CALIFORNIA OAK MORTALITY TASK FORCE REPORT
DECEMBER 2020

MONITORING, RESEARCH AND MANAGEMENT

The EU1 strain of *Phytophthora ramorum* has been detected in forest trees in Del Norte County. This recent detection represents two firsts: 1) the first time the EU1 strain has been detected in forest trees in California, and 2) the first officially confirmed detection of the pathogen in Del Norte County.

Figure 1a (left). A view from State Route 197 of the dead tanoak trees at the newly detected Del Norte County *P. ramorum* site. 1b (right). The infested site after tanoak removal.
Photos courtesy of UC Cooperative Extension, Humboldt and Del Norte Counties.

The detection also represents an epidemiological puzzle. Is the pathogen related to Oregon or California infestations? The nearest *P. ramorum* infestation is 12 miles to the north along the Winchuk River in Curry County, Oregon; those trees are infected with the NA1 strain, not the EU1 strain. The nearest known EU1 infestation is between the Pistol and Rogue Rivers in Oregon, approximately 35 miles away. The closest well-established California infestation is from the NA1 strain, and it is in Redwood National Park, 55 miles to the south.

The EU1 infested trees were found uphill of State Route 197 (also called North Bank Road) in a ~70-year-old redwood (*Sequoia sempervirens*) forest with a minor tanoak (*Notholithocarpus densiflorus*) component and minimal California bay laurel (*Umbellularia californica*). This

location is 1 mile from Highway 101, near the Smith River. After official sampling and confirmation of the pathogen by the California Department of Food and Agriculture (CDFA) and the USDA Animal and Plant Health Inspection Service (APHIS) in September, genetic work at both the USDA Agricultural Research Service in Oregon and UC Berkeley determined that the genotypes present in the new infestation match genotypes previously collected both from Oregon forest samples, and from Oregon and California ornamental nursery samples. The pathway for introduction to this site is still not understood.

After the detection, UC Cooperative Extension and Cal Fire participated in a helicopter flight to survey for dead tanoaks from the air in northern Humboldt and Del Norte Counties. The surveyors could see the existing (and growing) infestations within Redwood National Park (Humboldt Co.), but no tanoak mortality of note was observed in Del Norte County.

Once official testing was completed, UC Cooperative Extension and Cal Fire organized a consortium of landowners and public agencies to implement management activities to slow *P. ramorum* spread and minimize its landscape impacts. Involved groups included private landowners, UC Cooperative Extension, the County of Del Norte, Caltrans, and Cal Fire. The EU1 find followed the 2019 detection of the NA1 strain of the pathogen in Jedediah Smith State Park, approximately 3 miles south of the new infestation site, as part of the UC Berkeley-led SOD Blitz. This detection could not be reconfirmed after 12 consecutive months of sampling over 2019-2020. The isolate is a close match to California-based ornamental nursery genotypes and not California wildland types.

Del Norte County will be added to the list of counties regulated for the movement of host plant material by CDFA, APHIS, and the California Department of Forestry and Fire Protection. The presence of *P. ramorum* in the county, which has the potential to threaten numerous agricultural and natural resource-based industries, increases the number of confirmed and regulated California counties with *P. ramorum* wildland infestations to 16. For more information about *P. ramorum* in Del Norte County, contact Yana Valachovic, UC Cooperative Extension, yvala@ucanr.edu or Chris Lee, Cal Fire, christopher.lee@fire.ca.gov.

FUNDING

Request for proposals for sudden oak death monitoring, extension, management and mitigation. The USDA Forest Service, Pacific Southwest Region, Forest Health Protection is seeking proposals aimed at limiting the impact of *P. ramorum* in California and southwestern Oregon. Proposals are encouraged for activities that will provide new information on *P. ramorum* spread and for extension projects to share relevant information to diverse parties. Awards will need to be matched dollar-for-dollar with nonfederal support. Tribal groups are especially encouraged to apply and do not need to provide matching funds. The deadline for submission is January 15, 2021. For more information, contact Phil Cannon, Regional Pathologist, phil.cannon@usda.gov.

REGULATIONS - POLICY

New chairperson of the National Plant Board *P. ramorum* Regulatory Working Group. Megan Abraham, Director, Division of Entomology and Plant Pathology, Indiana Department of Natural Resources, is the new chairperson for the National Plant Board, USDA APHIS, PPQ, *P.*

ramorum Regulatory Working Group, that assists William Wesela, National Policy Manager, USDA APHIS *P. ramorum* program. This work group is made up of representative members including both State Plant Regulatory Officials (SPROs) and APHIS State Plant Health Directors (SPHDs) of the shipping states from the Pacific West and the receiving states throughout the nation. The group reviews and update policies and manuals to assist in regulating and limiting the spread of *P. ramorum* within the USA. In the last few years, they updated the USDA *P. ramorum* Program Manual. Current work includes a new Manual chapter for retail locations with guidance to respond to receipt of potentially infested plant shipments. Over the next few years, the group will work on improving communication between shipping and receiving states, ensuring that trace-forwards are addressed as efficiently as possible according to federal and state guidelines, and providing training to inspectors in identifying *P. ramorum* symptoms. These steps will be taken to reduce the likelihood of the pathogen moving from quarantined areas to the rest of the country. More information about the USDA APHIS *P. ramorum* program can be found at **https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/phytophthora-ramorum/sod.**

NURSERIES

California Department of Food and Agriculture (CDFA) *P. ramorum* program update. In November and December, nine California nurseries that were previously positive for *P. ramorum* and that ship *P. ramorum* host material interstate are being inspected and sampled for quarantine compliance. One previously positive interstate shipping nursery successfully completed six biannual inspections with negative results so reverted back to annual sampling. This brought the total number of previously positive nurseries participating in increased sampling to nine and total positive nurseries in California in 2020 to five.

Official wildland samples collected near Crescent City on August 26th were determined to be positive for *P. ramorum* by the CDFA Plant Pest Diagnostics Center. These positive samples confirmed that the pathogen is present in wildlands in Del Norte County. The positive trees are tanoaks (*Notholithocarpus densiflorus*). Del Norte County is in the process of being added into Federal and State regulations for *P. ramorum* to become the 16th quarantined county in California. For more information contact Carolyn Lambert, Carolyn.Lambert@cdfa.ca.gov.

Washington State Department of Agriculture (WSDA) *P. ramorum* program update. Four residential sites in King County placed under the Confirmed Residential Protocol during the summer of 2020 have met requirements for release from quarantine. The positive residential sites were a result of a trace-forward on Rhododendron 'Polarnacht' from an out-of-state nursery. Steam treatment of positive soil occurred at two sites. All four residential sites will be monitored for two years by WSDA.

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 2021.

In late October, a two-day survey was conducted at the Kitsap County Botanical Garden first found positive for *P. ramorum* in 2015. A total of 226 samples were collected near previous positive sites and around the perimeter areas of the garden. Final results are still pending. For more information contact Scott Brooks, SBrooks@agr.wa.gov.

RESEARCH (ABBREVIATED ABSTRACTS)

Carleson, N.C.; Daniels, H.; Reeser, P.; Kanaskie, A.; Navarro, S.; Leboldus, J. and Grünwald, N.J. Early View. Novel introductions and epidemic dynamics of the sudden oak death pathogen *Phytophthora ramorum* in Oregon forests. Phytopathology**.** https://doi.org/10.1094/PHYTO-05-20-0164-R**.**

Sudden oak death caused by *Phytophthora ramorum* has been actively managed in Oregon since the early 2000s. To date, this epidemic has been driven mostly by the NA1 clonal lineage of *P. ramorum*, but an outbreak of the EU1 lineage has recently emerged. Here we contrast the population dynamics of the NA1 outbreak first reported in 2001 to the outbreak of the EU1 lineage first detected in 2015. We tested if any of the lineages were introduced more than once. Infested regions of the forest were sampled between 2013-2018 (n = 903) and strains were genotyped at 15 microsatellite loci. Most genotypes observed were transient, with 272 of 358 unique genotypes emerging one year and disappearing the next. Diversity of EU1 was very low and isolates were spatially clustered (< 8 km apart), suggesting a single EU1 introduction. Some forest isolates are genetically similar to isolates collected from a local nursery in 2012, suggesting introduction of EU1 from this nursery or simultaneous introduction to both the nursery and latently into the forest. In contrast, the older NA1 populations were more polymorphic and spread over 30 km^2. Principal component analysis supported two to four independent NA1 introductions. The NA1 and EU1 epidemics infest the same area but show disparate demographics owing to initial introductions of the lineages spaced 10 years apart. Comparing these epidemics provides novel insights into patterns of emergence of clonal pathogens in forest ecosystems.

Davis, F.W. Early View. More trees are dying due to drought and wildfire, but don't lose sight of forest pathogens. Earth's Future. e2020EF001792. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020EF001792.

Accelerated forest dieback has been documented at many locations around the world that have experienced severe drought, warming, and wildfires associated with global climate change. Exotic forest diseases pose a comparably large threat to wild forests. Synthesizing surveillance plot data to parameterize spatial epidemiological models, Cobb et al. (2020, The Magnitude of Regional-Scale Tree Mortality Caused by the Invasive Pathogen *Phytophthora ramorum* **https://doi.org/10.1029/2020EF001500**) estimate that the introduced invasive water mold, *Phytophthora ramorum* (Sudden Oak Death), has already killed 43 million trees in coastal evergreen forests of northern California and southern Oregon. Their results highlight the value of long-term surveillance networks for monitoring and modeling the spread of invasive forest pathogens and underscore the need for stronger public policy to reduce the global spread of these extremely harmful organisms.

Elliott, M.; Rollins, L.; Bourret, T.; Chastagner, G. 2020. First report of leaf blight caused by *Phytophthora ramorum* on cherry laurel (*Prunus laurocerasus*) in Washington State, USA. Plant Disease. https://apsjournals.apsnet.org/doi/abs/10.1094/PDIS-07-20-1489-PDN.

In April 2014, *Phytophthora ramorum* (Werres, De Cock & Man in't Veld) was recovered from symptomatic foliage of cherry laurel (*Prunus laurocerasus*) at an ornamental plant nursery in Washington State. Cherry laurel, also known as English laurel, is widely propagated in WA

because it is commonly used in landscaping. It is invasive in forests near the urban/wildland interface in the western US and in Europe. Given its popularity as an ornamental species, the potential of this host to spread *P. ramorum* is of regulatory concern due to possible long distance spread to other states via nursery stock. Foliar symptoms consisted of dark brown lesions near wounds or around leaf margins where water collected. Shot-hole symptoms characterized by abscission zones and dropping of infected tissues were also observed. Lesions expanded beyond the margin of the shot-hole in some cases. Pathogenicity of *P. ramorum* on cherry laurel was confirmed by completing Koch's Postulates using the isolate taken from this host. To our knowledge, this is the first report of *P. ramorum* naturally infecting cherry laurel in the United States.

Garbelotto, M.; Schmidt, D.; Popenuck, T. Early View. Pathogenicity and infectivity of *Phytophthora ramorum* vary depending on host species, infected plant part, inoculum potential, pathogen genotype and temperature. Plant Pathology. https://doi.org/10.1111/ppa.13297.

A summary highlighting this work is available on the British Society for Plant Pathology homepage, https://www.bspp.org.uk/.

A total of 25 ornamental plant species representing 10 families were inoculated using three genotypes, each representing one of the genetic lineages NA1, NA2 and EU1 of the pathogen *Phytophthora ramorum*. Leaves were inoculated using liquid suspensions with two zoospore concentrations and exposure at three temperatures, while stems were inoculated using agar plugs colonized by mycelia. Susceptibility was determined by measuring either the pathogen's reisolation success or lesion length caused by the pathogen. Infectivity was determined by counting sporangia in washes of inoculated leaves or stems. Results from all three pathogen genotypes combined were used to rank each of the 25 plant species for susceptibility and infectivity, while pooled results from all 25 hosts combined were employed for a preliminary comparison of pathogenicity and infectivity among genotypes. Statistical analyses showed that leaf results were affected by the concentration of zoospores, temperature, plant host, pathogen genotype and by the interaction between host and pathogen genotype. Stem results were mostly affected by host and by the interaction between host and pathogen genotype. Hosts ranked differently when looking at the various metrics, and differences in rankings were also significant when comparing stem and leaf results. Differences were identified among the 25 hosts and the three pathogen genotypes for all metrics: results can be used for decision making regarding regulations or selection of plants to be grown where infestations by *P. ramorum* are an issue.

Harris, A.R.; Brasier, C.M.; Scanu, B. and Webber, J.F. Early view. Fitness characteristics of the European lineages of *Phytophthora ramorum*. Plant Pathology. https://doi.org/10.1111/ppa.13292.

As an introduced pathogen, *Phytophthora ramorum* exists as four near-clonal evolutionary lineages, of which only EU1 and EU2 are established in the UK. The EU1 has become widespread since the first findings in 2002 whereas the EU2, detected in 2011, has a more limited distribution. Both lineages are epidemic in plantation-grown larch, sporulating asexually on needles but also causing heavy dieback and mortality. To understand if EU1 and EU2 pose different threats to forest health, we compared their growth characteristics on agar, pathogenicity

on several hosts and sporulation on Japanese larch needles. When pathogenicity was evaluated by measuring colonization at 20ºC in mature bark (phloem) of Japanese and European larch (*Larix kaempferi and L. decidua*), English oak (*Quercus robur*) and beech (*Fagus sylvatica*), Japanese larch was the most susceptible and oak the least susceptible. On average, EU2 isolates produced significantly larger lesions than EU1 isolates in Japanese larch and oak although not in the other hosts. With tests using young saplings of Japanese and European larch, damaging bark lesions formed at both 10ºC and 20ºC, but the EU2 was significantly more pathogenic at 20ºC on both hosts compared with EU1. In contrast, both lineages caused similar amounts of necrosis on inoculated leaves of rhododendron (*Rhododendron ponticum*). Moreover, EU2 isolates usually sporulated less abundantly on larch needles compared with EU1 isolates, suggesting a trade-off in pathogenicity and sporulation between lineages. As the EU2 tends to have smaller sporangia than the EU1 this could also reduce the inoculum potential of the EU2.

Layman, M.L.; Ramsey, C.; Schweigkofler, W. and Newman. S.E. 2020. Field evaluation of a novel, granular soil fumigant for controlling *Phytophthora ramorum* in field nursery soils. Global Journal of Agricultural Innovation, Research & Development 7:12-19.

Phytophthora ramorum, the causal agent of Sudden Oak Death (SOD) and ramorum blight, infects a wide range of hardwood and nursery ornamental species. Chlamydospores of *P. ramorum* can survive for extended periods of time in soils. Two studies were conducted, including: 1) a laboratory study to evaluate two liquid disinfectants for controlling *P. ramorum* chlamydospores, and 2) a field study to evaluate a novel soil fumigation treatment as an alternative to soil steaming or methyl bromide soil fumigation. The liquid disinfectants were ElectroBiocide and Oxidate 2.0. The laboratory study resulted in complete inactivation of the *P. ramorum* chlamydospores after six minutes of contact time for both the liquid disinfectants. The field study evaluated a chlorine dioxide granule formulation that was applied at two rates in a nursery soil. Rhododendron leaf discs were inoculated with *P. ramorum*, placed in permeable sachets and buried at two soil depths in a research nursery. Soil treatments also included saturated hydrogels (with and without gels) so that soil moisture effects on chlamydospore survival could be estimated. The sachets were recovered 5, 15 and 30 days after the soil treatment. Efficacy of the soil treatments was evaluated by the number of leaf discs showing *P. ramorum* growth recovered from the sachets. The soil fumigation treatment with highest efficacy occurred when the sachets were buried at the 5 cm soil depth, were treated with hydrogels, at the highest Z-series granule rate (800g/tube), and had a contact time of 30 days. The probability of *P. ramorum* growth for this soil treatment was 0.18, or 18%, i.e. the probability of that fumigation treatment inactivating the pathogen was 82%. Also, as the soil moisture increased, the efficacy of the fumigation treatments also increased.

Rosenthal, L.M.; Fajardo, S.N.; Rizzo, D. Early View. Sporulation potential of *Phytophthora ramorum* differs among common California plant species in the Big Sur region. Plant Disease. https://doi.org/10.1094/PDIS-03-20-0485-RE.

Sudden oak death (SOD), caused by the generalist pathogen *Phytophthora ramorum*, has profoundly impacted California coastal ecosystems. SOD has largely been treated as a two-host system, with *Umbellularia californica* as the most transmissive host, *Notholithocarpus densiflorus* less so, and remaining species as epidemiologically unimportant. However, this understanding of transmission potential primarily stems from observational field studies rather

than direct measurements on the diverse assemblage of plant species. Here, we formally quantify the sporulation potential of common plant species inhabiting SOD-endemic ecosystems on the California coast in the Big Sur region. This study allows us to better understand the pathogen's basic biology, trajectory of SOD in a changing environment, and how the entire host community contributes to disease risk. Leaves were inoculated in a controlled laboratory environment and assessed for production of sporangia and chlamydospores, the infectious and resistant propagules, respectively. *P. ramorum* was capable of infecting every species in our study and almost all species produced spores to some extent. Sporangia production was greatest in *N. densiflorus* and *U. californica* and the difference was insignificant. Even though other species produced much less, quantities were non-zero. Thus, additional species may play a previously unrecognized role in local transmission. Chlamydospore production was highest in *Acer macrophyllum* and *Ceanothus oliganthus*, raising questions about the role they play in pathogen persistence. Lesion size did not consistently correlate with the production of either sporangia or chlamydospores. Overall, we achieved an empirical foundation to better understand how community composition affects transmission of *P. ramorum*.

RELATED RESEARCH

Burgess, T.I.; Villamor, A.L.; Paap, T.; Williams, B.; Belhaj, R.; Crone, M.; Dunstan, W.; Howard, K. and Hardy, G.S.J. Early View. Towards a best practice methodology for the detection of *Phytophthora* species in soils. Plant Pathology. https://doi.org/10.1111/ppa.13312.

RESOURCES, EDUCATION AND OUTREACH

Parke, J. 2020. Managing epidemics: whether dealing with plant pathogens or COVID-19, common principles apply. Growing Knowledge. Oregon State University. Digger Magazine. November, http://www.diggermagazine.com/managing-epidemics/.

"Beastie the Bug" visited U.S. sudden oak death sites. For the International Year of Plant Health, the European Plant Protection Organization created Beastie the Bug whose travels around the world are documented with photos near plant health problems. Beastie can be seen near *P. ramorum* infected trees in Humboldt and Curry Counties and in England.
See https://beastiebug.eppo.int/ and https://beastiebug.eppo.int/bug/121.