



One Year Later, Fire Research Continues to Support the Community

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One year after the 2025 Los Angeles fires, Caltech researchers are pressing forward with research projects to provide answers in service of public health and safety. Through investigations that included testing for heavy metal contamination, monitoring air quality, and assessing the burn area's erosion hazards, Caltech scientists immediately launched into action in the days and weeks following the fires, bringing scientific tools and expertise to tackle fundamental questions for the broader public—even as many of these individuals were impacted by the fires themselves.

"The Eaton and Palisades fires were a tragedy for so many in the Caltech-JPL community, as well as our many friends and neighbors, yet that disaster inspired some of the most magnanimous acts of goodwill I've personally experienced," says John



Francois Tissot surveys his damaged home after the Eaton Fire, clad in safety gear. Tissot's research demonstrates that lead and other toxic metals were carried by the fire's smoke into homes even outside of the burn zone.

Eiler, the Robert P. Sharp Professor of Geology and Geochemistry and Ted and Ginger Jenkins Leadership Chair of the Division of Geological and Planetary Sciences (GPS). "Our community came together to help each other with housing and all manner of other needs, while simultaneously directing our skills and energy as scientists at societally important problems created by the fire—the unique and poorly understood sources of pollution, life-threatening debris flows, and more. This scientific effort addressed questions faced by everyone living in the Los Angeles region, involved truly remarkable innovations and discoveries, and provided a much-needed means for us to focus our attention on helping others. The action of the Caltech community, particularly the program of rapid response research, required a tremendously open-hearted outpouring of support from friends of the institute, and I think was possible only because our small size and close connections with each other allowed us to mobilize for science in service to the community."

Measuring Heavy Metal Contamination

A few miles north of Caltech's campus, the 14,000-acre Eaton fire burned thousands of structures that were built before 1978, the year lead began being regulated in building materials. When the fire struck, lead and other toxic heavy metals were released into the air as structures burned. After the fire was contained, nearby residents living outside of the burn zone were concerned that the smoke had deposited these toxic chemicals in and around their homes. Lead, in particular, is highly toxic for young children; [Environmental Protection Agency \(EPA\) regulations](#) allow for only 5 micrograms of lead per square foot of dust on floors and 40 micrograms per square foot on windowsills.

After evacuating his family from his Altadena home, Caltech's Francois Tissot, professor of geochemistry and a Heritage Medical Research Institute Investigator, sent a message to his lab members. "I asked my team to let me know if anyone was interested in using our resources to help assess the hazards from the fire, ash, and smoke," he says. "Everyone immediately said, 'yes.'"

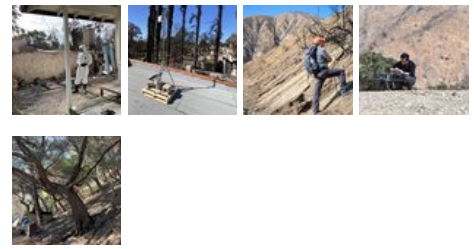


Francois Tissot surveys his damaged home after the Eaton Fire, clad in safety gear. Tissot's research demonstrates that lead and other toxic metals were carried by the fire's smoke into homes even outside of the burn zone.

Credit: Courtesy of F. Tissot

their technology to study bulk ash samples taken outdoors, as well as finer dust samples taken from surfaces in homes in and around the burn area. Led by graduate student Merritt McDowell and postdoctoral researcher Theo Tacail, the team worked with local residents to take samples from 52 homes within five weeks after the fire.

Credit: Courtesy of F. Tissot



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As a cosmochemistry laboratory, the Tissot group has access to sophisticated instrumentation to measure concentrations of elements in samples. Normally used to examine meteorites and other ancient objects from the early solar system, the team turned

Many insurance companies refused to cover professional testing for homes outside of the immediate burn area, but Tissot's lab provided these measurements to residents free of charge thanks to support from the Caltech GPS division.

Lead in dust on surfaces can be remediated with straightforward cleaning processes in cases of moderate contamination levels. However, lead in smoke can pervade a building's walls and other porous materials, becoming re-released into the indoor air. Testing, therefore, was critical to understand the levels of remediation necessary.

"The tools we have in the lab are extremely complex, but the first measurement we always make is a concentration measurement," Tissot says. "We need to know how much of an element is in the sample, so that we know what to do with it. How much lead, how much of the heavy metals, how much of the toxic elements have been released by this particular fire? Here, this was the crucial question. We started working on it immediately."

McDowell and Tacail worked quickly to process over 300 samples taken from different surfaces in the 52 homes. The team discovered unsafe levels of lead, above the EPA limits, on homes as far away as 7 miles from the burn zone. Within a month after sampling, the team presented their preliminary findings in a Caltech Science Exchange [webinar](#) attended by hundreds of community members from Caltech and fire-impacted communities.

Another graduate student, Isaac Aguilar Rivera, is developing a project to support the lead testing process. Aguilar, who is a student in the laboratory of Julia Tejada, assistant professor of geobiology and a William H. Hurt Scholar, is developing an X-ray fluorescence technique that can be attached to a drone and flown over burned areas to remotely measure the presence of lead. The technique has its challenges in determining exact concentrations, so Aguilar is benchmarking his data with the precise measurements collected by Tissot's team.

The team will return to the same homes in January 2026 to resample the same areas and compare lead levels a year after the fires. In the meantime, Tissot has begun collaborations with colleagues in atmospheric chemistry and atmospheric dynamics to combine their lead data with a model of dust dispersion and transport. The goal is to build a tool that can be used in other urban firestorms to assess risks from heavy metals, particularly lead, carried by smoke plumes.

"It's interesting how we can leverage the same knowledge from solar system formation to fire dynamics," Tissot says. "The fires are going to become an important project within my group for the next few years. It takes time for the data to be impactful, for us to have interactions with policymakers and government officials. We need to make sure the data we produce has an impact beyond just helping people locally and improves responses for all future fires, because they will continue to happen. We want to get our data in front of the people who have the power to make decisions."

Monitoring Air Quality

Caltech researchers have studied the air quality in and around Los Angeles since the 1940s, when the late Arie Jan Haagen-Smit, professor of chemistry, first began work that ultimately helped define the nature of smog and led to its regulation. During the January 2025 wildfires, many existing air-quality monitors in the Altadena area were destroyed. Air-quality researchers in the laboratory of Paul Wennberg, Caltech's R.

Stanton Avery Professor of Atmospheric Chemistry and Environmental Science and Engineering, immediately began work on a new project to provide air-quality data to the community in the fires' aftermath.

Led by graduate student Haroula Baliaka and research scientist Coleen Roehl, the team deployed a network of low-cost, solar-powered sensors throughout Altadena called PHOENIX (**P**ost-fire airborne **H**azard **O**bservation **E**nvironmental **N**etwork for **I**ntegrated **X**posure-monitoring). These sensors detect and measure the concentrations of particulate matter in the air based on the particles' sizes, which range from 1 to 10 micrometers across.

Breathing in particulate matter has a negative impact on health; previous studies show that exposure to contaminants released in urban wildfires is linked with worsening of respiratory and cardiovascular outcomes like asthma and chronic obstructive pulmonary disease. Air-quality data is thus crucial for individuals to know when it is safe to go outside, and when they should probably wear a mask.

The sensors were installed on top of homes and other local buildings, and community members were eager to participate. Within a month after the fire, the team had worked with 28 different business owners and residents—including Roehl herself—to install PHOENIX sensors.

"As an Altadena resident and atmospheric scientist, I was strongly compelled to participate in the PHOENIX project and to help in providing critical air-quality data to my community," Roehl says.

The PHOENIX data in the weeks after the fire showed that, on average, low levels of particulate matter in the air were recorded for the majority of each day, with concentrations classified as "good" by the EPA. However, the sensors showed that concentrations tended to spike



A PHOENIX air quality monitor is mounted on a building in the aftermath of the Eaton Fire. The effort to provide air quality data to the community was rooted in local participation.
Credit: Haroula Baliaka

into unhealthy levels at certain times of day for up to 60 minutes, usually in the morning. Baliaka suggests that this phenomenon was potentially associated with clean-up activities and construction trucks kicking up dust and other particles as they rumbled through town.

"PHOENIX was the most rewarding thing I did during my PhD," Baliaka says. "It was very community driven, speaking to the residents and hearing their stories. It's rewarding to be able to provide them with the data they need to make decisions for their health."

As a student in the Wennberg lab, Baliaka's research focused on air-quality measurements even before the fires. In particular, she utilizes a nationwide network of sensors, called ASCENT ([Atmospheric Science and Chemistry mEasurement NeTwork](#)), each composed of multiple instruments that detect not only particulate concentrations but the composition of those particles. Wennberg, along with Richard Flagan, the Irma and Ross McCollum-William H. Corcoran Professor of Chemical Engineering and Environmental Science and Engineering; and John Seinfeld, the Louis E. Nohl Professor of Chemical Engineering, Emeritus, are principal investigators at the Los Angeles node of ASCENT, located in Pico Rivera, 13 miles from the burn area. ASCENT is funded by the National Science Foundation and was created by Caltech alumna Sally Ng (PhD '07) of the Georgia Institute of Technology.

In the aftermath of the Eaton fire, Baliaka looked at the data from the Pico Rivera ASCENT site and was surprised to find that potassium levels in the air, usually a signal of a wildfire, were not as high as she expected. But then, she looked at lead levels. ASCENT measured lead levels 10 times higher than usual for the area, confirming that the burned buildings did in fact release lead into the air throughout the Los Angeles region.

As Altadena rebuilds, the team is continuing to monitor the air quality during construction.

"We want the members of our local Pasadena community to have access to trustworthy air-quality data," Wennberg says. "We anticipated that having high-quality data available would help build confidence in the quality of the cleanup work undertaken by the Army Corp of Engineers."

Erosion and the Fire-Flood Cycle

On New Year's Eve 1933, millions of tons of mud and rock swept from the San Gabriel Mountains through the Crescenta Valley after a major winter storm hit the area. The region, which had been burned the previous year by wildfires, was inundated by debris flows. The catastrophic flows of mud and rock destroyed an estimated 483 homes and killed at least 42 people.

This event was an example of the so-called fire–flood cycle, in which a burned landscape produces a burst of flooding and erosion during its first major rainstorm following a fire. While the process is not limited to California, the Los Angeles area is one of the most well-studied examples. In the aftermath of the Eaton fire, researchers knew that the region could expect serious debris flows with the next rainstorm.

Back in the 1930s, after the Crescenta Valley flood, Los Angeles County built large basins at the foot of the mountains to trap and contain the surging debris flows before they reach residential neighborhoods. Today, there are about 120 of them along the San Gabriel Mountains. After the Eaton fire, the question emerged: Would these engineered debris basins be sufficient to contain the coming debris flows, or would residents need to evacuate?

"In February, after the fire, the weather report was indicating a major rainstorm was coming, and we were particularly worried that the catchment above the Sierra Madre Dam might be too small to contain the coming debris flows," says Emily Geyman, a graduate student in the Caltech laboratory of Michael Lamb, professor of geology. As an ultrarunner, Geyman had run through the San Gabriel Mountains every weekend during her three years at Caltech prior to the fire; now, she returned to the trails to measure their erosion.



Lamb came to Caltech in 2009, shortly before the 160,000-acre Station Fire burned in the Angeles National Forest, located in the mountains north of Caltech. Lamb, a

Mike Lamb surveys a burned slope after the Eaton Fire. Lamb and his team study how sediment from burned mountainsides piles up to become debris flows after rain.

Credit: Emily Geyman

geomorphologist, studies how mountains erode, and how to translate that science into the development of hazard assessments for public safety. The San Gabriel Mountains are among the fastest-eroding mountain ranges in the US, and urban development has spread right up against the mountain front. After the Eaton fire, Lamb, Geyman, and postdoc Zhiang Chen began to run computer models of the mountains to understand the expected volume of debris flows to come.

Lamb's team tested a new model of how fire leads to increased erosion in the San Gabriel Mountains. These mountains are steep, meaning that soil can only build up on their slopes when held there by vegetation (the nearby Santa Monica Mountains, in contrast, are less steep and accumulate soil differently). When the vegetation burns, the loose soil and rock tumbles downhill. These dry piles of sediment then simply need a large rainstorm to become a catastrophic debris flow.

With this model, the team calculated the expected sizes of upcoming debris flows by using drones to measure the amount of dry sediment that had accumulated in the channel network. The work was carried out with support from local, regional, and federal government agencies—including the Los Angeles County of Public Works, the California Geological Survey, and the United States Forest Service. Indeed, their model correctly predicted the volume of debris flow during the next rainstorm—more than 677,000 cubic meters, or enough to fill more than 270 Olympic-sized swimming pools with mud, sand, and boulders.

The predictions also proved correct for the Sierra Madre Dam. Prior to the February rainstorm, county crews worked around the clock to excavate the dam and create more space to catch the debris. Their work was fortunate: The basin did fill up and slightly spill over its capacity, but it protected the nearby residents from catastrophic levels of debris flows.

The team is now developing a method that can be applied to other fire-prone mountain ranges. This project will involve scanning mountains with drone laser altimeters (sensors that use laser light to measure elevation) in the immediate aftermath of a fire and calculate how much sediment could fuel an upcoming debris flow.

Due to a combination of climate change and increasing human development at the boundary with wildlands, the frequency of wildfire in California has increased fourfold in the last century. However, the team's new model suggests that there may not be an analogous increase in the sizes of post-wildfire debris flows.

"At least in the steep and rocky terrain such as the San Gabriel Mountains, more frequent wildfire may actually lead to smaller post-fire debris flows because the post-fire erosion is exhausting the stores of loose soil—the fuel for debris flows—faster than the soil can reform,"



Zhiang Chen prepares a drone that will survey the burned region and measure built-up soil and sediment. After heavy rains, this material can turn into catastrophic debris flows.

Credit: Emily Geyman

Geyman says. "There are implications for whether or not debris flow hazards will increase or decrease in the coming decades, and whether our debris basin infrastructure in LA needs to be expanded."

Lamb presented his research on the science of debris flows in a [sold-out Watson Lecture](#) for the community in late January 2025.

"Our work at Caltech is building on decades of studies from others, most notably state and federal government scientists, and the Herculean efforts by LA County Public Works to literally move mountains of rocks," Lamb says. "Collectively, the continuation of government-supported science and debris-basin defenses is needed for us to live in the beautiful landscapes at the foothills of the San Gabriel Mountains."

The Ecology of Recovery

A year after the fires, remediation and rebuilding in Los Angeles is underway. Hundreds of Caltech and JPL community members were directly affected by the disaster, and efforts to provide actionable insights often hit close to home for Institute researchers.

As the community rebuilds, wildlife does as well. Caltech entomologist Joe Parker, professor of biology and biological engineering, has spent eight years studying ant colonies that are crucial to the ecology in the Angeles National Forest. After the Eaton fire, he and his team returned to the area and assumed that the ecosystem they studied had been destroyed.

However, while a few of the team's field cameras were lost to the fire, the team was surprised to find that the majority of the ant colonies—13 of the 15 they studied—survived. These colonies of millions of worker ants build complex nest structures inside Coast Live Oak trees, and Parker studies the complex symbiotic relationships that they develop with certain beetle species. His team has been sequencing the genome of multiple ant colonies throughout the region, and they have now collected genome data on the surviving colonies to study how they may have been affected by and survived the burn.

"Fire is an intrinsic part of the ecology of natural ecosystems in Southern California, and the oaks are clearly adapted to withstand burns," Parker says. "It was amazing to see how the ants were still there, protected inside the trees in which they nest. By

spring, the colonies seemed to be back to normal activity levels, and many ephemeral plants, including lots of wildflowers, had bloomed in the fire's wake. It was beautiful."



An oak that survived the Eaton Fire. Many ant colonies that nested inside of these oaks also were able to survive the blaze.

Credit: Courtesy of Joe Parker

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