CALIFORNIA OAK MORTALITY TASK FORCE REPORT TO THE BOARD OF FORESTRY DECEMBER 2015

***Note*: The COMTF report will be produced every other month in 2016. The first report of the year will be issued January 27, 2016.**

NURSERIES

The seven California nurseries that opted into the USDA Animal and Plant Health Inspection Service *P. ramorum* Compliance Program have completed their fall inspections. A total of 3,073 plant, water, and soil samples were collected by USDA, California Department of Food and Agriculture, and county inspectors. All samples tested negative for the pathogen.

In October, extensive surveys were conducted at the Kitsap County, WA botanical garden where *P. ramorum* was first detected last spring. Inspections encompassed the property's perimeter, a large undisturbed woodland adjacent to the landscaped garden, and areas in the garden where *P. ramorum* had been detected in the spring and plants were subsequently destroyed. All 224 samples collected around the perimeter of the property and in the native woodland were negative for *P. ramorum*.

Four samples collected in the managed garden were positive for the pathogen. The new detections were confirmed on *Rhododendron* (2), *Camellia* (1), and *Vaccinium* (1). An additional positive on a *Gaultheria* was found during a delimitation survey. All detections were in close proximity to previously positive sites, and all infected plants were destroyed in November. Monthly surveys near previously positive sites will be conducted through the winter. In addition to the best management practices already in place, the garden staff will be implementing an Integrated Pest Management program in certain areas to reduce the overall *Phytophthora* population. The staff will also be modifying their overhead irrigation practices during the dry months. Washington State Department of Agriculture staff continues to work closely with USDA, Washington State University, and garden staff to implement the best strategies to prevent future infections.

From January to December 1, 2015, *P. ramorum* was reported in 13 nurseries (CA 1, NY 1, OR 9, WA 1, VA 1), one commercial landscape (LA), two residences (OH, OR), and a botanic garden (WA) in non-quarantine areas. *P. ramorum* was detected in *Arctostaphylos* (1); *Camellia* (3); *Gaultheria* (1); *Kalmia* (1); *Mahonia* (1); *Osmanthus* (1); *Pieris* (5); *Rhododendron* (43); soil samples (13); *Vaccinium* (5); *Viburnum (9); Vinca* (1); and water samples (2). Six of the nurseries ship interstate and are in the USDA APHIS federal compliance program (started spring, 2014; Federal Order DA-2014-02). The Confirmed Nursery Protocol is completed in all nurseries and resulted in two detections at two sites (1 nursery in CA, 1 residence in OH). The OH resident and CA

nursery detections were the result of trace-forward investigations from a positive WA nursery. The OR residential confirmation was identified by a Master Gardener who found suspicious symptoms in his yard.

MANAGEMENT

Redwood National Park staff has completed treating the additional 131 acres of *P. ramorum*-positive trees and the surrounding buffer zone in the park this past summer (See the COMTF August report for more information.). Since October 2014, the park has treated 283 acres of mixed old-growth and second-growth redwood forests in an effort to slow the spread of SOD. For more information, contact Leonel Arguello at leonel_arguello@nps.gov.

MONITORING

A mutant tanoak was found on Marin Municipal Water District (MMWD) redwood forest property this summer by UC Davis researchers collecting data for a sudden oak death (SOD) management project. The small seedling (~0.5m tall) exhibited leaf morphology very similar to the mutants found in the Challenge Experimental Forest, Yuba Co. (described by P.M. McDonald, et al. in Madrono, 69(2): 107-117, 2013), with lobed, rather than serrated leaves that have unusually hairy undersides. Most leaves on the seedling also had elongated tips (see photo). All other tanoak trees and seedlings in the immediate area looked normal; however, an exhaustive search was not completed at the time of discovery. If confirmed, it would be the farthest south a mutant similar to the ones described by McDonald has been found and the first discovered outside the Challenge Experimental Forest in a very long time. UC Davis researchers and MMWD staff are working to protect the tree from planned management activities aimed at preventing the spread of SOD and reducing fuels in a severely *P. ramorum*-infested area.

MMWD Mutant tanoak.
Photo by: K. Frangioso, UC Davis

There are only a few mutants left in existence on the Challenge Experimental Forest. According to McDonald, most known seedlings may have died from the harsh winter of 1973 and no new seedlings have been found in recent years. For more information on the Marin find or to offer suggestions on how it should be protected, contact Kerri Frangioso kfrangioso@ucdavis.edu.

FUNDING

The USDA Forest Service, Pacific Southwest Region, State and Private Forestry, Forest Health Protection program has issued its 2016 *Phytophthora ramorum* Request for 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 Jan. 7, 2016. Those applying should make note of new requirements for 2016, listed under "Important notes" found in the Pre-Proposal guidelines. For questions, contact Phil Cannon at: pcannon@fs.fed.us or (707) 562-8913.

RESEARCH

Anderson, L.G.; Rocliffe, S.; Haddaway, N.R.; and Dunn, A.M. 2015. The Role of Tourism and Recreation in the Spread of Non-Native Species: A Systematic Review and Meta-Analysis. PLoS ONE 10(10): e0140833. doi:10.1371/journal.pone.0140833.

Abstract: Managing the pathways by which non-native species are introduced and spread is considered the most effective way of preventing species invasions. Tourism and outdoor recreation involve the frequent congregation of people, vehicles and vessels from geographically diverse areas. They are therefore perceived to be major pathways for the movement of non-native species, and ones that will become increasingly important with the continued growth of these sectors. However, a global assessment of the relationship between tourism activities and the introduction of non-native species–particularly in freshwater and marine environments–is lacking. We conducted a systematic review and meta-analysis to determine the impact of tourism and outdoor recreation on non-native species in terrestrial, marine and freshwater environments. Our results provide quantitative evidence that the abundance and richness of non-native species are significantly higher in sites where tourist activities take place than in control sites. The pattern was consistent across terrestrial, freshwater and marine environments; across a variety of vectors (e.g. horses, hikers, yachts); and across a range of taxonomic groups. These results highlight the need for widespread biosecurity interventions to prevent the inadvertent introduction of invasive non-native species (INNS) as the tourism and outdoor recreation sectors grow.

Elliot, M.; Schlenzig, A.; Harris, C.M.; Meagher, T.R.; and Green, S. 2015. An Improved Method for qPCR Detection of Three *Phytophthora* spp. in Forest and Woodland Soils in Northern Britain. Forest Pathology. DOI: 10.1111/efp.12224.

Abstract: Using TaqMan qPCR assays, DNA of *P. ramorum*, *P. kernoviae* and *P. austrocedri* was detected in 500 g soil samples collected from twelve infected forest and woodland sites in northern Britain. *Phytophthora* DNA was also amplified in soil adhering to boots after walking transects along footpaths or animal trails. At two sites, *Phytophthora* DNA was detected in soil over a 4-year period following removal of infected hosts. This new method enabling assessment of larger quantities of soil demonstrates the contamination risk of these pathogens in soil at infected sites and improves our understanding of the mechanisms of persistence and spread.

Jung, T.; Orlikowski, L.; Henricot, B.; Abad-Campos, P.; Aday, A.G.; Aguín Casal, O.; Bakonyi, J.; Cacciola, S.O.; Cech, T.; Chavarriaga, D.; Corcobado, T.; Cravador, A.; Decourcelle, T.; Denton, G.; Diamandis, S.; Doğmuş-Lehtijärvi, H.T.; Franceschini, A.; Ginetti, B.; Glavendekić, M.; Hantula, J.; Hartmann, G.; Herrero, M.; Ivic, D.; Horta Jung, M.; Lilja, A.; Keca, N.; Kramarets, V.; Lyubenova, A.; Machado, H.; Magnano di San Lio, G.; Mansilla Vázquez, P.J.; Marçais, B.; Matsiakh, I.; Milenkovic, I.; Moricca, S.; Nagy, Z.Á.; Nechwatal, J.; Olsson, C.; Oszako, T.; Pane, A.; Paplomatas, E.J.; Pintos Varela, C.; Prospero, S.; Rial Martínez, C.; Rigling, D.; Robin, C.; Rytkönen, A.; Sánchez, M.E.; Scanu, B.; Schlenzig, A.; Schumacher, J.; Slavov, S.; Solla, A.; Sousa, E.; Stenlid, J.; Talgø, V.; Tomic, Z.; Tsopelas, P.; Vannini, A.; Vettraino, A.M.; Wenneker, M.; Woodward, S.; and Peréz-Sierra, A. 2015. Widespread *Phytophthora* Infestations in European Nurseries Put Forest, Semi-Natural and Horticultural Ecosystems at High Risk of *Phytophthora* Diseases. Forest Pathology. DOI: 10.1111/efp.12239.

Abstract: An analysis of incidence of *Phytophthora* spp. in 732 European nurseries producing forest transplants, larger specimen trees, landscape plants and ornamentals, plus 2525 areas in which trees and shrubs were planted, is presented based on work conducted by 37 research groups in 23 European countries between 1972 and 2013. Forty-nine *Phytophthora* taxa were recorded in 670 nurseries (91.5%); within these nurseries, 1614 of 1992 nursery stands (81.0%) were infested, although most affected plants appeared healthy. In forest and landscape plantings, 56 *Phytophthora* taxa were recovered from 1667 of 2525 tested sites (66.0%). Affected plants frequently showed symptoms such as crown thinning, chlorosis and dieback caused by extensive fine root losses and/or collar rot. Many well-known highly damaging host–*Phytophthora* combinations were frequently detected but 297 and 407 new *Phytophthora*–host associations were also observed in nurseries and plantings, respectively. On average, 1.3 *Phytophthora* species/taxa per infested nursery stand and planting site were isolated. At least 47 of the 68 *Phytophthora* species/taxa detected in nurseries and plantings were exotic species several of which are considered well established in both nurseries and plantings in Europe. Seven known *Phytophthora* species/taxa were found for the first time in Europe, while 10 taxa had not been previously recorded from nurseries or plantings; in addition, 5 taxa were first detections on woody plant species. Seven *Phytophthora* taxa were previously unknown to science. The reasons for these failures of plant biosecurity in Europe, implications for forest and semi-natural ecosystems and possible ways to improve biosecurity are discussed.

Nelson, M.F. and Bone, C.E. 2015. Effectiveness of Dynamic Quarantines against Pathogen Spread in Models of the Horticultural Trade Network. Ecological Complexity 24:14–28.

Abstract: The live plant nursery trade is a potential vector for pests and pathogens, which can spread to natural and developed environments with unintended ecosystem consequences. Simulated, approximately scale- free, tiered horticultural trade networks consisting of growers, wholesalers, and retailers were used to study the efficacy of quarantine inspection and isolation procedures for reducing the spread of infected

materials to consumers. The quarantine algorithm temporarily isolated infected nurseries from the rest of the trade network, rewiring the affected trade connections to unquarantined nodes, until the infection was reduced below the detection threshold, at which time the formerly infected nursery was reincorporated into the trade network. Nodes were inspected for infection at regular intervals. Increasing the inspection interval resulted in higher levels of infection with large, system-wide oscillations whose period that matched the inspection interval. The timing of quarantine inspections of the largest hub in the grower tier drove the dynamics of the entire network. Increasing the proportion of growers or wholesalers increased infection level in most networks. Increasing the connectivity within the grower and wholesaler tiers led to large increases in mean infection levels. Focusing quarantine inspection efforts on hubs in the grower and wholesaler tiers may be the most efficient method for reducing the level of infected plant material sold by retailers in real plant trade networks.

Serra-Diaz, J.M.; Franklin, J.; Dillon, W.W.; Syphard, A.D.; Davis, F.W.; and Meentemeyer, R.K. 2015. California Forests Show Early Indications of Both Range Shifts and Local Persistence under Climate Change. Global Ecology and Biogeography. DOI: 10.1111/geb.12396.

Abstract:
Aim - Forest regeneration data provide an early signal of the persistence and migration of tree species, so we investigated whether species shifts due to climate change exhibit a common signal of response or whether changes vary by species.

Location - California Floristic Province, United States; Mediterranean biome.

Methods - We related Forest Inventory and Analysis (FIA) data from 2000−07 for 13 tree species to high-resolution climate and geographical data. Using methods from invasion ecology, we derived indices of species-specific regeneration overlap and central tendency change (range-wide global indicators) based on kernel density estimation of presence and absence of regeneration. We then built regeneration surfaces to identify areas of occurrence of high regeneration (regeneration hotspots, local indicators) in both geographical and climate space for 13 common tree species.

Results - Differences between presence and absence of regeneration in forests varied in magnitude across species, with little evidence that tree regeneration is shifting to higher latitudes and elevations, the expected geographical fingerprint of climate change. We also identified potential topographic mediators of regeneration dynamics. Multiple regeneration hotspots were found for many species, suggesting the influence of non-climatic factors on regeneration. Differences between the presence and absence of regeneration in geographic and climate spaces were not always congruent, suggesting that shifting climate space and range area are not entirely coupled.

Main conclusions - The distributions of regeneration in Californian forests show diverse signals, not always tracking the higher latitudinal–elevation fingerprint of climate change.

Local regeneration hotspots are common in our analysis, suggesting spatially varying persistence of forest linked to natural and anthropogenic disturbances. Our results emphasize that projections of tree range shifts in the context of climate change should consider the variation of regeneration drivers within species ranges, beyond the overall climate signal.

Kostov, K.; Verstappen, E.; Bergervoet, J.; de Weerdt, M.; Schoen, C.; Slavov, S.; and Bonants, P. *In press*. Multiplex Detection and Identification of *Phytophthora* spp. Using Target Specific Primer Extension and Luminex xTAG Technology. DOI: 10.1111/ppa.12481.

Abstract: There are more than 100 species that belong to the fungus-like genus *Phytophthora*, many of which can cause severe damage to plants both in natural and agricultural ecosystems. The availability of techniques for detection and identification are crucial for the monitoring and control of these pathogens. In recent years, new methods using molecular approaches, have been developed. The majority of them however are designed to detect single *Phytophthora* species. Techniques which are able to target multiple species in one sample would offer advantages, especially for the assessment of *Phytophthora* diversity in the environment. In this paper we describe a multiplex assay for simultaneous detection and identification of 26 Phytophthoras down to species level and another 22 to clade or subclade level through target specific primer extension (TSPE) and the Luminex xTAG array detection system. The assay starts with PCR amplification of two genomic regions ITS and *coxI* followed by multiplex TSPE reaction with clade-, subclade- and species-specific probes. As a result biotin-dCTP labelled products are generated and subsequently detected through hybridization with a set of anti-tag coupled, colour coded paramagnetic beads. The specificity of the method has been tested using DNA extracts from over 400 isolates representing 110 *Phytophthora* species and subspecies. The sensitivity and robustness have been determined by the use of DNA mixtures, dilution series and environmental samples. Herewith the developed technique allows simultaneous identification of multiple *Phytophthora* species, particularly useful for the detection of these pathogens in environmental samples such as soil, water and plant tissue.

Prigigallo, M.I.; Abdelfattah, A.; Cacciola, S.O.; Faedda, R.; Sanzani, S.M.; Cooke, D.E.L.; and Schena, L. *In press*. Metabarcoding Analysis of *Phytophthora* Diversity Using Genus Specific Primers and 454 Pyrosequencing. Phytopathology. http://dx.doi.org/10.1094/PHYTO-07-15-0167-R.

Abstract: A metabarcoding method based on genus-specific primers and 454 pyrosequencing was utilized to investigate the genetic diversity of *Phytophthora* spp. in soil and root samples of potted plants, from 8 nurseries. Pyrosequencing enabled the detection of 25 *Phytophthora* phylotypes distributed in 7 different clades and provided a much higher resolution than a corresponding cloning/Sanger sequencing approach. Eleven of these phylotypes, including *P. cactorum, P. citricola* s.str., *P. palmivora*, *P. palmivora*-like, *P. megasperma* or *P. gonapodyides*, *P. ramorum* and 5 putative new

Phytophthora species phylogenetically related to clades 1, 2, 4, 6 and 7, were detected only with the 454 pyrosequencing approach. We also found an additional 18 novel records of a phylotype in a particular nursery that were not detected with cloning/Sanger sequencing. Several aspects confirmed the reliability of the method: i) many identical sequence types were identified independently in different nurseries, ii) most sequence types identified with 454 pyrosequencing were identical to those from the cloning/Sanger sequencing approach and/or perfectly matched GenBank deposited sequences, and iii) the divergence noted between sequence types of putative new *Phytophthora* species and all other detected sequences was sufficient to rule out sequencing errors. The proposed method represents a powerful tool to study diversity providing that particular attention is paid to the analysis of 454 pyrosequencing raw read sequences and to the identification of sequence types.

RELATED RESEARCH

Brazee, N.J.; Wick, R.L.; and Hulvey, J.P. 2015. *Phytophthora* Species Recovered from the Connecticut River Valley in Massachusetts, USA. Mycologia. DOI: 10.3852/15-038.

Brown, N.; Jeger, M.; Kirk, S.; Xu, X.; and Denman, S. 2016. Spatial and Temporal Patterns in Symptom Expression within Eight Woodlands Affected by Acute Oak Decline. Forest Ecology and Management. Vol. 360: 97–109. DOI: 10.1016/j.foreco.2015.10.026.

Freer-Smith, P.H. and Webber, J.F. 2015. Tree Pests and Diseases: The Threat to Biodiversity and the Delivery of Ecosystem Services. Biodiversity and Conservation. pp 1-15. Available online at http://link.springer.com/article/10.1007/s10531-015-1019-0#.

Gardner, J.F.; Dick, M.A.; and Karl-Friedrich Bader, M. 2015. Susceptibility of New Zealand Flora to *Phytophthora kernoviae* and Its Seasonal Variability in the Field. New Zealand Journal of Forestry Science. 45:23. DOI: 10.1186/s40490-015-0050-y.

Shands, A.C.; Yamagata, J.S.; Wright, A.; and Miles, T.D. *In press*. First Report of *Phytophthora cinnamomi* Causing Root Rot of Southern Highbush Blueberry in California. Plant Disease. Available online at http://dx.doi.org/10.1094/PDIS-07-15-0738-PDN.

CALENDAR

6/21 – 23/16 Sudden Oak Death Science Symposium 6; Fort Mason, San Francisco;
Save the Date! More information will be available soon at http://www.suddenoakdeath.org/. For questions, contact Katie Harrell at kpalmieri@berkeley.edu or (510) 847-5482.