California Oak Mortality Task Force Report
JULY 2013

Monitoring

Sudden oak death (SOD) continues to be the primary cause of tree mortality in coastal California from Monterey County north to Humboldt County, according to USDA Forest Service Pacific Southwest Region aerial surveys underway this summer. Tanoak mortality is severe in the Santa Cruz Mountains as well as along the coast in Sonoma, Marin and Monterey Counties, with the worst impacted areas in Jenner/Guerneville (Sonoma County) and Big Sur and Mill Creek (Monterey County). Less severe areas of tanoak mortality were seen in coastal Mendocino County; however, new pockets of mortality were seen in and near Fort Bragg. Intense coast live oak mortality was mapped in the Oakland hills (Alameda County) and east of Watsonville (Santa Cruz County), about 9 miles from the closest SOD confirmation. No tanoak mortality was observed in Del Norte County this year. The total number of acres and trees killed due to SOD in the surveyed area to date this year appear to be similar to last year's levels, with approximately 257,000 trees killed across 39,600 acres. California's 2012 SOD mortality levels were the highest since 2007 and elevated mortality levels continue into 2013.

New *Phytophthora ramorum* confirmations near Six Rivers National Forest (SRNF) and the Trinity County line – Tanoak and California bay laurel trees were confirmed to be infected with *P. ramorum* as close as 1.1 miles from the SRNF boundary and 1.7 miles from the Trinity County line. The confirmations are within patches of tanoak mortality delineated by the 2012 aerial survey and from an adjacent area that is up to 1/3 of a mile away (on access roads). Preliminary 2013 US Forest Service aerial surveys of the area have identified more patches of tanoak mortality consistent with SOD that are located about 1.5-2 miles from where ground sampling was done, and as close as 0.4 miles from the SRNF boundary.

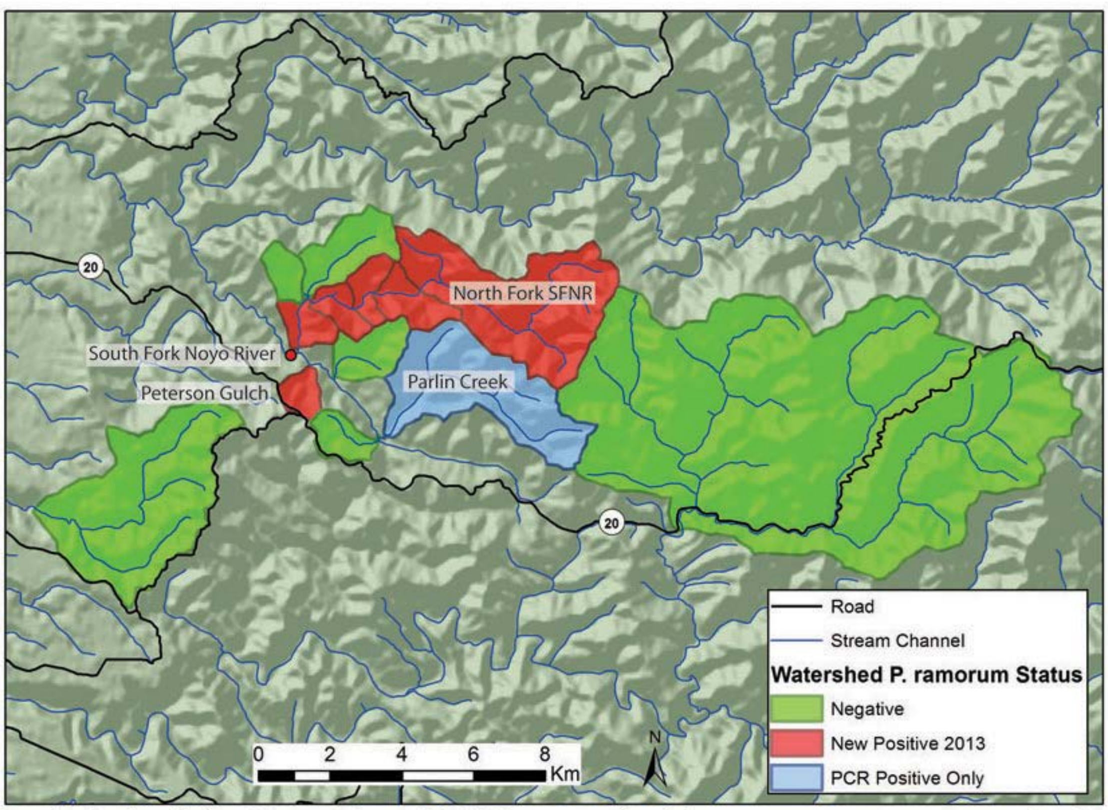
US Forest Service 2012 aerial surveys identified the tanoak mortality near the western edge of the SRNF's Mad River District. Stream baiting in 2013 at the mouth of north Dobbyn Creek from February through May confirmed that the watershed containing the dead tanoak is positive for the pathogen, and in May, ground surveys of two of the larger mortality patches confirmed *P. ramorum* presence. This area represents the eastern front of the Humboldt County sudden oak death infestation. The pathogen was also detected further north in the Larabee Creek corridor, and is now approximately 7.5 miles south of the town of Bridgeville. Management options for the region are being discussed.

First *P. ramorum* culture-positive water sample confirmed from Jackson Demonstration State Forest (JDSF) – Intensive sampling in the South Fork of the Noyo River (SFNR) watershed during this year's *P. ramorum* stream monitoring season led to the confirmation of *P. ramorum* presence in the JDSF (in April 2013). Specifically, pathogen presence in the JDSF was confirmed in the North Fork of the SFNR and Peterson Gulch drainages. However, Parlin Creek, which tested PCR positive in 2012, remained negative for the pathogen via culturing techniques during the 2013 monitoring season.

P. ramorum was first detected via culturing methods from a JDSF waterway sample collected in April 2012 from the SFNR. To better identify the source of inoculum, additional stream monitoring sites were established in May 2012 throughout several tributaries. Culturing methods did not recover *P. ramorum* a second time (so, the detection was not confirmed) from any of the sites during the 2012 stream monitoring season; however, the pathogen was identified via PCR in June 2012 from Peterson Gulch and Parlin Creek, both of which drain into the SFNR.

Culturing methods recovered *P. ramorum* from samples collected in the North Fork of the SFNR in April 2013. To better identify the source of inoculum, additional monitoring sites were established in May. These sites were located further upstream, along the main stem of the North Fork and in two tributaries feeding into the North Fork. All upstream sites on the main stem tested culture positive for the pathogen, while the sampled tributaries feeding into the North Fork were culture negative throughout the 2013 monitoring season.

To date, no terrestrial vegetation samples collected in JSDF have tested *P. ramorum* positive.



South Fork of the Noyo River (SFNR) watershed *P. ramorum* stream monitoring results for 2012 and 2013. The first positive site is a red point. For all other sites, the watershed area is shown. UC Davis, Rizzo lab.

***Phytophthora ramorum*-positive water samples were identified at two new sites in** Washington in June. The positive samples were retrieved from a river in Clallam County and a creek in Thurston County. Washington has focused water baiting and sampling efforts on waterways downstream from previously *P. ramorum* positive nurseries over the past eight years. The water positive in Thurston County was downstream from a previously *P. ramorum* positive nursery, while the Clallam County water positive was not. Delimitation and detection surveys are in the planning phase.

Early results from United Kingdom (UK) 2013 aerial survey reveal significant new areas of *P. ramorum*-infected Japanese larch, particularly in Wales and southwest Scotland. Most are contiguous with existing known areas of infection. Initial estimates include approximately 6,178 acres in Wales and 4,942 acres in Scotland (pending confirmation via ground surveys). It is estimated that England had a more modest increase, with approximately 988 new acres of infection. Factors that likely contributed to the significant increases were unusually wet and windy weather throughout 2012 as well as the inability to complete sanitation felling required in previous years in some locations.

British scientists are now investigating whether Japanese larch can sporulate for longer than previously thought without exhibiting symptoms and whether the spores can spread further than prior research has indicated. Additionally, UK plant health authorities and private-sector interests are assessing how best to respond to the developments as well as the future direction of the national management plan, including whether or not there are enough resources to undertake preventative felling fast enough to slow disease spread.

NURSERIES

A Snohomish County, WA production nursery was found to have *P. ramorum*- positive *Viburnum tinus* and *Pieris japonica* on 6/20/13. The nursery was previously positive in 2011, and has implemented many BMPs over the past two years in an effort to eliminate and prevent pathogen establishment. No interstate shipments have been made in the past six months.

RESEARCH

Brittain, I.; Selby, K.; Taylor, M.; and Mumford, R. 2013. Detection of Plant Pathogen Spores of Economic Significance on Pollen Trap Slides. Journal of Phytopathology. Early View. DOI: 10.1111/jph.12129.

Abstract: Real-time polymerase chain reaction (PCR) assays were used to evaluate a small number of samples from a volumetric spore trap normally used for counting pollen grains. Samples from a total of 6 days during July and August 2011 were screened. Pathogen DNA was detected from three of four groups of economically significant plant pathogens for which real-time PCR assays were available. These were *Tilletia* spp. on 1 day, *Puccinia* spp. on 2 days and *Fusarium* spp. on all 6 days. No amplification of real-time PCR assays was detected for *Phytophthora infestans* or *P. ramorum*. The results indicate that plant pathogens can be detected in air sampling networks, which are remote from arable cropping and deployed for other purposes. This has implications for rapidly identifying periods of pathogen dispersal and improving the accuracy of information on pathogen spore load in the atmosphere.

Burdon, J.J.; Thrall, P.H.; and Ericson, L. 2013. Genes, Communities and Invasive Species: Understanding the Ecological and Evolutionary Dynamics of Host–Pathogen Interactions. Current Opinion in Plant Biology. 16:1–6.

Abstract: Reciprocal interactions between hosts and pathogens drive ecological, epidemiological and co-evolutionary trajectories, resulting in complex patterns of diversity at population, species and community levels. Recent results confirm the importance of negative frequency-dependent rather than 'arms-race' processes in the evolution of individual host–pathogen associations. At the community level, complex relationships between species abundance and diversity dampen or alter pathogen impacts. Invasive pathogens challenge these controls reflecting the earliest stages of evolutionary associations (akin to arms-race) where disease effects may be so great that they overwhelm the host's and community's ability to respond. Viewing these different stabilization/ destabilization phases as a continuum provides a valuable perspective to assessment of the role of genetics and ecology in the dynamics of both natural and invasive host–pathogen associations.

Croucher, P.J.P.; Mascheretti, S.; and Garbelotto, M. 2013. Combining Field Epidemiological Information and Genetic Data to Comprehensively Reconstruct the Invasion History and the Microevolution of the Sudden Oak Death Agent *Phytophthora ramorum* (Stramenopila: Oomycetes) in California. Biological Invasions. Online First Articles. DOI 10.1007/s10530-013-0453-8.

Abstract: Understanding the migration patterns of invasive organisms is of paramount importance to predict and prevent their further spread. Previous attempts at reconstructing the entire history of the sudden oak death (SOD) epidemic in California were limited by: (1) incomplete sampling; (2) the inability to include infestations caused by a single genotype of the pathogen; (3) collapsing of non-spatially contiguous yet genetically similar samples into large meta-samples that confounded the coalescent analyses. Here, we employ an intensive sampling coverage of 832 isolates of *Phytophthora ramorum* (the causative agent of SOD) from 60 California forests, genotyped at nine microsatellite loci, to reconstruct its invasion. By using age of infestation as a constraint on coalescent analyses, by dividing genetically indistinguishable meta-populations into highly-resolved sets of spatially contiguous populations, and by using Bruvo genetic distances for most analyses, we reconstruct the entire history of the epidemic and convincingly show infected nursery plants are the original source for the entire California epidemic. Results indicate that multiple human-mediated introductions occurred in most counties and that further disease sources were represented by large wild infestations. The study also identifies minor introductions, some of them relatively recent, linked to infected ornamental plants. Finally, using archival isolates collected soon after the discovery of the pathogen in California, we corroborate that the epidemic is likely to have resulted from 3 to 4 core founder individuals evolved from a single genotype. This is probably the

most complete reconstruction ever completed for an invasion by an exotic forest pathogen, and the approach here described may be useful for the reconstruction of invasions by any clonally reproducing organism with a relatively limited natural dispersal range.

Eyre, C.A.; Kozanitas, M.; and Garbelotto, M. 2013. Population Dynamics of Aerial and Terrestrial Populations of *Phytophthora ramorum* in a California Forest Under Different Climatic Conditions. Phytopathology. *In Press*. DOI: http://dx.doi.org/10.1094/PHYTO-11-12-0290-R.

Abstract: Limited information is available on how soil and leaf populations of the Sudden Oak Death pathogen, *Phytophthora ramorum*, may differ in their response to changing weather conditions, and their corresponding role in initiating the next disease cycle after unfavorable weather conditions. We sampled and cultured from 425 trees in six sites, three times at the end of a 3-year long drought, and twice during a wet year that followed. Soil was also sampled twice with similar frequency and design used for sampling leaves. Ten microsatellites were used for genetic analyses on cultures from successful isolations. Results demonstrated that incidence of leaf infection tripled at the onset of the first wet period in 3 years in the spring of 2010, while that of soil populations remained unchanged. Migration of genotypes among sites was low and spatially limited under dry periods, but intensity and range of migration of genotypes significantly increased for leaf populations during wet periods. Only leaf genotypes persisted significantly between years, and genotypes present in different substrates distributed differently in soil and leaves. We conclude that epidemics start rapidly at the onset of favorable climatic conditions through highly transmissible leaf genotypes, and that soil populations are transient and may be less epidemiologically relevant than previously thought.

Pautasso, M. 2013. *Phytophthora ramorum* – a pathogen linking network epidemiology, landscape pathology and conservation biogeography. CAB Reviews 8, No. 024. DOI: 10.1079/PAVSNNR20138024.

Abstract: *Phytophthora ramorum* is a generalist plant pathogen that has been subject to a remarkable amount of research activity. One decade after its description, this oomycete now affects a wide range of hosts in both North America and Europe, both in the wild and in ornamental plant trade (e.g., *Camellia, Rhododendron, Pieris*). Research on the biology, epidemiology and management of *P. ramorum* has not only rapidly expanded, but has also become increasingly interdisciplinary. In this overview, three examples of interdisciplinary collaboration concerning *P. ramorum* are presented: (1) network epidemiology (the application of network theory to epidemiology), (2) landscape pathology (the use of landscape ecology tools in the study of regional outbreaks of tree pathogens) and (3) conservation biogeography (a biogeographical perspective in conservation biology). Building on these approaches, three-way collaboration among network epidemiologists, landscape pathologists and conservation biogeographers (as well as e.g., molecular biologists, social and climate change scientists) is now needed to

improve our understanding and management of the *P. ramorum* emergency, and many other challenges to plant health worldwide.

Potter, C. 2013. Ten Years of Land Cover Change on the California Coast Detected Using Landsat Satellite Image Analysis: Part 1—Marin and San Francisco Counties. Journal of Coastal Conservation. Online First. DOI: 10.1007/s11852-013-0255-2.

Abstract: Landsat satellite imagery was analyzed to generate a detailed record of 10 years of vegetation disturbance and regrowth for Pacific coastal areas of Marin and San Francisco Counties. The Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) methodology, a transformation of Tasseled-Cap data space, was applied to detected changes in perennial coastal shrubland, woodland, and forest cover from 1999 to 2009. Results showed several principal points of interest, within which extensive contiguous areas of similar LEDAPS vegetation change (either disturbed or restored) were detected. Regrowth areas were delineated as burned forest areas in the Point Reyes National Seashore (PRNS) from the 1995 Vision Fire. LEDAPS-detected disturbance patterns on Inverness Ridge, PRNS in areas observed with dieback of tanoak and bay laurel trees was consistent with defoliation by sudden oak death (*Phytophthora ramorum*). LEDAPS regrowth pixels were detected over much of the predominantly grassland/herbaceous cover of the Olema Valley ranchland near PRNS. Extensive restoration of perennial vegetation cover on Crissy Field, Baker Beach and Lobos Creek dunes in San Francisco was identified. Based on these examples, the LEDAPS methodology will be capable of fulfilling much of the need for continual, low-cost monitoring of emerging changes to coastal ecosystems.

Vannini, A.; Bruni, N.; Tomassini, A.; Franceschini, S.; and Vettraino, A.M. 2013. Pyrosequencing of Environmental Soil Samples Reveals Biodiversity of the *Phytophthora* Resident Community in Chestnut Forests. FEMS Microbiology Ecology. DOI: 10.1111/1574-6941.12132.

Abstract: Pyrosequencing analysis was performed on soils from Italian chestnut groves to evaluate the diversity of the resident *Phytophthora* community. Sequences analyzed with a custom database discriminated 15 pathogenic Phytophthoras including species common to chestnut soils, while a total of nine species were detected with baiting. The two sites studied differed in *Phytophthora* diversity and the presence of specific taxa responded to specific ecological traits of the sites. Furthermore, some species not previously recorded were represented by a discrete number of reads; among these species, *Phytophthora ramorum* was detected at both sites. Pyrosequencing was demonstrated to be a very sensitive technique to describe the *Phytophthora* community in soil and was able to detect species not easy to be isolated from soil with standard baiting techniques. In particular, pyrosequencing is a highly efficient tool for investigating the colonization of new environments by alien species, and for ecological and adaptive studies coupled with biological detection methods. This study represents the first application of pyrosequencing for describing Phytophthoras in environmental soil samples.

Widmer, T.L. and Dodge, S.C. 2013. Can Fungal Epiphytes Reduce Disease Symptoms Caused by *Phytophthora ramorum*? Biological Control. 65(1): 135-141.

Abstract: Leaf infection of ornamental species by *Phytophthora ramorum* has a significant impact on the spread of this disease. Fungicides have had limited success at controlling this disease. With increasing concerns that repeated fungicide applications will exacerbate the potential for fungicide resistance and mask symptoms, alternative control measures are desired. The potential of biological control has not been thoroughly examined. Fungi, isolated from soil, were screened in dual culture with *P. ramorum* for antagonistic activity. Three isolates, identified as *Penicillium daleae*, *Metarhizium anisopliae*, and *Penicillium herquei*, were selected for further testing on the aerial plant parts of rhododendrons. Different factors, including culture age, application timing, dose response, and additives in the formulation were studied to determine their effects on the antagonists to reduce leaf necrosis. Although responses were variable for the different antagonists, this study showed that fungi applied to the leaf surface could reduce necrosis caused by *P. ramorum*. The method developed can be used for screening potential antagonists *in planta*.

Related Research

Stam, R.; Jupe, J.; Howden, A.J.M.; Morris, J.A.; Boevink, P.C.; Hedley, P.E.; and Huitema, E. 2013. Identification and Characterization CRN Effectors in *Phytophthora capsici* Shows Modularity and Functional Diversity. PLOS ONE. 8(3): e59517.

R.C. Ploetz; Hulcr, J.; Wingfield, M.J.; and de Beer, Z.W. 2013. Destructive Tree Diseases Associated with Ambrosia and Bark Beetles: Black Swan Events in Tree Pathology? Plant Disease. 97(7): 856-872. DOI: http://dx.doi.org/10.1094/PDIS-01-13-0056-FE.

De Vita, P.; Serrano, M.S.; Ramo, C.; Aponte, C.; García, L.V.; Belbahri, L.; and Sánchez, M.E. 2013. First Report of Root Rot Caused by *Pythium spiculum* Affecting Cork Oaks at Doñana Biological Reserve in Spain. Plant Disease. 97(7): 991-991.

Resources

A revised "Stop the Spread of Sudden Oak Death" brochure is available from Oregon at http://scholarsarchive.library.oregonstate.edu/xmlui/bitstream/handle/1957/37904/ec1608.pdf?sequence=1. The document, updated to include new *P. ramorum* quarantine information for the state, also provides information on how to prevent disease spread, shows disease symptoms on various host plants, and gives several resources for more information.

Calendar of Events

8/24 - 25 - Fifth *Phytophthora*, *Pythium*, and Related Genera Workshop; Beijing,

China; The first day focuses on the methodology for studying Oomycetes (particularly *Phytophthora* and *Pythium* species), while the second day will cover contemporary research topics. The meeting is being held in conjunction with the 10th International Congress of Plant Pathology. For abstract submission, registration, and workshop information, go to http://www.icppbj2013.org/file/workshop/5thInternationalWorkshop.asp.

9/4 - **SOD Treatment Workshop; meet at oak outside of Tolman Hall, UC** Berkeley Campus; 1:00 – 3:00 p.m.; Pre-registration is required. This class is free and will be held rain or shine. To register, or for questions, email kpalmieri@berkeley.edu, and provide your name, phone number, affiliation, license number (if applicable), and the date for which you are registering. For more information, go to http://nature.berkeley.edu/garbelotto/english/sodtreatmenttraining.php.

10/2 - **SOD Treatment Workshop; meet at oak outside of Tolman Hall, UC** Berkeley Campus; 1:00 – 3:00 p.m.; Pre-registration is required. For more information, see the 9/4 listing above.

10/23 - **SOD Treatment Workshop; meet at oak outside of Tolman Hall, UC** Berkeley Campus; 1:00 – 3:00 p.m.; Pre-registration is required. For more information, see the 9/4 listing above.

11/13 - **SOD Treatment Workshop; meet at oak outside of Tolman Hall, UC** Berkeley Campus; 1:00 – 3:00 p.m.; Pre-registration is required. For more information, see the 9/4 listing above.