

CLIMATE CHANGE

Is Global Warming Causing More, Larger Wildfires?

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On 3 April 2006, the U.S. weekly news magazine *Time* ran a report on global warming with the cover title “Be worried, be very worried.” Similar coverage of global warming has emerged in other general-interest magazines in recent months, triggered by scientific studies that are finding evidence for adverse impacts of global warming occurring today, not merely projected for future decades. These adverse impacts—from higher probabilities of category 4 and 5 hurricanes (1, 2) to higher rates of sea-level rise (3)—are found not in some distant unpopulated region, but rather right in our own back yards.

On page 940 of this issue, Westerling *et al.* (4) come to a similarly discomfoting conclusion for wildfires. They show that warmer temperatures appear to be increasing the duration and intensity of the wildfire season in the western United States. Since 1986, longer, warmer summers have resulted in a fourfold increase of major wildfires and a sixfold increase in the area of forest burned, compared to the period from 1970 to 1986. A similar increase in wildfire activity has been reported in Canada from 1920 to 1999 (5).

Westerling *et al.* used the most comprehensive data set of wildfire occurrences yet compiled for the western United States to analyze the geographic location, seasonal timing, and regional climatology of the 1166 recorded wildfires with an extent of more than 400 ha. They found that the length of the active wildfire season (when fires are actually burning) in the western United States has increased by 78 days, and that the average burn duration of large fires has increased from 7.5 to 37.1 days. Based on comparisons with climatic indices that use daily weather records to estimate land surface dryness, Westerling *et al.* attribute this increase in wildfire activity to an increase in spring and summer temperatures by $\sim 0.9^\circ\text{C}$ and a 1- to 4-week earlier melting of mountain snowpacks. Snow-dominated forests at elevations of ~ 2100 m show the greatest increase in wildfire activity.

The hydrology of the western United States is dominated by snow; 75% of annual streamflow comes from snowpack. Snowpacks keep

fire danger low in these arid forests until the spring melt period ends. Once snowmelt is complete, the forests can become combustible within 1 month because of low humidities and sparse summer rainfall. Most wildfires in the western United States are caused by lightning and human carelessness, and therefore forest dryness and hot, dry, windy weather are the necessary and increasingly common ingredients for wildfire activity for most of the summer. Snowpacks are now melting 1 to 4 weeks earlier than they did 50 years ago, and streamflows thus also peak earlier (6, 7).

Westerling *et al.* found that, in the 34 years studied, years with early snowmelt (and hence a longer dry summer period) had five times as many wildfires as years with late snowmelt. High-elevation forests between 1680 and 2690 m that previously were protected from wildfire by late snowpacks are becoming increasingly vulnerable. Thus, four critical factors—earlier snowmelt, higher summer temperatures, longer fire season, and expanded vulnerable area of high-elevation forests—are combining to produce the observed increase in wildfire activity.

The fires in Yellowstone Park in 1988 (see the first figure) seemed to inaugurate this new era of major wildfires in the western United States. The fires lasted more than 3 months, burning 600,000 ha of forest, and—despite

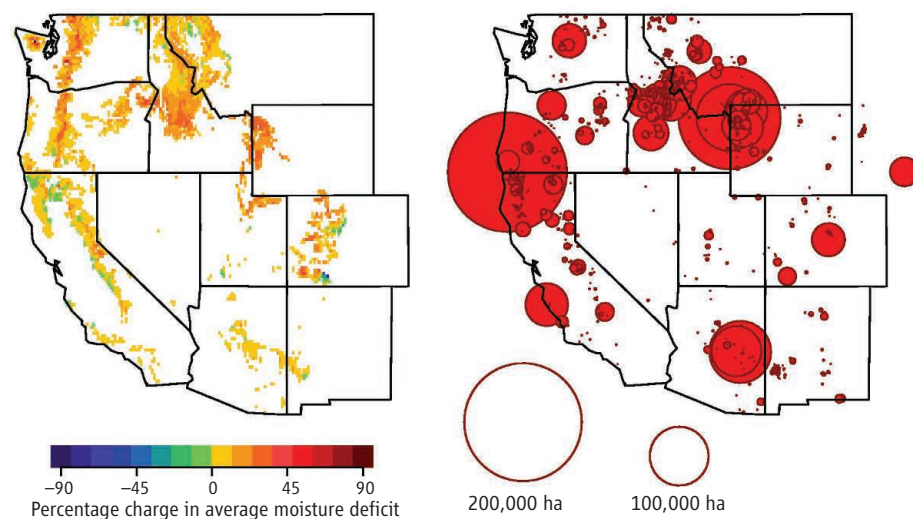
Higher spring and summer temperatures and earlier snowmelt are extending the wildfire season and increasing the intensity of wildfires in the western United States.



Too close for comfort. Wildfire is seen approaching Old Faithful Village, Yellowstone National Park, in 1988.

the investment of \$120 million and deployment of 25,000 firefighters—were only extinguished when snow began to fall in mid-September (8).

The Yellowstone fires exemplify a common statistic of wildfires: Less than 5% of all wildfires account for more than 95% of the area burned. A small fraction of fires get very large and become uncontrollable despite human efforts to suppress them, regardless of money expended. Such efforts can cost more than \$20 million per day, and seasonal expenditures by governmental agencies in recent years have reached \$1.7 billion.



Less moisture—more fires. Between 1970 and 2003, spring and summer moisture availability declined in many forests in the western United States (left). During the same time span, most wildfires exceeding 1000 ha in burned area occurred in these regions of reduced moisture availability (right). [Data from (4)]