

Sudden Oak Death/Ramorum Dieback – implications for the HNS industry

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Phytophthora ramorum is causing dieback of several nursery stock species in the UK. In Western USA the pathogen is causing the death of some native oaks and other woodland species. Legislation has been introduced as a precautionary measure to eradicate the organism where found and to prevent spread within the EU.

This factsheet provides valuable information about *Phytophthora ramorum* in the UK, including its symptoms, sources and spread and gives practical advice about how to reduce risks and what to do if you suspect the disease is present on a site.

Background

Where has *Phytophthora ramorum* been found?

Phytophthora ramorum was first found in Germany and the Netherlands in 1993, but it was not described as a distinct new species until 2001. Since

then, it has been reported in Belgium, Denmark, France, Poland, Spain, Sweden and the UK, and may occur elsewhere in Europe. In the UK, over 5000 nurseries, garden centres and amenity areas have been inspected since 2002 and approximately 6% have been found to have plants affected by *P. ramorum*.

Outside Europe, *P. ramorum* has only been found on the west coast of the USA and Canada. It was only after the death of native oaks in California was attributed to *P. ramorum* in 2001 that the potential threat that this pathogen posed to the UK flora was recognised.



1 Dark brown lesions on shoots of *Rhododendron* caused by *P. ramorum*

Which plants are susceptible?

In the UK, outbreaks of the disease have occurred mainly on species/hybrids of *Rhododendron* and *Viburnum* but also occasionally on *Camellia*, *Kalmia*, *Leucothoe*, *Pieris*, *Syringa* and *Taxus* (see Table 1 for more details).

Of major concern is that important components of UK woodlands, such as oaks, European beech and sweet chestnut could be threatened along with heathland flora, such as bilberry and

cowberry. Concern has arisen because these species show susceptibility in experimental inoculation studies undertaken in the laboratory. However, the potential of *P. ramorum* to infect and seriously damage these plants in the natural environment is not known. On-going research will help determine risks more fully.

In California and Oregon, *P. ramorum* causes the death of native oaks, such as tanoak coast live oak and black oak.

In addition, it causes dieback or leaf blight of many other woodland species including the coast redwood, Douglas fir, and a number of understory shrubs and plants. Some ornamental hosts have also recently been found affected in garden centres/nurseries in California, Oregon, Washington and British Columbia.

Table 1
Hosts of *Phytophthora ramorum* in the UK (July 2003)

Family	Species
Caprifoliaceae	<i>Viburnum davidii</i> <i>Viburnum farreri</i> (syn. <i>Viburnum fragrans</i>) <i>Viburnum lantana</i> <i>Viburnum opulus</i> <i>Viburnum plicatum</i> <i>Viburnum tinus</i> <i>Viburnum</i> x <i>bodnantense</i> (<i>Viburnum farrerii</i> x <i>Viburnum grandiflorum</i>) <i>Viburnum</i> x <i>burkwoodii</i> (<i>Viburnum carlesii</i> x <i>Viburnum utile</i>) <i>Viburnum</i> x <i>carlcephalum</i> x <i>Viburnum. utile</i> <i>Viburnum</i> x <i>pragnense</i> (<i>Viburnum rhytidophyllum</i> x <i>Viburnum utile</i>)
Ericaceae	<i>Kalmia latifolia</i>
	<i>Leucothoe fontanesiana</i>
	<i>Pieris formosa</i> var. <i>forrestii</i> <i>Pieris formosa</i> var. <i>forrestii</i> x <i>Pieris japonica</i> <i>Pieris japonica</i>
	<i>Rhododendron augustinii</i> <i>Rhododendron balfourianum</i> <i>Rhododendron brachycarpum</i> <i>Rhododendron ferrugineum</i> <i>Rhododendron ponticum</i>
	<i>Rhododendron</i> hybrids – hybrids found infected have been derived from crosses involving: <i>Rhododendron arboreum</i> , <i>Rhododendron campylocarpum</i> , <i>Rhododendron catawbiense</i> , <i>Rhododendron campylocarpum</i> , <i>Rhododendron caucasicum</i> , <i>Rhododendron dichroanthum</i> , <i>Rhododendron facetum</i> , <i>Rhododendron forrestii</i> , <i>Rhododendron fortunei</i> , <i>Rhododendron galactinum</i> , <i>Rhododendron geraldii</i> , <i>Rhododendron grande</i> , <i>Rhododendron griffithianum</i> , <i>Rhododendron griersonianum</i> , <i>Rhododendron maximum</i> , <i>Rhododendron ponticum</i> , <i>Rhododendron smirnowii</i> , <i>Rhododendron strigillosum</i> , <i>Rhododendron viscidifolium</i> , <i>Rhododendron wardii</i> , <i>Rhododendron yakushmanum</i> and possibly other species
Oleaceae	<i>Syringa vulgaris</i>
Taxaceae	<i>Taxus baccata</i>
Theaceae	<i>Camellia japonica</i> <i>Camellia reticulata</i> <i>Camellia</i> x <i>williamsii</i> (<i>Camellia saluenensis</i> x <i>Camellia japonica</i>)

Symptoms

Symptoms that occur on known hosts in the UK are described below. Other pathogens can produce symptoms similar to those caused by *P. ramorum* so care must be taken with the diagnosis. Laboratory analysis is required before diseases can be positively attributed to *P. ramorum*.

Rhododendron dieback

The pathogen primarily causes an aerial dieback on both nursery plants and mature bushes.

Diseased shoots have brown to black lesions that usually begin at the tip and move towards the base. However, cankers may form on any part of the shoot (Fig 1) or stem. The internal tissue of the diseased twig is killed causing a light brown discolouration which is distinctly different to the normal off-white colour visible when the bark is removed. Cankers near ground level can result in rapid wilting of shoots, causing the leaves, which remain attached, to hang down (Fig 2).

The most characteristic leaf symptom is the blackening of the leaf petiole extending into the leaf base (Fig 3). This may spread further along the midrib causing blackening of the leaf.

Leaves can become diseased with and without shoot infection. Diffuse brown spots or blotches frequently



2 Dieback on a Rhododendron bush caused by *P. ramorum*



3 Dark brown lesion on leaf of *Rhododendron ponticum*. *P. ramorum* has entered the leaf from a shoot via the petiole and is developing along and out of the line of the midrib. Infection has also occurred along the margins of a wound (right)

occur at the leaf tip (where moisture can accumulate and remain for extended periods encouraging infection), but can form elsewhere. Eventually, entire leaves can turn brown to black and may fall prematurely.

Although *P. ramorum* has been isolated from roots and stem bases, the pathogen is not considered to cause significant rotting in these areas, unlike other *Phytophthora* species.

Viburnum dieback

Infection usually occurs at the stem base (Fig 4) causing plants to wilt and collapse very quickly. The cambial tissue in the stem initially turns brown, but eventually becomes dark brown. Leaf spots or leaf blight may also occur, especially on evergreen species (Fig 5). Twigs and shoots may also be affected. Minor root rotting has been observed.



4 Dieback of *Viburnum tinus*, due to a basal canker (arrow) caused by *P. ramorum*. The outer layers of the affected stem have been removed to show discoloured inner tissues. The exposed stems on either side are unaffected



5 Lesion on leaf of *Viburnum davidii*. Infection has probably occurred at the leaf tip with the pathogen subsequently invading the lamina from the line of the midrib. Older dead tissue has changed from dark to light brown

Pieris dieback

Leaf symptoms are similar to those on *Rhododendron*. Black lesions can develop at leaf bases as a result of infections spreading down the shoot and along the petiole (Fig 6). Lesions also typically occur at the leaf tip or leaf edge where water accumulates. The whole leaf can also become blighted. Individual stem cankers lead to aerial dieback.

Kalmia and Leucothoe leaf spot

Infection usually occurs at the leaf tip (Figs 7 and 8). The pathogen subsequently grows through leaf tissues towards the leaf base causing a brown to black discolouration.

Camellia leaf blight

Brown to black leaf-tip spots (Fig 9) form that may result in entire leaf death. Stems have been found to be susceptible in laboratory-based, inoculation experiments so it is possible that dieback could also occur.

Lilac leaf and bud blight

Leaf symptoms observed so far on *Syringa vulgaris* have been similar to those seen on *Kalmia*, *Leucothoe* and *Camellia*. Necrosis begins on leaf tips and at leaf margins. Greyish-brown, diffuse, water-soaked lesions become evident later (Fig 10). Under laboratory conditions, the infection has not progressed into the shoot as leaves have abscised. Bud blight leads to the brown to black discolouration of shoots as the infection spreads.



6 Brown lesion at base of leaf of *Pieris japonica* caused by *P. ramorum*. The pathogen has entered the leaf from the petiole



7 Lesions on leaves of *Kalmia latifolia*. Infection has occurred at the leaf tips where moisture accumulates. Older dead tissue has changed from dark to light brown



8 Brown lesions on leaves of *Leucothoe fontanesiana*. Infection has occurred at the leaf tips



9 Brown lesion on leaf of *Camellia japonica*. Infection has occurred at the leaf tip where moisture accumulates



10 Light brown lesion on leaf of *Syringa vulgaris*. Infection has occurred at the leaf tip

Yew leaf blight

P. ramorum has been isolated from brown lesions on young leaves on new shoots of container-grown *Taxus baccata*. Yew leaf blight has only been found on plants at one nursery and has not been seen on mature trees.

Sudden oak death in California and Oregon

On oaks native to the Pacific coast of the USA, such as coast live oak and

black oak, a typical symptom is the oozing or 'bleeding' of a reddish-brown to black viscous discharge from bark lesions at the base of the trunk (Fig 11). Trees wilt and foliage turns brown. Some oaks die quickly while the decline of others may take several years. Some trees may survive infection.

Basal trunk cankers on tanoak cause rapid mortality (Fig 12). However, unlike coast live oak and black oak, infections can occur on all aerial plant

parts, including leaves, shoots, branches and any place on the trunk.

P. ramorum has not been found causing a lethal disease of trees in Europe.



11 'Bleeding' canker caused by *P. ramorum* at the base of the main trunk of a coast live oak (*Quercus agrifolia*) in California



12 Dead and dying tanoak (*Lithocarpus densiflorus*) as a result of disease caused by *P. ramorum* in a forest in Marin County, California

Biology

How does the disease spread?

The movement of infected plants in trade is the main means of long-distance spread. Plants may not show symptoms for some time after infection, especially if growth of the pathogen is suppressed by the use of fungicides with activity against *Phytophthora* species. Symptoms may develop after the plant has been sold or moved to a different location. In this way, the pathogen can be spread on host plants from location to location and country to country.

Localised spread of the pathogen is by fungal spores (sporangia), produced on the surface of infected leaves and shoots. These are spread by rain splash, wind-driven rain or irrigation water and possibly aurally or by insects. Sporangia germinate under moist conditions to release water-motile zoospores. Both spore types are short-lived and have

been found in stream water, ponds and small reservoirs. Care must be taken to ensure sources of irrigation water are not contaminated especially where there is a risk of recontamination from soil and plant debris.

Thick-walled, long-lived spores which allow the long-term survival of the pathogen, can be produced within infected tissues or on the surface of fallen leaves under moist conditions.

Growing media, debris and soil on vehicles, machinery, footwear or livestock can also harbour the pathogen.

How do plants become infected and develop symptoms?

Spores germinate on plant surfaces and infect through wounds and natural openings, such as stomata and lenticels. Once inside the plant, the pathogen grows through the tissue causing cells to die. After many cells have been killed, symptoms appear.

Other organisms that invade weakened and wounded plant tissues may accelerate the process. Roots are rarely invaded.

What conditions favour disease development?

Phytophthora species, commonly known as water moulds, are dependant on moisture for completion of their lifecycles. Wet environments favour spore production, germination and infection. Therefore, conditions that allow moisture to remain on plant surfaces favour disease.

Laboratory tests have shown that the pathogen is a cool, temperate organism with an optimum temperature for growth of 20°C. Its minimum growth temperature is 2°C and maximum 30°C.

Management and control

What should you do if you know/suspect a disease caused by *P. ramorum*?

The disease is notifiable. Inform your local Plant Health Inspector if you know or suspect that species of *Rhododendron*, *Viburnum* or any other plant genus is affected by *Phytophthora ramorum*.

Contact Defra Plant Health and Seeds Inspector or the PHSI HQ, York, Tel: 01904 455174, Fax: 01904 455197 Email: planthealth.info@defra.gsi.gov.uk, Website: www.defra.gov.uk


What is being done to manage the disease situation?

Early detection followed by prompt quarantine action is the basis of effective disease management.

The Plant Health and Seeds Inspectorate (PHSI) are conducting surveys throughout England and Wales to check for the presence of the pathogen in garden centres, nurseries and public gardens/parks. Similar action is being undertaken by equivalent agencies in Scotland, Northern Ireland and the rest of the UK. When detected, the pathogen is being eradicated. The origins of diseased stocks are traced to determine possible sources of infection. Sources can be from within the UK or elsewhere in Europe.

The Forestry Commission is investigating oak and other trees with suspicious symptoms and checking for the presence of *P. ramorum*. The pathogen has not been implicated in the decline of trees in any cases investigated.


Why eradicate the pathogen?

The eradication of the pathogen in the UK would eliminate the potential threat that it poses to native oaks, other forest and amenity trees, heathland plants and ornamental hosts. The further spread of *P. ramorum* within and 

between countries in Europe is also undesirable. Hence, the movement of most species of *Rhododendron* and all species of *Viburnum* is being controlled by plant passporting (see Panel 1 for more details).

Currently, no compensation is offered for losses due to disease eradication.

How is the eradication being undertaken?

- When an outbreak has been confirmed by a Plant Health Inspector, all affected plants and all known natural hosts within a 2m radius must be destroyed.
- All known natural hosts within a 10m radius of affected plants cannot be moved for three months. These plants have to be inspected by a Plant Health Inspector on at least two occasions during this period and found free of disease symptoms.
- All known natural hosts must also be inspected and found free of disease before movement off site can occur.
- Follow-up inspections will take place every three months for nine months after eradication.
- For infected container-grown stock, the surface on which the containers were standing, such as benches and concrete platforms/slabs, must be disinfected. Antec Farm Fluid S[®] (acetic acid, dodecyl benzene sulphonic acid and hydroxy hybridenes) is suitable for footwear and equipment at a concentration of 2%. Panacide-M[®] (sodium dichlorophen) should be used for gravel and standing-out areas at a concentration of 1.66%. Surfaces to be treated should be cleaned to remove soil and debris before application of disinfectants. After treatment, surfaces should be left for at least 10 minutes before washing off with water. 

- Soil that has supported the growth of diseased plants could be contaminated with spores of *P. ramorum*. This soil should be either removed and deep buried or sterilised by an appropriate method, such as steam or chemical treatment before reuse.

Can the disease be controlled with fungicides?

Although fungicides active against *Phytophthora* may provide some protection against this disease, they will not eradicate it. Once infection has occurred, the use of fungicides will only suppress disease development and mask symptoms, as has been demonstrated at nurseries where outbreaks have persisted despite regular treatment. Suppression of symptoms by fungicides could seriously compromise eradication of the disease. Therefore, fungicides should not be used when eradication is being attempted.

What research is being undertaken on disease management?

Research is underway at the Central Science Laboratory of Defra and the Forestry Commission to determine risks to ornamental plants, trees and ecosystems in the UK. The pathogen has a wide experimental host range, but this does not necessarily mean that all species will become infected under natural conditions. The epidemiology of the pathogen is being studied, as are the most effective measures for control. Disinfectants and fungicides are under evaluation in HDC-funded work.

Scientists in the UK liaise regularly with their counterparts in overseas research groups. As a result, information between programmes investigating *P. ramorum* is rapidly exchanged and utilised.

Panel 1

Plant passporting scheme

Certain plants and plant products moving within and between countries in the EU must be accompanied by a plant passport. A plant passport must include the words 'EC Plant Passport', a country identifier such as UK, NL or FR and a 5 digit reference number. It may include 'ZP' if the plants have a replacement passport. Check that your supplier is providing a valid passport. Plants that do not have a valid passport will be destroyed. This passport provides documentary evidence that:

- The plants covered have been grown by a registered grower, whose premises are regularly inspected, and who is authorised to issue plant passports

- The plants are, to the best of the producer's knowledge, free from all quarantine pests and pathogens and, where appropriate, grown in an environment which is also free from these pests and pathogens
- Plants imported from outside the EU have been landed by a registered importer, inspected on arrival in the UK or in another Member State (or at an approved destination) and found to be free from quarantine pests and pathogens prior to being passported for movement within the EU.

The scheme aims to provide protection against the dissemination of

harmful organisms, which now include *P. ramorum*.

Species/hybrids of *Rhododendron*, (other than *R. simsii*, which is resistant to *P. ramorum* in tests) and *Viburnum* are now subject to plant passporting requirements. The conditions of the passport are that the material originates in areas where *P. ramorum* is known not to occur or where there have been no signs of the pathogen at the place of production. In cases where signs of the pathogen have been found, appropriate procedures for eradication should have been implemented.

What can be done to minimise risks on the nursery/garden centre?

Although there are currently no fungicides available to control *P. ramorum* on nurseries, garden centres and amenity areas, there are a number of steps which will help reduce the risk of infection and spread of the disease.

Guidance on disease prevention

- Nurseries and garden centres should not accept susceptible plant material without a plant passport (see Panel 1 above).
- Notify your Plant Health Inspector if you are offered susceptible material without a plant passport or an invalid passport. Follow up action by PHSI will help to cut the risk of importing the disease.
- Growers buying in stock of susceptible plants are advised to ask their suppliers for a written assurance that the plants they intend to purchase have not been sprayed with a disease suppressant within six weeks of the date of shipment.

- Where possible, growers should try to obtain an agreement with their supplier that payment will be subject to the plants remaining healthy for a specific period.
- Inspect all susceptible plant species for signs of the disease BEFORE placing them on the main nursery beds or sales areas.
- Consider establishing a 'quarantine' area to hold bought-in material away from the main production nursery. This would enable signs of disease suppressed by fungicides to develop without risking the main stock.
- Remove all leaf and plant debris from the beds underneath susceptible material.

Steps to follow on the nursery

- Inspect all known hosts, especially *Rhododendron* and *Viburnum*, for signs of disease at regular intervals. Other pathogens may give rise to similar symptoms and laboratory tests, arranged by PHSI, will be needed to verify the cause.
- Train nursery staff to look out for symptoms so that any disease present can be identified at an early stage.

- Ideally, blocks of susceptible plants should be spaced at least 10m apart. In this way, if the disease is found on any plants, only the block around it will be subject to control measures.
- Consider if it is possible to reduce the number of highly susceptible species on the site and if possible, change crops on previously infected areas to non-susceptible genera.
- Implement hygiene measures to reduce the likelihood of spread by contaminated soil, equipment or staff. Disinfect pruning tools and Danish trolley shelves regularly. It may be worthwhile disinfecting footwear and plant beds. Antec Farm Fluid S[®] is effective on footwear and equipment, whilst Panicide-M[®] is suitable for gravel and standing out areas.
- Where possible, avoid the use of overhead irrigation as water splash can spread the disease. Similarly, placing susceptible material under protection will cut rain splash.
- If plants have been standing on capillary matting, sterilise or replace the matting before any new crop is stood out.

- Do not use hosepipes from infected areas on uninfected areas.
- Fungicides active against *Phytophthora* may afford some protection against infection, but are unlikely to eradicate any infection.
- Growers are advised to communicate to their customers that they have complied with all the necessary legislation and advise them of the steps they have taken to minimise the risk. It might be an option to offer an alternative lower risk variety or plant.
- If in doubt, seek advice from the local PHSI Inspector.

Guidance to landscapers

- Landscapers are required to comply with all the relevant legislation relating to *P. ramorum*, including the destruction and quarantine of infected and suspected plants, as required by PHSI.
- Landscapers must comply with all the requirements of the plant passport legislation and should not accept or sell any plants without the necessary passport documentation.

- Landscapers buying in stock of susceptible plants are advised to talk to their suppliers and ask for a written assurance that plants they intend to purchase have not been sprayed with a disease suppressant within six weeks of the date of shipment.

Further information

In England and Wales, your local office of the Plant Health and Seeds Inspectorate (PHSI) should be notified if an outbreak of the disease is suspected.

PHSI can also be contacted for details of the plant passporting scheme and

for advice on the disease eradication process). A handbook of plant passporting can be downloaded at <http://www.defra.gov.uk/planth/publications/passport/pass.pdf>

PHSI Headquarters is located in York (Tel: 01904 455174; Fax: 01904 455197; Email: planthealth.info@defra.gsi.gov.uk).

The Horticultural Trades Association could also be contacted for information (Tel: 01189 303132).

If seeping bark cankers that could be caused by *P. ramorum* are seen on trees, the Forestry Research Advisory Service should be contacted (Tel: 01420 23000 or 01420 22255).

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