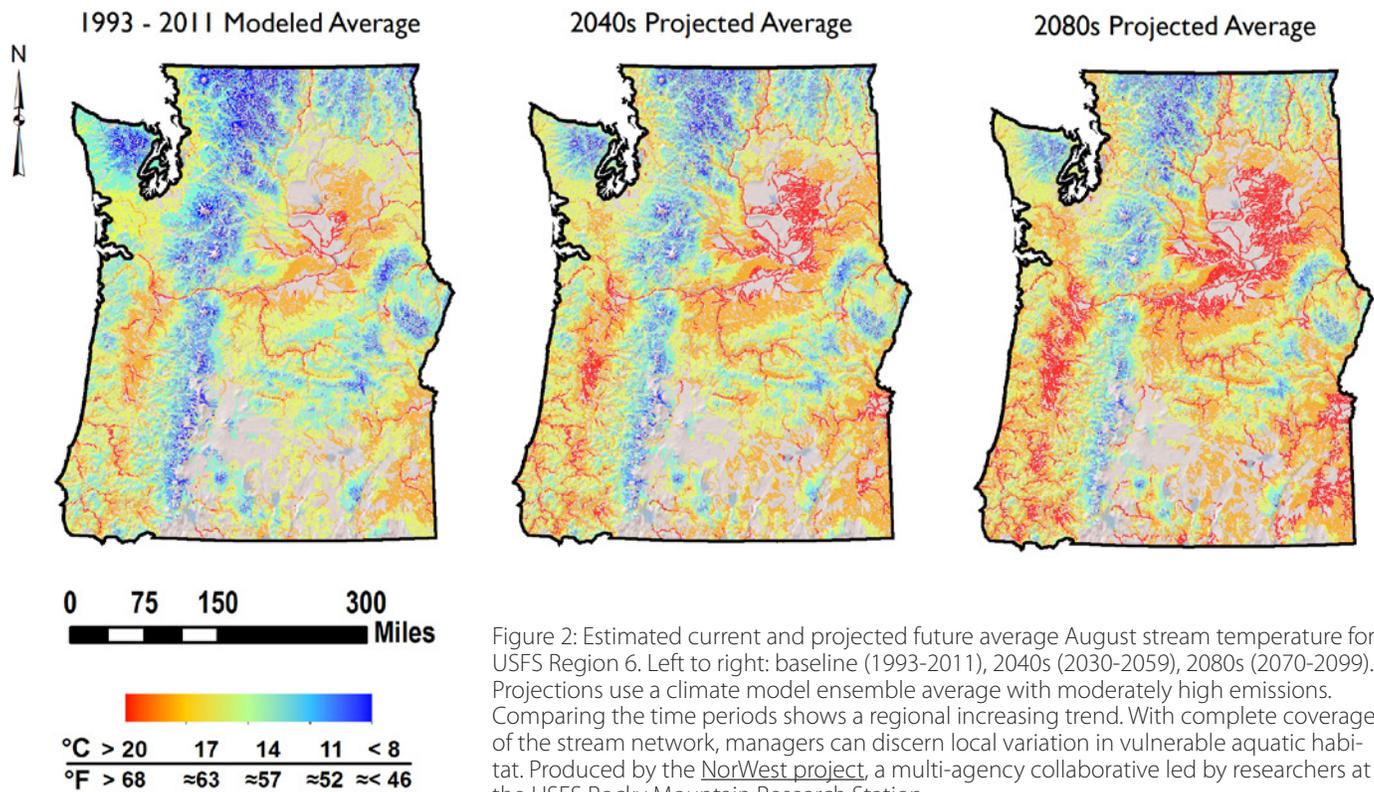
## Anticipated Climate Change in the Pacific Northwest

### Temperature

- The past century saw an average increase of 0.13 °F per decade. Most of the warming occurred in the last 30 years.<sup>4</sup>
- Heat waves have become more frequent, and cold waves have decreased.<sup>4</sup>
- By 2050, climate models estimate an average temperature increase of 4.3 to 5.8 °F, and an average summer temperature increase of 3.4 to 9.4 °F when compared to 1950-2011 temperatures. The actual temperature increase will depend on greenhouse gas emissions (Figure 1).<sup>5</sup>

### Precipitation and Snowpack

- Average annual precipitation has increased slightly in the Northwest over the past century.<sup>4,5</sup>
- Annual precipitation projections do not show a consistent increasing or decreasing trend; projections differ among climate models. Interannual variability is not expected to change markedly from historical variability.<sup>4,5</sup>



## Precipitation and Snowpack [...continued]

- Most climate model projections show a slight increase in precipitation in winter and a slight decrease in summer. Extreme rain events may increase.<sup>2,5,6</sup>
- Average snowpack has declined by 29% over the last half of the 20th century for western Washington and Oregon, and further decline is expected in the future.<sup>7</sup>

## Region 6 Projected Risks and Vulnerabilities

### Streamflow Dynamics

- As winters become warmer, many watersheds will experience a larger fraction of streamflow earlier in the year.<sup>2,8</sup>
- Autumn and winter flood events will likely increase in frequency and magnitude, and winter soil moisture will likely be higher, thus increasing landslide risk.<sup>2,8</sup>
- Aging roads and infrastructure are vulnerable to damage and potential loss from flooding and landslides, which degrade aquatic habitat.<sup>9,10</sup>

### Stream Temperature and Fish

- Warmer air temperatures have been linked to warmer streams in the Pacific Northwest.<sup>11</sup>
- Lower summer streamflows and warmer air temperatures will likely lead to increased stream temperatures in the future (Figure 2).
- Higher stream temperatures reduce habitat for cold-water-adapted trout and salmon species, thus impeding migration and restricting populations to isolated refugia.<sup>11</sup>

### Forest Vegetation

- A warmer climate and longer growing seasons alter a plant's ability to survive, grow, and reproduce.<sup>12</sup>
- Longer, hotter summers increase soil water deficits, leading to drought-stress in plants. Drought-stressed plants are more susceptible to mortality from fire and insect and disease outbreaks (Figure 4).<sup>12</sup>
- Plant species distributions will likely shift northward and upward in elevation with warming temperatures, and the area of alpine and subalpine communities may shrink.<sup>13</sup>



**Sea-level Rise**

One typically thinks of the vast inland forests and majestic mountain ranges when it comes to the Forest Service, so it may be a surprise to some that the Forest Service manages oceanfront real estate.

The region's coastline includes the Oregon Dunes National Recreation Area, the largest coastal dune fields in the U.S. (Figure 3). Like coastal features everywhere, these resources are vulnerable to sea-level rise (SLR). Expansion of warm water and melting land ice contributed to a global 8 in. SLR since the 1880s and projections for the next century range from 1-4 ft. depending on emissions and local factors. SLR amplifies the effects of storms and wave action making extreme events even more damaging. Coastal features like sand dunes and tidal marshes will be subjected to an intensified pattern of inundation and erosion.<sup>14</sup>

Figure 3: Sea-level rise enhances the erosion potential of storm surges in places like Eel Creek within the Siuslaw National Forest's Oregon Dunes National Recreation Area. It is uncertain if delivery of sediments from inland sources needed to maintain these features can keep up with the accelerated losses in the future putting these unique areas at risk (Photo: USDA Forest Service).

**Forest Vegetation (...continued)**

- Lower fuel moisture and longer fire seasons with climate change will likely lead to increased area burned by wildfires (Figure 5). Burned areas are more sensitive to erosion, floods, and invasive species.<sup>12,13</sup>
- Increased disturbance and shifting species distributions will likely increase opportunities for invasive species to establish.<sup>13</sup>

**Socioeconomic Effects**

- Degradation or loss of natural resources from climate change could affect the economic well-being and cultural character of communities.<sup>15</sup>
- Increasing scarcity of water could lead to greater conflicts among users on and adjacent to federal forests.<sup>2</sup>
- The Pacific Northwest First Nation Tribes have deep concerns about climate change effects on traditional hunting, fishing, and gathering activities.<sup>3</sup>



Figure 4: Mountain Pine Beetle outbreaks like this one in an eastern Oregon Lodgepole Pine stand will likely be more frequent under milder winters and hotter, drier summers. (Photo: Dave Powell, USDA Forest Service (retired), Bugwood.org).

- Culturally-important food and medicine sources provided by ceded land on national forests could move or disappear, making access for tribal people difficult to impossible. Community cohesion and economic well-being may be put at risk.<sup>3</sup>

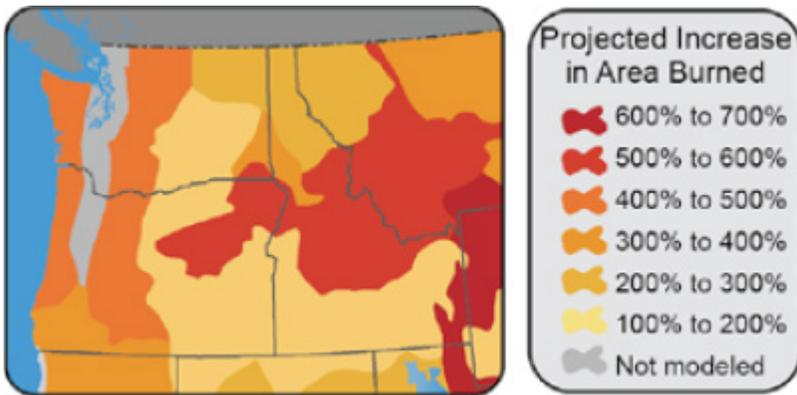


Figure 5: Estimated increase in area burned resulting from regional temperature and precipitation changes based on 2.2 °F global warming. Performed at the ecoregional scale, there will be local variation in impacts in these large areas with fuel sensitivity to climate. (From The National Climate Assessment, Ch. 21).<sup>2</sup>

## What is being done?

The Forest Service recognizes the threat climate change poses to its mission to sustain forests and grasslands for future generations. As part of its Roadmap for Responding to Climate Change, the agency uses a performance scorecard to assess progress of national forests in climate change adaptation and mitigation.

To meet its objectives in the Pacific Northwest, regional managers, scientists from the PNW Research Station, and outside collaborators are partnering to do climate change vulnerability assessments to determine what the most significant impacts of climate change will be on national forests in the region. These vulnerability assessments set the stage for development of adaptation options, or ways in which national forests can prepare for and plan to decrease the negative effects of climate change.

Vulnerability assessments and adaptation options are included in published reports, which inform national forest restoration activities, post-fire management, and the forest plan revision process.

Complementary to these assessments, a region-wide socio-economic vulnerability assessment is also being developed. The results of this work are being packaged in innovative ways to aid in their use in management decision-making. These tools are crucial to an effective climate change response that supports the Forest Service mission now and in the years to come.

## Looking for More?

Please see the cited references (located on the back) for more in-depth information about climate change impacts in the region.

The US Forest Service Climate Change Resource Center hosts a wide array of information from basic science to forest impact topics – [www.fs.usda.gov/ccrc](http://www.fs.usda.gov/ccrc)

**Climate Facts** is produced by the Pacific Northwest Region 6 Climate Change Team. US Forest Service, 1220 SW 3rd Ave., Portland, OR 97205.

**For inquiries or additional information, contact:**

Becky Gravenmier, Climate Change Coordinator, [bgravenmier@fs.fed.us](mailto:bgravenmier@fs.fed.us)

Wes Hoyer, Climate Change Program Associate, [robertwhoyer@fs.fed.us](mailto:robertwhoyer@fs.fed.us)

**References**

1. Walsh, J.; Wuebbles, D.; Hayhoe, K.; Kossin, J.; Kunkel, K.; Stephen, G.; Thorne, P.; Vose, R.; Wehner, M.; Willis, J.; Anderson, D.; Kharin, V.; Knutson, T.; Landerer, F.; Lenton, T.; Kennedy, J.; Somerville, R. 2014. [Appendix 4: Frequently Asked Questions](#). In: Melillo, J.; Richmond, T.C.; Yohe, G., eds. Climate change impacts in the United States: The third national climate assessment. U.S. Global Change Research Program: 790–820.
2. Mote, P.; Snover, A.K.; Capalbo, S.; Eigenbrode, S.D.; Glick, P.; Littell, J.; Raymondi, R.; Reeder, S. 2014. [Chapter 21: Northwest](#). In: Melillo, J.; Richmond, T.C.; Yohe, G., eds. Climate change impacts in the United States: The third national climate assessment. U.S. Global Change Research Program: 487–513.
3. Lynn, K.; MacKendrick, K.; Donoghue, E.M. 2011. [Social vulnerability and climate change: Synthesis of literature](#). Gen. Tech. Rep. PNW-GTR-838. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 70 p.
4. Kunkel, K.E.; Stevens, L.E.; Stevens, S.E.; Sun, L.; Janssen, E.; Wuebbles, D.; Redmond, K.T.; Dobson, J.G. 2013. [Regional climate trends and scenarios for the U.S. national climate assessment. Part 6: Climate of the Northwest](#). U.S. Technical Report NESDIS 142-6. Washington, D.C.: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service. 75 p.
5. Mote, P.W.; Abatzoglou, J.T.; Kunkel, K.E. 2013. [Chapter 2. Climate: Variability and change in the past and the future](#). In: Dalton, M.M.; Mote, P.W.; Snover, A.K., Eds. Climate change in the Northwest: Implications for our landscapes, waters, and communities. Washington D.C.: Island Press: 25–40.
6. Dominguez, F.; Rivera, E.; Lettenmaier, D.P.; Castro, C.L. 2012. [Changes in winter precipitation extremes for the western United States under a warmer climate as simulated by regional climate models](#). Geophysical Research Letters. 39:L05803
7. Mote, P.W.; Hamlet, A.F.; Clark, M.P.; Lettenmaier, D.P. 2005. [Declining mountain snowpack in western North America](#). Bulletin on the American Meteorological Society. 86(1): 39–49.
8. Raymondi, R.R.; Cuhacyan, J.E.; Glick, P.; Capalbo, S.M.; Houston, L.L.; Shafer, S.L.; Grah, O. 2013. [Chapter 3: Water resources: Implications of changes in temperature and precipitation](#). In: Dalton, M.M.; Mote, P.W.; Snover, A.K., Eds. Climate change in the Northwest: Implications for our landscapes, waters, and communities. Washington D.C.: Island Press: 25–40.
9. Halofsky, J.E.; Shelmerdine, W.P.; Stoddard, R.; Metzger, R.; Hamlet, A.F.; Hawkins Hoffman, C. 2011. [Chapter 4: Climate change, hydrology, and road management at Olympic National Forest and Olympic National Park](#). Halofsky, J.E.; Peterson, D.L.; O'Halloran, K.A.; Hawkins Hoffman, C., eds. Adapting to climate change in Olympic National Forest and Olympic National Park. Gen. Tech. Rep. PNW-GTR-844. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 130 p.
10. Strauch, R.L.; Raymond, C.L.; Hamlet, A.F. 2014. [Chapter 4: Climate change, hydrology, and access in the North Cascade range](#). In: Raymond, C.L.; Peterson, D.L.; Rochefort, R.M. Climate change vulnerability and adaptation in the North Cascades region, Washington. Gen. Tech. Rep. PNW-GTR-892. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 279 p.
11. Isaak, D.J.; Wollrab, S.; Horan, D.; Chandler, G. 2012. [Climate change effects on stream and river temperatures across the northwest U.S. from 1980–2009 and implications for salmonid fishes](#). Climatic Change. 113: 499–524.
12. Peterson, D.W.; Kerns, B.K.; Dodson, E.K. 2014. [Climate change effects on vegetation in the Pacific Northwest: A review and synthesis of the scientific literature and simulation model projections](#). Gen. Tech. Rep. PNW-GTR-900. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 183 p.
13. Vose, J.M.; Peterson, D.L.; Patel-Weynand, T., eds. 2012. [Effects of climatic variability and change of forest ecosystems: A comprehensive science synthesis for the U.S. forest sector](#). Gen. Tech. Rep. PNW-GTR-870. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 265 p.
14. National Research Council. 2012. [Sea-level rise for the coasts of California, Oregon, Washington: Past present, and future](#). Committee on Sea Level Rise in California, Oregon, Washington, Board of Earth Sciences Resources, Ocean Studies Board, Division on Earth Life Studies, The National Academies Press. 201pp.
15. Hales, D.; Hohenstein, W.; Bidwell, M.D.; Landry, C.; McGranahan, D.; Molnar, J.; Morton, L.W.; Vasquez, M.; Jadin, J. 2014. [Chapter 14: Rural communities](#). In: Melillo, J.; Richmond, T.C.; Yohe, G., eds. Climate change impacts in the United States: The third national climate assessment. U.S. Global Change Research Program: 333–349.

**USDA Non-Discrimination Policy**

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the bases of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, or all or part of an individual's income is derived from any public assistance program, or protected genetic information in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases will apply to all programs and/or employment activities.)

**To File an Employment Complaint**

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (PDF) within 45 days of the date of the alleged discriminatory act, event, or in the case of a personnel action. Additional information can be found online at [www.ascr.usda.gov/complaint\\_filing\\_file.html](http://www.ascr.usda.gov/complaint_filing_file.html).

**To File a Program Complaint**

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form (PDF), found online at [www.ascr.usda.gov/complaint\\_filing\\_cust.html](http://www.ascr.usda.gov/complaint_filing_cust.html), or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter to us by mail at U.S. Department of Agriculture, Director, Office of Adjudication, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, by fax (202) 690-7442 or email at [program.intake@usda.gov](mailto:program.intake@usda.gov).

**Persons with Disabilities**

Individuals who are deaf, hard of hearing or have speech disabilities and you wish to file either an EEO or program complaint please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish). Persons with disabilities who wish to file a program complaint, please see information above on how to contact us by mail directly or by email. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.) please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).