CALIFORNIA OAK MORTALITY TASK FORCE REPORT
MAY 2024

MONITORING - CALIFORNIA

The wet 2022-2023 winter has been followed by new detections of *Phytophthora ramorum* in Del Norte County. Recent stream monitoring has detected the pathogen in several streams relatively near ones with previous detections along the State Route 197 (North Bank Road) corridor; these "new" infested streams include Peacock Creek, the North Fork of Rowdy Creek, and Sultan Creek. Stream baits have been placed farther upstream on tributaries to the North Fork to ascertain the extent of the terrestrial infestation in this watershed.

Additionally, an infected tanoak sapling has been found along the banks of Peacock Creek very close to the creek's intersection with SR 197. Further sampling is forthcoming; the above-mentioned watersheds will be surveyed more intensively during the UC Berkeley-coordinated SOD Blitz in Del Norte County planned for early May. For more information, contact Wallis Robinson, wlrobinson@ucanr.edu, or Chris Lee, christopher.lee@fire.ca.gov.

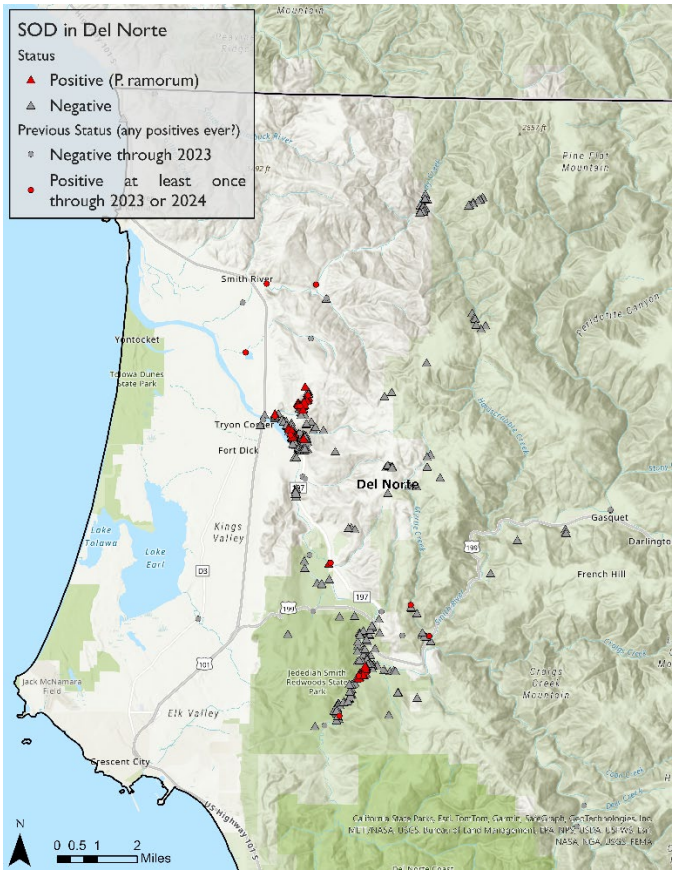

Figure 1. Confirmed *P. ramorum* detected in Del Norte County to date. Circles denote stream positives; triangles denote positive wildland plants.

NURSERIES AND MANAGED LANDSCAPES

California Department of Food and Agriculture Update. Six California nurseries that were previously positive for *P. ramorum* are undergoing enhanced inspections in March and April. Three nurseries, two of which were previously positive, were found positive for *P. ramorum* in the first months of 2024. All three 2024 positive nurseries are undergoing the USDA's Protocol for Interstate Nurseries Confirmed Positive for *Phytophthora ramorum* from the *Phytophthora ramorum* Domestic Regulatory Program Manual. Plants confirmed positive for *P. ramorum* in 2024 are: *Cornus capitata* 'Mountain Moon', *Loropetalum chinense, Cornus* 'Porlock*',* *Rhododendron* sp., and *Camellia sasanqua* 'Shishi Gashira'. Trace forward investigations have yielded no additional positive plants that were shipped to other nurseries. For more information contact Carolyn Lambert, Carolyn.Lambert@cdfa.ca.gov.

In March, Washington Department of Agriculture (WSDA) received trace-forward information on plants that shipped to 70 homeowners from a positive out-of-state nursery. Of the specific varieties found positive at the nursery, only one plant was shipped into Washington. Inspectors are in the process of following up at each location to inspect and collect samples, if needed.

Washington has a new *P. ramorum* coordinator. Haley Palec is the WSDA Plant Services Program Supervisor for Western Washington and is based in Tacoma. For more information contact Haley Palec, hpalec@agr.wa.gov.

REGULATIONS

In March, USDA Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine revised the *Phytophthora ramorum* Domestic Regulatory Program Manual. The revisions updated figures and definitions, clarified operational steps, and revised Chapter 4, "Confirmed Retail Nursery and Retail Nursery Dealer Protocol. Protocol for Intrastate Retail Nurseries and Retail Nursery Dealers when *Phytophthora ramorum* is Present (rCNP)." For more details see the APHIS *P. ramorum* website, Information for Cooperators, https://www.aphis.usda.gov/plant-pests-diseases/pramorum.

FUNDING

In January, the USDA APHIS announced over $62 million for the Plant Pest and Disease Management and Disaster Prevention Program (PPDMDPP) portion of the Plant Protection Act, Section 7721 (PPA 7721, formerly known as "the Farm Bill"). The funds aim to strengthen U.S. infrastructure for pest detection and surveillance, identification, threat mitigation, and safeguarding of the nursery production system. Funding for *Phytophthora ramorum* and related species totals more than $1 million to be awarded in 17 states. Nursery survey is funded in 11 states. Other related projects include "Evaluating the threat of the NA2 and EU2 lineages of *Phytophthora ramorum* (Sudden Oak Death) to nurseries and forests" and "Development of a portable, small-scale steam system for treating *P. ramorum* at nurseries and landscape sites." Funds are provided for survey, research, mitigation, and outreach. For more details, view the fiscal year 2024 Plant Protection Act's Section 7721 spending plans online: www.aphis.usda.gov/ppa-projects.

P. RAMORUM INFECTION - LOOK-ALIKES ON CALIFORNIA BAY LAUREL

This spring, numerous reports and observations have been made of symptomatic bay laurel trees in coastal counties from Marin (CA) up through Curry (OR). A variety of symptoms and tree conditions have been reported, from complete mortality of trees and associated sprouts to leaf lesions leading to substantial crown defoliation. A similar variety of symptoms also appeared on bay laurels after last year's wet winter, and they appear to be connected to a wide variety of pathogenic organisms. This is a brief rundown of some of the pathogens observed over the last two years by personnel from Dominican University (NORSDUC), CAL FIRE, CDFA, CA State Parks, the University of California, and others.

Table 1 lists some pathogens associated with the various symptoms on bay laurel in California. This list is not exhaustive, as dozens of microorganisms have been isolated from bay laurel leaves alone (D. Rizzo, UC Davis, Plant Pathology, pers. comm.).

Whole-tree dieback gradual or sudden	Individual branch dieback	Root or stem decay	Leaf spotting or blackening
Phytophthora cinnamomi	*Neofusicoccum nonquaesitum*	*Ganoderma brownii*	*Phytophthora ramorum, P.pseudosyringae, P. nemorosa*
Phytophthora pseudosyringae	*Botryosphaeria dothidea*	*Armillaria gallica*	*Diplodia corticola*
Other *Phytophthora* species?	Other bot canker fungi?	Other decay fungi?	*Neoscytalidium dimidiatum*
			Fusarium sp.
			Neofusicoccum nonquaesitum
			Kabatiella spp.
			Calonectria californiensis
			Many others

Table 1. Pathogens associated with California bay laurel.

Most confusing are foliar symptoms, all of which tend to look identical on bay laurel leaves. Two foliar pathogens in particular stand out over the past two wet-winter years. An "anthracnose" disease of bay laurel leaves caused by a species of *Kabatiella* was reported some eighty years ago; it was not widely noted again until 2023, when it was seen in multiple locations all around the San Francisco Bay area. In some areas this pathogen has been responsible for extensive browning and defoliation of bay laurel crowns, although it is uncertain whether it has led to tree mortality. Another widely noticed pathogen in 2023 and 2024 is the recently named *Calonectria californiensis.* This fungus has the potential to cause great confusion with the sudden oak death pathogen because it produces symptoms on a wide variety of native plants, including (besides bay laurel) tanoak, salal, mock-orange, Oregon-grape, and rhododendron.

On most of these plants this fungus causes black spots that can grow to encompass and kill entire leaves, but it does not appear to be a pathogen of woody plant parts. The initial symptoms of

infection on bay laurel appear identical to those caused by *P. ramorum*. Extensive pathogen infection of bay laurel usually occurs in humid areas such as river canyon bottoms, and defoliation is usually confined to the bottom two-thirds of the tree crown. Symptoms on tanoak leaves can also be easily confused with those caused by *P. ramorum,* but in the case of *C. californiensis* the typical black twig and petiole cankers associated with the former pathogen are usually absent. Most importantly, unlike the case of *P. ramorum,* the disease caused by *C. californiensis* does not appear (not yet, at least) to lead to lasting debilitating disease or tree mortality.

Figure 2. **Suspected *Calonectria californiensis* symptoms on (top) tanoak and (bottom) bay laurel, from Del Norte County, CA and Curry County, OR. In the second tanoak photo, note that the infection does not involve the twigs or petioles, as is typical with symptoms caused by *Phytophthora ramorum.***

RESEARCH

Belisle, W.H.; Rooney-Latham, S.; Soriano, M.C; Grünwald, N.; Blomquist, C.L. 2024. First report of *Phytophthora ramorum* causing leaf spots on *Cornus capitata* (evergreen dogwood) in United States. Plant Disease. https://doi.org/10.1094/PDIS-12-23-2638-PDN.

Cornus capitata (evergreen dogwood) is a bushy evergreen tree or shrub native to East Asia grown for its showy creamy bracts in late spring followed by attractive red fruit. In Feb 2023, a sample of foliage with leaf spots and tip dieback from *C. capitata* 'Mountain Moon' was submitted from a Humboldt Co. nursery as part of a CDFA inspection program for *Phytophthora ramorum*. The leaf spots were medium to dark brown, irregularly shaped, and ranged from 5 to 8 mm in diameter. They were located primarily along the leaf midrib and covered up to 1/4 of the leaf surface. Six 6-mm-diameter leaf discs taken from the margins of brown lesions and tip dieback were plated on *Phytophthora* selective media. After 6 to 10 days, colonies resembling *P. ramorum*, with coralloid coenocytic hyphae, chlamydospores, ellipsoidal semi-papillate and caducous sporangia, and a relatively slow growth rate were recovered. Microsatellite loci placed the *P. ramorum* isolate in the NA2 clonal lineage. Pathogenicity of *P. ramorum* isolate 0254-32A was tested using five *C. capitata* plants (2.5-year-old, 28-cm-tall, 3.78-liter pot). Two days after inoculation, brown spots were visible on leaves on all inoculated plants, initiating from where the drops of inoculum had persisted. After 3 days, brown lesions, from water drop- to majority of entire leaf-sized, were observed on approximately 75% of inoculated leaves. After 6 days, lesions expanded to the edges of leaves, causing leaf curling and defoliation. Lesions stopped expanding after 3 weeks, and by 4 weeks, most infected leaves had abscised, with no new infections observed. *Phytophthora ramorum* was detected on *C. capitata* in the UK in 2015. To our knowledge, this is the first report of *P. ramorum* infecting *C. capitata* in the United States and the completion of Koch's postulates on any *Cornus* spp. Incidence on *C. capitata* in the California nursery was low. However, their proximity to other infected foliar hosts suggests *Cornus* spp. may present a potential risk for the spread of *P. ramorum*.

Beltran, A.; Laubray, S.; Ioos, R.; Husson, C.; Marçais, B. 2024. Low persistence of *Phytophthora ramorum* (Werres, De Cock, and Man in 't Veld) in western France after implementation of eradication measures. Annals of Forest Science. 81: 7. https://doi.org/10.1186/s13595-024-01222-1.

Presence of *Phytophthora ramorum* (Werres, De Cock, and Man in 't Veld**)** in western France was studied after the detection of this invasive pathogen in 2017 in *Larix kaempferi* (Lamb.) and eradication of the affected stands. *P. ramorum* was seldom detected in the area of the outbreak in the year following eradication. However, we confirm that *P. ramorum* can multiply to epidemic level on chestnuts (*Castanea sativa* Mill.) in the absence of larch (*Larix* spp.). This represents the major risk in France.

González, M.P.; Mizubuti, E.S.G.; Gonzalez, G.; Sanfuentes, E. 2024. Uncovering the hidden hosts: Identifying inoculum reservoirs for *Phytophthora pseudosyringae* in *Nothofagus* forests in Chile. Plant Pathology. 73(4): 937-947. https://doi.org/10.1111/ppa.13855.

Mortality of *Nothofagus* trees in native forests in Chile has been observed for more than 30 years. *Phytophthora pseudosyringae* was identified as the causal agent of partial defoliation

and bleeding cankers on *Nothofagus obliqua* and *N. alpina*. Nevertheless, to improve the conservation of natural resources it is crucial to determine potential native hosts that may act as inoculum reservoirs. Two *N. obliqua* stands were visited and all native plant species with symptoms resembling those caused by *Phytophthora* spp. were examined. Seven isolates from cortical and foliar tissues were isolated and subsequentially identified as *P. pseudosyringae*. Pathogenicity tests were carried out on eight species from a native forest. *P. pseudosyringae* caused cankers in *N. obliqua*, *N. dombeyi* and *Persea lingue*. Under natural conditions, no symptoms were detected on leaves of *Cryptocarya alba*, *N. dombeyi*, *N. obliqua* or *Peumus boldus*, but lesions were formed in inoculation assays under a controlled environment, suggesting that these species may act as hosts. Leaf necrosis in *P. lingue* was observed in both natural and controlled conditions. *P. pseudosyringae* can sporulate on lesions of *C. alba*, *N. dombeyi* and *N. obliqua* leaves. In *Sophora macrocarpa*, sporulation was observed both on asymptomatic tissues and on lesions. The frequent association of *S. macrocarpa* in the understorey of *Nothofagus* spp. strengthens the putative role of *S. macrocarpa* as an inoculum reservoir for epidemic events in *Nothofagus*. This is the first study carried out in the Southern Hemisphere on the life cycle of *P. pseudosyringae* in native *Nothofagus* forests.

Kozanitas, M.; Knaus, B.J.; Tabima, J.F.; Grünwald, N.J.; Garbelotto, M. 2024. Climatic variability, spatial heterogeneity and the presence of multiple hosts drive the population structure of the pathogen *Phytophthora ramorum* and the epidemiology of Sudden Oak Death. Ecography. https://doi.org/10.1111/ecog.07012.

We implement a population genetics approach to clarify the role that temporal and environmental variability, spatially distinct locations and different hosts may have in the epidemiology of a plant disease and in the microevolution of its causative pathogen. In California and southern Oregon (USA), the introduction of the invasive pathogen *Phytophthora ramorum*, causal agent of the widespread disease Sudden Oak Death (SOD), has resulted in extensive mortality of various oaks *Quercus* sp. and of tanoak *Notholithocarpus densiflorus*. Although the disease can infect over a hundred hosts, California bay laurel *Umbellularia californica* is the most competent transmissive host but is not lethally affected by the disease. Using population genetics data, we identify the relationship among *P. ramorum* populations in bay laurels, oaks and tanoaks to clarify the contribution of each host on the epidemiology of SOD and on the microevolution of its causal agent and to explore differences in population structure across sites and years. We conclude that bay laurel is the primary source for infections of both tanoak and oak, and that tanoak contributes minimally to oak infection but can infect bay laurel, creating a secondary pathogen amplification process. Overall, pathogen diversity is associated with rainfall and presence of bay laurels, which sustain the largest populations of the pathogen. Additionally, we clarify that while bay laurels are a common source of inoculum, oaks and tanoaks act as sinks that maintain host-specific pathogen genotypes not observed in bay laurel populations. Finally, we conclude that different sites support a dominance of different pathogen genotypes. Some genotypes were widespread, while others were limited to a subset of the plots. Sites with higher bay laurel densities sustained a higher genotypic diversity of the pathogen. This work provides novel insight into the ecology and evolutionary trajectories of SOD epidemics in natural ecosystems.

Mullet, M.S.; Harris, A.R.; Scanu, B. [and others]. 2024. Phylogeography, origin and population structure of the self-fertile emerging plant pathogen *Phytophthora pseudosyringae.* Molecular Plant Pathology. https://doi.org/10.1111/mpp.13450.

Phytophthora pseudosyringae is a self-fertile pathogen of woody plants, particularly associated with tree species from the genera *Fagus*, *Notholithocarpus*, *Nothofagus* and *Quercus*, which is found across Europe and in parts of North America and Chile. It can behave as a soil pathogen infecting roots and the stem collar region, as well as an aerial pathogen infecting leaves, twigs and stem barks, causing particular damage in the United Kingdom and western North America. The population structure, migration and potential outcrossing of a worldwide collection of isolates were investigated using genotyping-by-sequencing. Coalescent-based migration analysis revealed that the North American population originated from Europe. Historical gene flow has occurred between the continents in both directions to some extent, yet contemporary migration is overwhelmingly from Europe to North America. Two broad population clusters dominate the global population of the pathogen, with a subgroup derived from one of the main clusters found only in western North America. Index of association and network analyses indicate an influential level of outcrossing has occurred in this preferentially inbreeding, homothallic oomycete. Outcrossing between the two main population clusters has created distinct subgroups of admixed individuals that are, however, less common than the main population clusters. Differences in life history traits between the two main population clusters should be further investigated together with virulence and host range tests to evaluate the risk each population poses to natural environments worldwide.

Wang, Y.; Chang, L.; Zhang, H.; Chen, Y.Q.; Chen, W.; Chen, H. 2024. Characterization of three types of elongases from different fungi and site-directed mutagenesis. Journal of Fungi. 10(2):129. https://doi.org/10.3390/jof10020129.

Fatty acid elongases play crucial roles in synthesizing long-chain polyunsaturated fatty acids. Identifying more efficient elongases is essential for enhancing oleaginous microorganisms to produce high yields of target products. We characterized three elongases that were identified with distinct specificities: McELO from *Mucor circinelloides*, PrELO from *Phytophthora ramorum*, and PsELO from *Phytophthora sojae*. Heterologous expression in Saccharomyces *cerevisiae* showed that McELO preferentially elongates C16 to C18 fatty acids, PrELO targets Δ6 polyunsaturated fatty acids, and PsELO uses long chain saturated fatty acids as substrates. McELO and PrELO exhibited more homology, potentially enabling fatty acid composition remodeling and enhanced LC-PUFAs production in oleaginous microorganisms. Site-directed mutagenesis of conserved amino acids across elongase types identified residues essential for activity, supported by molecular docking. Alanine substitution of conserved polar residues led to enzyme inactivation, underscoring their importance in the condensation reaction. Our findings offer promising elongase candidates for polyunsaturated fatty acid production, contributing to the bioindustry's sustainable development.

RELATED RESEARCH

Cai, Y.; Anderson, E.; Xue, W. [and others]. 2024. Assembly and analysis of the genome of *Notholithocarpus de*nsiflorus. G3: Genes, Genomes, Genetics. jkae043. https://doi.org/10.1093/g3journal/jkae043.

European Food Safety Authority (EFSA) Panel on Plant Health (PLH); Bragard, C.; Baptista, P. [and others]. 2024. Commodity risk assessment of *Corylus avellana* plants from the UK. EFSA Journal. 22(1): e8495.

Gougherty, A.V.; Davies, T.J. 2024. Evolutionary history of host trees amplifies the dilution effect of biodiversity on forest pests. PLOS Biology. 22(2): e3002473.

Li, Q.; Zhu, H.; Ai, G.; Yu, J.; Dou, D. 2024. Plant genes related to *Phytophthora* pathogens resistance. Phytopathology Research. 6(15): https://doi.org/10.1186/s42483-024-00229-w.

Sherwood, P.; Nordström, I.; Woodward, S.; Bohman, B.; Cleary, M. 2024. Detecting pathogenic *Phytophthora* species using volatile organic compounds. Molecules. 29(8): 1749. https://doi.org/10.3390/molecules29081749.

Socorro Serrano, M.; Villa-Sanabria, E.; Homet, P.; Gutiérrez, E.; Gómez-Aparicio, L. 2024. Impact of a drier climate on the exotic pathogen *Phytophthora cinnamomi* in Mediterranean forests differing in soil properties and species composition. Forest Ecology and Management. 556: 121721.

EDUCATION AND OUTREACH

Ten SOD Blitzes will be held in May, and you are invited to participate. The schedule, registration, online training, and more are available at the UC Berkeley Forest Pathology and Mycology Laboratory. The SOD Blitz is a citizen science survey of California counties to determine trends in *P. ramorum* infection. For questions contact. Doug Schmidt, dschmidt@berkeley.edu.

FAREWELL

Congratulations to Betsy Randall-Schadel upon her retirement from the USDA APHIS. Betsy served for the past seven years as *P. ramorum* National Operations Manager, and previously as a Risk Analyst with APHIS Science &Technology. The COMTF sends our thanks to Betsy for her assistance over all the years.