Rising temperatures bump up risk of wildfires

By Melanie Lenart and Zack Guido

Note: CLIMAS Associate Staff Scientist Zack Guido adapted and updated this article from a version by Melanie Lenart that was published in the Southwest Climate Outlook in 2006. The scientific results and statements from local experts remain unchanged.

A bolt of lightning singed the dry earth in 2005, sounding the death knell of the Grand One. The resulting Cave Creek Fire raced through knee-high grasses and shrubs, burning nearly 250,000 acres in the Arizona Sonoran Desert, including the site where the Grand One had stood for an estimated 150 to 200 years. The world's largest recorded saguaro, standing 45 feet tall and nearly 7 feet wide, could not withstand the flames, finally collapsing to the desert floor in 2007.

Other recent blazes have consumed large swaths of forests, deserts, and grasslands in the Southwest. In 2000, a fire burned 47,000 acres around Los Alamos, New Mexico, destroying about 260 homes and requiring the evacuation of about 20,000 people. Arizona's largest fire on record, the 468,000 acre Rodeo-Chediski Fire in the northern part of the state, destroyed about 400 homes and forced the evacuation of 30,000 people in 2002.

With dry conditions prevailing in many regions in the Southwest this winter, wildland fire fighters are gearing up for a potentially active season. This may be a harbinger of the future, as the number of wildfires is expected to increase as a result of warming temperatures.

Figure 1. The world's largest recorded saguaro cactus burned during the 2005 Cave Creek Fire outside of Phoenix and later died. Image source: Stephanie Doster, Institute of the Environment.

The fuel factor

In the forest, it takes about 40 hot, dry days (roughly 1,000 hours) to convert fallen branches on the forest floor into flammable material that will magnify a fire's heat—perhaps enough to ignite live saplings. These saplings, in turn, can become ladders to lift the flames into the crowns of established trees. Branches and logs from three to six inches in diameter are the "1,000-hour fuels" that firefighters worry about when gauging forest fire danger and evaluating whether a surface fire might spring into a crown fire.

Seasonally, fire danger fluctuates with the moisture condition of grasses and downed wood, respectively known as fine and heavy fuels in firefighter parlance. At longer time scales, explosive growth of saplings makes southwestern forests more prone to large-scale crown fires.

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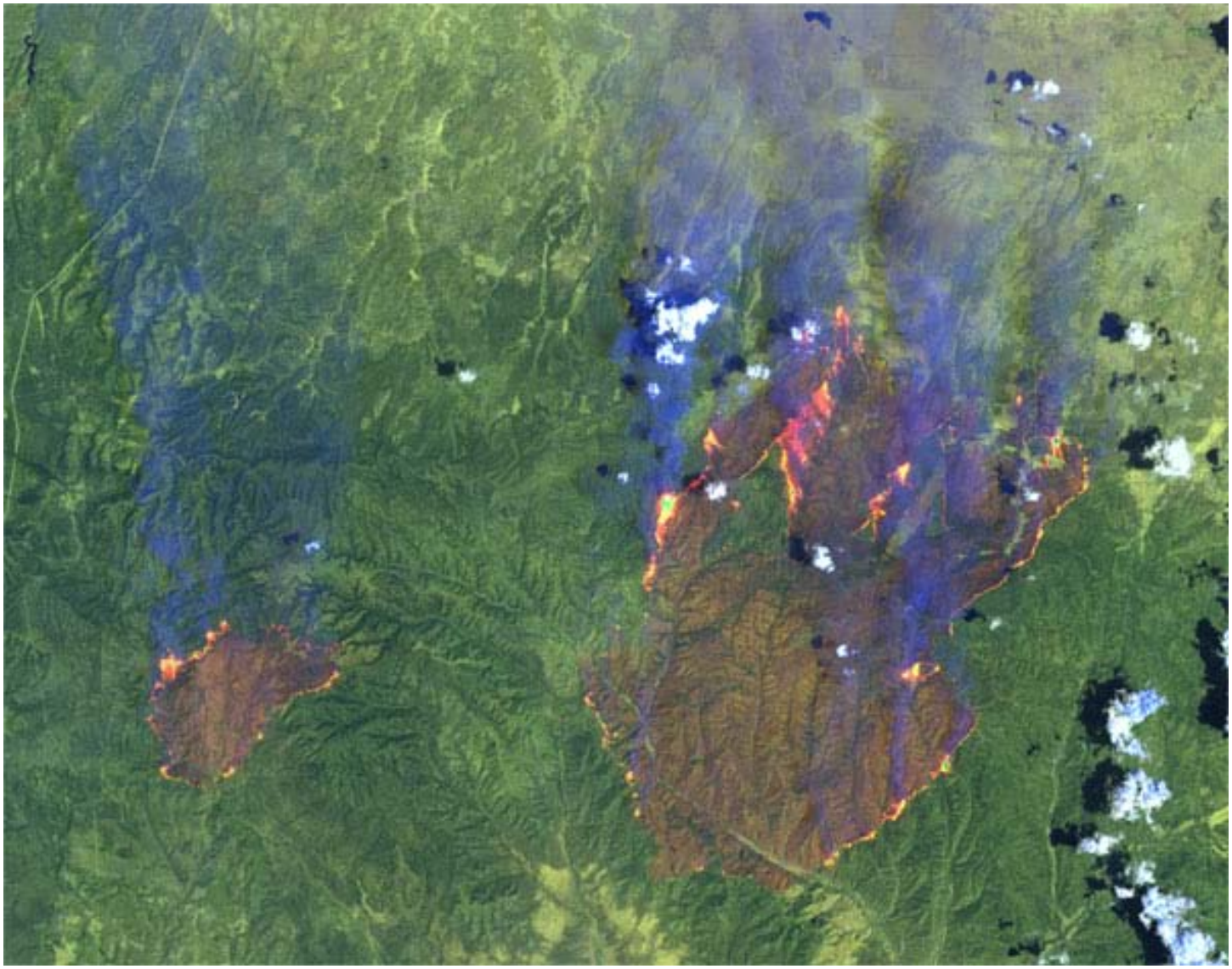

Figure 2. The Rodeo-Chediski Fire was the largest wildland fire on record in Arizona. It burned 468,000 acres in northern Arizona, destroyed about 400 homes, and forced 30,000 people to evacuate in 2002. This image is from June 21, 2002. Image credit: Jesse Allen, NASA.

The bark beetles and drought that killed millions of pines in recent years appear to have contributed to reducing fire risk—at least temporarily—by reducing the amount of flammable foliage in the forest.

"If you don't have a canopy—all you have is dead sticks sitting up there—you probably decrease the risk of catastrophic crown fires," said Neil Cobb, professor in the department of biological sciences at Northern Arizona University. However, once the beetle-killed trees start falling to the ground, their wood will join the 1,000-hour fuels that potentially can ignite future conflagrations.

Climate variability and change also influences fuel build-up to an extent that makes it difficult for people to reduce fire danger on the regional scale without allowing a return to the natural fire regime. Global warming is likely to increase climate variability, with larger swings from wet to dry and back again. Some project global warming will increase the magnitude of events associated with El Niño and La Niña.

Records compiled from historic observations, tree rings, and charcoal deposits all indicate large climate swings boost the potential for severe fires in highland forests. Wet periods encourage abundant growth in forests—many small trees pop up to celebrate the moisture. This increases the risk of stand-level drought during dry periods that follow, with a multitude of tree stems drawing from the same pool, like too many straws in a drink.

When it's hot

Temperature has an established link with fire danger on several fronts. Fires light more readily when the sun is beating down and raising daily temperatures. Lightning bolts fly more often with

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higher temperatures, too, providing more opportunities for fire ignitions. And fires can spin out of control more easily when overlying air is warm, especially in the absence of cool nights that help the fire to "lay down."

In 2006, researchers reported that the number of large western wildfires tends to move up and down with spring and summer temperatures, based on U.S. Forest Service and National Park Services data from 1970 to 2003. The groundbreaking paper published by Anthony Westerling and colleagues, including the UA's Thomas Swetnam, linked the earlier snowmelt during warmer-than-average springs and summers to an increase in large, western wildfires, especially since the mid-1980s.

In another analysis, published in 2004, which included 11 western states, New Mexico and Arizona were among the most sensitive to temperature effects on the annual "area-burned"—the amount of land crossed by fire in a given year. U.S. Forest Service researcher Donald McKenzie and colleagues found higher temperatures led to a "sharp increase" in area-burned in the historical record, using data spanning 1916 through 2002. New Mexico's annual area-burned fluctuates with spring temperatures in particular, the analysis by McKenzie and colleagues showed.

Similarly, research by the University of Arizona's Michael Crimmins and Andrew Comrie in 2004 found low-elevation fires in southern Arizona increased during warm springs when they followed wet winters.

Warm air also can generate winds that fan a blaze, potentially turning a small fire into a firestorm.

"If you have warmer surface temperatures, the atmosphere is more unstable. That's more conducive to strong convection and to blow-up fires" like the Rodeo-Chediski, said Charles Maxwell, fire weather program manager for the Southwest Coordination Center.

A warm surface, whether caused by a fire or a mountainside baking in the hot summer sun, will lift air parcels up into the atmosphere. A fire tends heat and lift air parcels faster, which adds to the instability. The ascent of these air parcels leaves a void that surrounding air quickly moves to fill. These winds further fan the flames.

Warmer air also tends to increase the incidence of lightning, which causes about 80 percent of the fire starts in the West. However, lightning strikes remain relatively unpredictable despite their importance in igniting western wildfires.

Looking to the future, observed links between warm temperatures and fires spark concern for the impacts of global warming.

Woody materials are likely to remain dry longer as the climate warms, Timothy Brown of the Desert Research Institute in Nevada and colleagues projected, based on the expected impact of warmer temperatures and their influence on relative humidity. Their modeling experiment focused on forests, comparing conditions for two decades through 1996 to those projected for two decades through 2089 using a global warming scenario.

"The key thing was an increase in the number of days of high fire danger," Brown said. "We basically found throughout the West that the number of days increased by about two to three weeks."

When it's humid

Air temperature also wields an important effect on relative humidity.

Hot air can hold more moisture than cool air, which is partly why higher daytime temperatures are linked to higher evaporation rates. Conversely, when air cools during the night, its relative humidity increases, sometimes to the point of saturation. If the air drops down to the dewpoint temperature, some of the moisture it contains will condense into dew, fog, or some other form of precipitation.

Whether moisture condenses or not, higher relative humidity levels reduce fire danger.

"In the evening, temperatures will go down and the humidity levels will start to increase again. We call it a recovery. If we have not much of a recovery at all at night, we can have active burning during the night and this can also make it worse the next day," said Gary Daniel, Tonto National Forest fire manager.

Both global warming and the urban heat island effect tend to boost nighttime temperatures more than daytime temperatures. That's because greenhouse gases and concrete absorb solar radiation. After a long day of solar heating, they release some of the energy they've collected as infrared radiation—in other words, heat. This is most noticeable at night, once the sun's direct rays are out of the picture.

Recent temperature trends in the Southwest amount to warming of a few degrees Fahrenheit in the last 100 years. For many, this small change is imperceptible. To the landscape, it is tactile. More and larger fires have been charring the region than in the past, some with devastating effects like the Cave Creek and Rodeo-Chediski fires.

Whether or not this year contributes to increasing trends is anyone's guess. But conditions look ripe for an active fire season. Both temperature and precipitation forecasts for the next several months show increased chances for above-average temperatures and below-average rainfall. If these expectations unfold, more saguaros, like the Grand One, could find themselves in the path of fire.