Climate Change

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Climate change ("global warming") is expected to have significant impacts on the Pacific Northwest (PNW) by mid-21st century. The following provides an overview of past and projected climate change as researched by the Climate Impacts Group (CIG) (for regional change) and research communities around the world (for global change). For more detailed information on global climate change, please see our recommended links.

Global Climate Change

The basic facts about global climate change are simple:

- Earth has a natural greenhouse effect; water vapor, carbon dioxide, methane, and other gases slow the loss of heat to space, making the planet warm enough to support life as we know it.
- Amounts of almost all greenhouse gases are increasing as a result of human activities (since 1750, carbon dioxide has increased 32%, methane has increased 150%). In the absence of significant changes in human activities, atmospheric concentrations of greenhouse gases will continue to increase.
- Earth's surface has warmed about 1.1°F (0.6°C) since 1900. The warming is most likely a consequence of the increase in greenhouse gases, but other factors cannot be completely ruled out. Most of the warming observed since 1950 is likely attributable to human activities. Other related changes, such as decreases in snow cover and ice extent, increases in global average sea level, and altered rainfall patterns, have also been observed.

Global average temperature and sea level are projected to continue to rise during the 21st century. According to the most recent projections from the Intergovernmental Panel on Climate Change (IPCC Third Assessment Report 2001):

- Global average temperature is projected to increase 2.7 to 10.4°F (1.5 to 5.8°C) by 2100 (compared to 1990).
- Precipitation changes are expected, with increases in some regions and seasons and decreases in others.
- Global average sea level is projected to rise 3.5 to 35" (0.09 to 0.88 meters) between 1990 and 2100. Regional sea level rise will differ from the global average depending on factors such as: changes in atmospheric circulation (weather) patterns, tectonic processes, and regional differences in thermal expansion rates of ocean water.

For More Information

Recommended links for more information on global climate change

Pacific Northwest 20th Century Climate Change

The climate of the PNW has changed during the past 100 years. Observed 20th century changes include:

- **Region-wide warming of about 1.5°F (0.8°C) in 100 years.** The warming has been fairly uniform and widespread, with little difference between warming rates at urban and rural weather monitoring stations. Only a handful of locations recorded cooling. Although the warmest year was 1934, the warmest decade was the 1990s. Largest increases occurred during winter (Figure 1a) (Mote 2003).
- **Increase in precipitation in most of the PNW.** Trends in precipitation are more variable than trends in temperature, but most monitoring stations show increases. The largest relative increases were observed in northeast Washington and south central British Columbia, especially in spring (Figure 1b) (Mote 2003).
- **Decline in snowpack – especially at lower elevations – since 1950.** Trends in April 1 snowpack have been negative at most monitoring sites in the PNW, and are largest (>50%) at lower elevations where snowpack is more sensitive to temperature. Declines have been largest in the central and southern Cascade Mountains (Figure 1c). (Mote 2003).
- **Spring is arriving earlier in the western U.S.** Analysis of changes in the timing of peak spring runoff in 279 snowmelt dominated streams in western North America finds that peak spring runoff has advanced 10-30 days earlier into the spring season in 2000 compared to 1948 (Stewart, I.T., D.R. Cayan and M.D. Dettinger, 2004: Changes in snowmelt runoff timing in western North America under a 'Business as Usual' climate change scenario. *Climatic Change* 62: 217-232.) The greatest trends occurred in the PNW, including the mountain plateaus of Washington, Oregon, and western Idaho (ibid). These results closely correlate with advances in average bloom-date trends for the purple common lilac (2 days per decade based on data from 1957-1994) and honeysuckle (3.8 days per decade based on data from 1968-1994). Similar results have been found in western Canada, the U.S. prairie states, and Europe. (Cayan et al. 2001. Changes in the onset of spring in the western United States. *Bulletin of the American Meteorological Society* 82(3):399-416.)

While it is premature to assume that anthropogenic (i.e., human caused) climate change is driving these trends, the trends are consistent with projected climate change impacts for the PNW.

click images to enlarge

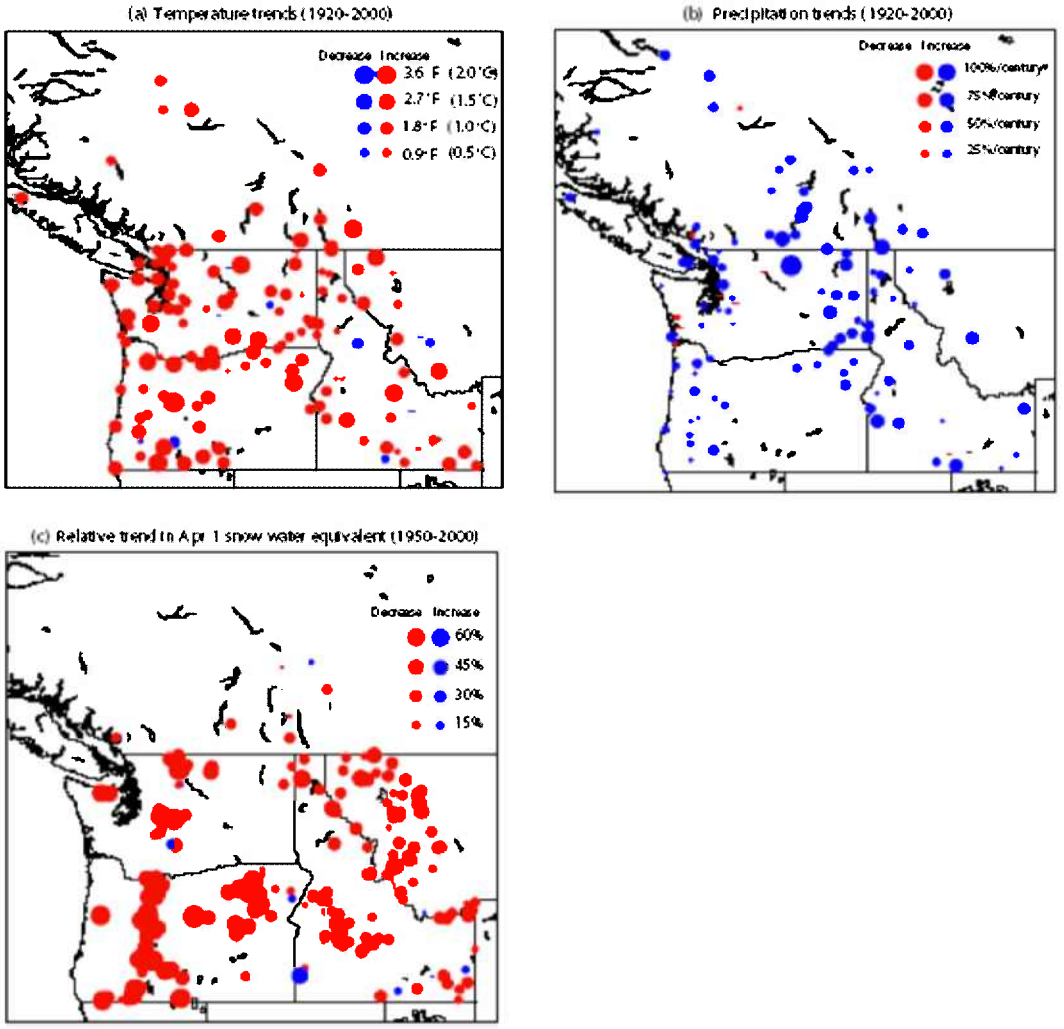

Figure 1 20th century trends in (a, b) average annual PNW temperature and precipitation (1920-2000) and (c) April 1 snow water equivalent (1950-2000). These figures show widespread increases in average annual temperature and precipitation for the period 1920 to 2000 and decreases in April 1 snow water equivalent (an important indicator for forecasting summer water supplies) for the period 1950 to 2000. The size of the dot corresponds to the magnitude of the change. Pluses and minuses indicate increases or decreases, respectively, that are less than the given scale.

Future Climate Change in the Pacific Northwest

Global climate models scaled to the PNW project an increase in average PNW temperature on the order of 0.3°-1°F (0.2°-0.6°C) per decade throughout the 21st century. Changes in annual precipitation are less certain. Increases in winter (October-March) precipitation range from 0-20% by mid-century. Changes in April-September precipitation are uncertain. A decrease in June-August precipitation is considered possible.

	Temperature Change / Decade		Precipitation Change
	Global Average	***Pacific Northwest***	***Pacific Northwest***
Observed, 20th century	+ 0.11°F (0.06°C)	+ 0.15°F (0.08°C)	Mostly wetter
Projected, 21st century	+ 0.25 to 0.9°F (0.14-0.53°C)	+ 0.3 to 1°F (0.2-0.6°C)	October-March: likely wetter April-September: uncertain June-August: possibly drier

For More Information

More details about climate change scenarios for the PNW

How will climate change affect climate variability? The El Niño/Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) influence PNW climate and natural resources on seasonal to interannual scales. How will climate change affect ENSO and PDO? The answer is not clear given the difficulty of simulating these patterns in complex global circulation models. The IPCC concluded in the Third Assessment Report that "little change or a small increase in the amplitude for El Niño events" is possible over the next century as a result of climate change (IPCC Summary for Policy Makers 2001). In fact, climate models offer disparate views of future changes, with some indicating that El Niño will be more frequent in the future, others that it will be less frequent, and still others that it won't change.

Overview of Climate Change Impacts

(click on each subject for more details)

- **Water resources** — As rising temperatures cause mountain snowpack to diminish, PNW rivers that derive some flow from snowmelt will see reduced summer flow, increased winter flow, and earlier peak flow. In many streams and rivers, these changes have already been observed. Winter hydropower production could increase to take advantage of increased winter streamflow. In summer, however, many competing uses (hydropower, irrigation, fish, recreation, etc.) will be negatively affected by lower flows. Lower elevation rivers that are fed mostly by rain may also see increased wintertime flow, due to increases in winter precipitation.
- **Forests** — High-altitude forests will very likely expand upward and into meadows as the growing season lengthens. Low-altitude forests may come under increased drought stress. Tree growth and regeneration will likely improve at high (currently snowy) elevations and diminish at low (currently dry) elevations. The risk of forest fires may increase.
- **Salmon** — Salmon fare poorly in high temperatures. Higher mortality rates are likely for juveniles in streams as a result of warmer water temperatures and lower summer streamflow. We do not yet know how climate change will affect salmon in the open ocean, where most salmon spend the majority of their lives.
- **Coastal resources** — Sea-level rise will affect parts of the Northwest coast, causing permanent inundation in low-lying areas and relative land motion is currently downward due to tectonic activity (e.g., Olympia), accelerated erosion at the base of bluffs and along the coast, and shrinking wetlands. Other changes may include more landslides (if winters are indeed wetter).
- **Agriculture** — Many crops will grow better with higher CO2 and a longer growing season before temperatures substantially increase, provided there is sufficient water. However, some pests and weeds will be similarly advantaged. Low-value irrigated crops may have difficulty competing for less abundant water.
- **PNW Ski Industry** — Warmer winter temperatures and increased winter precipitation are projected to delay the opening of the PNW ski season, shorten the length of the season, and increase the likelihood of rain when ski areas are open. The impacts are greater for mid-elevation ski areas (~3,000 to 4,000 feet) than for those at higher elevations.

For More Information

More information about the impacts of climate change on the PNW

Planning for Climate Change

An examination of the possible impacts of future climate changes provides information that can be used to inform planning in the PNW. Good decisions can be made in spite of the uncertainty associated with these projected changes, just as good decisions are made in spite of uncertainty about other factors, such as future economic conditions or rates of population growth. Careful consideration of the range of projected impacts, combined with an analysis of a resource's vulnerability to these impacts will support prudent approaches to planning. It's important to remember that decisions we make today will help determine our ultimate vulnerability to future climate change.

For More Information

Advice on using climate change information in natural resource management and planning

Specific climate change scenarios for the Pacific Northwest

Additional Information on Global Climate Change

Many web sites offer explanations of global climate change. The following provide explanations at varying levels of detail:

- Comprehensive reports on climate change
  - **Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report: Climate Change 2001**. *(Previous reports were issued in 1990 and 1996.)* The IPCC reports present a comprehensive overview of the latest in climate change research and the conclusions we can draw from this research as it relates to the causes and consequences of climate change. For a synthesis of the scientific assessment for climate change, see the Summary for Policy Makers. For a little more detail (without having to read the full report), see the Technical Summary.
  - **U.S. National Academy of Sciences Report: Climate Science: An Analysis of Key Questions (2001)**. This report, requested by the Bush Administration, summarizes science's current understanding of global climate change by characterizing the global warming trend over the last 100 years, and examining what may be in store for the 21st century and the extent to which warming may be attributable to human activity.
- Comprehensive sites with lots of information and links:
  - **USEPA**
- "Frequently Asked Questions" links
  - **NOAA National Climate Data Center**
  - **US Global Change Research Information Office**
  - **Climate Change Science: An Analysis of Some Key Questions** (National Academy of Sciences)
- Statements and testimony by the scientific community:
  - Position statement of the **American Geophysical Union** on **Human Impacts on Climate**.
  - **Testimony** by Dan Albritton, Director of NOAA Aeronomy Laboratory, to a U.S. House of Representatives committee. Very short, includes a "Confidence index" for each statement.

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