



# Climate Change Is Changing The West

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*the*  
**ROCKY  
MOUNTAIN  
CLIMATE**  
*Organization*

# Climate Change's Impacts in the West

Scientists believe that in the American West climate change likely will lead to more heat, less snow, less water from melting snow, and more drought.

If just a fraction of the predicted impacts materialize, that would jeopardize the qualities that make the West such a special place to live, work, and play.

## More Heat

Worldwide, climate change is predicted to warm the Earth by 3 to 10°F (or 1.4 to 5.8°C) between 1990 and 2100. Half of

the variation in the estimates results from differences in assumptions about future levels of greenhouse gases, and half from differences in climate-prediction models.

The mid-range of the estimates, a 5.4°F increase, is enough to make:

- Aspen as warm as Durango now is.
- Missoula as warm as Denver now is.
- Reno as warm as Albuquerque now is.

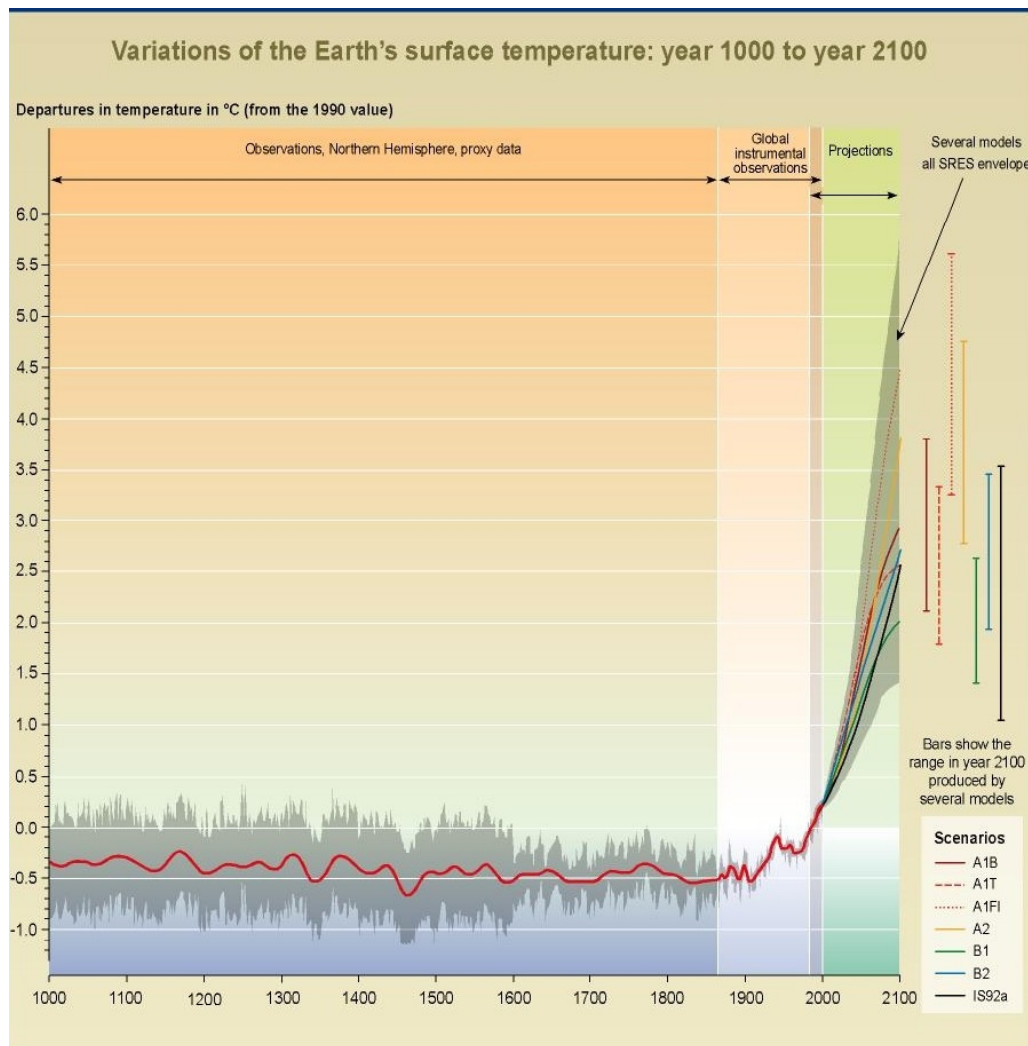


Figure 1. Source: Intergovernmental Panel on Climate Change (2001).

## Less Snow

The increases in temperature, rather than being uniform, are expected to be greater:

- Over land, not the oceans.
- At night.
- At higher elevations.
- In winter and early spring.

Higher temperatures at those places and times will lead to less snow.

Projections using two different climate models – a Canadian model, which predicts conditions becoming much hotter than other models do, and a Hadley model, which predicts milder and much wetter conditions – illustrate how mountain snowpacks could decline sharply across the West.

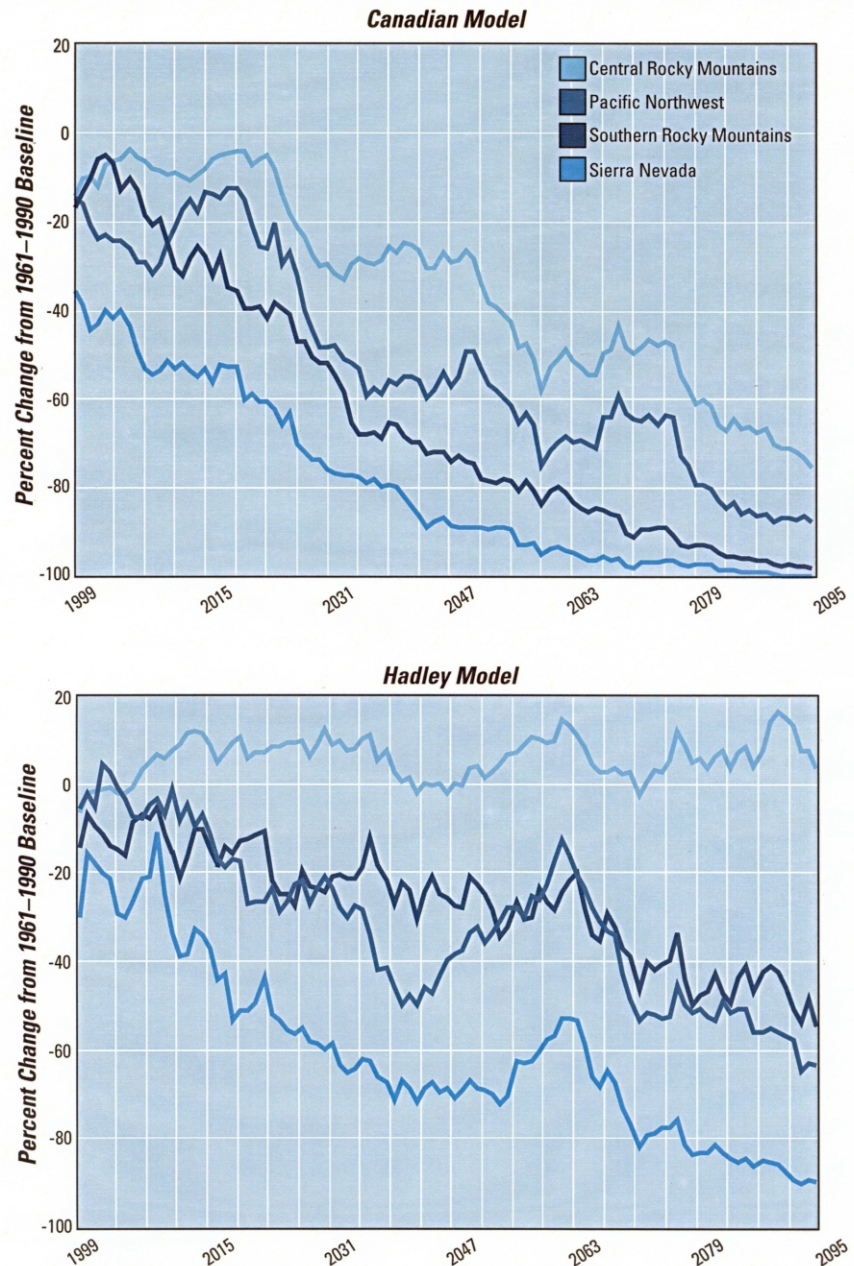


Figure 2. Source: *Climate Change Impacts on the United States* (2000).

*“Snowpack is very likely to decrease as the climate warms, despite increasing precipitation, for two reasons. It is very likely that more precipitation will fall as rain, and that snowpack will develop later and melt earlier.”*

*Climate Change Impacts on the United States* (2000)

## Less Water

As the Earth warms, it is likely that both precipitation and evaporation will increase, with local and regional variations that are still hard to predict. In the West, though, where snow supplies 80 to 90 percent of our water, less snow would mean less of the snowmelt that our reservoirs trap and on which we rely.

At the same time, higher temperatures will mean drier soils and therefore more need for water, as well as higher evaporation rates, increasing water losses from streams and reservoirs.

"Reduction in snowpack will very likely alter the timing and amount of water supply, potentially exacerbating water shortages and conflict, particularly throughout the western US."

*Climate Change Impacts on the United States (2000)*

"Current water source management along the eastern edge of the Rocky Mountains depends on the storage of winter precipitation as high elevation snowpack well into the growing season.

"Under a climate shift to earlier snowmelt runoff, not only would there be a great demand for water to irrigate during the extended growing season, but water would be released from its very efficient high-elevation natural seasonal reservoir well before the July and August interval of peak irrigation."

*Central Great Plains Regional Climate Change Assessment (2002)*

"Higher air temperatures increase the rate of evaporation, removing moisture from the soil faster than it can be added by increased precipitation, resulting in net soil moisture declines for a large part of the Great Plains."

*Climate Change Impacts on the United States (2000)*

*"The importance of snowpack to life in and around the Rocky Mountains cannot be overemphasized."*

*Rocky Mountain/Great Basin Regional Climate Change Assessment (2003)*

## More Drought

Even if we are fortunate enough to get more overall precipitation, climate change is expected to lead to more extreme weather of all types – including more frequent and longer-lasting droughts.

The nation's worst droughts are predicted to be in the Rocky Mountain region. Under the Hadley model, which predicts large increases in precipitation, droughts could be milder. Under the Canadian model, which predicts large temperature increases, droughts could be extreme.

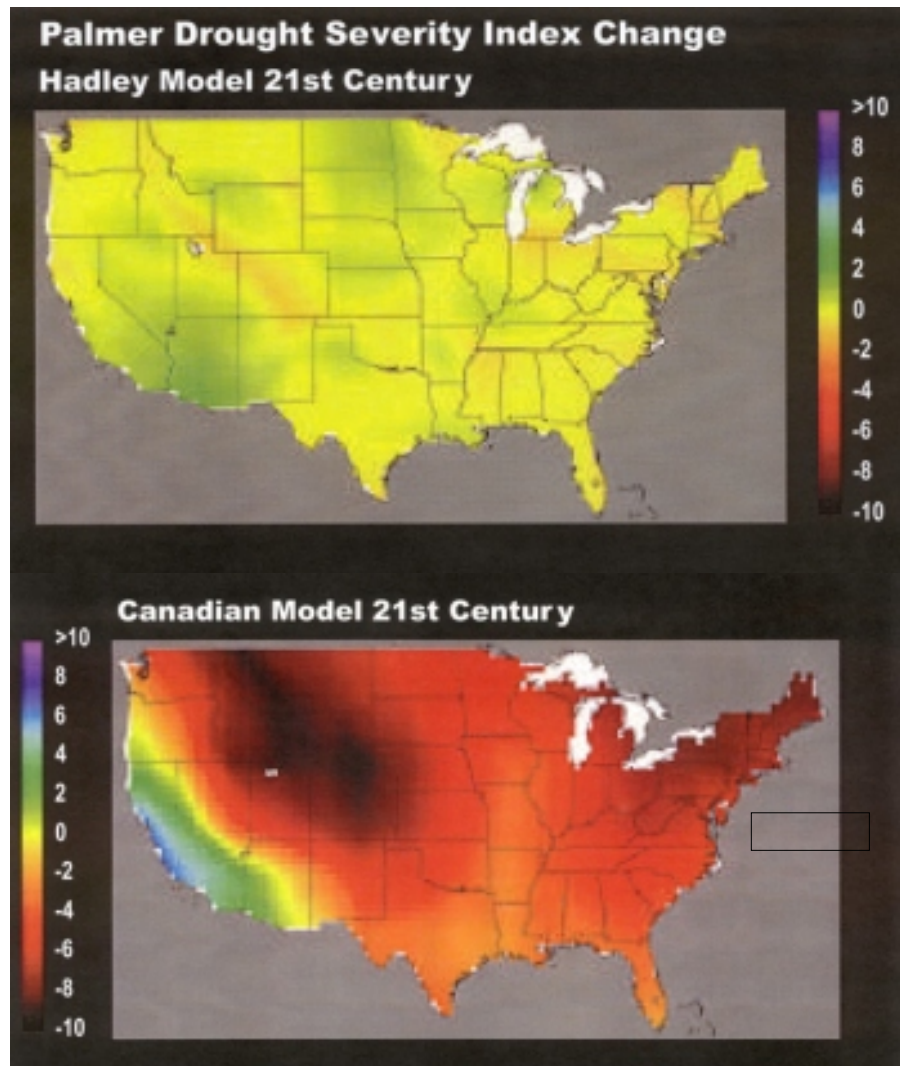


Figure 3. Source: *Climate Change Impacts on the United States* (2000). On the Palmer Drought Severity Index, a value of -4 represents extreme drought, and -7 the drought conditions in 2002 in much of the West.

*"By the end of the century, the Canadian scenario projects that extreme drought will be a common occurrence over much of the Great Plains. . . . Increased tendencies toward drought are also projected in the Hadley model for regions immediately east of the Rockies."*

*Climate Change Impacts on the United States* (2000)

# The Colorado River: A Case Study

Twenty five million Westerners, from Denver to Los Angeles and from Las Vegas to Albuquerque, depend on the water of the Colorado River. A recent study used a climate model predicting relatively modest

changes in climate to produce what the researchers called a "best-case" scenario of possible climate-change effects in the Colorado River system. That scenario, however, is hardly reassuring.

Climate Change Impacts In the Colorado River Basin Predicted Changes From Historical Averages					
Period	Average Temperature	Total Precipitation	Snowpack	Runoff	Water Storage
2010-2039	+ 1.8° F	- 3 %	- 24 %	- 14 %	- 36 %
2040-2069	+ 3.6° F	- 6 %	- 30 %	- 17 %	- 40 %

Table 1. Source: Christensen et al., "The Effects of Climate Change on the Hydrology and Water Resources in the Colorado River Basin," *Climatic Change* (2004)

*"What this work shows is that, even with a conservative climate model, current demands on water resources in many parts of the West will not be met under future climate conditions – much less the demands of a larger population and a larger economy."*

T. Barrett, et al., "The Effects of Climate Change on Water Resources in the West: Introduction and Overview," *Climatic Change* (2004)

*"The Colorado River is the canary in the coal mine for global warming."*

Eric Kuhn, General Manager  
Colorado River Water Conservation District (2004)

# Climate Change Is Already Happening

The scientific consensus is that human activities are already changing the climate, and that the changes are likely to accelerate as emissions of greenhouse gases increase.

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

Intergovernmental Panel on Climate Change (2001)

"The IPCC's conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the scientific community on this issue."

National Academy of Sciences (2001)

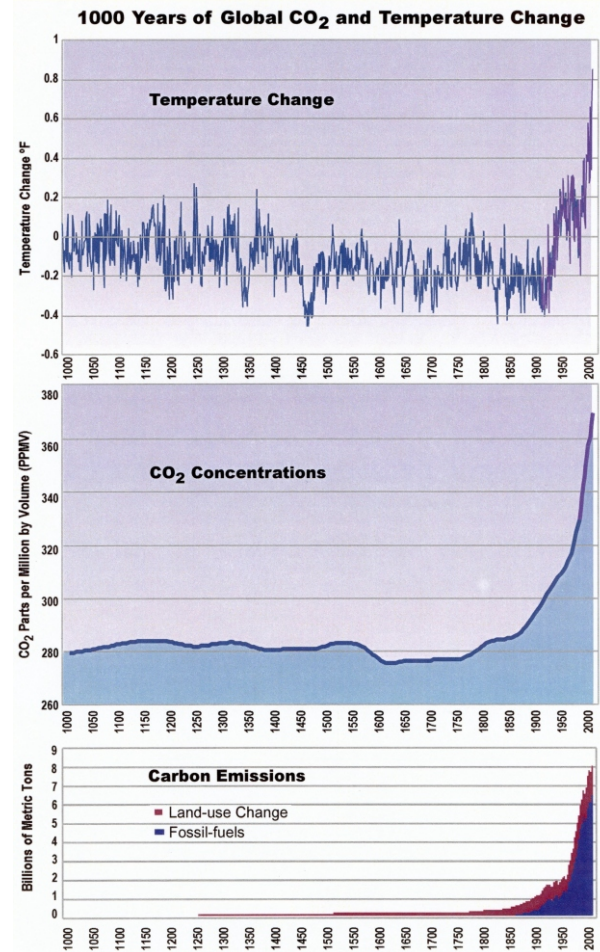


Figure 4. Source: *Climate Change Impacts on the United States* (2000).

## Climate Change Is Happening Here, Too

The climate is changing in the American West, too. The West has seen larger temperature increases than any other part of the country, according to government data.

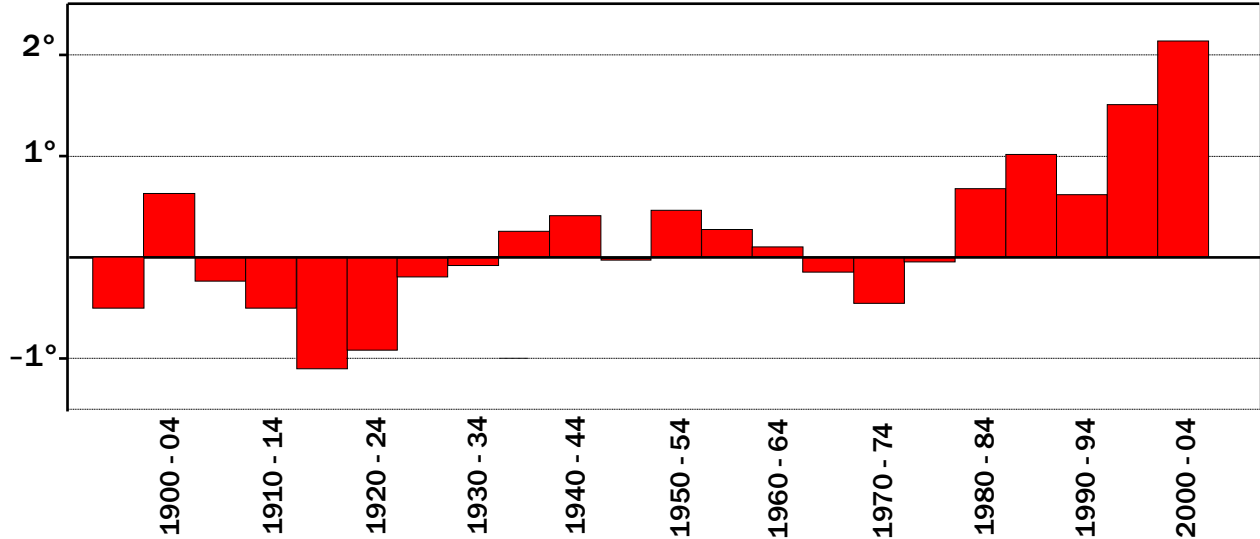
The top graph on the following page shows how temperatures have increased in the upper basin of the Colorado River, including portions of Wyoming, Utah,

Colorado, and New Mexico, the home of the snowpack that becomes most of the River's water.

The lower graph shows that the monthly pattern of the recent temperature increases (those of the last ten years) bear a tell-tale signature of climate change: They are greatest in winter and early spring.

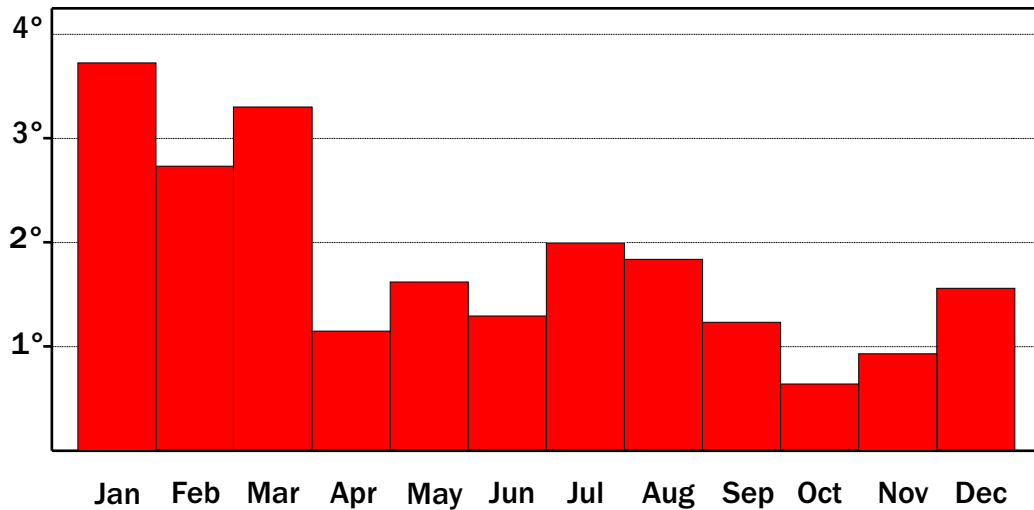
## Warming In The Upper Colorado River Basin

Variations in 5-Year Average Temperatures, 1895 to 2004  
Compared to Historical Average Temperature



## A Signature Of Climate Change: Increases Greatest in Winter, Early Spring

Average Monthly Temperatures in Upper Colorado River Basin  
1995-2004 Compared to Historical Averages



Figures 5 and 6. Data from the climate division time series, National Oceanic and Atmospheric Administration. Analysis by the Rocky Mountain Climate Organization. Historical averages are for the period 1895-1990.

## We Are Getting Less Snow

The West's snowpacks are getting smaller, primarily, scientists say, from the warming that is already underway. Less snow is falling, and it is melting earlier. The trend is evident across the West, with the greatest

reductions in areas with milder winter temperatures and at lower elevations – supporting the scientific conclusion that the reduction in snow results from the West's warming.

"Much of the mountain West has experienced declines in spring snowpack, especially since mid-century, and despite increases in winter precipitation in many places. Analysis and modeling shows that climatic trends are the dominant factor, not changes in land use, forest canopy, or other factors. The largest decreases have occurred where winter temperatures are mild, especially in the Cascade Mountains and Northern California. In most mountain ranges, relative declines grow from minimal at ridgetop to substantial at snowline. Taken together, these results emphasize that the West's snow resources are already declining as Earth's climate warms."

Philip Mote, et al., "Declining Mountain Snowpack in Western North America," *Bulletin of American Meteorological Society* (2005)

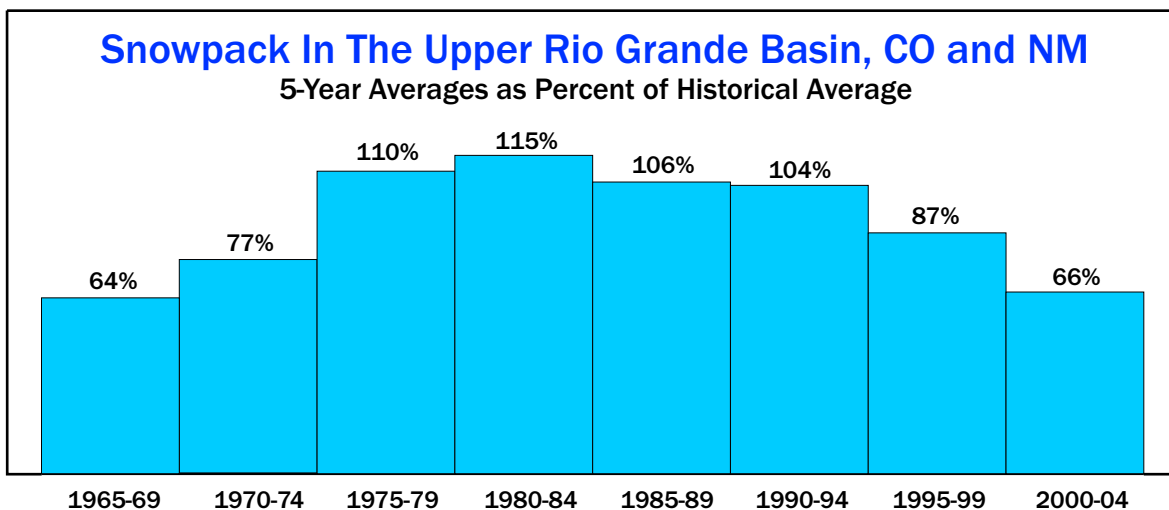


Figure 7. Data from the Natural Resources Conservation Service, USDA. Analysis by the Rocky Mountain Climate Organization. Data are from all snowpack measurement sites in the upper Rio Grande basin in Colorado and New Mexico (including the Rio Chama basin) that have records from 1961-2004. Historical averages are for the period 1961-1990.

*"It's kind of taken us all aback. It's kind of hard to see all this happening right under our nose without us noticing."*

Kelly Redmond, Western Regional Climate Center (2004)

# The Colorado River: Especially Hard-Hit

The Colorado River and the 25 million people who depend on its water are particularly vulnerable to the possible effects of climate change.

The Colorado River is experiencing its worst drought in 500 years. Lake Powell, which stores water from New Mexico and other upper-basin states for delivery to Arizona and California, was 95% full in early 2000. After five years with inflows of only 25 to 62% of normal, the reservoir is now only 35% full.

The drought in the Colorado River basin is part of a world-wide trend. Drought-affected areas doubled from the 1970s to 2002, according to a recent study, with half of that increase resulting from higher temperatures and half from less precipitation – conditions that have both been present in the Colorado River basin's current drought.

The Colorado River Compact, which puts the burden of water shortages primarily on the upper-basin states of Colorado, Utah, Wyoming, and New Mexico, makes them potentially even more vulnerable. The compact guarantees an average of 7.5 million acre-feet of water a year to lower-basin states – apparently regardless of how much that leaves for the upper basin.

Lake Powell is designed to protect the upper basin by storing and releasing that water to the lower basin. If Lake Powell cannot release enough water to fulfill the lower basin's entitlement, either because of a continuation of the current drought or in a future drought, water users throughout the upper-basin states could potentially face water restrictions to provide lower-basin states with the water they are guaranteed by the compact.

"If there is a compact call, we hit the wall. We wouldn't be able to use water called by the lower basin."

David Getches, Dean  
University of Colorado Law School (2004)

## Changing the Odds

The good news is that we can reduce the emissions that cause climate change, and by doing so reduce the extent of both climate change and its effects.

The United States, with under five percent of the world's population, emits 20 percent of all greenhouse gases, and so can have the largest effect on climate change.

The West can make a big difference. Arizona and Colorado each emit more carbon dioxide from fossil-fuel use than 174 nations do. Utah emits more than 172 nations, Wyoming more than 171, New Mexico more than 164, Nevada more than 156, and Montana more than 143. Even Idaho, with the region's lowest emissions, still emits more than 130 nations.

## Carbon Dioxide Emissions From Fossil-Fuel Use Rocky Mountain States Compared to Selected Nations

<u>State or Nation</u>	<u>Emissions Rank Among 212 Nations</u>	<u>Emissions (Millions of (Metric Tons of Carbon)</u>
Romania	38	23.5
<b>Arizona</b>	N/A	23.2
<b>Colorado</b>	N/A	22.9
Philippines	39	21.2
Iraq	40	20.8
<b>Utah</b>	N/A	17.3
Israel	41	17.2
<b>Wyoming</b>	N/A	16.9
Austria	42	16.6
Portugal	43	16.3
Chile	44	16.2
Belarus	45	16.1
Singapore	46	16.1
United Arab Emirates	47	16.1
Columbia	48	16.0
<b>New Mexico</b>	N/A	15.8
Viet Nam	49	15.7
Libya	50	15.6
Syria	51	14.8
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Sweden	56	12.8
<b>Nevada</b>	N/A	12.2
Denmark	57	12.2
***		
Cuba	69	8.4
<b>Montana</b>	N/A	8.3
Peru	70	8.1
***		
<b>Idaho</b>	N/A	4.2
Lebanon	83	4.1

Table 2. Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory.

Limiting greenhouse-gas emissions can reduce climate change and its impacts, as illustrated by a recent assessment using

two different models to predict impacts in California if emissions are limited or grow in a business-as-usual way.

## Climate Change's Effects Depend On Emissions: An Illustration

### Predicted Effects in California in 2070-2099

National Center for Atmospheric Research Climate Model		
	<u>Lower Emissions</u>	<u>Higher Emissions</u>
Changes in Temperature	+ 4°F	+ 7°F
Changes in Precipitation	+ 7%	-17%
Changes in Snowpack	-29%	-73%
Changes in River Flows	- 7%	-14%

Hadley Climate Centre Climate Model		
	<u>Lower Emissions</u>	<u>Higher Emissions</u>
Changes in Temperature	+ 6°F	+10°F
Changes in Precipitation	-22%	-30%
Changes in Snowpack	-72%	-89%
Changes in River Flows	-23%	-33%

Table 3. Source: Hayhoe, et al., "Emissions Pathways, Climate Change, and Impacts on California," *Proceedings of the National Academy of Sciences* (2004). "Lower emissions" reflect aggressive but realistic action to reduce greenhouse gas. "Higher emissions" reflect a business-as-usual approach. Differences are compared to historical averages from the period 1961-1990.

# Making a Difference

Across the nation and the world, public and private actions are being taken to reduce climate change and its impacts.

- 140 cities in the United States have programs to reduce local emissions of greenhouse gases.
- The governors of California, Oregon, and Washington recently adopted a plan for regional cooperation to reduce greenhouse gases.
- Maine has adopted a law establishing a state target of reducing its emissions of greenhouse gases to 1990 levels by 2010, and 10% lower by 2020.
- Other states have also established emission-reduction targets, although not yet through legislative action.
- Massachusetts and New Hampshire have adopted requirements that existing powerplants reduce their carbon dioxide emissions.
- Nine northeastern and mid-Atlantic states are adopting a "cap-and-trade" system to enable utilities to achieve cost-effective reductions in powerplant emissions of carbon dioxide.
- California, under a special waiver in the federal Clean Air Act, has adopted the nation's first standards to limit emissions of carbon dioxide from cars and trucks. Other states can adopt the California standards, as they have for other pollutants.
- Several states have adopted a uniform set of energy-efficiency standards for appliances not covered by federal standards.
- California requires utilities proposing new powerplants to assume that they will have to meet future carbon-dioxide emission standards – and to count the likely costs of doing so in the costs of the powerplants.
- In the U.S. Senate, a bill by Senators John McCain of Arizona and Joe Lieberman of Connecticut would establish the first national limits on emissions of greenhouse gases. Ski resorts across the country, among others, have endorsed it.
- 140 nations (with the United States and Australia the major hold-outs) have entered into the Kyoto Protocol, requiring developed nations to limit greenhouse gases, and allowing credits for reductions achieved in developing nations.
- Great Britain has set a target of reducing its greenhouse-gas emissions by 60% by 2050, choosing that target as the degree of reduction believed necessary worldwide to avoid unacceptable impacts from climate change.
- Businesses and individuals are taking voluntary actions to reduce emissions – often because doing so saves them money and has other benefits, too.

*"There are many benefits of reducing greenhouse gases that go beyond doing our part to stem the tide of climate change. Many actions outlined in this plan have significant local environmental and economic benefits. These benefits range from reduced air pollution, reduced energy bills for businesses and families, expanded recycling opportunities, new jobs, reduced urban sprawl and traffic congestion, and decreased reliance on non-renewable energy sources. If implemented, these actions will preserve and even improve the quality of life in our community."*

Local Action Plan to Reduce  
Greenhouse Gas Emissions

City of Fort Collins, Colorado



We spread the word about what climate change can do to us here and what we can do about it.

Our partners are the City and County of Denver and the cities of Fort Collins, Boulder, and Aspen, Colorado; Denver Water; Aspen Skiing Company; Colorado Mountain Club; The Nature Conservancy of Colorado; New Belgium Brewing Company; Roche Colorado; Rocky Mountain Farmers Union; Westcliffe Publishers; Wild Oats Markets, Inc.; and Wright Water Engineers, Inc.

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