

Phytophthora ramorum

a guide for Washington nurseries



Figure 1. —
Ramorum shoot
dieback and leaf
blight on
*Viburnum x
bodnantense*
'Dawn'.

A newly described fungus-like organism named *Phytophthora ramorum* was discovered in 1993 to cause leaf blight, stem canker, and tip dieback on nursery-grown rhododendrons and viburnums in Germany and the Netherlands. At about the same time, many tanoaks (*Lithocarpus densiflorus*) and oaks (*Quercus* sp.) in the San Francisco Bay Area were dying from a new disease. The cause of this “sudden oak death” was also *Phytophthora ramorum*.

In 2001, the disease was detected in forest sites near Brookings, in southwest Oregon, on tanoak, Pacific rhododendron, and evergreen huckleberry. A nine-square-mile area was quarantined, and infected plant material was cut, piled, and burned in an attempt to eradicate the disease. A few new infested forest sites have been detected since then, so the quarantined area has been increased slightly to 11.5-square-miles.

In May 2003, *P. ramorum* was discovered in a wholesale nursery in Clackamas County, Oregon, on *Pieris*, *Viburnum*, and *Rhododendron*. In June 2003, *P. ramorum* blight was reported on rhododendron and other hosts at a

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retail outlet in Washington that was affiliated with the Clackamas nursery. In a separate incident, in June 2003, infected camellias shipped from California were found in two Jackson County, Oregon, nurseries; they were destroyed. The same California nursery also had shipped camellias to two Portland-area garden centers. Approximately 300 of these plants were sold during January to July 2003. A public recall was initiated in summer 2003 to check plants and to remove and replace any infected plants found.

Further state and federal regulatory actions have been implemented to help prevent importing infected nursery stock; for more information, visit the Oregon Department of Agriculture Web site at <http://oda.state.or.us/plant/ppd/path/SOD/index.html>. Pacific Northwest nursery growers need to be alert for inadvertent introductions of this pathogen, especially when importing from areas with known infestations or insufficient survey coverage.

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Figure 2. — Initial symptoms of ramorum leaf blight on *Viburnum plicatum* var. *tomentosum* ‘Mariesii’, showing necrotic leaf spots and shoot dieback.

An up-to-date list of host and associated species is online at <http://www.aphis.usda.gov/ppq/ispmlsod/list.pdf>

Hosts

In the United States, the host list is growing; as of this writing, it includes 29 hosts (Table 2) and 31 associated species (Table 3) from many plant families. Associated species are those found infected under natural conditions, and from which the pathogen has been detected and/or cultured, but experimental confirmation of disease causality has not been demonstrated or documented. For an up-to-date list of hosts and associated species, see <http://www.aphis.usda.gov/ppq/ispmlsod/usdasodlist.html>

Laboratory tests indicate that many more plant species, both wild and cultivated, are potentially susceptible to *P. ramorum*. In Europe, nursery hosts include rhododendron cultivars, *Viburnum* spp., *Pieris* spp., *Hamamelis virginiana*, and *Camellia* spp. The disease has been reported from nurseries and gardens in Germany, the Netherlands, Belgium, France, Poland, Spain, Italy, Sweden, and the U.K. *P. ramorum* also has been detected in a park on mature red oak specimen trees (*Quercus rubra* and *Q. falcata*) and on beech (*Fagus sylvatica*), horse chestnut (*Aesculus hippocastanum*), and seedlings of holm oak (*Quercus ilex*) in U.K. woodlands.

Table 1. Nursery hosts reported in the Pacific Northwest, plant part infected, and known symptoms of *Phytophthora ramorum*.

Plant Species	Common Name	Symptoms
<i>Camellia japonica</i>	Japanese camellia	Leaf lesions
<i>Camellia sasanqua</i>	Sasanqua camellia	Leaf lesions
<i>Kalmia latifolia</i>	mountain laurel	Leaf lesions, shoot dieback
<i>Pieris floribunda</i> x <i>japonica</i>	<i>Pieris</i> x ‘Brouwer’s Beauty’	Leaf lesions, shoot dieback
<i>Pieris formosa</i> x <i>japonica</i>	<i>Pieris</i> x ‘Forest Flame’	Leaf lesions, shoot dieback
<i>Pieris japonica</i>	Japanese pieris	Leaf lesions, shoot dieback
<i>Rhododendron</i> hybrids	rhododendron	Leaf lesions, shoot dieback; death of mature plants
<i>Viburnum</i> x <i>bodnantense</i>	Bodnant viburnum	Stem lesions
<i>Viburnum plicatum</i> var. <i>tomentosum</i>	doublefile viburnum	Leaf lesions, shoot dieback; death of mature plants
<i>Viburnum tinus</i>	viburnum	Leaf lesions, shoot dieback

Symptoms

Phytophthora ramorum causes different symptoms on different hosts. “Sudden oak death” on tree species is characterized by “bleeding” cankers that girdle the trunks of tanoaks (Figure x) and some other oak species. On *Rhododendron*, *Pieris*, *Viburnum*, *Camellia*, and evergreen huckleberry, the disease is characterized by leaf blight and shoot dieback and is more appropriately called *Phytophthora ramorum* blight. Symptoms on rhododendron may be indistinguishable from those caused by other *Phytophthora* species. The leaf petiole and midrib may be discolored, or the leaf tip or entire leaf blade may be necrotic. Leaf spots can occur where water accumulates on the leaf margins. Shoots die back when disease is severe. On *Viburnum*, infected leaves may die and fall off, leaving dark, leafless stems. In more severe infections, *Viburnum* can be killed. On *Pieris*, infected leaves turn a dark brown. Young shoots and leaves of *Pieris* are very susceptible to infection. Other hosts such as camellia may be infected but have only subtle symptoms, such as small leaf lesions on the lower leaves. Infected leaves on these hosts often fall off.

Biology

Phytophthora ramorum is a fungus-like organism well adapted to the cool, wet conditions of the Pacific Northwest and at the same time tolerant of heat and drought. Unlike most *Phytophthora* species that infect roots, *P. ramorum* is mainly a foliar pathogen. It produces several spore types, which helps the organism survive and spread. Spores landing on wet leaves or stems germinate and infect the plant. Young leaves are especially susceptible. Within a few days, sporangia are produced, and they release tiny, swimming spores (zoospores). The sporangia



themselves can also detach, germinate, and infect. Sporangia and zoospores can be moved with windborne rain, in irrigation water, or with water splashed onto foliage.

P. ramorum produces chlamydospores, which in other *Phytophthora* species are important for surviving unfavorable conditions. There are two mating types, designated A1 and A2. The forest isolates from California and Oregon are the A2 mating type, while the European isolates are mainly A1.

Both mating types have been isolated from Oregon and Washington nurseries.

If both mating types are in an infected plant, the pathogen could undergo sexual

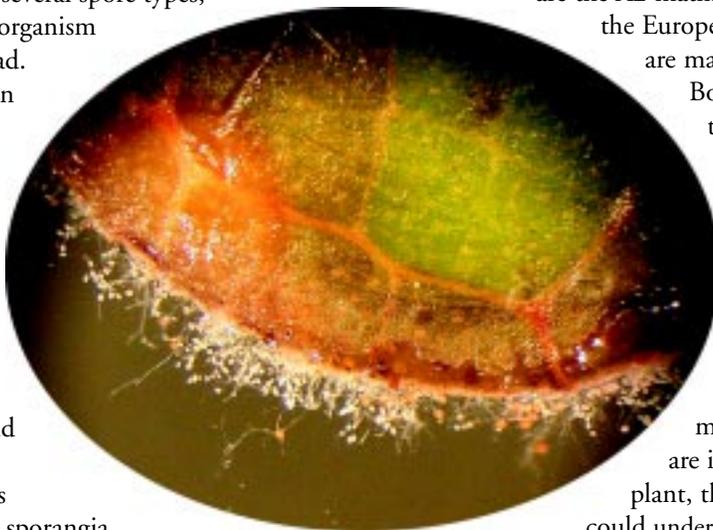


Figure 3 (above).

— *Viburnum plicatum* var. *tomentosum* ‘Mariesii’ infected with *P. ramorum*, showing a necrotic leaf as well as defoliation near the base of the plant.

Figure 4 (at left).

— Sporangia (clear) and chlamydospores (amber) of *P. ramorum* on an infected Oregon myrtlewood leaf.

Figure 5 (near right). — Symptoms on *Camellia* include leaf lesions and defoliation.

Figure 6 (far right). — Leaf spots on *Camellia japonica* caused by *P. ramorum*.



Table 2. Host plants for *Phytophthora ramorum*.

Plant species	Common name
<i>Acer macrophyllum</i>	bigleaf maple
<i>Aesculus californica</i>	California buckeye
<i>Arbutus menziesii</i>	madrone
<i>Arctostaphylos manzanita</i>	manzanita
<i>Camellia japonica</i>	Japanese camellia
<i>Camellia sasanqua</i>	Sasanqua camellia
<i>Hamamelis virginiana</i>	witch hazel
<i>Heteromeles arbutifolia</i>	toyon
<i>Lithocarpus densiflorus</i>	tanoak
<i>Lonicera hispidula</i>	California honeysuckle
<i>Pieris formosa</i>	Himalaya pieris
<i>Pieris formosa x japonica</i>	pieris 'Forest Flame'
<i>Pieris floribunda x japonica</i>	pieris 'Brouwer's Beauty'
<i>Pieris japonica</i>	Japanese pieris
<i>Pseudotsuga menziesii var. menziesii</i>	Douglas-fir
<i>Quercus agrifolia</i>	coast live oak
<i>Quercus chrysolepis</i>	canyon live oak
<i>Quercus kelloggii</i>	California black oak
<i>Quercus parvula var. shrevei</i>	Shreve oak
<i>Rhamnus californica</i>	California coffeeberry
<i>Rhododendron</i>	rhododendron (including azalea)
<i>Rosa gymnocarpa</i>	wood rose
<i>Sequoia sempervirens</i>	coast redwood
<i>Trientalis latifolia</i>	western starflower
<i>Umbellularia californica</i>	Oregon myrtlewood, California bay laurel
<i>Vaccinium ovatum</i>	evergreen huckleberry
<i>Viburnum x bodnantense</i>	Bodnant viburnum
<i>Viburnum plicatum var. tomentosum</i>	doublefile viburnum
<i>Viburnum tinus</i>	laurustinus

reproduction and form oospores. So far, oospores of *P. ramorum* have been observed only under laboratory conditions, so their role in disease epidemiology is not known. In other *Phytophthora* species, oospores are also thick-walled, like chlamydospores, and are important for surviving unfavorable conditions.

Disease prevention

Management efforts in Pacific Northwest nurseries are focused on eradicating the pathogen where it is found and preventing new infections. Early detection is vital to preventing disease spread. Practices useful in managing other foliar *Phytophthora* diseases also should help protect plants from infection by *P. ramorum*. The following strategies can reduce the risk of this disease in PNW nurseries.

Exclusion and avoidance

- ▲ If importing any species of trees, woody vines or shrubs from any source (out of state or international), you must notify the Nursery Inspection Program Supervisor, Plant Protection Division at the Washington Department of Agriculture by fax at (360) 902-2094 or email: nursery@agr.wa.gov. For more information on Washington's import regulations, go to <http://agr.wa.gov/PlantsInsects>, and click on "Plant Diseases" or "sudden oak death". Federal USDA quarantine regulations regarding *P. ramorum* are online at <http://www.aphis.usda.gov/ppq/ispm/sod>.
- ▲ Keep imported known hosts and plants associated with *P. ramorum* in separate block at least 7 feet from other plants in the nursery for 3 to 6 months. This will allow you to see symptoms develop that initially might have been masked by fungicides or delayed by weather conditions.
- ▲ If you visit infested areas, wash your vehicle and shoes before traveling to disease-free areas.

Cultural management

- ▲ Familiarize yourself and your staff with the range of symptoms caused by *Phytophthora ramorum*. Check your plants often. Diseases caused by other *Phytophthora* species can cause similar symptoms. If you suspect *P. ramorum*, call the Washington Department of Agriculture's Pest Hotline at 1-800-443-6684 or email them at nursery@agr.wa.gov. Diagnosis, using several techniques, may take 2 to 3 weeks.
- ▲ While waiting for the diagnosis, do not move or ship symptomatic plants or any nearby plants; even if they 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*.
- ▲ Disinfect tools and shoes that may have been in contact with contaminated plants or potting media. Incinerate contaminated pots and trays or treat them with aerated steam to kill the pathogen.
- ▲ Propagate cuttings only from plants known to have been free of disease for several months. Sanitize cuttings to eliminate the pathogen; soak cuttings in a disinfectant before storage and/or sticking in rooting medium. Use clean, pathogen-free potting media and clean, new pots.



Figure 7. — Leaf and stem necrosis and shoot dieback on *Pieris japonica*.

- ▲ Manage irrigation to reduce the length of time that foliage is wet. If possible, increase watering intervals. Improve drainage to avoid puddling and splashing. Place pots on fast-draining surfaces.
- ▲ Use only clean water for irrigation. Treat irrigation water to kill spores of *P. ramorum* and other *Phytophthora* species. Remove and destroy any fallen leaf material, dead branches, or plants.

Protection and suppression with fungicides

Use fungicides as preventive treatments on known host plant species. Most fungicides used to manage *Phytophthora* do not kill this organism. They can only prevent the organism from becoming established. They also can prevent continued growth if the organism is already inside the plant—thereby masking symptoms that might have developed. Once chemical activity has subsided with time (about 3 to 6 months), the organism 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.

If you choose to use fungicides, alternate among ones from different fungicide families with different modes of action. For specific fungicides, consult the PNW Plant Disease Management Handbook or An Online Guide to Plant Disease Control at <http://plant-disease.ippc.orst.edu/index.cfm>.

Detection and Eradication

If *P. ramorum* is found in your nursery, WSDA and USDA will work with you to prevent further disease spread, eradicate the infestation, and to monitor your nursery to verify when it is free from *P. ramorum*. The USDA is drafting uniform procedures for dealing with nursery infestations. Check the final regulatory action plan posted on the USDA-APHIS Web site for up-to-date information. The action plan may include many of the following provisions.

- ▲ Samples will be removed from symptomatic plants to confirm the identity of the pathogen. Testing usually will be part of the annual survey.
- ▲ Samples will be taken from other plants in the nursery to determine the extent of the infestation.

Table 3. Plant species associated with *P. ramorum*.

Plant species	Common name
<i>Abies grandis</i>	grand fir
<i>Aesculus hippocastanum</i>	horse chestnut
<i>Arbutus unedo</i>	strawberry tree
<i>Camellia reticulata</i>	camellia
<i>Camellia x. williamsii</i>	camellia hybrid
<i>Castanea sativa</i>	sweet chestnut
<i>Corylus cornuta</i>	California hazelnut
<i>Fagus sylvatica</i>	beech
<i>Kalmia latifolia</i>	mountain laurel
<i>Leucothoe fontanesiana</i>	drooping leucothoe
<i>Pieris formosa</i> var. <i>forestii</i>	Chinese pieris
<i>Pieris formosa</i> var. <i>forestii</i> x. <i>P. jaonica</i>	pieris hybrid
<i>Pittosporum undulatum</i>	Victorian box
<i>Pyracantha koidzumii</i>	Formosa firethorn
<i>Quercus cerris</i>	European turkey oak
<i>Quercus falcata</i>	southern red oak
<i>Quercus ilex</i>	holm oak
<i>Quercus rubra</i>	northern red oak
<i>Rhamnus purshiana</i>	cascares
<i>Rubus spectabilis</i>	salmonberry
<i>Syringa vulgaris</i>	lilac
<i>Taxus baccata</i>	European yew
<i>Toxicodendron diversiloba</i>	Poison-oak
<i>Vaccinium vitis-idaea</i>	lingonberry
<i>Viburnum davidii</i>	David viburnum
<i>Viburnum farreri</i> (= <i>V. fragrans</i>)	fragrant viburnum
<i>Viburnum lantana</i>	wayfaringtree viburnum
<i>Viburnum opulus</i>	European cranberrybush viburnum
<i>Viburnum x. burkwoodii</i>	Burkwood viburnum
<i>Viburnum carlcephalum</i> x. <i>V. utile</i>	viburnum hybrid
<i>Viburnum x. pragense</i>	Prague viburnum

- ▲ Host plants will not be sold or moved during the investigation.
- ▲ Blocks of plants containing infested plants will be destroyed by deep burial or incineration under USDA's or WSDA's direct supervision.
- ▲ Healthy host plants within 10 meters of infested blocks will be held for 90 days* to observe symptoms.
- ▲ Nonhost plants can be shipped during this time.
- ▲ Surrounding properties will be surveyed for *P. ramorum*.
- ▲ Trace-back investigations will be conducted to determine the source of infested plants, and trace-forward investigations will be conducted if any plants from the infested block(s) were shipped.
- ▲ WSDA will monitor water, potting mix, soil, and plants for the presence of *P. ramorum*.
- ▲ The nursery will be tested each year for the next 2 years as a precaution.

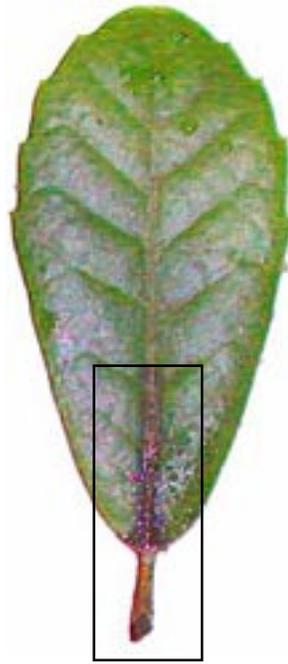


Figure 8 (above left). — Foliar symptoms on susceptible oaks include a darkened petiole and midrib, as on this tanoak leaf, or necrosis at the leaf base.

Figure 9. (above right). — Bleeding canker on the trunk of a mature tanoak.

For further information and updates

Oregon State University Extension Service.
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, University of Idaho, and Washington State University.

Washington Department of Agriculture
▲ <http://agr.wa.gov/PlantsInsects/> (see Plant Diseases or Sudden Oak Death)

California Oak Mortality Task Force
▲ <http://suddenoakdeath.org/>

Davidson, J.M., Werres, S., Garbelotto, M., Hansen, E., and Rizzo, D.M. 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, Sudden Oak Death Alert

▲ <http://oda.state.or.us/plant/ppd/path/SOD/index.html>

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/sod/>

* The 90-day period must be during active plant and pathogen growth; otherwise, the waiting period may be extended.



Figure 10 (above left). — Rhododendron ‘Unique’ plants with ramorum leaf blight. Plant in center foreground was killed by ramorum leaf blight; plant in background shows early symptoms of ramorum leaf blight on lower leaves.

Figure 11 (above right). — Lesions on leaf margins of Rhododendrons ‘Unique’.

Figure 12 (at right, below). — Ramorum shoot dieback on wild rhododendron.



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