Climate Change and Utah

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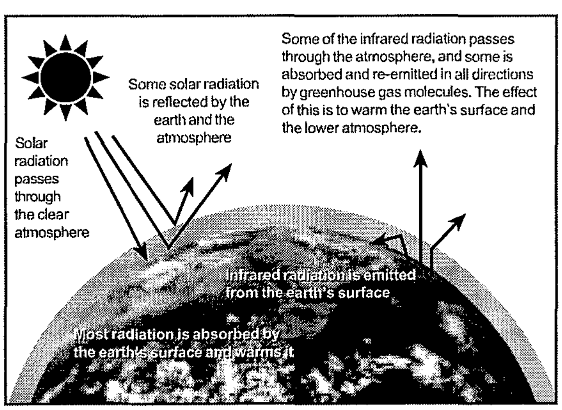
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

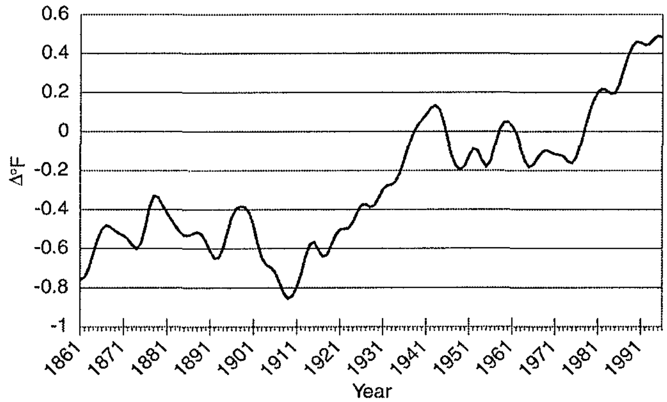
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

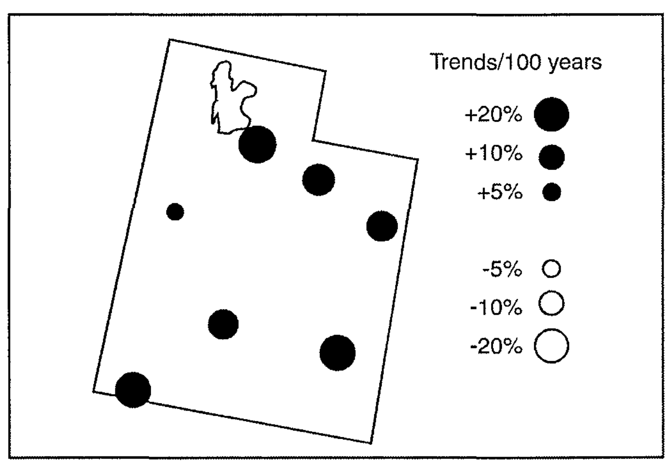
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency 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 Logan, Utah, has increased 1.4°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 Utah 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 Utah 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 by 10% in summer (with a range of -5 to -20%), to increase by 10% in spring (with a range of 5-20%), to increase by 30% (with a range of 10-50%) in fall, and to increase by 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, especially 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. In Salt Lake City, one study estimates little change in heat-related deaths during the summer given a 3-4°F warming (the current population appears to be accustomed to intense, dry heat). This study also shows a slight increase in winter-related deaths. However, the exact reasons for this increase are unknown.

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 Salt Lake City area is classified as a "moderate" nonattainment area for ozone. Warming could worsen air quality further. Ground-level ozone is associated with respiratory illnesses such as asthma, reduced lung function, and respiratory inflammation.

Upper and lower respiratory allergies 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 Utah can carry malaria, and others can carry western equine 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.

In 1993, hantavirus pulmonary syndrome emerged in Utah, and the deer mice that are the primary reservoir for the hantaviruses are prevalent in Utah. Long droughts punctuated by heavy rains can decrease the predators (owls, snakes, and coyotes) of rodents, and the heavy rains can provide the rodents with added food supplies (grasshoppers and piñon nuts).

Water Resources

Winter snow accumulation and spring snowmelt strongly affect Utah's rivers. A warmer climate could result in less winter snowfall, more winter rain, and faster, earlier spring snowmelt. In the summer, without increases in rainfall of at least 15-20%, higher temperatures and increased evaporation could lower streamflows and lake levels. Less spring and summer recharge also could lower groundwater levels. Less water would be available to support irrigation, hydropower generation, public supply, fish and wildlife habitat, recreation, and mining. Concerns about adequate water supplies could be exacerbated along the highly populated and industrialized Wasatch Front, which runs from Ogden to Provo. Groundwater levels, which are declining because of large withdrawals for public supply and for irrigation in southwestern Utah, could be lowered further. Energy development and mining operations in the eastern part of the state depend on adequate water supplies. Major water quality concerns such as the saline content of irrigation return flows and pollutant levels in urban streams would be aggravated by lower flows and higher temperatures. Surface and groundwater have been fully allocated in many parts of Utah. Reductions in water availability could complicate water rights issues and interstate compacts. Changes in the timing and accumulation of snow could affect skiing conditions in positive and negative ways, such as the timing and length of season and snow depth.

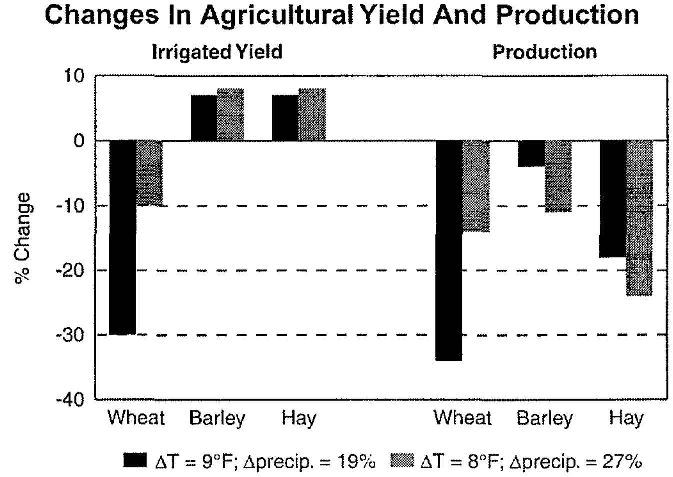
In a warmer climate, earlier and more rapid snowmelt, heavier rains, and the possibility of more rain could all contribute to flooding, particularly in the winter and spring. Densely populated urban areas in the Wasatch Front are susceptible to springmelt floods, and high lake levels around Utah and Great Salt lakes have caused considerable damage to farmland, wildlife habitats, industries, transportation routes, recreation facilities, and residential areas. Increased and more intense rains also could increase landslides and mudslides in the state's mountainous regions, as well as pollution in runoff from urban and mining areas.

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 Agricultural Yield And Production



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

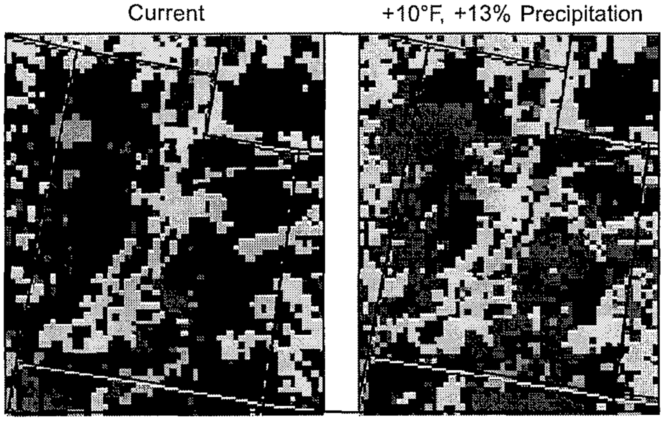
In Utah, production agriculture is an $800 million annual industry, three-fourths of which comes from livestock, mainly cattle. About 80% of the farmed acres are irrigated. The major crops in the state are wheat, barley, and hay. Climate change could significantly affect agricultural production, for example, reducing wheat yields by 10-30% as temperatures rise beyond the tolerance level of the crop. Irrigated barley, hay, and pasture yields, however, could rise by about 7%; unirrigated yields of those crops could rise by 3% or fall by 9%, depending on how climate changes. One model estimates that agricultural production of grain and forage crops could decline 5-30%. Farmed acres are projected to remain fairly constant. Livestock and dairy 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.

Changes In Forest Cover

Current | +10°F, +13% Precipitation



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

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

With changes in climate, the extent of forested areas in Utah 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, and increase their susceptibility to fire. Grassland, 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 Utah forests and the activities that depend on them. However, increased rainfall could reduce the severity of these effects.

Ecosystems

Utah is at the intersection of four unique regions: the basin and range country of the Great Basin, the alpine peaks of the Rocky Mountains, the canyon country of the Colorado Plateau, and the Mojave Desert. This variety of habitats supports over 3,500 species of native plants and animals, making Utah the fifth-ranked state in the nation in terms of biodiversity. The Great Basin region alone contains a rich array of ecosystems, including playas and alkaline flats that are home to salt-tolerant plants, salt lakes and dunes, marshes that are crucial habitat for migratory waterfowl, vast expanses of sagebrush, the piñon-juniper woodlands, the mountain islands of the Great Basin, aspen glens, and the subalpine forests that are home to the oldest living trees on the planet, 4,000-year-old bristlecone pines. The Great Salt Lake, the world's 33rd largest waterbody, is a migratory stopover and breeding site of international importance for a myriad of bird species, including Wilson's phalaropes, American avocets, white-faced ibis, white pelicans, and the world's largest colony of California gulls.

The Great Salt Lake may be one of the most vulnerable wetlands in the United States to changing climate. A warmer climate would increase evaporation and, without offsetting increases in rainfall, the lake would shrink and the salinity levels would increase. These changes would have adverse impacts for migratory bird populations for which this ecosystem is crucial. The rangelands of the Great Basin are already threatened by the expansion of non-native weedy species such as European cheatgrass. Climate change could exacerbate such threats, because opportunistic exotic species are well-suited to take advantage of the ecosystem disturbances caused by warming temperatures, such as increases in the frequency and severity of wildfires. Climatic variability also could lead to increased susceptibility of rangelands to droughts, insect pest outbreaks, and floods. Streams, rivers, and other freshwater oases situated in this arid landscape are highly vulnerable to climate change, particularly to warmer and drier conditions. Coupled with increasing human demands on water resources, these changes could destroy or seriously degrade the few wetland habitats that exist in this state.

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.