Fighting fire damage with fungus

ASU researchers turn to mycelium as a cost-effective, sustainable way to stabilize land after a fire

By Monique Clement, ASU News
May 14, 2026

Smoke smudged the view along a remote stretch of Arizona State Route 79 north of Tucson last spring. Bright orange flames burned hot and fast, devouring nearly everything they touched as they surged toward Falcon Valley Ranch.

“That was scary with the wind blowing in our direction of (the ranch’s) headquarters and my house,” said Grant Wilson, who co-owns the family ranch with his sister, Jennifer Wilson.

As the flames approached, the family grabbed their valuables and Wilson got ready to defend the ranch. The fire had come during calving season, and calves lie still in the grass waiting for their mothers, no matter what is happening around them.

Crews contained the March 2025 Saddlebrooke Fire within two days. The immediate danger to the ranch and cattle was over, but a new chapter in the land’s story was beginning. More than 200 acres of State Trust Land that the Wilsons lease for grazing were left charred.

On a brisk Monday the following November, an Arizona State University research team traveled down Route 79, through Falcon Valley Ranch and over a rough dirt road to one of the burn scars. The fire’s damage was still clear.

On one side of the road, green cacti, yucca and trees rose from pale grasses. On the other, the burned land was mostly bare. Only stubs of most grasses remained. Skeletons of trees and blackened husks of cacti peppered the landscape. Heavy rains had washed away the soil with so few living plants to hold it together, carving deep gullies into the ground.

Henry Nakaana, a junior majoring in civil engineering, scanned the area.

“It's been seven months. Can you imagine?” he said. “This is the recovery nature could do after seven months — just a few grasses.”

Lune Martin, an environmental engineering sophomore, noticed invasive grasses among the returning plants.

Nakaana and Martin are among the first researchers to address a problem with no good solution: helping the land heal from wildfire damage.

"For a rancher right nearby who says the wildfire burns down the food for his cattle, how do you help him in a very short time to bring back the vegetation after a wildfire?" Nakaana said. "It gets me excited when you actually know you have a solution for it. And what better way to solve the problem than going back to the world's largest creature?"

That creature is not what most people would expect. It is fungus — a soil-dwelling organism that can stabilize land after fire in a cost-effective, sustainable way.

A spreading problem in the desert

Deserts are not adapted to fire. Unlike ponderosa forests on nearby Mount Lemmon, Sonoran Desert plants like saguaros and palo verdes rarely survive being burned. Others are slow to recover.

Historically, the patchy placement of desert plants limited the spread and damage of lightning-strike fires.

Today, invasive grasses fill the open space between native plants. Now a small spark — like from a dragging chain, the suspected cause of the Saddlebrooke Fire — can ignite a fast-moving wildfire.

Invasive grasses are invigorated by these fires and outcompete native grasses in the aftermath. Combined with severe drought and rising temperatures from climate change, this has created a cycle of more frequent and intense wildfires.

And yet, the fire is not the biggest danger — it's what comes after. Burned soil loses structure. Wind and rain erode it away. Heavy storms can trigger shallow landslides that damage land, infrastructure and water supplies. The soil remains vulnerable for years.

"Soil instability is one of our greatest concerns in post-fire mitigation. And presently, there's just not much we can do," said Russell Benford, the policy and research advisor at the Arizona Department of Forestry and Fire Management. He also advises firefighting teams managing wildfires, repairing damage from suppression efforts and mitigating post-fire risks to communities, infrastructure and natural resources.

Benford said ASU's work offers real potential to address one of the biggest challenges of post-fire risk mitigation. Soil erosion, debris flows and catastrophic flooding are among the greatest threats in the post-fire environment.

"It's a ray of sunshine to see that researchers have ideas relevant to our needs and that would have an immediate and significant impact on our work," Benford said. "We don't often get that in the fire world."

Trailblazing a new research path

This type of problem-solving is what inspired Nakaana to study civil engineering in the Ira A. Fulton Schools of Engineering at ASU.

He also wants to be a trailblazer who uncovers new knowledge to help humanity, kind of like Isaac Newton. Nakaana is inspired by the fact that we still use the theory of gravity Newton wrote down more than 300 years ago in today's scientific advances.

He joined Emmanuel Salifu's lab during his first semester at ASU in fall 2023 to pursue these goals.

Salifu is an assistant professor in the School of Sustainable Engineering and the Built Environment, part of the Fulton Schools, and a senior Global Futures Scientist with ASU's Julie Ann Wrigley Global Futures Laboratory.

The SALIFULAB studies nature-based engineering solutions, an emerging field known as biogeotechnics. Salifu's team explores how bacteria and fungi can stabilize soil, remove contaminants and repair infrastructure.

One fungus they use is Pleurotus ostreatus, the common oyster mushroom. While its fruiting body is often used in cooking, the researchers work with its mycelium.

Mycelium is the underground network of rootlike structures that break down dead plant matter and recycle nutrients back into the soil.

P. ostreatus is already used to clean up pollution, turn crop waste into biofuel, make renewable packaging and more. Nakaana wondered: Could fungi help prevent erosion and landslides after a wildfire?

When he searched for existing research to build upon, he found none. That meant he was one of the first to study it.

Salifu encouraged Nakaana, still a first-year student, to lead the project.

"In many ways, first-year students are ideal for this," Salifu said.

He believes students bring bold aspirations and free-flowing creativity that allow them to make significant contributions to exploratory research like this.

About a year into the project, Martin joined the lab — also as a first-year student.

During high school, Martin spent his summers restoring tallgrass prairies around Plano, Texas. He conducted prescribed burns, removed invasive grasses and conducted research with a local soil scientist.

"Nobody talks about the soil — who likes dirt?" Martin said. "But there's really not much you can do without soils. And soil is precious out here in the desert."

When he arrived at ASU — with a poster of the 12 soil orders — he sought out research opportunities with professors focused on soil systems. That's how he found Salifu.

A growing understanding

The first stage of the research began in the lab to understand what fungus could do for wildfire recovery.

Working with fungus is a little like maintaining a sourdough starter — but with specialized lab equipment instead of a mason jar on a kitchen counter.

Nakaana and Martin have grown gobs and gobs of mycelium. Occasionally they get a batch contaminated with other microorganisms — which can be identified by its terrible smell. For the good ones that only contain P. ostreatus, they use a lab-grade immersion blender to break up the mycelium clusters and create a slurry.

Preparing burned soil samples for experiments also involves more than just preheating an oven. One of Martin's most memorable experiences involved monitoring a controlled "wildfire" in the lab with Nakaana over 24 hours.

They have tested hundreds of combinations of mycelium concentrations, soil recipes and application methods on burned and unburned soil samples.

"The fungi has been shown to be very resilient and will grow in any situation we put it in," Nakaana said.

Their findings show that mycelium can significantly reduce soil erosion after about a week of growth, especially in burned soil. It also helps store and release nutrients for plants.

These early results are promising, but they come from controlled lab conditions. After two years of work, the team was ready to go out in the field.

Students shaping new field with published research

Nakaana is the lead author on a peer-reviewed paper in Biogeotechnics, a leading journal for the emerging field. Publication is a notable achievement for undergraduate students.

"Finally having something new that is not (already) out there is really amazing," Nakaana said about the opportunity.

Martin and Nakaana also contributed a conference paper about their early findings to the American Society of Agricultural and Biological Engineers 2025 Annual International Meeting in Toronto, Canada.

The papers strengthen their work's credibility, attract more funding and invite collaboration from other experts.

Digging into the problem

To move the project forward, Salifu connected with Benford and the Arizona Department of Forestry and Fire Management.

"That conversation was extremely productive, helping us better understand agency priorities, stakeholder needs and where our research could be most impactful for communities affected by wildfire," Salifu said.

Benford helped the team access the Saddlebrooke Fire site to collect burned soil samples.

“We’re always so clean and precise in the lab,” Martin said as he got digging. “Getting my hands dirty I feel is a necessary step.”

In the field, Benford also showed the students how post-fire soil stabilization works — and where it can fall short.

Emergency response teams use satellite images taken before and after a wildfire to estimate where it burned and how severely. On federal land, crews also verify the damage on the ground.

On State Trust Land, this type of ground assessment had never been done before — until that November day.

Equipped with soil knives and warned about falling into holes left behind by burned out tree roots, the team began the first on-the-ground assessment of soil burn severity on Arizona State Trust Land.

This action is part of a new post-fire risk mitigation strategy Benford is helping shape to better protect state land resources — one in which Arizona is at the forefront.

Learning from history

A simple sign at the front gate of Falcon Valley Ranch reads “Established 1941,” but the family’s cattle ranching roots go deeper into Arizona history.

In 1906, 19-year-old George Wilson — Grant Wilson’s great-grandfather — came west from New York to heal his asthma and hay fever in Arizona’s dry air. After a few years, he recovered and left to work in Portland, Oregon. But he returned, having grown fond of Arizona territory, and went into cattle ranching.

The Wilsons began ranching during a time of early land management decisions that shape today’s fire risk.

In the late 1800s, heavy grazing stripped vegetation and increased erosion. Later, fire suppression disrupted natural fire cycles that kept fuel levels low.

In the 1930s, people planted grasses from other arid regions of the world to prevent erosion and feed livestock. By the 1980s, species now considered invasive, such as Lehmann lovegrass and the even more notorious buffelgrass, had spread widely. Wildfire activity increased with their spread.

“(At the time), we didn’t conceive that we were doing great harm for generations to that landscape,” Benford said.

Building a better solution

Salifu’s team is cautious about avoiding unintended consequences.

In rare cases, fungi can be invasive, but P. ostreatus is not. Still, it’s not the only option.

“Different fungi have different characteristics, but they’re not so different,” Nakaana said. “It’s not only P. ostreatus (that would work), it could be any fungi that you have, and it would do just the same job.”

The researchers want to explore how to stimulate native fungi already in the soil to offer similar benefits.

P. ostreatus remains a useful tool to explore new areas of research, such as how an introduced fungus will affect plant growth.

“Our current focus has shifted toward understanding how this engineered fungal growth influences the establishment of vegetation, both native and invasive species, and potentially impacts fuel continuity,” Salifu said. “This question is critical for long-term soil stabilization, resilience and ecological restoration following wildfire.”

To reap any of these benefits, however, the solution must fit into real workflows.

“Industry is not going to buy it if you need them to develop new machines,” Salifu said. “It’s way easier for uptake if you have something that can be plugged into existing systems.”

For example, drones used for spraying mulch could apply a fungal slurry or nutrient boost for native fungi.

When could fungi be used to treat wildfire burn scars? A prototype solution could be done in a few months, Salifu said, with the resources and funding in place.

So far, the research has been supported by Salifu’s ASU faculty funding and the Fulton Undergraduate Research Initiative. The early results are starting to draw more attention and support for their work.

Nakaana received a 2025 student research grant from the Society of Fire Protection Engineers. He was the only undergraduate recipient. This win drives the research forward and emphasizes the importance of this work for fire scientists and engineers.

Benefiting Arizona and beyond

Wilson has seen fire activity increase near his ranch in the last five years. Fires damage fencing needed to contain his cattle, leading to expensive and time-consuming repairs.

Research prepares students for engineering careers

Research gives students direct experience solving practical problems and helps them build important skills.

Nakaana said conducting research and writing a peer-reviewed paper has given him relevant experience that will prepare him to be a professional geotechnical engineer. During a summer internship at an engineering consulting firm, he conducted fieldwork, analyzed soil samples, reviewed lab test results, and wrote proposals and reports — work that closely mirrors what he does in Salifu's lab.

For Martin, the research fieldwork with Benford was a valuable networking opportunity. He learned how his interests and lab skills could translate to fire and land management careers.

"Fire is completely devastating to a ranch if it gets out of control," he said. "You lose it all. You don't only lose the land, but you lose your infrastructure and your fences, the corrals, the wells, let alone the animals."

Wilson also sees how devastating fire is to wildlife. All the animals his family enjoys seeing on their land either perish or are forced to move on when fire destroys their habitat.

It's not only the Sonoran Desert that needs help. Similar fire risks threaten all arid regions across the Western United States.

This year is shaping up to be especially perilous for wildfire risk. Ten states in the West had the warmest March on record, according to the National Oceanic and Atmospheric Administration. January through March was the driest period in NOAA records stretching back more than 100 years.

Increased wildfires are also a worldwide problem, with countries such as Brazil and Australia experiencing similar fire problems.

Salifu said, "We are trying to develop something that can be applicable to different sites where there are wildfires across the world."

Why this research matters

Research is the invisible hand that powers America's progress. It unlocks discoveries and creates opportunity. It develops new technologies and new ways of doing things.

Learn more about ASU discoveries that are contributing to changing the world and making America the world's leading economic power at researchmatters.asu.edu.

This story originally appeared on ASU News.

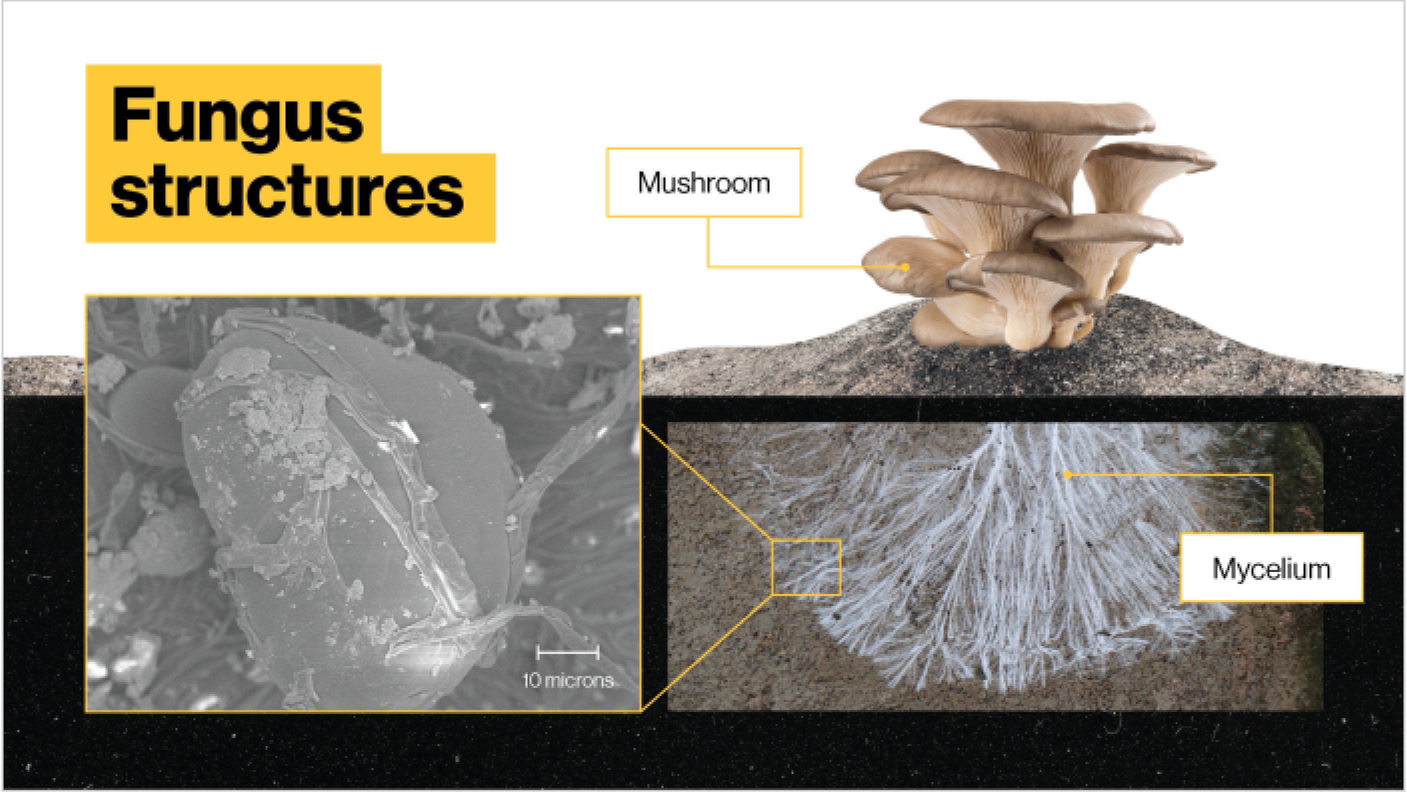
Main image

Arizona State University graduate student Adesola Adegoke and visiting researcher Manoj Kumar walk through the Saddlebrooke Fire burn site near Mount Lemmon in November 2025. They are part of an ASU research team developing a new approach to desert wildfire recovery using fungus. The research team includes undergraduate students Henry Nakaana and Lune Martin and is led by Assistant Professor Emmanuel Salifu. Photo by Andy DeLisle/ASU

Text image(s)

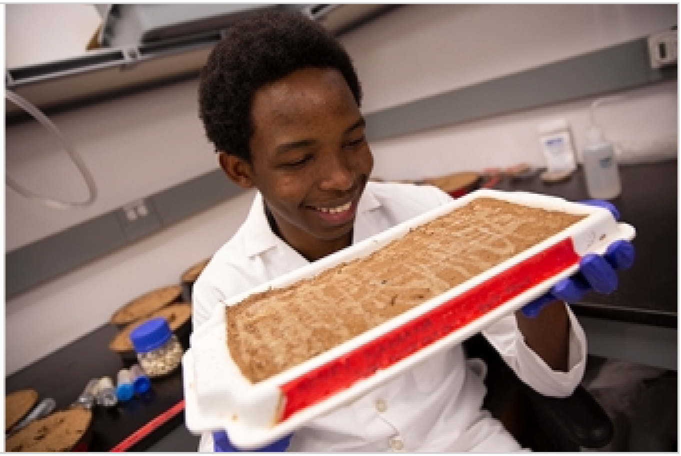
ASU undergraduate researchers Lune Martin (left) and Henry Nakaana assess the fire damage to soil at the Saddlebrooke Fire burn site in November 2025. Photo by Andy DeLisle/ASU

Physical barriers for erosion control are among the only solutions to prevent further damage to land after a wildfire. Existing methods are labor-intensive, slow, expensive, require maintenance and either have limited effect or environmental costs. Nakaana and the research team saw the need for a sustainable, cost-effective and natural solution to this problem. Photo by Andy DeLisle/ASU



Fungus is a fascinating type of organism that is neither plant nor animal. Mushrooms are the most familiar and visible part of a fungus. But mushrooms are like the fruit on a tree — a temporary part used for dispersing spores. The main body of a fungus colony is its mycelium. Mycelium are tiny, rootlike structures that live underground and on decaying plant material. An electron microscope image from the SALIFULAB shows how mycelium wrap around soil particles, which gives fungus the stabilizing properties needed to help with wildfire recovery. Graphic by Andy Keena/ASU; electron microscope image courtesy of Emmanuel Salifu

Henry Nakaana began the wildfire recovery research project in the SALIFULAB as a first-year student. His early research was funded by the Fulton Undergraduate Research Initiative in the Ira A. Fulton Schools of Engineering at ASU. Photo by Erika Gronek/ASU



Seeing the fungal growth for the first time was a particularly memorable early research experience for Nakaana. Observing the students' progress has reinforced Salifu's belief in the value of early student involvement. “Seeing their development in real time and knowing that these experiences will leave a lasting positive impression is one of the most meaningful aspects of my work,” he said. Photos by Erika Gronek/ASU

Benford (left) provides resources like access to wildfire sites and insight about post-fire recovery and risk mitigation. He helps Salifu's lab members navigate regulations and processes that govern use and management of the land. Photo by Andy DeLisle/ASU

Salifu (left) and Adegoke collect samples with the ASU research team. Martin (not pictured) could still smell fire on the charred plant material in the soil — a good sign that it contained a lot of carbon, the fungi's preferred food source. Photo by Andy DeLisle/ASU

A soil knife (a skinny shovel with measurement markings engraved on it), water bottle, soil condition guide and smartphone camera were the only tools they needed to “field truth” categories of low, moderate and severe burns at the Saddlebrooke Fire. Martin and the other researchers measured plant cover, ash depth, soil structure, surviving roots and how quickly water infiltrated the soil. Photos by Andy DeLisle/ASU

Martin holds a sample of Lehmann lovegrass collected from the Saddlebrooke Fire site. This species of invasive grass was introduced from South Africa to Arizona in the 1930s to help with erosion and provide more forage for livestock. Photo by Andy DeLisle/ASU

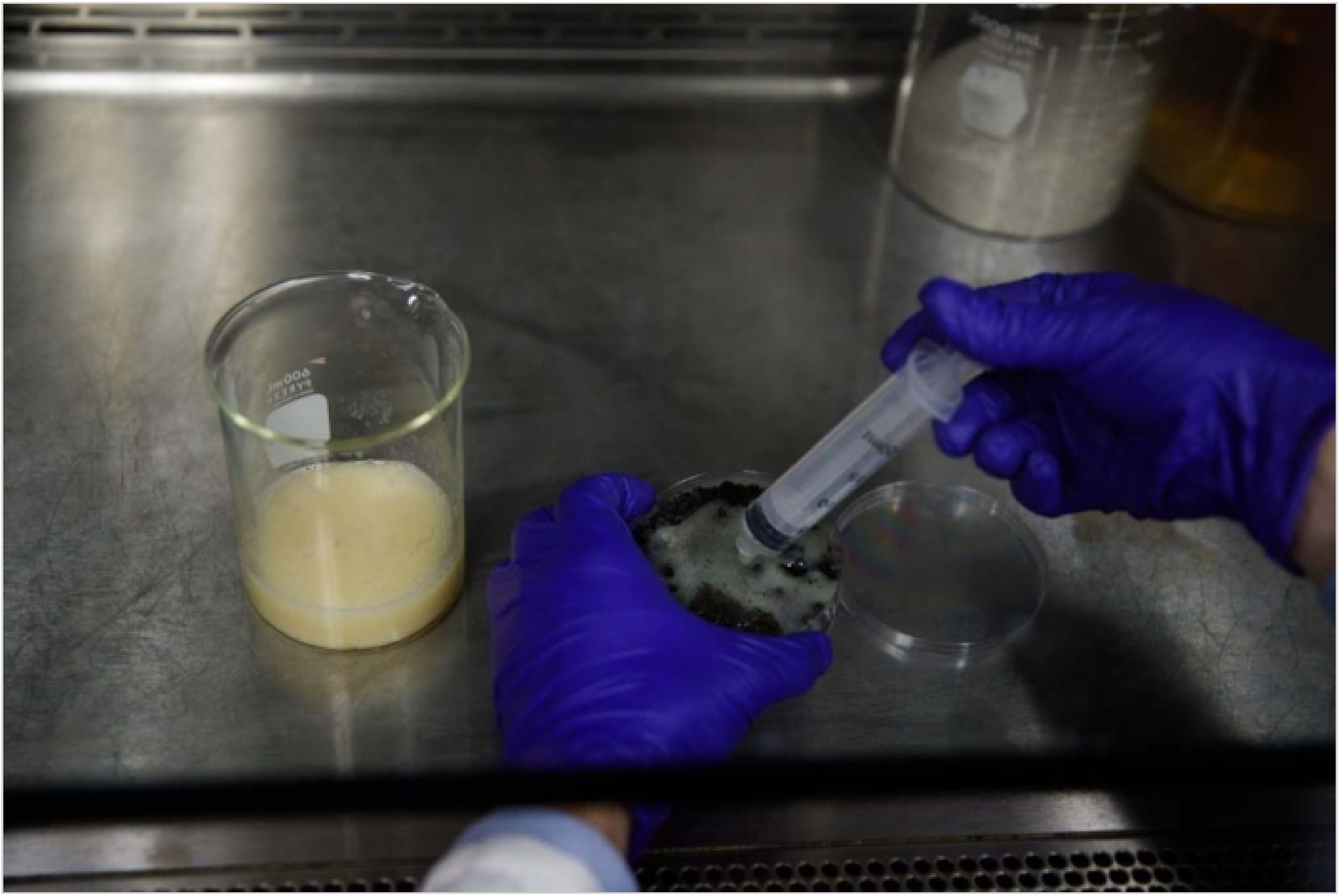
Using the collected soil samples, Nakaana and Martin have confirmed that P. ostreatus grows well in actual wildfire-burned soil. The next phase of experiments involves understanding how the fungus affects plant growth. Martin is studying how mycelium can control the spread of invasive grasses after a fire and reduce dried grass fuel loads before a wildfire strikes. Photos by Andy DeLisle/ASU

The stakes of this research extend beyond the area of the Saddlebrooke Fire. State Trust Land raises money to support schools, universities and public institutions through leases and permits. Hunters, ranchers and recreationists rely on it. So do native plants and wildlife found nowhere else. Photo by Andy DeLisle/ASU

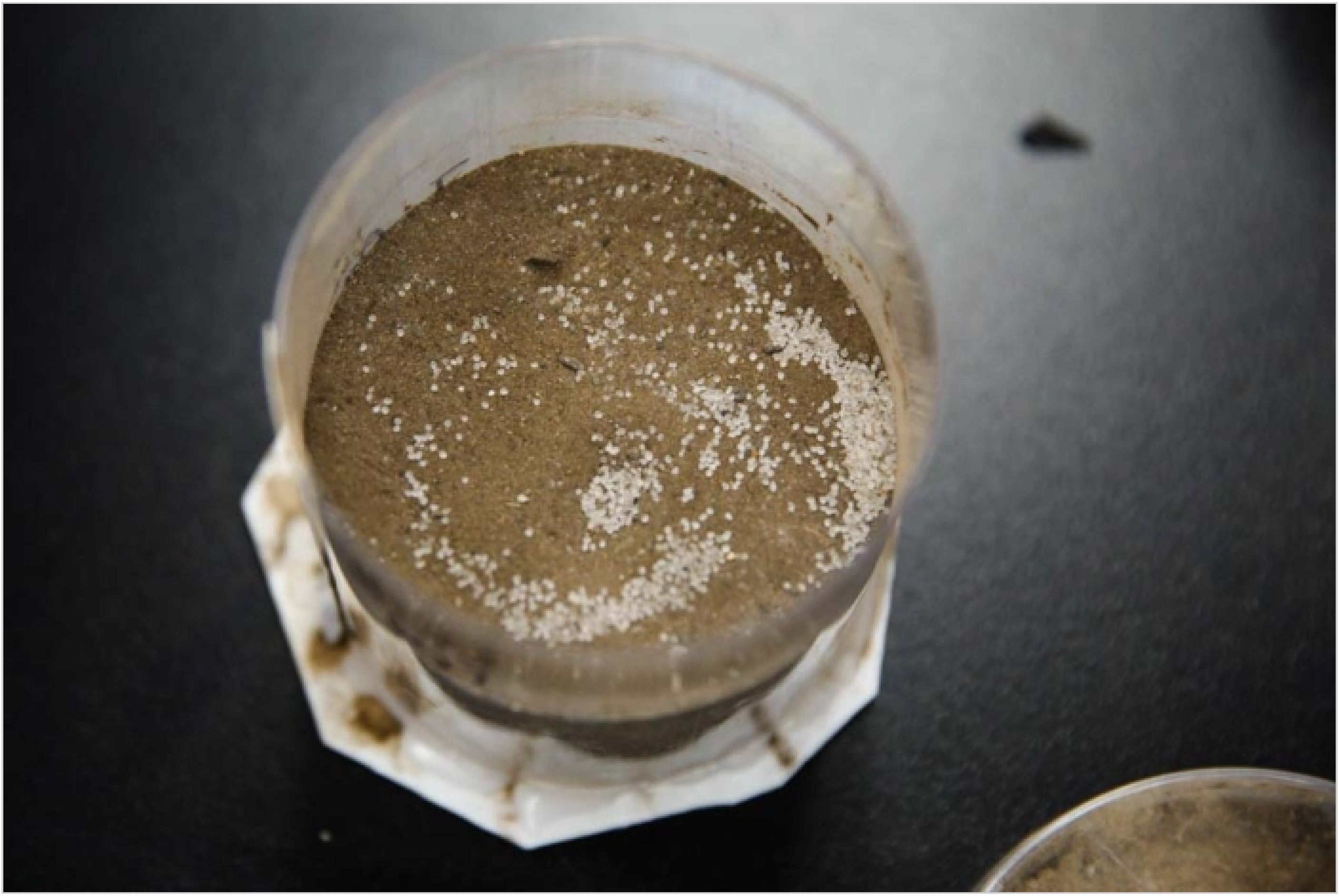
Gallery

The research team feeds flasks of mycelium clusters a potato-based sugar broth and swirls them in a warm incubator to help them grow.

They blend the samples to distribute the mycelium strands more evenly. This creates a spreadable slurry of fungus for testing.

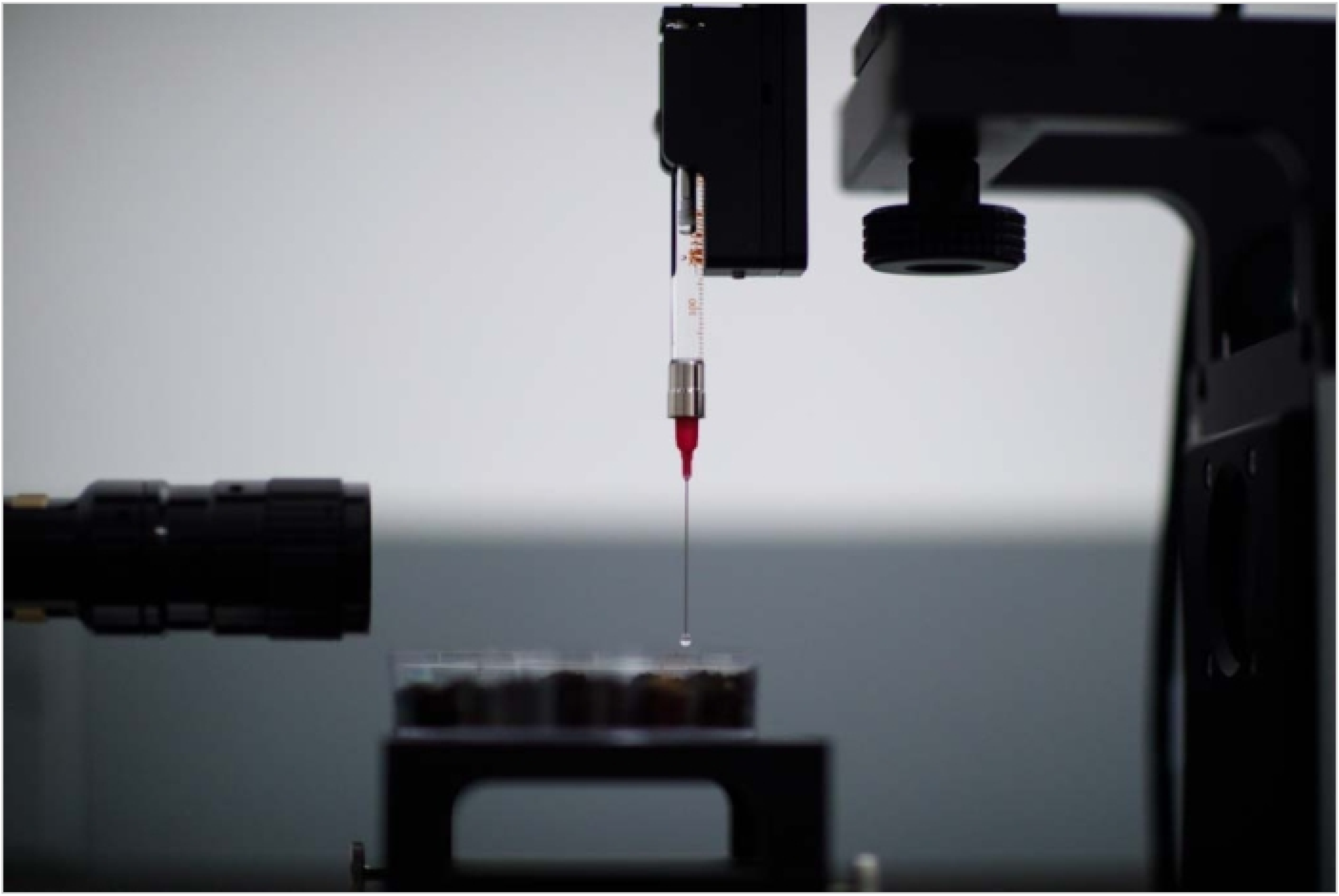


The slurry is added in precise doses to soil samples in petri dishes for testing.



In the early phases of the project, the researchers created artificial soil samples with precise amounts of different particle sizes and nutrients to mimic real soil, but without any of the unknown variables.

Mycelium growth in soil samples. The fungus helped with soil stability and retaining nutrients for other plants to use. It doesn't take much mycelium slurry to form a mat of fungus in a short period of time, making it a cost-effective method.



After the fungus was left to grow for a week, the researchers tested the samples to see how quickly water soaks into the soil. This is important to understand how the fungus affects soil water repellency, infiltration and erosion.