CALIFORNIA OAK MORTALITY TASK FORCE REPORT
DECEMBER 2021

RESEARCH

Hamelin, R.; Bilodeau, G.; Heinzelmann, R.; Hrywkiw, K.; Capron, A.; Dort, E.; Dale, A.; Giroux, E.; Carleson, N.; Grünwald, N.; Feau, N. *Pre-print*. Genomic biosurveillance detects a sexual hybrid in the sudden oak death pathogen. Research Square.
DOI: 10.21203/rs.3.rs-699860/v1.

Genomic biosurveillance reveals a sexual hybrid of *Phytophthora ramorum* in a nursery. Richard Hamelin and colleagues report the discovery, in a plant nursery, of novel variants of *P. ramorum* that are the result of hybridization via sexual recombination between European (EU1) and North American (NA2) clonal lineages. The research shows that these hybrids are viable, can infect plants and produce spores for long-term survival and propagation. The *P. ramorum* samples, from infected rhododendron plants, were obtained during regulatory nursery inspections by the Canadian Food Inspection Agency (CFIA). To date, the *P. ramorum* EU1 x NA2 hybrid has only been found in a single nursery in British Columbia; the pathogen has not spread to natural forests. The pathogen is considered eradicated in that nursery, thereby preventing further reproduction of the hybrid.

This is the first report of a viable *P. ramorum* hybrid between clonal lineages being recovered from a live plant. Previously, hybridization has been demonstrated in laboratory crosses between the EU1 (mating type A1) and NA1 (mating type A2) lineages, but the progeny displayed aberrant genotypic and phenotypic variation. This discovery is disconcerting since, as the authors note, “Hybridization provides a source of new genetic variation upon which natural selection can act to modify traits such as pathogenicity and transmission.”

MONITORING – CALIFORNIA AERIAL SURVEY

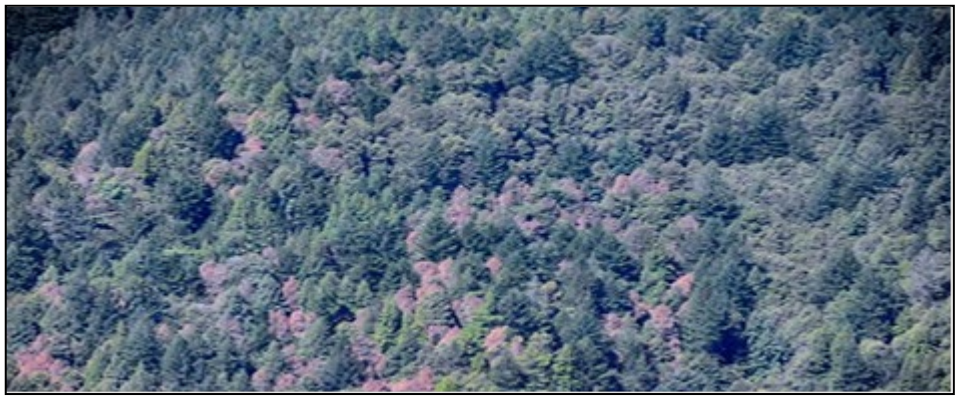

**Figure 1. Sudden oak death on tanoak in the San Francisco North Bay, July 2021.
Credit: US Forest Service, PSW Forest Health Protection, Aerial survey program.**

California sudden oak death aerial survey preliminary results. In 2021, due to drought conditions, the number of trees killed by *P. ramorum* in California appears to be reduced compared to prior years. Recent tree mortality was mapped in summer 2021 by the US Forest Service, Pacific Southwest Region, Forest Health Protection using Digital Mobile Sketch

Mapping systems. Coastal areas of California were flown in a fixed-wing aircraft, covering the entire length of the *P. ramorum* known infested counties in California (from the Oregon border south through Monterey Co.). These areas have not been ground-checked; the mortality estimate is based on visual appearance from the plane.

Along the North Coast, tanoak mortality attributed to *P. ramorum* was recorded on approximately 17,000 acres with intensity rated at light (4 -10% trees per acre), to moderate (11-30%). The heaviest mortality observed is west and north of Healdsburg (Fig. 1, Sonoma Co.) and around Garberville (Humboldt Co.). Mortality overall has greatly decreased from 2019. Along the Central California Coast, tanoak mortality was detected across 1,600 acres and was mostly observed at light to very light (1-3% per acre) intensity. Mortality is concentrated south of the San Francisco Peninsula (San Mateo Co.), along Big Sur and along the southern Santa Lucia Range (Monterey Co). Some tanoak mortality was also detected outside of known infestation areas and categorized as "damage causal agent unknown". For more information see "Aerial Detection Survey: 2021 Results" or contact Jeffrey Moore, jeffrey.moore@usda.gov.

MONITORING – 2021 SOD-BLITZ

Results from the 2021 California SOD-BLITZ show *P. ramorum* incidence on bay laurel and tanoak leaves is at a historic low in California, comparable only to the incidence recorded in 2018. In 2021, 10.2 % of samples were positive for *P. ramorum* for an estimated general infection rate of 3.3% compared to 7.4% in 2020. Areas with higher infection rates ranged between 18.6% in East Sonoma (including Petaluma, Rohnert Park, Santa Rosa, and Sonoma) and 8.4% on the western slopes of the Oakland-Berkeley Hills, to 3.4% in Marin County. In Del Norte County two positive tanoaks were identified by PCR using two distinct assays (nuclear ITS and mitochondrial Cox I). Both belonged to the EU1 lineage based on the Cox I sequence. The pathogen was not detected in San Luis Obispo County.

Twenty-four local SOD blitzes, in 16 Counties, were held from Del Norte south to San Luis Obispo County. Nearly 500 volunteers participated, with 15,000 leaves from 2,067 trees analyzed by the University of California Berkeley, Forest Pathology and Mycology Laboratory. Follow this link for maps, tables, a summary and a recorded results presentation or, for questions, contact Matteo Garbelotto, matteog@berkeley.edu.

FUNDING

A **Request for Pre-Proposals for "Conducting Activities Related to Monitoring, Extension, Management and Mitigation of Sudden Oak Death Caused by *Phytophthora ramorum*"** Is now available from the US Forest Service, Pacific Southwest Region, Forest Health Protection. The deadline to submit pre-proposals is January 11, 2022. For more information contact Phil Cannon, Regional Forest Pathologist at Philip.Cannon@usda.gov.

MANAGEMENT - OREGON

Sudden oak death continues to spread within the Oregon Generally Infested Area. Since 2001, the Oregon Sudden Oak Death Program has cooperatively managed *P. ramorum* on the landscape with the original intent of pathogen eradication in Oregon forests. But by 2010, it became apparent that sudden oak death (SOD) had expanded to the point that complete eradication was no longer feasible due to the amount of infection on the landscape coupled with insufficient funds for treatment. State quarantine regulations were amended to create a Generally

Infested Area (GIA) where treatments to remove infested tanoaks were no longer required on private and state-owned lands.

Figure 2. Sudden oak death on tanoak in the SOD GIA near Brookings, OR. Credit: ODF.

Creation of the GIA provides an opportunity to view how sudden oak death impacts a susceptible forest in a conducive climate (Figure 2). Since the creation of the GIA, SOD has continued to spread and intensify within the designated zone. The GIA has been expanded eight times since its establishment in 2012 and now encompasses 123 sq. mi. Since 2010, the lack of treatments within the GIA has led to an immediate increase in tanoak mortality. For example, along Alder Ridge Road images from 2012 and 2015 show disease progression to over 70% tanoak mortality in these stands (Figures 3a & b).

Figure 3a & b. Sudden oak death along Alder Ridge Road in 2012 vs 2015. Credit: ODF.

Over the decade since the creation of the GIA, SOD progressed through the Brookings area and surrounding rural neighborhoods (Figure 4). Accordingly, landowners and agencies involved in the early SOD eradication work have adjusted their expectations. The management objective has changed from complete pathogen eradication to learning to live with a disease that is killing tanoak, a keystone tree species. Management has shifted to mitigating the hazards from large numbers of standing dead tanoaks across the landscape. Many of these dying trees and snags are near homes or along roads and pose hazards, being vulnerable to both wind damage and fire. To maintain community safety, landowners and local agencies have had to shoulder the burden of

removing these dead and dying tanoaks themselves. There have been numerous projects conducted to remove dead or dying trees on private parcels at the landowners' expense. This has been a concern because a large percentage of landowners are retirees, on fixed incomes, who may be unable to afford the expense.

Figure 4. Dead tanoak above a residence in the SOD GIA, Curry County, Oregon. Credit: ODF.

Over the last few years, new funding opportunities for removal of hazardous tanoaks within the GIA have opened for landowners. In partnership with the Natural Resources Conservation Service, Environmental Quality Incentives Program (EQIP) financial and technical assistance is available to manage SOD and hazard trees on private ownerships. Another new opportunity is through the Coos Forest Protection Association, which was awarded $300,000 through a 2021 State Fire Assistance Wildland Urban Interface Grant for hazardous fuels reduction within the GIA. ODF SOD foresters have continued to offer technical assistance to landowners to reduce hazards. For more information contact, Randy Wiese, Randall.S.WIESE@odf.oregon.gov or Gabi Ritokova, Gabriela.Ritokova@odf.oregon.gov, Oregon Department of Forestry.

NURSERIES AND MANAGED LANDSCAPES

California Department of Food and Agriculture (CDFA) *P. ramorum* program update. Eight California nurseries that were previously positive for *P. ramorum* and that ship host material interstate are being inspected and sampled in November and December for quarantine compliance. For more information contact Carolyn Lambert, Carolyn.Lambert@cdfa.ca.gov.

Oregon Department of Food and Agriculture (ODA) *P. ramorum* program update. Currently**,** ODA's *P. ramorum* program includes four interstate shippers under federal compliance agreements (7 CFR 301.92) located in Washington (1 facility), Marion (2 facilities), and Columbia (1 facility) Counties. Fall compliance inspections were completed by mid-November. Of the four nurseries in the program, one nursery tested positive and one tested negative for *P. ramorum,* while two are pending results. The nursery that tested negative needs two more consecutive negative compliance inspections before it can be released from the program in Fall of 2022.

The positive nursery had seven plants confirmed positive for *P. ramorum*. Confirmed cultivars include Azalea 'Kurume Hino Crimson', Azalea 'Herbert', Azalea 'Elsie Lee', Azalea 'Girard's Rose', Rhododendron 'Polarnacht', and Rhododendron 'Helikki'. In total 372 plants were sampled. Water from a drainage canal and two holding ponds was sampled and tested negative. ODA inspectors completed the Confirmed Nursery Protocol (CNP), confirmed that all infected plants were destroyed by the nursery, and sampled additional plants. As per USDA protocol, the blocks where positive plants were located must be treated using an approved treatment before host plants can be reintroduced to that area. The nursery will fumigate the ground with Basamid® (dazomet). All the plants in one greenhouse, which had three confirmed positive plants, were destroyed, and the gravel will be fumigated. The grower destroyed all plants within a 20 ft radius from confirmed positive plants in several other positive blocks. Trace investigations are ongoing and will continue into 2022. For more information contact: Chris Benemann, sbenemann@oda.oregon.gov.

Washington State Department of Agriculture (WSDA) *P. ramorum* program update.
The fall certification survey at the only regulated interstate shipping nursery in Washington was negative for *P. ramorum*. The next survey will be in spring of 2022.

The USDA and WSDA are taking steps to deregulate the Kitsap County Botanical Garden where *P. ramorum* was first found in 2015. Over the past 6 years, more than 5,000 samples have been collected and 99.1% have tested negative for *P. ramorum*. The last positive plant sample was detected in February 2016. Instead of ongoing surveys, WSDA will implement a compliance agreement at the site that keeps in place the successful Best Management Practices for garden staff, including a process for identifying symptomatic plants for testing by WSDA.
For more information contact Scott Brooks at SBrooks@agr.wa.gov.

RESEARCH

Peterson, E.; Grünwald, N.J. and Parke, J. 2021. Risk of epidemic development in nurseries from soil inoculum of *Phytophthora ramorum*. Phytopathology. *Early View*. https://doi.org/10.1094/PHYTO-06-21-0245-R.

Soilborne inoculum arising from buried, infested leaf debris may contribute to the persistence of *Phytophthora ramorum* at recurrently positive nurseries. To initiate new epidemics, inoculum must not only survive, but produce sporangia during times conducive to infection at the soil surface. To assess this risk, we performed two one-year-long experiments in a soil plot at the National Ornamentals Research Site at Dominican University of California. Inoculated rhododendron leaf disks were buried at a depth of 5 or 15 cm in the early summer of 2014 or 2015. Inoculum was baited at the soil surface with non-infested leaf disks (2014 only), then retrieved to assess pathogen viability and sporulation capacity every five weeks. Two 14-weeklong trials were conducted in 2016. We were able to consistently culture *P. ramorum* over all time periods. Soil incubation rapidly reduced the capacity of inoculum to sporulate, especially at 5 cm; however, sporulation capacity increased with the onset of seasonally cooler temperatures. *P. ramorum* was baited most frequently between November and January, especially from inoculum buried at 5 cm 1 day before the baiting period; in January we also baited *P. ramorum* from inoculum buried at 15 cm the previous June. We validate prior observations that *P. ramorum* poses a greater risk after exposure to cooler temperatures and

provide evidence that infested leaf debris plays a role in the perpetuation of *P. ramorum* in nurseries. This work provides novel insights into the survival and epidemic behavior of *P. ramorum* in nursery soils.

RELATED RESEARCH

"Managing Stubborn Oomycete Plant Pathogens" a special issue of Plant Health Progress is now available online. The issue contains 28 articles on a wide range of oomycete-related topics.

Azad, A.K.; Ahmed, J.; Hakim, A.; Hasan, M.; Alum, M. and others. 2021. Genome-wide characterization deciphers distinct properties of aquaporins in six *Phytophthora* species. Current Bioinformatics. 16(6): 880-898.

Benavent-Celma, C.; López-García, N.; Ruba, T.; Ściślak, M.E.; Street-Jones, D.; van West, P.; Woodward, S. and Witzell, J. *In press*. Current practices and emerging possibilities for reducing the spread of oomycete pathogens in terrestrial and aquatic production systems in the European Union. Fungal Biology Reviews. https://doi.org/10.1016/j.fbr.2021.10.001.

Bily, D.; Nikolaeva, E.V.; Olson, T. and Kang, S. *First Look*. *Phytophthora* spp. associated with Appalachian oak forests and waterways in Pennsylvania, with *P. abietivora* as a pathogen of five native woody plant species. Plant Disease. https://doi.org/10.1094/PDIS-05-21-0976-RE.

Heungens, K. and Chandelier, A. 2021. Response of European forests and society to invasive pathogens. Final Report. BRAIN-be - Belgian Research Action through Interdisciplinary Networks. Brussels, 95 pages. http://www.belspo.be/belspo/brain-be/projects/FinalReports/RESIPATH_FinRep.pdf.

Punalekar, S.M.; Planque, C.; Lucas, R.M.; Evans, D.; Correia, V.; Owers, C.J., and others. 2021. National scale mapping of larch plantations for Wales using the Sentinel-2 data archive. Forest Ecology and Management. 501: 119679.

Scanu, B.; Jung, T.; Masigol, H.; Linaldeddu, B.T.; Jung, M.H.; Brandano, A. and others. 2021. *Phytophthora heterospora* sp. nov., a new pseudoconidia-producing sister species of *P. palmivora*. Journal of Fungi. *7*(10): 870, https://doi.org/10.3390/jof7100870.

RESOURCES - RECORDED MEETINGS

A seminar on risks of *Phytophthora* spread from native plants that are resold after being bought-in from wholesale nurseries is posted HERE. Highlights include Christa Conforti, Presidio Trust and Betty Young, California Native Plant Society, Sonoma County sharing ideas and results from pre-testing incoming plants for infection. The seminar, held November 15, 2021, was sponsored by the Phytophthoras in Native Habitats Work Group, Northern California Native Plant Network, and the California Native Plant Society *Phytophthora* Ad Hoc Committee.