

# Phytophthora ramorum in the USA: A Time Line of Knowledge and Events

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## Abstract

*Phytophthora ramorum*, a recently discovered plant pathogen, has caused widespread mortality in certain native tree species in 14 counties in coastal California and in southern Oregon. It also causes a less-severe foliar blight of native understory species, and of numerous ornamental hosts such as Camellias. Much has been learned about the diagnosis, management, and biology of this pathogen since its first detection in the late 1990s.

## 1994-1995

• **Tanoaks and Coast Live Oaks** observed dying in coastal California (Marin County & Santa Cruz County) by many including Pavel Svirha (UCCE) and Tomas Pastalka (CDFA Pest Exclusion), who submit samples to various scientists and laboratories but no pathogens are isolated from the wood and bark samples.

## 2000

• **August:** California Oak Mortality Task Force (COMTF) is established to "bring together public agencies, other nonprofit organizations, and private interests to address the issue of elevated levels of oak mortality. The Task Force will implement a comprehensive and unified approach for research, management, education and public policy." [WWW.suddenoakdeath.org](http://WWW.suddenoakdeath.org) COMTF hosts several meetings and field training sessions.

• **November:** Clive Brasier, of the UK Forestry Commission, notes that an unknown species of *Phytophthora* isolated from Rhododendrons in Germany and the Netherlands appears to be identical to the species causing oak and tanoak mortality in California. Through sequencing, they are eventually determined to be the same species on both continents.

## 2001

• **January:** The new *Phytophthora* pathogen of oaks and tanoaks in California is isolated from containerized Rhododendrons growing at a Santa Cruz County Nursery; The Rhododendron nursery is in close proximity to dying oaks.

• **May:** UC Berkeley researcher Matteo Garbelotto develops a PCR test to detect the presence of the new *Phytophthora*'s DNA.

• **May:** CDFA issues emergency regulations that requires permits to move plants known to be hosts of the new *Phytophthora* from the 8 known infested counties. There are 10 infested counties reported by October.

• **July:** Surveys for the new *Phytophthora* are conducted in high risk sites of Oregon beginning 2001 after infested trees are detected in Curry County. **Official survey of Oregon agricultural commodities for *Phytophthora ramorum*.** 2003. N.K. Osterbauer, L. Rehms, and J. Hedberg, Oregon Dept. of Agriculture, Salem, OR 97301. *Phytopathology* 93:568. Publication no. P-2003-0493-AMA.

## 2001

• The oak and tanoak pathogen in CA is officially identified as *Phytophthora ramorum*. ***Phytophthora ramorum* as the cause of extensive mortality of *Quercus* spp. And *Lithocarpus densiflorus* in California.** Rizzo, D.M., Garbelotto, M., Davidson, J.M., Slaughter, G.W., and Koike, S.T. 2002. *Plant Dis.* 86:205-214.

• **August:** South Korea implements a *P. ramorum* quarantine against importation of known host species from California and Oregon.

• Significant developments in knowledge of *P. ramorum* biology. **Transmission of *Phytophthora* associated with Sudden Oak Death in California. 2001.** J. M. Davidson, D. M. Rizzo, and M. Garbelotto. 2001. *Phytopathology* 91:S108. Publication no. P-2001-0049-MSA.

• A distinct aerial phase to the disease in oaks and tanoaks is recognized.

• The pathogen produces chlamydozoospores and sporangia in culture.

• Oaks and tan oaks infested via trunk cankers.

• Rhododendrons and *Vaccinium ovatum* are infested via branches.

• Spores of the *Phytophthora* are trapped in rainwater captured from trees demonstrating spread via rain.

• *Phytophthora* is baited from soil and from litter under infested trees.

## 2002

• Several ornamental landscape shrubs common in the nursery trade are discovered to be highly susceptible to *P. ramorum*, which displays a higher degree of virulence than other common foliar *Phytophthora* pathogens. Scientists begin to realize the implications and risks of nursery stock infection by *P. ramorum*. **Relative virulence of *Phytophthora* species, including the sudden oak death pathogen *P. ramorum*, on leaves of several ornamentals. 2002.** R. G. Linderman, J. L. Parke, and E. M. Hansen. 2002. Sudden Oak Death Science Symposium.

• **December:** European isolates of *P. ramorum* are determined to be a different mating type than American isolates, suggesting that the pathogen in CA and OR may not have been introduced from Europe or vice-versa.

• Disease Surveys begin in California and Oregon. Eradication efforts begin in Oregon. **Sudden oak death caused by *Phytophthora ramorum* in Oregon.** Goheen, E. M., Hansen, E. M., Kanaskie, A., McWilliams, M. G., Osterbauer, N., and Sutton, W. 2002. *Plant Dis.* 86:441.

• **July:** Additional *Phytophthora* species are occasionally isolated along with *P. ramorum* from hosts in California and Oregon with the same symptoms as those caused by *P. ramorum*. They are referred to as "Pils-like" at this point, but are later identified as *P. pseudosyringae*, and *P. nemorosa* which morphologically are clearly recognized as different *Phytophthora* species.

## 2003

• USDA "confirmed Nursery Protocol" is released.

• **January:** Christmas tree farms enter the SOD picture. C. Blomquist (CDFA) isolates *P. ramorum* from Grand fir (*Abies grandis*) from a Christmas tree farm in Santa Clara County, California.

• *P. ramorum* is detected in 3 Florida Nurseries.

• **May:** *P. ramorum* is detected on Camellias in Stanislaus County, which is in the hot, dry, California Central Valley, 100+ miles inland from the known zone of infestation. Within a month, *P. ramorum* is detected on Camellias at a nursery in Jackson County, Oregon, and are traced back to the California nursery from Stanislaus County.

• **June:** *P. ramorum* first detected in Washington state at a commercial nursery.

• **August:** The A1 mating type, heretofore only known in Europe, is detected in Washington State. Further investigations reveal that related nurseries in Oregon and Washington have both the American (A2) and European (A1) mating type. **First report of A1 mating type of *Phytophthora ramorum* in North America.** Hansen, E. M., Reeser, P. W., Sutton, W., and Winton, L. M. 2003. *Plant Dis.* 87:1267.

• **October:** USDA *P. ramorum* nested PCR diagnostic protocol is implemented.

• USDA Nursery Protocol implemented: delimitation surveys begun in California nurseries; destruction and disposal of infected plants; 90 day monitoring of positive nurseries and trace-forward investigations are underway.

## 2004

• **June:** Camellia becomes a federally regulated host of *P. ramorum*.

• A National Survey of Nurseries (and some forested sites) is conducted. The pathogen is detected in large wholesale nurseries in CA and OR which had shipped numerous Camellia and Rhododendron plants to several states and Canada. 21 states in all received infected nursery stock. NPDN Laboratories begin testing nursery stock from the Western USA for *P. ramorum* including those on stand-by alert for overflow samples from other states. By the end of the year, there are 177 confirmed positive *P. ramorum* sites in 22 states from trace forward, national, and other surveys.

• Numerous states adopt quarantines against host material from the West Coast states.

• Soil borne inoculum of *P. ramorum* recognized as a potential means of disease spread, requiring reconsideration of appropriate disease management strategies. Research also indicates that *P. ramorum* may persist in nursery container media for at least 66 days. **Persistence of *Phytophthora ramorum* in nursery plants and soil.** 2004. N. Shiskoff and P. Tooley. *Phytopathology* 94:S95. Publication no. P-2004-0649-AMA.

## 2005

• **January:** A new federal order regulates interstate movement of nursery stock from infested areas of CA, OR, and WA. All nurseries must be inspected and found free of *P. ramorum* before they can ship nursery stock.

• **September:** CPHST validates a Real-time PCR diagnostic test for *P. ramorum*.

• A *Phytophthora* species is detected that yields a PCR product identical to that of *P. ramorum* using the USDA nested PCR protocol, and which causes disease symptoms that mimic those of *P. ramorum* blight.

• ***Phytophthora hibernalis* a new pathogen of Rhododendron and evidence of Cross amplification with two PCR detection assays for *Phytophthora ramorum*.** Blomquist, C., Irving, T., Osterbauer, N., Reeser, P. July 28, 2005. Online. *Plant Health Progress* doi: 10.1094/PHP-2005-0728-01-HN.

## 2006

• Three distinct genotypes are now recognized, and all three are known in USA nurseries, including the European type, the West Coast type, and a progenitor type. **Microsatellite markers identify three lineages of *Phytophthora ramorum* in US nurseries, yet single lineages in US forest and European nursery populations.** Ivors, K., Garbelotto, M., Vries, D.E., Ruyter-Spira, C., Helkett, B., Rosenzweig, N., and P. Bonants. 2006. *Molecular Ecology* 15:1493-1505.

• **May:** New Zealand implements quarantine against the USA for *P. ramorum*.

• Taiwan, Penghu, Kinmen, and Matsu quarantine virtually every country or state from North America and Europe where *P. ramorum* has been detected.

• **July:** Description of new Azalea blight pathogen is published. This pathogen yielded PCR bands indistinguishable from those of *P. ramorum* using the USDA nested PCR procedure, but cultures were clearly different from *P. ramorum*. ***Phytophthora fallorum* sp. nov., A new species causing leaf blight of Azalea.** Donahoe, R., Blomquist, C.L., Thomas, S.L., Moulton, J.K., Cooke, D.E.L., and Lamour, K.H. 2006. *Mycological Research* 110:1309-1322.

• **September:** To date, 105 host species are now regulated for *P. ramorum*.

• A real-time assay is published which eventually becomes the USDA-approved protocol for *P. ramorum* diagnostics. **Development of a one-step real-time polymerase chain reaction assay for diagnosis of *Phytophthora ramorum*.**

Hughes, K., J.A. Tomlinson, R.L. Griffin, N. Boonham, A.J. Inman, and D.R. Lane. 2006. *Phytopathology* 96:975-981.

• USFS and several states conduct nursery perimeter and general forest detection surveys. To date, 567 nursery perimeter surveys and 320 forest surveys have been conducted in 29 states, with no detections of *P. ramorum*.