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Climate Change And Washington

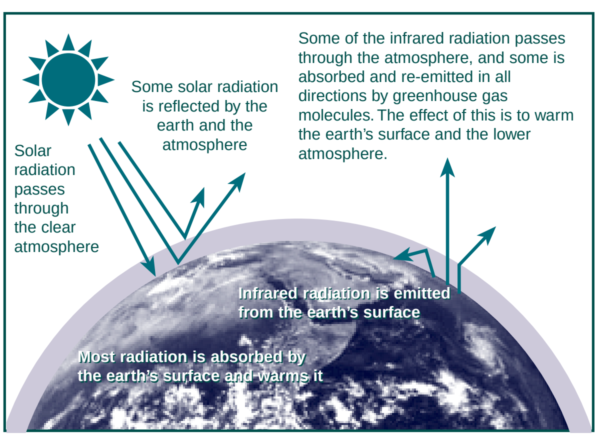
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed. Although there is uncertainty about exactly how and when the earth's climate will respond to enhanced concentrations of greenhouse gases, observations indicate that detectable changes are under way. There most likely will be increases in temperature and changes in precipitation, soil moisture, and sea level, which could have adverse effects on many ecological systems, as well as on human health and the economy.

The Climate System

Energy from the sun drives the earth's weather and climate. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the energy from the sun, creating a natural "greenhouse effect." Without this effect, temperatures would be much lower than they are now, and life as known today would not be possible. Instead, thanks to greenhouse gases, the earth's average temperature is a more hospitable 60°F. However, problems arise when the greenhouse effect is ***enhanced*** by human-generated emissions of greenhouse gases.

Global warming would do more than add a few degrees to today's average temperatures. Cold spells still would occur in winter, but heat waves would be more common. Some places would be drier, others wetter. Perhaps more important, more precipitation may come in short, intense bursts (e.g., more than 2 inches of rain in a day), which could lead to more flooding. Sea levels would be higher than they would have been without global warming, although the actual changes may vary from place to place because coastal lands are themselves sinking or rising.

The Greenhouse Effect



Source: U.S. Department of State (1992)

Emissions Of Greenhouse Gases

Since the beginning of the industrial revolution, human activities have been adding measurably to natural background levels of greenhouse gases. The burning of fossil fuels — coal, oil, and natural gas — for energy is the primary source of emissions. Energy burned to run cars and trucks, heat homes and businesses, and power factories is responsible for about 80% of global carbon dioxide emissions, about 25% of U.S. methane emissions, and about 20% of global nitrous oxide emissions. Increased agriculture and deforestation, landfills, and industrial production and mining also contribute a significant share of emissions. In 1994, the United States emitted about one-fifth of total global greenhouse gases.

Concentrations Of Greenhouse Gases

Since the pre-industrial era, atmospheric concentrations of carbon dioxide have increased nearly 30%, methane concentrations have more than doubled, and nitrous oxide concentrations have risen by about 15%. These increases have enhanced the heat-trapping capability of the earth's atmosphere. Sulfate aerosols, a common air pollutant, cool the atmosphere by reflecting incoming solar radiation. However, sulfates are short-lived and vary regionally, so they do not offset greenhouse gas warming.

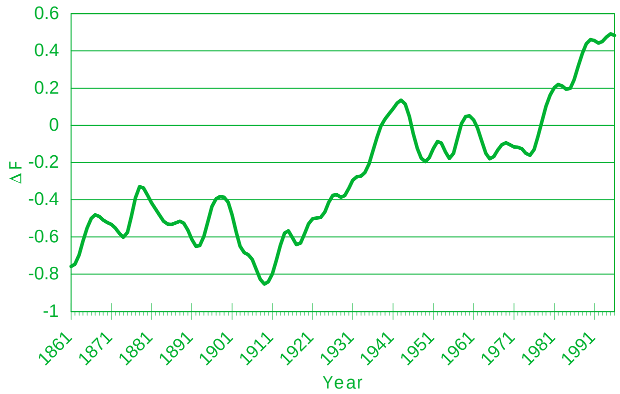
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and institutional developments. Several emissions scenarios have been developed based on differing projections of these underlying factors. For example, by 2100, in the absence of emissions control policies, carbon dioxide concentrations are projected to be 30-150% higher than today's levels.

Current Climatic Changes

Global mean surface temperatures have increased 0.6-1.2°F since the late 19th century. The 9 warmest years in this century all have occurred in the last 14 years. Of these, 1995 was the warmest year on record, suggesting the atmosphere has rebounded from the temporary cooling caused by the eruption of Mt. Pinatubo in the Philippines.

Several pieces of additional evidence consistent with warming, such as a decrease in Northern Hemisphere snow cover, a decrease in Arctic Sea ice, and continued melting of alpine glaciers, have been corroborated. Globally, sea levels have risen

Global Temperature Changes (1861–1996)



Source: IPCC (1995), updated

4-10 inches over the past century, and precipitation over land has increased slightly. The frequency of extreme rainfall events also has increased throughout much of the United States.

A new international scientific assessment by the Intergovernmental Panel on Climate Change recently concluded that ***"the balance of evidence suggests a discernible human influence on global climate."***

Future Climatic Changes

For a given concentration of greenhouse gases, the resulting increase in the atmosphere's heat-trapping ability can be predicted with precision, but the resulting impact on climate is more uncertain. The climate system is complex and dynamic, with constant interaction between the atmosphere, land, ice, and oceans. Further, humans have never experienced such a rapid rise in greenhouse gases. In effect, a large and uncontrolled planet-wide experiment is being conducted.

General circulation models are complex computer simulations that describe the circulation of air and ocean currents and how energy is transported within the climate system. While uncertainties remain, these models are a powerful tool for studying climate. As a result of continuous model improvements over the last few decades, scientists are reasonably confident about the link between global greenhouse gas concentrations and temperature and about the ability of models to characterize future climate at continental scales.

Recent model calculations suggest that the global surface temperature could increase an average of 1.6-6.3°F by 2100, with significant regional variation. These temperature changes would be far greater than recent natural fluctuations, and they would occur significantly faster than any known changes in the last 10,000 years. The United States is projected to warm more than the global average, especially as fewer sulfate aerosols are produced.

The models suggest that the rate of evaporation will increase as the climate warms, which will increase average global precipitation. They also suggest increased frequency of intense rainfall as well as a marked decrease in soil moisture over some mid-continental regions during the summer. Sea level is projected to increase by 6-38 inches by 2100.

Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency of hot or cold spells, and the intensity of associated fire and pest outbreaks) could increase.

Local Climate Changes

Over the last century, the average temperature in Ellensburg, Washington, has increased from 46.2°F (1900-1929 average) to 47.2°F (1966-1995 average), and precipitation has increased by up to 20% in some areas of the state, especially in the west.

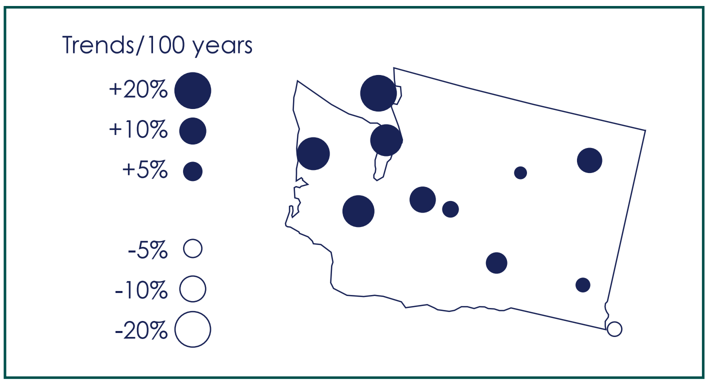
Over the next century, Washington's climate may change even more. Based on projections given by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model (HadCM2), a model that has accounted for both greenhouse gases and aerosols, by 2100 temperatures in Washington could increase by about 5°F in winter and summer, and by about 4°F in spring and fall (with a range of 2-9°F). Precipitation is projected to change little in spring, summer, and fall, and to increase by around 10% in winter.

The frequency of extreme hot days in summer is expected to increase along with the general warming trend. It is not clear how severe storms would change.

Climate Change Impacts

Global climate change poses risks to human health and to terrestrial and aquatic ecosystems. Important economic resources such as agriculture, forestry, fisheries, and water resources also may be affected. Warmer temperatures, more severe droughts and floods, and sea level rise could have a wide range of impacts. All these stresses can add to existing stresses on resources caused by other influences such as population growth, land-use changes, and pollution.

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

Similar temperature changes have occurred in the past, but the previous changes took place over centuries or millennia instead of decades. The ability of some plants and animals to migrate and adapt appears to be much slower than the predicted rate of climate change.

Human Health

Winter-related mortality in Washington could increase if such a warming occurs, because the frequency of air masses associated with inclement weather is expected to increase. One study has estimated that a 3°F warming in Seattle would increase winter-related mortality from 15 today to about 40. The elderly, particularly those living alone, are at greatest risk.

There is concern that climate change could increase concentrations of ground-level ozone. For example, high temperatures, strong sunlight, and stable air masses tend to increase urban ozone levels. Air pollution also is made worse by increases in natural hydrocarbons emissions during hot weather. If a warmed climate causes increased use of air conditioners, air pollutant emissions from power plants also will increase.

Increased emissions and accelerated atmospheric chemistry could slow progress being made in Washington to provide healthy and clean air. Currently, the Seattle-Tacoma area does not meet the national health standards for ozone and particulate matter. The particulate matter standard is also not met in Olympia, Spokane, Wallula, and Yakima. Ground-level ozone has been shown to aggravate existing respiratory illnesses such as asthma, reduce lung function, and induce respiratory inflammation. In addition, ambient ozone reduces agricultural crop yields and impairs ecosystem health.

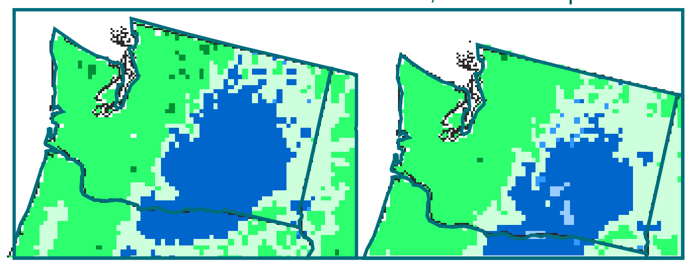
Coastal Areas

Sea level rise could lead to flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater contamination of drinking water, and decreased longevity of low-lying roads, causeways, and bridges. In addition, sea level rise could increase the vulnerability of coastal areas to storms and associated flooding.

At Seattle, Washington, sea level already is rising by 8 inches per century, and it is likely to rise another 19 inches by 2100. Washington's coastal region consists primarily of cliffs and a few low-lying tidal flats. The Puget Sound region contains tidal flats, river deltas with salt marshes, and swamps, as well as a heavily modified urban shoreline around Seattle. Many marshes in this region have been diked, drained, and converted to farmland during the last century. Sea level rise could gradually inundate the remaining tidal flats. Over half of these could be lost under a 1-3 foot rise in sea level.

Possible responses to sea level rise include building walls to hold back the sea, allowing the sea to advance and adapting to it, and raising the land (e.g., by replenishing beach sand and/or elevating houses and infrastructure). Each of these responses will be costly, either in out-of-pocket costs or in lost land and structures. For example, the cumulative cost of sand replenishment to protect Washington's coastline from a 20-inch sea level rise by 2100 is estimated at $143 million to $2.3 billion.

Changes In Forest Cover



Tundra
Conifer Forest
Savanna/Woodland
Shrub/Woodland
Grasslands
Arid Lands

Source: VEMAP Participants (1995); Neilson (1995)

Forests

Trees and forests are adapted to specific climate conditions, and as climate warms, forests will change. These changes could include changes in species, geographic extent, and health and productivity. If conditions also become drier, the current range and density of forests could be reduced and replaced by grasslands and pasture. Even a warmer and wetter climate would lead to changes; trees that are better adapted to these conditions, such as hemlock and sitka spruce, would thrive. Under these conditions, forests could become more dense. These changes could occur during the lifetimes of today's children, particularly if they are accelerated by other stresses such as fire, pests, and diseases. Some of these stresses would themselves be worsened by a warmer and drier climate.

With changes in climate, the extent of forested areas in Washington could change little, or they could decline by 15-25%, primarily east of the Cascades. The uncertainties depend on many factors, including whether soils become drier and, if so, by how much drier. Wildfire frequency and intensity could increase and threaten the important timber producing areas of the state. In Washington's highly productive conifer forests, drier conditions would favor an expansion of Douglas fir, lodgepole pine, and ponderosa pine forests at the expense of the wet-loving hemlock and sitka spruce along the coast. These changes could affect the character of some of Washington's forests and the activities that depend on them.

Water Resources

Water resources are affected by changes in precipitation as well as by temperature, humidity, wind, and sunshine. Changes in streamflow tend to magnify changes in precipitation. Water resources in drier climates tend to be more sensitive to climate changes. Because evaporation is likely to increase with warmer climate, it could result in lower river flow and lower lake levels, particularly in the summer. In addition, more intense precipitation could increase flooding. If streamflow and lake levels drop, groundwater also could be reduced.

All of Washington to the east of the Cascade Mountains lies within the Columbia River drainage basin, where flow is dominated by spring snowmelt. The third of the state that lies to the west of the Cascades is drained by numerous smaller streams that flow to Puget Sound, the Pacific Ocean, or the lower Columbia. Those streams with headwaters at high elevations, especially in the Cascades and Olympics, are affected by winter snow and spring snowmelt, but lower elevation streams are dominated by winter rainfall. The seasonal pattern of flow in most streams in the eastern part of the state, and many in the west, would be highly susceptible to warmer temperatures. Runoff peaks would occur earlier in the year, which could cause problems for many of the state's reservoirs, which are small in comparison to their inflows and therefore might not be able to supply water with the same reliability as they do under current climatic conditions.

The reduced summer and fall flows that would accompany a warmer climate almost certainly would result in degraded water quality. In addition, increased snowmelt could increase winter flooding for some westside streams. Some eastside streams, which are now rarely affected by fall and winter flooding, also could become susceptible to winter snowmelt flooding. On the other hand, the susceptibility of eastside streams to spring snowmelt floods, which now account for most large floods in eastern Washington, most likely would decrease because of reduced spring snow accumulations.

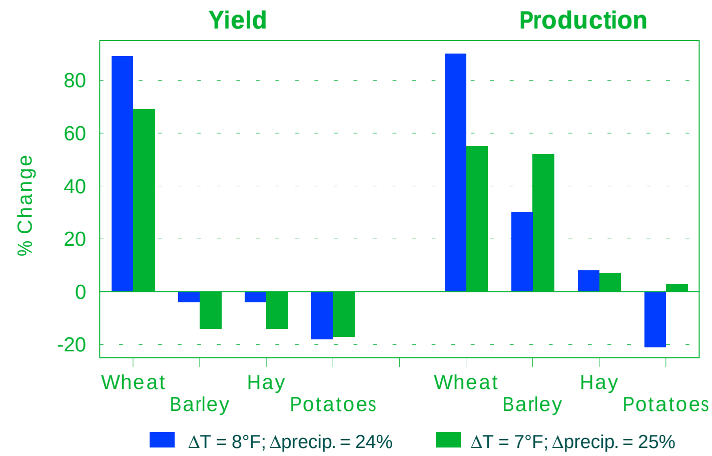
Agriculture

The mix of crop and livestock production in a state is influenced by climatic conditions and water availability. As climate warms, production patterns will shift northward. Increases in climate variability could make adaptation by farmers more difficult. Warmer climates and less soil moisture due to increased evaporation may increase the need for irrigation. However, these same conditions could decrease water supplies, which also may be needed by natural ecosystems, urban populations, and other economic sectors.

Understandably, most studies have not fully accounted for changes in climate variability, water availability, and imperfect responses by farmers to changing climate. Including these factors could substantially change modeling results. Analyses based on changes in average climate and which assume farmers effectively adapt suggest that aggregate U.S. food production will not be harmed, although there may be significant regional changes.

In Washington, agriculture is about a $4 billion annual industry, two-thirds of which is crops like wheat, barley, hay, and potatoes. About 28% of the state's farm acres is irrigated. With warmer temperatures, wheat yields could increase by up to 70-90%. Barley and hay yields could decrease by 4-14%, and potato yields could fall by 17%. Farm income could double or triple. The number of irrigated acres could increase. This could further stress water supplies, which may already be lower in the summer, and water quality could be degraded further.

Changes In Agricultural Yield And Production



Source: Mendelsohn and Neumann (in press); McCarl (personal communication)

Ecosystems

The primary natural features of Washington that are vulnerable to climate change are its extensive rivers, streams, and coastal estuaries. These environments are critical for a wide diversity of wildlife, endangered species, and commercial and sport fisheries.

Reduced flows of headwater streams, or changes in their seasonal flows, could reduce the amount of suitable salmon spawning habitat. In recent years, populations of salmon and steelhead have been reduced to less than 10% of historical levels. While these past losses cannot be attributed to climate change, pink and chum salmon could lose all of their habitat with climate change. Other cold water species such as brook trout, brown trout, and mountain whitefish could lose most of their habitat. Farther downstream, increases in sea level and decreases in river flow could affect estuaries, increasing salinities and decreasing tidal marsh area. Valuable commercial shellfish communities (e.g., oysters and clams) and duck and geese populations that utilize these flats for habitat and feeding also may decline accordingly.

In addition, mountain ecosystems could shift upslope, reducing habitat for many subalpine species. At lower elevations, species now found in warmer climates may survive. For example, the climate in eastern Washington could become warm enough to support saguaro cactus.

For further information about the potential impacts of climate change, contact the Climate and Policy Assessment Division (2174), U.S. EPA, 401 M Street SW, Washington, DC 20460.