40. Sudden Oak Death

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Hosts

The exotic, federally quarantined plant pathogen *Phytophthora ramorum* causes Sudden Oak Death (fig. 40.1) and ramorum shoot or leaf blight on more than 100 hosts from 36 different families. Hosts include a number of conifers, maples, tanoak, beech, and oak species (table 40.1). Although some hosts, such as oak and tanoak, develop stem cankers, most hosts only develop leaf spots and twig dieback when infected by *P. ramorum*, and are not usually killed by the pathogen. These diseases are commonly referred to as ramorum blight or dieback. In addition to hosts that have been naturally infected in the field, laboratory research indicates that a number of conifers, particularly many true firs and larch, may also be potential pathogen hosts.

Figure 40.1—*Tanoaks killed by* Phytophthora ramorum *in a California forest.* Photo by Gary Chastagner, Washington State University.

Distribution

Naturally infected hosts have been reported in forests and landscapes in California and southwestern Oregon coastal areas. Infected ornamental nursery stock, has been detected throughout the United States and British Columbia, Canada. Despite efforts to eradicate the pathogen from nurseries, the pathogen has spread to waterways and plants outside of infected nurseries at a limited number of sites. The distribution of this disease is expected to increase over time.

Table 40.1—*Partial list of forest tree species that are hosts of* Phytophthora ramorum.

Name	Species	Symptom type
Tanoak	*Notholithocarpus densiflorus*	Stem and foliage
Coast live oak	*Quercus agrifolia*	Stem
California black oak	*Quercus kelloggii*	Stem
Shreve's oak	*Quercus parvula* var. *shrevei*	Stem
Canyon live oak	*Quercus chrysolepis*	Stem
Douglas-fir	*Pseudotsuga menziesii*	Foliage, stem, and shoot dieback
Grand fir	*Abies grandis*	Foliage and shoot dieback
White fir	*Abies concolor*	Foliage and shoot dieback
California red fir	*Abies magnifica*	Foliage and shoot dieback
Coast redwood	*Sequoia sempervirens*	Foliage
European yew	*Taxus baccata*	Foliage
Pacific yew	*Taxus brevifolia*	Stem, foliage, and shoot dieback
California nutmeg	*Torreya californica*	Foliage and shoot dieback
Japanese larch	*Larix kaempferi*	Stem, foliage, and shoot dieback
Western hemlock	*Tsuga heterophylla*	Stem, foliage, and shoot dieback
California bay laurel	*Umbellularia californica*	Foliage
Pacific madrone	*Arbutus menziesii*	Foliage
Horse chestnut	*Aesculus hippocastanum*	Stem
Oregon ash	*Fraxinus latifolia*	Foliage
Bigleaf maple	*Acer macrophyllum*	Foliage

Damage

Depending on the host species affected, *P. ramorum* may cause leaf spots, shoot blight, leaf and twig dieback, and outright tree mortality from stem cankers. Besides the direct damage this pathogen may cause, Federal and State regulatory actions associated with the detection of infected host material have the potential for significant economic losses to individual nurseries and the forest nursery industry.

Diagnosis

Symptoms caused by *P. ramorum* on conifer hosts look much like injury from a late frost or Botrytis tip blight. Initial infections occur on new growth in spring, and during bud break and shoot elongation periods. After the initial infection, the pathogen causes the emerging shoot to wilt (fig. 40.2). The pathogen may continue to spread down the shoots, resulting in dieback. Dieback extent varies by host, when the infection occurs, and environmental conditions. When shoots are infected just after bud break, the pathogen commonly grows down the shoot into the previous year's growth. Often the needles on the previous year's growth are shed as the pathogen grows down the shoot, resulting in dead twigs with tufts of dead terminal needles (fig. 40.3). If infection occurs later during shoot elongation, the pathogen may only cause a dieback of the newly developing shoot. Repeated infection may kill seedlings and saplings or greatly alter young tree growth and form. On conifer nursery stock, where shoot elongation often occurs throughout the growing season, it is likely that *P. ramorum* infections are not limited to the spring. Symptoms on hosts other than conifers can vary greatly, from leaf spots to mature tree death.

Figure 40.2—*Tip dieback of Douglas-fir caused by* Phytophthora ramorum *in a California Christmas tree plantation.* Photo by Gary Chastagner, Washington State University.

Phytophthora species produce no easily recognizable fruiting bodies or spores on infected tissue, and diagnosis can be confirmed only through isolating the organism into pure culture. Because *P. ramorum* causes symptoms similar to those caused by other plant pathogens and abiotic conditions, samples must be sent to a lab for diagnosis. Selective media are often used in attempts to isolate the pathogen from infected tissues. *P. ramorum* produces copious amounts of chlamydospores in culture (fig. 40.4). *Phytophthora* species identification is usually left to specialists. Polymerase chain reaction (PCR) molecular tests are often used to confirm *P. ramorum* presence in samples.

Figure 40.3—*Tip dieback of grand fir caused by* Phytophthora ramorum *in a California Christmas tree plantation. Photo was taken in May shortly after infection following spring rainstorms.* Photo by Gary Chastagner, Washington State University.

Biology

During wet periods, *P. ramorum* produces copious amounts of sporangia and zoospores from spots on infected leaves of epidemiologically important (spore-producing) hosts such as California bay laurel (fig. 40.5). The spores are then carried by wind-driven rain to the foliage and bark of other susceptible hosts. Research on Christmas tree varieties in California shows that fairly high inoculum (spores) levels are necessary for Douglas-fir infection, and that little infection risk exists for trees located 5 to 8 m (16 to 26 ft) away from infected, epidemiologically important hosts. Recent observation and research in the United Kingdom indicates that infected Japanese larch support high foliar sporulation levels, unlike Douglas-fir and grand fir, which are most likely epidemiologically unimportant because inoculum is not produced on infected tissues. In addition to its natural dispersal, *P. ramorum* can also be spread via contaminated irrigation water and the movement of contaminated soil and infected plants.

This pathogen grows between 2 and 28 ºC (35 and 82 ºF), with optimum growth at 20 ºC (68 ºF). Hyphae can survive short time periods at temperatures as low as -5 ºC (23 ºF) and as high as 30 ºC (86 ºF). Chlamydospores embedded in host tissue can survive temperature extremes from -10 to 35 ºC (14 to 95 ºF) for up to 1 week.

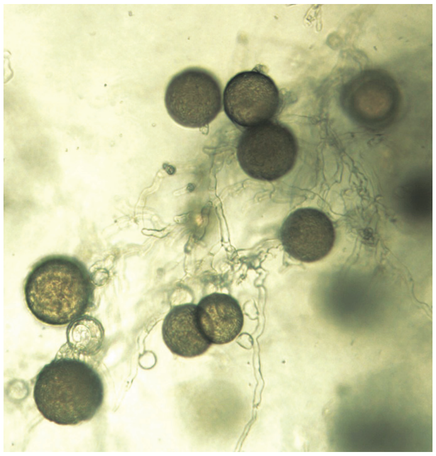

Figure 40.4—*Chlamydospores and hyphae of* Phytophthora ramorum *as seen in culture.* Photo by Marianne Elliott, Washington State University.

Figure 40.5—*Tips of California bay laurel leaves infected with* Phytophthora ramorum. *This host is responsible for much of the disease spread in California forests.* Photo by Kathy Riley, Washington State University.

In water, zoospore release from sporangia is stimulated by exposure to low temperatures around 4 ºC (39 ºF), and direct sporangia germination occurs at higher temperatures.

Control

Prevention

Although the risk of *P. ramorum* developing on conifer nursery stock is unclear, excluding the pathogen from the nursery is the single most effective way to reduce risks. Do not transplant seedlings from infested nurseries into disease-free ones. In infested areas, a seedling in close proximity to a spore-producing host has an increased *P. ramorum* infection risk. In these areas, nursery perimeters should be inspected for the presence of inoculum-producing hosts that could potentially serve as an inoculum source. Inform crews about *P. ramorum* implications on nursery stock and sanitation practices that reduce pathogen transfer when working in infested areas. Avoid equipment and crew movement between infested and noninfested areas. Scrape, brush, and hose off accumulated soil and mud from clothing, gloves, boots, and shoes and sanitize these items with a disinfectant.

Cultural

Remove potential landscape hosts that are located within 10 m (33 ft) of the nursery site. Don't irrigate crops with water from streams or ponds potentially contaminated with the pathogen unless the water has been treated. Several methods for treating *Phytophthora*-infested water can be employed, which include adding chemicals such as chlorine to the water and filtrating the water.

Chemical

Several fungicides are registered for *P. ramorum* control in nurseries. Soil fumigation is an effective treatment for soil infested with chlamydospores.

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