United States Environmental Protection Agency
Office of Policy (2111)
EPA 236-F-98-007o
September 1998

Climate Change And Nevada

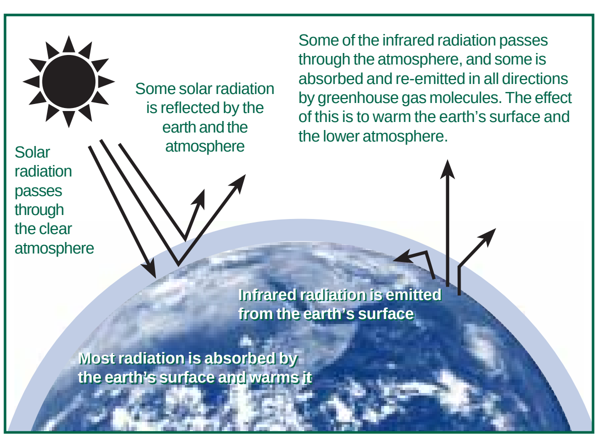
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

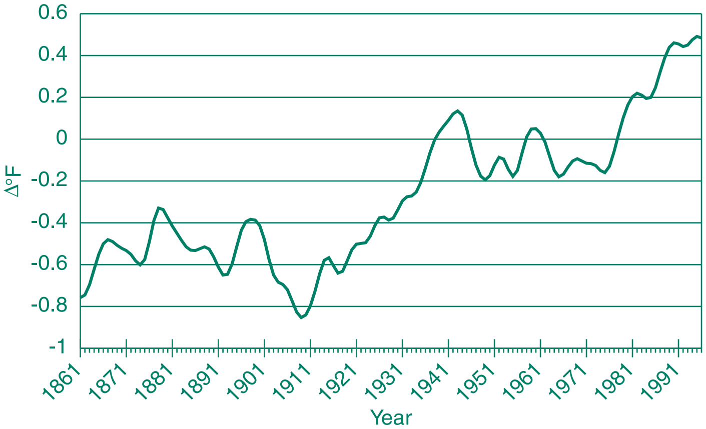
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

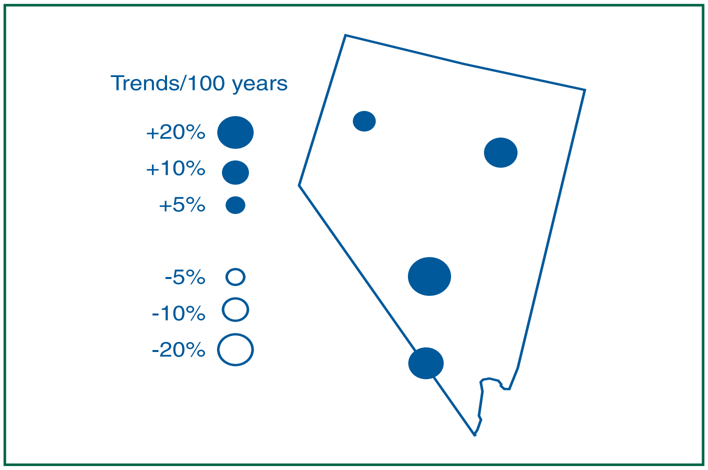
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency 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 Elko, Nevada, has increased 0.6°F, and precipitation has increased by up to 20% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in Nevada 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 Nevada could increase by 3-4°F in spring and fall (with a range of 1-6°F), and by 5-6°F in winter and summer (with a range of 2-10°F). Precipitation is estimated to decrease in summer by 10% (with a range of -5% to -20%), to increase by 15% in spring (with a range of 5-25%), to increase by about 30% in fall (with a range of 10-50%), and to increase by about 40% in winter (with a range of 20-70%). 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. The elderly, particularly those living alone, are at greatest risk. These effects have been studied only for populations living in urban areas; however, even those in rural areas may be susceptible.

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. Currently, the Reno area is classified as a "marginal" nonattainment area for ozone. Increased temperatures could make attaining compliance more difficult. Ground-level ozone is associated with respiratory illnesses such as asthma, reduced lung function, and respiratory inflammation.

Upper and lower respiratory allergies also are influenced by humidity. A 2°F warming and wetter conditions could increase respiratory allergies.

Infected individuals can bring malaria to places where it does not occur naturally. Also, some mosquitoes in Nevada can carry malaria, and others can carry St. Louis and California encephalitis, 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 are introduced into the area. Increased runoff from heavy rainfall could increase water-borne diseases such as giardia, cryptosporidia, and viral and bacterial gastroenteritides. Developed countries such as the United States should be able to minimize the impacts of these diseases through existing disease prevention and control methods.

Water Resources

The sustained streamflow in Nevada largely results from spring and summer snowmelt in the mountains. At lower altitudes, intense storms can contribute to streamflow, but because of high evaporation, most smaller streams run dry in the summer. A warmer climate could lead to more winter rainfall and an earlier, more rapid snowmelt. This could result in higher winter and spring flows, and the inability to store flood waters for use later in the summer. Additionally, without large increases in rainfall, higher temperatures and increased evaporation could lower lake levels and streamflows in the summer. In western Nevada, the Truckee and Carson rivers serve the rapidly growing population of the Reno-Sparks-Carson City area, as well as irrigated agriculture. Competition for water between agricultural, municipal, industrial, and instream uses could intensify. In north-central Nevada, competition for water is acute on the Humbolt River, and when snowpacks are meager, demand for irrigation greatly exceeds supply. The expanding metropolitan area of Las Vegas uses a large portion of Nevada's allotment of the Colorado River. Under current conditions, without significant increases in either reuse of water or alternative supplies, future development could be limited by this allotment. In several areas of the state, particularly near large urban areas, groundwater has been withdrawn at rates that exceed natural replenishment, and groundwater levels have seriously declined. Less spring and summer recharge could exacerbate this situation.

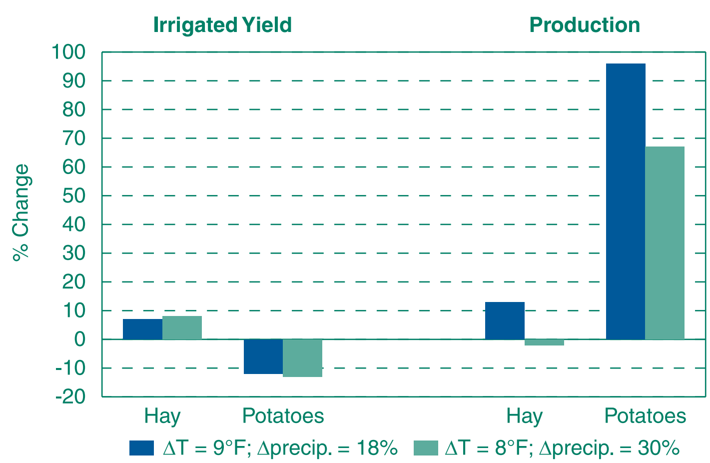
Lower streamflows and higher temperatures could also impair water quality by concentrating pollutant levels and reducing the assimilative capacity of streams. Sewage effluent and pollutants from agricultural and urban runoff are concerns in the Truckee and Carson rivers, Lake Tahoe, and Lake Mead. Nevada's surface waters are fully appropriated. Changes in water availability would complicate the complex water-rights and interstate compacts that govern water allocation.

More rain could ease competition for water, but it also could increase flooding. Earlier, more rapid snowmelts could contribute to winter and spring flooding, and more intense summer storms could increase the likelihood of flash floods. Although Nevada is extremely dry, intense rains can produce torrents of water and debris. Residential and industrial developments on the valley floors and near the foothills are especially vulnerable. Increased rain also could increase erosion and pollution from runoff from mining areas, and exacerbate levels of pesticides and fertilizers from runoff from agricultural lands. The Las Vegas Wash, which drains into Lake Mead, is susceptible to erosion. Sediment and urban runoff from Las Vegas have affected the water quality of Lake Mead. Similarly, sediment and fertilizer runoff from developing areas on the quality of Lake Tahoe is a matter of concern. Fertilizer runoff from agricultural lands has also adversely affected water quality in the Truckee and Carson rivers.

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.

Changes In Agricultural Yield And Production



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

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. Including these factors could change modeling results substantially. 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 Nevada, production agriculture is a $300 million annual industry, two-thirds of which comes from livestock, mainly cattle. Almost all of the farmed acres are irrigated. The major crops in the state are hay and potatoes. Climate change could have a small impact on crop production reducing potato yields by about 12%, and hay and pasture yields increasing by about 7%. Farmed acres could rise by 9% or fall by 9%, depending on how climate changes. Livestock production may not be affected, unless summer temperatures rise significantly and conditions become significantly drier. Under these conditions, livestock tend to gain less weight and pasture yields decline, limiting forage.

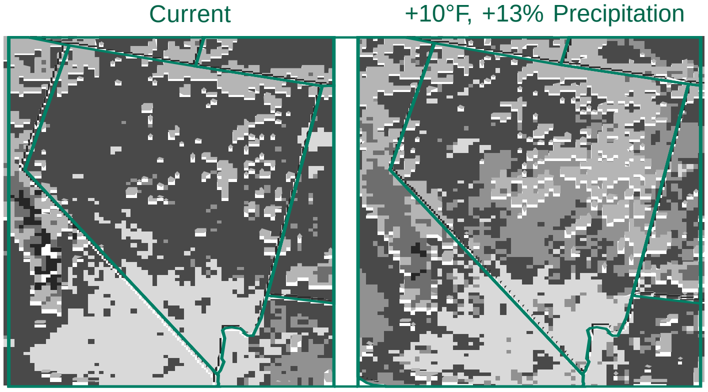
Forests

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. Even a warmer and wetter climate could lead to changes; trees that are better adapted to these conditions, such as fir and 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.

With changes in climate, the extent of forested areas in Nevada could change little or decline by as much as 15-30%. 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 both property and forests. Drier conditions would reduce the range and health of ponderosa and lodgepole forests in the northern and western areas of the state, and increase their susceptibility to fire. Grasslands, rangeland, and even desert could expand into previously forested areas. Milder winters could increase the likelihood of insect outbreaks and of subsequent wildfires in the dead fuel left after such an outbreak. These changes would significantly affect the character of Nevada forests and the activities that depend on them. However, increased rainfall could reduce the severity of these effects.

Changes In Forest Cover

Current | +10°F, +13% Precipitation



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

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

Ecosystems

Nevada supports a great variety of ecosystems, including the Mojave Desert and more than 300 mountain ranges. The Great Basin region, situated between the Rockies and the Sierra Nevada and Cascades, contains a rich array of ecosystems: playas, alkaline flats that are home to salt-tolerant plants, salt lakes, sand dunes, marshes that are crucial habitat for migratory waterfowl, vast expanses of sagebrush, the pi–on-juniper woodlands, the alpine islands of isolated mountain peaks that are home to remnant plant populations, the aspen glens, and the subalpine forest that is home to 4,000-year-old bristlecone pines, the oldest living trees on earth. Springs and stream-riparian ecosystems support a great diversity of plant and animal life that depends on these oases of water and food resources. These isolated aquatic ecosystems are unique, and they contain many rare plants and animals, including White River springfish, Railroad Valley springfish, White River mountainsucker, White River spinedace, Pahranagat spinedace, White River Colorado gila, and White River speckled dace. Marshes such as Ruby Lake and Stillwater are important for migratory birds in both the Central and Pacific flyways. Hundreds of thousands of waterfowl such as canvasback and redhead ducks, long-billed dowitchers, snowgeese, tundra swans, white-faced ibis, and great and snowy egrets overwinter or breed in these areas.

The region's inherently variable and unpredictable hydrological and climatic systems could become even more variable with changes in climate, putting additional stress on wetland ecosystems. The streams and rivers in Nevada are entirely spring-fed or derived from runoff from the mountains. A warmer climate would increase evaporation and shorten the snow season in the mountains, resulting in earlier spring runoff and reduced summer streamflow. This would exacerbate fire risk in the late summer. These threats, coupled with increasing human demands on water resources, could severely reduce the number and quality of wetland habitats, which are already stressed and ephemeral. This would degrade habitat essential for migrating and breeding birds, and could further stress rare and endangered fish species. Many desert-adapted plants and animals already live near their tolerance limits, and could disappear under the hotter conditions predicted under global warming.

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.