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RAMORUM BLIGHT (SUDDEN OAK DEATH) (*PHYTOPHTHORA RAMORUM*)

BACKGROUND

"Ramorum Blight" is the common and inclusive term for a complex of diseases – the best known of which is "Sudden Oak Death" – caused by the oomycete pathogen *Phytophthora ramorum*. "Sudden Oak Death" (SOD) refers to the extensive and rapid mortality, caused by girdling bleeding cankers, of tanoaks (*Lithocarpus densiflorus*) and three species of true oak (coast live oak, *Quercus agrifolia*; California black oak, *Q. kelloggii*; Shreve oak, *Q. parvula* var. *shrevei*), which was initially observed in coastal forests of California and southwestern Oregon. Thousands of acres of California and Oregon forest have been devastated by this disease since it was first observed in Marin County, CA in 1995. It was not until five years later, in 2000, that researchers identified the cause of SOD to be an unknown species of *Phytophthora*. Shortly thereafter, a plant pathologist recognized that the SOD pathogen was identical to an as-yet unnamed *Phytophthora* species first noticed in 1993 causing foliar and tip blights on ornamental rhododendrons and viburnums in Germany and the Netherlands. In 2001 the pathogen was formally named *Phytophthora ramorum*. Since that time, the host list for this federally regulated pathogen has expanded to nearly 140 species of trees, shrubs, and annuals. Hosts span a broad range of genera and plant families, including many that are important in both landscapes and forests of Connecticut and the Northeast (Table 1). The United States Department of Agriculture, Animal and Plant Health Inspection Services, Plant Protection and Quarantine (USDA-APHIS-PPQ) maintains and periodically updates a host list that can be viewed at http://www.aphis.usda.gov/plant_health/plant_pest_info/pram/downloads/pdf_files/usdaprlist.pdf.

The geographic origin of *P. ramorum* is still unknown, but the consensus among scientists is that the introductions into North America and Europe were recent but independent events.

Movement of *P. ramorum* on nursery stock was not observed in CA until 2001. By the spring of 2004, infected plants turned up in nurseries throughout the United States, precipitating an "emergency order" issued by USDA-APHIS-PPQ to restrict the interstate movement of potential host plants from commercial nurseries in California. That same year, the USDA instituted nursery and forest surveys, in which

Connecticut has participated annually to date. As a result of these surveys, nursery plants in Connecticut that had been shipped from west coast nurseries have been confirmed to be positive for *P. ramorum* in 2004 and 2006. In 2011, a positive rhododendron from an Oregon mail-order company was traced to a residential landscape in Connecticut, marking the first time for the state, and for the northeast, that this pathogen was detected outside of a nursery (Figure 1). It is important to note that positive finds are always followed by thorough and rigorous eradication procedures as mandated by USDA-APHIS-PPQ.

Figure 1. A mail-ordered *Rhododendron pronum* plant, infected with *Phytophthora ramorum*. This plant was identified as the result of a USDA-APHIS "trace forward" protocol in 2011. Photograph: S. M. Douglas.

Throughout this time, in several southern states *P. ramorum* has been isolated from streams and drainage ditches immediately adjacent to positive nurseries. However, the pathogen has not been found in forests or landscapes beyond these areas; some scientists speculate that extreme summer heat in these regions does not favor spread of *P. ramorum*, a cool weather pathogen.

Also of note, is the rapidity with which *P. ramorum* has spread throughout plantations of Japanese larch (*Larix kaempferi*) in the United Kingdom. Japanese larch was first identified as a host in 2009 when it was found infecting a few dying trees in southwest England. Within three years, *P. ramorum* has devastated nearly 250,000 square miles of larch plantations in all four countries of the UK.

SYMPTOMS

The disease symptoms associated with *P. ramorum* are diverse and primarily determined by the host species. They can range from oozing, killing cankers on trunks and branches to foliar symptoms. Two distinct sets of symptoms have been called Sudden Oak Death and Ramorum Blight (Ramorum Dieback, Ramorum Leaf Blight). The symptoms characteristic of "Sudden Oak Death" result from lethal stem cankers in the bark, cambium, and outer xylem that expand and girdle the stem and kill the tree. These cankers often ooze and bleed. Tanoaks and certain oaks in the red oak subgenus exhibit these symptoms.

Disease symptoms characteristic of "Ramorum Blight" are foliar blighting and shoot dieback. These are the typical symptoms exhibited by many non-oak host species. These symptoms are less severe than cankers and include leaf spots and blotches. In extreme cases, juvenile and mature plants with Ramorum Blight symptoms can be killed. Among the hosts that exhibit these types of symptoms are rhododendron, viburnum, and mountain laurel.

Unfortunately, disease symptoms characteristic of *P. ramorum* infections are often indistinguishable from other diseases

or insect injuries that we encounter in Connecticut woodlands and landscapes. If in doubt about what is causing a particular symptom on a plant, The Connecticut Agricultural Experiment Station (CAES) can provide assistance and expert advice.

SPREAD

P. ramorum is unique among other species in the *Phytophthora* genus in that it can infect hosts both through aerial dispersal as well as through soil and water. Extensive studies in California, Oregon, and the U.K. have shown that *P. ramorum* can spread through movement of infected plant material, irrigation water, and soil. The pathogen is only known to reproduce asexually, but it does so with two very different types of asexual spores (Figure 2).

Figure 2. Microscopic view of two types of asexual spores produced by *Phytophthora ramorum*. Photograph: S. M. Douglas.

Sporangia are produced on infected foliage and stems, and are borne aerially, dispersing by means of wind or water. Sporangia can infect directly, or can give rise in water to motile zoospores, which because they are *chemotactic* can recognize and swim to suitable host material (a rhododendron leaf, for example). Chlamydospores form within leaf tissue, and are involved in long-term survival under harsh conditions, such as drought, heat, and cold. None of these spore types has been found on bark cankers.

DETECTION AND DIAGNOSIS

The likeliest means by which this pathogen can be introduced to the eastern United States is by movement of infected plant material. USDA-APHIS-PPQ oversees surveys whose purpose is to limit the potential for accidental spread of this potentially devastating pathogen. Nurseries located in states where *P. ramorum* infections have been documented are inspected prior to shipment, and nurseries in participating states are inspected after shipments from these states are received.

Because symptoms are not diagnostic, presence of the pathogen is determined most efficiently using DNA-based diagnostic assays in the laboratory. These assays are expensive, requiring that both laboratory and personnel be certified by APHIS-PPQ to perform the diagnostics. Currently, only twelve states maintain laboratories and personnel certified for *P. ramorum* diagnostics; the Molecular Plant Diagnostics Laboratory, in the Department of Plant Pathology and Ecology at the Connecticut Agricultural Experiment Station in New Haven, is one of these.

RISK TO CONNECTICUT

Researchers modeling the risk that *P. ramorum* poses to regions of the country not yet affected by the pathogen combine knowledge of the biology of the pathogen with geographic and climatic data. Several such models have been developed; Figure 3 shows the most recently available consensus risk map based on agreement among these models. An important conclusion to be drawn from this map is that Connecticut is at considerable risk for supporting establishment and spread of *P. ramorum* in both landscape and forest. This is due to

numerous susceptible hosts, as well as a climate—wet cool periods in both spring and fall—that supports growth of the pathogen.

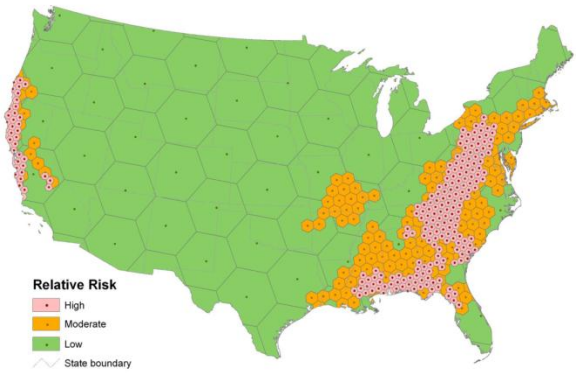

Figure 3. A 2009 risk map generated by the USDA Forest Service, based on host, pathogen, climate, and geographic data.

MANAGEMENT

The best defense against Ramorum blight (SOD) is prevention, since there is no known cure for this disease, once a tree or shrub is infected. And the best way to prevent accidental introduction is to be an informed consumer, knowing the origin of any host material you buy. Research in California has shown that products containing phosphorous acid (phosphite) can be effective in managing the SOD-form of this disease in some cases. These can be applied as bark-drenches or through injection. Either way, they can only be applied by licensed arborists. However, there are no data on the efficacy of this method with susceptible eastern tree species, such as red oak and chestnut oak.

If you are concerned about plants on your property with symptoms suggestive of Ramorum Blight, you can contact the Experiment Station's *Plant Disease Information Office* for assistance: http://www.ct.gov/caes/pdio; 203.974.8601.
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Table 1. A partial list of plant species known to serve as hosts for *Phytophthora ramorum*. Those not listed as "regulated" by APHIS but have been determined to be susceptible (either experimentally in controlled-atmosphere greenhouses) or through natural infection in landscapes outside the eastern United States.

Scientific Name	**Common Name**
Acer pseudoplatanus ‡	Planetree maple
Aesculus hippocastanum ‡	Horsechestnut
Arctostaphylos uva-ursi *‡	Bearberry
Betula alleghaniensis *	Yellow birch
Castanea sativa ‡	Sweet (European) chestnut
Cornus florida *	Dogwood
Fagus sylvatica ‡	European beech
Fraxinus americana *	White ash
Gaultheria procumbens *	Wintergreen
Hamamelis mollis ‡	Chinese witchhazel
Hamamelis virginiana *‡	Witchhazel
Hamamelis x intermedia ‡	Hybrid witchhazel
Kalmia spp. *‡	Mountain laurel, all species
Maianthemum racemosum *‡	False Solomon's seal
Physocarpus opulifolius *‡	Ninebark
Pieris spp. ‡	all species and cultivars
Prunus laurocerasus ‡	Cherry laurel
Prunus serotina *	Black cherry
Quercus alba *	White oak
Quercus prinus *	Chestnut oak
Quercus rubra *‡	Northern red oak
Rhododendron spp. *‡	All species, including azalea
Sassafras albidium *	Sassafras
Syringa vulgaris ‡	Lilac
Viburnum spp. *‡	all species, hybrids, cultivars

* native to northeastern United States

‡ from APHIS list of Regulated Hosts, "proven" or "associated" with *P. ramorum, as of January 2012*