

# Climate Change and the Great Basin

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Climate change is expected to have significant impacts on the Great Basin by the mid-21<sup>st</sup> century. The following provides an overview of past and projected climate change for the globe and for the region. For more detailed information, please see the list of references and recommended links.

## **Global Climate Change**

There is scientific consensus on the key elements of climate change:

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, atmospheric carbon dioxide has increased 32 percent and methane has increased 150 percent. In the absence of significant changes in human activities, atmospheric concentrations of greenhouse gases will continue to increase.

Earth's surface has warmed about 0.6 °C (1.1 °F) since 1900. This 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 due 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, also have been observed.

## **Great Basin 20th Century Climate Change**

The climate of the Great Basin has changed during the past 100 years. Observed 20<sup>th</sup> century changes include:

*Region-wide warming of 0.3 to 0.6 °C (0.6° to 1.1 °F) in 100 years*—This warming, while widespread, has varied across the region (Wagner 2003). Minimum temperatures have increased more than maximum temperatures and variability in interannual temperatures has declined. As a result, the probability of very warm years increased and very cold years declined.

*Increase in precipitation across most of the Great Basin*—Annual precipitation has increased from 6 to 16 percent since the middle of the last century. Interannual variability in precipitation also has increased, with an increase in the probability of extreme high-precipitation years. This has been reflected in increases in streamflow across the region, especially in winter and spring (Baldwin and others 2003).

*Decline in snowpack since about 1950*—Trends in April 1 snow pack have been negative at most monitoring sites in the Great Basin. Elevation and mean winter temperature have a strong effect on snowpack with the warmest sites exhibiting the largest relative losses. In the warmer mountains, winter melt events have a strong negative effect on April 1 snow pack. Snow pack decline in the dry interior, which includes the Great Basin, has been among the largest observed, with the exception of central and southern Nevada (Mote and others 2005).

*Earlier arrival of spring affecting streamflow and plant phenology*—The timing of spring snowmelt-driven streamflow is now about 10 to 15 days earlier than in the mid-1900s, and there has been an increase in interannual variability in spring flow (Baldwin and others 2003, Stewart and others 2004). Phenological studies indicate that in much of the West, the average bloom-date is earlier for both purple lilac (2 days per decade based on data from 1957 to 1994) and honeysuckle (3.8 days per decade based on data from 1968 to 1994) (Cayan and others 2001).

## **Future Climate Change in the Great Basin**

Projected warming for the West ranges from about 2 to 5 °C (3.6 to 9 °F) over the next century (Cubashi and others 2001). Regional estimates for areas such as California indicate that the upper value may be as high as 7 °C (12.6 °F) for some areas (Dettinger 2005). The degree of change will depend on the increase in CO<sub>2</sub> by 2100 and will vary across the Great Basin due to the large differences in topography. Projected changes in precipitation in the West are inconsistent as to sign and the average changes are near zero (Cubashi and others

2001). The losses in snow pack observed to date are likely to continue and even accelerate with more rapid losses in milder climates and slower losses in high elevation areas (Mote and others 2005).

### **Overview of Climate Change Impacts**

*Water resources*—A reasonable scenario for western stream flows is change in the current seasonal proportionality of flows: increased winter flow, reduced and earlier spring peaks, and reduced summer and fall flows. The change in absolute flows will depend on the actual increase in precipitation relative to the degree of warming and its effects on evapotranspiration. Most watersheds in the Great Basin exhibit high natural variability in unregulated streamflow (Hurd and others 1999) and this variability may increase. In summer, lower flows coupled with higher variability may negatively affect various water uses (hydropower, irrigation, fish, recreation, and so forth). In winter, hydropower production could increase to take advantage of increased winter streamflow.

*Agriculture*—Many crops will grow better with higher CO<sub>2</sub> and a longer growing season before temperatures substantially increase, provided there is sufficient water. However, some weedy species and pests will have similar advantages. Low-value irrigation crops may have difficulty competing for less abundant irrigation water.

*Native ecosystems*—Similar to agricultural systems, growth of many native species (those with C3 photosynthetic pathways) is likely to increase provided there is sufficient water. Higher levels of CO<sub>2</sub> increase production and water-use efficiency of C3 native grasses but may increase the invasibility of cheatgrass and other annual grasses (Smith and others 2000, Ziska and others 2005). Other invaders, including perennial forbs and woody species, may be similarly advantaged. Increased temperatures will likely extend fire seasons with more fires occurring earlier and later than is currently typical, and this will increase the total area burned in some regions (McKenzie and others 2004). If climate change increases the amplitude and duration of extreme fire weather, we can expect larger and more severe fires. In more arid parts of the Great Basin, the frequency and extent of fires is likely to be higher in years that promote the growth of fine fuels (high fall, winter and spring precipitation) and as a result of fuel accumulation during the previous growing season (Westerling and others 2006). Progressive invasion of cheatgrass, which has greater flammability and fire spread than natives, is likely to continue to increase fire frequency and extent (Link and others 2006). Continued

expansion of pinyon-juniper species and increases in tree densities could result in an increase in high severity crown fires, especially under drying scenarios (Miller and others, in press). Infectious diseases and insect outbreaks could increase under several different warming scenarios (Logan 2006).

*Biodiversity and species at risk*—As temperatures increase, species shifts are likely to occur. Inhabitants of high elevation zones will likely experience shrinking habitats and local extinctions will probably increase (Wagner 2003) among mammalian, avian, and butterfly species (Murphy and Weiss 1992). If climate change favors invasive species, then certain native species are likely to be displaced. If the fire severity and burn area increase, shifts in the distribution and abundance of dominant plant species could occur that may also affect the habitat of some sensitive plant and animal species (McKenzie and others 2004). An increase in infectious disease and insect outbreaks also could place certain species at risk.

*Winter sports*—Warmer winter temperatures and increased winter precipitation are projected to delay the beginning of the winter sport season, shorten the length of the season, and increase the likelihood of rain during the season. The impacts will be greater for mid-elevation areas than for higher elevation areas.

## **Research and Management Questions**

Research and management questions revolve around the need to improve our ability to accurately predict the effects of climate change on the environment and, consequently, on human and natural systems.

### **Social and economic**

How do land use and climate change jointly affect social and economic dynamics?

How do the combined effects of land use and climate change affect ecosystem services, and the capacity of the landscape to support communities and economies?

What institutional options exist for improving the application of global-change science results in land use and water use decisions?

### **Water resources**

How will the loss of snow pack and change in stream flows affect water resources?

How will the change in climate variability (duration of droughts; frequency and magnitude of extreme events) affect water management?

How will the loss of snowpack and change in stream flows affect aquatic and riparian ecosystems?

How will the increase in climate variability affect aquatic, riparian, and upland ecosystems?

### ***Native ecosystems and species at risk***

What are the past fire responses to long-term trends in temperature and drought?

How does climate variability between years and decades affect the frequency, severity, and extent of wildfire?

What are the relationships among elevation, climate change, and the responses of native species?

What are the relationships between climate change and invasion by non-native species?

How does climate variability affect colonization, migration, local population extinction, and range expansion of sensitive plant and animal species?

What are the relationships among climate change, infectious disease, and insect outbreaks?

## **Existing Programs and Resources**

### ***National efforts***

NOAA Climate Program Office. <http://www.climate.noaa.gov> [2007, July 17]

U.S. Environmental Protection Agency Climate Change Science. <http://www.epa.gov/climatechange/index.html> [2007, July 17]

U.S. Global Change Research Program <http://www.usgcrp.gov/usgcrp/default.php> [2007, July 17]

USDA Forest Service, U.S. Global Change Research in the USDA Forest Service. 21 Oct. 2007. <http://www.fs.fed.us/ne/global/fsgrp/index.html> [2007, July 17]

U.S. Geological Survey, Global Climate Change Research. <http://geochange.er.usgs.gov/>

<http://pubs.usgs.gov/fs/climate-change/index.html> [2007, July 17]

U.S. Climate Change Science Program. <http://www.climatechange.gov> [2007, July 17]

University of California, Santa Cruz, Department of Earth and Planetary Sciences. Paleoclimate and

Climate Change Research Group. <http://www.es.ucsc.edu/~lcsloan/> [2007, July 17]

University of Wisconsin Milwaukee, U.S. National Phenological Network. 14 Mar. 2007. <http://www.uwm.edu/Dept/Geography/npn> [2007, July 17]

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Desert Research Institute, Division of Earth and Ecosystem Science. 2006. Nevada Desert FACE Facility. [http://www.dees.dri.edu/Projects/lynn\\_ndff.htm](http://www.dees.dri.edu/Projects/lynn_ndff.htm) [2007, July 17]

National Environmental Observatory Network. Inter-mountain Regional Observatory Network. <http://www.neoninc.org/> [2007, July 17]

Consortium for Integrated Climate Research in Western Mountains <http://www.fs.fed.us/psw/cirmount/> [2007, July 17]

The Western Mountain Initiative – A Network of Mountain Protected Areas for Global Change Research. 8 Feb 2007 <http://www.cfr.washington.edu/research.fme/wmi/index.htm> [2007, July 17]

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