



CALIFORNIA OAK MORTALITY TASK FORCE REPORT SEPTEMBER 2016

FEATURED RELATED RESEARCH

First detection of *Phytophthora quercina* in the US, associated with outplanted *Quercus lobata*, valley oak – *P. quercina* was recently isolated from valley oaks (*Quercus lobata*) as part of an evaluation conducted by the Rizzo Lab (UC Davis) and Phytosphere Research on restoration sites managed by the Santa Clara Valley Water District. To confirm the detection, soil samples with roots from planted valley oak trees that showed symptoms of stunting in a restoration site near San Jose were collected by Santa Clara County agricultural officials and sent to the CDFA Plant Pathology Lab for diagnosis. DNA was extracted from soil baits and determined to be a 100% match to *P. quercina*. The find was confirmed by the USDA APHIS Beltsville lab in June. This is the first officially confirmed detection of the pathogen in the US, although there are other reports of a *P. quercina* ‘like’ organism associated with oak decline in forests in Minnesota, Wisconsin, and Missouri. *P. quercina* is a pathogen associated with oak decline across Europe. It has been rated the # 1 *Phytophthora* species of concern for introduction into the US in a USDA Plant Epidemiology and Risk Analysis Laboratory (PERAL) report. *P. tentaculata*, recently found in association with multiple native plant species in CA native plant nurseries, was rated as # 5 on the same list.

MONITORING

New *P. ramorum*-positive stream in Humboldt County - Gilham Creek, a tributary of the Mattole River, has tested *P. ramorum* positive for the first time. Of the 20 Humboldt County sampling locations in 2016, Gilham Creek was the only waterway to test positive, compared to 4 new positive waterways in 2015. Located in the Honeydew area in the southwest portion of the county, the creek is adjacent to previously positive (2013) Grindstone Creek. Efforts are underway to locate the inoculum source.

Nine eastern states are participating in the 2016 National *P. ramorum* Early Detection Survey of Forests (AL, FL, GA, MS, NC, PA, SC, TN, and TX). Of the 308 samples collected this spring, 9 samples from 4 locations were *P. ramorum* positive – 3 locations in AL (site a/3 positives and site b/2 positives were first detected in 2009; site c/1 positive was first detected in 2007) and 1 location with 3 positives in MS (first positive in 2008). All positive samples were collected from streams associated with previously positive nurseries. Fall surveying will begin in October.

The United Kingdom (UK) *P. ramorum* spring/summer aerial surveys were completed in July. Observations were generally consistent throughout the survey season, with limited, low-level pathogen symptoms resulting in relatively small areas of Japanese larch (*Larix kaempferi*) trees requiring felling under Statutory Plant Health Notices. Infection sites were primarily associated with previous Japanese larch, rhododendron, and sweet chestnut infestations. The autumn/fall aerial survey is underway; early reports are following the same trend with a low level of detection.



UK Forest Research is continuing investigations into crown deterioration, dieback, and death of European sweet chestnut (*Castanea sativa*) in southwest England, some of which has been confirmed as being caused by *P. ramorum*. Unlike previous cases of sweet chestnut infection, which could be attributed to high inoculum pressure from other heavily infected host plants nearby, many of the recent cases are not in close proximity to other infected hosts, suggesting there may be a new epidemiology on sweet chestnut and prompting research to understand what is happening.

NURSERIES

A Sacramento County nursery had 2 camphor (*Cinnamomum camphora*) trees with branch cankers and foliar symptoms found to be *P. ramorum* positive in August. The nursery ships interstate and has been undergoing the confirmed nursery protocol (CNP) since June, 2016. Follow-up soil and water samples have been taken and results are pending. The USDA Animal and Plant Health Inspection Service (APHIS) recommended the 90-day quarantine at the facility be restarted. California currently has 7 nurseries participating in the USDA APHIS federal *P. ramorum* program. The Sacramento County facility is the only nursery in the program that is currently undergoing the CNP.

A Santa Clara County nursery, currently part of the USDA *P. ramorum* program, was also found *P. ramorum* positive in May when one *Loropetalum* plant was identified as positive. The nursery completed the Alternative Quarantine Release Strategy, which includes plant destruction, site modification, and implementation of best management practices. After final inspection, the facility was released from the CNP and is able to resume interstate shipping.

A July survey of the Washington Kitsap County botanical garden (*P. ramorum* positive in 2015) was negative for the pathogen. Surveys have been conducted throughout 2016 near previously positive sites or in outlying areas of the garden, with all results negative since January. The next survey is scheduled for late September. Botanical garden staff continues to utilize best management practices at the garden.

FUNDING

The USDA Forest Service, Pacific Southwest Region, State and Private Forestry, Forest Health Protection program has issued its FY2017 *Phytophthora ramorum* Request for Management Pre-Proposals ([RFP](#)). Proposals should focus on management activities that could help limit the impact of sudden oak death (SOD) in California and/or southwest Oregon, improve understanding of pathogen spread, and promote the exchange of relevant information. In general, proposals should be for grants of between \$10,000 and \$90,000 per year. Multi-year collaborative projects are encouraged. The submission deadline is 4:00 pm on **November 25, 2016**. Those applying should make note of the early due date. For questions, or for a copy of the Request for Proposals, please contact Phil Cannon at: pcannon@fs.fed.us or (707) 562-8913.

FEATURED RESEARCH

Buffer Plant Trial at the National Ornamentals Research Site at Dominican University of California (NORS-DUC): A Search for *P. ramorum* Non-Hosts



By Karen Suslow, NORS-DUC Program Manager

In April, 2014, a study was implemented at NORS-DUC to identify ornamental plants that are not susceptible to *P. ramorum* and could be used by growers to break up large, contiguous blocks of high-risk host plants, helping to reduce destruction zones should the pathogen be found at their facility. The 3 buffer plants tested were: *Buxus sempervirens* 'Suffruticosa,' (American boxwood) *Nandina domestica*, (heavenly bamboo) and *Liriope muscari* variegata (lilyturf), 2 sun plants and 1 shade plant, respectively, and all heavily traded in the industry. In November 2014, the plants were arranged around infected rhododendrons (plot FM5). Plants were also placed in a field bed with infested, contained, runoff irrigation water for an 8-month period (plot FM7).

In January 2015, a hoop structure was placed over all the plants to simulate Northeastern and Midwestern practices of protecting unsold product in winter. No *P. ramorum* symptoms were detected on the selected buffer plants; however, the pathogen infected another rhododendron plant in the outer ring of plants (FM5; approximately 1 ft. from the three central diseased plants). In early March 2015, the hoop structure was removed. Heavy rains occurred on April 7th, and plants were examined for symptoms weekly.

In early June 2015, all roots and foliage from the buffer plants were ELISA tested and all foliage was negative. Of the plants in the *P. ramorum*-infested water (FM7), several had faint ELISA reactions. Roots from those samples were analyzed; *P. ramorum* was not detected. Pour-through tests were also conducted. *P. ramorum* was not recovered; however, other *Phytophthora* species were detected on 1 plant.

The experiment was repeated in winter 2016. Several healthy *Nandina*, *Liriope*, and *Buxus* were set out under *P. ramorum*-infected California bay laurel trees, one on the Dominican campus and another near Muir Woods in Marin County. After very heavy rains, leaf symptoms were observed on *Nandina* under the infected bay trees in both locations and in the FM5 buffer plant trial. *Liriope* was also found to be infected under the infected bay laurel near Muir Woods. Samples were sent to CDFR for culturing. Results confirmed *Nandina* was infected with *P. ramorum* at all 3 locations. Infected leaves defoliated from the plant (Figure 1).



Figure 1. *P. ramorum*-infected *Nandina domestica* leaves

Healthy rhododendron plants were also placed under a bay tree on the Dominican campus. After several months of rain, the rhododendrons were heavily infected. In FM5, 8 of 12 healthy rhododendrons (forming the outer ring) were found to be infected with *P.*



ramorum, compared to 1 plant the previous year. Optimal environmental conditions for *P. ramorum* spread were observed this past winter, which have not been seen in the past 4 years, highlighting the important role of weather in disease establishment and spread.

NORS-DUC is testing Koch's Postulates on *Nandina domestica*, and *Liriope muscari variegata*. Based on these results and other sources of information, USDA will determine if these plants will be added to the *P. ramorum* host list.

RESEARCH

Alonso Chavez, V.; Parnell, S.; and Van Den Bosch, F. 2016. Monitoring Invasive Pathogens in Plant Nurseries for Early-Detection and to Minimise the Probability of Escape. *Journal of Theoretical Biology.* 407: 290–302.

Abstract: The global increase in the movement of plant products in recent years has triggered an increase in the number of introduced plant pathogens. Plant nurseries importing material from abroad may play an important role in the introduction and spread of diseases such as ash dieback and sudden oak death which are thought to have been introduced through trade. The economic, environmental and social costs associated with the spread of invasive pathogens become considerably larger as the incidence of the pathogen increases. To control the movement of pathogens across the plant trade network it is crucial to develop monitoring programmes at key points of the network such as plant nurseries. By detecting the introduction of invasive pathogens at low incidence, the control and eradication of an epidemic is more likely to be successful. Equally, knowing the likelihood of having sold infected plants once a disease has been detected in a nursery can help designing tracing plans to control the onward spread of the disease. Here, we develop an epidemiological model to detect and track the movement of an invasive plant pathogen into and from a plant nursery. Using statistical methods, we predict the epidemic incidence given that a detection of the pathogen has occurred for the first time, considering that the epidemic has an asymptomatic period between infection and symptom development. Equally, we calculate the probability of having sold at least one infected plant during the period previous to the first disease detection. This analysis can aid stakeholder decisions to determine, when the pathogen is first discovered in a nursery, the need of tracking the disease to other points in the plant trade network in order to control the epidemic. We apply our method to high profile recent introductions including ash dieback and sudden oak death in the UK and citrus canker and Huanglongbing disease in Florida. These results provide new insight for the design of monitoring strategies at key points of the trade network.

Cobb, R.C. and Rizzo, D.M. 2016. Litter Chemistry, Community Shift, and Non-Additive Effects Drive Litter Decomposition Changes Following Invasion by a Generalist Pathogen. *Ecosystems.* DOI:10.1007/s10021-016-0017-8.

Abstract: Forest pathogens have strong potential to shape ecosystem function by altering litterfall, microclimate, and changing community structure. We quantified changes in litter decomposition from a set of distinct diseases caused by *Phytophthora ramorum*, an



exotic generalist pathogen. *Phytophthora ramorum* causes leaf blight and increased litterfall %N, but no mortality on California bay laurel (*Umbellularia californica*), a common overstory tree that accumulates high levels of infection. Lethal twig and bole cankers on tanoak (*Notholithocarpus densiflorus*) lead to the disease sudden oak death which creates canopy openings and alters litterfall in mixed-species forests dominated by redwood (*Sequoia sempervirens*) which is minimally susceptible. Species identity had the greatest effect on mass loss and N dynamics with the most rapid rates in bay laurel, slowest in redwood, and intermediate in tanoak. Decomposing litter from infected sources had increased N accumulation, and although these changes were of lower magnitude relative to species identity, the region-scale invasion of *P. ramorum* suggests that this effect could occur over an extensive area. Canopy mortality was a significant and slowing influence on litter N dynamics in all species and also dampened non-additive effects within mixed litter bags. Redwood—the lowest quality litter—demonstrated non-additive interactions with consistently lower C:N when decomposed in mixed litter bags, but this effect did not alter the entire mixture. Mortality and subsequent changes in community composition have the greatest magnitude effects on litter decomposition for sudden oak death, but our study implies that different and sometimes cryptic mechanisms will drive decomposition changes for other forest diseases.

Junker, C., Goff, P., Wagner, S., and Werres, S. 2016. Occurrence of *Phytophthora* in commercial nursery production. *Plant Health Progress*. 17:64-75.

Two commercial woody ornamental nurseries were sampled for the presence of *Phytophthora* species over a period of three years between 2011 and 2014. The samples were taken every two months at different propagation (greenhouses, plastic tunnels) and cultivation (container stands) areas as well as from nearby pathways and from a water recycling system with a slow sand filter. Furthermore, different materials like soil, substrates, residues, wind-carried leaves, water and sediment were sampled. In total, 12 known *Phytophthora* species could be detected. Further, three isolates did not match any of the known species. *Phytophthora ramorum*, *P. gonapodyides*, and *P. plurivora* were the species with the highest detection rates. *Phytophthora ramorum* could be detected during all seasons of the year. In total, the puddles on the pathways had the highest percentage of positive detections. Residues, wind-carried leaves and water and sediment from the water runoffs were also good places for *Phytophthora* survival. In both nurseries, the plant samples showed very low infection rates. Ideas for surveys and management are discussed.

O'Hanlon, R., Choiseul, J., Grogan, H. 2016. In-vitro Characterisation of the Four Lineages of *Phytophthora ramorum*. *European Journal of Plant Pathology*. DOI: 10.1007/s10658-016-1019-2.

Abstract: *Phytophthora ramorum* is a plant pathogen with a wide host range including many ornamental hosts and tree species. In Ireland and the UK *P. ramorum* is known to cause sudden larch death. There are four distinct genetic lineages of *P. ramorum*, with the fourth lineage (EU2) described in 2012 and only present in Northern Ireland and



Scotland. In this work, experiments that compare all four lineages of *P. ramorum* using several phenotypic characters are described. A total of 166 isolates (EU1: 116, EU2: 40, NA1: 8, NA2: 2) from several EU countries and the United States and several hosts were amassed, and a selection of isolates were compared according to standard phenotypic tests. The EU1 and EU2 isolates tested were all A1 mating type. Regarding linear growth rate, we found the isolates ranked as follows EU2 > NA2 > EU1 > NA1, with all lineages growing fastest at 20 °C. The lineages ranked as NA2 > EU1 > EU2 > NA1 based on their in-vitro aggressiveness on detached wounded *Rhododendron* leaves, all lineages most aggressive at 20 °C. At 20 °C, we found that there was no significant difference between the EU1 and EU2 lineage based on their linear growth rate or in-vitro aggressiveness. Temperature, host ramet and *P. ramorum* lineage all had statistically significant effects on the observed aggressiveness of the isolates. From an experimental point of view, our results are broadly in agreement with other phenotypic studies of *P. ramorum*, finding variation between the lineages, but also variation within the lineages. From an applied perspective, our work on *Rhododendron* indicates that the EU1 and EU2 lineages pose similar levels of threat to plant health in Ireland and the UK, however, how these results transfer to other hosts (e.g. *Larix kaempferi*) needs more study.

Preuett, J.A.; Collins, D.J.; Luster, D.G.; and Widmer, T.L. 2016. The Effect of Salinity on the Survival, Growth, Sporulation and Infection of *Phytophthora ramorum*. Fungal Ecology. 23:123–130.

Abstract: *Phytophthora ramorum* has been found in waterways outside infested nurseries, but little is known about its behavior in water. This study examined the effect of salinity on survival, growth, sporulation, and infection. *P. ramorum* survival and growth was negatively correlated with salt concentration (range of 0–45 g l⁻¹), but showed a level of tolerance even at 45 g l⁻¹. No sporangia were observed in cultures with higher than 20 g l⁻¹ of salt and zoospores were not released from sporangia above 14 g l⁻¹. Water sources with different salinity were used to understand the environment where *P. ramorum* can survive and infect host material. Water from natural bodies and water amended with different salt concentrations were added to *P. ramorum*-infested sand and baited with rhododendron leaf disks. Infection decreased with increasing salt concentration and increased with higher initial concentration of *P. ramorum*. This research helps to better understand the effects of water quality on survival and infectivity of *P. ramorum*, expanding the potential survey range.

Tooley, P.W. and Browning, M. 2016. The Effect of Exposure to Decreasing Relative Humidity on the Viability of *Phytophthora ramorum* sporangia. Journal of Phytopathology. DOI: 10.1111/jph.12506.

Abstract: Sporangia of three isolates of *Phytophthora ramorum* representing three different clonal lineages were subjected to relative humidity (RH) levels between 80 and 100% for exposure periods ranging from 1 to 24 h at 20°C in darkness. Plastic containers (21.5 × 14.5 × 5 cm) were used as humidity chambers with 130 ml of glycerine solution added to each container. Glycerine concentrations corresponded to 100, 95, 90, 85 and



80% RH based on refractive index measurements. Sporangia suspensions were pipeted onto nitrile mesh squares (1.5 × 1.5 cm, 15 micron pore size) which were placed in the humidity chambers and incubated at 20°C in darkness. Following exposure periods of 1, 2, 4, 8, 12 and 24 h, mesh squares were inverted onto Petri dishes of selective medium and sporangia germination assessed after 24 and 48 h. At 100% RH, we observed a mean value of 88% germination after 1 h exposure declining to 18% germination following 24 h incubation. At 95% RH, a steeper decline in germination was noted, with means ranging from 79% at 1 h to less than 1% at 24 h exposure. At 90% RH, no germination was noted after 8 or more h exposure, and values were 57%, 22% and 3% germination for the 1, 2 and 4 h exposures, respectively. Germination was only observed at 1 h exposure for both the 85% RH treatment (52% germination) and the 80% RH treatment (38% germination). The three isolates responded similarly over the range of RH values tested. The germination response of *P. ramorum* sporangia to RH values between 80% and 100% was comparable to that reported for other *Phytophthora* species. Knowledge of conditions that affect *P. ramorum* sporangia germination can shed light on pathogenesis and epidemic potential and lead to improved control recommendations.

RELATED RESEARCH

Brazeo, N.J.; Yang, X.; and Hong, C.X. 2016. *Phytophthora caryae* sp. nov., a New Species Recovered from Streams and Rivers in the Eastern United States. Plant Pathology. DOI: 10.1111/ppa.12617.

Denman, S.; Plummer, S.; Kirk, S.; Peace, A.; and McDonald, J.E. *In press*. Isolation Studies Reveal a Shift in the Cultivable Microbiome of Oak Affected with Acute Oak Decline. Systematic and Applied Microbiology.
<http://dx.doi.org/10.1016/j.syapm.2016.07.002>.

Fichtner, E.J.; Kallsen, C.E.; and Blomquist, C.L. 2016. First Report of Crown Rot Caused by *Phytophthora parsiana* on Pistachio in the Southern San Joaquin Valley, California. Plant Disease. 100(8): 1795-1795.

Kong, P. and Hong, C. 2016. Soil Bacteria as Sources of Virulence Signal Providers Promoting Plant Infection by *Phytophthora* Pathogens. Scientific Reports. 6(33239). DOI: 10.1038/srep33239.

MEETINGS

Presentations and posters from the “Sixth Sudden Oak Death Science Symposium: Biosecurity, Plant Trade, and Native Habitats,” are available online in agenda order at http://ucanr.edu/sites/sod6/Schedule/Presentations_and_Posters/?editon=1.

RESOURCES

Suslow, K. and Kosta, K. 2016. [Solarization - A Simple and Low Cost Method for Disinfecting Horticultural Containers](#). Ecesis 26(2): 4 – 7.



The reuse of pots by nursery growers, while an economically beneficial practice, has been shown to facilitate transfer of plant pathogens within nurseries as well as into landscape and natural settings. Used-pot solarization is an easy and efficient way to eliminate Phytophthoras from recycled pots as explained in this trail.

CALENDAR

11/15 – 11/16 – California Forest Pest Council 65th Annual Meeting, “California Forests – Severe Drought Takes Its Toll;” UC Davis Student Community Center, Davis; For agenda information or to register, go to <http://caforestpestcouncil.org/2016/07/save-the-date/>. For more information, contact Katie Harrell at kpalmieri@berkeley.edu.