CALIFORNIA OAK MORTALITY TASK FORCE REPORT
TO THE BOARD OF FORESTRY
JANUARY 2016

MEETINGS

January 29th is the Call for Papers deadline for the Sixth Sudden Oak Death Science Symposium: Biosecurity, Plant Trade, and Native Habitats. This meeting (June 21-23, Ft Mason, San Francisco) will expand the concept of the Sudden Oak Death Science Symposiums, with presentations on sudden oak death research and management progress as well as other nursery and wildland *Phytophthora* issues. For more information on the Symposium, including the Call for Papers and a sample abstract, go to http://ucanr.edu/sites/sod6/.

NURSERIES

Two new *P. ramorum*-positive plants (*Rhododendron* and *Vaccinium parvifolium*) were confirmed at the Kitsap County, WA botanical garden (first found *P. ramorum* positive in March 2015) in December. Monthly surveys are now being performed in areas considered at risk in the garden. Both plants were in close proximity to one another and to a previously positive site. The positive plants and all vegetation in a surrounding buffer zone (12 ft downslope and 6 ft uphill and to the sides of the positive plants) were destroyed. Results from the January garden facility survey are pending.

In 2015, the California Department of Food and Agriculture Plant Pest Diagnostic Center tested 7,613 plant, water, and soil samples for *P. ramorum*. Two of the samples were positive and the result of a trace-forward investigation from a positive Washington nursery. Ninety-one nurseries in the quarantine area received monthly inspections to retain their *P. ramorum* clean nursery stock certification, allowing them to ship host material outside of the quarantine zone. The seven nurseries participating in the USDA's *P. ramorum* compliance program for previously positive nurseries were all negative for the pathogen.

In 2015, *P. ramorum* was recovered from 14 U.S. nurseries (CA 1, NY 1, OR 10, WA 1, VA 1), one commercial landscape (LA), two residences (OH, OR), and a botanic garden (WA) in non-quarantine areas. The pathogen was detected in *Arctostaphylos* (1); *Camellia* (3); *Gaultheria* (1); *Kalmia* (1); *Mahonia* (1); *Osmanthus* (1); *Pieris* (6); *Rhododendron* (57); soil samples (17); *Vaccinium* (6); *Viburnum* (9); *Vinca* (1); and water samples (3). Six of the nurseries ship interstate and are in the USDA APHIS federal compliance program (Federal Order DA-2014-02). The Confirmed Nursery Protocol has been completed in all nurseries and resulted in two site detections (1 CA nursery, 1 OH residence). Survey, sampling, mitigations and IPM work in the Botanic Garden will continue into 2016 through the collaborative efforts of the USDA Animal and Plant Health Inspection Service, Washington State Department of Agriculture, Washington State University, and botanic garden staff.

MONITORING

The 2015 United Kingdom *P. ramorum* aerial survey covered 146,000 acres of Japanese larch plantations and 2.5 million wooded acres. The pathogen remained generally consistent on larch, with low-level symptoms (single crowns and individual branches infested) found on individuals or small groups of trees in close proximity to previously confirmed larch and rhododendron infestations. *P. ramorum*-positive larch was found for the first time in North Yorkshire, northeast England, 53 miles from the nearest known larch infestation. Follow-up surveys revealed previously undetected infected rhododendron, which is believed to be the inoculum source. Investigations are continuing into the progressive crown deterioration, dieback, and death of sweet chestnut trees (*Castanea sativa*) in southwest England, some of which have been confirmed *P. ramorum* positive. Areas where *P. ramorum*-positive larch was felled continue to cause residual damage to Douglas-fir, Noble fir, and Western hemlock. Continued dieback and death of these hosts indicates the potential for *P. ramorum* to persist on sites where large amounts of inoculum have been present.

The aerial surveys also monitored other tree pests and diseases, including *Hymenoscyphus fraxineus* (cause of ash dieback), *P. austrocedri* (affecting juniper), and *P. lateralis* (affecting Lawson's cypress), as well as deer and squirrel damage. Observations of note were increased *Dendroctonus micans* (great spruce bark beetle) activity in spruce plantations (particularly southwest England) and localized infestations of *Elatobium abietinum* (green spruce aphid).

RESEARCH

Ginetti, B.; Carmignani, S.; Ragazzi, A.; and Moricca, S. *In press*. Biological and Epidemiological Aspects of the Quarantine Pathogen *Phytophthora ramorum*. Micologia Italiana. Vol. 44. DOI: 10.6092/issn.2465-311X/5590.

Abstract: *Phytophthora ramorum* is a quarantine pathogen that causes leaf blight and shoot dieback of the crown, bark cankers and death on a number of both ornamental and forest trees, especially in North America and northern Europe, where it has produced severe outbreaks.

In Italy it was first reported in 2002, on *Rhodondendron yakushimanum* in a Piedmont nursery; after that it seemed to have disappeared, only to re-emerge in 2013 when numerous isolates were detected on batches of *Viburnum tinus* plants growing in some nurseries in the Pistoia area (Tuscany), which is an important district in the trade of nursery plants world-wide. This work reports on a number of laboratory tests that were carried out on isolates from infected plant samples. The micromorphological and macromorphological characteristics of the pathogen growing on carrot agar (CA), corn meal agar (CMA), malt extract agar (MEA) potato dextrose agar, and V8 agar with added PARPNH (see text) were determined, as was the growth rate at 10º, 15º, 20º, 25°, 30º, 32º and 35ºC. Molecular analysis was employed to identify the isolates more precisely. Inoculation trials under the bark were also carried out to ascertain the isolate virulence and the Koch’s Postulates.

The Plant Protection Service of the Tuscan Region (SFR, Servizio Fitosanitario Regionale) was alerted as soon as the pathogen infection was detected and it took the prescribed steps to eradicate the infection in the field and prevent the recurrence of an epidemic.

Grünwald, N.J.; Larsen, M.M.; Kamvar, Z.; Reeser, P.W.; Kanaskie, A.; Laine, J.; and Wiese, R. *In press*. First Report of the EU1 Clonal Lineage of *Phytophthora ramorum* on Tanoak in an OR Forest. Plant Disease. http://dx.doi.org/10.1094/PDIS-10-15-1169-PDN.

Abstract: Initially reported in California as the causal agent of sudden oak death (SOD), efforts to limit spread of *Phytophthora ramorum* in Oregon natural forests have concentrated on quarantine regulations and eradication of the pathogen from infested areas. *P. ramorum* has four clonal lineages NA1, NA2, EU1 and EU2 (Grünwald et al. 2012; van Poucke et al. 2012). Forest infestations in Oregon have been limited to the NA1 clonal lineage whereas EU1, NA1 and NA2 clonal lineages have all been found in US nurseries (Kamvar et al. 2015; Prospero et al. 2007). In February 2015, in response to an aerial survey, *P. ramorum* was isolated from a dying *Notholithocarpus densiflorus* tree in the South Fork Pistol River drainage of Curry County, Oregon. The isolated strain was identified as *P. ramorum* based on presence of chlamydospores, characteristic hyphae and sporangial morphology. Microsatellite genotyping at 14 loci (Vercauteren et al. 2011) and comparison to reference cultures revealed that these isolates belonged to the EU1 clonal lineage. Subsequently, five more isolates were obtained from the original tree stump and the EU1 lineage was confirmed. Microsatellite alleles of the forest EU1 isolates were nearly identical to EU1 isolates collected in 2012 from a nearby nursery during routine *P. ramorum* nursery monitoring, except for one allele at locus PrMS145a. Interestingly, several isolates differed at locus ILVOPrMS131a within both the 2015 forest and the 2012 nursery findings with identical allele frequencies in each population for this locus. These data provide inconclusive support for the introduction of EU1 into Curry County from the 2012 populations found in nurseries given that no direct match was found, probably due to the paucity of EU1 samples from nurseries. These results provide further evidence that multiple distinct *P. ramorum* introduction events into the Curry County forest are a critical component of the epidemic (Kamvar et al. 2015). The impact of the EU1 clonal lineage of *P. ramorum* on Oregon natural forests is uncertain, but it may result in potential sexual reproduction given that EU1 is of A1 mating type while the prior population consisted of NA1 A2 mating type individuals. While sexual populations have not been observed in nature or were aberrant in the laboratory for *P. ramorum*, the presence of both A1 and A2 mating types makes the potential for sexual recombination more likely. The EU1 forest infestation is undergoing eradication treatments. Additional monitoring is necessary to determine if the EU1 clonal lineage occurs elsewhere in Curry county forests.

Thompson, R.N.; Cobb, R.C.; Gilligan, C.A.; and Cunniffe, N.J. 2016. Management of Invading Pathogens Should be Informed by Epidemiology Rather than Administrative

Boundaries. Ecological Modelling. 324: pgs. 28–32. DOI: 10.1016/j.ecolmodel.2015.12.014.

Abstract: Plant and animal disease outbreaks have significant ecological and economic impacts. The spatial extent of control is often informed solely by administrative geography – for example, quarantine of an entire county or state once an invading disease is detected – with little regard for pathogen epidemiology. We present a stochastic model for the spread of a plant pathogen that couples spread in the natural environment and transmission via the nursery trade, and use it to illustrate that control deployed according to administrative boundaries is almost always sub-optimal. We use sudden oak death (caused by *Phytophthora ramorum*) in mixed forests in California as motivation for our study, since the decision as to whether or not to deploy plant trade quarantine is currently undertaken on a county-by-county basis for that system. However, our key conclusion is applicable more generally: basing management of any disease entirely upon administrative borders does not balance the cost of control with the possible economic and ecological costs of further spread in the optimal fashion.

The following 4 abstracts on *P. ramorum* were presented at the "Seventh California Oak Symposium: Managing Oak Woodlands in a Dynamic World." Proceedings from the meeting are available online at http://www.fs.fed.us/psw/publications/documents/psw_gtr251/.

Standiford, Richard B.; Purcell, Kathryn L., tech. cords. 2015. Proceedings of the seventh California oak symposium: managing oak woodlands in a dynamic world. Gen. Tech. Rep. PSW-GTR-251. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 579 p.

Euphrat, F.D. Managing Redwood Ecosystems Using Sudden Oak Death as a Silvicultural Tool.

Abstract: In response to the wave of sudden oak death (SOD), caused by *Phytophthora ramorum*, sweeping the redwood forest ecosystems of California's North Coast, the role of foresters and other ecosystem managers is being tested. On Bear Flat Tree Farm, near Healdsburg, California, Forest, Soil & Water, Inc. (FSW) has conducted a multi-year, multi-treatment approach to take advantage of SOD. Because the seral stage of tanoak is a component of hardwood dominance intermediary between brush and conifers, FSW has used the oncoming wave of SOD to accelerate the ecosystem towards redwood (*Sequoia sempervirens*).

The combination of pathogen and cultural treatments of harvest, planting, pruning and thinning has quickly created a redwood-dominated, vigorously growing stand. The key to this rapid change was planting redwoods near tanoaks prior to mortality and timely thinning. These actions have nearly doubled diameter growth of redwood saplings in a statistically significant test. In addition, the timely management of large woody debris

from dead tanoaks creates greater stocking in the forest and addresses damaged crop trees.

McPherson, B.A.; Mori, S.R.; Conrad, A.O.; Opiyo, S.; Bonello, P.; and Wood, D.L. Biomarkers Identify Coast Live Oaks That are Resistant to the Invasive Pathogen *Phytophthora ramorum*.

Abstract: California coast live oaks (*Quercus agrifolia*) trees have suffered large losses from sudden oak death, caused by the introduced oomycete *Phytophthora ramorum*. In this review paper, we discuss oak plant chemistry as a potential predictor of disease susceptibility. We have recorded an annual mortality rate of three percent in long-term monitoring plots in Marin County, resulting in greater than 40 percent loss since 2000. Despite this mortality rate, asymptomatic trees still persist in many heavily infected stands. We hypothesized that varying responses to *P. ramorum*, including apparent recovery from infections, reflected phenotypic differences in susceptibility. In a Marin County inoculation study, a logit model showed that external canker lengths measured 9 months following inoculation predicted both resistance and survival 7 years later. The distribution of canker length was consistent with quantitative resistance to *P. ramorum*. The role of plant chemistry in resistance was examined by quantifying soluble phenolics in phloem methanol extracts prepared from the surviving trees. A logistic regression model found that expression of resistance was associated with total phenolics and four phenolic compounds; ellagic acid, a partially characterized ellagic acid derivative, and two chromatographic peaks representing two uncharacterized phenolic compounds. *In vitro* tests showed that ellagic acid was fungistatic against *P. ramorum* and total phenolics were fungicidal at physiologically relevant concentrations. A subsequent inoculation study in Briones Regional Park, Contra Costa County, California, showed that some of the same compounds were correlated with resistance. The association of certain phenolics with resistance may facilitate the use of biomarkers in minimally invasive assays to predict the response of trees to *P. ramorum*, thereby increasing the options for managing threatened forests.

McPherson, B.A.; O'Neill, J.; Biging, G.; Kelly, M.; and Wood, D.L. Development of a Management Plan for Coast Live Oak Forests Affected by Sudden Oak Death in East Bay Regional Parks.

Abstract: The East Bay Regional Park District maintains the largest urban park system in the United States, comprising over 45 000 ha, and more than 1900 km of trails, with extensive forests bordering residential areas. Sudden oak death (SOD), caused by the introduced oomycete *Phytophthora ramorum*, was first detected in a district park in 2001. Both increased fire risk and structural failure of large trees located near sites with heavy public usage are concerns for managers. Management requires reliable data about the location and severity of the disease. To produce disease incidence and risk maps, between 2008 and 2013 we placed 537 georeferenced 10-m radius fixed plots in oak-bay stands in five parks in the East Bay Hills in the San Francisco Bay Area. We recorded data for all woody vegetation and the disease status of coast live oaks. Between 6 and 17 percent of

coast live oaks were symptomatic and 2 to 8 percent were dead with symptoms of SOD. Infection rates of 2.1 and 3 percent/year were estimated for Tilden Park and Huckleberry Preserve, respectively. Logistic regression analysis for Anthony Chabot Park identified two predictors of SOD incidence: topographic moisture indices and increasing coast live oak diameter at breast height (1.37 m; DBH). Model results for the other parks confirm that DBH is a significant predictor of SOD infection. Modeled results for the other four parks found consistently significant associations between symptomatic coast live oak and remote sensing derived tasseled cap greenness vegetation index values, and distance to stream channels.

Swiecki, T.J. and Bernhardt, E. *Phytophthora ramorum* Canker (Sudden Oak Death) Disease Risk and Progress in Coast Live Oak, 2000-2012.

Abstract: From 2000 through 2012, we collected annual observations on disease symptoms and stand conditions in 128 coast live oak plots in forests affected by sudden oak death (SOD), caused by the introduced pathogen *Phytophthora ramorum*. Elevated rainfall in one or both of the previous wet seasons was associated with pulses of new infections. However, persistent differences in infection rates between nearby locations and among plots within locations show that tree and site specific factors influence disease risk on the local scale. Because California bay is the primary source of *P. ramorum* spores in these affected forests, variables describing the proximity and density of California bay in the local oak neighborhood are the strongest predictors of disease risk. Tree growth rate and bark characteristics are also predictors of disease risk. Faster-growing, more dominant trees had elevated SOD risk whereas trees declining from other diseases had reduced SOD risk. Coast live oaks with SOD followed one of several disease progress trajectories, ranging from rapid decline to disease remission. Extensive initial trunk girdling by cankers was associated with rapid decline. More than half of the trees that developed symptoms between 2001 and 2010 had inactive or undetectable cankers by 2012.

RELATED RESEARCH

Klapwijk, M.J.; Hopkins, A.J.M.; Eriksson, L.; Pettersson, M.; Schroeder, M.; Lindelöw, Å.; Rönnberg, J.; Keskitalo, E.C.H.; and Kenis, M. 2016. Reducing the Risk of Invasive Forest Pests and Pathogens: Combining Legislation, Targeted Management and Public Awareness. Ambio. 45(Supplement 2): pp 223-234.

Namm, B.H. and Berrill, J.P. 2016. Tanoak (*Notholithocarpus densiflorus*) Coarse Root Morphology: Prediction Models for Volume and Biomass of Individual Roots. Open Journal of Forestry. 6: 1-13.

Pautasso, M. 2016. Scientometrics of Forest Health and Tree Diseases: An Overview. Forests. *7*(1): 17. DOI: 10.3390/f7010017.

Rooney-Latham, S.; Blomquist, C.; Swiecki, T.; and Bernhardt, E. 2015. *Phytophthora tentaculata.* Forest Phytophthoras. Vol 5(1). DOI 10.5399/osu/fp.5.1.3727.

Available online at http://journals.oregondigital.org/index.php/ForestPhytophthora/issue/view/451.

Swett, C.L.; Kirkpatrick, S.C.; and Gordon, T.R. 2016. Evidence for a Hemibiotrophic Association of the Pitch Canker Pathogen *Fusarium circinatum* with *Pinus radiate*. Plant Disease. 100(1): 79-84.

Yang, X. and Hong, C.X. 2015. Diversity and Populations of *Phytophthora*, *Phytopythium*, and *Pythium* Species Recovered from Sediments in an Agricultural Run-off Sedimentation Reservoir. Plant Pathology. DOI: 10.1111/ppa.12488.

RESOURCES

DeNitto, G.A.; Cannon, P.; Eglitis, A.; Glaeser, J.A.; Maffei, H.; and Smith, S. 2015. Risk and Pathway Assessment for the Introduction of Exotic Insects and Pathogens that Could Affect Hawai'i's Native Forests. Gen. Tech. Rep. PSW-GTR-250. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 171 p. A 510 page appendix is also available online only at http://www.fs.fed.us/psw/publications/documents/psw_gtr250/.

Swiecki, T.J. and Bernhardt, E.A. 2016. Sudden Oak Death in California. In T.D. Paine and F. Lieutier (Eds.). Insects and Diseases of Mediterranean Forest Systems. Switzerland: Springer International Publishing. pp. 731-756. http://www.springer.com/us/book/9783319247427.

PERSONNEL

Sarah Navarro has been hired as the new forest pathologist with the Oregon Department of Forestry (ODF), following the retirement of Alan Kanaskie. Before joining ODF, Sarah was a plant health specialist with the Oregon Department of Agriculture *P. ramorum* detection program for plant and landscape nurseries. Sarah can be reached at sarah.navarro@oregon.gov.

CALENDAR

1/29 – Call for Papers Deadline for Sixth Sudden Oak Death Science Symposium; For a sample abstract, go to http://www.suddenoakdeath.org/wp-content/uploads/2010/07/SOD6.Sample.abstract.12.03.15.pdf.

6/21 – 23/16 Sixth Sudden Oak Death Science Symposium: Biosecurity, Plant Trade, and Native Habitats; Fort Mason, San Francisco; For more information, go to http://ucanr.edu/sites/sod6/**.** For questions, contact Katie Harrell at kpalmieri@berkeley.edu or (510) 847-5482.