

Phytophthora ramorum

A Practical Guide for Established Parks & Gardens, Amenity Landscape and Woodland Areas



Department for Environment, Food and Rural Affairs
Nobel House
17 Smith Square
London SW1P 3JR
Telephone 020 7238 6000
Website: <http://www.defra.gov.uk>

© Crown copyright 2008

Copyright in the typographical arrangement and design rests with the Crown.

This publication (excluding the logo) may be reproduced free of charge in any format or medium provided that it is reproduced accurately and not used in a misleading context. The material must be acknowledged as Crown copyright with the title and source of the publication specified.

Further copies of this publication are available from:
Defra Publications
Admail 6000
London
SW1A 2XX
Tel: 08459 556000

This document is also available on the Defra website.

Published by the Department for Environment, Food and Rural Affairs. Printed in the UK, November 2008, on material that contains a minimum of 100% recycled fibre for uncoated paper and 75% recycled fibre for coated paper.

Product code PB12983

Acknowledgements

Thanks to all those involved in the development of this Action Plan, both within and outside Defra, including those who attended our policy and research seminars and those who gave feedback on earlier drafts. We look forward to working with partners and stakeholders in taking this forward.

Further information

Requests for further information can be sent to the Natural Environment Strategic Unit, which leads this work within Defra. Please email ecosystems@defra.gsi.gov.uk or write to the Natural Environment Strategic Unit, Area 3D, Nobel House, 17 Smith Square, London SW1P 3JR.

This Action Plan, along with further information on our research programme, is available online at <http://www.defra.gov.uk/wildlife-countryside/natres/eco-actionp.htm>

What to do if *P. ramorum* or *P. kernoviae* is suspected

Check symptoms carefully and if you suspect disease is present, notify Defra PHSI (or your relevant Plant Health Authority) immediately. In woodland situations, notify the Forestry Commission (Plant Health Service). This is a legal requirement. If confirmed, a Statutory Notice will be issued specifying required actions. In the meantime:

- Cordon off the area concerned and restrict public access.
- Do not handle or move the plants.
- Inspect other susceptible plants for symptoms and keep under review. Include the perimeters of sites containing trees or likely hosts such as 'wild' *Rhododendron*.
- Do not apply anti-*Phytophthora* fungicides to plants where infection is suspected. Such fungicides are likely to suppress but not eradicate the pathogens.
- Restrict or, where practical, avoid the use of overhead watering with plants known or thought to be infected.
- Provide the authorities concerned with all necessary documentation and records including, where appropriate, plant passport information.

What to do if *P. ramorum* or *P. kernoviae* is confirmed

If either disease is confirmed, a Statutory Notice will be issued detailing the eradication and containment actions required (see eradication and containment policy at 10.3). Ensure all the required actions including any stipulated removal and destruction of plant material, containers and associated soil or growing media are implemented as soon as possible within the timeframe laid out in the Statutory Notice. The following actions may be specified:

- Removal of plant debris and surrounding leaf litter.
- Prevention/removal of re-growth.
- Excision of infected bark and wood on trees with bleeding cankers.
- Prohibition on the movement of infected plants and use of infected material (e.g. propagation/foilage display purposes).
- Prohibition on the use of anti-*Phytophthora* fungicides on any plants held under Statutory Notice.

The Notice will also require appropriate measures to be taken to prevent re-infection of the site. These measures may include:

- Restricting public access (e.g. appropriate signage, cordoning off).
- Not planting susceptible plants within a four metre radius of where infected plants were for a period of three years or,
- The removal and deep burial of soil.

Phytophthora ramorum and *Phytophthora kernoviae*

A Practical Guide for Established Parks & Gardens, Amenity Landscape and Woodland Areas

1. Summary	3
2. Reasons for concern	3
3. Biology	5
3.1 Disease spread	5
3.2 Infection	6
3.3 Favourable conditions	6
4. Hosts	7
4.1 <i>Phytophthora ramorum</i>	7
4.2 <i>Phytophthora kernoviae</i>	8
5. Symptoms	9
<i>Phytophthora ramorum</i>	9
5.1 On ornamentals	9
5.2 On trees	14
<i>Phytophthora kernoviae</i>	15
5.3 On ornamentals	15
5.4 On trees	19
6. Biosecurity measures	21
6.1 Risk assessment and surveillance	21
6.2 Quarantine	22
6.3 Hygiene	24
6.4 Watering plants	26
6.5 Good husbandry	26
6.6 Dealing with wild <i>Rhododendron</i>	27
7. Recording and propagating important plants	29
8. Dealing with enquiries, garden visitors and public access	30
9. Plant passports – what are they and how do they work?	31
10. Disease management and control	32
10.1 Who does what	32
10.2 Notification	32
10.3 Eradication and containment policy	32
10.4 Dealing with waste	34
10.5 Publicity and outbreak sites	35
11. Research	36
11.1 Risk analysis for <i>Phytophthora ramorum</i> (RAPRA) project	36
11.2 Further research information	36
12. Contact points for advice and further information	37

Loose Posters

- What to do if the diseases are suspected or confirmed (A4)
- *Phytophthora ramorum* symptoms in ornamental plants and trees (A3)
- *Phytophthora kernoviae* symptoms in ornamental plants and trees (A3)

1. Summary

Phytophthora ramorum is a fungus-like organism capable of causing serious damage to a wide range of ornamental and native plants, as well as some commercially grown trees. In Western USA, it has caused the death of more than a million native oak trees and is commonly known as 'Sudden Oak Death'. In Europe, *P. ramorum* has been confirmed on a range of plants, principally varieties of *Rhododendron*, *Viburnum*, *Pieris* and *Camellia* but also some trees. It has also been found on a variety of different sites including public parks and historic gardens. In such situations, public access and the heightened potential for disease spread is a particular concern; many such gardens house historically important plant collections. More rarely, *P. ramorum* has also been found within unmanaged woodland sites.

Phytophthora kernoviae is a similar organism and attacks some of the same hosts as *P. ramorum*. In the field it can be more virulent than *P. ramorum* and capable of killing or severely damaging *Rhododendron*. So far, most tree finds have been in woodland areas close to heavily infected *Rhododendron ponticum*, the principal carrier host.

Legislation has been introduced to control, contain and eradicate *P. ramorum* and *P. kernoviae*. Both diseases are subject to statutory control measures.

This guide deals principally with *P. ramorum*, but includes important information (specifically host and symptom details) about *P. kernoviae*. It is aimed at public parks and historic gardens, amenity landscape and woodland situations and provides details of disease symptoms, means of spread, current host range and practical control measures.

2. Reasons for concern

P. ramorum and *P. kernoviae* have the potential to kill some species of native British trees and are a serious threat to the environment and commerce including amenity plantings, heathland flora, historic gardens and woodland sites. A major epidemic amongst native trees and amenity plantings would have debilitating consequences for the horticultural industry, the wider landscape and biodiversity in general. The impact across many aspects of local economies for example would be significant, particularly in terms of lost revenue from tourism in some areas. In woodland situations, commercial timber values would also suffer.

A range of European and forest trees are at risk and the ability of *P. ramorum* to spread quickly is a particular concern. Although *P. kernoviae* has, to date, only been found at a limited number of sites in England and Wales, and recently in New Zealand, early observations suggest it causes more serious disease on *Rhododendron* than *P. ramorum*. It does, though, appear to have a more limited host range.

Progression of *Phytophthora kernoviae* on Beech

Containment and eradication measures can only work if they have the support of all stakeholders; prompt reporting of suspicious symptoms, for example, is very important. Control measures can then be implemented swiftly to reduce the impact of the diseases – and associated costs to commerce, tourism and leisure. The impact of statutory action will vary depending on the extent of the problem. Eradication does not necessarily mean widespread disruption or damage to the character of a garden or woodland, particularly when carried out promptly and sensitively. It may also provide opportunities to diversify, do something different and 'begin again' with the replanting and regeneration of new or alternative plants. Future design considerations should take account of this.

Early symptoms



Progression at approximately 3 months



Progression at approximately 6 months



Progression at approximately 12 months



3. Biology of *Phytophthora ramorum*

3.1 Disease spread

There are several pathways for disease spread:

- Movement of infected plants and material between different sites, particularly nursery and landscape developments.
- Splash dispersal of spores, which are produced on infected foliage, by rain and overhead irrigation systems.
- Water run-off.
- Wind driven rain carrying and dispersing spores.
- Movement of contaminated soil, growing media or debris particularly around nursery, garden and landscape developments.
- Movement of contaminated soil, growing media or debris on footwear, vehicles or via animals can spread the pathogen.
- Water courses and irrigation reservoirs with contaminated water.
- Contaminated pruning/nursery tools.
- Plant sales or holding areas where contamination may be near the surface of display beds (e.g. sand/gravel).

The movement of infected plants is the principal means of long distance spread. However, contaminated footwear is another potentially significant source of disease spread, particularly in areas of public access. There is evidence that the disease can be readily transferred on muddy boots.

Localised spread of the pathogen is by (asexual) spores (sporangia), produced on the surface of infected leaves and shoots. Plants which suffer leaf and shoot infection, such as *Rhododendron*, are, therefore an important source of inoculum for initiating and maintaining epidemics of tree mortality. *Rhododendron ponticum* is the principal leaf host in semi-natural and natural environments contributing inoculum to trees (causing lethal bark infections), although some tree species with susceptible leaves may also contribute. These include holm oak (*Q. ilex*), ash (*Fraxinus* spp.) and sweet chestnut (*C. sativa*).

Water is also a transport mechanism for *P. ramorum* and it has been detected in rivers and streams near to some of the outbreak sites. Irrigation (particularly overhead watering) from infected sources also spread the disease. Routine disease monitoring should, therefore, include water testing. (In outbreak sites, this is usually undertaken by the local plant health inspector.) Sporangia germinate under moist conditions to release water-mobile zoospores capable of spreading the disease still further. Both these spore types may be relatively long lived under humid conditions and have been found in streams, ponds and 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 spores, known as chlamydospores, allow the long-term survival of the pathogen and are primarily produced within infected plant tissue. Growing media, debris and soil on vehicles, garden tools, machinery, footwear or animals can also harbour and spread the pathogen. A disciplined approach to hygiene is, therefore, particularly important.

In general, symptoms will develop soon after infection with *P. ramorum* during the growing season. However, symptom development may be suppressed by the use of fungicides with activity against *Phytophthora* species. Symptoms may develop after plants have been sold or moved to a different location and so, in this way, the disease can quickly spread.

P. kernoviae also produces sporangia but not chlamydospores, although it does produce potentially long lived oospores that can allow it to persist in the environment for some time.

3.2 Infection

Like other *Phytophthora* species, *P. ramorum* is a primary pathogen and can infect directly into healthy plant tissue as well as through wounds. For example, container plants blowing over onto contaminated ground/beds can also become infected. Spores germinating on the surfaces of leaves and stems infect through wounds or natural openings, such as leaf stomata and lenticels. Infections often occur in association with areas on the leaf where water accumulates, such as the tips or edges. Pruning cuts are ideal entry points for infection. Plant cells are killed as the infection spreads through plant tissue and disease symptoms follow. Following infection under optimal conditions, symptoms may appear after only a few days. Symptom development may be affected by a number of factors such as temperature and humidity. In the winter months, disease progression may be slower, leading to delayed symptom development. Tests in the laboratory using *Rhododendron* leaves indicate no evidence of any latent infection.

3.3 Favourable conditions

P. ramorum is a cool temperature pathogen; optimum growth temperature is 20°C, whilst minimum and maximum temperatures are 2°C and 30°C respectively. It can survive extended periods of freezing temperatures, even if it doesn't grow. Like other *Phytophthora* species, it requires moisture to complete its life cycle; wet environments favour spore production, dispersal, germination and infection. Therefore, humid conditions, which allow moisture to remain on plant leaves and stems, favour disease infection and spread. This may partly explain why *P. ramorum*/*P. kernoviae* are more prevalent in established plantings in the south-west. The topography of the area is also likely to be a factor: sheltered valleys, densely wooded ravines and enclosed garden sites, heavily populated with principal host plants, provide an ideal microclimate for disease spread.

Distribution of the disease, both in North America and in Europe, may also reflect where the pathogens were first introduced from their original (unknown) source. It would be unwise to assume that conditions are unfavourable in all those areas where the disease has not been found.

4. Hosts

4.1 *Phytophthora ramorum*

Table 1 provides a listing of recorded hosts of *P. ramorum* in the UK; updated host details can be found at www.defra.gov.uk/planth/newsitems/suscept.pdf. Particular attention should be paid to these, especially *Rhododendron* which is the principle host, when monitoring and undertaking inspections.

Table 1: Recorded natural hosts of *Phytophthora ramorum* in the UK (December 2007)

Family	Species and cultivars of listed species
Aceraceae	<i>Acer laevigatum</i> , <i>Acer pseudoplatanus</i>
Caprifoliaceae	<i>Viburnum</i> spp.
Cornaceae	<i>Cornus kousa</i> x <i>Cornus capitata</i> , <i>Griselinia littoralis</i>
Ericaceae	<i>Arbutus unedo</i> , <i>Gaultheria shallon</i> , <i>Kalmia latifolia</i> , <i>Leucothoe fontanesiana</i> , <i>Pieris</i> spp., <i>Rhododendron</i> spp., <i>Rhododendron</i> hybrids (disease infection has been confirmed on a range of hybrids derived from various crosses)
Fagaceae	<i>Castanea sativa</i> , <i>Castanopsis orthacantha</i> , <i>Fagus sylvatica</i> , <i>Quercus acuta</i> , <i>Quercus cerris</i> , <i>Quercus falcata</i> , <i>Quercus ilex</i> , <i>Quercus petraea</i>
Garryaceae	<i>Garrya elliptica</i>
Hamamelidaceae	<i>Hamamelis mollis</i> , <i>Hamamelis virginiana</i> , <i>Parrotia persica</i>
Hippocastanaceae	<i>Aesculus hippocastanum</i>
Lauraceae	<i>Cinnamomum camphora</i> , <i>Laurus nobilis</i> , <i>Umbellularia californica</i>
Magnoliaceae	<i>Magnolia</i> spp., <i>Michelia doltsopa</i> , <i>Michelia maudiae</i>
Myrtaceae	<i>Eucalyptus haemastoma</i>
Nothofagaceae	<i>Nothofagus obliqua</i>
Oleaceae	<i>Fraxinus excelsior</i> , <i>Syringa vulgaris</i> , <i>Osmanthus delavayi</i> , <i>Osmanthus heterophyllus</i>
Salicaceae	<i>Salix caprea</i>
Taxaceae	<i>Taxus baccata</i>
Theaceae	<i>Camellia</i> spp., <i>Schima</i> sp., <i>Schima wallichii</i>
Winteraceae	<i>Drimys winteri</i>

Source: Defra Plant Health Division & Central Science Laboratory (CSL)

Although Oak (*Quercus* spp.) is the most common tree host, the increasingly recognised wide host range of *P. ramorum* in the UK is a particular concern. In addition to the UK recorded natural hosts listed in Table 1, other confirmed hosts found outside the UK, but which are commonly grown here, include *Acer*, *Arctostaphylos*, *Calluna*, *Lonicera*, *Photinia*, *Pittosporum*, *Pyracantha*, *Pseudotsuga menziesii*, *Quercus rubra*, *Rhamnus*, *Sequoia* and *Vaccinium*. Also, in laboratory tests, some genera (e.g. *Sambucus*) have been found to be particularly susceptible and may become future hosts. Azalea species and varieties have not so far been found with *P. ramorum* infection in commercial or natural situations, although laboratory inoculation studies indicate that some species, particularly deciduous types, are susceptible.

The RAPRA (Risk Analysis for *Phytophthora ramorum*) project databases of natural and potential hosts are useful sources of reference (these can be found on the website at: <http://rapra.csl.gov.uk>). Further details about this research project can be found at Section 11.1.

4.2 *Phytophthora kernoviae*

Like *P. ramorum*, the principal host of *P. kernoviae* is *Rhododendron*, mainly *R. ponticum* although laboratory tests indicate that *Vaccinium myrtillus* is also highly susceptible. In addition to English oak and beech, a number of other native tree species are also known to be susceptible to *P. kernoviae*. Table 2 provides a listing of recorded natural hosts of *P. kernoviae*. Up-to-date host listings can be found at: www.defra.gov.uk/planth/kernovii/kernhost.pdf. Particular attention should be paid to these when monitoring and undertaking inspections.

Table 2 : Recorded natural hosts of *Phytophthora kernoviae* (January 2008)

Family	Host	Type of infection
Annonaceae	<i>Annona cherimola</i>	Shoot and fruit necrosis
Aquifoliaceae	<i>Ilex aquifolium</i>	Leaf infection
Araliaceae	<i>Hedera helix</i>	Stem infection
Ericaceae	<i>Pieris formosa</i>	Leaf infection
	<i>Pieris japonica</i>	Leaf infection
	<i>Rhododendron</i> spp.	Shoot die-back and leaf infection
Fagaceae	<i>Vaccinium myrtillus</i>	Leaf infection and stem lesions
	<i>Fagus sylvatica</i>	Bleeding canker
	<i>Quercus ilex</i>	Leaf necrosis
Magnoliaceae	<i>Quercus robur</i>	Bleeding canker
	<i>Magnolia amoena</i>	Leaf infection
	<i>Liriodendron tulipifera</i>	Bleeding canker and leaf infection
	<i>Magnolia brooklynensis</i>	Leaf infection
	<i>Magnolia cylindrica</i>	Leaf spot and bud blast
	<i>Magnolia delavayi</i>	Leaf blight
	<i>Magnolia</i> Gresham hybrid 'Joe McDaniel'	Leaf infection
	<i>Magnolia</i> Gresham hybrid 'Sayonara'	Leaf infection
	<i>Magnolia kobus</i> DC	Bud base death
	<i>Magnolia</i> Leonard Messel	Leaf spot and bud blast
	<i>Magnolia liliflora</i>	Leaf spot
	<i>Magnolia mollicomata</i>	Leaf infection and stem tip die-back
	<i>Magnolia salicifolia</i>	Leaf infection
	<i>Magnolia sargentiana</i>	Leaf infection
Podocarpaceae	<i>Magnolia x soulangeana</i>	Leaf spot
	<i>Magnolia sprengeri</i>	Leaf infection
	<i>Magnolia stellata</i>	Leaf infection
	<i>Magnolia wilsonii</i>	Foliage necrosis and blossom blight
	<i>Michelia doltsopa</i>	Leaf infection
Podocarpaceae	<i>Podocarpus salignus</i>	Shoot tip wilt and foliar blight
Proteaceae	<i>Gevuina avellana</i>	Leaf infection
Rosaceae	<i>Prunus laurocerasus</i>	Leaf and stem die-back
Winteraceae	<i>Drimys winteri</i>	Foliage necrosis

5. Symptoms

5.1 *Phytophthora ramorum* – On ornamentals

Disease symptoms of *P. ramorum* vary depending on the host plant and include leaf blight, leaf and shoot/stem lesions and shoot die-back. Other disease pathogens may produce similar symptoms to those of *P. ramorum* so care must be taken with diagnosis. *Viburnum tinus* is a good example where symptoms of *P. ramorum* are very similar to those of the leaf and stem pathogen *Phoma exigua* var. *viburnii*. Also, other *Phytophthora* species can cause similar symptoms in *Rhododendron*, though prior to *P. ramorum*, foliage infections were uncommon. Root infection by other *Phytophthora* species is a common problem in *Rhododendron*.

Disease symptoms in gardens and woodlands are not necessarily the same as those on commercial nurseries: a large, mature *Camellia*, *Rhododendron* or *Viburnum* may have different symptoms in a garden situation to when grown as a young plant for sale in a pot. For example, infected *Viburnum* exhibits more of a shoot tip die-back rather than the very visible basal collapse more commonly seen with potted plants.

Symptoms due to fertiliser scorch, chemical (e.g. pesticide) injury, drought stress, freezing damage and sun scorch can also appear similar to *P. ramorum* infection on a range of hosts. Laboratory analysis is required for accurate diagnosis.

***Rhododendron* die-back**

Infected *Rhododendron* bush next to an infected holm oak (*Q. ilex*)



Infected re-growth from a *Rhododendron* stump



Rhododendron leaf base necrosis



Heavily infected *Rhododendron*



The principal symptom in both nursery stock and established plantings is blight of leaves and die-back of the shoots. Diseased shoots have brown to black lesions that usually start at the tip and move towards the base although cankers may also form on any part of the shoot or stem, spreading up or down. Tissue may be soft and water soaked and quite different from natural browning as shoots age. Cankers near ground level can result in rapid wilting of shoots and leaves. On woody stems, infected internal tissue takes on a light brown discoloration which is distinctively different to the usual off-white colour visible when the bark is peeled back.

The most characteristic leaf symptom is the blackening of the leaf petiole extending into the base of the leaf blade. This may spread along the midrib causing blackening of the leaf. Leaves can become diseased with and without shoot infection. Diffuse brown spots or blotches frequently occur at the leaf tip where moisture can accumulate and remain for extended periods encouraging infection. Such spots or blotches can also form elsewhere. Eventually, the entire leaf can turn brown to black and may fall prematurely.

Other *Phytophthora* species can attack *Rhododendron* causing various symptoms, including leaf necrosis. However, unlike these, *P. ramorum* is not usually associated with causing significant rotting in the root tissue.

***Pieris* die-back**

Pieris dieback and leaf necrosis



Leaf symptoms are similar to those described for *Rhododendron* with brown lesions developing at leaf bases due to infections spreading down the shoot and along the petiole. Lesions also typically occur at the leaf tip or leaf edge where water accumulates. The leaf blade can also become blighted and individual stem cankers lead to further die-back. Leaf symptoms could be confused with those caused by the opportunistic leaf pathogens *Glomerella*, *Monochaetia* and *Pestalotiopsis*, and laboratory tests are essential for accurate diagnosis. Other diseases of *Pieris* also include aerial *Phytophthora* species that can cause leaf lesions similar to *P. ramorum* and various other *Phytophthora* species that can also cause root rots (e.g. *P. citricola*).

***Viburnum* die-back**

Viburnum dieback and leaf necrosis



Infection usually occurs at the stem base causing plants to wilt quickly and collapse. Cambial stem tissue initially turns brown and then eventually dark brown. Leaf spots or blotches may also occur, especially on evergreen species, whilst twigs and shoots may also be affected. Minor root rotting has also been noted. Symptoms can be confused with those of other *Phytophthora* species causing root death and also frost damage that may cause blackening of young shoots and branch die-back. With *Viburnum tinus* varieties, leaf symptoms are often very similar to those caused by *Phoma* infection and so are easily confused; for accurate diagnosis, laboratory tests are essential. *Botrytis cinerea*, the common grey mould pathogen, can also cause die-back in *Viburnum*.

***Kalmia* & *Leucothoe* leaf spot**

Infection usually occurs at the leaf tip and spreads through the leaf tissue towards the leaf base, causing a brown to black discoloration. Other disease pathogens known to cause leaf infections in *Kalmia* are *Mycosphaerella* and *Phomopsis*. In *Leucothoe*, *Cylindrocladium* can cause leaf lesions but unlike *P. ramorum*, it can also girdle and kill stem tissue.

Leucothoe leaf necrosis



Kalmia leaf blight



***Camellia* leaf blight**

Brown to black spots occur at the tips or edges of the leaves and can result in entire leaf death and rapid leaf drop. Stem die-back may also occur. Symptoms caused by the opportunistic wound pathogens *Pestalotiopsis* and *Glomerella* can be confused with those of *P. ramorum* and laboratory tests are essential for correct diagnosis.

Camellia leaf blight



Camellia leaf necrosis and wilting



***Syringa* (Lilac) leaf & bud blight**

Lilac leaf necrosis



Leaf symptoms are very similar to those described for *Camellia*, *Kalmia* and *Leucothoe*, with leaf necrosis starting at the tips and margins. Greyish-brown diffuse, water soaked lesions become evident later. Bud blight leads to a brown to black shoot discoloration as the infection spreads. Other, similar appearing, diseases of *Syringa* include the well known bacterial shoot, stem and leaf blight *P. syringae*, although *P. ramorum* primarily affects the leaves of lilac rather than leaves and shoots.

***Taxus baccata* (Yew) leaf blight**

Yew leaf blight (next to a healthy stem)



Leaf blight caused by *P. ramorum* is uncommon but has been isolated from brown lesions on young leaves of container grown *T. baccata*. Yew is very prone to leaf bronzing, due to a wide range of diseases and disorders, but usually the leaf tips die first, whilst with *P. ramorum*, the necrosis occurs more commonly in the leaf axils and appears more water soaked.

5.2 *Phytophthora ramorum* – On trees

Trees display a range of symptoms depending on the host species. With beech, for example, only the bark is infected, whilst in other trees, the infection is limited to the leaves, e.g. ash, magnolia and holm oak. In the case of sweet chestnut, both leaves and bark can be infected. Laboratory tests have indicated that bark of beech is more susceptible to infection by *P. ramorum* than that of European oak species.

Bark infections usually appear as large lesions known as cankers, visible where brown to black liquid seeps or 'bleeds' from the bark, usually on the lower trunk. When the outer bark is removed from these bleeding areas, mottled areas of necrotic, dead and discoloured inner bark tissue may be seen. When cankers girdle the trunk, death of the tree occurs, resulting in wilting and a rapid change in foliage colour. In the USA, some oak species die quickly whilst others decline more slowly and may take several years to die; mature oaks can be killed in less than two years.

Bleeding canker on *Q. falcata*
(American southern red oak)



Close up of lesions on *Nothofagus* sp. (Southern beech)
showing lesions in the inner bark



Cankers do not extend below the soil line and do not appear to infect root systems. Leaf infections most commonly appear as brown necrotic areas, often at the edge or tip of the leaf. On broad-leaved tree hosts in Europe, leaf and shoot infections have to date been found on several hosts including holm oak (*Quercus ilex*), sweet chestnut (*Castanea sativa*) and ash (*Fraxinus excelsior*).

Q. ilex (holm oak) infected foliage



Fraxinus excelsior (Ash) infected foliage



Symptoms of bark death with associated **stem/canker bleeding** are not solely indicative of one particular disease pathogen such as *P. ramorum* or confined to just one host. Many tree species, including beech, oak, sweet chestnut, sycamore, alder and horse chestnut, can suffer from *Phytophthora* root infection, particularly on sites that are liable to be wet. In such situations, *Phytophthora* can infect roots and the root collar and lesions may extend upwards by as much as 1 to 3m and be visible as bleeding areas on the tree trunk. Some *Phytophthora* species such as *P. cactorum* and *P. citricola* may also cause aerial lesions on horse chestnut and sycamore. Therefore, with any tree with bleeding cankers, unless it is located near to a source of *P. ramorum* (such as infected *Rhododendron*), then the likelihood of infection by *P. ramorum* is negligible. Instead, the bleeding canker is likely to have been caused by another pathogen.

Q. ilex (holm oak) aerial blight



Extensive bleeding on the root flares of a mature beech tree



In the UK, and elsewhere across Europe, oak mortality and die-back of a complex cause known as '**oak decline**' has existed for some time. It is fairly widespread, although individual pockets can be localised and intense. In some situations, the decline is associated with infection by various other *Phytophthora* species whereas *P. ramorum* causes stem cankers. Oak decline can also be linked to recurrent periods of drought, other root infecting fungi, repeated insect defoliation and scale insect attack.

5.3 *Phytophthora kernoviae* – On ornamentals

Rhododendron (*R. ponticum*, *R. catawbiense*, *R. yakushimanum* + hybrids)

Although symptoms are similar to those caused by *P. ramorum*, there are some differences. Early leaf symptoms are principally a blackening of the leaf petiole. This often extends into the base of the leaf. The lesion may progress further into the leaf tissue, and in extreme cases the necrosis can affect the whole leaf. Occasionally, however, only blackening of the leaf tip is observed. Both old and young leaves appear to be affected equally. Unusually for a *Phytophthora* infection of *Rhododendron*, leaves often fall within a few weeks of infection. Die-back of *Rhododendron* shoots and cankers frequently occurs. Where the die-back or cankers girdle the stem tissue, the leaves above the lesion wilt. In severe infections the bush may be killed. Leaf and stem infections can be found at any height or position on a *Rhododendron* bush.

Rhododendron leaf tip necrosis



Rhododendron leaf necrosis leading to stem lesion



Rhododendron wilting symptoms



Heavily infected *Rhododendron*



Pieris formosa

Pieris leaf necrosis and Wilting



Similar leaf blight symptoms to *Rhododendron*, but there is no obvious die-back or cankers. Typically, lesions on leaves of *Pieris* species are a light tan to rusty brown colour. Necrosis progresses directly towards the midrib vein and along the vein causing a visually striking leaf blight.

Michelia doltsopa

Michelia doltsopa leaf necrosis (early symptoms)



Foliar infection is characterised by necrotic lesions on the tips of leaves and these may progress along the leaf margins and into the tissue of the leaf blade. The necrotic tissue is characteristically a dark black-brown colour.

***Magnolia* spp.**

Multiple infection on *Magnolia*



Infection can occur anywhere on the leaf surface in the form of black-brown necrotic patches that give the leaves a spotty appearance. If the infection is heavy, then the necrotic patches tend to merge and develop as larger lesions towards the midrib. Leaves become very conspicuously mottled when lesions have had time to develop and merge. The necrotic spots often have angular edges and uninfected tissue between them becomes chlorotic. If infection takes place at the leaf edge, the margin ridge of tissue may collapse and form a hard dry rim. The petioles can be infected and disease often progresses along the leaf base following petiole infection. Shoot die-back also occurs and the blackened, withered shoots may remain attached to the plant. When buds can become diseased they turn light khaki grey.

***Drimys winteri* (Winter's bark)**

Drimys winteri (Winter's bark leaf necrosis)



Foliar infection is characterised by marginal or leaf tip necrotic, often water soaked lesions. These may extend throughout the leaf lamina. Blackening of the petiole has also been observed. To date, no evidence of die-back or cankers have been seen on *D. winteri* in association with infection by *P. kernoviae*.

***Gevuina avellana* (Chilean Hazelnut) leaf necrosis**

Gevuina avellana (Chilean hazelnut) leaf necrosis



The foliar symptoms take the form of a leaf blight, characterised by dramatic coppery, rusty brown coloured leaf lesions. The lesions usually begin along the leaf margin or tip and then progress rapidly through tissues causing widespread necrosis. Unlike other hosts, the leaf blight on *Gevuina* is not characterised by lesion advance in the midrib or lateral leaf veins and there is no blackening of infected tissue. Instead the diseased parts of leaves turn a reddish brown colour. A few discrete lesions are sometimes apparent on leaves delineated by dark brown margins. Diseased areas of the leaf are sharply contrasted against the bright green colour of the healthy parts.

5.4 *Phytophthora kernoviae* – On trees

Fagus sylvatica (European beech)

Bleeding canker on *F. sylvatica* (European beech)



The main symptoms consist of cankers or lesions on the trunk which are similar to those caused by *P. ramorum*. The lesions can occur at any point from ground level to up to 12m above ground level and are dark brown to black in colour, ranging from a few small spots just a few centimetres in diameter to much larger (> 3 metres long) necrotic areas. A gummy dark brown or blue-black ooze or bleed may be exuded from the lesion surface.

Canker on the trunk of a mature beech tree, next to an infected *Rhododendron*



Underlying the bleeding areas, orange-pink to pink-brown areas of necrosis are visible in the inner bark. In some cases the necrosis can girdle the trunk causing tree death. On trees with chronic infection, the older lesions or cankers may develop into sunken or erumpent chambers and on some trees the lesion extension may become arrested.

***Quercus robur* (English oak)**

Bleeding lesion on *Q. robur* (English oak)



Stem cankers or lesions occur which are similar to those seen on *F. sylvatica*, but they are more difficult to discern both internally and externally because of the thick outer bark ridges and incurse outer bark plates of *Q. robur*. Bleeding occurs from the lesions, oozing out between the furrowed bark ridges. Older cankers do not appear sunken as they do with beech.

***Liriodendron tulipifera* (English oak)**

Bleeding canker on the trunk of a Tulip tree (*Liriodendron tulipifera*)



Disease symptoms can occur on foliage, shoots and trunks of trees. Symptoms have been observed only on a single tree to date. Multiple bleeding lesions form on the trunk from ground level up to 9m. The bark becomes highly corrugated as a result of these multiple lesions. Internally, lesions in the inner bark range in colour from pale brown to dark brown to blue-black. They tend to be limited in size and often develop into erumpent chambers.

Lesions develop on leaves and are usually restricted to the leaf-tips and leaf margins. Infection appears to dry the tissue out to a dark black colour. Shoot die-back can also occur and the infected shoots are abscised.

***Quercus ilex* (Holm oak)**

Holm oak (*Q. ilex*) leaf necrosis



Severe necrotic leaf lesions and die-back is associated entirely with epicormic shoots. No evidence of sunken or bleeding cankers on the trunk of trees has been observed.

6. Biosecurity measures

There are a number of biosecurity measures that should be taken in order to prevent, contain and control both *P. ramorum* and *P. kernoviae*. Some of these are more appropriate to parks and gardens than woodland situations, which are managed less intensively. For example, measures recommended for quarantine and commercial sales areas are unlikely to apply to woodlands to the same extent. However, vigilance, awareness of disease symptoms and a disciplined approach to hygiene are always important. Bought in consignments of plants and propagation material are significant potential sources of disease spread. Check plants carefully and only propagate from plant material of known health status (Plant Clinic disease checks will help determine this). This is particularly important when dealing with historic plant collections (see Section 7).

6.1 Risk assessment and surveillance

Different situations pose different levels of risk. Commercial or managed woodland situations, for example, may carry a lower disease risk than intensive parks or gardens where public access and the potential for disease spread is likely to be greater. However, wild *Rhododendron*, the principal carrier host, may be widespread in unmanaged woodland areas and require clearing or some level of control to reduce disease risk.

Plant sales areas may attract a higher level of risk due to visitor traffic and the constant movement of plants. Also, the mix of ornamental plants and likely hosts may be greater in park and garden situations than in commercial woodland sites. Other points to consider when assessing disease risk are the key hosts and the extent to which they may be present. Also, the main methods by which *P. ramorum* and *P. kernoviae* can spread (e.g. water, movement of infected plants, contaminated soil/growing media/equipment etc).

Be familiar with the disease and its host range to help ensure symptoms are recognised promptly. Staff (including garden volunteers) should be briefed to report any suspected problems at an early stage. They should also understand why precautionary and statutory control measures are required.

Surveillance – Best Practice

- Prior to carrying out monitoring, it is important to be familiar with the susceptible host lists and be aware of visual symptoms for hosts. If you are concerned, contact your local PHSI office*. Lateral Flow Device (LFD) test kits can be used, initially to indicate whether a *Phytophthora* species is present. Samples need to be sent to the Plant Clinic at the Central Science Laboratory (CSL)** to determine if *P. ramorum* or *P. kernoviae* is present. LFD test kits can be purchased from CSL** for use on site. Plant Clinic checks for *P. ramorum*/*P. kernoviae* are free of charge when submitted by PHSI and are usually undertaken at CSL** or, in the case of tree samples, at Forestry Research.
- Carry out regular disease monitoring of known hosts. A site or garden layout map showing the locations of likely hosts is a useful aid to routine monitoring. Disease symptoms are likely to be easier to spot during the spring and autumn months, especially after rainy periods, and so these are ideal times for regular monitoring.

*Or the appropriate Plant Health Authority.

** In England and Wales. For Scotland and Northern Ireland please contact the appropriate Plant Health Authority – see contacts at section 12.

6.2 Quarantine

Good quarantine protocols are important and apply to both plant sales areas handling bought in plant material and park/garden estates that may also source plants from external suppliers. Ideally, at least one staff member from each department familiar with *P. ramorum*/*P. kernoviae*, should have delegated responsibility for checking incoming plant material and accompanying documentation and for ensuring quarantine protocols are followed.

Quarantine Areas: Best Practice

- Ensure **incoming plant material** is properly certificated, i.e. plant passports as required from within the EU and phytosanitary certificates with plants from outside the EU.
- Retain and file all necessary **documentation for traceability** requirements.
- **Inspect plants** carefully on arrival.
- Limit quarantine areas to **one entrance** for **trained, designated** staff only.
- Site the quarantine area **well away from public access** points.
- Provide a **loading/unloading area** with direct access to the quarantine area that can be readily cleaned and disinfected.
- Place **baths of soapy water and brushes** for removing any soil at the entrance, together with a suitable **disinfectant** to treat footwear, and ensure these are properly maintained. Use disposable leggings to protect overalls from contamination.
- DO NOT set down any **incoming plants** of known hosts in the main garden area or site(s) that may be carrying sub-clinical levels of disease. Such plants should be quarantined and screened for disease presence (contact PHSI*).

- Keep **tools and handling equipment** for the quarantine area separate from those used in the main site. Clean and disinfect them regularly.
- Take appropriate measures to **exclude animals** that might spread the disease such as badgers, deer, foxes, rats, mice, squirrels, cats, dogs and birds from the quarantine areas.
- Prevent **water run-off** to the main site (e.g. by channelling, drainage, ditches).
- Avoid **overhead watering** as much as is practicable and only use water taken from **clean supplies**. Take particular care when considering recycled water sources.
- **Abstracted water** taken from streams or ponds in areas of infected native hosts may also be contaminated with *P. ramorum*/*P. kernoviae* and should be tested periodically. Tests are chargeable and usually undertaken at CSL* (price on application).
- Where possible, use a **concrete/solid floor area** in the quarantine area to aid good hygiene practice (e.g. disinfection/collection of leaf debris).
- **Do not use fungicides** that have activity to *Phytophthora* on susceptible host plants for a minimum period of six weeks after taking delivery.

* In England and Wales. For Scotland and Northern Ireland please contact the appropriate Plant Health Authority – see contacts at section 12.

Only source plants from reputable suppliers and when buying in plants establish a **quarantine area** so they can be isolated and held away from the main site. Ensure this area is at least 10m from any susceptible genera. Check the plants carefully and monitor weekly; plants should be held for at least two weeks, longer if possible and during periods of cold or dry weather when disease symptoms may take longer to appear.

Be particularly careful with plant gifts from the general public or other garden sites. Where it is necessary to import plants with a supply chain involving several sources, specify seed raised or micro-propagated material where this is practicable, particularly where sources involve plant material from affected geographic areas.

Keep accurate records of all bought in plant material. Such records should include source of supply, arrival date, previous cropping history/treatments (check with supplier), plant passport details (which must be retained for at least 12 months) and any batch or consignment numbers. Also, keep a record of any plant losses and where these occur, check other material from the same consignment.

Do not accept *Rhododendron*, *Viburnum* or *Camellia* without a plant passport (see Panel at Section 9). If you are offered susceptible material without a plant passport or with an invalid passport, notify your local PHSI (or the relevant Plant Health Authority). This is a legal requirement. Follow up action by PHSI will reduce the risk of importing the disease. Note, plant material that should have a plant passport and doesn't, will need to be destroyed.

6.3 Hygiene

Good hygiene practice is the key to effective disease control. Remove and destroy all plant and leaf debris from areas housing susceptible material on a regular basis. Implement routine hygiene measures to reduce the likelihood of spread by contaminated soil or growing media, tools, equipment or staff. Clean and disinfect tools and equipment (including chain saws) regularly with an appropriate product; secateurs or pruning knives frequently (and always between varieties). Ideally, tools and equipment used in affected areas of the site should be kept separate to those used elsewhere. Control the movement of incoming plant material and potentially contaminated machinery, footwear and water. Review procedures regularly.

Hygiene: Best Practice

This section sets out best practice covering a number of areas. These are recommended as essential in known infected sites and advisable in all other sites where host plants are present and where steps should be taken to minimise the possibility of introducing and spreading disease.

Contaminated leaf debris is a frequent source of disease. Ensure any plant prunings and fallen leaf debris are collected and removed promptly, particularly from areas housing susceptible plants and where *P. ramorum*/*P. kernoviae* has been confirmed. Ensure trailers or similar means of transport used to move such debris are covered and that the covers (e.g. twin sided tarpaulin) are changed, cleaned and disinfected regularly. Leaf debris is usually much easier to blow off/collect and burn when dry. Smaller volumes of leaf/plant debris should be collected, bagged and removed for disposal away from the main garden/park/areas.

In large garden, park or amenity situations where it may be impractical to collect all **leaf debris** or where time constraints/labour resources do not allow this, ensure **pathways are kept clear** of fallen leaf debris on a regular basis, particularly those subject to frequent public access/footfall. Leaf blowers are especially useful for this task.

Solid **pathways** are much easier to maintain and keep clean than those made from bark chips or similar and so are recommended for areas of greater disease risk and frequent public access.

Only propagate **cutting material** taken from healthy, disease free plants. If necessary, arrange Plant Clinic disease checks for mother plants of listed hosts. These are usually chargeable and can be undertaken at CSL* (price on application).

Wounded leaves can be more susceptible to infection, so handle plants and cutting material with care. Try to avoid handling host plants if they might be wounded or damaged when environmental conditions are particularly favourable to disease infection. **Prune susceptible host plants** in dry weather if at all possible.

Cut foliage of host plants used in local flower show or civic displays also presents a risk in terms of disease transfer and should be handled with care. Do not remove or use foliage from unhealthy plants or plants under Statutory Notice and ensure standard hygiene requirements are followed, for example regular cleaning/disinfection of knives and secateurs. Try to select display foliage from plants that are not listed hosts.

Avoid soil or growing media contact with the foliage of key hosts especially young plants, or splashing water from soil to foliage. In display border situations where established plants such as *Rhododendron* regularly 'hug' the ground, prune away lower branches to lift the canopy cover away from soil or pathways. Such work is particularly important in large, established borders near to pathways used frequently by garden visitors and so likely to carry a greater attendant risk of disease spread. Whilst this needs to be done with care so as not to spoil the overall effect of the border, it does have the advantage of allowing light and air to penetrate densely packed borders, so helping to reduce predisposition of plants to disease infection.

In **plant sales areas**, where possible, use **raised benches** and **isolated display beds** to elevate susceptible plants above the soil. This also helps to maintain good air movement around the plants. Wherever possible, the foliage of key host plants should not come into contact with the ground and any container grown plants that have blown or fallen over should be returned to an upright position as soon as possible. **Keep display beds and benches clean and tidy.**

Periodic **treatment of display beds** (e.g. sand or gravel standing areas) with an appropriate disinfectant, particularly where known host plants have been or are due to be set down, will help reduce disease risks. Use of a permeable membrane over the bed surface to enable them to be swept clean of fallen leaves and debris should also be considered. Such membranes should be **disinfected** periodically.

Shooting parties should also be made aware of their duty of care and follow the necessary biosecurity measures where appropriate. Potentially, such parties (including dogs) are a source of disease spread especially when straying 'off path' away from the main garden/woodland areas. As such, they must show particular regard to necessary hygiene measures, including the routine cleaning and disinfection of footwear/tools/vehicles etc.

In **forest or woodland situations**, anyone who comes into contact with *Rhododendron* during the course of any forest operation should ensure that before leaving the site, all tools (including boots), equipment, plant and machinery is free from any soil and plant debris. As this is common practice when moving machinery between sites via main roads, it is recommended that it is extended to all movement of plant, machinery, tools and equipment within the forest boundary. This should be achieved by simple brushing to remove as much soil and plant debris as is reasonably practicable. In areas where *P. ramorum*/*P. kernoviae* is detected, measures will be imposed by the serving of a Statutory Notice and these will include disinfection with an appropriate product. All staff working in forest and woodland situations should be aware of and familiar with the Forestry Commission's Plant Health Service Best Practice Note, number 01, which can be viewed on their website at: www.forestry.gov.uk/forestry/INFD-66THS4

* In England and Wales. In Scotland and Northern Ireland please contact the appropriate Plant Health authority – see contacts at section 12.

6.4 Watering plants

Careful **watering** is also an important aspect of effective disease management, particularly in plant sales areas. Wherever possible, overhead watering should be avoided because splash dispersal by water (or, rain) droplets of disease spores is one of the principal means by which *P. ramorum*/*P. kernoviae* can spread to infect other plants.

Watering Plants: Best Practice

- Where **overhead watering** is used (e.g. garden sprinklers and spray-lines) apply it in a controlled and measured way to minimise disease spread by water splash. Ensure uniform distribution, check regularly for leaking pipes or connections and correct any areas of poor drainage.
- Do not water for **any longer than is necessary**.
- For known host plants, **avoid watering at night**.
- Ideally, use a **low level watering system** such as capillary matting, lay-flat tubing or drip-point watering (e.g. in plant sales areas/newly planted borders).
- Ensure any water collected for recycling is **clean or disinfected** prior to re-use (e.g. by slow sand filtration).
- **Abstracted water** taken from streams or ponds in areas of infected native hosts may also be contaminated with *P. ramorum*/*P. kernoviae* and should be tested periodically.
- Disinfect or replace **capillary matting** before re-using it (e.g. in plant display areas).
- Do not use **hosepipes** from infected areas in uninfected areas.
- Ensure plants are **not standing in water** for any length of time by providing good drainage.

6.5 Good husbandry

P. ramorum/*P. kernoviae* are primary disease pathogens that can infect healthy, undamaged plants, and good husbandry alone (as distinct from effective quarantine) cannot solve a *Phytophthora* problem. However, plants are more susceptible to infection if they become predisposed by other factors, for example, poor husbandry. Tools and equipment should be regularly cleaned and kept in good order. Disciplined hygiene and correct watering are typical examples of good husbandry. Plants /woodland areas should also receive appropriate nutrition and not suffer undue competition from weeds or pests that may weaken their defences and so render them more liable to disease attack. The traditional practice of mulching ornamental borders in spring, for example, whilst time consuming, provides important nutrition, moisture retention and weed suppression. Similar remarks apply to regular top dressing to ensure adequate nutrition and newly planted areas must receive adequate irrigation during dry periods. Equally, soil preparations should include the provision of good winter drainage. Correct and timely pruning are important too, and include the prompt removal of dead or decaying branches. Similarly, large pruning wounds should, where possible, be avoided as these often provide ideal entry points for disease infection.

6.6 Dealing with wild *Rhododendron*

Wild *Rhododendron*, *R. ponticum*, is the principal carrier host of *P. ramorum* and *P. kernoviae*. It is also an invasive species. The effective control of wild *Rhododendron* is an important control measure where the eradication and containment of *P. ramorum*/*P. kernoviae* is concerned. In high risk situations, this may involve *Rhododendron* clearing as a preventative measure.

Wild *Rhododendron* should, therefore, be monitored and kept under control, particularly in affected sites and woodlands. Any suspect disease symptoms should be checked out promptly. Infected plants will usually have to be removed (or, at least contained) under Statutory Notice. (*Rhododendron* is classed as an invasive species and its removal from woodland areas may qualify for funding under the Forestry Commission Woodland Improvement Grant Schemes. Woodland owners are encouraged to seek advice whenever they suspect that a problem is present as early remedial action is essential if losses are to be kept to a minimum and the value of the crop protected as far as possible.)

The four stage process outlined overleaf is recommended by Forestry Research for eradication in woodlands. It is published in their Practical Guide: *Managing and Controlling Invasive Rhododendron*. This process should form the basis for eradication in woodland garden situations. Further information on *Rhododendron* control in other situations is available in the Guide (copies of which can be purchased from the Forestry Commission, or downloaded free of charge from their website at: www.forestry.gov.uk/publications).

It is important that potential clearance sites are surveyed prior to the commencement of work to ensure that any action taken complies with existing legislation and guidance (such as the Habitat Regulations and the Wildlife and Countryside Act etc). Please refer to the Forestry Commission website (www.forestry.gov.uk) for guidance and information on the legislative requirements.

Ideally, large volumes of diseased/dead plant debris (e.g. from dense, carpeted areas of wild *Rhododendron*) should be burnt in situ or in the nearest possible place so as to reduce the potential for disease spread, particularly in disease 'hot spots' and where labour resources are limited. However, in areas of frequent public access this is seldom possible due to health and safety considerations. Such waste material should therefore be transported (under covers) to a separate compound well away from visitors and the main garden area (see Section 10.4).

Sprayed areas must be signed and cordoned off from garden visitors. Ensure any dead material is dry before attempting to burn it.

In historic gardens, when dealing with larger carpeted areas of wild *Rhododendron*, spray application must be done with particular care near other garden plants or when in close proximity to water courses.

Four stage process recommended by Forestry Research for eradication in woodlands:

1. Remove rhododendron bush top growth

Bushes must be cut down with either clearing saws or chainsaws; the risk of spreading infection in debris precludes the use of mechanical flails. Cut the stems so that the stump sits relatively high above ground level to facilitate later operations, but do not leave any live branches or shoots attached to it after cutting. Taller stumps will be easier to find later for herbicide applications and will reduce the chance for reinfection of any shoots that may begin to re-grow.

2. Apply approved herbicide to cut stumps

Cut stumps will re-grow if not treated with herbicide and the new shoot growth is liable to become reinfected with the pathogen; young shoots regrowing close to ground level appear to be more readily infected than older live material. Cut stumps must therefore be treated with an approved herbicide.

The two herbicides approved for use on rhododendron as cut stump applications within woodland are glyphosate (e.g. Roundup ProBiactive), and triclopyr (e.g. Timbrel). Several glyphosate based products marketed by different companies are approved for use in forestry situations. Always check the product label and ensure the product has approval for use in forestry before purchase or application. Herbicides should be applied at the correct product rate (see table below).

Rate of product application and best time of year for the treatment of freshly cut rhododendron stumps. Only the herbicides listed are approved for cut stump applications to rhododendron in woodlands.

Herbicide	Product rate	Optimal time of year
Glyphosate (360 g l⁻¹) e.g. Roundup ProBiactive	20% solution in water	October – February
Triclopyr (480 g l⁻¹) e.g. Timbrel	8% solution in water	October – March

For safety information on using herbicides consult the Defra publication *Pesticides: code of practice for using plant protection products*, AFAG leaflet 202 *Application of pesticides by hand-held equipment* and the HSE leaflet, *Pesticides – Use Them Safely*. Always read the label before applying herbicides.

3. Apply approved herbicide to foliar regrowth

Cut stump applications to rhododendron are rarely 100% successful. Stumps are often missed and not treated, particularly if marker dyes are not used, or the herbicide is not fully effective at preventing shoot regrowth. Furthermore, small seedlings are often overlooked and missed in any cut stump treatment. It is vital that a follow-up application of herbicide to any shoot regrowth or small seedlings is planned into the management of control sites.

Three herbicides are recommended for directed foliar spray applications to control rhododendron within woodland at the rates and times specified. These applications will also kill any live vegetation growing next to or under the target foliage so care must be taken to ensure that only the rhododendron foliage is treated.

Rate of product application and best time of year for overall foliar applications of herbicides. Only the herbicides listed are approved for foliar applications to rhododendron in woodlands.

Herbicide	Product rate	Optimal time of year
2,4-D / dicamba/triclopyr (200: 85: 65 g l ⁻¹) (e.g. Nufarm NuShot)	7.5% solution in water (maximum of 5 l ha ⁻¹)	July – September
Glyphosate (360 g l ⁻¹) (e.g. Roundup ProBiactive)	2% solution in water plus 2% adjuvant* (High Trees Mixture B). (maximum of 10 l ha ⁻¹)	March – October
Triclopyr (480 g l ⁻¹) (e.g. Timbrel)	2.5 % solution in water (maximum of 8 l ha ⁻¹)	June – September

*When near water do not use adjuvant – apply 2.5% solution of glyphosate instead.

For safety information on using herbicides consult the Defra publication *Pesticides: code of practice for using plant protection products*, AFAG leaflet 202 *Application of pesticides by hand-held equipment* and the HSE leaflet, *Pesticides – Use Them Safely*. Always read the label before applying herbicides.

4. Monitor subsequent re-growth or seedling establishment

Shoot regrowth or new seedlings can become infected with the *Phytophthora* pathogens after the initial clearance operations have been completed. It is, therefore, vital that the sites are monitored at yearly intervals for at least five years. Recovery of partially controlled stumps, or the establishment of new plants from seed, will only become apparent several years after control measures were started. Any new foliage from either source must be treated with a recommended herbicide before it reaches a height of 1.3m.

7. Recording and propagating important plants

Keep **accurate, up to date records** that allow prompt traceability in the event of future disease problems. Records should cover all mother plants and progeny, particularly where bought in plant material is involved and especially when dealing with material from affected geographic areas or the continent. Records should include source of supply, arrival date, previous husbandry/fungicide treatments (check with supplier), plant passport details (which must be retained for at least 12 months) and any batch or consignment numbers. Also, propagation dates, treatments and mother stock from which material was taken.

Set up and maintain a **plant database** through which records of plant material within the garden can be held, particularly those of historical importance. Ensure management and propagation plans are in place; such plans should consider how and where this material will be propagated and, where the new plants will be located in the garden.

Use **reputable suppliers** and be particularly vigilant with material collected from other garden sites. Where it is necessary to import plants with a supply chain involving several sources, specify seed raised or micro-propagated material where this is practicable, particularly if sources involve plant material from affected geographic areas. Rare species such as first generation introductions from the wild of genetic importance or those forming part of prestige/historic botanical collections/heritage gardens warrant special care as do plants with a particular conservation requirement.

Seed storage via the **Millenium Seed Bank** is a useful way of safeguarding future requirements and **micro-propagation** provides a convenient way of bulking up important collections quickly whilst helping to maintain a high health status. Off-site propagation using the facilities of unaffected sites should also be considered to reduce the risk of disease contamination and spread.

Propagation of **high value/unique garden plants under Statutory Notice**, for example to preserve rare or 'Champion' trees (i.e. tallest or widest girth of its type in the British Isles), can only be considered in consultation and agreement with the appropriate Plant Health Authority. In such situations, off-site propagation (e.g. micro-propagation) must only be undertaken on nursery sites licensed by PHSI.

When reviewing future propagation requirements, consider **alternative subjects** less susceptible to *P. ramorum*/*P. kernoviae*. This will help reduce disease risk, although such hosts must be in keeping with the history and character of the garden or park.

8. Dealing with enquiries, garden visitors and public access

Visitors to parks and gardens need to be dealt with carefully as regards managing information, particularly where a disease outbreak has been confirmed. In some situations, it may be appropriate to handle the matter quietly and without undue publicity. For example, if an outbreak is confirmed in an isolated location away from everyday public access, it may be preferable to simply cordon off the area whilst the necessary control measures are implemented. Visitors are, however, a potential source of disease spread and in some situations, it may be more appropriate to inform the public about the disease. For example, if they are considered to be a potentially significant source of disease spread or, where a disease outbreak has occurred in a highly visible part of the garden, it may also be good policy to make the public aware that the necessary legislation has been complied with and advise them of the steps that have been taken to minimise risk. This highlights the role they can play in protecting the wider environment from further disease spread. Each situation will need to be assessed on its own merits before such policy decisions are taken.

A sensitive balance needs to be struck between encouraging public access for garden enjoyment, conservation, leisure and education purposes and restricting the movement of garden visitors, where necessary, in the interests of disease control.

Defra and the Forestry Commission do not generally release the names and addresses of affected sites, but do have an obligation under access to information legislation to publish details of risks to the environment, which may include the geographical location of outbreaks (see section 10.5).

Where a decision has been taken to inform the public about the disease, information signs relevant to the site will help alert garden visitors. Typically these may include the following advice:

- Keep to pathways and do not stray into roped/signed off areas.
- Keep children under control and away from roped off areas.
- Keep dogs on short leads.
- Do not remove plant material including wood from the site.
- Clean footwear, pets, equipment (e.g. mountain bikes) before leaving the site.

It is important that such signs are carefully located; plant sales areas and tea rooms are useful places to locate discreet but visible information cards/small posters. Information leaflets are also an effective way of informing the public about the disease, what it looks like and why it is important to implement control measures and, sometimes, restrict public access. Such publicity could, where appropriate, highlight the threat of *P. ramorum*/*P. kernoviae* to the wider environment and local economies to help garden visitors understand the importance of the disease and gain their co-operation without creating undue alarm.

Media enquiries should be handled with care and by trained personnel. Larger enterprises frequently open to the public and local authorities may have their own Public Relations Department to whom press enquiries should be referred. However, enterprises such as smaller private gardens are unlikely to have ready access to such resources and should consider some form of PR training. Your local Defra PHSI* contact will also be able to provide some guidance on dealing with media enquiries and is an invaluable resource to refer to when drafting/updating press releases. Similarly, the Defra and Forestry Commission websites are a useful source of up to date information.

With regard to enquiries from garden visitors, members of the public should be advised to remain vigilant and if concerned that a plant may be infected with *P. ramorum*/*P. kernoviae*, to report it

immediately to a member of staff. In home garden situations, they should be referred to their local PHSI office*. In woodland situations, the Forestry Commission's Plant Health Service should be contacted. All enquiries are followed up.

In public garden situations, where possible, try to undertake any major pruning, clearing work or path cleaning/leaf blowing outside of normal opening hours to minimise disruption (and, noise levels). Ensure areas where garden staff are working, particularly with dangerous machinery such as chain saws, are cordoned off and clearly signed.

*Or the appropriate Plant Health Authority – please see contacts at section 12

9. Plant Passports – what are they and how do they work?

Plants of *Rhododendron* (except *R. simsii*), *Viburnum* and *Camellia* moving within and between EU states require a plant passport at all stages of production down to the final retailer. The passport must always accompany the plant and include the words 'EC Plant Passport', a country identifier (e.g. UK/EW, NL or FR) and a reference number. It may include RP if the plants have a replacement passport. Ensure that your plant supplier is providing a valid passport; plants that do not have a valid document will be destroyed.

Plant Passports At A Glance

The Plant Passport provides important documentary evidence that:

- The plants concerned 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 disease pathogens and, where appropriate, grown in an environment which is also free from pests and disease 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 including *P. ramorum*. Species/hybrids of *Camellia*, *Rhododendron* (other than *R. simsii* which has been shown to be resistant to *P. ramorum* in tests) and *Viburnum* are now subject to plant passporting requirements to the point of final retail sale. **Note: import and plant passport controls have reduced substantially the amount of infected plant material moving in the trade and it is in the interests of all key stakeholders that the requirements of this scheme are upheld.**

The conditions of the passport are that 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 must have been implemented.

PHSI can ask to see original passports; photocopies or retrospective plant passports are not acceptable. Further information can be found at www.defra.gov.uk/planth/pass.htm

10. Disease management and control

10.1 Who does what

Defra's Plant Health Division (PHD) has overall policy and legislative responsibility for *P. ramorum* /*P. kernoviae* relating to plants and plant produce in England; liaison with direct stakeholders and interested parties at UK level and for co-ordination of action across Defra.

Defra's Plant Health and Seeds Inspectorate (PHSI) is responsible for enforcing all aspects of policy in England and Wales; carrying out inspections, surveys, eradication campaigns and liaison with local Government and stakeholders.

The **Central Science Laboratory (CSL)** is responsible for research, scientific and technical advice/support to PHD/PHSI and, provide diagnostic services.

The **Forestry Commission's Plant Health Service (FC PHS)** has overall policy and legislative responsibility for all aspects of *P. ramorum*/*P. kernoviae* relating to forest trees and woodlands. **Forest Research (FR)** is responsible for research, scientific advice and diagnosis of *P. ramorum*/*P. kernoviae* on trees. Its **Technical Support Unit (TSU)** carries out woodland surveys. Further information on the measures undertaken by the Forestry Commission (FC) and guidance on the symptoms of the pathogen in trees, can be found on the Forestry Commission's website at: www.forestry.gov.uk/forestry/inf-d-6ab15v.

Full contact details can be found at Section 12.

10.2 Notification

Prompt and effective eradication and containment policies in the UK are essential to minimise and eliminate the potential threat to native trees such as beech and oak species as well as heathland species and ornamental hosts (see Tables at Section 4). They are also important to control the spread of *P. ramorum*/*P. kernoviae* between other European countries and so the movement of *Camellia* sp., *Rhododendron* (except *R. simsii*) and *Viburnum* sp. is being controlled by Plant Passports (see Section 9).

***P. ramorum*/*P. kernoviae* are notifiable plant pathogens and so there is a legal requirement to notify PHSI if you know or suspect that species of *Camellia*, *Rhododendron*, *Viburnum* or any other known host plant is affected by either disease.** In the first instance, contact your relevant plant health authority (see contact details at Section 12). Early detection followed by prompt quarantine action is the basis of effective disease management.

10.3 Eradication and containment policy

In parks, gardens and uncultivated land situations, the following actions may be required under official Notice against all findings of *P. ramorum*/*P. kernoviae*:

- Prohibition on the movement of infected plants and parts of plants (e.g. must not be used for propagation purposes or foliage purposes).
- Destruction by burning or deep burial (at an approved landfill site – see Section 10.4 for important information on dealing with waste) of infected plants, susceptible plants within an appropriate cordon sanitaire, and associated plant debris.
- Prevention of re-growth.

- Felling or pruning of infected trees depending on the part of the tree infected and the extent of the infection.
- Implementation of measures to prevent re-infection at the site. These may, for example, include a prohibition on planting susceptible plants in contaminated soil, removal or sterilisation of contaminated soil.

Containment measures in situations where immediate eradication is not deemed appropriate (for example, sites considered a lower risk or where comprehensive eradication would completely destroy the character of a historic garden) may include a protocol of measures. These measures will require a degree of flexibility to take account of site differences but are likely to include:

Biosecurity protocol

- A regular programme of cleaning to remove plant debris from the surface of paths and standing areas.
- Safe disposal of all waste susceptible plants and plant material by burning or deep burial (at an approved landfill site – see Section 10.4 for important information on dealing with waste).
- Repair and maintenance to the physical structure of the footpaths e.g. where possible gravelling of mud paths.
- Restrictions on access to contaminated areas e.g. cordoning-off or re-routing of footpaths to avoid contaminated areas.
- Hygiene measures for employees and contractors including cleaning and disinfection of footwear and machinery before leaving the site.
- Some restraint on the movement of dogs or domestic stock e.g. for parks and gardens open to the public, all dogs to be kept on short leads.
- Erection of information signs to alert the public of the presence of the disease and include advice relevant to the site.

Control measures

Whilst complete eradication may not be attempted, some eradication work may be required under Notice to ensure containment, to protect the public (from falling trees and/or from taking the problem home with them) or to protect important or valuable specimens. These measures may include:

- Removal and destruction of infected plants adjacent to the footpath(s).
- Removal and destruction of infected plants, especially large shrubs and trees that are deemed to be unsafe.
- Removal and destruction of infected plants (e.g. large shrubs or trees that have leaf infection) which pose a risk to neighbouring plants (e.g. those directly in the drip line).
- Fungicide treatment to reduce either inoculum or to protect valuable specimens.

Surveillance

The site and its surroundings will be subject to a regular programme of official surveillance to provide confirmation that the disease situation is not increasing to levels where containment is compromised.

Additional measures for parks, gardens and woodland involved in the movement or sale of plants

Some parks, gardens and woodlands where immediate eradication is not being attempted may have separate production or sales areas from which plants are moved or sold. Given the risk that the movement of plants from these areas poses, additional measures over those specified above are required to confirm continued freedom from *P. ramorum* and *P. kernoviae*.

If either *P. ramorum* or *P. kernoviae* is confirmed on plants in the commercial production area, the legally required eradication and containment measures will apply.

10.4 Dealing with waste

Where the destruction of **infected plants** is necessary under Statutory Notice, such plant material including tree stumps and associated leaf debris, should be destroyed as specified, usually by deep burial at an approved landfill site. Usually, such Notices will also require the destruction of **associated containers** and a requirement for all surfaces that have come into contact with infected plants to be cleaned and disinfected. **Soil or growing media** that has been used with the diseased plants and so may be contaminated with *P. ramorum*/*P. kernoviae* should also be destroyed. Statutory Notices will have a deadline for implementation.

Leaf debris collected from garden borders housing susceptible hosts or from plants under disease surveillance should be destroyed, preferably by burning. Such leaf litter should be collected regularly as part of a routine hygiene programme. Further guidance on the transport and handling of leaf debris is given at Section 6.3.

Ideally, large volumes of **collected leaf/plant debris** should be burnt in situ or the nearest possible place so as to reduce the potential for disease spread, particularly in disease 'hot spots' and where labour resources are limited. However, in areas of frequent public access this is seldom possible due to health and safety considerations. Such waste material should therefore be transported (under covers) to a separate compound well away from visitors and the main garden area.

Grass clippings/mowings used for mulching border plants should be evenly spread and not left in large heaps where temperature rises may trigger disease activity. In affected sites, mowers used in areas of disease findings (and so which may be contaminated with infected leaf debris mixed with the grass), should be cleaned/disinfected regularly. Grass from these areas should preferably be dried and burnt and not used for mulching purposes.

In order to ensure that waste is recovered or disposed of without endangering human health or harming the environment, a permit is required by any establishment or undertaking carrying out a waste management activity. Permits need to be obtained from the competent authority, which for England and Wales is the Environment Agency.

However, EU member states are allowed to provide exemptions from the need for a permit for waste recovery operations (or disposal operations at the place of production of the waste). There is a requirement to register to operate under an exemption, again with the Environment Agency, and the amount of information required to register varies depending on the level of risk the activity poses.

Full details of the exemptions available and how to register can be found on the Environment Agency website. Examples of relevant available exemptions are those for the chipping, shredding, cutting or pulverising of plant waste matter or the exemption for the deposit of plant tissue agricultural waste at the place of production.

With regards to disposal activities not at the place of production, as well as the permitting requirements of the Waste Framework Directive, disposal operations may also be subject to requirements from additional Directives, such as the Landfill Directive (1999/31/EC). All waste must be treated before it is sent to a landfill site. This applies to all businesses and is designed to increase waste recycling and recovery and to reduce potentially polluting emissions from landfills.

Agricultural waste was incorporated into waste management regulation through the Waste Management (England and Wales) Regulations 2006. The Environment Agency has issued a series of guidance notes explaining the impact of the regulations and providing advice on what to do (see contacts at Section 12). The code of practice for the management of Agricultural and Horticultural Waste produced by Defra's Plant Health Division provides further guidance and is an important source of reference. This can be viewed on the Defra website at: www.defra.gov.uk/planth/publicat/waste/index.htm. A practical guide for farmers and growers called 'Saving money by reducing waste' (PB11674) is available free from Defra publications on 08458 556000.

10.5 Publicity and outbreak sites

The Environmental Information Regulations govern the release of information and environmental risks concerning both *P. ramorum* and *P. kernoviae*. Departments do not generally release details of sites where prompt eradication action is being taken at the occupier's expense, where there is no plant health benefit in doing so. Where there is a continuing risk of disease spread from a site, Defra and the Forestry Commission (FC) may require the precise geographical location of the site to be published, for example on their respective websites. Outbreaks are presented on the websites as dots on maps of the UK. These do not identify individual sites/premises.

Where an occupier has particular concerns about the potential effects of publicity on their business, Departments will work with them to try to ensure that the publicity is accurate and presents any risks in an appropriate way.

11. Research

11.1 Risk Analysis for *Phytophthora ramorum* (RAPRA) project

An important component of present research programmes is the Risk Analysis for *Phytophthora ramorum* (RAPRA) project being undertaken by Forest Research and CSL and co-funded by Defra and the Forestry Commission with support from the European Commission. The overall objective of this project is to produce a European Pest Risk Analysis for *P. ramorum* including harmonised risk management strategies and contingency plans applicable to the pathogen within the EU. The current host and geographical range of the pathogen will also be documented, including confirmation of the distribution of mating types within each population. The socio-economic and environmental impact of both European and American populations is also being studied as is the epidemiology of the pathogen relative to establishment risk. The results of the project will include a review of phytosanitary policy in relation to risk whilst minimising disruption to trade. Further details of research results are available at: <http://rapra.csl.gov.uk>

11.2 Further research information

Information on *P. ramorum* surveys and research activities, including a summary of key research findings, can be found at: www.defra.gov.uk/planth/pramorom6.htm.

Information on *P. kernoviae* research activities can be found at: www.defra.gov.uk/planth/pkernovii5.htm.

Details of the Forestry Commission's woodland surveys can be found at: www.forestry.gov.uk/forestry/inf-d-6kzblh.

12. Contact points for advice and further information

If you suspect an outbreak of the disease:

In **England and Wales**, your local office of the Defra Plant Health & Seeds Inspectorate (PHSI) should be notified immediately; or the PHSI Headquarters located at York:

Tel: 01904 455174, **Fax:** 01904 455197

e-mail: planthealth.info@defra.gsi.gov.uk

Website: www.defra.gov.uk/planth/ph.htm

Details of **local PHSI offices** can be found at: www.defra.gov.uk/planth/offices.pdf

In **Scotland**, contact The Scottish Government, Rural Payments and Inspections Directorate, Horticulture & Marketing Unit, Edinburgh:

Tel: 0131 244 6303, **Fax:** 0131 244 6449

e-mail: hort.marketing@scotland.gsi.gov.uk

Website: www.scotland.gov.uk

In **Northern Ireland**, contact DARDNI (Department of Agriculture and Rural Development Northern Ireland) at DARD (NI), Quality Assurance Branch, Magnet House, 81-93 York Street, Belfast, BT15 1AD:

Tel: 02890 547106, **Fax:** 02890 547204

e-mail: qab.admin@dardni.gov.uk

or for **woodland enquiries Tel:** 02890 765391, **Fax:** 02890 524380

e-mail: grants.forests@ardni.gov.uk

In **England, Wales and Scotland**, all **tree and woodland enquiries** should be directed to the Forestry Commission Plant Health Service:

Tel: 01546 602382, **Fax:** 0131 314 6148

Website: www.forestry.gov.uk

If seeping cankers that could be caused by *P. ramorum* or *P. kernoviae* are seen on trees, contact the Forest Research Advisory Service:

Tel: 01420 23000 or 01420 22255

E-mail: info@forestry.gsi.gov.uk

Website: www.forestresearch.gov.uk

The Central Science Laboratory (CSL) can be contacted at:

Tel: 01904 462000, **Fax:** 01904 462111

E-mail: science@csl.gov.uk

Website: www.csl.gov.uk

Enquiries concerning the **Waste Management (England and Wales) Regulations 2006**, "The Agricultural Waste Regulations", should be directed to the Environment Agency:

Customer Contact Centre Tel: 0845 603 3113

Emergency Hotline: 0800 80 70 60

Website: www.environment-agency.gov.uk

Further information can also be found at:

www.environment-agency.gov.uk/business

www.defra.gov.uk/environment/waste/topics/agwaste.htm

www.wasterecycling.org.uk



Department of
**Agriculture and
Rural Development**

www.dardni.gov.uk



The Scottish
Government



ADAS



Llywodraeth Cysullad Cymru
Welsh Assembly Government



Forestry Commission



defra

Department for Environment
Food and Rural Affairs