CALIFORNIA OAK MORTALITY TASK FORCE REPORT
SEPTEMBER 2011

NURSERIES

***Molinadendron sinaloense* was found *P. ramorum* positive for the first time on** 6/30/11 during a routine light brown apple moth (LBAM) inspection at a research garden in Alameda County, CA. *Molinadendron sinaloense* is not currently on the federal host or associated host list for *P. ramorum*. The symptomatic plant was identified by the county biologist who recognized the leaf symptoms as similar to those seen on *P. ramorum*-infected California bay laurel leaves. The sample was confirmed positive by the USDA Animal and Plant Health Inspection Service (APHIS) on 8/1/11. The site previously shipped research material interstate under a compliance agreement; however, as a result of the positive find, the compliance agreement has been canceled.

MANAGEMENT

The UK Forestry Commission has revised the larch risk zone map for *P. ramorum* in Great Britain, dividing the county into three zones, based on recent positive findings. Zone 1 encompasses high climatic risk areas where infection has been found on larch, Zone 2 includes high-risk areas where no infection has been found, and Zone 3 is low-risk areas where no larch infection has been found to date. The newly defined zones are intended to more accurately reflect relative risk as well as guide the handling of licenses for felling larch and restocking of felled sites.

New applications for felling larch trees in Zone 1 will not be approved during winter months when needles are not present on the trees, making it more difficult to detect *P. ramorum* disease. The Commission also does not approve the use of larch species for restocking or new plantings in Zone 1, and will discourage the use of larch in Zone 2 as the pathogen can stay viable in soil for several years, causing a high risk of infection in subsequent larch crops. Forestry Commission Scotland is considering whether to apply similar conditions.

The zone boundaries are set on main trunk roads or easily identifiable physical features, such as rivers, to ease identification on the ground. They will continue to be reviewed in light of any new outbreaks. A map of the zone boundaries can be found at: www.forestry.gov.uk/pramorum.

Preventing the spread of *Phytophthora ramorum* via water was the focus of a 2 ½ day workshop in Puyallup, WA, June 28-30, 2011. Attended by over 50 regulators, researchers, and industry representatives from the western and southeastern US, as well as Washington, DC, the workshop's mission was to coalesce research, management, and regulations for effective, economical, and environmentally acceptable ways of limiting *P. ramorum* spread via contaminated nursery water runoff. The group began the meeting with a visit to the site of a previously positive Gig Harbor retail nursery (where *P. ramorum*-infested water had escaped the nursery and infected riparian salal plants) to review treatments and mitigations implemented. Meeting presentations addressed the

incidence and distribution of *P. ramorum* detections in waterways, water baiting techniques, risks and impacts for WA, and treatments to reduce the risk of spreading inoculum in water. Research and education/outreach needs were identified, with group exercises and discussion concentrated on nursery treatments as well as water management, monitoring, and notification of downstream users of contaminated water. More information on the workshop can be found at: http://www.puyallup.wsu.edu/ppo/sod/extension/workshops/Pr_water_jun_2011/index.html. The meeting was organized by Gary Chastagner, Washington State University, and Susan Frankel, USDA-Forest Service, Pacific Southwest Research Station, and sponsored by Washington State University and the California Oak Mortality Task Force.

RESEARCH

Chadfield, V. and Pautasso, M. 2011. *Phytophthora ramorum* in England and Wales: which environmental variables predict county disease incidence? Forest Pathology. DOI: 10.1111/j.1439-0329.2011.00735.x.

Abstract: *Phytophthora ramorum* is the oomycete pathogen responsible for Sudden Oak Death on the West Coast of the USA and Sudden Larch Death in the British Isles. It also causes twig dieback and leaf blight on a series of ornamental hosts (e.g. *Rhododendron*, *Viburnum*, *Pieris* and *Camellia*) commonly grown in plant nurseries, traded by garden centers and cultivated in public and private gardens. The role of the plant trade in the dispersal of *P. ramorum* has been well documented, but there is a need for regional analyses of which environmental variables can predict disease expression in the trade and in the wild, so as to be able to better predict the further development of this worldwide plant health issue. In this study, we analyze data on the incidence of *P. ramorum* (2002–2009, thus before the reports in Japanese larch plantations) in counties in England and Wales as a function of environmental variables such as temperature and rainfall, controlling for confounding factors such as county area, human population and spatial autocorrelation. While *P. ramorum* county incidence in nurseries and retail centers was positively related to county area and human population density, county incidence in gardens and the wild did not show such correlations, declined significantly towards the East and was positively correlated with disease incidence in the trade. The latter finding, although not conclusively proving causation, suggests a role of the trade in the dispersal of this pathogen across English and Welsh landscapes. Combined together, *P. ramorum* county incidence in the trade and in the semi-natural environment increased with increasing precipitation and with declining latitude. This study shows the importance of environmental variables in shaping regional plant epidemics, but also yields results that are suggestive of a role of people in spreading plant diseases across entire countries.

Haas, S.E.; Hooten, M.B.; Rizzo, D.M.; and Meentemeyer, R.K. 2011. Forest species diversity reduces disease risk in a generalist plant pathogen invasion. Ecology Letters. 9 pages. DOI: 10.1111/j.1461-0248.2011.01679.x.

Abstract: Empirical evidence suggests that biodiversity loss can increase disease transmission, yet our understanding of the 'diversity-disease hypothesis' for generalist

pathogens in natural ecosystems is limited. We used a landscape epidemiological approach to examine two scenarios regarding diversity effects on the emerging plant pathogen *Phytophthora ramorum* across a broad, heterogeneous ecoregion: (1) an amplification effect exists where disease risk is greater in areas with higher plant diversity due to the pathogen's wide host range, or (2) a dilution effect where risk is reduced with increasing diversity due to lower competency of alternative hosts. We found evidence for pathogen dilution, whereby disease risk was lower in sites with higher species diversity, after accounting for potentially confounding effects of host density and landscape heterogeneity. Our results suggest that although nearly all plants in the ecosystem are hosts, alternative hosts may dilute disease transmission by competent hosts, thereby buffering forest health from infectious disease.

Ireland, K.B.; Hüberli, D.; Dell, B.; Smith, I.W.; Rizzo, D.M.; and St. J. Hardy, G.E. 2011. Potential susceptibility of Australian native plant species to branch dieback and bole canker diseases caused by *Phytophthora ramorum*. Plant Pathology. DOI: 10.1111/j.1365-3059.2011.02513.x.

Abstract: Susceptibility to branch dieback caused by *Phytophthora ramorum* was tested using a detached branch assay for 66 Australian native plant species sourced from established gardens and arboreta in California. Six of these species were further tested for their susceptibility to bole cankers caused by *P. ramorum* using a sealed log assay. *Isopogon formosus* and *Eucalyptus denticulata* were identified as potentially highly susceptible Australian branch dieback hosts. Thirteen potentially tolerant Australian host species included *Banksia attenuata*, *B. marginata*, *E. haemastoma*, *E. regnans*, *Pittosporum undulatum* and *Billardiera heterophylla*. *Eucalyptus regnans* was identified as a potentially highly susceptible bole canker host, while *E. diversicolor* and *E. viminalis* were considered potentially tolerant species to bole cankers caused by *P. ramorum*. *Phytophthora ramorum* was able to infect all 66 species, as confirmed by reisolation. These results extend the known potential host range for *P. ramorum*, confirm it as a possible threat to Australian plant industries and ecosystems and highlight additional associated hosts that are important in the global horticultural trade, native forests and plantation forestry.

Meentemeyer, R.K.; Cunniffe, N.J.; Cook, A.R.; Filipe, J.A.N.; Hunter, R.D.; Rizzo, D.M.; and Gilligan, C.A. 2011. Epidemiological modeling of invasion in heterogeneous landscapes: spread of sudden oak death in California (1990–2030). Ecosphere, Volume 2(2), Article 17.

Abstract: The spread of emerging infectious diseases (EIDs) in natural environments poses substantial risks to biodiversity and ecosystem function. As EIDs and their impacts grow, landscape- to regional-scale models of disease dynamics are increasingly needed for quantitative prediction of epidemic outcomes and design of practicable strategies for control. Here we use spatio-temporal, stochastic epidemiological modeling in combination with realistic geographical modeling to predict the spread of the sudden oak death pathogen (*Phytophthora ramorum*) through heterogeneous host populations in

wildland forests, subject to fluctuating weather conditions. The model considers three stochastic processes: (1) the production of inoculum at a given site; (2) the chance that inoculum is dispersed within and among sites; and (3) the probability of infection following transmission to susceptible host vegetation. We parameterized the model using Markov chain Monte Carlo (MCMC) estimation from snapshots of local- and regional-scale data on disease spread, taking account of landscape heterogeneity and the principal scales of spread. Our application of the model to Californian landscapes over a 40-year period (1990–2030), since the approximate time of pathogen introduction, revealed key parameters driving the spatial spread of disease and the magnitude of stochastic variability in epidemic outcomes. Results show that most disease spread occurs via local dispersal (,250 m) but infrequent long-distance dispersal events can substantially accelerate epidemic spread in regions with high host availability and suitable weather conditions. In the absence of extensive control, we predict a ten-fold increase in disease spread between 2010 and 2030 with most infection concentrated along the north coast between San Francisco and Oregon. Long-range dispersal of inoculum to susceptible host communities in the Sierra Nevada foothills and coastal southern California leads to little secondary infection due to lower host availability and less suitable weather conditions. However, a shift to wetter and milder conditions in future years would double the amount of disease spread in California through 2030. This research illustrates how stochastic epidemiological models can be applied to realistic geographies and used to increase predictive understanding of disease dynamics in large, heterogeneous regions.

The following seven projects are underway at the National Ornamentals Research Site at Dominican University of California (NORS-DUC). Funding for 2011-2012 fiscal year projects will be provided by the Farm Bill, pending California Department of Pesticide Regulation approval.

Use of Trichoderma to Remediate *P. ramorum*-Infested Soil (permit pending); Timothy Widmer and Nina Shishkoff, USDA Agricultural Research Service, Ft. Detrick, MD

Summary: *P. ramorum* has been repeatedly detected in nurseries even after the removal of infected plants and sanitation of the growing area. Although methods, such as chemical fumigation, oxidation, and heat treatment, exist to sterilize soil they are often costly, impractical, and raise health and environmental concerns. It is the purpose of this study to repeat an ongoing study to examine methods to remediate *P. ramorum*-infested soil that are environmentally friendly, safe, and effective. The field site will be infested with a known amount of *P. ramorum* propagules and then partitioned off using fiberglass, circular microplots. A specific treatment will then be applied to the microplots in replication. These treatments will be: 1) a non-treated control; 2) a commercially-registered chemical treatment; 3) a commercially-available biological control agent; 4) a different commercially-available biological control agent; and 5) an experimental fungal isolate of Trichoderma that was demonstrated to reduce *P. ramorum* populations to non-detectable limits in the laboratory. Over the course of the experiment, soil samples will be taken within each microplot and the populations of *P. ramorum* and the biological

control agents will be monitored. It is the hope that the biological control agents will be effective in reducing or eliminating the populations of *P. ramorum*.

The Risk of Asymptomatic *P. ramorum* Infection on Fungicide-Treated *Rhododendron* (permit pending); Gary Chastagner and Marianne Elliott, Washington, State University, Puyullap

Summary: A number of systemic and contact fungicides have been shown to be effective in controlling *P. ramorum* development on several nursery crops. One of the concerns about using fungicides to manage this pathogen on nursery stock relates to the possibility that fungicides are masking symptom development, thus making it more difficult to detect infected plants during routine visual inspections and increasing the risk of spreading this pathogen on asymptomatic infected plants. Results from earlier artificial inoculation studies have indicated that Subdue MAXX and Insignia fungicides may pose a high risk of masking symptom development on rhododendron foliage. This research project will determine the risk that fungicide applications will mask symptom development on rhododendrons under commercial production practices and determine how long suppression of symptom development lasts following the cessation of fungicide treatments.

Potential Efficacy of a Copper Fungicide for Preventing Establishment and Dissemination of *P. ramorum* in Ornamental Plant Nurseries (permit pending); Steven Jeffers, Clemson University

Summary: *P. ramorum* has been brought to nurseries in the eastern US by the shipment of infected and infested ornamental plants. Consequently, this pathogen poses a real threat to forests in the eastern US because native plant species are susceptible and the environment is conducive. We repeatedly have found *P. ramorum* at ornamental plant nurseries throughout the southeastern states, and it has become established in some of these nurseries. Currently, management options for *P. ramorum* at a nursery are very limited once the pathogen has become established in field soil; therefore, an effective mitigation strategy for soil is needed. Our hypothesis is that a topical application of a copper-based fungicide to the soil surface may be an option. Most copper fungicides are only weakly soluble in water so they withstand weathering for long periods, and copper is relatively immobile in the soil profile. Recently, research in our laboratory has demonstrated that relatively low concentrations of copper ions are lethal to propagules of *Phytophthora* spp. Consequently, we propose to apply a topical, prophylactic application of a copper-based fungicide to the soil surface in a nursery bed to determine if propagules of *P. ramorum* washing or splashing out of infested containers that come into contact with copper residues on the soil surface are affected. Likewise, we will determine if a topical application of copper fungicide to the soil surface affects the ability of an established population in soil from splashing onto healthy plants and initiating new infections.

Effect of Fungicides and Biocontrol Agents on Sporulation and Persistence of *P. ramorum* on Nursery Hosts (permit pending); Steve Tjosvold, UC Cooperative Extension, Santa Cruz and Monterey Counties, Gary Chastagner, and Marianne Elliott

Summary: *P. ramorum* is the causal agent of Sudden Oak Death (SOD) and can infect many commonly grown nursery crops. Once *P. ramorum* is introduced into a nursery on a host, its local spread and establishment is primarily dependent on sporangia and zoospores production for its spread. Nursery operators commonly use fungicides to prevent the establishment of *Phytophthora* diseases, although current research only supports the use of fungicides for preventing infection. It is still unknown, however, what effect fungicide treatments have on sporulation, spread, and persistence of the pathogen on established infections. With this additional knowledge, fungicide treatments could more effectively be used to prevent the spread and establishment of the pathogen in nursery operations. This research will evaluate activity of foliar applied fungicides and biocontrol agents to inhibit sporulation and reduce pathogen persistence in ornamental hosts.

Solarization to Eliminate *P. ramorum* from Nursery Beds (permit pending); Jennifer L. Parke, Oregon State University

Summary: Elimination of *P. ramorum* from infested nursery soil continues to be one of the most formidable challenges in limiting the persistence and spread of this pathogen. Although soil fumigants are effective under controlled lab conditions, there are reasons they often cannot be used in nurseries: restrictions on application of fumigants near roads, homes, and schools, and ineffective fumigant penetration of nursery beds in container nurseries, which typically consist of compacted soils topped with a layer of gravel or rock. Previous research on the distribution of *P. ramorum* in the soil profile, and studies on the effects of elevated soil temperature on *P. ramorum* viability, indicate that soil solarization has potential for decontaminating infested nursery soils. Soil solarization is a widely used means of decontaminating soil in several agricultural production systems, and was effective in eliminating *P. ramorum* from field soil in a small preliminary study. However, solarization of nursery beds typical of container nurseries has not been tested. Recent improvements in plastic films which could optimize solarization of nursery beds have also not been tested. The objective of the proposed research is to determine the effectiveness of six different solarization treatments on the survival of *P. ramorum* in nursery beds typical of a container nursery. In two field trials conducted during summer 2011-2012, *P. ramorum* inoculum buried at three different depths in the soil profile will be recovered after 2,4, 6, and 8 weeks. Soil temperature at each depth will also be determined. Data analysis will include determination of temperature x time parameters most critical in influencing pathogen survival, which can be used to predict solarization effectiveness in different locations. Results of this study will inform APHIS about the feasibility of including soil solarization as a treatment option in the Confirmed Nursery Protocol.

Episodic Abiotic Stress and Ramorum Blight in Nursery Ornamentals: Impacts on Symptom Expression and Chemical Management of *P. ramorum* in *Rhododendron* (permit pending); Richard M. Bostock, UC Davis

Summary: For all plant diseases caused by *Phytophthora* spp. water status of the host and the environment critically influences disease occurrence and severity. Water potential influences pathogen behavior and the formation and activity of infective propagules. Importantly, water stress and other abiotic stresses, including transient episodes of soil salinity, root hypoxia associated with waterlogged soils, and low temperatures affect host physiology to increase vulnerability of roots and shoots to disease. Previous work has shown that zoospores of *P. ramorum* readily infect roots of Rhododendron sp. and *Viburnum tinus* and that a brief episode of salt stress predisposes roots to infection to significantly increase disease severity. There is evidence that root infections may play a role in the disease cycle of ramorum blight in some hosts, and it is likely that such infections can remain cryptic. Thus, a better understanding of specific edaphic and abiotic factors that contribute to disease development from soilborne infections will inform and guide management decisions. These factors could have a large effect on inoculum thresholds necessary for disease, the extent and significance of root infections in various hosts, the consistency and reliability of pathogenicity tests for the assessment of host resistance, and the efficacy of chemical treatments to manage disease. The proposed research will examine abiotic factors – nitrogen fertility, waterlogging, water deficit, and chilling – that are encountered in nurseries as potential triggers for disease development arising from low inoculum levels or cryptic root infections. We will assess the importance of these stresses as they may contribute to rapid development of ramorum blight in seemingly healthy nursery plants, such as might occur following shipment and planting. The proposed studies will focus on Rhododendron sp., a good model and important host for ramorum blight in ornamentals. We will also examine the impact of mild episodic stress on the efficacy of selected chemicals for managing ramorum blight, including plant activators that induce host resistance. The proposed research will suggest measures to complement or refine disease management practices.

Risk of Root-to-Root Spread of *P. ramorum* in Ornamental Production Nurseries (permit pending); Gary Chastagner, Marianne Elliott, Steve Tjosvold, and Nina Shishkoff

Summary: Laboratory studies have shown that *P. ramorum* is able to colonize and infect root systems of a number of plants. Studies have also shown that this pathogen is able to sporulate on infected root tissues of *Viburnum, Camellia* and *Rhododendron*. The epidemiological significance of root infections in production nurseries is unknown. We are proposing to examine the root-to-root spread of *P. ramorum* on *Viburnum tinus* in ground or raised beds at the NORSDUC research site. This research will provide a better understanding of the risk associated with this pathway of spread.

FUNDING

The USDA APHIS, Center for Plant Health Science and Technology fiscal year 2012/2013 NORS-DUC request for proposals opens Friday, September 9, 2011. Short-

term applied research projects are being sought that support of the broad goal of safeguarding nursery production and the forest industry. Research priorities include, but are not limited to: methods development to inhibit *P. ramorum* spread, mitigations to manage *P. ramorum*, epidemiological studies on inoculum sources, pathways, soil sampling focal points, and disease distribution in nurseries. Each proposal must comply with the California Environmental Quality Act and the National Environmental Policy Act for bio-safety. Applicants must also obtain a Plant Pest Permit from the California Department of Food and Agriculture and a permit from the California Department of Pesticide Regulation. The deadline for submission is Friday, December 9, 2011. For more information on the application process, go to http://www.dominican.edu/academics/hns/sciencemath/community-partnerships-and-initiatives/norsduc/proposals.html or email Sibdas Ghosh at sibdas.ghosh@dominican.edu.

RELATED RESEARCH

Fichtner, E.J.; Rizzo, D. M.; Kirk, S.A.; and Webber, J.F. 2011. Infectivity and sporulation potential of *Phytophthora kernoviae* to select North American native plants. Plant Pathology. DOI: 10.1111/j.1365-3059.2011.02506.x.

KUDOS

Gary Chastagner, professor of plant pathology at the Washington State University Puyallup Research and Extension Center, received an award of Excellence in Extension from the American Phytopathological Society (APS) in August at the 2011 annual meeting in Honolulu, HI. Gary was recognized for his "success in addressing stakeholders' needs through translational research" with diseases of ornamental bulbs and Christmas trees.

JOB ANNOUNCEMENT

A plant pathologist research position is available at NORS-DUC. Responsibilities include working collaboratively with NORS-DUC scientists, training undergraduates using NORS-DUC research as a teaching tool, developing and carrying out new projects based on NORS-DUC *P. ramorum* research priorities, and assisting with NORS-DUC-related grant writing. Review of applications will begin immediately and continue until the position filled. For more information, contact Sibdas Ghosh at sibdas.ghosh@dominican.edu or (415) 482-3583.

EDUCATION AND OUTREACH

"Super Rangers and the Legion of Bugs" is a new Don't Move Firewood animated educational outreach video now available online at http://www.dontmovefirewood.org/super-rangers.html. Nearly five minutes in length, the cartoon features Asian Longhorned Beetle, Sirex Woodwasp, Emerald Ash Borer, Goldspotted Oak Borer, Ambrosia Beetle, and Sudden Oak Death as these pests and pathogens can be transported long distances on infested firewood.

CALENDAR OF EVENTS

9/15 – 9/17 - California Urban and Community Forests Conference; Crown Plaza Hotel in Palo Alto; For more information, go to http://www.caufc.org/Annual%20Conference.

10/5 - SOD Treatment Workshop; meet at oak outside of Tolman Hall, UC Berkeley Campus; 1 – 3 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 date for which you are registering. For more information, go to http://nature.berkeley.edu/garbelotto/english/sodtreatmenttraining.php.

10/5 – 10/6 – The Seventh Meeting of the Continental Dialogue on Non-Native Forest Insects and Diseases; Boulder, Colorado; To register, go to: https://www.energymeetings.com/calendar/register.asp?CalendarID=11333. For more information, contact Debbie Lee at dlee@resolv.org or (202) 965-6381 or Beth Weaver at bweaver@resolv.org or (202) 965-6211. For more information about the Dialogue go to www.continentalforestdialogue.org.

10/10 – 10/14 - The 59th Western International Forest Disease Work Conference; Enzian Hotel, Leavenworth, WA. This meeting is intended for forest pathologists from western North America (and beyond); For more information, go to www.fs.fed.us/foresthealth/technology/wif/index.htm. For questions, contact Greg Filip at gmfilip@fs.fed.us or (503) 808-2997.

10/26 - SOD Treatment Workshop; meet at oak outside of Tolman Hall, UC Berkeley Campus; 1 – 3 p.m.; Pre-registration is re quired. For more information, see the 10/5 listing above.

11/8 – 11/11 - 2011 IUFRO Forest Protection Joint Meeting, Research Groups 7.02 – 7.03; Colonia del Sacramento, Uruguay; More information will be forthcoming. For questions, contact Alina Greslebin at agreslebin@ciefap.org.ar.

11/9 - SOD Treatment Workshop; meet at oak outside of Tolman Hall, UC Berkeley Campus; 1 – 3 p.m.; Pre-registration is required. For more information, see the 10/5 listing above.

6/18 – 6/22/12 – Sudden Oak Death Fifth Science Symposium; More information will be forthcoming.

9/9 – 9/14/12 – Sixth Meeting of the International Union of Forest Research Organizations IUFRO Working Party 7-02-09 "*Phytophthora* in Forests and Natural Ecosystems;" Colegio Mayor Universitario Nuestra Señora de la Asunción, Avd. Menéndez Pidal s/n, 14004 Córdoba, Spain; For more information, contact Mª Pérez Sierra at aperesi@eaf.upv.es.