CALIFORNIA OAK MORTALITY TASK FORCE REPORT
TO THE BOARD OF FORESTRY
JANUARY 2017

MONITORING

Nine eastern states participated in the 2016 National *P. ramorum* Early Detection Survey of Forests (AL, FL, GA, MS, NC, PA, SC, TN, and TX). Of the 288 fall samples collected, 45 have been analyzed and are negative for *P. ramorum*. In the spring, 308 samples were collected, with 9 samples from 4 locations found positive – 3 locations in AL (site A - 3 positives and site B - 2 positives, sites were first detected in 2009; site C - 1 positive, was first detected in 2007) and 1 location with 3 positives in MS (site first positive in 2008). All positive samples were collected from streams associated with previously positive nurseries.

USDA APHIS Washington State, 2016 Summary - USDA APHIS certification surveys for Washington's two "opt-in" *P. ramorum* host plant interstate shipping nurseries were negative for the pathogen in 2016. Additionally, all 1,338 samples taken in 2016 from the Kitsap County botanical garden (found *P. ramorum* positive in 2015) were negative for the pathogen. Surveys were conducted throughout the year in areas near previously positive sites and included plant material sampling as well as water baiting. Destruction protocol was implemented in January 2016 for a single positive *Mahonia* plant found during the December 2015 survey. Additional voluntary mitigation measures were implemented by garden staff in 2016, including implementing an IPM fungicide spray program (with WA State University assistance) in key garden areas and cutting back (to the ground) and removing low-value native host plants in some areas. The long-term effectiveness of all mitigation measures and BMPs will be monitored.

In 2016, 65 new *P. ramorum* infestations were detected within Oregon's 515 mi^2 quarantine area (Figure 1). Compared to 2015, disease and tanoak mortality continued to intensify within the quarantine area and inside the Generally Infested Area. Given the large number of infestations, treatment priority areas have been set based on location within the quarantine zone, number of nearby sites, potential for pathogen spread, and genetic lineage. The EU1 infestation has continued to be a top priority and is currently undergoing eradication treatments. With the exception of one tanoak, lineage testing of the remaining symptomatic tanoaks and grand fir seedling at the EU1 infestation site has confirmed presence of the EU1 lineage in each tree.

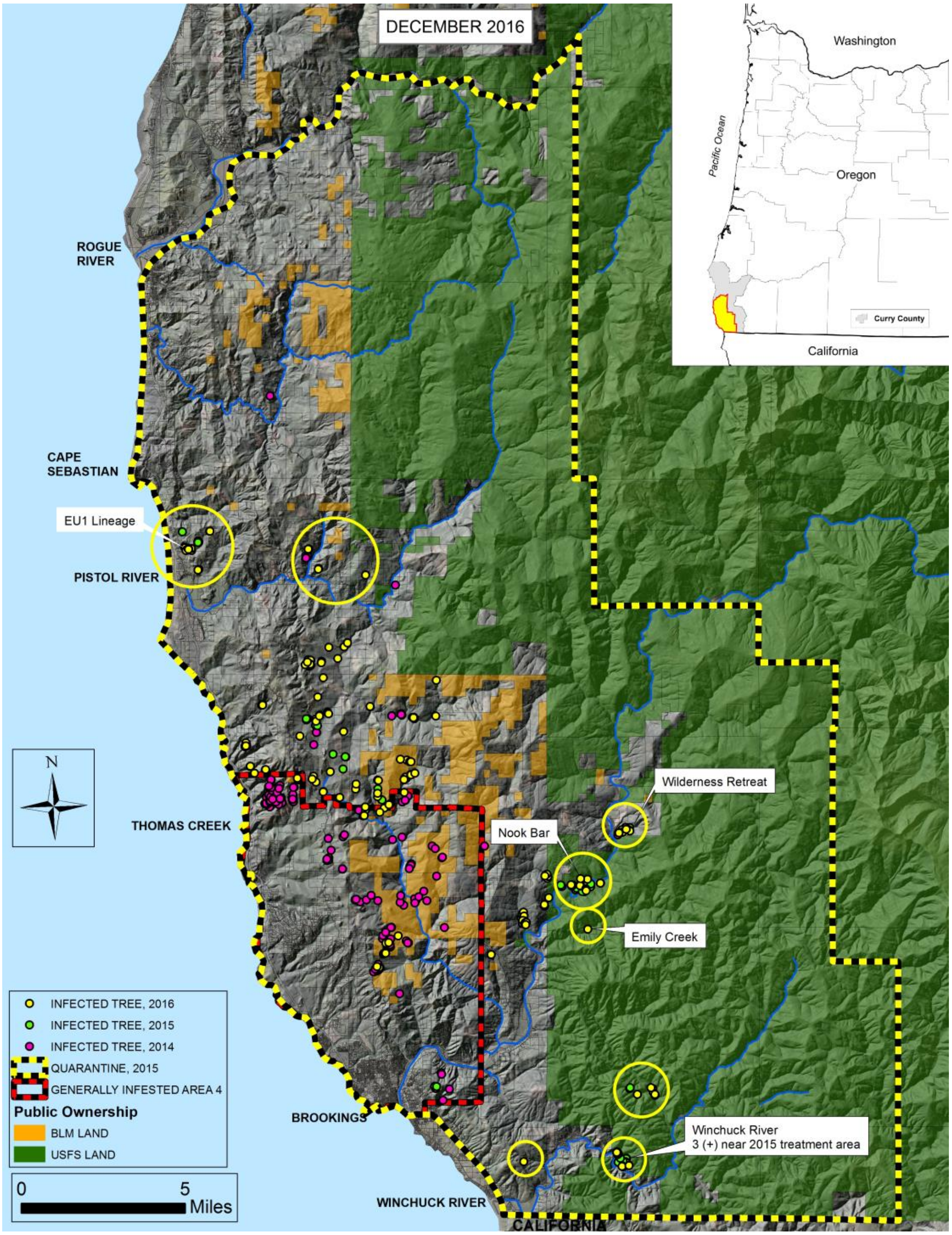

Figure 1: Location of sites infested with *P. ramorum* in southwestern Oregon detected from 2014-2016. Yellow circles designate infestations prioritized for treatment in the coming months.

NURSERIES

California's 2016 fall federal *P. ramorum* compliance surveys of 7 previously positive nurseries were all negative for the pathogen. California currently has 7 'opt in' nurseries participating in the federal interstate shipping program that have increased sampling protocols for previously positive nurseries per Federal Order 2014-02 (January 2014). With the conclusion of the third year of negative results, four of these nurseries are pending release from the increased sampling protocol portion of the program, leaving three nurseries remaining with the additional oversight.

NORS-DUC conducted a fall sampling of native plant nurseries and interstate wholesale nurseries to determine if plant exchanges between them allows for movement of *Phytophthora* species; e.g. if *P. tentaculata*-infested plants have entered the commercial nursery mainstream market; and, if movement has occurred, to determine genetic markers for source tracking. Surveying and sampling of symptomatic plants occurred at five commercial nurseries that purchase from native plant nurseries, five commercial nurseries that do not purchase from native plant nurseries, and five native plant nurseries that supply commercial nurseries with native plants. Half of the samples from each site were sent to CA State University, Monterey Bay (CSUMB) for genetic testing and half were kept at NORS-DUC. Cultures of all plant samples determined to be infested with *Phytophthora* will be analyzed by the Miles lab, CSUMB, to determine species and genetic fingerprinting for source tracking. Spring sampling will begin in February for southern California nurseries.

RESEARCH

Clime, L.; Li, K.; Geissler, M.; Hoa, X.D.; Robideau, G.P.; Bilodeau, G.J.; and Veres, T. 2017. Separation and Concentration of *Phytophthora ramorum* Sporangia by Inertial Focusing in Curving Microfluidic Flows. Microfluid Nanofluid. 21: 5. DOI: 10.1007/s10404-016-1844-9.

Abstract: We present an integrated microfluidic system for performing isolation and concentration of *Phytophthora ramorum* pathogens using a chip whose working principle is based on inertial lateral migration in curving flows. The chip was fabricated from multiple layers of thermoplastic polymers and features an embedded spiral separation channel along with peristaltic microvalves for fluidic operation and process control. A pumping system paired with a fully programmable pressure manifold is used to boost concentration levels by recirculating the sample liquid multiple times through the separation chip, making it possible to reduce sample volumes from 10 to 1 mL or less. The system was calibrated using fluorescent polymer particles with a nominal diameter of 30 µm which is comparable to that of *P. ramorum* sporangia. The separation process has been shown to be highly effective and more than 99% of the beads can be recovered in the concentrated batch. Experiments conducted with *P. ramorum* sporangia have shown that a 5.3-fold increase in pathogen content with 95% recovery can be achieved using three subsequent concentration cycles. The utility of the method has been validated by processing a sample derived from infested *Rhododendron* leaves where a 6.1-fold increase in the concentration of *P. ramorum* has been obtained after four concentration cycles. Although specifically designed and demonstrated for sporangia of *P. ramorum*, the method and related design rules can easily be extended to other microbial organisms, effectively supporting bioanalytical applications where efficient, high-throughput separation of target species is of primary concern.

Derevnina, L.; Petre, B.; Kellner, R.; Dagdas, Y.F.; Sarowar, M.N.; Giannakopoulou, A.; De la Concepcion, J.C.; Chaparro-Garcia, A.; Pennington, H.G.; van West, P.; and Sophien Kamoun. 2016. Emerging Oomycete Threats to Plants and Animals. Philosophical Transactions of the Royal Society B. DOI: 10.1098/rstb.2015.0459.

Abstract: Oomycetes, or water moulds, are fungal-like organisms phylogenetically related to algae. They cause devastating diseases in both plants and animals. Here, we describe seven oomycete species that are emerging or re-emerging threats to agriculture, horticulture, aquaculture and natural ecosystems. They include the plant pathogens *Phytophthora infestans*, *Phytophthora palmivora*, *Phytophthora ramorum*, *Plasmopara obducens*, and the animal pathogens *Aphanomyces invadans*, *Saprolegnia parasitica* and *Halioticida noduliformans*. For each species, we describe its pathology, importance and impact, discuss why it is an emerging threat and briefly review current research activities.

Gagnon, M.C.; Feau, N.; Dale, A.L.; Dhillon, B.; Hamelin, R.; Brasier, C.; Grünwald, N.J.; Brière, S.C.; and Bilodeau, G. *In press*. Development and Validation of Polymorphic Microsatellite Loci for the NA2 Lineage of *Phytophthora ramorum* from Whole Genome Sequence Data. Plant Disease. http://dx.doi.org/10.1094/PDIS-11-16-1586-RE.

Abstract: *Phytophthora ramorum* is the causal agent of sudden oak death and sudden larch death, and is also responsible for causing ramorum blight on woody ornamental plants. Many microsatellite markers are available to characterize the genetic diversity and population structure of *P. ramorum*. However, only two markers are polymorphic in the NA2 lineage which is predominant in Canadian nurseries. Microsatellite motifs were mined from whole-genome sequence data of six *P. ramorum* NA2 isolates. Of the 43 microsatellite primer pairs selected, 13 loci displayed different allele sizes among the four *P. ramorum* lineages, 10 loci displayed intra-lineage variation in the EU1, EU2 and/or NA1 lineages, and 12 microsatellites displayed polymorphism in the NA2 lineage. Genotyping of 272 *P. ramorum* NA2 isolates collected in nurseries in British Columbia, Canada from 2004 to 2013 revealed 12 multilocus genotypes (MLGs). One MLG was dominant when examined over time and across sampling locations, and only a few mutations separated the 12 MLGs. The NA2 population observed in Canadian nurseries also showed no signs of sexual recombination, similar to what has been observed in previous studies. The markers developed in this study can be used to assess *P. ramorum* inter- and intra-lineage genetic diversity and generate a better understanding of the population structure and migration patterns of this important plant pathogen, especially for the lesser-characterized NA2 lineage.

Jiang, H.; Cao, C.; Chen, W.; Fang, Z.; and Liu, C. 2016. Simulation and Prediction of the Spatiotemporal Transmission of Sudden Oak Death (SOD) Based on Spatial Information Technology. IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Beijing. pp. 1300-1303. DOI: 10.1109/IGARSS.2016.7729330.

Abstract: Sudden Oak Death (SOD) has emerged rapidly and repeatedly in US and Europe, with devastating impact upon forest ecosystems and causing severe economic hardship to nursery operation. It has potential host vegetation with large spans in China which has similar environment and climate. Yunnan province was selected as typical study area here for EU and NA evolutionary lineage. It is assumed that there was a SOD outbreak in Yunnan, and then a temporal and spatial dynamic model simulating disease spreading within a short range was deduced preliminarily based on the transmission mechanism abroad, environmental factors derived from spatial information technique and Cellular Automation. The research result shows that the spore contact rate and dispersion area of NA lineage is higher than EU lineage's, and the

simulation result is certainly consistent with seasonal fluctuation in the outbreaks. Control measurements must be performed before April if SOD happened in China.

O'Hanlon, R.; Choiseul, J.; Corrigan, M.; Catarame, T.; and Destefanis, M. 2016. Diversity and Detections of *Phytophthora* Species from Trade and Non-Trade Environments in Ireland. EPPO Bull. 46: 594–602. DOI: 10.1111/epp.12331.

Abstract: The genus *Phytophthora* is one of the genera of organisms that poses the most threat to plant health worldwide. Statutory monitoring for *Phytophthora* species focuses on the species regulated in the European Union and recommended for regulation by EPPO (Plant Health Directive 2000/29 EC and the EPPO A2 List). This research provides details of the *Phytophthora* species detected from trade and non-trade environments in Ireland between 2013 and 2015. The results of statutory surveys for the regulated species *Phytophthora ramorum*, *Phytophthora kernoviae* and *Phytophthora lateralis* from 2003 to 2015 are also presented. Testing of more than 11 000 samples was carried out using morphological and/or DNA identification with specifically designed *Phytophthora* conserved primers. This led to the detection of 19 species and 3 informally designated taxa of *Phytophthora*, including 8 new records for Ireland. Eight species were found in both trade and non-trade locations, and three informally designated taxa were also detected. *Phytophthora ramorum* was found on the most hosts (30 hosts), followed by *Phytophthora syringae* (6 hosts) and *Phytophthora kernoviae* (3 hosts). *Rhododendron* was the host on which *Phytophthora* species were most frequently detected (12 *Phytophthora* species). The role of the plant trade in spreading invasive *Phytophthora* species is discussed.

Shaw, D.C.; Woolley, T.; Kelsey, R.G.; McPherson, B.A.; Westlind, D.; Wood, D.L.; and Peterson, E.K. 2017. Surface Fuels in Recent *Phytophthora ramorum* Created Gaps and Adjacent Intact *Quercus agrifolia* Forests, East Bay Regional Parks, California, USA. Forest Ecology and Management. 384: 331–338.

Abstract: *Phytophthora ramorum*, cause of “sudden oak death” or SOD, has had significant impacts on composition and structure in coastal forests of central and northern coastal California and southwestern Oregon. Despite the proximity of susceptible coast live oak (*Quercus agrifolia*) forests to densely populated urban areas, the impacts of SOD on their fuels have not been studied. We sampled surface fuels and vegetation structure in 16 plots in both SOD-caused gaps and intact stands (32 plots total) across two parks in the East Bay Regional Park District, east of San Francisco Bay. Plots were selected from a set of randomly placed pre-existing locations used in determining the disease distribution and intensity across the park system. Among the vegetation characteristics examined, only coast live oak basal area and live and dead tree density, canopy cover and maximum forb height differed between SOD created gap plots and adjacent intact forest plots. However, surface fuels such as vegetation cover, litter cover, wood cover, duff depth, fuels height, ladder fuels abundance, 1 h, 10 h, 100 h, and 1000 h fuels were greater in gap plots than intact forest plots. Although no fire behavior models were run, surface fuels suggest SOD created gaps may facilitate passive crown fire due to increased ladder and other fuels. This study represents a spatially explicit (gap focused) point-in-time estimate of surface fuels that will continue to change through time as disease progresses through these stands causing vegetation changes as fuels accumulate and decompose.

RELATED RESEARCH

Daniels, D.A.; Nix, K.A.; Wadl, P.A.; Vito, L.M.; Wiggins, G.J.; Windham, M.T.; Ownley, B.H.; Lambdin, P.L.; Grant, J.F.; Merten, P.; Klingeman, W.E.; and Hadziabdic, D. 2016. Thousand Cankers Disease Complex: A Forest Health Issue that Threatens Juglans Species across the U.S. Forests. 7(11): 260. DOI: 10.3390/f7110260.

Macpherson, M.F.; Kleczkowski, A.; Healey, J.R.; and Hanley, N. 2016. The Effects of Disease on Optimal Forest Rotation: A Generalisable Analytical Framework. Environmental and Resource Economics. DOI: 10.1007/s10640-016-0077-4.

Takemoto, D. and Mizuno, Y. 2016. Belowground and Aboveground Strategies of Plant Resistance Against *Phytophthora* Species. In Belowground Defence Strategies in Plants. Springer International Publishing. pp. 151-169.

Vettraino, A.M.; Brasier, C.M.; Webber, J.F.; Hansen, E.M.; Green, S.; Robin, C.; Tomassini, A.; Bruni, N.; and Vannini, A. 2017. Contrasting microsatellite diversity in the evolutionary lineages of *Phytophthora lateralis*. Fungal Biology. 121(2): 112–126. http://dx.doi.org/10.1016/j.funbio.2016.10.002.

RESOURCES

The Forest Phytophthoras of the World website http://forestphytophthoras.org/ has added four additional *Phytophthora* species profiles: *P. agathidicida* (cause of kauri dieback) and *P. boemeriae*, *P. frigida*, and *P. nicotianae* (cause of black wattle gummosis). Peer-reviewed, citable, printer-friendly versions of these articles were published in the December 2016 issue of *Forest Phytophthoras:* http://journals.oregondigital.org/index.php/ForestPhytophthora/issue/view/461.

Bellgard, S.E.; Pennycook, S.R.; Weir, B.S.; Ho, W.; and Waipara, N.W. 2016. *Phytophthora agathidicida*. Forest Phytophthoras 6(1). DOI: 10.5399/osu/fp.5.1.3748.

dos Santos, A.F. 2016. *Phytophthora boehmeriae.* Forest Phytophthoras. 6(1). DOI: 10.5399/osu/fp.6.1.3851.

dos Santos, A.F. 2016. *Phytophthora frigida.* Forest Phytophthoras. 6(1). DOI: 10.5399/osu/fp.6.1.3887.

dos Santos, A.F. 2016. *Phytophthora nicotianae.* Forest Phytophthoras. 6(1). DOI: 10.5399/osu/fp.6.1.3890.

CALENDAR

2/9 - Southern California Green Waste-Wood Biomass Management Symposium; The Handlery Hotel, 950 Hotel Cir N, San Diego, CA; 8:00 a.m. – 5:00 p.m.; Registration deadline 2/1; For more information or to register, go to http://ucanr.edu/sites/SoCA_GWWood__Mgmt_Symposium/.

3/19 – 3/25 - 8th Meeting of IUFRO Working Party 7.02.09: *Phytophthora* in Forests and Natural Ecosystems; Sapa Vietnam; For information or to register, go to http://www.iufrophytophthora2017.org/.

3/28 – 3/30 - 63rd Annual Conference on Soilborne Plant Pathogens

(formerly Soil Fungus Conference) and the 49th Annual California Nematology Workgroup; University of California, Davis, Storer and Hutchison Halls; For more information or to register, go to http://soilfungus.wsu.edu.