California campus is one big laboratory to fight tree-killing beetle

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When the first few sycamores began dying in Aldrich Park at the at the University of California, Irvine, in late 2014, the victims numbered in the dozens. But over the next several months, hundreds of cottonwood, native willow, golden rain and coral trees met the same fate.

"We've seen infestations of pests, but nothing to this extent," said Richard Demerjian, director of the university's Office of Environmental Planning and Sustainability. "It came as quite a shock."

It was the work of the polyphagous shot hole borer, an invasive beetle that's been attacking and killing an astonishing range of trees throughout Southern California.

Plant pathologists are overmatched. The beetle isn't native to the area and has no natural predators here. When it strikes, the only thing to do is to try to contain it before it spreads. As the beetle has spread farther into five counties, even that has seemed like a losing strategy.

But the UC Irvine outbreak presented scientists with an opportunity to change that - by turning the leafy grounds into a giant outdoor research lab.

The university is home to researchers who design malaria-fighting mosquitoes and hunt for dark matter in distant galaxies. Why not apply the scientific process to the campus itself?

Dozens of trees around the campus now bear white tags that read: "This tree is part of a joint UC research project. Please do not touch or climb on the tree."

One of the scientists running the giant experiment is Akif Eskalen, the plant pathologist who first identified the beetle in a South Gate avocado tree in 2012. He's been studying infested plants about 45 miles away at the University of California, Riverside.

At UC Irvine, with so much devastation concentrated in one place, the conditions are practically tailor-made for a controlled study to test different chemical and biological treatments using the same kind of trees growing under the same environmental conditions. With any luck, the results will help Eskalen hone his response to the pest.

The beetles burrow tunnels into trees, ejecting a sawdust-like frass behind them. They use the empty space to farm several species of fungus, which they eat and feed to their young. But the fungus also spreads through the tree's system, ultimately killing it.

A quick inspection is enough to make the scientists feel like underdogs. Eskalen pulled out a pocketknife and scraped the bark off several trees, revealing bore holes beneath.

The university has identified 2,000 infested trees, many of which will have to be cut down. Many now resemble amputees, their main branches or entire tops lopped off. About 400 hardwoods on campus were so badly injured that officials have already removed them.

Nearly every sycamore in sight bears some kind of wound, and the damage is more than cosmetic. Heavy branches, structurally weakened by the beetles' relentless drilling, pose a threat to public safety if they fall.

After trees die, their wood can become a hazard as it's hauled away, giving the beetles a free ride to new territory.

There's also an economic risk, since the beetles have a taste for avocado trees. It's also not clear what will happen if - or when - the beetle moves into the Central Valley, California's agricultural heartland.

At UC Irvine, Eskalen selected 130 sycamores for his experiment and divided them into 13 groups of 10. Four of the groups were treated with different insecticides; three were treated with different fungicides; four others got one of each.

Another group was given a beneficial bacterium found in some California trees that's thought to kill the fungus.

The final group served as a control and received no treatment.

To keep track of how well each intervention works, researchers are counting the holes the beetles leave in each tree. Each dot is a data point.

These pinpoint wounds are marked with a different color of paint every month, to help the scientists see how many holes are freshly drilled. Any unmarked holes are a sign that the beetles are still drilling.

The scientists are allowed to cut down and section the trees, sample them - and even leave some infested ones alone. Having this flexibility is essential to understanding the success - or failure - of a given pesticide, said John Kabashima, an environmental horticulture adviser and entomologist with the UC Cooperative Extension.

As with a lot of high-level research, there's quite a bit of grunt work. On a recent sunny day, Eskalen checked in on Joey Mayorquin and Beth Peacock as they painted blue dots on the paper-thin bark of a sycamore in Aldrich Park. Nearby trees are speckled with orange, white and green - so many colors that they bear a vague resemblance to a Georges Seurat painting.

Mayorquin, a UC Riverside graduate student, knelt at the tree's base while Peacock, a UCR research assistant, used a stepladder to reach higher. Both daubed blue dots next to each new hole and used clickers to keep count of them.

"It is very time-consuming," Mayorquin said. "We actually made good time last week when we were here; we were able to get through 40 trees in about a full day."

Soon after he started the experiment, Eskalen began to worry that his dot-painting procedure wouldn't tell him which holes were empty and which ones were occupied. After a sleepless night, he came up with an additional strategy.

To see which holes were in active use by beetles, the researchers painted white rectangles on the bark. Some paints were too thick; others seemed to darken. After several tests, he settled on a water-based latex paint that would not interfere with the beetles' drilling and would wear off without hurting the tree. Eskalen knew that the mother beetles guarding their young inside couldn't stand to have their only means of entry and exit clogged up. And indeed, they burrowed out of the holes that had been covered with paint - revealing those holes that were still in use.

"That's why it's very important for us to study the biology of the enemy," he said.

Eskalen checked one of the painted white patches. He points to numbers scribbled on the bark from early in the experiment. On Oct. 23, he'd counted 25 new holes. On Oct. 27, only 20 were active.

The researchers also used 3D-printed traps designed by UC Riverside entomologist Richard Stouthamer and colleagues to catch beetles that come out of their holes. The researchers don't even need beetles to fall into the traps; if they catch any frass, the team will know the hole is active.

The team has been monitoring these trees since June. This June they will gather all the data, analyze their results and continue monitoring for a few more years. Eskalen hopes they will lead him to a chemical or microbial weapon that could help beat back the infestation.

The scientists expect that any ammunition they find here will also help them fight the Kuroshio shot hole borer, a closely related beetle species with its own fungi that has invaded San Diego County and established a foothold in Orange County.

On the highly monitored and manicured campus, UC Irvine's trees are relatively lucky; in wilder areas the beetle has gone unchecked, ravaging natural habitats. A four-mile-wide willow forest in the Tijuana River Valley now has 140,000 severely damaged trees, according to John Boland, an ecologist who has been studying the area for more than 14 years.

In spite of all this effort, Eskalen doesn't believe pesticides are a long-term solution - they're expensive and require repeated applications, and they may not be allowed on crops or in many of the wild, thickly wooded areas under attack.

Ultimately, he said, the only way to defeat the polyphagous shot hole borer is to identify and deploy another creature that naturally preys on the beetle or its fungi.

Although the beetle infests trees in many parts of Southeast Asia, it does not run rampant there the way it has in Southern California. Eskalen and Stouthamer suspect it has predators there that keep it in check naturally, and they've traveled to Vietnam and Taiwan to search for them.

Finding them would just be the first step. Before they could bring them to California, they'd have to study them there to ensure they don't attack the state's beneficial native insects.

In the short term, the best-case scenario for UCI is to manage the pest without allowing it to spread. With some 30,000 trees remaining on campus, Demerjian is prepared for a lengthy fight.

"This is going to be a pest that we're going to have to deal with for many years," he said.