SUDDEN OAK DEATH

and

Phytophthora ramorum

A guide for forest managers, Christmas tree growers, and forest-tree nursery operators in Oregon and Washington

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Figure 1. A tanoak killed by Sudden Oak Death in Curry County, OR.

Sudden Oak Death: a summary

- Sudden Oak Death is the common name for a disease caused by *Phytophthora ramorum*, a previously unknown and recently introduced non-native pathogen.
- *Phytophthora ramorum* has killed hundreds of thousands of oak and tanoak trees in 14 coastal counties in California and hundreds of tanoak trees in Curry County, Oregon.
- The pathogen has a wide host range including Douglas-fir, grand fir, coast redwood, and many other tree and shrub species common in Oregon and Washington forests. Tree mortality, branch and shoot dieback, and leaf spots result from infection depending on host species and location.
- *Phytophthora ramorum* spreads aerially by wind and wind-driven rain and moves within forest canopies from tree tops to stems and shrubs and from understory plants to overstory trees. The pathogen survives in infested plant material, litter, soil, and water. It is moved long distances in nursery stock.
- State and federal personnel regularly survey forests and nurseries in the Pacific Northwest to detect the disease.
- Quarantine regulations, which include inspection and sanitation, are in place and are revised as necessary.
- In Oregon and Washington, when infected plants are discovered, they and neighboring host plants are destroyed.
- YOUR HELP is needed to protect Oregon and Washington from further damage from *Phytophthora ramorum*!

Introduction

Not since white pine blister rust was introduced accidentally to the Northwest, nearly 100 years ago, has a forest tree disease caused so much turmoil in the western forestry community. Even before *Phytophthora ramorum* was discovered in Oregon in 2001, disease survey and monitoring programs were in place. Since 2001, the pace of survey, eradication, and cooperative research continues to accelerate, all while the popular media and an interested public anxiously await results.

Why are forest tree growers and forest resource managers in the Pacific Northwest paying such close attention? Because:

- Sudden Oak Death readily kills dominant tanoak, coast live oak, and California black oak trees.
- Extensive tree mortality already has dramatically altered forest landscapes.
- The disease has appeared in horticultural nurseries and garden centers and can be moved long distances quickly via infected plants.
- The causal agent has a broad host range of more than 100 species in several plant families, and many susceptible forest species grow from California to British Columbia.
- The disease can spread from plants in the understory to nearby trees and from tree crowns to plants on the forest floor.
- Economically and ecologically valuable conifers, including Douglas-fir, coast redwood, and true firs, are on the host list.
- State, national, and international quarantines have been imposed. All host plant species grown in affected areas are regulated.
- Horticultural nurseries in Oregon and Washington, as well as in California, have lost millions of dollars from destruction of infected stock and loss of markets.
- Activities ranging from timber harvest to collecting wild greens, and from growing Christmas trees to managing forest-tree nurseries, could be affected.

Figure 2 (below). An aerial view of tanoak trees killed by *Phytophthora ramorum* in Curry County, OR. Note the orange-red crowns of recently killed trees.

Figure 3 (at bottom). The same site after eradication treatment.

Some history

Unprecedented levels of tanoak *(Lithocarpus densiflorus)* and coast live oak *(Quercus agrifolia)* mortality were noted first in Marin County, CA in the early to mid-1990s. Local residents coined the phrase "Sudden Oak Death" to describe the apparently rapid tree mortality they observed. The cause was then unknown. In 2000, a new species of *Phytophthora*, a fungus-like water mold of unknown origin, was isolated from cankers (localized areas of dead cambium) on dying trees and later was found to be the causal agent. Soon it was recognized that the same pathogen was causing leaf blight, stem cankers, and tip dieback on nursery-grown rhododendrons and viburnums in Europe. The new species was named *Phytophthora ramorum* in 2001. With the European connection, attention in California turned to plant nurseries in affected areas, and diseased rhododendron plants soon were found in several nurseries.

In 2001, *P. ramorum* was detected in Curry County, in extreme southwestern Oregon, on tanoak, Pacific rhododendron *(Rhododendron macrophyllum)*, and evergreen huckleberry *(Vaccinium ovatum)*. Nine disease centers, ranging from 0.5 to 11 acres and totaling less than 40 acres, were found in tanoak forests in a rural residential area, on private forest industry land, and on federal land administered by the U.S. Department of Interior Bureau of Land Management. The Oregon Department of Agriculture immediately quarantined a 9-square-mile area. Infected and surrounding plant material in disease centers was cut, piled, and burned in a continuing program to eradicate the pathogen (Figures 2 and 3, at left).

In May 2003, *P. ramorum* was discovered in a wholesale horticultural nursery in Clackamas County, OR on *Pieris, Viburnum,* and *Rhododendron;* in June 2003, *P. ramorum* was reported on rhododendron and other hosts at a retail outlet in Washington State that was

affiliated with the Clackamas nursery. An international shipment of rhododendrons was the suspected source of contamination in those incidents. That same month, infected camellias shipped from California were found in other Oregon nurseries. In March 2004, it was determined that infected camellias from another large wholesale nursery in southern California had been shipped throughout the United States and Canada, including to Oregon, Washington, and British Columbia. Nationwide, state and federal agencies continue to track, confirm, and destroy infected plants and to search for new infections in landscapes and forest areas surrounding introduction sites.

Distribution and damage

Currently in California *P. ramorum* is found in forest or woodland environments in 14 coastal counties from Monterey County in the south to Humboldt County in the north (Figure 4). Mortality of coast live oak and tanoak continues throughout the affected area. Not all stands are affected; in 2004, mortality was particularly intense in the Big Sur area, south of Monterey, and in 2005 attention was focused on an outbreak in southern Humboldt County.

Hundreds of thousands of coast live oak, tanoak, and California black oak trees have been killed by *P. ramorum* in California. Thousands of hazardous dead trees have been removed from campgrounds, private property, and roadsides. High-value trees have died in parks and backyards, changing aesthetics and reducing property values. Extensive areas of mortality have led to concerns about increased fire hazard, particularly in the wildland–urban interface and in municipal watersheds. Scientists are studying the short-term impacts on a variety of wildlife species for whom the loss of oaks means loss of food and habitat. Native Americans living in or near infested areas are concerned about the direct effect of oak mortality on their food-gathering traditions and about how damage to other hosts might impact traditional activities such as berry picking and basket making.

Figure 4. Distribution of Sudden Oak Death as of December 12, 2005. Red triangles are confirmed isolations of *Phytophthora ramorum;* counties in darker yellow have *P. ramorum* confirmed in wildland. Data from California Department of Food and Agriculture and pathologists at the University of California, Davis and Berkeley campuses. California host data from CAL GAP Analysis Project. Oregon host data from OR GAP Analysis Project. Nursery confirmations are not depicted. Map by UCB CAMFER, http://kellylab.berkeley.edu/SODmonitoring/

In Oregon, new infested forest sites have been detected in Curry County since 2001 (Figure 5 and Table 1). Most of the new finds in Oregon have been adjacent to older sites, although a few trees have been identified up to a mile away from previous infections. Tanoak is the only species being killed by *P. ramorum* in Oregon, although wild rhododendron and evergreen huckleberry suffer dieback. A recent find of disease within a few hundred yards of the current boundary has resulted in expansion of the Curry County quarantine area in February 2006. The eradication effort continues.

Long-term impacts of Sudden Oak Death at the watershed or forest ecosystem level are hard to predict. Changes in forest cover result in changes in microclimates, influencing species composition and forest succession. The loss of a single species or more subtle shifts in species composition may have profound effects in the decades ahead.

Nurseries on the West Coast have been surveyed for the disease, and several have been found infested. When found, infected plants and their neighbors have been destroyed and adjacent environs surveyed for *P. ramorum*.

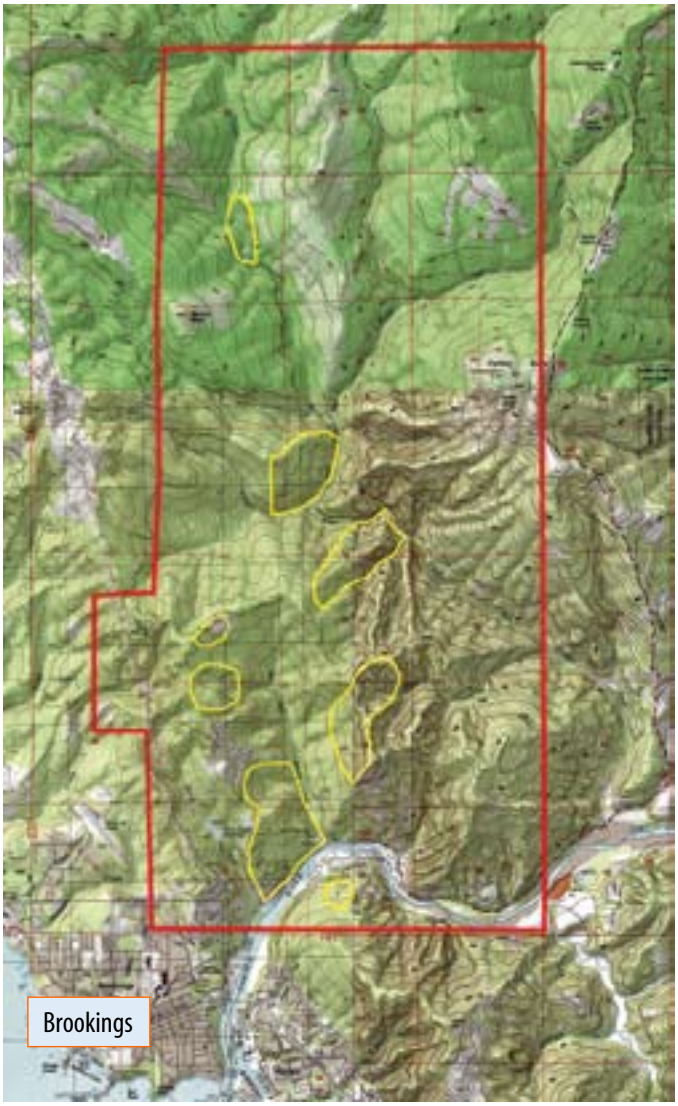


Figure 5. Distribution of *P. ramorum* in Curry County, OR, and the boundary of the regulated area (red lines) as of February 2006.

In Europe, *P. ramorum* has been widely dispersed through the nursery trade and in some locations has become established in woodland settings. It is in nurseries, garden centers, or some landscape plantings in 15 countries. The most common hosts are *Rhododendron, Viburnum,* and *Pieris,* but it also has attacked mature landscape trees, including North American red oak and some other oak species, beech, and horse chestnut. The native oaks of northern Europe, in the white oak group, have not been affected. European countries are attempting to stop further spread of the pathogen and to eradicate it from the nursery trade. In England, where spread from understory rhododendrons to nearby trees has been observed, scientists are attempting to eradicate the disease from the few parks and wildlands where it is established. They are using methods similar to those used in Oregon.

Table 1. Eradication progress in Curry County, Oregon.

	2001	2002	2003	2004	2005
New SOD trees	91	85	49	30	49*
Acres treated	40	8	12	10	18*
Quarantine area (square miles)	9	9	11	11	21.5**

* as of December 2005
** as of February 2006

There is great concern about the vulnerability of the oak forests of the eastern United States to *P. ramorum* (Figure 6). Laboratory tests and experience in the United Kingdom indicate that native red oak species are at risk. In thousands of acres of forest, understory host composition and climate may be similar enough to affected areas in California and Oregon that the disease could become established. The recent transport of the pathogen on nursery stock from West Coast nurseries to eastern states caused great alarm and triggered intensive efforts to find and destroy infected plants in the eastern nurseries and to survey surrounding forest areas for disease. To date there is no evidence that Sudden Oak Death has become established in eastern forests.

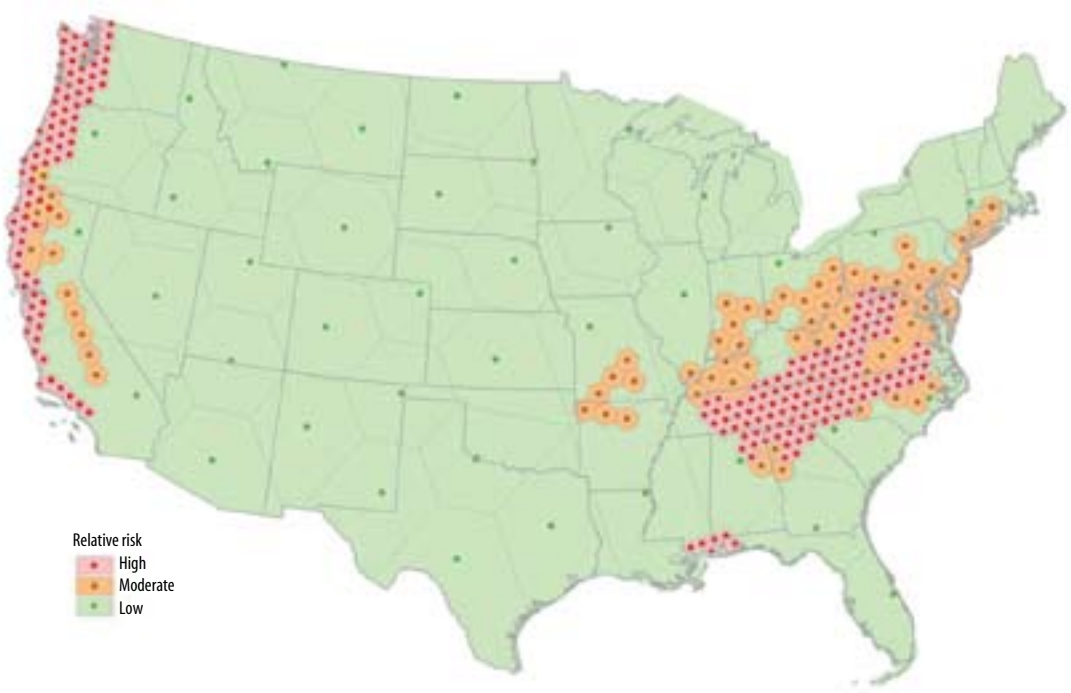


Figure 6. Predicted vulnerability of forests in the United States to *Phytophthora ramorum,* based on presence of potentially susceptible vegetation, favorable climate, and likely pathways. Map by USDA Forest Service.

The full economic impact of Sudden Oak Death has not been tallied, but it will be many tens of millions of dollars. Direct losses are greatest in the horticultural nursery industry, where thousands of plants have been destroyed to stop the spread of disease. Further losses from disrupted and lost markets also must be borne by the industry. Neither tanoak nor coast live oak is a valuable timber tree, but in both California and Oregon outbreak areas, the amenity value of trees around homes can be great. We also must include the costs to remove dead trees, to dispose of the infective green waste sanitarily, and to survey and monitor as well as the costs of the regulatory and eradication efforts.

Losses to date could be dwarfed if the disease spreads northward and impacts conifer production areas. Even though current knowledge suggests Douglas-fir and coast redwood are unlikely to suffer serious growth loss or mortality, the economic impact of quarantine regulations affecting trade in conifer and hardwood products, logs, Christmas trees, and tree seedlings could be great.

The pathogen

Phytophthora ramorum is an Oomycete, a water mold that looks like a fungus but is more closely related to some marine algae. Most *Phytophthora* species are root pathogens, but

Phytophthora ramorum affects aboveground plant parts. *P. ramorum* is well adapted to the mild, wet conditions of the Pacific Northwest. The pathogen forms sporangia (sacs of spores) on infected leaves or twigs (Figure 7). The sporangia are spread in wind and rain and can release swimming zoospores if they land on a wet surface. The zoospores germinate and infect the plant, starting a new infection. *Phytophthora ramorum* also makes thick-walled resting spores (chlamydospores) in infected plant parts, which allow it to survive heat and drought and to persist for months in soil and plant debris (Figure 8).

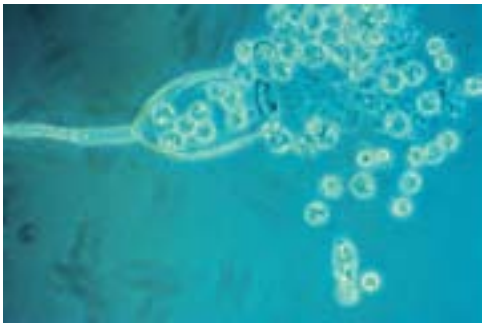


Figure 7. Closeup of a *Phytophthora* sporangium releasing swimming spores (zoospores) in water. Photo courtesy of Fred Schwenk, Kansas State University.

In addition, *P. ramorum* has two mating types, designated A1 and A2. Sexual spores (oospores) form if the opposite mating types join. Only the A2 mating type has been found in the forests of California and Oregon, while only the A1 mating type (with a single exception) has been found in Europe. This suggests that the North American forest epidemic did not originate in Europe and vice versa. Presumably this disease spread from some unknown place in the world where both mating types are present. Both mating types have been isolated from Northwest nurseries, however, suggesting at least two introductions into the nursery trade. To date, no evidence of sexual recombination has been found in nurseries or forests, but the threat of new races of the pathogen adds one more reason to halt introductions.

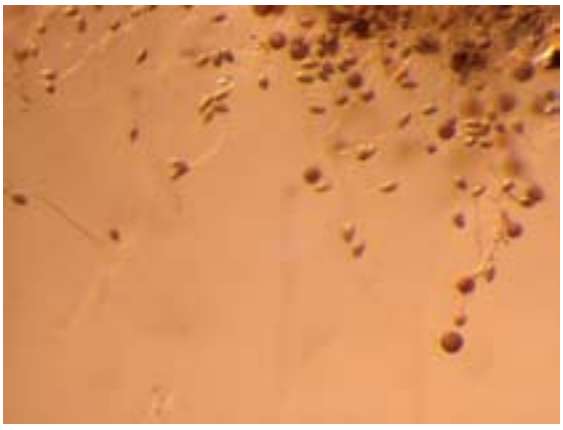


Figure 8. Sporangia and round chlamydospores (resting spores) of *P. ramorum* formed when an infected Oregon myrtlewood leaf was placed in water.

Recently, a third genetic type of *P. ramorum*. was found in a West Coast nursery. It is the A2 mating type but is genetically distinct from the fungus as known from either Europe or North America. It may provide important clues to the origin and evolutionary history of *P. ramorum*.

Spread of *Phytophthora ramorum*

In the forest, the pathogen spreads from tree to tree as zoospores or sporangia in water: via rain splash, drip and stem flow, and wind-driven rain. Tanoak twigs and leaves are infected first in the upper crown. New growth in spring is most susceptible. Zoospores swim through water films on the surface of leaves or stems, then settle, germinate, and penetrate the plant. New sporangia are formed on infected leaves and twigs in wet weather (Figure 7) and may wash or splash down the stem. The trunk cankers that kill the tree apparently originate from spores washed from above. Rhododendrons and huckleberries, and occasionally other hosts growing beneath infected trees, may be infected. Meanwhile, dislodged sporangia from the upper crown infections also may be carried by the wind to distant trees. Half of newly infected trees are found within about 300 feet of previously infected trees, a pattern consistent with wind and rain dispersal.

Infected leaves drop to the ground, and many spores land on the soil. Infested soil and leaves can be transported on boots, vehicles, and animals, especially in wet weather. Spores can be splashed back up on low-hanging foliage and there initiate new infections. Natural root infection has been observed in California forests where the spore load is very high. *Phytophthora ramorum* also is found in streams draining infested areas, although no new forest infections have been traced to streams. Irrigation water drawn from infested streams or other water sources can start new infections.

Not all hosts are equal when it comes to spreading *P. ramorum*. It is believed that wood and bark of oaks produce few *P. ramorum* spores, while leaf surfaces, particularly on Oregon myrtlewood (also known as California bay laurel), are excellent spore production factories. Understory plants may play a very important role in how the disease is maintained and spread within a given site.

To date, extensive *P. ramorum* wildland infestations have been reported in forest communities with known associated epidemiologically important hosts (spore factories) such as

tanoak (California and Oregon), California bay laurel (California), and/or coast redwood (California). Currently it is not known whether other hosts can produce spore loads capable of sustaining *P. ramorum* and associated diseases in regions of the Pacific Northwest outside the native range of tanoak, California bay laurel, or coast redwood.

Phytophthora ramorum also is moved long distances in infected nursery stock. Plants may show no symptoms or only cryptic indications of infection at the time of sale. Some fungicides that are used routinely in nurseries suppress symptoms of *Phytophthora* infection, but the pathogen survives and may become active again in a favorable environment as the chemical wears off.

Diseases caused by *Phytophthora ramorum*

Phytophthora ramorum affects different plant species in different ways (Table 2). Not all affected species are killed; some suffer tip and shoot dieback while others experience relatively harmless leaf spotting. Sudden Oak Death on trees in the oak family is characterized by "bleeding" cankers that girdle the trunks of tanoaks (Figures 9a–f) and some other oak species.

Figure 9a

Figure 9b

Figure 9c

Figure 9d

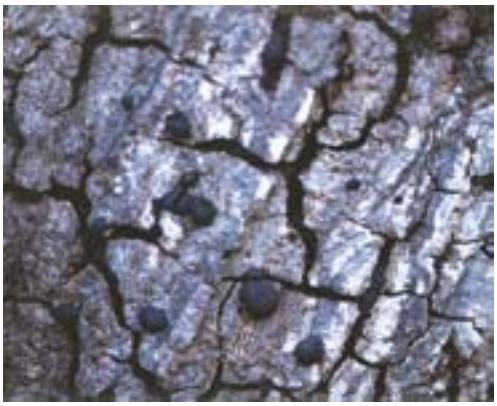
Figure 9e

Figure 9f

Figures 9a–f. Two symptoms of *P. ramorum* on tanoak: (9a–c) bleeding on bark surface; and (9d–f) mottled discoloration of inner bark.

Table 2. One pathogen, three diseases.

Disease	Symptoms	Hosts
Sudden Oak Death	Bleeding cankers; tree death.	Oak, tanoak
P. ramorum shoot blight	Shoot tip dieback.	Coast redwood, Douglas-fir, evergreen huckleberry, true fir hosts, Pacific madrone, Pacific yew, rhododendron, tanoak
P. ramorum leaf blight	Petiole and midrib necrosis; leaf spots on edges or leaf tips; leaf spots with margins that look water soaked.	Cascara, myrtlewood, rhododendron, tanoak



Figures 10 a–b. Ambrosia beetles, as evidenced by characteristic boring dust (at left above) and sapwood decay fungi *Hypoxylon thouarsianum* (above right) often are associated with *P. ramorum*-infected oaks.

Ambrosia beetles and sapwood decay fungi such as *Hypoxylon thouarsianum* often are associated with infected trees, hastening death (Figures 10 a–b). On rhododendron, evergreen huckleberry, Pacific madrone, Douglas-fir, true fir hosts, and coast redwood, the disease is characterized by leaf blight and shoot dieback and is more appropriately called *Phytophthora ramorum* shoot blight (Figure 11 and Figures 12 a–c). The leaf petiole and midrib may be discolored, or the leaf tip or entire leaf blade may be necrotic (Figure 13). Leaf spots often occur where water

Figure 11. Symptoms of *P. ramorum* infection on shoot tips of Douglas-fir.

Figures 12 a–c. Shoot dieback symptoms of *P. ramorum* on evergreen huckleberry (above), rhododendron (at right), and tanoak (at far right).

Figure 13 (at right). Blackened petioles and midribs are typical symptoms of *P. ramorum* on tanoak leaves.

accumulates on the leaf margins. Shoots die back when the disease is severe. On tanoak, Douglas-fir, true fir hosts, and coast redwood, small twigs, sprouts, and new shoots are affected (Figure 11, Figure 12c, and Figures 14a–c); succulent stems droop or become crooked, symptoms similar to those of frost damage. Other hosts, such as Oregon myrtlewood or cascara, may be infected but show only subtle symptoms, such as yellow tips on the lower leaves (Figure 15). Because Oregon myrtlewood loses its older leaves in early summer after new leaves emerge, whether infected or not, symptomatic leaves may not be readily available for inspection.

In general, symptoms caused by *P. ramorum* are similar to symptoms caused by other agents, in particular other *Phytophthora* species. Diagnostic techniques such as culturing or DNA analysis are critical for identifying this pathogen.

Figures 14a–c. Symptoms of *P. ramorum* on coast redwood (at far left) and grand fir (at left). Note sprout dieback and dead needles on coast redwood and (below, left) dieback of grand fir leader.

Figure 15 (above). Symptoms of *P. ramorum* on Oregon myrtlewood (California bay laurel).

Hosts and symptoms

The host list for *Phytophthora ramorum* is large and growing and includes many species commonly found in Pacific Northwest forests (Table 3). For regulatory purposes, the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture (USDA APHIS) maintains two official host lists. One list is of **confirmed host species**: plants that have been infected naturally in forests or nurseries and whose susceptibility has been proven by accepted scientific methods. The other list is of **"associated" host species**: that is, plants that have been naturally infected but on which testing is not yet complete. The associated-host list includes some important western wildland species such as white fir, grand fir, red fir, and vine maple. For an up-to-date list of confirmed hosts and associated species, see http://www.aphis.usda.gov/ppq/ispm/pramorum/

In addition to the APHIS lists, laboratory tests using artificial inoculation indicate that many more plant species, both wild and cultivated, are susceptible to *P. ramorum,* but these species are not regulated because they have not been found naturally infected. Artificial inoculation uses high spore loads and optimum environments for infection.

In California forests where infection levels are very high, more understory species are infected than in Oregon forests where the spore load is kept very low by the eradication program.

Table 3. Western woodland confirmed host species of *Phytophthora ramorum*. Additional host species are known from nurseries and from Europe.

Plant species	Common name and location[1]	Symptoms
Lithocarpus densiflorus	tanoak OR, CA	Bole cankers, death
Quercus agrifolia	coast live oak CA	Bole cankers, death
Quercus chrysolepis	canyon live oak CA	Bole cankers, death
Quercus kelloggii	California black oak CA	Bole cankers, death
Quercus parvula var. *shrevei*	Shreve oak CA	Bole cankers, death
Arbutus menziesii	madrone CA	Shoot dieback
Arctostaphylos manzanita	manzanita CA	Shoot dieback
Pseudotsuga menziesii	Douglas-fir CA	Shoot dieback
Rhododendron macrophyllum	Pacific rhododendron OR	Shoot dieback
Sequoia sempervirens	coast redwood CA	Shoot dieback
Taxus brevifolia	Pacific yew	Shoot dieback
Vaccinium ovatum	evergreen huckleberry OR, CA	Shoot dieback
Acer macrophyllum	bigleaf maple CA	Leaf blight
Adiantum aleuticum	western maidenhair fern CA	Leaf blight
Adiantum jordanii	California maidenhair fern CA	Leaf blight
Aesculus californica	California buckeye CA	Leaf blight
Frangula (Rhamnus) californica	California coffeeberry CA	Leaf blight
Frangula (Rhamnus) purshiana	cascara CA, OR	Leaf blight
Heteromeles arbutifolia	toyon CA	Leaf blight
Lonicera hispidula	California honeysuckle CA	Leaf blight
Rosa gymnocarpa	wood rose CA	Leaf blight
Trientalis latifolia	western starflower CA	Leaf blight
Umbellularia californica	Oregon myrtlewood OR California bay laurel CA	Leaf blight

[1] CA = California, OR = Oregon

Infection of conifers

Susceptibility of conifer hosts deserves special mention because of their importance in Pacific Northwest forests. No natural infection of any conifer has been observed in Oregon or Washington. In California, however, Douglas-fir, red fir, grand fir, white fir, coast redwood, and Pacific yew are infected when growing beneath infected oaks and California bay laurel (Figure 11 and Figures 14a–c, pages 8 and 9 respectively). Inoculation studies indicate that other conifers, especially *Abies* species, are susceptible and may be damaged if exposed to high inoculum levels.

Infection occurs in spring through bud scars at the base of new growth; only foliage and twigs are affected (Figure 11 and Figures 14a–c, pages 8 and 9 respectively). The damage on Douglas-fir and true fir hosts looks much like injury from a late frost or Botrytis tip blight. Repeated infection may kill seedlings and saplings or greatly alter their growth. Similarly, only the foliage and small-diameter sprouts of coast redwood have been found infected. Because trunk cankers have not yet been found on Douglas-fir and coast redwood, only nursery stock, foliage, and materials less than 1 inch diameter (such as sprouts and shoots) are regulated, not logs or lumber. True fir hosts, currently on the associated-hosts list, are regulated as nursery stock at this time.

Everyone in the field should be on alert

Field-going forestry, plantation, and nursery personnel should be aware of the symptoms caused by *P. ramorum*. Several guides to diagnosing *P. ramorum* infection are available on the Web. Master Gardeners, county Extension agents, and plant pathologists in forestry and agricultural agencies throughout Washington and Oregon are being trained to recognize the symptoms of *P. ramorum* and to be the "First Detector" in diagnosis. Symptoms caused by *P. ramorum* are easily confused with those caused by other *Phytophthora* species and other plant pathogens and insects. Positive diagnosis can be made only using laboratory techniques.

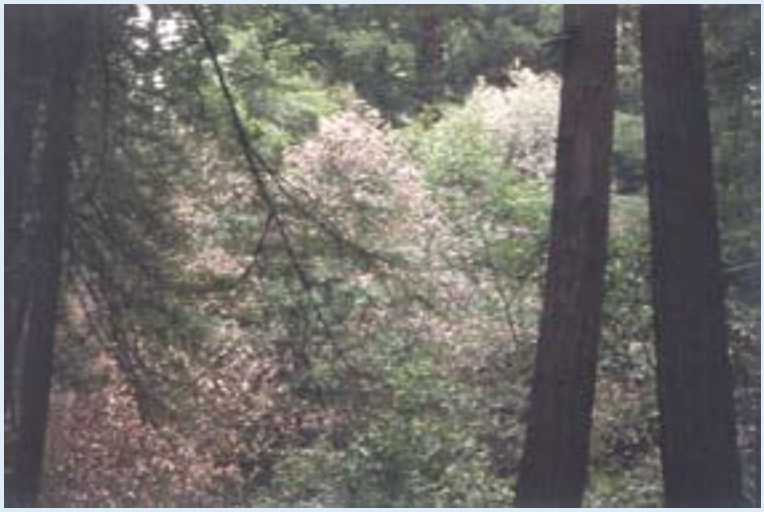


Figure 16. Tanoak mortality in the understory.

Stopping Sudden Oak Death

Management efforts in Pacific Northwest forests and nurseries focus on eradicating the pathogen where it is found and on preventing new infections. In California, where the disease is more extensive, a "slow the spread" strategy is in place. Early detection is vital to preventing disease spread. Practices useful in managing other foliar *Phytophthora* diseases in nurseries also will help protect plants from *P. ramorum* infection.

Detection surveys

Several *P. ramorum* detection surveys are conducted each year in at-risk forest areas by the Oregon Department of Forestry (ODF) and the USDA Forest Service. The forest range of tanoak is systematically surveyed from a fixed-wing aerial survey plane, and suspicious trees are mapped. A follow-up helicopter survey provides a closer look for symptomatic trees and enables more precise map coordinates. All suspect trees are checked from the ground and samples collected for confirmation as appropriate. In addition, annual ground surveys check the perimeters of previously treated areas for newly infected trees.

Nurseries, Christmas tree plantations, and other sites considered at high risk also are surveyed and sampled by the Oregon Department of Agriculture (ODA) and the Washington State Department of Agriculture (WSDA) with assistance from USDA APHIS. If *P. ramorum* is found in a nursery or other site, the eradication protocol requires additional perimeter surveys in the surrounding landscape plantings and wildlands.

Eradication

If *P. ramorum* is found, ODA, WSDA, and USDA APHIS work with the landowner to prevent further disease spread and to eradicate the infestation. The agencies continue to monitor the site after eradication until it has been free of *P. ramorum* for 2 years. The USDA has drafted uniform procedures for dealing with nursery, residential, and landscape infestations. Check the final regulatory action plan posted on the ODA, WSDA, and USDA APHIS websites (see last page) for up-to-date information.

Nurseries and Christmas tree plantations

Under current federal regulations, nurseries and Christmas tree plantations are treated similarly. *Phytophthora ramorum* has not been found in forest-tree nurseries or Christmas tree plantations in Oregon or Washington. It has

If you work in infested forest areas

- Inform your crews that they are working in an area infested with *P. ramorum*.
- Inform them that unauthorized collection or transport of host plant material is prohibited.
- Provide them with sanitation kits containing: chlorine bleach solution (one part bleach to nine parts water) or a product such as Clorox Clean-up; a scrub-brush; a metal scraper; a boot brush; and plastic gloves.
- Use all reasonable methods to sanitize personal gear and crew equipment before leaving a *P. ramorum*-infested site. Scrape, brush, and/or hose off soil and mud from clothing, gloves, boots, and shoes (Figure 17). Remove mud and plant debris from vehicles and equipment by sweeping, blowing, or power washing.
- When possible, work on *P. ramorum*-infested sites during the dry season or during dry spells. When working in wet conditions, keep equipment on paved or dry surfaces.
- Work in disease-free areas before proceeding to infested sites.

Figure 17. A forest pathologist washes his boots before he leaves the regulated area in Curry County, OR.

been found in Christmas tree plantations in California, however, where it affects Douglas-fir and several true fir species.

If *P. ramorum* **is** found in Northwest nurseries or Christmas tree plantations, eradication will be ordered. Shipment of host and associated host plants will be prohibited until the extent of infection within the site has been determined. All plants within a block that contains infected plants, and susceptible plants within 2 meters of that block, will be destroyed by burning or burial. Healthy-appearing host plants within 10 meters of the infested block(s) will be held for a period of time to observe symptoms; fungicide treatment will be prohibited during this time so that symptoms will not be masked. Soil, irrigation water, and potting media also will be tested for *P. ramorum*. Additional treatments may be ordered to deal with infested soil or containers.

Properties and naturalized areas surrounding infested nurseries also will be surveyed for *P. ramorum*. Trace-back investigations will be conducted to determine the source of infected plants, and trace-forward investigations will be conducted if any plants from the infested block(s) or field were shipped. Shipment of host and associated host plants may resume after tests show the disease is gone. Nurseries will be tested for at least the next 2 years.

In Oregon and Washington horticultural nurseries, the eradication program has been largely successful. However, the importation of new infected stock from out of state is a continuing threat. Should a recurrent infection be found within a nursery, a more stringent eradication protocol will likely be enforced.

Forest settings

State of Oregon regulations mandate the eradication of *Phytophthora ramorum* where found in the forest on state and private lands. Infected trees are cut and burned, along with all host plants growing within at least 100 feet or more of infected plants. Herbicides have been used to reduce the likelihood of resprouting from cut stumps (Figures 18 a–c). Federal forestry agencies are cooperating with Oregon in eradication efforts and have completed environmental analyses for eradication activities on federal lands when necessary. ODA continues to monitor new growth and soil on the eradication sites. So far, about 88 forest acres have been treated in Curry County.

Figures 18 a–c. Infected tanoak is burned on a site in Curry County, OR (above left and right). After the burn (left), the site's alders remain.

Prevention

The greatest risk of spreading *P. ramorum* to new areas in the Northwest is through movement of infected plants or plant parts. If infected plants are transported to areas with hosts and a suitable environment, the pathogen will likely become established over time. Always be sure of the source and health of your planting stock. If possible, purchase planting stock that has been certified as *P. ramorum*-free through an official inspection and certification program. *P. ramorum* also survives in and can be spread via movement of infested soil and water.

Prevention and suppression with fungicides

Most conventional fungicides are not effective against *Phytophthora* species because the species are not true fungi. Several classes of compounds are active against *Phytophthoras*, however. Carefully used, these can be useful in protecting plants against infection. They seldom kill the pathogen, however, if the plant is already infected. Instead, they may mask symptom development and lead to inadvertent transport of infected stock and spread of the disease. Once chemical activity has subsided (about 3 to 6 months), *Phytophthora* can resume growth within infected plants. This is why plants from other nurseries must be held for several months to see whether symptoms become evident.

For specific fungicides, consult the latest edition of the *PNW Plant Disease Management Handbook* (see the last page of this publication for ordering information) or visit An Online Guide to Plant Disease Control at: http://plant-disease.ippc.orst.edu/index.cfm.

Protecting yourself

Forest resource managers in the Pacific Northwest need to be alert for inadvertent introductions of this pathogen, especially when importing material from areas with known infestations. Managers also need to be aware of the regulations on moving host material. Regulations help slow spread, but common sense is your best protection.

Transporting plant material

Do not transport oak firewood or other potentially infected plant materials from infested areas in California and Oregon to other areas.

Visiting infested areas

If you visit infested areas, wash your vehicle and shoes and remove leaf litter and other plant debris from vehicles, other equipment, and clothing before traveling to disease-free areas.

Importing nursery stock

In Oregon, if importing nursery stock of host trees or shrubs from any source (out of state or international), you must notify the Nursery & Christmas Tree Program Supervisor at the Oregon Department of Agriculture by fax (503-986-4786) or by e-mail (quarantine@oda.state.or.us). Plants must be certified as being free from *P. ramorum*. Further information on Oregon's import regulations is online at http://egov.oregon.gov/ODA/PLANT.

In Washington, if importing any host plants you must be in compliance with the Washington notification rule and notify the Nursery Inspection Supervisor in Olympia by fax (360-902-2094) or e-mail (nursery@agr.wa.gov). Further information is available online at http://agr.wa.gov/PlantsInsects/Diseases/SOD/.

Illegal importations may result in significant fines. USDA quarantine regulations pertaining to *P. ramorum* are online at http://www.aphis.usda.gov/ppq/ispm/pramorum.

Learning the range of symptoms

Familiarize yourself and your staff with the range of symptoms caused by *P. ramorum*. Check your plants often. Diseases caused by other *Phytophthora* species can cause similar symptoms.

If you suspect *P. ramorum,* contact either the Oregon Department of Agriculture's Invasive Species Hotline, 1-866-INVADER, or the Washington State University plant disease diagnostician, 1-253-445-4582.

For questions related to backyard or woodland plants, the OSU or WSU Extension office in your county and/or Master Gardeners in Extension offices can assist with identification, or local USDA Forest Service offices can put you in contact with appropriate diagnostic experts.

Diagnosis, using several techniques, may take 1 to 2 weeks or up to a month or more. ***While waiting for the diagnosis, do not move or ship symptomatic plants or any nearby plants.*** Even if the latter look healthy, they may be contaminated.

Be alert for symptoms on ***any*** shrub and tree species, not just those on the list of hosts and plant species associated with *P. ramorum*.

If your business is conifer nursery stock, Christmas trees, or forest products, don't bring ornamental plants near your production areas. An infected rhododendron planted as an ornamental will trigger inspection and holds on your conifer stock as quickly as an infected Douglas-fir.

Quarantines and regulations

State and federal regulatory actions have been implemented to help prevent the movement of infested wood, bark, forest greenery and other wild material, soil, and host nursery stock from infested areas. At this time, 21.5 square miles of forest in Curry County, OR are subject to this regulation. For current information on quarantines and other Sudden Oak Death regulations, visit the ODA website at http://egov.oregon.gov/ODA/PLANT, the WSDA website at http://agr.wa.gov/PlantsInsects/Diseases/SOD/, and the USDA APHIS website at http://www.aphis.usda.gov/ppq/ispm/pramorum.

In addition to USDA APHIS regulations, several foreign countries have imposed quarantines on movement of host materials from infested areas in California, Oregon, and Washington. These restrictions cover horticultural and forest nursery stock, Christmas trees, and in some cases logs and lumber.

Inspection and certification

USDA APHIS adopted a Federal Order on December 21, 2004, that requires all nursery and planting stock from California, Oregon, and Washington to be inspected and certified free of *P. ramorum* prior to export from these states.

All nurseries exporting plant material must be visually inspected for *P. ramorum*.

Growers of host or associated host plant stock must have their plants tested for *P. ramorum* in addition to the visual inspection.

More information about this program is available online at http://www.aphis.usda.gov/ppq/ispm/pramorum.

Oregon has adopted a similar regulation for nursery and planting stock grown for export and for sale within the state. Lists of nurseries participating in the inspection and certification program are available online from the Oregon Department of Agriculture (http://egov.oregon.gov/ODA/PLANT) and the Washington State Department of Agriculture (http://agr.wa.gov/PlantsInsects/Diseases/SOD/).

For more information

Oregon State University Extension Service SOD website
http://extension.oregonstate.edu/emergency/oak_death.php

The Extension Services of Oregon State University, Washington State University, and University of Idaho. An Online Guide to Plant Disease Control
http://plant-disease.ippc.orst.edu/index.cfm

Pscheidt, J.W. and C.M. Ocamb, eds. Pacific Northwest Plant Disease Management Handbook (revised annually). Corvallis, OR: Extension Services of Oregon State University, Washington State University, and University of Idaho. Order form for print edition online at
http://extension.oregonstate.edu/catalog/orderform.pdf

California Oak Mortality Task Force website
http://suddenoakdeath.org/

Information on Sudden Oak Death is constantly changing. Be sure to check online sources regularly.

Davidson, J.M., S. Werres, M. Garbelotto, E. Hansen, and D.M Rizzo. 2003. Sudden Oak Death and associated diseases caused by *Phytophthora ramorum*. Plant Health Progress, Plant Management Network International.
http://www.plantmanagementnetwork.org/pub/php/diagnosticguide/2003/sod/

Oregon Department of Agriculture website
http://egov.oregon.gov/ODA/PLANT

USDA Animal and Plant Health Inspection Service (APHIS), Pest Detection and Management Programs, Invasive Species and Pest Management: Sudden Oak Death
http://www.aphis.usda.gov/ppq/ispm/pramorum

Washington State Department of Agriculture website
http://agr.wa.gov/PlantsInsects/Diseases/SOD/

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