CALIFORNIA OAK MORTALITY TASK FORCE REPORT
JUNE 2015

MONITORING

Five new *Phytophthora ramorum* hosts were detected during a rare plant survey in February on Marin County Municipal Water District property when unusual *Arctostaphylos* symptoms were identified. Samples submitted to the California Department of Food and Agriculture (CDFA) Plant Pest Diagnostics Lab tested negative for root pathogens, but the leaves and branches tested positive for *P. ramorum*. Follow-up official samples were collected for testing by CDFA scientists, which resulted in the identification of five new *P. ramorum* hosts: *Arctostaphylos virgata*, *Arctostaphylos glandulosa*, chinquapin (*Chrysolepsis chrysophylla*), blackberry (*Rubus ursinus*), and chaparral pea (*Pickeringia montana*). *Arctostaphylos virgata* and *Arctostaphylos glandulosa* symptoms include leaf spots and necrosis, petiole dieback, stem lesions and cankers, and tip dieback. Many plants of both species were showing symptoms. Chinquapin (*Chrysolepsis chrysophylla*) symptoms include canopy dieback, leaf spots, and vascular discoloration. Many chinquapin were showing symptoms; two trees were confirmed positive. Blackberry (*Rubus ursinus*) symptoms include leaf spots and stem lesions. Chaparral pea (*Pickeringia montana*) symptoms include leaf spots, stem lesions, and thorn dieback. CDFA scientists are in the process of obtaining healthy container plants of each host species to confirm pathogenicity. A follow-up site visit to the water district is planned for July to observe disease progression on these hosts.

The Kitsap County botanical garden found to have a *P. ramorum*-positive *Pieris* plant in April had additional positive plants found in May during the delimitation survey. All infected plants were destroyed and trace-back investigations are underway. The facility will undergo a Critical Control Point Assessment (CCPA) at which time best management practice (BMP) mitigations will be identified for implementation. The BMPs will be enforced through a state compliance agreement. Federal regulatory oversight will continue to ensure the pathogen is being managed effectively.

The UK Forestry Commission 2015 Japanese larch *P. ramorum* aerial survey is underway, beginning with flights over western England. Sporadic, low-level symptoms, including subtle branch and crown dieback in individual trees and small groups of trees, were observed in southwest England (primarily near previous outbreaks). Symptoms were also observed in a small number of larch sites at higher elevations that are not associated with previous infestations. Further north, symptoms were limited to individual trees and crowns in areas previously associated with confirmed infection on larch or rhododendron. Follow-up ground surveys of symptomatic sites will confirm the presence or absence of the pathogen.

Other observations of note included pine crops showing significant *Dothistroma* needle blight symptoms, ongoing *Phytophthora austrocedri* juniper infection in the Lake District of northwest England, and mortality of individual oak trees on a site with acute oak decline in the West Midlands (the region around Birmingham).

NURSERIES

***Vaccinium parvifolium* (red huckleberry) was found *P. ramorum* positive for the first** time from two samples taken at a Lewis County, WA interstate shipping nursery during their 2015 spring Federal *P. ramorum* Certification Program survey. The Lewis County facility was also positive in 2014 and had undergone a CCPA as well as extensive mitigation activities. A new CCPA has been conducted to determine possible ways the pathogen has continued to infect plant material; additional mitigation efforts will completed in 2015. As a result of the new host confirmation, *Vaccinium parvifolium* will be added to the federally recognized *P. ramorum* host and associated host list.

From January 1 to June 3, 2015, *P. ramorum* was reported in 10 nurseries (OR 8, WA 1, VA 1), one commercial landscape (LA), and a botanical garden (WA) in non-quarantine areas. *P. ramorum* was detected in *Camellia* (2), *Kalmia* (1), *Mahonia* (1), *Osmanthus* (1), *Pieris* (10), *Rhododendron* (40), *Viburnum* (4), *Vinca* (2), and soil samples (8). Four of the nurseries ship interstate and are in the USDA APHIS compliance program (started spring, 2014; Federal Order DA-2014-02). The Confirmed Nursery Protocol is underway in all nurseries and no findings were made at trace-forward sites. Detections at the WA botanical garden are in managed landscapes; survey and disinfestation procedures are underway.

Spring inspections for the seven California nurseries participating in the 2015 Federal *P. ramorum* Certification Program are complete. All were negative for the pathogen. Forty-seven nurseries in the quarantined counties also completed their annual inspection and all were negative for the pathogen. A total of 3,589 plant, water, and soil samples have been processed to date this year.

Fourteen native plant nurseries have joined the California Department of Food and Agriculture (CDFA) Best Management Program (BMP) for Ornamental and Native Plant Nurseries. The program also serves 14 ornamental nurseries. The discovery of *Phytophthora tentaculata* infecting several native plant species in nurseries and restoration sites has alerted the industry to the cryptic nature of plant pathogens and how easily they can move into the environment. Although the program has been voluntary to date, with the nurseries choosing which BMPs to employ, CDFA and the National Ornamentals Research Site at Dominican University of California are working to identify minimum requirements for acceptance into the program for ornamental interstate shipping nurseries as well as native plant nurseries. CDFA is developing a website to further support the BMP Program.

MANAGEMENT

An Update on Sudden Oak Death in Oregon Wildlands – Fifty-one dead tanoaks were identified during a helicopter survey of the Curry County quarantine area on May 6. All were ground-checked. Thus far in 2015, 11 new infestations have been confirmed outside of the Generally Infested Area (GIA; figure 1). One large site is located on the Winchuck River, 1.5 miles north of the California border.

Eradication treatments for 2015 infestations include two sites north of Pistol River. The small (northern) site has been cut and piled; however, the larger (southern) site will be delayed until fall because of wildfire risk and landowner concerns. Treatment at the Winchuck River site (50 acres) will be deferred until fall, and most other new infested sites will receive minimal management (cut and pile within 20-50 ft of infected trees, burning in autumn/winter to limit wildfire risk). The three highest priority sites (to the north) detected in 2014 have been treated to a 300 foot buffer. All other high-priority sites received minimal management (cut and burn or cut and pile infected trees, plus a 20-50 ft buffer). Treatments on federal land have either been completed or are underway.

Funding for detection surveys (aerial, ground, stream baits) is adequate; however, funds for private land treatments are exhausted. New state and federal funds are expected mid-summer, but they will not be sufficient to fully treat all of the infestations located outside of the GIA. Size and intensity of eradication treatments will be adjusted accordingly. Funding for eradication treatments on Bureau of Land Management and US Forest Service land is sufficient to continue treatments at current disease levels.

The GIA was expanded slightly to 58 sq. mi. in 2014 because of the large infestations along its northern edge. There has been no further expansion thus far in 2015; however, the Oregon Department of Agriculture is considering expanding the Curry County *P. ramorum* quarantine area (figure 2). With the proposed expansion, the quarantine area would increase from 264 sq. mi. to 519 sq. mi. and would provide a buffer from infested sites approximately 8 mi to the north/northeast and 6 mi to the east. The new quarantine area would also extend south to the California border. The Department will hold a public information meeting in the Docia Sweet Exhibit Hall in Gold Beach on June 15th at 7:00 p.m., which will be followed by a public hearing on the proposed expansion June 16th at 8:30 a.m. in the same location. Written comments on the proposed expansion will be accepted until 5:00 p.m. on June 22nd and should be addressed to Rules Coordinator; Oregon Department of Agriculture; 635 Capitol St NE; Salem, OR 97301.

Alternative management strategies for Oregon's SOD program are being considered. Preventing spread into Coos or other adjacent counties is of high importance.

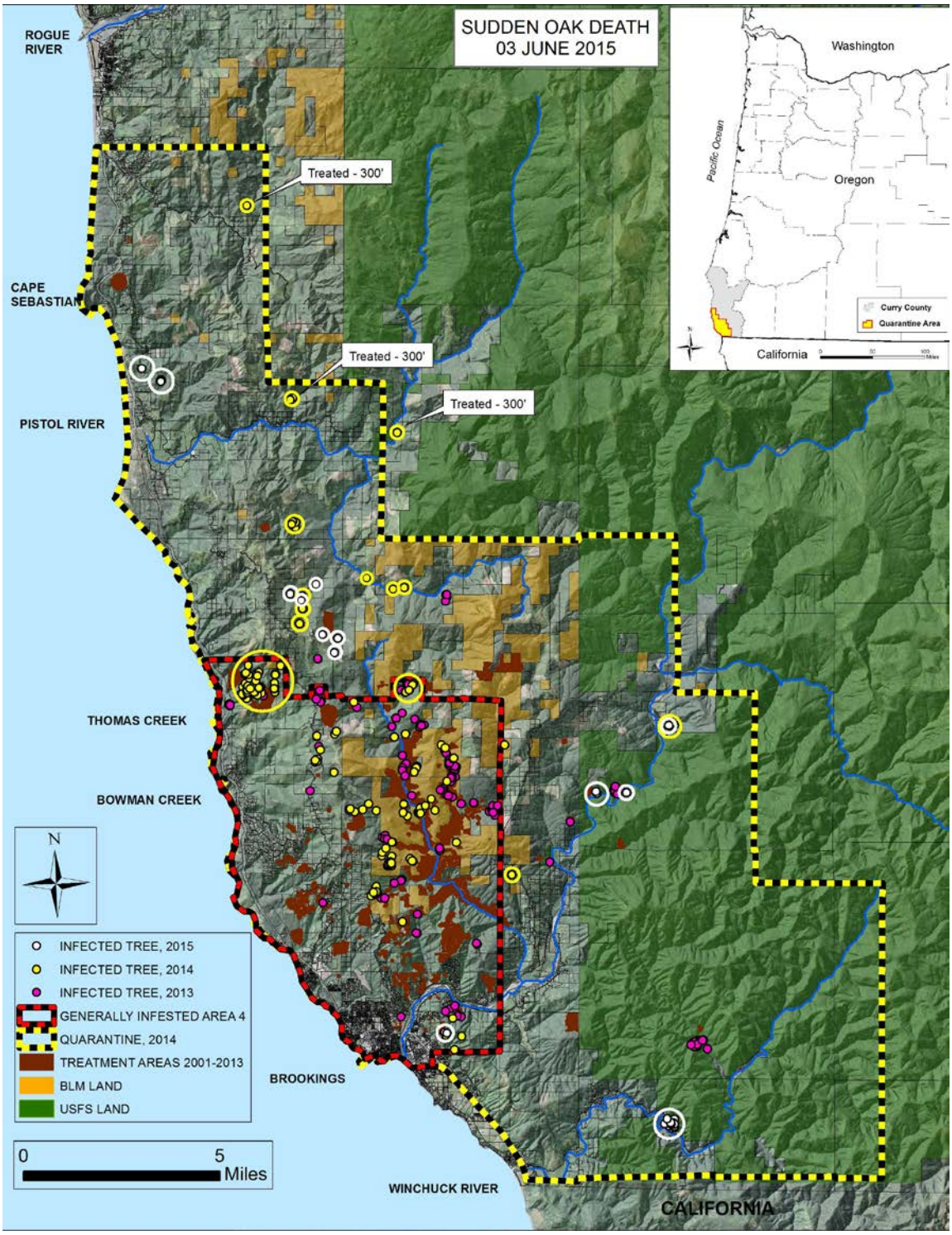

Figure 1. Location of sites infested with *P. ramorum* in southwest Oregon that were discovered in 2013-2015, as of June 3, 2015. Larger yellow circles indicate 2014 infestations of particular importance for disease spread. Larger white circles indicate sites discovered in 2015. All 2014 infestations have received some level of eradication treatment. Nearly all 2015 infestations have not been treated.

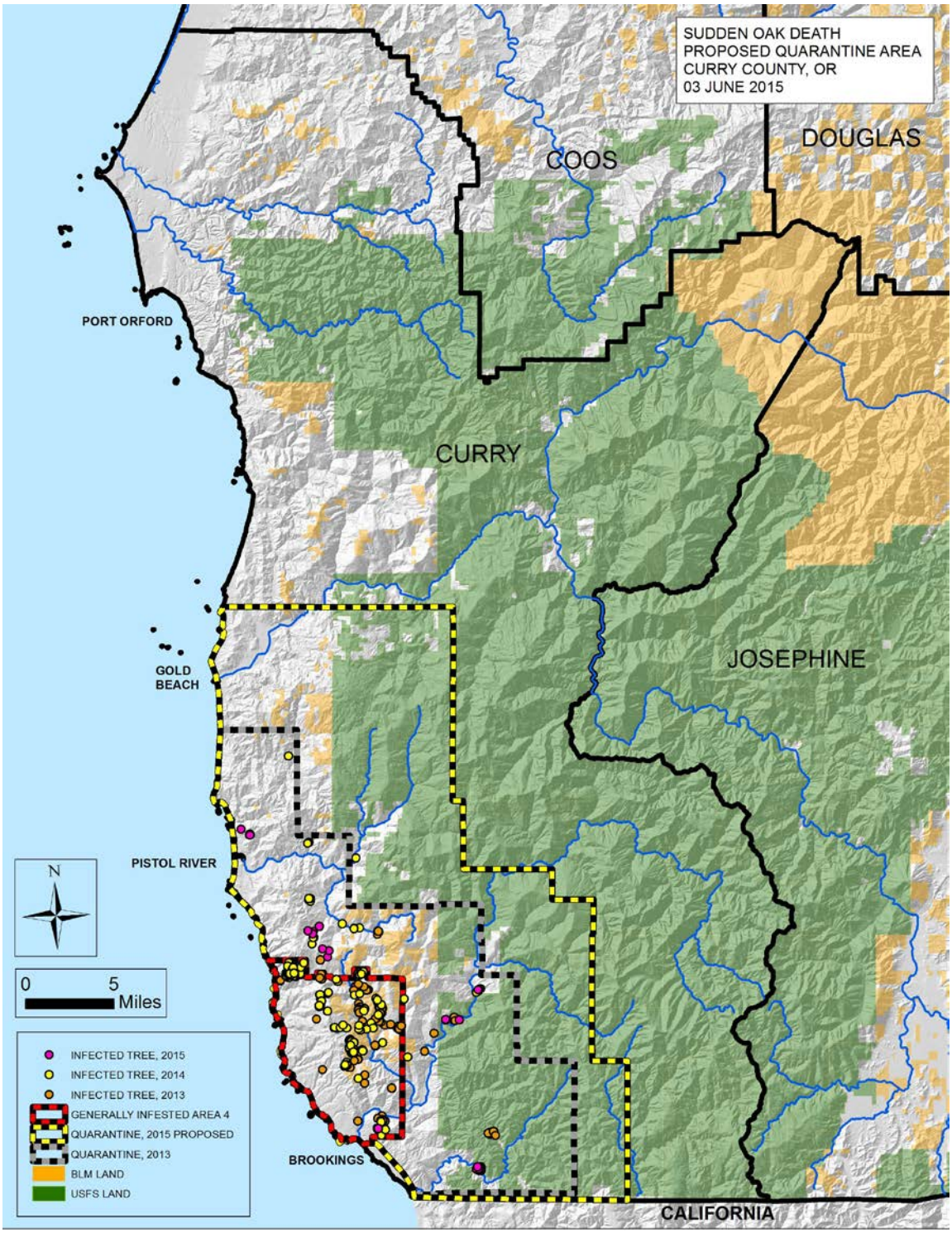

Figure 2. Proposed Expansion of Quarantine Area and Generally Infested Area. The proposed expansion would increase the quarantine area from 264 mi^2 to 519 mi^2.

FEATURED MANAGEMENT UPDATE

Revised Oak Phosphonate Application Recommendations for Sudden Oak Death

The following recommendations are exclusively for coast live oak, California Black oak, Shreve's oak, and canyon live oak.

Due to the aggressive nature of sudden oak death, there are no therapeutic treatments proven to be effective once an oak tree is infected. However, it is possible to help prevent oak infection by removing California bay laurels within 5-20 m (16.5 – 65.5 ft) of oak tree trunks (See bay removal guidelines at http://nature.berkeley.edu/garbelottowp/?p=1063.) and applying phosphonates to uninfected oak trees. Phosphonates can be applied by bark application (See bark application at http://nature.berkeley.edu/garbelottowp/?p=1039.) or trunk injection. Application of phosphonates is best done in the fall, from early November to mid-December, when oaks become physiologically active after summer dormancy. Phosphonates need to be systemically translocated and metabolized in the canopy in order to increase oak resistance, hence treatment during hot and cold periods should be avoided as that is when tree metabolic rates are substantially lower. Field experiments have shown that 4-6 weeks are required after application for maximum tree resistance to develop. Most oak infections occur in April and May during sustained periods of rain and mild temperatures, thus fall treatments allow enough time for trees to increase their resistance before the peak infection period. As injections require drilling holes in the bark, the wounds may be colonized by *P. ramorum* in the spring, making tree injections in late winter and spring unadvisable. After 16 weeks, wounds naturally heal and do not favor *P. ramorum* establishment.

Injections should be performed on cool, sunny, mild days, between 10 a.m. and 3 p.m. Normally one injection is performed every 15 ¼ cm (6 in) along the circumference of a tree; however, spacing may need to be irregular as areas with wood defects (punks, knots, stubs) and areas immediately below defects should be avoided. Injections should take between 1 and 15 minutes to be absorbed. In cases where absorption takes less than 1 minute, it is likely that the phosphonate was injected into a cavity rather than into sound wood. More than 15 minutes for absorption could mean the tree evapotranspiration rate may be too low to effectively assimilate the treatment. If this occurs, it is advisable to stop the treatment and try again at a later date (See the slide show at http://nature.berkeley.edu/garbelottowp/?p=1039 for how to properly dilute phosphonates and inject them.). Injections performed in the same year should be at the same height on the trunk. Injection sites in subsequent years should be done 5 cm (2 in) higher and offset horizontally, as previous injections damage the vertical vessels and hinder absorption of the treatment. Remember that injections should target the outer rings of the xylem and not the inner sapwood or the heartwood which do not contain functional vessels. Injectors should be applied immediately after each injection hole is drilled.

NOTE: Concentrations of phosphonates indicated on current label dosages have been shown to cause significant wood damage and should no longer be used. See the following

figures 1 and 2 and table 1 for new phosphonate damage and efficacy data as well as the revised injection dilution ratio recommendations.

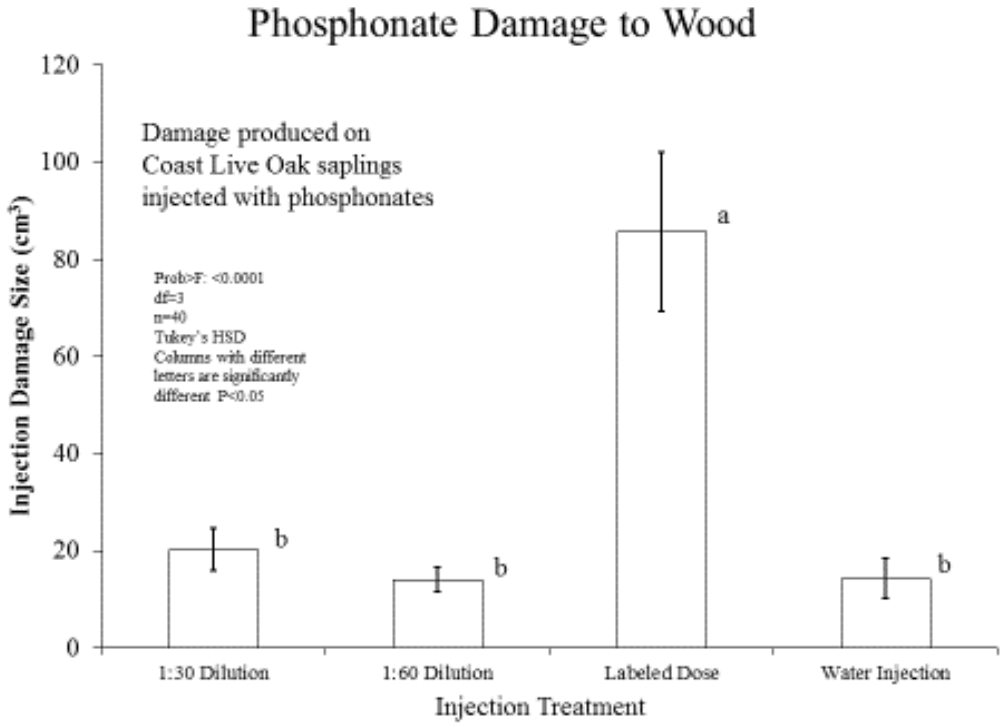

Figure 1. Injection damage caused by labeled dose vs updated dilution ratios. Note that at updated dosage (1:30 or 1:60) damage is indistinguishable from damage caused by only injecting water.

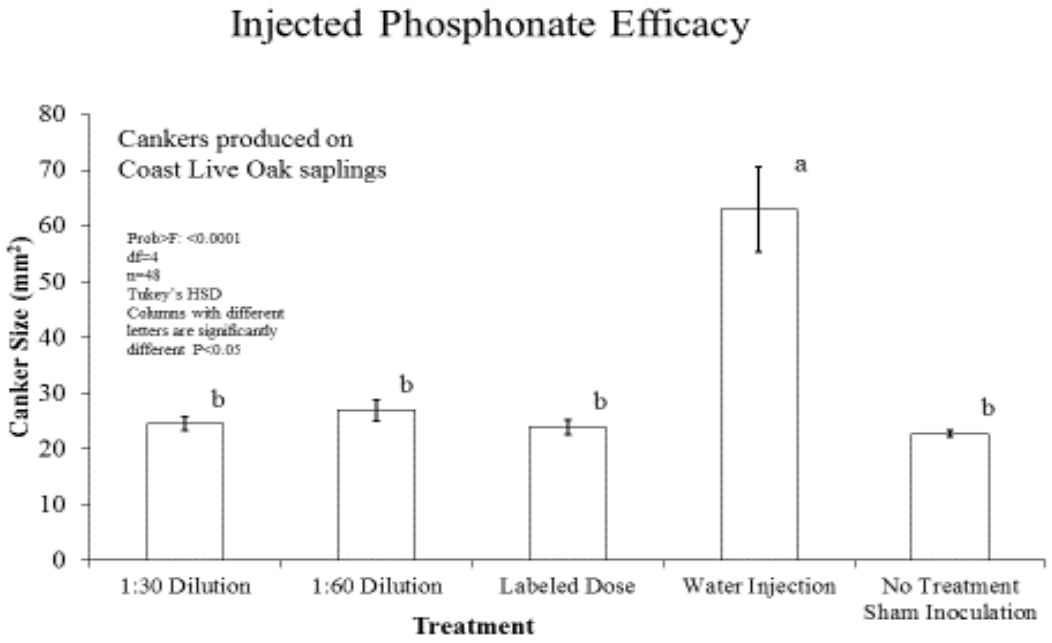

Figure 2. Efficacy of labeled dose vs updated dilution ratios. Smaller lesions equal higher efficacy.

New Recommended Phosphonate Injection Ratios

Label Dose	1 part chemical + 2 parts water= 1:3 delivered in 10ml dose	**DISCONTINUE**
Updated Dilution #1	1 part chemical +29 parts water = 1:30 delivered in 20ml dose (20 psi)	Chemjet injector
Updated Dilution #2	1 part chemical + 59 parts water = 1:60 delivered in 40ml dose (35 psi)	Arborjet injector

Table 1. The two updated dilutions differ in active ingredient concentration, injection volume, and recommended injection pressure. Pressurized injections maximize uptake of phosphonates, allowing the injected material to bypass the embolisms caused by the drilling of a hole in the xylem.

RESEARCH

Conrad, A. 2015. Metabolomics of *Quercus* spp. to Understand and Predict Resistance to *Phytophthora ramorum* . Electronic Dissertation. Ohio State University available at https://etd.ohiolink.edu/.

Condensed Abstract: Sudden oak death (SOD) is a devastating disease of oak and tanoak in the western United States, caused by the non-native, generalist pathogen *Phytophthora ramorum* [Werres et al.] *Quercus agrifolia* [Nee] (CLO—coast live oak) is a highly susceptible host of *P. ramorum* in California forests and *Quercus rubra* [L.] (NRO—

northern red oak) is an important Eastern forest species that is also susceptible to *P. ramorum*. CLO naturally resistant to *P. ramorum* have been observed and include trees that fail to develop symptoms of infection or appear to recover after symptom development. Variability in CLO susceptibility has been associated with variation in the concentration of certain phenolic compounds produced in CLO phloem tissue, and putative phenolic biomarkers of resistance were identified from trees already infected with *P. ramorum*. However, the association between constitutive (i.e. pre-infection) levels of phenolics in naive CLO and variation in host susceptibility has not been examined, and little is known about the relationship between NRO susceptibility and variation in phenolic levels. This research aimed to elucidate chemical mechanisms of resistance and identify factors that may affect the production of phenolic defenses in susceptible *Quercus* spp., including CLO and NRO, before and after infection with *P. ramorum*.

Desprez-Loustau, M.-L.; Aguayo, J.; Dutech, C.; Hayden, K.J.; Husson, C.; Jakushkin, B.; Marçais, B.; Piou, D.; Robin, C.; Vacher, C. 2015. An Evolutionary Ecology Perspective to Address Forest Pathology Challenges of Today and Tomorrow. Annals of Forest Science. DOI: 10.1007/s13595-015-0487-4.

Abstract: *Key message* Increasing human impacts on forests, including unintentional movement of pathogens, climate change, and large-scale intensive plantations, are associated with an unprecedented rate of new diseases. An evolutionary ecology perspective can help address these challenges and provide direction for sustainable forest management.

Context Forest pathology has historically relied on an ecological approach to understand and address the practical management of forest diseases. A widening of this perspective to include evolutionary considerations has been increasingly developed in response to the rising rates of genetic change in both pathogen populations and tree populations due to human activities.

Aims Here, five topics for which the evolutionary perspective is especially relevant are highlighted.

Results The first relates to the evolutionary diversity of fungi and fungal-like organisms, with issues linked to the identification of species and their ecological niches. The second theme deals with the evolutionary processes that allow forest pathogens to adapt to new hosts after introductions or to become more virulent in homogeneous plantations. The third theme presents issues linked to disease resistance in tree breeding programs (e.g., growth-defense trade-offs) and proposes new criteria and methods for more durable resistance.

The last two themes are dedicated to the biotic environment of the tree–pathogen system, namely, hyperparasites and tree microbiota, as possible solutions for health management.

Conclusion We conclude by highlighting three major conceptual advances brought by evolutionary biology, i.e., that (i) “not everything is everywhere”, (ii) evolution of pathogen populations can occur on short time scales, and (iii) the tree is a multitrophic community. We further translate these into a framework for immediate policy recommendations and future directions for research.

Taylor, T.; Ingram-Smith, C.; and Smith, K. S. 2015. Biochemical and Kinetic Characterization of the Eukaryotic Phosphotransacetylase Class IIa Enzyme from *Phytophthora ramorum*. Eukaryotic Cell, EC-00007.

Phosphotransacetylase (Pta), a key enzyme in bacterial metabolism, catalyzes the reversible transfer of an acetyl group from acetyl phosphate to CoA to produce acetyl-CoA and P_i. Two classes of Pta have been identified based on the absence (Pta^I) or presence (Pta^{II}) of an N-terminal regulatory domain. Pta^I has been fairly well studied in bacteria and one genus of archaea; however, only the *Escherichia coli* and *Salmonella enterica* Pta^{II} enzymes have been biochemically characterized, and both are allosterically regulated. Here we describe the first biochemical and kinetic characterization of a eukaryotic Pta from the oomycete *Phytophthora ramorum*. The two Ptas from *P. ramorum*, designated as $PrPta^{II}1$ and $PrPta^{II}2$, both belong to class II. $PrPta^{II}1$ displayed positive cooperativity for both acetyl phosphate and CoA and is allosterically regulated. We compared the effect of different metabolites on $PrPta^{II}1$ and the *S. enterica* Pta^{II} and found that although the N-terminal regulatory domains share only 19% identity, both enzymes are inhibited by ATP, NADP, NADH, PEP, and pyruvate in the acetyl-CoA/P_i–forming direction but are differentially regulated by AMP. Phylogenetic analysis of bacterial, archaeal, and eukaryotic sequences identified four subtypes of Pta^{II} based on the presence or absence of the P-loop and DRTGG subdomains within the N-terminal regulatory domain. Although the *E. coli*, *S. enterica*, and *P. ramorum* enzymes all belong to the IIa subclass, our kinetic analysis has indicated that enzymes within a subclass can still display differences in their allosteric regulation.

RELATED RESEARCH

Espindola, A.; Schneider, W.; Hoyt, P.R.; Marek, S.M.; and Garzon, C. 2015. A New Approach for Detecting Fungal and Oomycete Plant Pathogens in Next Generation Sequencing Metagenome Data Utilising Electronic Probes. International Journal of Data Mining and Bioinformatics. 12(2). DOI: 10.1504/IJDMB.2015.069422.

Hancock, D.J. 2015. Towards New Nursery Industry Protocols for 'Phytophthora' Control: Supply of Stock for Restoration and Revegetation. Australasian Plant Conservation: Journal of the Australian Network for Plant Conservation. 23(4): 13-15. Available online at http://search.informit.com.au/documentSummary;dn=161440193396776;res=IELNZC.

Haque, M.M.U.; Martín-García, J.; and Diez, J.J. 2015. Variation in Pathogenicity Among the Three Subspecies of *Phytophthora alni* on Detached Leaves, Twigs and Branches of *Alnus glutinosa*. Forest Pathology. DOI: 10.1111/efp.12198.

Hansen, E.M.; Reeser, P.; Sutton, W.; Gardner, J.; and Williams, N. 2015. First Report of *Phytophthora pluvialis* Causing Needle Loss and Shoot Dieback on Douglas-fir in Oregon and New Zealand. 99(5): 727. http://dx.doi.org/10.1094/PDIS-09-14-0943-PDN.

Kubiak, K.; Błaszczyk, M.; Sierota, Z.; Tkaczyk, M.; and Oszako, T. 2015. Slow Sand Filtration for Elimination of Phytopathogens in Water Used in Forest Nurseries. Scandinavian Journal of Forest Research. DOI: 10.1080/02827581.2015.1048716.

Scanu, B. and Webber, J.F. 2015. Dieback and Mortality of *Nothofagus* in Britain: Ecology, Pathogenicity and Sporulation Potential of the Causal Agent *Phytophthora pseudosyringae*. Plant Pathology. DOI: 10.1111/ppa.12399.

CALENDAR

6/6 – Tribal SOD Blitz; 11:00 a.m. – 3:00 p.m.; Kashia Band of Pomo Indians; Stewarts Point Rancheria - Community Center; 31455 Skaggs Springs Road; Stewarts Point; For more information, contact Nina Hapner at nina@stewartspoint.org.

8/23 – 8/28 - 5th International Workshop on the Genetics of Tree-Parasite Interactions; Orléans, France; For more information, or to register, go to https://colloque.inra.fr/tree-parasite-interactions2015.

10/21 - 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 and license number (if applicable), and the name and date of the class.

11/4 – 11/5 - 2014 Annual Meeting of the California Forest Pest Council; USDA Forest Service, Wildland Fire Training & Conference Center, Hamm and Loop rooms; 3237 Peacekeeper Way; McClellan; More information will be forthcoming. For more information, contact Katie Palmieri at kpalmieri@berkeley.edu.