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Climate Change And Oregon

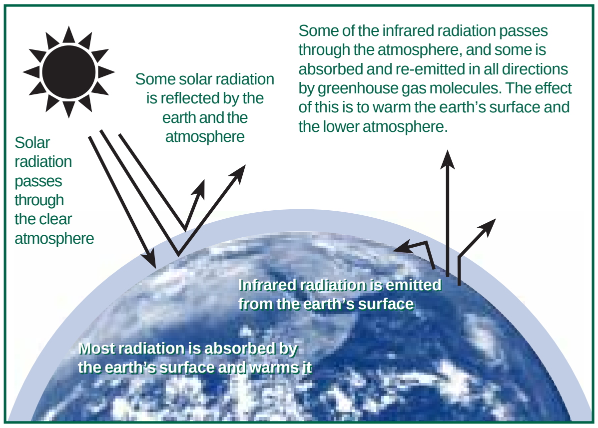
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed. 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.

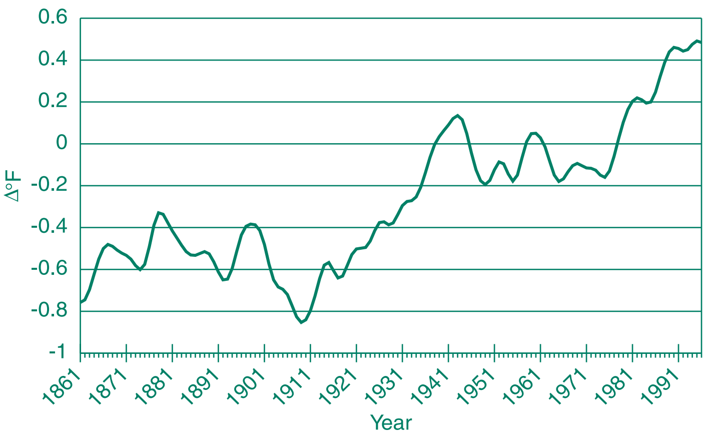
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and 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 between 1890 and 1996. 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.

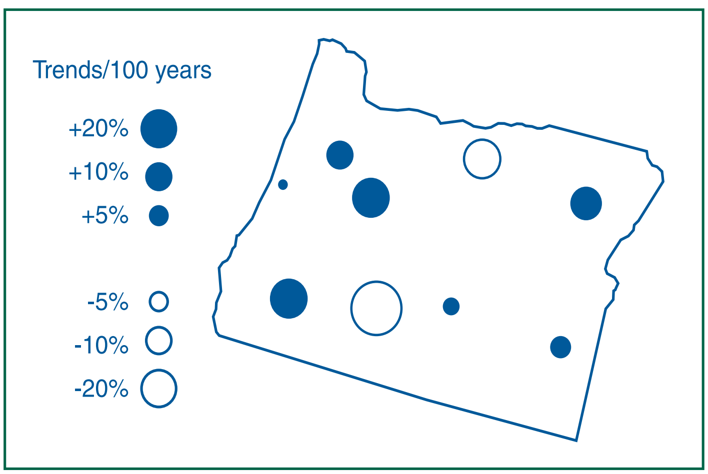
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency 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 Corvallis, Oregon, has increased 2.5°F, and precipitation has increased by up to 20% in many parts of the state, except along the leeward side of the Cascades where precipitation has fallen by 20%. These past trends may or may not continue into the future.

Over the next century, climate in Oregon may change even more. For example, based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model (HadCM2), a model that accounts for both greenhouse gases and aerosols, by 2100 temperatures in Oregon could increase by 5°F (with a range of 2-9°F) in winter and summer and 4°F (with a range of 2-7°F) in spring and fall. Precipitation is estimated to increase slightly in spring (with a range of 0-10%), decrease slightly in summer (with a range of 0 to -10%), and increase by 15% in fall and winter (with a range of 5-25%). Other climate models may show different results, especially regarding estimated changes in precipitation. The impacts described in the sections that follow take into account estimates from different models. The amount of precipitation on extreme wet or snowy days in winter is likely to increase. The frequency of extreme hot days in summer would increase because of the general warming trend. It is not clear how the severity of storms might be affected, although an increase in the frequency and intensity of winter storms is possible.

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

Human Health

Higher temperatures and increased frequency of heat waves may increase the number of heat-related deaths and the incidence of heat-related illnesses. Oregon, with its occasional, intense heat waves, may become more susceptible if its climate changes. In Portland, heat-related deaths are estimated to increase by nearly 150% given a summer warming of 4°F (although increased air conditioning use may not have been fully accounted for). The elderly, especially those living alone, are at greatest risk. This study also projects little change in winter-related deaths in Portland if the temperature warms by 2-3°F.

Warming and other climate changes could expand the habitat and infectivity of disease-carrying insects, thus increasing the potential for transmission of diseases such as malaria and dengue ("break bone") fever. Warmer temperatures could increase the incidence of Lyme disease and other tick-borne diseases in Oregon, because populations of ticks, and their rodent hosts, could increase under warmer temperatures and increased vegetation.

St. Louis and California encephalitis are present in California, and some studies indicate that these diseases could move north under a warmer climate. Western equine encephalitis has also been found in domestic animals in Oregon. Mosquitoes can carry these diseases, which can be lethal or cause neurological damage. If conditions become warmer and wetter, mosquito populations could increase, thus increasing the risk of transmission if these diseases, as well as malaria, are introduced into the area. Increased runoff from heavy rainfall could increase water-borne diseases such as giardia and cryptosporidia.

Developed countries such as the United States should be able to minimize the impacts of these diseases through existing disease prevention and control methods.

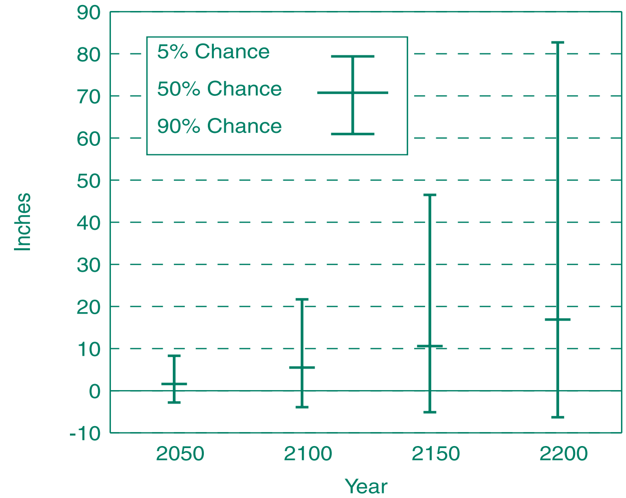
Coastal Areas

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.

Oregon has a 1,400-mile tidally influenced shoreline that consists mostly of steep slopes, pocket beaches, and small embayments, with a few natural coastal plains. The steep, rocky cliffs that dominate most of the coastline limit vulnerability to sea level rise. Coastal marshes in Oregon are limited to the Tillamook and Coos Bay regions. Under a sea level rise of 1-3 feet, the salt marshes along these bays and harbors could be lost (although some migration onto undeveloped lowlands could partially offset losses).

Evidence suggests that uplift may help mitigate the effects of sea level rise on the Oregon coast. Along much of the coast, land is being uplifted as a result of tectonic activity at approximately 4 inches per century. However, sea level rise could reverse that

Future Sea Level rise At Yaquina



Source: EPA (1995)

trend. Accounting for sea level rise from climate change, sea level on the Oregon Coast is estimated to rise 6 inches by 2100. Nonetheless, the rocky shore of Oregon may limit erosion, and help protect the coastline. The cumulative cost of sand replenishment to protect the coast of Oregon from a 20-inch sea level rise by 2100 is estimated at $60-$920 million.

Water Resources

Runoff in Oregon is highly variable, and summer flows are often low. Reservoir storage is used throughout the state to augment summer flows with captured winter and spring runoff. Major regulated rivers include the Columbia along the northern border, the Snake along the northeast border, and the Willamette.

Some models for the Pacific Northwest project warmer, wetter winters and warmer, drier summers. In the mountains, warmer winter temperatures could mean less snowfall, more winter rain, and a faster, earlier snowmelt. More rain and greater streamflow, particularly during the winter, could benefit hydropower production and water supplies, but also could increase flooding in some areas. In the rainfall-dominated rivers in the west, projected changes result in increased winter streamflows and decreased summer streamflows. Because of limited storage capacity, there could be lower reservoir and water supplies in the summer and fall. Less water would be available to reliably support important uses such as hydropower production, fish protection, irrigation, recreation, and water supply. Oregon is a major producer of hydropower, and lower flows could affect its ability to meet energy production requirements, particularly during critical low flow periods. Provision of adequate water for fish protection is also an important issue. In rivers such as the Columbia, instream flow requirements are difficult to meet because of the limited storage available to support them. Similarly, in heavily allocated basins such as the Snake River, current irrigation demand cannot always be met. The public also demands high lake levels in the summer for recreation. Lower streamflows and lake levels would exacerbate current stresses and increase competition among water uses. Additionally, lower summer flows and higher temperatures could impair water quality by concentrating pollutants and reducing the ability of streams to assimilate wastes.

Agriculture

The mix of crop and livestock production in a state is influenced by climatic conditions and water availability. As climate warms, production patterns could 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, industry, and other users.

Understandably, most studies have not fully accounted for changes in climate variability, water availability, crop pests, changes in air pollution such as ozone, and adaptation by farmers to changing climate. Analyses that assume changes in average climate and effective adaptation by farmers suggest that aggregate U.S. food production would not be harmed, although there may be significant regional changes.

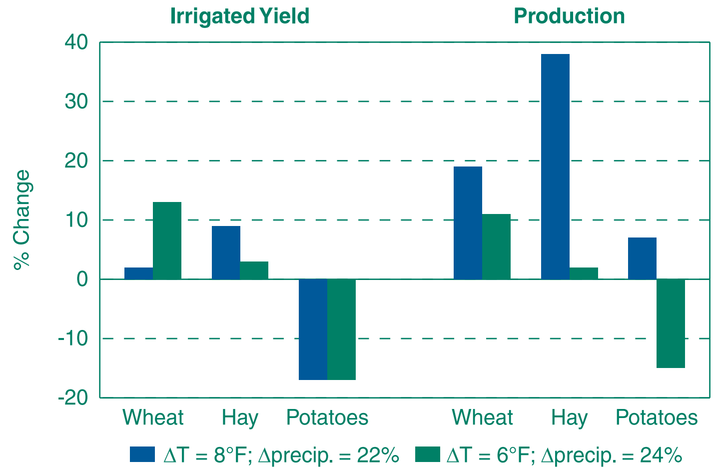
In Oregon, production agriculture is a $2.5 billion annual industry, three-fourths of which comes from crops. Almost one-half of the farmed acres are irrigated. The major crops in the state are wheat, hay, and potatoes. Climate change could increase wheat yields by 2-13%. Hay and pasture yields could rise by 10% or fall by 7%, depending on how climate changes and whether irrigation is used. Potato yields could fall by 17% as temperatures rise beyond the tolerance level of the crop. Farmed acres could remain fairly constant or could decrease by as much as 23%.

Forests

Trees and forests are adapted to specific climate conditions, and as climate warms, forests will change. These changes could include changes in species composition, geographic range, 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 (or in some forests lead to changes in the types of trees that flourish). Even a warmer and wetter climate could 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 the change is accelerated by other stresses such as fire, pests, and diseases. Some of these stresses would themselves be worsened by a warmer and drier climate. Commercial timber production could also be affected by resulting changes in growth rates, plantation acreage and management, and market conditions.

With changes in climate, the extent of forested areas in Oregon 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, how much drier. Hotter, drier weather could increase the frequency and intensity of wildfires, threatening the important timber-producing areas of the state. In the state's highly productive conifer forests, drier conditions would favor Douglas fir, lodgepole pine, and ponderosa pine forests at the expense of the wet-loving hemlock and sitka spruce along the coast. Warmer conditions could increase the elevation of the timberline, resulting in a reduction or the disappearance of alpine tundra and its unique (and in some cases already endangered) species. These changes could affect the character of Oregon forests and the activities that depend on them.

Changes In Agricultural Yield And Production



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

Ecosystems

Lower streamflow in the hot summer months would have negative consequences for fish populations in Oregon waters, which are already under pressure from dams and other human disturbances. Less summer and fall runoff could affect salmon migration and spawning. More flooding and winter runoff could alter sedimentation processes in rivers and streams, perhaps harming fish habitat and decreasing egg-smolt survival. Warmer water temperatures affect dissolved oxygen concentrations, which could decrease the survival rate, reproduction, and growth of certain fish, perhaps favoring the increased range expansion of exotic species at the expense of native species. Changing aquatic ecosystem conditions could result in a general northward shift of species distributions. Populations at the extremes of their range will be those most susceptible to change.

As low-lying coastal areas are gradually squeezed between rising sea levels and coastal development, a permanent loss of terrestrial coastal habitats is expected. Changes in offshore upwelling could cause changes in nutrient supplies, which could have adverse impacts for anadromous fish such as salmon. The rangelands of the Great Basin are already imperiled by the expansion of non-native weedy species such as European cheatgrass. Climate change could exacerbate such threats, because opportunistic non-native species are well-suited to take advantage of ecosystem disturbances caused by warming temperatures, such as increases in the frequency and severity of wildfires.

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, or visit http://www.epa.gov/globalwarming/impacts.