CALIFORNIA OAK MORTALITY TASK FORCE REPORT
SEPTEMBER 2006

REGULATIONS

Eucalyptus haemastoma* Sm. (Myrtaceae – Myrtle family), *Cornus kousa* x *Cornus *capitata* (Cornaceae – Dogwood family), and *Castanopsis orthacantha* Franchet (Fagaceae – Beech family) have been added to the UK Department for Environment, Food**,** and Rural Affairs (DEFRA) list of Plants Reported as Natural Hosts of *Phytophthora ramorum.* All three hosts were found *P. ramorum*-positive in the United Kingdom. Symptomatic *Eucalyptus haemastoma* Sm. had chlorotic leaves, while *Cornus kousa* x *Cornus capitata* exhibited shoot tip die-back and *Castanopsis orthacantha* Franchet was found to have mid-rib necrosis and leaf symptoms. The USDA Animal and Plant Health Inspection Service (APHIS) is researching the findings and anticipates adding these plants to APHIS *P. ramorum* Associated Host Plant list soon.

Canada has added five new genera to the Canadian Food and Inspection Agency (CFIA) *P. ramorum* host list: *Loropetalum*, *Distylium*, *Manglietia*, *Parakmeria*, and *Ilex*. These additions are the result of positive confirmations from the species: *Loropetalum chinese*, *Distylium myricoides*, *Manglietia insignis*, *Parakmeria lotungensis*, and *Ilex purpurea*. *Ilex* and *Manglietia* plants not only displayed leaf spots, but also some dieback. All of the confirmations came from container plants grown in a polyhouse. Canada's updated *P. ramorum*-regulated genera list can be found on the CFIA website at: (http://www.inspection.gc.ca/english/plaveg/protect/dir/sodspe.shtml). APHIS is reviewing the findings and anticipates adding the new hosts to the APHIS *P. ramorum* Associated Host Plant list in the near future.

USDA APHIS has updated the Confirmed Nursery Protocol (CNP), and posted it to the APHIS website at: http://www.aphis.usda.gov/ppq/ispm/pramorum/protocols.html**.** Effective September 1, 2006, any newly confirmed *P. ramorum*-positive nurseries must comply with the new version of the protocol.

RESEARCH

The Call for Papers deadline for the Sudden Oak Death Science Symposium III, to be held in Santa Rosa, CA (March 2007), has been extended to November 1, 2006. Please note that each researcher may only submit one paper as the lead author; however, poster submissions are unlimited. For more information on the Symposium and the Call for Papers, go to the Symposium website: http://nature.berkeley.edu/comtf/sodsymposium/.

The National Science Foundation/National Institutes of Health (NSF/NIH) program "Ecology of Infectious Diseases" is funding a 5-year, $2.4 million grant for "Sudden Oak Death: Feedback Between a Generalist Pathogen, Hosts, and Heterogeneous Environments at Multiple Spatial and Temporal Scales." Dave Rizzo, Matteo Garbelotto, and Ross Meentemeyer, in collaboration with Christopher Gilligan, are the recipients of the grant.

The project will examine the environmental and biological circumstances that initially led to the emergence of *P. ramorum* and the subsequent disease-related changes to the forest environment. A combination of field, greenhouse, and laboratory experiments, along with geographical information system and mathematical modeling approaches to research the spatial and temporal dynamics of Sudden Oak Death (SOD) will be used. How human-induced changes in landscape structure and composition of forests when combined with weather patterns (e.g., El Nino) may have influenced the establishment and spread of pathogen in California forests will also be examined.

Following *P. ramorum* invasion, changes to the pathogen, host, and forest environment may also occur. SOD epidemics in California forests are primarily driven by the presence of associated host species that serve as sources of the pathogen, and not by the oaks themselves. Because mortality is often restricted to oak and tanoak, the broad host range of *P. ramorum* will allow hypotheses of plant competition mediated by a pathogen to be tested. The broad host range of the pathogen may also allow for *P. ramorum* populations to evolve towards increased virulence and/or increased diversity. However, over time we would also expect that *P. ramorum* invasion will influence the occurrence and spatial distribution of resistant and tolerant host genotypes. Finally, the role of parasites in influencing ecosystem functioning (e.g., nutrient cycling) has often been overlooked. In areas where *P. ramorum*-associated overstory mortality has significantly impacted composition of coastal forests, changes in forest floor inputs, organic matter, decomposition rates, and nitrogen dynamics will be analyzed.

In response to continued tanoak mortality, a project to evaluate tanoak resistance and genetic make-up is under way. The cooperative effort is being carried out by Richard Dodd, Matteo Garbelotto, and Katy Hayden (UC Berkeley); Richard Sniezko and Jessica Wright (USDA Forest Service); Cindy Roessler (Mid-Peninsula Open Space District); and David Schirokauer and Jane Rogers (Pt. Reyes National Seashore).

This year's acorn crop, while more abundant than last year, is still rather limited; however, collections are being made at five locations from Big Sur to Southern Oregon for evaluation of tanoak resistance, genetic make-up, and genetic variation in growth characteristics, along with other traits. An off-shoot of the Sudden Oak Death genetics white paper presented at the March 2006 COMTF Carmel Research and Management meeting, this project will be focusing on developing the protocols and methods that would be needed if a full-scale tanoak resistance program were launched. Any potential future development of *P. ramorum*-resistant tanoak will take five to 10 years and millions of dollars in funding; however, resistance remains one of the most promising management strategies to maintain tanoak populations in wildland areas severely impacted by *P. ramorum*. Project goals also include gaining a greater understanding of tanoak genetic variation in susceptibility to *P. ramorum*, which will aid in understanding pathogen distribution and long-term impacts and risks. For more information on the project, contact Richard Sniezko, Center Geneticist, USDA Forest Service Dorena Genetic Resource Center, Cottage Grove, Oregon at: rsniezko@fs.fed.us.

Tyler, Brett M; Tripathy, Sucheta; Zhang, Xuemin; Dehal, Paramvir; Jiang, Rays H.Y.; Aerts, Andrea; Arredondo, Felipe D.; Baxter, Laura; Bensasson, Douda; Beynon, Jim L.; Chapman, Jarrod; Damasceno, Cynthia M.B.; Dorrance, Anne E.; Dou, Daolong; Dickerman, Allan W.; Dubchak, Inna L.; Garbelotto, Matteo; Gijzen, Mark; Gordon, Stuart G.; Govers, Francine; Grunwald, Niklaus J.; Huang, Wayne; Ivors, Kelly L.; Jones, Richard W.; Kamoun, Sophien; Krampis, Konstantinos; Lamour, Kurt H.; Lee, Mi-Kyung; McDonald, W. Hayes; Medina, Mónica; Meijer, Harold J.G.; Nordberg, Eric K.; Maclean, Donald J.; Ospina-Giraldo, Manuel D.; Morris, Paul F.; Phuntumart, Vipaporn; Putnam, Nicholas H.; Rash, Sam; Rose, Jocelyn K.C.; Sakihama, Yasuko; Salamov, Asaf A.; Savidor, Alon; Scheuring, Chantel F.; Smith, Brian M.; Sobral, Bruno W.S.; Terry, Astrid; Torto-Alalibo, Trudy A.; Win, Joe; Xu, Zhanyou; Zhang, Hongbin; Grigoriev, Igor V.; Rokhsar, Daniel S.; Boore, Jeffrey L. September 1, 2006. *Phytophthora* Genome Sequences Uncover Evolutionary Origins and Mechanisms of Pathogenesis. Science Vol. 313, no. 5791. Pages 1261-1266. Online at: www.sciencemag.org.

Sequencing the *Phytophthora sojae* and *Phytophthora ramorum* genomes has revealed that these *Phytophthoras* have an unprecedented number of genes and genetic flexibility compared to fungal pathogens. Results also indicate that these pathogens (relatives of algae and diatoms) have a large arsenal of recently acquired proteins, such as toxins, protein inhibitors, and enzymes that likely enable them to debilitate a host plant's immune system during infection and then kill and destroy plant tissue later on in the infection process. Studies disclosed that nearly half of the genes are undergoing rapid adaptation, likely as a result of pressure from the host plants' defense systems. As a result of the sequencing, genetic markers have already been developed for population studies and for tracking the movement of different strains of *P. ramorum*. Gaining insight into how these pathogens have become successful has helped to target potential weak points in the organisms. In an effort to further help scientists find clues to stopping these pathogens by narrowing the list of potential target genes from thousands to hundreds, the Department of Energy's Joint Genome Institute is planning to sequence the genomes of two more closely related microbes, including *P. infestans*, responsible for potato blight.

Tjosvold, S.A., Chambers, D.L., Thomas, S.L., and Blomquist, C.L. 2006. First Report of *Phytophthora ramorum* infecting *Camellia* flower buds in North America. Online at: http://www.plantmanagementnetwork.org/php/elements/sum.asp?id=5447&photo=3089. Plant Health Progress doi:10.1094/PHP-2006-0825-01-BR.

Public Summary: Camellias are important nursery and landscape plants and are known to be highly susceptible hosts of *Phytophthora ramorum*, the pathogen that causes Sudden Oak Death. This is the first report of camellia flower bud infection in the field with the North American genotype of *P. ramorum*.

Venette, R.C. and Cohen, S.D. 2006. Potential climatic suitability for establishment of *Phytophthora ramorum* within the contiguous United States. Forest Ecology and Management 231:18–26.

Abstract: *Phytophthora ramorum* has caused extensive mortality to tanoak and several oak species in coastal California. This pathogen has infected at least 72 plant species under natural conditions and 32 additional species in the laboratory. Many infected hosts have been distributed across the United States by the horticultural industry. We developed a simulation model using CLIMEX software to evaluate the suitability of the climate in the United States for establishment of *P. ramorum*. CLIMEX was driven by monthly climate normal data for 1971–2000 collected from >5300 weather stations in the contiguous United States. CLIMEX growth-requirement and stress-response parameters were derived from literature data. Values for the ecoclimatic index (EI), a measure of overall climatic suitability based on temperature and soil moisture, were between 0 and 53. Much of the Intermountain West and the Great Plains was climatically unsuitable for establishment of *P. ramorum* (EI = 0). Many states bordering the Great Lakes were marginal (0 < EI < 11). Areas considered climatically highly favorable (EI > 25) for establishment of *P. ramorum* were common in the Gulf States, and areas considered favorable (10 < EI < 26) extended into southern Illinois, southern Indiana, and northwards into southern Maine. Predictions derived from CLIMEX matched known occurrences of *P. ramorum* in California and Oregon. Finds of the pathogen were 3.4-times more likely in areas classified as favorable or very favorable than in areas classified as marginal or unsuitable. Model results were only modestly sensitive to changes in values assigned to temperature parameters for growth but were more sensitive to changes in values assigned to moisture parameters for growth. Additional research is needed to determine the effects of low moisture on population growth of the pathogen. Nevertheless, our model distinguishes some areas within the contiguous United States that do not have a suitable climate for the pathogen. Such information could be used to refine survey and detection programs.

Hughes, K.J.D., Tomlinson, J.A., Griffin, R.L., Boonham, N., Inman, A.J., and Lane, C.R. 2006. Development of a one-step real-time polymerase chain reaction assay for diagnosis of *Phytophthora ramorum*. Phytopathology 96:975-981.

Abstract: *Phytophthora ramorum* is a recently described pathogen causing bleeding cankers, dieback, and leaf blight on trees and shrubs in parts of Europe and North America, where the disease is commonly known as sudden oak death. This article describes the development of a singleround real-time polymerase chain reaction (PCR) assay based on TaqMan chemistry, designed within the internal transcribed spacer 1 region of the nuclear ribosomal (nr)RNA gene for detection of *P. ramorum* in plant material. Unlike previously described methods for the molecular detection of *P. ramorum*, this assay involves no post amplification steps or multiple rounds of PCR. The assay was found to have a limit of detection of 10 pg of *P. ramorum* DNA, and could detect *P. ramorum* in plant material containing 1% infected material by weight within 36 cycles of PCR. The assay also was used to test DNA from 28 other *Phytophthora* spp. to

establish its specificity for *P. ramorum*. A quick and simple method was used to extract DNA directly from host plant material, and detection of *P. ramorum* was carried out in multiplex with an assay for a gene from the host plant in order to demonstrate whether amplifiable DNA had been extracted. Amplifiable DNA was extracted from 84.4% of samples, as demonstrated by amplification of host plant DNA. The realtime protocol was used to test 320 plant samples (from 19 different plant species) from which DNA extraction had been successful, and was shown to give results comparable with a traditional isolation technique for diagnosis of *P. ramorum* in plant material from common U.K. hosts.

Bakthavatsalam, Deenadayalan, Meijer, Harold J.G., Noegel, Angelika A., and Govers, Francine. September 2006. Novel phosphatidylinositol phosphate kinases with a G-protein coupled receptor signature are shared by *Dictyostelium* and *Phytophthora.* Trends in Microbiology Vol. 14, Issue 9. Pages 378-382. doi:10.1016/j.tim.2006.07.006. Available online at: www.sciencedirect.com.

Abstract: G-protein coupled receptors (GPCR) and phosphatidylinositol phosphate kinases (PIPK) are important key switches in signal transduction pathways. A novel class of proteins was identified in the genomes of two unrelated organisms that harbor both a GPCR and a PIPK domain. *Dictyostelium discoideum* contains one GPCR–PIPK, which is crucial in cell-density sensing, and the genomes of *Phytophthora sojae* and *Phytophthora ramorum* each encode twelve GPCR–PIPKs. Intriguingly, these are currently the only species that have these two domains combined in one protein. Here, the structural and regulatory characteristics of GPCR–PIPKs are presented and discussed. It is hypothesized that, upon activation, GPCR–PIPKs are able to trigger heterotrimeric G-protein signaling and phosphoinositide second-messenger synthesis.

Costanzo, Stefano, Ospina-Giraldo, M.D., Deahl, K.L., Baker, C.J., and Jones, Richard W. October 2006. Gene duplication event in family 12 glycosyl hydrolase from *Phytophthora* spp. Fungal Genetics and Biology Vol. 43, Issue 10. Pages 707-714. doi:10.1016/j.fgb.2006.04.006. Available online at: www.sciencedirect.com.

Abstract: A total of 18 paralogs of xyloglucan-specific endoglucanases (EGLs) from the glycosyl hydrolase family 12 were identified and characterized in *Phytophthora sojae* and *Phytophthora ramorum*. These genes encode predicted extracellular enzymes, with sizes ranging from 189 to 435 amino acid residues, that would be capable of hydrolyzing the xyloglucan component of the host cell wall. In two cases, four and six functional copies of these genes were found in tight succession within a region of 5 and 18kb, respectively. The overall gene copy number and relative organization appeared well conserved between *P. sojae* and *P. ramorum*, with apparent synteny in this region of their respective genomes. Phylogenetic analyses of *Phytophthora* endoglucanases of family 12 and other known members of EGL 12, revealed a close relatedness with a fairly conserved gene sub-family containing, among others, sequences from the fungi *Emericella desertorum* and *Aspergillus aculeatus*. This is the first report of family 12 EGLs present in plant pathogenic eukaryotes.

NURSERIES

CA had one *P. ramorum*-positive nursery identified in August. The San Joaquin County producer was found to have five positive Camellia varieties ('Jean May,' 'Bonanza,' 'Showa-no-sakae,' 'Chansonette' and 'Nuccio's Pearl') during a compliance agreement inspection. Also found *P. ramorum*-positive in 2004, the nursery does not ship interstate, their compliance agreement has been suspended, and they are undergoing the Confirmed Nursery Protocol.

MANAGEMENT

The creation of a Sonoma County SOD Task Force is under way to facilitate the crafting and implementation of a *P. ramorum* management program in an effort to protect County forests and address fire threat concerns. To assist with planning, CDF personnel have flown the local area, mapping current mortality levels, and they will also be assessing fire risks. Researchers also plan to assess inoculum levels in heavily impacted areas, and plans for an educational outreach campaign are being developed. On the ground strategies for public and private lands have been discussed, in addition to options for utilizing and/or destroying trees.

The Government Accountability Office posted a June 21, 2006 invasive species report **"**Invasive Forest Pests: Recent Infestations and Continued Vulnerabilities at Ports of Entry Place U.S. Forests at Risk" (GAO-06-871T) to their website. The entire report may be viewed at: http://www.gao.gov/new.items/d06871t.pdf.

Abstract: Invasive forest pests have seriously harmed our environment and imposed significant costs on our economy. The U.S. Department of Agriculture (USDA) is the lead agency for responding to forest pests and coordinates with the Department of Homeland Security (DHS) to prevent pests from entering the country. GAO issued two reports in 2006 on these programs. This testimony describes (1) the status of USDA's efforts to eradicate the Asian longhorned beetle, emerald ash borer, and *Phytophthora ramorum*; (2) the factors affecting the success of those eradication efforts; and (3) areas of continued vulnerability in regard to preventing the arrival and spread of forest pests.

On the basis of the available evidence, it appears that the Asian longhorned beetle will be eradicated in the three states that have infestations, although funding reductions have extended the likely completion date. In contrast, the emerald ash borer and *P. ramorum*--the pathogen that causes Sudden Oak Death--are likely to continue to infest and damage forest ecosystems in the Midwest and on the West Coast, despite efforts to control them. The success of the federal responses to these infestations has been affected by several factors. First, the unique biological characteristics of each species greatly influences the ability to effectively control them. Second, quarantines have helped contain the spread of the pests, but implementing and enforcing quarantines has been difficult. Third, the only available method for eradicating these pests is to destroy infested trees and plants--a costly and sometimes impractical approach. Fourth, despite budgeting over $420 million to control these three pests, USDA program managers told GAO that funding has not

been sufficient to fully implement their programs. We also found that USDA had not adequately prepared up-to-date management plans to provide decision makers and the public with current information on the extent of the infestation, eradication goals, and long-term funding needs. We identified areas of vulnerability that we believe increase the risk of future forest pest infestations. Specifically, we found that despite efforts to expand USDA's forest health monitoring programs, they do not adequately provide for comprehensive monitoring in urban forests or other locations considered at high risk from pest invasions. Monitoring in such areas is important because they are common destination points for internationally traded cargo, which is a frequent pathway for pests. Improvements could help prevent situations such as those experienced with the Asian longhorned beetle, the emerald ash borer, and *P. ramorum*, in which years of delay in detection allowed them to become established before control programs began. In our report on port inspections, we found that DHS has not used a risk-based staffing model to assign newly hired agricultural specialists to ports of entry. As a result, DHS does not have assurance that staff are assigned to areas of greatest vulnerability. In addition, despite an interagency agreement intended to facilitate coordination between DHS and USDA, agricultural specialists are not consistently receiving notifications of changes to policies and urgent inspection alerts in a timely manner. We also reported that DHS has allowed the canine inspection program--dogs trained to locate items that might harbor pests--to deteriorate. Dozens of canine units are vacant, and the proficiency scores of the remaining canine units have declined.

RESOURCES

A "*Phytophthora ramorum* and *Phytophthora kernoviae*: Key findings from UK research" has been posted to the DEFRA website at: http://www.defra.gov.uk/planth/science/resdec04.pdf. While some of the DEFRA-funded studies are complete, others are new or ongoing, and intended to be referenced as provisional information to be amended as more information is obtained.

The Canadian Food Inspection Agency (CFIA) has updated Canada's Plant Health Risk Assessment "*Phytophthora ramorum*: causal agent of sudden oak death, *ramorum* blight, *ramorum* bleeding canker, *ramorum* (shoot) dieback." The document rates the overall risk of *P. ramorum* as 'high' for British Columbia and 'medium' for Southern Ontario, Quebec, and the Maritime Provinces. The 126-page document is not posted to the Internet, but is available upon request through the CFIA, Plant Health Division, Horticulture Section; Floor 3, Room 3103; 59 Camelot Drive; Ottawa, Ontario; K1A 0Y9 (Tel.: 613/221-4342 Fax: 613/228-6603). For more information, contact Janice Morlidge, Administrative Assistant at morlidgej@inspection.gc.ca.

EDUCATION

A Christmas tree research field tour is being offered to growers by Gary Chastagner and staff from the Washington State University (WSU) Puyallup Research and Extension Center on October 19, 2006 in Los Gatos, CA. The tour will include a discussion on WSU research results as well as potential ways to manage *P. ramorum* on Christmas trees, and will also provide growers with an opportunity to examine trees with

different *P. ramorum* symptoms. Additional information on the field tour can be found below under the "Calendar of Events."

Two free day-long *P. ramorum* nursery training sessions are being offered in southern California in October. One session will be held on 10/30/06 in Riverside County and the second session will be held in Los Angeles County on 10/31/06. Additional information will be forthcoming in the October newsletter.

PERSONNEL

John Bienapfl left his position with the UC Davis Rizzo Lab as the *Phytophthora* diagnostician to pursue a PhD in plant pathology at the University of Minnesota. John can be reached in St. Paul via email at: biena003@umn.edu.

Kamyar Aram has been hired to replace John Bienapfl. **Kamyar received his MS in** Horticulture with a minor in Plant Pathology from Cornell University in 2002. His thesis study was focused on the use of compost for nitrogen fertility and suppression of soilborne fungal and oomycete diseases in vegetable production. In the last four years he has worked in viticulture and winemaking in New York, Chile, and California, but recently decided he wanted to be engaged again in the challenges of plant pathology. He loves the woods, and has an interest in plant and plant disease identification. Kamyar can be reached via email at: kamaram@ucdavis.edu or by phone at: (530) 754-9894.

CALENDAR OF EVENTS

10/9 – 12 – 6th California Oak Symposium, titled "California's oaks: Today's challenges, tomorrow's opportunities;" The conference features a field trip and two indoor sessions on Sudden Oak Death, and is intended for academics, planners, conservation practitioners, foresters, arborists, land owners, and oak enthusiasts. For more information, visit the Symposium website at: http://danr.ucop.edu/ihrmp/symposium.html.

10/19 – Christmas Tree Research Field Tour; Gary Chastagner and staff will provide growers an opportunity to examine trees with different SOD symptoms, discuss the results of their research and discuss potential ways to manage *P. ramorum* on Christmas trees; 1:00 p.m.; Black Road Christmas Tree Farm; 19749 Black Rd; Los Gatos, CA 95033; For more information, go to the CA Oak Mortality (COMTF) website at: www.suddenoakdeath.org or contact Janice Alexander at: jalexander@ucdavis.edu.

10/30 – Free all day Nursery Training Session; Riverside County Department of Agriculture; Begins at 9:00 a.m.; More information will be forthcoming on the COMTF website at: www.suddenoakdeath.org as well as in the October newsletter.

10/31 – Free all day Nursery Training Session; Los Angeles County Department of Agriculture; Begins at 10:00 a.m.; More information will be forthcoming on the

COMTF website at: www.suddenoakdeath.org as well as in the October newsletter.

11/1 - Call for Papers deadline for the Sudden Oak Death Science Symposium III in Santa Rosa, CA (March 2007); for more information, go to the Symposium website at: http://nature.berkeley.edu/comtf/sodsymposium/.

11/14 – 15 – 2006 Annual Meeting of the CA Forest Pest Council; Heidrick Agricultural History Center; 1962 Hays Lane; Woodland, CA; An update on SOD and efforts to control *Phytophthora lateralis*, *P. ramorum*, and a *P. cinnamomi* on a rare Manzanita will be presented; For more information, contact Mike Bohne, USDA-FS, at: mbohne@fs.fed.us.

3/5 -3/9/2007 - Sudden Oak Death Science Symposium III; Hyatt Vineyard Creek Hotel and Spa; 170 Railroad Street; Santa Rosa, CA 95401; Additional information will be forthcoming. For questions, contact Katie Palmieri, CA Oak Mortality Task Force Public Information Officer, at: palmieri@nature.berkeley.edu or (510) 847-5482.