National Parks in Peril
The Threats of Climate Disruption

State Fact Sheet: Colorado

Human disruption of the climate is the greatest threat ever to our national parks.

At risk are nearly every resource and value that make our national parks so special. In National Parks in Peril, the Rocky Mountain Climate Organization and the Natural Resources Defense Council identify 25 national parks as having the greatest vulnerabilities to human-caused climate change. In Colorado, Mesa Verde and Rocky Mountain national parks are on the list of most endangered parks. Mesa Verde is vulnerable to a loss of water, more downpours and floods, a loss of plant communities, a loss of wildlife, and a loss of cultural resources. Rocky Mountain is vulnerable to a loss of ice and snow, a loss of water, more downpours and floods, a loss of plant communities, a loss of wildlife, more crowding, a loss of fishing, and more air pollution. Other parks in Colorado, including Black Canyon of the Gunnison National Park, Great Sand Dunes National Park and Preserve, and Dinosaur National Monument, face similar vulnerabilities.

Many of these impacts are already happening, as human activities—the emission of heat-trapping gases—are now changing the climate. To preserve our national parks for ourselves and future generations, we need to both stop changing the climate and take actions to preserve the resources and values that make our parks special. For detailed recommendations, see the full report, National Parks in Peril.

the ROCKY MOUNTAIN CLIMATE Organization

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To read the full report on the impacts of global warming on national parks, visit www.nrdc.org/policy or www.rockymountainclimate.org

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Loss of Ice and Snow

As the climate gets hotter, national parks in the North and in mountain ranges are losing snow and ice—one of the most obvious effects of a changed climate on our national parks. Scientific forecasts for future springtime peak snowpack levels across the West are shocking, with projected declines of 30 percent in the higher and colder mountains of the Colorado River basin. In the future, sadly, visitors to Rocky Mountain will be less likely to see snow-capped mountains in summer. Opportunities for snow-based winter recreation are also likely to be reduced: researchers project that for one basin a 7ºF increase in temperature could lead to a 50 percent reduction in the basin's snowpack.

Loss of Water

In the West, a changed climate likely will bring less snowfall, earlier snowmelt, and hotter and drier summers, reducing water availability, especially in the summer when it is most needed by wildlife, plants, and entire ecosystems. In Rocky Mountain, the portion of the park on the western side of the Continental Divide contains the highest headwaters of the main stem of the Colorado River, which scientists project will be especially hit with reduced flows. The park's staff and other experts expect consequences for all park ecosystems. The western side of the park is naturally much wetter than the eastern side, as the prevailing western winds wring water out of air as it is forced up and over the Divide and gets too high to continue holding all its moisture. The resulting lush

forests and meadows on the park's west side support the park's largest populations of moose, pine martens, and other animals, as well as different plant species.

The hotter and drier conditions of the Colorado Plateau are already having dramatic effects on the piñon-juniper forests that are the region's dominant wooded ecosystem. Sustained heat and drought in the early years of this century weakened piñon pines so much that an infestation by a piñon bark beetle has caused widespread regional forest die-back. In 2002 and 2003 alone, heat, drought, and beetles combined to kill 90 percent of the piñon pines in studied portions of Mesa Verde. This region has known drought before and trees have died before, but more trees died in the recent drought than during an even drier period in the 1950s. The difference, researchers say, is that this century's higher temperatures increased the forest die-off. In Colorado, Dinosaur National Monument is similarly vulnerable.

With less water in western rivers, there will be fewer opportunities for boating, rafting, and kayaking, including in Black Canyon of the Gunnison National Park and Dinosaur.

More downpours and floods

With a changed climate, more precipitation now comes in downpours. The amount of rain falling in heavy storms increased by 20 percent over the past century, while there has been little change in the amount from light and moderate storms. In its recent report, the U.S. Global Change Research Program says there is at least a 90 percent likelihood that heavy downpours will become even more frequent and intense. With an increase in downpours, flooding also is likely to increase. Virtually all national parks in Colorado and elsewhere are at risk, as the forecast is for more downpours everywhere.

Loss of Plant Communities

An altered climate can lead to fundamental changes in the natural plant communities of parks, including a disruption of mountain forests, tundra, meadows, and wildflowers, and a disruption of desert ecosystems. A recent U.S. government report and the Intergovernmental Panel on Climate Change point out that rising temperatures increase outbreaks of insects in forests. One such large outbreak, by mountain pine beetles, is killing most large lodgepole pines in Rocky Mountain, as it is across Colorado.

Mountain pine beetles are unusual parasites in that they kill their hosts—in this outbreak, primarily mature lodgepole pines. When conditions are right, large outbreaks can occur, killing most large trees in a forest. Much of today's western lodgepole is vulnerable to such outbreaks, in part because widespread fires and logging in the 19th Century and human fire suppression since then have increased the proportion of mature trees that beetles favor. The changing climate is also making it possible for bark beetles to spread faster and higher. Hotter and drier conditions have stressed trees, making them more vulnerable to beetle attacks. Longer, hotter summers have extended reproductive and growth periods, while fewer cold snaps and higher winter temperatures have permitted increased bark beetle survival in winter, spring, and fall, and infestation of higher elevations. As the report from a recent scientific symposium put it, "Mature forests are the loaded gun for severe bark beetle infestations, and weather is the trigger." One key way in which the current bark-beetle epidemic in Rocky Mountain and elsewhere differs from previous ones is that the beetles now are able to proliferate in high- elevation forests that used to be too cold to sustain epidemic-level populations.

The resulting mountain pine beetle epidemic is especially widespread in Colorado. In 2008, officials of the U.S. Forest Service and the Colorado State Forest Service declared, "At current rates of spread and intensification of tree mortality, the MPB [mountain pine beetle] will likely kill the majority of

Colorado's large diameter lodgepole pine forests within the next 3 to 5 years." A more accurate statement would be that the majority of large lodgepole pine *trees* will be killed; the forests are being changed, but not eliminated. (See below.) Aerial surveys later in 2008 showed that areas infested since 1996 had reached 1.9 million acres—an area half again as large as Delaware—with 400,000 acres newly infested that year.

The infestation has spread across Rocky Mountain**.** The NPS is now spraying thousands of trees a year with an insecticide in high-value areas such as around visitor centers. A campground was closed for over a year to let the NPS remove standing dead trees that could have fallen on campers. Visitors are shocked by the expanses of dead and dying trees. And the park is on its way to losing most of its large lodgepole pines, substantially changing the park's current mixed-conifer forest ecosystem.

Ultimately, though, the forests themselves are not being lost. Post-outbreak forests will recover much as Yellowstone National Park's forests are recovering after large fires in 1988. In Rocky Mountain, researchers from Colorado State University have confirmed that even in areas of heavy beetle infestation, all lodgepole pines under four inches in diameter and some mature ones have survived. The smaller, younger trees now are likely to grow more rapidly without competition from mature trees. Other tree species may move into what have been nearly single-species forests, creating different types of mixed forests. Still, to the extent that this bark-beetle epidemic has spread higher, and perhaps faster and wider than previous outbreaks, it illustrates how ecosystems can be changed, on a landscape-wide scale, when one natural force (the beetle) is no longer held in natural check by another (cold weather).

Another development in western forests recently linked to a changed climate is a rapid dieback of aspen trees that scientists have labeled "sudden aspen decline," which could put at risk the scenic aspen groves of Rocky Mountain. Beginning in 2004, people noticed that aspen trees in Colorado were dying in large numbers and that the dead trees were not regenerating as usual through new trees growing from the roots of the old. This aspen dieback has increased rapidly, with the affected acreage in Colorado having increased four-fold between 2006 and 2008. Research by the U.S. Forest Service has identified the hotter and drier conditions that represent an altered climate in the interior West as likely causes of the sudden aspen decline in Colorado.

A particularly ominous finding is from a team of scientists who recently found in undisturbed western forests that trees of all types and ages are dying faster than they used to. The increase in "background" tree mortality—not caused by fires, insects, wind, or any other obvious agent of forest change—was documented through examinations of census records of all individual trees in 76 undisturbed forest stands with counts of all living trees as far back as 1955. In studied forests, eighty-seven percent of the plots had experienced an increase in the rate of tree deaths; in interior West forests, like those of Rocky Mountain, the dieback rate doubled in 29 years. The researchers suggested that higher temperatures and drier conditions—manifestations of a changed climate—may be the reasons for the accelerated tree deaths.

Alpine tundra—a mountain ecosystem that is treeless because conditions are too harsh for tree growth—may be especially vulnerable to a warming climate. Temperature increases have been greater atop mountains that at lower elevations. As mountaintop temperatures warm, plants adapted for survival there may not be able to tolerate the changed conditions and may have no nearby higher, cooler environments in which to disperse. At the same time, forests may move upslope and overtake the tundra as mountaintop conditions become less harsh and trees have a chance to survive there.

In Rocky Mountain, millions of Americans have driven up Trail Ridge Road, the highest paved through road in the United States, to experience the largest easily accessible expanse of alpine tundra in the United States outside of Alaska. Scientists have projected that a temperature increase of 5.6°F (consistent with a lower-emissions future by the end of the century) could cut the park's area of tundra

in half. They also projected that a temperature increase of 9 to 11°F (possible with a higher-emissions future) could virtually eliminate it.

In work that suggests what could happen in national parks in mountains across the West, researchers at the Rocky Mountain Biological Laboratory near Crested Butte, Colorado—the official wildflower capital of the state—have documented how higher temperatures suppress the growth of mountain wildflowers. Using electric heaters to raise summer temperatures of test plots by 4ºF for more than a decade, they have observed a reduction in wildflowers and their replacement by sagebrush, normally found in lower-elevation, dryer areas. Another study shows that, paradoxically, earlier snowmelt—a result of warmer winters—actually leads to more wildflowers being lost to frost. With earlier snowmelt, the growing season starts earlier and flower buds open sooner, leaving them exposed to mid-spring frosts. From 1999 through 2006, the percentage of wildflower buds lost to frost doubled, compared to the previous seven years.

Loss of Wildlife

For many Americans, the highlight of a trip to a national park is the wildlife they see. But a changed climate could mean less of the wildlife species now in the parks. Some species may go completely extinct, and, local populations in particular parks may be eliminated or decline sharply.

At Rocky Mountain, the National Park Service has expressed concern that the park's bighorn sheep population could decline over time due to loss of open alpine habitat as forests move upslope.

Pikas, which look like hamsters but are more closely related to rabbits, are mountaintop residents unusually sensitive to high temperatures, making them candidates as "early sentinels" to a changed climate. Researchers recently surveying 25 sites in the Great Basin (between the Rocky Mountains and the Sierra Nevada) known to have previously had pika populations failed to find any pikas in nine sites—primarily those at lower, hotter elevations.
As the climate continues getting hotter, this raises concerns for the future of the species at higher elevation parks, also, such as Rocky Mountain. The U.S. Fish and Wildlife Service is now considering whether the species qualifies for protection under the Endangered Species Act because of the threats of climate change.

To American bird-watchers, one of the most accessible and famous population of white-tailed ptarmigan is on the tundra of Rocky Mountain along Trail Ridge Road. Between 1975 and 1999, though, their numbers have been cut in half in response to increases in April and May temperatures and corresponding earlier hatching of ptarmigan chicks. If the same relationship between ptarmigan numbers and increasing temperatures persists, researchers have suggested that the birds could become locally extinct in the park in another 10 to 20 years as temperatures continue rising—although the researchers did not identify a particular cause related to higher temperatures for the birds' decline.

In Mesa Verde, Mexican spotted owls apparently no longer can be found in the park, which the park staff attributes to the drier conditions and altered habitat that represent a changed climate in this region.

An altered climate is likely to reduce inland populations of cold-water fish species, including trout and salmon. For trout in the interior West, a hotter climate is the single greatest threat to their survival; when water temperatures reach the mid-70°s, trout can die. Under a high-emissions future, streams in the Rocky Mountains could warm up enough to reduce trout habitat by 50 percent or more by the end of the century; losses in some regions of the West could exceed 60 percent.

Loss of Historical and Cultural Resources

By preserving some of the best of our historical and cultural resources—buildings, landscapes, archaeological sites, and artifacts—America's national parks provide information about the past and provide important links to the present. Many of these resources are at risk from the possible effects of a climate disrupted by human activities.

Increased downpours, flooding, and erosion likely will increase damage to ancient structures and cause a loss of artifacts. This is particularly true in arid areas like Mesa Verde and Dinosaur, where the land is dry and hard enough that downpours are not absorbed into the soil but instead produce floods and erosion. The results can include a loss of historic and prehistoric structures and, particularly, undiscovered artifacts.

More Overcrowding

As temperatures soar with a changed climate, to escape oppressive heat enough people may flock to cooler mountain parks to overcrowd them. In Rocky Mountain, a survey of park visitors suggests that under the climate conditions projected by as soon as 2020 enough people could come more often and stay longer to increase the number of visitor days by more than one million a year—nearly a one-third increase.

Loss of Fishing

Anglers have long enjoyed fishing amid the natural settings of our national parks. But now a changed climate threatens to reduce fish populations and recreational fishing opportunities in the parks. Populations of trout, a cold-water fish, are threatened with widespread declines because of hotter water temperatures. In the future, if populations of trout species decline as precipitously as scientists project, anglers might face more restrictions on trout fishing in Rocky Mountain and Black Canyon of the Gunnison.

More Air Pollution

A hotter climate is projected to worsen concentrations of ground-level ozone, a component of smog created when pollutants mix in sunlight. Ground-level ozone has been firmly established to harm people's health, and the U.S. Environmental Protection Agency has set air quality standards at the levels necessary to prevent adverse health effects.

Many people think of ozone as a big-city air pollution issue, but it is a problem in many national parks, affecting both the enjoyment and the health of visitors. Rocky Mountain had ozone levels right at (but not violating) the new standard. Because future climate-change driven increases in ozone levels are expected to be greatest where ozone levels already are high, the park is at risk of continued, perhaps worsened, levels of unhealthful air.

For documentation of the sources used for this fact sheet, please see the full report, *National Parks in Peril: The Threats of Climate Disruption*, at www.nrdc.org/policy or www.rockymountainclimate.org.