

# Regulatory Considerations in Assessing the Potential for *Phytophthora ramorum* to Cause Environmental Impact to Ecozones Outside the West Coast “Fog Belt” in North America<sup>1</sup>

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## Abstract

Sudden oak death (SOD) is a disease caused by *Phytophthora ramorum* that is characterized by lethal trunk lesions that affect tanoak (*Lithocarpus densiflorus*), and a few oak species, principally coast live oak (*Quercus agrifolia*). It was first observed in Marin County, California, in 1994, and now has been reported to have caused extensive tree mortality in the West Coast “fog belt” area that generally extends less than 30 km inland, from Monterey County, California, in the south, to Curry County, Oregon, in the north. While the plant communities vary somewhat, it is notable that the zone closely mirrors the distribution of the coast redwood (*Sequoia sempervirens*). Tanoak and California bay laurel (*Umbellularia californica*) are present throughout the zone. In California, infected bay laurel produce abundant *P. ramorum* sporangia which facilitate the spread of the pathogen, but in Oregon pathogen spread is primarily attributed to inoculum produced on tanoak foliage. Climate-host models generated to assist in early detection, survey, mitigation, and formulation of regulatory policy, have generally indicated that the west coast and the eastern conterminous United States (U.S.), especially the Appalachian Mountains, are at similar risk for infection. This risk area also extends up into coastal British Columbia, Canada. Indeed, regulatory surveillance and certification programs to detect *P. ramorum* on nursery plants moving in inter-state trade, both in the U.S. and Canada, have resulted in detections in many of these areas since 2002, suggesting the ability of the pathogen to survive and move within the nursery environment. However, no *P. ramorum* forest or wildland areas has been reported outside the current ecozone in California and Oregon, despite large shipments of host plants from known infested areas. Possible reasons for this, with consideration of when and how *P. ramorum* may have been introduced to North America, what is achievable through nursery certification, and the epidemiological uniqueness of the *P. ramorum* ecozone in the West Coast “fog belt”, are discussed from a regulatory perspective.

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## When and How *P. ramorum* was Introduced to North America

Microsatellite analyses of *Phytophthora ramorum* populations in California (Mascheretti and others 2008) have suggested that the most likely pathway for introduction of the pathogen into the state was through the importation of infected nursery plants. When this might have occurred is quite speculative, but working back from the time it might take for the pathogen to enter a nursery, establish, escape into the wild and be noticed, it has been estimated that it has been in the California nursery pathway since at least the mid-1980s (M. Garbelotto, Extension Specialist and Adjunct Professor, University of California, Berkeley, personal communication). This scenario would suggest that *P. ramorum* has now been present in California nurseries for over 25 years.

## Regulatory Control Through Nursery Certification

Regulatory surveillance to prevent the interstate movement of *P. ramorum* in the nursery pathway began in 2002 with controls put on the infested counties in California and Oregon (USGAO 2006). In 2004, this regulated area was expanded to include all of California. By 2005, a Federal Order was issued that required that all nurseries in California, Oregon, and Washington that shipped host plant nursery stock interstate, be inspected and certified free of evidence of *P. ramorum* (USGPO 2007). It has been argued that this regulatory nursery certification program appeared to have been effective at minimizing the interstate dissemination of the pathogen (Suslow 2008). Inspection and survey data from 2004 to 2006 indicated that the number of infested nurseries dropped by more than 50 percent, from 110 nurseries to 50 (representing one to two percent of the nurseries inspected), respectively. However, despite this progress, positive nurseries have continued to be detected every year since.

Nursery certification faces a number of challenges. *P. ramorum* detection is predicated on observing, sampling, and testing symptomatic tissue. Plant infections with asymptomatic sporulation, as reported by Denman and others (2008), can occur and therefore be missed. *P. ramorum* also has the potential to be moved from a nursery in the potting media of asymptomatic non-hosts (Dart and Chastagner 2007).

Testing for certification is typically done in a two step process: first by conducting an enzyme-linked immuno-sorbent assay (ELISA) for the *Phytophthora* genus and then confirming the presence of *P. ramorum* by either polymerase chain reaction (PCR) or by culturing the organism (Bulluck and others 2006). The overall sensitivity of this process is limited by ELISA as it is less sensitive than the confirming tests, particularly as selection of the ELISA threshold is influenced by the need to minimize the number of false positives. Thus, a certain proportion of false negatives are inevitable. In addition, the resource constraints, imposed by the costs of sampling and testing, generally mean that no more than 40 samples per nursery are taken, which relative to the potential thousands of plants and millions of leaves in a typical nursery, is a small number.

The effects of all these challenges mean that *P. ramorum* has almost certainly been moving undetected in the North American nursery pathway for many years. The

potential for widespread dissemination through this pathway is illustrated by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA APHIS) investigation of a California nursery outside the quarantine counties in 2004. In this instance, it was determined that the nursery had shipped potentially infected camellias to over 1,200 establishments in 39 states. *P. ramorum* was subsequently detected at 175 of these sites in 22 states (USGPO 2007).

## Epidemiological Uniqueness of the SOD Ecozone in Relation to Regulatory Policy

In considering why *P. ramorum* has not been reported to have caused tree mortality in North America, outside its current coastal redwood forest ecozone in the West Coast (Rizzo and others 2005), one possibility is that it has not had the opportunity to jump from infected nursery plants to vulnerable wildlands, as it apparently did in California. However, prior to 2005, when regulatory restrictions on its interstate movement started, there were likely 20 years when there was extensive and unimpeded movement of host nursery stock from the West Coast to eastern areas, including those considered at highest risk (Koch and Smith 2008, Magarey and others 2008), thus suggesting opportunities, comparable to those that apparently occurred in California, for *P. ramorum* to be introduced to these areas. Indeed, since the start of national surveillance in the U.S. in 2004, documented detections have repeatedly occurred in various states in addition to California, Oregon, and Washington ([http://www.aphis.usda.gov/plant\\_health/plant\\_pest\\_info/pram/downloads/updates/2008-annual-update.pdf](http://www.aphis.usda.gov/plant_health/plant_pest_info/pram/downloads/updates/2008-annual-update.pdf)).

In California, evidence of SOD was present in the early 1990's and by the mid 2000's much of the current range had been filled in. The apparent rapidity with which this spread occurred, combined with the empirical evidence for movement through the North American nursery pathway, would suggest that the conditions in the high-risk areas in the east are probably less conducive to tree mortality than those on the West Coast.

The coastal redwood forest is a unique ecozone that is not duplicated elsewhere in North America. The epidemiology there of *P. ramorum* suggests a critical need for extensive sporangia production, principally on California bay laurel, in close proximity (<10 m) to tanoak and oak trees, in order for formation of bole cankers to occur in a conducive environment (Swiecki and Bernhardt 2007). Thus, the apparent requirement for these particular conditions may place very real constraints on the potential for *P. ramorum* to cause bleeding cankers on bole hosts elsewhere. It is noteworthy though that bole cankers from *P. ramorum* can occur in other ecozones as approximately 40 trees with this disease have been reported from the United Kingdom and the Netherlands (Webber 2008). However, in contrast to the situation in California, these infections have been very limited and have been principally associated with diseased rhododendrons growing in close physical proximity to the infected trees. The differences in both scope and impact between the North American and European situations illustrates how differences in host plant communities and environmental conditions can profoundly affect the impact of this pathogen.

As noted by Hansen (2008), one of the breakthroughs in *P. ramorum* research has been the realization that the pathogen causes very different diseases on its many

different hosts (Davidson and others 2003). These diseases range from minor foliar lesions to stem cankers and tree death. Despite that, the sudden oak death moniker is commonly applied indiscriminately to all infections of *P. ramorum*. For regulators, though, these disease differences are important as the International Plant Protection Convention (IPPC) obliges the phytosanitary measures of contracting parties be “limited to what is necessary to protect plant health” and that these measures should “represent the least restrictive available” (FAO 2006a). Thus, if there is potential in an area for a quarantine pest to cause tree mortality, strong regulatory measures, commensurate with the potential impact, can be justified to protect that area. Conversely, if there is negligible risk of observable impact, strong measures may not be justified.

The regulatory history of *P. ramorum* has been cited in arguing for a more precautionary approach to trade in plants-for-planting (Brazier 2008). Indeed, where appropriate, a case can be made for using precautionary measures, such as post-entry quarantine, when new plant species are imported from new origins, to reduce the risk of introduction of new and damaging pathogens. However, whether current policies to prevent economic and environmental impact from the introduction and/or movement of *P. ramorum* in North America and Europe continue to be needed, or are effective, is another question. It can be argued that in contrast to the situation that regulators faced in 2001, when this alarming new pathogen was reported, the subsequent accumulation of scientific and empirical evidence today has now greatly reduced uncertainty in the epidemiology of *P. ramorum*, which should now allow for a less precautionary approach in assessing risk and in setting regulatory policy.

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