National Parks in Peril
The Threats of Climate Disruption

State Fact Sheet: California

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 California, Joshua Tree and Yosemite national parks are among the 25 parks most at risk. Joshua Tree is vulnerable to more downpours and floods, a loss of plant communities, a loss of wildlife, a loss of cultural resources, intolerable heat, and more air pollution. Yosemite 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, overcrowding, a loss of fishing, and more air pollution. Other parks in California, including Channel Islands, Death Valley, Lassen Volcanic, and Sequoia/Kings Canyon national parks; Golden Gate National Recreation Area; Mojave National Preserve; and Point Reyes National Seashore 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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September 2009

Loss of Ice and Snow

As the climate gets hotter, national parks in the North and in mountain ranges are losing ice and snow—one of the most obvious effects of a changed climate on our national parks. The Intergovernmental Panel on Climate Change reported in 2007 that glaciers are melting worldwide in response to higher temperatures since 1970. In the United States, glacial melting is concentrated in our national parks, a handful of which contain the vast majority of the nation's glaciers.

In Yosemite and Sequoia/Kings Canyon, six glaciers (along with a seventh just outside Yosemite) lost an average of 55 percent of their area since 1900. After about a quarter century of relative stability, since 1985 the glaciers have been in a period of retreat, which accelerated after the turn of the century. The glaciers' retreat appears to be driven by higher spring and summer temperatures, much more than by reductions in snowfall levels.

Snow-covered mountains are in many parks, where they contribute to some of the most spectacular scenery in the nation. But higher temperatures, less snowfall, and earlier snowmelt are already leading to less snow in parks. One study has documented that springtime snowpack levels have declined across most of the West between 1950 and 1997 as a result of higher winter temperatures. Another study attributed about half of the observed reduction in snowpack to the effects of human emissions

of heat-trapping gases. Scientists project that springtime peak snowpack levels will continue dropping across the West. In the future, sadly, visitors to Death Valley, Lassen Volcanic, Sequoia/Kings Canyon, and Yosemite will be less likely to see snow-capped mountains in summer. Opportunities for snow-based winter recreation are likely to be reduced in these parks also, including Yosemite's Badger Pass Ski Area, the oldest downhill ski area in California and the only one in the national park system.

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. When glaciers disappear and produce no more meltwater, rivers and streams lose reliable late-season flows that are not dependent on the vagaries of the previous winter's snowpack or that summer's rainfall. Yosemite and Sequoia/Kings Canyon could be among other parks suffering a loss of water as glaciers shrink.

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 California and elsewhere are at risk, as the forecast is for more downpours everywhere. Strong storms caused floods that closed Yosemite Valley in January 1997 and May 2005.

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. Bark beetles are unusual parasites in that they kill their hosts—when conditions are right, large outbreaks can occur, killing most large trees in a forest. The changing climate is also making it possible for bark beetles to spread faster and higher. 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."

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. Among the studied forests were those in Yosemite and Sequoia/Kings Canyon. Westwide, eighty-seven percent of the plots had experienced an increase in the rate of tree deaths. 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 California, scientists have documented that the lower edge of the mixed conifer forests in the Sierra Nevada has moved upslope in the last 60 years, with ponderosa pines—the dominant lower-elevation tree of the forests—giving way to oak and chaparral. The change in forest types has coincided with a change in temperature; areas that formerly but no longer have sub-freezing temperatures are where the conifers have given way to other plants. These changes have already reached the lowest elevations of Yosemite.

Mountain meadows exist where the combination of heavy snow cover in the winter and a short growing season in the summer makes it impossible for tree seedlings to survive. Global warming is likely to reduce snow cover and extend the growing season, shrinking alpine meadows. Scientists have already detected that a loss of mountain meadows is underway in Sequoia/Kings Canyon and Yosemite.

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.

Joshua trees need winter freezes to flower and set seeds. In a hotter future, they may not be able to survive in much of their current range, including all or major parts of Joshua Tree. As a result, Joshua Tree National Park may end up with no Joshua trees.

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.

In Yosemite, a pioneering biologist's inventory of mammals early in the 20th century established a rare baseline for assessing changes in which species live where in the park. A recent resurvey shows that about half of the mammal species are now at different elevations. Most have moved to higher elevations—on average, about 500 yards higher—as would be expected in response to the park getting hotter. The Yosemite movements are consistent with changes in wildlife ranges around the world; an analysis of 143 separate studies shows that many species are changing where they live, and more than 80 percent of those changes are consistent with adaptation to a changed climate, such as moving north or up in elevation to stay ahead of higher temperatures

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. This raises concerns for the future of the species at Sequoia/Kings Canyon and Yosemite as the climate continues getting hotter. 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.

Of 80 separate populations of desert bighorn sheep in California about 65 years ago, 30 no longer exist. Scientists have determined that the local extinctions occurred most often in the hottest, driest areas of its former range, as the bighorn has been limited to higher (and therefore cooler) and wetter areas. The probabilities of additional local extinctions are projected to go up the more that California's desert climate becomes even hotter and drier. This warrants monitoring of desert bighorn populations in Death Valley, Joshua Tree, and Mojave National Preserve.

At Rocky Mountain National Park, 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. Other parks where forests could encroach on bighorn sheep habitat include Yosemite, and Sequoia/Kings Canyon.

Researchers from Yale University studied the possible effects of climate change on mammals in eight national parks projected that a doubling of atmospheric levels of heat-trapping gases could change habitat in Yosemite enough to eliminate six species and to add 25 species. A major caveat here, though, is that the researchers did not consider whether there would be geographic or other barriers to species moving into parks. Should as many new species move into parks as the researchers projected, there would be substantial new competition for habitat and food, creating another stress on the native local wildlife.

Worldwide, amphibians appear to be the first large-scale wildlife victims of a hotter climate, in part because higher temperatures promote the spread of a fungus that kills amphibians. In Yosemite and Sequoia/Kings Canyon, researchers have discovered a recent 10 percent decline per year in the population of mountain yellow-legged frogs in park lakes and streams. Most remaining frogs are infected with the same fungal disease becoming more widespread elsewhere. Researchers also link the decline to shrinking snowpacks that dry up ponds and make the frogs more vulnerable to the trout that prey on them. The vulnerability of the frogs to hotter, drier conditions is an illustration of how a changed climate is causing amphibian declines in ways other than promoting the spread of the fungus.

An altered climate is likely to reduce populations of cold-water fish species, including trout and salmon. For trout, a hotter climate is the single greatest threat to their survival; when water temperatures reach the mid-70°s, trout can die. Losses in some regions of the West could exceed 60 percent; Lassen Volcanic, Sequoia/Kings Canyon, and Yosemite could see significant losses.

Wildlife of all types are vulnerable to a variety of other impacts of a changed climate—for example, the effects of a loss of snow and water. Local populations of the Edith's checkerspot butterfly, which inhabits Yosemite and Sequoia/Kings Canyon and other locations in California, have gone extinct in certain areas during extreme drought and low-snowpack years.

Loss of 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 historic structures and cause a loss of artifacts. This is particularly true in arid areas, where the land is dry and hard enough that downpours are not absorbed into the soil but instead produce floods and erosion. The National Park

Service identified in a “Vanishing Treasures” program irreplaceable cultural resources that are “rapidly disappearing from the arid West,” often because they are “in immediate, imminent danger from natural erosive factors.” Parks containing the vanishing treasures include three in California, including Joshua Tree.

Rising seas and stronger coastal storms also threaten cultural resources in coastal parks. Vulnerable are Channel Islands National Park, with archaeological treasures on Santa Rosa Island dating back 11,000 years; Point Reyes National Seashore, with more than 120 known sites of Coast Miwok Indian settlements going back 5,000 years; and Golden Gate National Recreation Area, with historic Fort Mason and portions of the grounds of the Presidio of San Francisco, the oldest continuously used military post in the nation.

Intolerable Heat

As the world continues to heat up, heat itself will become a real problem in areas that are already hot to begin with and could get much hotter. People visiting national parks in these areas will particularly feel the heat, since they typically are outdoors, not in air-conditioned buildings. These parks may simply become intolerably hot for long stretches of the year for many people.

In Death Valley, the hottest place in North America, average high temperatures already are 99°F in May, 109°F in June, 115°F in July, 113°F in August, and 106°F in September. The park’s record high temperature is 134°F. At nearby Joshua Tree, it is nearly as hot, with average high temperatures of 100°F or more in June, July and August. These parks already are too hot for many people during the summer, when the number of people visiting the parks declines while it is going up in most parks. If these hot parks get even hotter because of human-caused changes to the climate, they would be intolerably hot for many people for longer stretches.

Climate models project that these parks are likely to get substantially hotter, especially in a higher-emissions future. Stretches of the country that include Joshua Tree and Mojave National Preserve are projected to average more than 100 days a year over 100°F and to average 90°F or hotter for half or more of the entire year.

More Overcrowding

As temperatures soar with a changed climate, to escape oppressive heat enough people may flock to cooler mountain and seashore parks to overcrowd them. In these parks, the impacts of additional visitation could include less visitor enjoyment and damage to park resources.

Overcrowding could be a significant problem particularly for those parks that offer a break from heat and are close to major population centers, including Golden Gate National Recreation Area, with several beaches in the San Francisco Bay area and 14.5 million visitor-days of use in 2008, and Yosemite, the most visited mountain park in the West, with 3.4 million visits.

Loss of Fishing

Anglers have long enjoyed fishing amid the natural settings of our national parks. In the nation’s coastal parks, fishing for marine species could be affected. 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 Lassen Volcanic, Sequoia/Kings Canyon, and Yosemite.

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. In 2005-2007, Joshua Tree and Yosemite were among 11 national parks with permanent air-quality monitoring stations that had levels of ozone violating the national health-based air quality standards for ozone, as recently strengthened by EPA. Because future climate-change driven increases in ozone levels are expected to be greatest where ozone levels already are high, these parks are 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.rockymountainclimate.org or www.nrdc.org/policy.