It’s not sudden, it doesn’t just affect oaks, and it doesn’t always cause death, but sudden oak death (SOD)—or at least Phytophthora ramorum, the insidious water mold that causes it—continues to torment scientists and resource managers and bring ruin to coastal California and southern Oregon forests. The toll of the disease is alarming: An estimated three million trees have been killed in California alone. The epidemic, first detected in the San Francisco Bay Area in 1993, now stretches from around Big Sur up through central Mendocino County, with a couple of hot spots in southern and northern Humboldt County and one in southern Oregon.

P. ramorum hitches a ride on the leaves of plants other than oaks, where it sporulates, and then finds its way to oak trees. It mostly affects the trunks of oaks, with ugly, black, oozing cankers and fruiting bodies that look like black mushrooms. It favors the native California bay laurel as a host, where it infects the leaves, but it also infects the leaves and small branches of more than 100 other hosts. Most of the host plants do not die, except for tanoak, which has been hit especially hard, says Dave Rizzo, a professor of plant pathology at the University of California, Davis, and...
one of the leading researchers on the disease. Victims include the true oaks (the genus *Quercus*)—red oak, coast live oak, canyon live oak, California black oak, and Shreve's oak—and tanoak (*Notholithocarpus*). Oaks in the white oak subgenus—valley oak, blue oak, and Oregon white oak—do not seem to become infected, Rizzo says. Although it is pretty clear that there is some natural tolerance in oak populations—and that oaks won't go the way of the chestnut—Rizzo says that in certain areas of California and Oregon, the forests are changing, and there is a lot of oak mortality. One of his areas of ongoing research is to find resistant trees and see how they are distributed across the landscape.

Tanoaks show less resistance than the true oaks and are “incredibly susceptible” to the disease, Rizzo says, with a mortality rate of 90 to 98 percent. Tanoaks are not a popular commercial species, but they are very important ecologically. In a redwood or Douglas fir forest, “there’s no other acorn-producing species,” he says. “If it disappears, there’s really nothing to replace it in the conifer forests north of Mendocino.” And the tanoak is sacred to Native American tribes along California’s north coast, which still harvest the acorns for food. “They are devastated by this,” Rizzo says. “We’re working with them to try to develop some management strategies.”

But how to manage a pathogen that has more than 100 hosts? One unexpected help has been California’s ongoing drought. Surveys taken between early April and early June of this year show that the infection rate among California bay laurels is between 2 percent and 10 percent, compared with 20 percent to 80 percent during a normal rainfall year. “The disease is almost exclusively spread by spores on infected leaves during warm late spring rains,” Rizzo says. “It requires a lot of moisture, and we haven’t had that in the last three years. It likes continuous wetness.”

But the combination of the drought and the disease is causing other problems. When the tanoaks die, dead leaves remain on the trees, and they can burn ferociously. “It’s a huge concern,” says Tom Smith, a forest pest specialist with the California Department of Forestry and Fire Protection. “It creates a huge buildup of fuel loads in the forests.” The upside of the fires is that they have wiped out the disease in some places. But in other areas, Rizzo says, “[the disease] has survived fires and is coming back. It’s much more complicated than we thought.” Smith says his agency has come to accept the fact that *P. ramorum* is probably not going to be eradicated. “We are still trying to learn how to live with it. We know we’re not going to get rid of it. How do we keep it from spreading?”
Oregon tried to eradicate the disease by going in and cutting out infected trees to create a large buffer zone. “It worked to some extent, but it did not eradicate the pathogen,” Rizzo says. “It’s too hard to keep ahead of it. Once you see dead trees, you know that P. ramorum has been in that spot for two years or more. It gets really expensive and hard to do.”

Another worry is that the disease is being spread into forests from nursery plants in the backyards of homes, especially at the interface of suburbs and wildlands. Rizzo traced leaves carrying P. ramorum in a stream in Northern California to a rhododendron plant in the backyard of a ranchette 25 miles upstream. Bay laurels and tanoaks are the primary vectors for P. ramorum, but five other plant genera—known as the “filthy five”—Rhododendron, Camellia, Pieris, Kalmia, and Viburnum—are also big drivers.

Jennifer Parke, an associate professor in the department of crop and soil science and the department of botany and plant pathology at Oregon State University, has been working with horticultural nurseries since about 2002 to help prevent them from becoming infested. Parke is alarmed that as of March 31 of this year, some of the very stringent quarantine regulations that had been in place for a long time in California, Oregon, and Washington have been relaxed. Until then, nurseries that grew any of the known host plants had to be inspected thoroughly by state departments of agriculture before any plants could be shipped out of state. But now only nurseries that have tested positive in the past three years must be inspected.

“I’m quite nervous about this,” Parke says. “Maybe in the end, this will prove to be more efficient, but I worry that a number of nurseries could be shipping host material that is not being caught.” Parke has been working to stop unsafe practices in nurseries, particularly the practice of bringing plants in from other nurseries and immediately mixing them with existing stock. “What we want to do is make sure that nurseries put those [new arrivals] in separate areas—kind of in quarantine—watch them like a hawk, and withhold any pesticides that would delay the onset of symptoms. That way, they can make sure the plants are healthy before mixing them in.” Parke also advises nurseries to clean pots thoroughly before reusing them or before using pots from another nursery.

“Just one careless mistake can expose the whole nursery to the pathogen,” she says. She is experimenting with using solarization to kill the pathogen, which is not very tolerant of high temperatures. Parke is focusing on soils, because when infected leaves fall off plants in nurseries and onto the ground, they work their way into the soil and decompose, with P. ramorum usually thriving in the top 15 to 20 centimeters. “Once it’s in the soil it can survive..."
for a very long time,” Parke says. So if a grower puts a bunch of new plants on top of infected soil, the pathogen can be “splashed up into a new crop,” she says. “That seems to be what is happening in most of the nurseries that have tested positive year after year.”

Parke is especially concerned about native plant nurseries. Because they do not usually ship plants out of state, they are often not inspected as rigorously as other nurseries, she explains. On a recent trip to the Bay Area, she visited a retail nursery selling coast live oaks and bay laurels. “They had coast live oak seedlings and saplings in pots underneath a beautiful bay tree loaded with *P. ramorum,*” she says. “There were actually bay leaves that had fallen into the *Quercus* pots. We need to do a better job of getting the word out to those growers, and also to landscape architects who want to use this material.”

Parke says landscape architects should be careful that the plants they purchase are free of pests and pathogens: “Otherwise, they could be responsible for unleashing those pathogens into the wild. Once it gets out there, there’s no way to reel it back in.” She suggests thinking about what is likely to be a problem in the next 10 to 50 years. “If they’re purchasing plants for any landscaping or restoration project, they should visit the nursery and ask questions about what steps that nursery is taking to ensure that its plants are free of pests and diseases.”

Parke is one of five authors who have published a free manual for nursery growers on how to reduce their risk of contamination, which can be downloaded from the Oregon Association of Nurseries website.

If *P. ramorum* can’t be eradicated—as most everyone agrees—the question becomes one of how to live with it. Rizzo says the fact that the true oaks are a “dead-end” host for the pathogen ("It gets in and kills and has fun but doesn’t spread.") as well as current knowledge about the association between known hosts and oaks are driving current thinking about how to manage and prevent the disease. He points out that there are several scales at which scientists and others are trying to manage it—from homeowners who want to protect individual trees to broad quarantines and forest management at the landscape scale. “That’s the hardest one,” he says. “When you’ve got hundreds of thousands of acres, you’re not going to inject every tree with chemicals. It’s more about stand management—removing bay laurels, thinning the forest—we’re just...
scratching the surface of what works and what doesn’t. If it takes five years to kill a tree, we have to wait five years to see if what we’re doing works.”

Individual trees can be treated with a product called Agri-Fos. This phosphonate treatment does not kill the pathogen but boosts the tree’s immunity. The tree must also be injected with the chemical or have its bark sprayed before the disease is found. If bay laurels within 200 yards of a susceptible oak are found to be positive for the pathogen (people can take samples as part of the SOD blitzes in April and May each year and send them to UC Berkeley for analysis), they can be removed or, at the very least, pruned up so they get more light and less moisture. And not every bay laurel is a carrier.

Matteo Garbelotto, as the director of the forest pathology and mycology laboratory at UC Berkeley, is working at the microscopic and genetic scales to better understand the disease. He has sequenced the entire genome of tanoaks and is developing a quick lab test to discover whether a tree is SOD tolerant and will respond to phosphonate treatment. He is also growing seedlings from acorns produced by the same tree that have been determined to be tolerant after garden and lab experiments. One of his grad students is studying the chemical composition of the fungi on the leaves of uninfected bay laurels. “It could be that spores from a beneficial fungi microbiome could help control _P. ramorum_,” Garbelotto says. If a protective fungi could go inside the leaf, he says, that’s a more solid and safer application than spraying with a biocontrol for which there may be unknown side effects.

Garbelotto is also continuing to collect data about the spread of the disease by engaging the public in a citizen science effort. His “SOD blitzes” have resulted in valuable information that will help him predict what will happen next year, he says. This year, people in 17 coastal communities from San Luis Obispo to Mendocino County learned to identify and collect symptomatic bay leaves and record sample locations on their mobile devices or GPS units. The results of that data collection will be posted to a mapping tool called SODMAP in the fall at www.sodblitz.org. “SODMAP is incredibly useful for homeowners and property managers, as the risk of infection is highest if infected bay trees are within 200 yards of oaks,” Garbelotto says.

Garbelotto is also studying what happens to the pathogen after it kills the (true) oaks. When those “dead-end” hosts die, so does the pathogen, he says, and we may be able to learn from the process of the death of the microbe.

FOR MORE INFORMATION:
Learn about SOD blitzes (citizen science): www.sodblitz.org
A map of sudden oak death: http://nature.berkeley.edu/garbelotto/english/sodmap.php
The California Oak Mortality Task Force: www.suddenoakdeath.org
The SOD mobile app can be found at the App store for Apple or Droid. The SOD maps they work with: http://nature.berkeley.edu/garbelotto/english/sodmap.php
A SOD FAQ: www.fs.usda.gov/detail/mendocino/landmanagement/resourcemanagement/?cid=fstb ev3_004446
See the Safe Procurement and Production Manual: www.oan.org/?page=861

LISA OWENS VIANI IS A WRITER IN THE BAY AREA AND IS A CONTRIBUTING EDITOR TO LAM.