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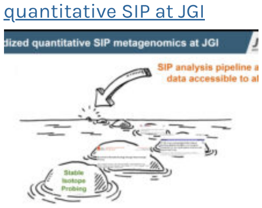

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OCTOBER 27, 2023

Tracking & Subduing the Plague of California's Oak Woodlands

To mark the JGI's 25th anniversary in 2022, we revisited a number of notable achievements that showcase our collaborations and capabilities to enable great science that will help solve energy and environmental challenges.

Scanning the California oak woodlands from the air, large swaths of the bleached, skeletal remains of trees can be seen. These plagued patches have become kindling for the inevitable next firestorm.

Left to right: Lea Green, Matteo Garbelotto, Douglas Schmidt and Natalie Chapman. At UC Berkeley, Garbelotto and Schmidt launched a concerted SOD defensive campaign. Green and Chapman are a couple of the community college students who conduct DNA analyses of samples collected on SOD Blitz expeditions. (Thor Swift/Berkeley Lab)

The majestic sentinel oaks of the Golden State have been succumbing to a pathogen. This '"alien"' organism — one previously unseen — is, in fact, a microscopic water mold, genetically related to such aquatic species as diatoms and kelp. Dubbed *Phytopthora ramorum* (pronounced: Fy-TOFF-thor-uh ra-MOR-um) the genus in Latin translates to "plant destroyer" and it has served as just that on a catastrophic scale from Baja California north into Oregon and beyond. The disease is known more commonly as Sudden Oak Death or by its acronym, SOD. Of the dozens of *Phytophthora* species, the most globally-recognizable relative of SOD is *P. infestans*, responsible for the mid-19th century Irish potato famine.

Shortly before the emergence of the SOD environmental crisis, Matteo Garbelotto joined the faculty at UC Berkeley to lead the Forest Pathology and Mycology Laboratory. Together with his colleague Douglas Schmidt and UC Davis professor David Rizzo, they launched a concerted SOD defensive campaign beginning in 2000. In an effort to fingerprint the pathogen and trace its origins, the researchers engaged the DOE Joint Genome Institute (JGI), with support of the US Department of Energy Office of Science, as well as from the US Department of Agriculture and the National Science Foundation. The monumental challenge of this multi-institutional, multi-investigator effort was to decode the complex *Phytophthora ramorum* genome.

The JGI generated the organism's DNA code in tandem with a closely-related plant pathogen species, *Phytophtora sojae*, which imperils soybean harvests. The subsequent comparative analysis of these two pathogens, led by the JGI and Virginia Polytechnic Institute State University, was released to the public in a highly-cited 2006 publication in the journal *Science*. This provided a framework essential to understanding how these plant pathogens cause disease and how to control them.

Despite advances in the years since this landmark publication, SOD continued to sweep through dozens of California and Oregon counties. It has been detected at scores of nurseries across the nation, elevating concerns about the pathogen to an all-time high. California homeowners witnessed how their once stout oaks, the anchors of their properties, became stricken by the disease, eventually having to be removed. All told, the disease has accounted for upwards of $30 billion in losses, including the death of tens of millions of trees in California alone.

With the genome sequence in hand, the UC team led the charge to develop rapid diagnoses for SOD. These techniques were also instrumental in tracing the genetic signature of the organism back to commercial nursery plants in Europe, when seemingly innocuous ornamental plants like rhododendrons and azaleas became unintentional Trojan Horse-carriers of the disease.

Recently the JGI reconnected with Garbelotto and Schmidt out in the forested slopes of Mount Tamalpais in Marin County, dubbed by Garbelotto as the epicenter of SOD's proliferation.

Recognizing the enormity of the SOD problem throughout the state, the UC team designed a set of engagement activities under the umbrella of the SOD Blitz Project. In hopes of controlling the spread of the disease, this effort has proven effective in organizing, training and deploying hundreds of community members in their neighborhoods and nearby forests with the right tools to track infection.

The parallel development of the SODmap Mobile app enabled SOD Blitz participants to geotag specimens they collect. Later, those are annotated with the results of the lab SOD infection analysis. These collaborations represent the first-ever large-scale "citizen science" project to generate real-time data for modeling and predicting the spread of a plant disease, according to Garbelotto. In one year alone, 500 people participated in SOD Blitz activity, and these data were subsequently used by three million others in the community.

Returning from the woodlands, the UC Berkeley team, along with local community college students Lea Green and Natalie Chapman, headed to their lab in Mulford Hall. There, they conducted DNA analyses of samples collected on recent SOD Blitz expeditions. The team then reflected on the challenges they took on, what they have learned and where the research has taken them.

Garbelotto said coast live and other oaks are susceptible to spores transmitted through their close association with the California bay laurel. Because the oaks are considered "dead-end" hosts, he suggested that the epidemiology of the disease could be altered by removing the infectious hosts — the bay laurels. Garbelotto insisted that the intent is not to remove all the bay laurels, but only ones in close association with the oaks. Another benefit of the removal strategy was to reduce fuel in the forest and diminish the threat of intense wildfires.

Moisture is also a factor in transmission and infection, Garbelotto noted. Under wet conditions, moss growing on the oak bark provides scaffolding onto which infectious spores from bay laurels can take hold, propagate, and ultimately penetrate the bark of oaks and threaten the health of the tree. While drought conditions may slow the progress of SOD, the debilitated trees become susceptible to other secondary assaults, such as those posed by bark-boring beetles, he said.

An additional response to the crisis implemented by the UC team was the development of a protocol for injecting a solution that bolsters the immune system of oaks and enables them to fend off the effects of infections.

As SOD testing may be prohibitively expensive and too complex to perform even for tree-care specialists, Garbelotto and his colleagues have also launched OakSTeP, which facilitates the further cooperation between professional tree care specialists, property owners, and UC researchers to provide rapid and inexpensive diagnostic services.

This long-term investment in foundational research across the University of California, including Berkeley Lab and the JGI, continues to engage community members and inspire next-generation researchers while preserving biodiversity and yielding demonstrable economic benefits.

Natural Prodcast Episode 21 – Elizabeth Parkinson

A Collaboration to Improve Plant Genome Annotations Across Species

Relevant Links:

Publication: Tyler BM et al. Phytophthora genome sequences uncover evolutionary origins and mechanisms of pathogenesis. Science. 2006 Sep 1;313(5791):1261-6. doi: 10.1126/science.1128796

Science News of the Day: Stokstad E. Genetics. Genomes highlight plant pathogens' powerful arsenal. Science. 2006 Sep 1;313(5791):1217. doi: 10.1126/science.313.5791.1217a.

JGI Release: JGI, VBI Describe Evolutionary Origin, Disease-Causing Mechanisms of Sudden Oak Death, Related Soybean Disease Pathogens

UC Berkeley Forest Pathology and Mycology Laboratory

SOD Blitz Project

SODmap Mobile

Oak SOD Testing Program (OakSTeP)

California Oak Mortality Taskforce