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Fierce and Unpredictable: How Wildfires Became Infernos

Sara McAllister and Mark Finney, researchers at the Missoula Fire Sciences Laboratory in Montana, demonstrate a fire whirl in an effort to better understand how wildfires spread. Lido Vizzutti for The New York Times

By Jim Robbins

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MISSOULA, Mont. — In a large metal warehouse, Mark Finney opens a tall, clear glass tower and pours alcohol into a tray at the bottom and lights it. When he closes the door, an open vent at the bottom sucks in air and suddenly fire spirals upward, a narrow column of flame 12 feet tall.

In the wild, these fire whirls are unpredictable and dangerous. An exceptionally powerful whirl in late July during California's unrelenting Carr Fire whipped winds up to 143 miles per hour, roaring and spinning for 90 minutes and scooping up ash, debris and flames. It uprooted trees, stripped the bark off them, and downed power lines. The whirl, sometimes nicknamed a "firenado," was so large it was picked up on Doppler radar.

At the Missoula Fire Sciences Laboratory, Dr. Finney and other researchers are recreating and studying whirls, as well as the paths that out-of-control blazes cut through millions of acres of forests and grassland in the West. The scientists are racing to develop a deeper understanding of the combined effects of a warmer climate, massive tree die-offs that feed the wildfires, and developments encroaching into the wilderness.

“Nature hides its mysteries pretty well,” Dr. Finney said. “It’s hard to believe, but the physics of how fires behave is largely mysterious. We’re in the days before the Enlightenment in this field. We need better science.”

Dr. Finney, right, and Randy Pryhorocki, a machine tool operator, creating fire whirls on a sand burner in the Missoula lab. Credit: Lido Vizzutti for The New York Times

Big fires burn differently than small fires: logs, branches and other sources of fuel behave differently at varying temperatures. And wildfires often exhibit nonlinear behavior or act counterintuitively. The lab here hopes within a few years to create a new computer model that can better represent these mind-bogglingly complex behaviors and help anticipate their patterns.

In recent years, the researchers have found to their surprise that the energy release rate of a wildfire is variable. “As it gets bigger, it burns fuel at a higher rate, and that means they are a lot less predictable than we thought,” Dr. Finney said.

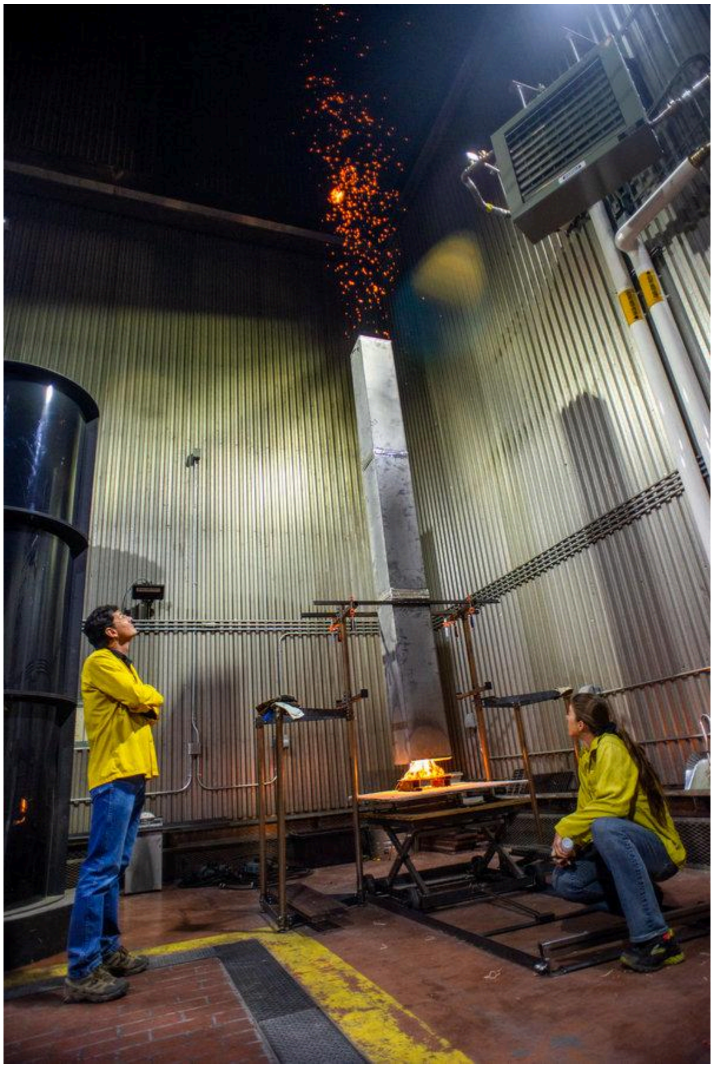
The need for more scientific analysis couldn’t be more urgent. California this year is experiencing an unprecedented season, with 17 fires burning and the Mendocino Complex fire now the largest in state history. Yosemite National Park was closed because of the Ferguson fire, and was scheduled to reopen only on Tuesday.

Researchers believe that the hundreds of millions of trees killed by bark beetles in the West — an estimated 129 million in California alone — will cause even more severe fires as they collapse. “A giant heap of dead forest is a new reality,” Dr. Finney said.

Immense piles of long-burning wood and underbrush can suck in air from below "like a forge," Dr. Finney said, quickly twisting into a violent fire whirl and burning three to eight times faster than a routine blaze.

During a fire, heat rises in a vertical column, and as it rises and cools, it pulls in more hot air at the bottom and can create enough energy to begin spinning.

A fire whirl can pick up and toss around a fire truck. In 1989, near Susanville, Calif., a fire whirl swept up four firefighters, burning them seriously.



Dr. McAllister, right, and Dr. Finney burn a pressed square of shredded wood through a chimney to study the paths embers take.
Credit: Lido Vizzutti for The New York Times

"The fuel conditions we're seeing have implications for fire behavior beyond our current understanding and models," Dr. Finney said. "It can lead to fire behaviors beyond any kind of control."

The bombing campaigns of World War II offered a guide to fire spread. Military researchers would use aerial photos to study structures in German and Japanese cities and plan their attacks accordingly. "They learned how to bring cities down by creating firestorm conditions," Dr. Finney said. "They learned a lot, and it's directly related to very large forest fire behavior."

Another factor under examination is the "spotting" behavior produced by embers. Increasing amounts of deadwood are leading to more spotting — the shower of hot embers that high winds pick up from burning trees and scatter a mile or two in front of the flames. These showers set homes, forests and everything else in their path on fire.

The Sundance fire in Idaho in 1967 cast embers eight miles in advance of the flames, and in Australia some eucalyptus trees — which also grow throughout California — have been shown to spot 10 to 15 miles in front of a blaze. Their characteristic papery bark catches fire first, splintering and soaring into the sky like flaming paper airplanes.

Firefighters battling the Carr fire near Redding, Calif., last month. Credit: Mark Ralston/Agence France-Presse — Getty Images

Even the more normal spotting range of a mile or two signals that many homes and many cities that are within a forest — like Redding, Calif. — can be devastated by spotting and fast-moving flames. “It pretty much renders fire containment impossible,” said Dr. Finney.

Researchers at Oregon State University are studying the physics of ember generation and transport to better predict which forest types in different conditions will generate firebrands and where they will rain down.

“They are a major method of fire spread,” said David Blunck, an assistant professor of mechanical engineering at the university. “If there are structures a certain distance from the fire, it would be ideal to know the risk from spotting in order to evacuate or put in defenses.”

Juniper trees, with their lacy foliage and flammable oils, produce some of the hottest embers and are not recommended for planting near houses in fire zones.

Fire weather is not well understood, either.

“We’re finally getting meteorological observation on active wild fires, which we have never had,” said Craig Clements, a fire meteorologist at San Jose State University. “There has been a lack of data on wildfire unlike any other atmospheric phenomenon, such as tornadoes and hurricanes.”

Extreme fires can occasionally create so-called pyrocumulus clouds above the flames, which sometimes bring severe thunderstorms, including lightning, which in turn can start more fires. The clouds have been seen forming above California’s fires this season.

A wildfire in the Texas Panhandle earlier this year was so strong it created an especially powerful thunderstorm called a supercell that included one-inch hail and high winds.

Even the basics of flame spread are being studied. “We still have a hard time describing a pile of sticks burning, let alone a complex fuel bed of trees and shrubs,” said Sara McAllister, a research mechanical engineer at the Missoula lab.

With better forecasting, experts hope people will find fires less overwhelming and frightening, and be more accepting of controlled burns to keep wildfires from becoming catastrophic.

Before widespread human settlements, fuel buildup in the forests would be reduced by frequent, low-intensity fires every decade or two. Now, after a century or more of fire suppression and recent widespread tree die-offs, there is so much fuel that when a fire occurs, it is larger and more intense — not only destroying property, but damaging the natural systems of which it was once an integral part.

Dr. McAllister, seated, and Dr. Finney, center, with Mike Heck, a graduate student at the University of Maryland, watch flames move across a sand table in a wind tunnel at the Missoula laboratory.Credit: Lido Vizzutti for The New York Times

“We’ve taken an ecosystem that was sustained by fire,” said Dr. Finney, “and turned it into one that is destroyed by fire.”

A recent study documented the effects of severe fires on lichen, for example. It grows on the surface of trees and rocks, providing food for wildlife like flying squirrels and helping improve nitrogen in forest soil.

While lichen tolerated less severe fires, researchers found, growth did not return as long as 16 years after major fires.

Major home developments in the wild-land-urban interface — in and near the forest — have mushroomed, making it far more difficult for firefighters to protect such vastly populated areas during a fast-moving blaze.

There's no doubt a warmer world is changing the nature of fires, even if it's not the main culprit. California just set an-all time record for high July temperatures, and fuels in the forest are drier than they have ever been.

Triple-digit temperatures "preheat the fuels, and it makes them much more receptive to igniting," said Scott L. Stephens, a fire ecologist at the University of California, Berkeley.

The heat also appears to be changing nighttime fire behavior.

"There are more nights of not having recovery," he said. "At night, the sun goes down, temperatures go down and humidity goes up. You could count on that to make sure you could do suppression activities. But fires now have so much severe behavior at night, almost the same as the day."

He pointed to the Valley Fire that swept through Lake County California in 2015. "It moved uphill in the middle of the night and caught people off guard," Dr. Stephens said.

While warmer temperatures are a factor, Dr. Finney said, we shouldn't just throw up our hands. "The climate is changing, there's no dispute about that," Dr. Finney said. "But it becomes an excuse to do nothing."

Thinning forests with heavy equipment or hand crews helps reduce fire severity, but in the end the only way to solve the problem of these big fires "is to remove the materials that carry fire, with prescribed or managed fire."

Lido Vizzutti for The New York Times

https://www.nytimes.com/2018/08/13/science/wildfires-physics.html