

*“Climate change, once considered an issue for a distant future, has moved firmly into the present.”*

– Third U.S. National Climate Assessment

# Colorado

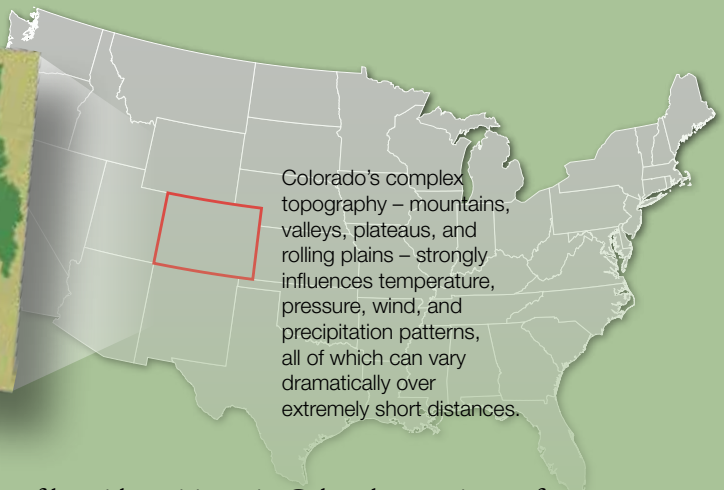
Observed Trends and Projected Future  
Conditions for Climate Change  
Preparedness and Resilience



Dallas Divide, Uncompahgre National Forest, Colorado  
Thalibou

climate change

# the setting



## About Colorado

Located far from the moderating impacts of humid maritime air, Colorado experiences frequent sunshine, low humidity, and rapid and large variation in temperatures. Colorado's complex topography – mountains, valleys, plateaus, and rolling plains – strongly influences temperature, pressure, wind, and precipitation patterns, all of which can vary dramatically over extremely short distances.

While most of Colorado is semi-arid and receives less than 20 inches of precipitation annually, Colorado's mountain ranges receive up to 60 inches, mostly as snow. The spring and summer runoff from these deep snowpacks provides a large majority of annual streamflow in Colorado's major rivers.



**Dust-Covered Late-Spring Alpine Snowpack**

The Cooperative Institute for Research in Environmental Sciences



**Damage from Flooding in Jamestown, Colorado**

Federal Emergency Management Agency





Because Colorado serves as a vital source of water for much of the western and central U.S., water users in Colorado and 19 downstream states rely on this snowmelt-dominated hydrology. The State’s tourism and recreation sector likewise depends on the snowpack for skiing and other winter sports, and the runoff as the basis for rafting, fishing, and other river, lake, and reservoir activities. The primary use of water in Colorado is for agriculture purposes, supporting 3 million acres of irrigated row crops, and fruits and vegetables.

Colorado frequently experiences droughts; nearly every year, some part of the state has experienced a short-term drought (~6 months or less) impacting local agriculture services and increasing wildfire occurrence. Persistent multi-year droughts, which also tend to be more widespread, have occurred every 3–4 decades, causing significant impacts to agriculture and recreation, and stressing water supplies.

Colorado’s forests, woodlands, and rangelands experience periodic wildfires. With rapid development in the wildland–urban interface in recent decades, particularly on the Front Range, up to 300,000 homes statewide are thought to be at risk of damage from wildland fires. Wildfire-scarred areas are also more prone to flooding and debris flows, as they lack vegetation to hold soils in place. This can impact watershed health and water quality.



**Forest Damage From Wildfire (Left of Watershed) and Bark Beetle (Orange Patches on the Right)**  
United States Geological Survey



**2013 East Peak Wildfire Near La Veta, Colorado**  
defenseimagery.mil

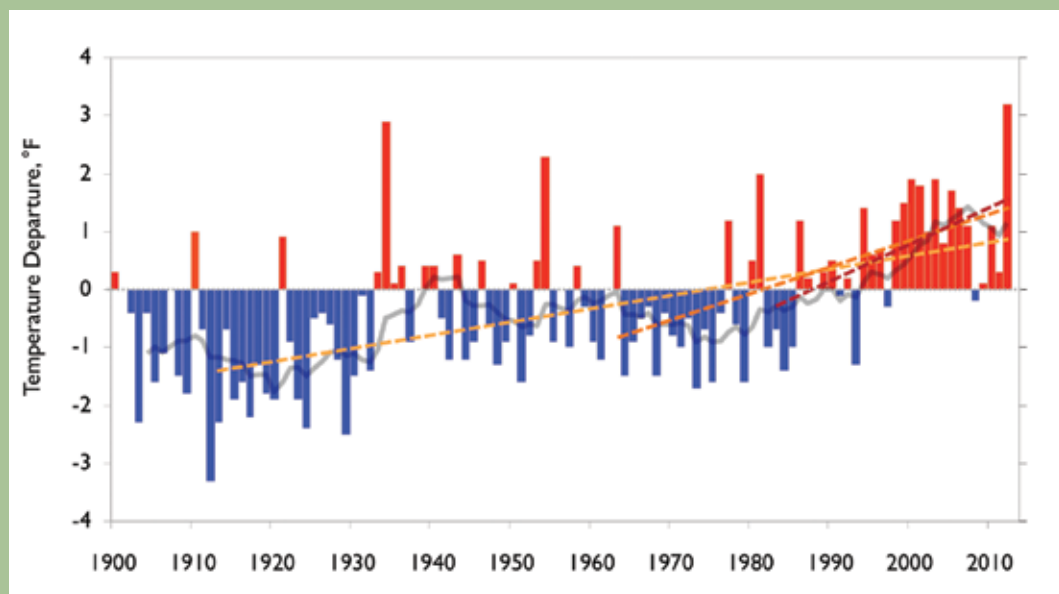


# the issue

We know with increasing certainty that climate change is happening now. As the impacts of climate change are becoming more prevalent, Americans face choices. Especially because of past emissions of long-lived heat-trapping gases, some additional climate change and related impacts are now unavoidable. This is due to the long-lived nature of many of these gases, as well as the amount of heat absorbed and retained by the oceans and other responses within the climate system. The amount of future climate change, however, will still largely be determined by choices society makes about emissions. Lower emissions of heat-trapping gases and particles mean less future warming and less- severe impacts; higher emissions mean more warming and more severe impacts.

## Observed Climate Trends

**Temperatures have increased.** Statewide annual average temperatures have increased by 2.0°F over the past 30 years and 2.5°F over the past 50 years (see Figure 1). Warming trends have been observed over these periods in most parts of the state and in all seasons. Daytime high temperatures and nighttime low temperatures are both rising in Colorado. This could have negative impacts on crops and animal production for example. Heat waves have also become more frequent.



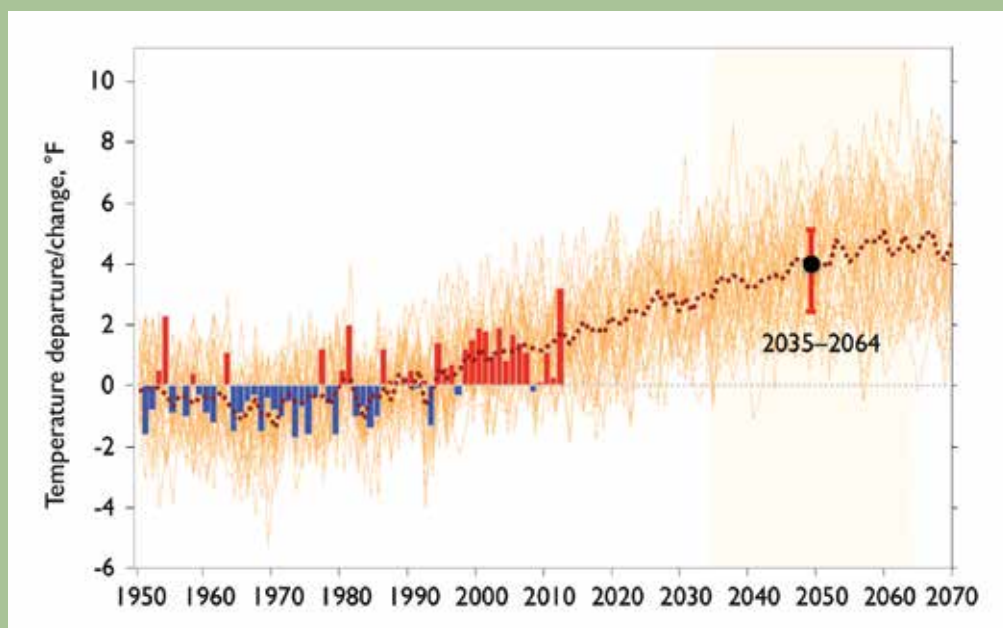
**Figure 1.** Colorado Statewide Annually-averaged Temperature. Colorado statewide annually-averaged temperature (°F), 1900–2012. Annual departures are shown relative to a 1971–2000 reference period. The light-orange, orange, and red lines are the 100-year, 50-year, and 30-year trends, respectively. (Source: *Climate Change in Colorado, A Synthesis to Support Water Resources Management and Adaptation, Second Edition, August 2014*)

**Snowpack has declined recently.** While a definitive decline has not yet been established (based on 30- or 50-year trends), snowpack, as measured by April 1 snow-water equivalent, has been below-average since 2000 in all of Colorado's river basins. Over the past 30 years, the timing of snowmelt and peak runoff has shifted earlier in the spring by 1–4 weeks across Colorado's river basins because of the combination of lower snow-water equivalent since 2000, the warming trend in spring temperatures, and enhanced solar absorption from dust-on-snow.

**Drought severity has increased.** The Palmer Drought Severity Index shows a trend towards more severe soil-moisture drought conditions in Colorado over the past 30 years, reflecting the combination of the below-average precipitation since 2000 and the warming trend. Climate change may have increased the severity of recent drought conditions in the western U.S., due to the influence of the warming on snowpack, streamflow, and soil moisture.

## Projected Future Climate Conditions

**Much warmer annual and seasonal temperatures are projected.** As climate changes, temperatures in Colorado are projected to continue to increase (see Figure 2). If heat-trapping gas emissions continue on a high-emissions trajectory, temperatures in Colorado are projected to increase between 3.5°F and 6.5°F by 2050 and much more later in the century. Typical summer temperatures by 2050 are projected to be similar to the hottest summers that have occurred in the past 100 years.



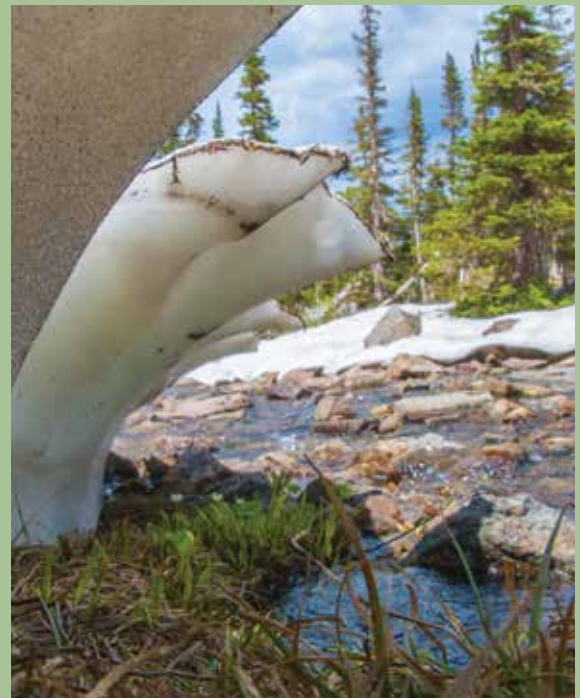
**Figure 2.** Projected Colorado Annual Temperature from 1950–2070. Modeled by 37 climate models under RCP 4.5 (yellow/orange lines) compared to the observed Colorado annual temperature anomalies, 1900–2012 (red/blue bars). All values are shown relative to the 1971–2000 baseline (gray dashed line). The models project a continuation of the recent warming trend through 2050, with typical temperatures by then matching or exceeding the warmest years of the 20th century. (Source: *Climate Change in Colorado, A Synthesis to Support Water Resources Management and Adaptation, Second Edition, August 2014*)



**Annual streamflows for Colorado's river basins are projected to decrease.** As a result of increased temperatures, projections for changes in annual streamflow indicate a tendency toward future decreases for Colorado's river basins. The peak of the spring runoff is projected to shift 1–3 weeks earlier by 2050 due to warming. Late-summer flows are projected to decrease as the peak shifts earlier. Changes in the timing of runoff are more certain than changes in the amount of runoff.

**Spring snowpack is projected to decline.** Most projections of Colorado's spring snowpack (April 1 snow-water equivalent) show declines for 2050 due to projected warmer temperatures.

**Heat waves, droughts, and wildfires are projected to increase.** Most climate projections indicate that heat waves, droughts, and wildfires will increase in frequency and severity in Colorado by 2050 due to the projected warming.



**Snowmelt in the Rockies**  
Thinkstock



**Wildfire**  
Corbis



**Beetle Damage in Northern Williams Range Mountains**  
United States Geological Survey



**Denver Skyline at Sunset**  
Thinkstock

# what's at stake?

**Human health and well-being.** Exposure to excessive heat can threaten human health and well-being, especially for those who suffer from respiratory or heart disease. Higher temperatures can reduce air quality because atmospheric chemical reactions occur faster in warmer conditions. More frequent wildfires would also reduce air quality. Wildfire smoke exposure increases respiratory and cardiovascular hospitalizations, emergency department visits, and medication dispensations for asthma, bronchitis, chest pain, chronic obstructive pulmonary disease, respiratory infections, and medical visits for lung illnesses. Higher temperatures and longer warm seasons will also lead to shifts in the distribution of disease-transmitting mosquitoes.

**Essential infrastructure.** Warmer temperatures, drier conditions, and population increase can stress Colorado's energy infrastructure. Warmer temperatures will likely place higher demands on power production facilities in summer, as residents across the state increase air conditioner use. Warmer lakes and streams as well as earlier runoff could affect water use for cooling power plants and in other industries.

**Economic activity.** The food, agriculture, tourism, and recreation sectors crucial to Colorado's economy face potential disruption in the face of possible future climate change. Changes in reservoir storage would affect recreation on-site and downstream. Earlier streamflow timing would affect rafting and fishing. Declining snowpacks would impact winter mountain recreation and tourism. Warming temperatures will lengthen the growing season and increase crop water use. The severity of future impacts will depend upon the complex interaction of water supply, crop pests, and changes in the seasonal timing of crop development.

**Water availability.** Earlier snowmelt and runoff, decreasing summer flows, and likely declines in average annual streamflow will create challenges for storage, delivery, and use of water supplies. The projected drying of arid lands southwest of Colorado may lead to more dust-on-snow events<sup>1</sup>, which would hasten the shift towards earlier snowmelt and runoff caused by warming. Lower summer flows and warmer water temperatures could cause water quality to decline.

**Ecosystem services.** Higher temperatures enable more frequent and severe wildfires, and make trees more vulnerable to insect infestation such as bark beetles (see Figure 3). While bark beetles are native to Colorado's forests and have periodically erupted in epidemics every several decades, the epidemics in Colorado in the last 15 years are historically unprecedented in their scale. Since 2000, bark beetle epidemics have caused extensive tree mortality across 4 million acres of forested watersheds in Colorado. The synchronous timing of these widespread outbreaks of bark beetles has been attributed to the overall warm and dry conditions, which have promoted beetle over-wintering survival and reproduction and reduced the trees' resistance to beetle attacks. Other impacts from higher temperatures have implications for water quality and watershed health. Warmer stream temperatures could have direct and indirect effects, including the spread of non-native species and diseases to higher elevations on aquatic ecosystems. Changes in streamflow timing could also affect river ecosystems.



**Figure 3.** Forest Mortality. Forest mortality due to fire and insect activity is increasingly evident in Colorado. Continued changes in climate in coming decades are expected to increase these effects. (Source: William M. Ciesla, Forest Health Management International, Bugwood.org)

# About the National Exercise Program Climate Change Preparedness and Resilience Regional Workshops

The National Exercise Program Climate Change Preparedness and Resilience Regional Workshops are an element of the overarching Climate Change Preparedness and Resilience Exercise Series sponsored by the White House National Security Council Staff, Council on Environmental Quality, and Office of Science and Technology Policy, in collaboration with the National Exercise Division. The workshops are tailored to address issues of particular concern to the host region, such as the impacts of warmer and drier climate conditions in the State of Colorado. The workshops also feature interactive climate change science panel sessions (at multiple scales) and a facilitated scenario-driven tabletop exercise. The exercise scenario focuses on specific jurisdictional impacts derived from the Third U.S. National Climate Assessment regional scenarios. Ultimately, the regional workshops are intended to help answer the following question: “What can we do now, as a whole community, to collaboratively and sustainably prepare for future projected climate change impacts?” For more information on National Exercise Program Climate Change Preparedness and Resilience Regional Workshops, please contact: [NEP@fema.dhs.gov](mailto:NEP@fema.dhs.gov).

**The Third U.S. National Climate Assessment**, released in May 2014, assesses the science of climate change and its impacts across the United States, now and throughout this century. It integrates findings of the U.S. Global Change Research Program with the results of research and observations from across the U.S. and around the world. The report documents climate change impacts and responses for each region of the country and key sectors of the economy and society, with the goal of better informing public and private decision-making at all levels. For more information, visit: [nca2014.globalchange.gov](http://nca2014.globalchange.gov). For questions, contact: [engagement@usgcrp.gov](mailto:engagement@usgcrp.gov)

## Additional Resources

**The Third U.S. National Climate Assessment** assesses the science of climate change and its impacts across the United States, now and throughout this century. It integrates findings of the U.S. Global Change Research Program with the results of research and observations from across the U.S. and around the world. The report documents climate change impacts and responses for each region of the country and key sectors of the economy and society, with the goal of better informing public and private decision-making at all levels. For more information, visit: [nca2014.globalchange.gov](http://nca2014.globalchange.gov). For questions, contact: [engagement@usgcrp.gov](mailto:engagement@usgcrp.gov)

**The U.S. Global Change Research Program** was established by a Presidential Initiative in 1989 and mandated by Congress through the Global Change Research Act of 1990 to “assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.” For more information, visit: [globalchange.gov](http://globalchange.gov).

**The White House Council on Environmental Quality** coordinates Federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives. For more information, visit: [whitehouse.gov/administration/eop/ceq](http://whitehouse.gov/administration/eop/ceq).

**The White House Office of Science and Technology Policy** was established by Congress in 1976 with a broad mandate to advise the President and others within the Executive Office of the President on the effects of science and technology on domestic and international affairs. For more information, visit: [whitehouse.gov/administration/eop/ostp](http://whitehouse.gov/administration/eop/ostp).

**The Cooperative Institute for Research in Environmental Sciences**, a joint institute of the National Oceanic and Atmospheric Administration and the University of Colorado at Boulder, explores all aspects of the earth system and searches for ways to better understand how natural and human-made disturbances impact our dynamic planet. For more information, visit: [cires.colorado.edu](http://cires.colorado.edu).

**The Colorado Water Conservation Board** provides information about Colorado’s water conservation programs, and resources to assist water management efforts throughout the state. For more information, visit: [cwcb.state.co.us](http://cwcb.state.co.us).

**The State of Colorado Recovery Office** works to create a more innovative, safer, and resilient Colorado. For more information, visit: [coloradounited.com](http://coloradounited.com).

## Considerations with Projecting Future Climate

Climate projections and impacts, like other types of research about possible future conditions, are characterized by uncertainty, to include, but not limited to:

- Human activities and the emissions produced by those activities
- The response of different parts of the planet to human-caused changes in the atmosphere
- Natural variability in climate and weather patterns

Even though quantitative climate projections at the local scale have uncertainties, the information provided here can guide stakeholders as they seek to identify and manage the risks associated with climate variability and climate change.

## The text in this brochure was derived from the following sources:

- *Climate Change in Colorado, A Synthesis to Support Water Resources Management and Adaptation*, Second Edition - August 2014, A Report for the Colorado Water Conservation Board, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder, Jeff Lukas, University of Colorado Boulder, CIRES, Joseph Barsugli, University of Colorado Boulder, CIRES, Nolan Doesken, Colorado State University, Colorado Climate Center, Imtiaz Rangwala, University of Colorado Boulder, CIRES, Klaus Wolter, University of Colorado Boulder, CIRES
- Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

## Endnotes

<sup>1</sup>Dust-on-snow: Strong winds associated with springtime storms periodically strip the upper soil from the drylands of the Colorado Plateau region and deposit it as reddish dust on the snowpacks of Colorado’s mountains. The dust darkens the snow surface so that it absorbs more of the sun’s energy, causing snowmelt and runoff to occur earlier in the spring. This dust-on-snow effect appears to have worsened in the past few decades due to drier, warmer conditions and increased soil disturbance in the Colorado Plateau region.

