

Field Identification Guide

Phytophthora ramorum



Photograph: Barnaby Wylder, Forestry Commission, Scotland, tree health team

Phytophthora ramorum

Phytophthora ramorum is an aggressive fungus-like pathogen that causes extensive damage to a wide range of trees and shrubs. The disease affects the foliage and bark of a number of both broadleaved and conifer trees and is particularly prevalent on the western side of the UK where climatic conditions favour its growth and spread. When multiple hosts occur on infected sites, symptoms of *P. ramorum* are likely to occur in a variety of species. The disease is often fatal to the trees it affects and it has had a major impact on forestry in the UK.

Species affected	<i>Phytophthora ramorum</i> can infect numerous tree and shrub hosts, which can be divided into two host types: (1) 'Sporulating/spore-producing' or 'foliar' hosts whose leaves are susceptible to the disease. The pathogen is able to reproduce in, and spread from, these hosts to produce new infections on the same or different hosts. (2) 'Terminal' hosts are those within which the pathogen cannot easily reproduce or from which it cannot spread. Development of symptoms in terminal hosts may take a number of years before the infection becomes severe enough to be fatal. In these hosts the bark rather than the leaves is susceptible to infection. The main sporulating forestry hosts in the UK are larch (<i>Larix</i> spp.), rhododendron (<i>Rhododendron ponticum</i>), <i>Vaccinium myrtillus</i> and sweet chestnut (<i>Castanea sativa</i>). In larch, both the leaves and the bark are susceptible to the disease. In areas of high inoculation, the foliage of native oak species has also been infected. Terminal hosts include broadleaved trees such as European beech (<i>Fagus sylvatica</i>), southern beech (<i>Nothofagus</i> spp.), oaks (<i>Quercus</i> spp.) including the northern red oak (<i>Q. rubra</i>), Turkey oak (<i>Q. cerris</i>), holm oak (<i>Q. ilex</i>), horse chestnut (<i>Aesculus hippocastanum</i>) and birch (<i>Betula</i> spp.). The disease can also affect a number of conifers including grand fir (<i>Abies grandis</i>), noble fir (<i>Abies procera</i>), Douglas fir (<i>Pseudotsuga menziesii</i>) and western hemlock (<i>Tsuga heterophylla</i>). It has also occasionally been found on Sitka spruce (<i>Picea sitchensis</i>). In most cases, bark infections are a result of infection by spores that have spread from the leaves/needles of nearby sporulating hosts such as rhododendron or larch.
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Signs and symptoms	The signs and symptoms of this disease vary according to the host species it is affecting. On larch: An obvious symptom of <i>P. ramorum</i> disease is the occurrence of bleeding cankers on the bark of side shoots, branches and the main stem of infected trees. Profuse production of a sticky, translucent resin is often associated with these cankers and this becomes white and crusty with age. As lesions underlying the bleeding cankers girdle shoots, branches and stems, the tree's needles become a distinctive yellow/ginger colour. The girdling lesions also cause partial or complete dieback of branches and the crowns of infected trees. Partial or abnormal needle flushing and retention of dead/dying needles is also a common symptom on infected trees. Epicormic growth (profuse sprouting) may be visible among dead branches and the crowns of infected trees. Larch trees can be killed rapidly (within 2–3 years of infection), especially after suffering multiple aerial infections on branches and stems. Foliar symptoms which are specifically associated with sporulation of the pathogen include wilted, withered shoot tips with blackened needles often with a dark grey/purple hue. The infected shoots can shed their needles prematurely with just the needles at the shoot tips remaining. Flushing of buds can also be abnormal or completely aborted. Look-alike symptoms such as shoot dieback and discoloured, distorted needles can be caused by larch woolly aphids (adelgids/sap-sucking insects). The needles can become a purplish brown colour before they drop. However, secretions of a white waxy wool can distinguish infestations of adelgids from symptoms of <i>P. ramorum</i> on larch needles. In heavy infestations the tree can begin to die back with the needles becoming a yellow colour. Infestations of other insects such as the larch case-bearer (<i>Coleophora laricella</i>) may also result in discoloured and dead needles in larch. Another pest that causes look-alike symptoms in larch is the bark boring beetle <i>Ips cembrae</i>, which introduces a pathogenic fungus to its host tree as it bores into the main stem for breeding. The disease lesions and galleries caused by the beetle larvae in combination eventually become extensive and girdle the tree,
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resulting in the tops of the trees becoming discoloured and dying. The presence of the galleries in the bark distinguishes a *P. ramorum* infection from an infestation by *I. cembrae*. Top death in larch is also a feature of drought stress to which larch is particularly vulnerable.

Needle cast diseases and needle blights can also affect larch species, with the main symptoms being discoloration and dieback of needles and defoliation of shoots. The fungal pathogen *Meria laricis* causes one such disease in which the needles at the tip of the shoots look green and healthy while the needles along the length of the shoot have died. *Sirococcus conigenus* is another fungus that can cause shoot blight in larch. Bark-killing fungi such as *Cytospora* spp. and *Allantophomopsis pseudotsugae* (previously known as *Phacidium coniferarum*) cause shoot death when the lesions they produce girdle the base of the shoot, thereby depriving the tree of water. Cankers on the bark of larch can also be caused by the fungus *Lachnellula willkommii*.

Discoloration and death of foliage in the crowns of larch trees can also be caused by squirrel damage to the bark of branches and stems.

On *Rhododendron ponticum*:

Typical foliar symptoms include leaf-blackening, wilted leaves and shoots and shoot dieback. The leaf stalks of infected leaves can become blackened, with the discoloration extending into the leaf along the midrib. Blackening at the leaf tip can also occur and this will again progress along the midrib towards the leaf base and stalk. Watery lesions with undefined margins develop in leaves as the infection advances within the leaf tissue. The infection process can occur rapidly, causing the shoots to wilt and the leaves to hang down. Shoot dieback originating at the shoot tip and extending downwards, causing shoots to have a bent over/shepherd's crook appearance, is also a common symptom of *P. ramorum* in rhododendron. Lesions or cankers may form on twigs or stems, progressing back from, or spreading into, side shoots and leaves. Cankers near ground level can cause rapid wilting of shoots and leaves.

Other *Phytophthora* species and honey fungus (*Armillaria* spp.) can also affect roots of rhododendron causing

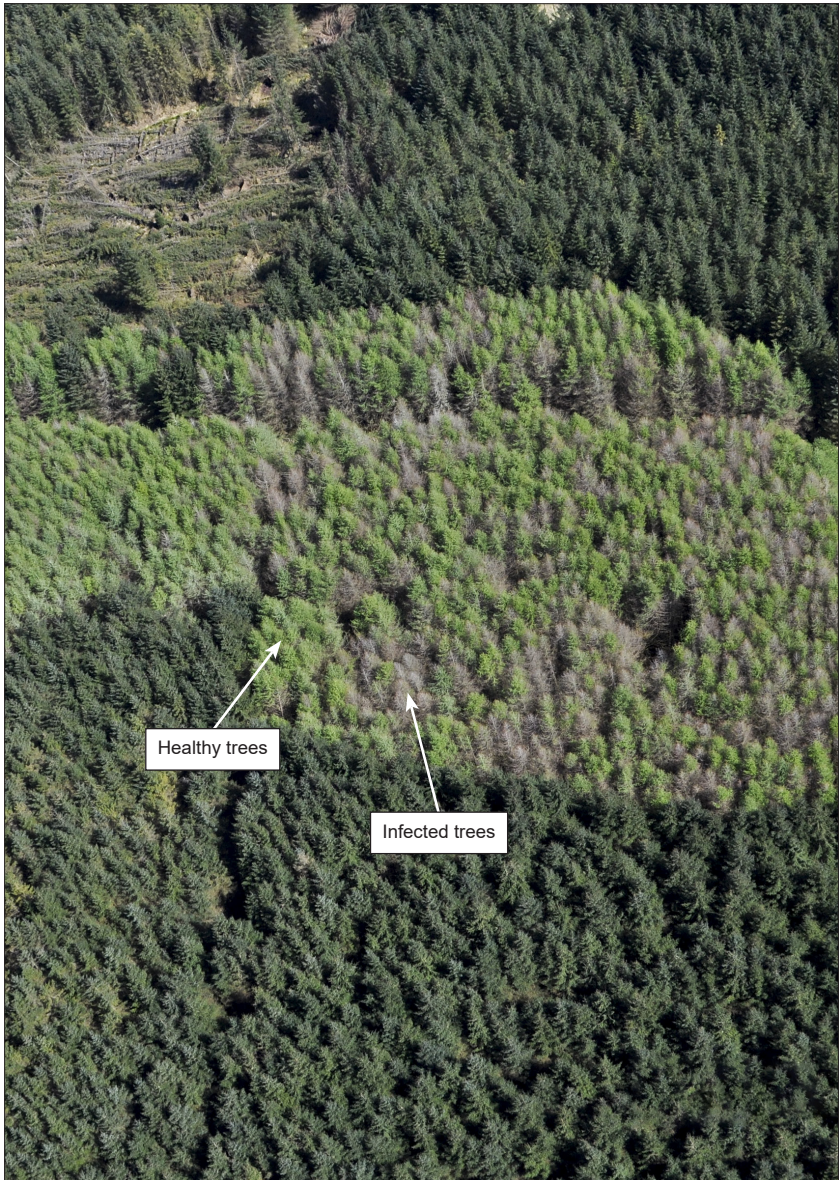
	symptoms such as wilting, yellow or sparse foliage and shoot and branch dieback. Other pathogens can cause blotches on the leaves of rhododendron, for example the fungal leaf spot fungus (<i>Glomerella cingulata</i>), but they do not follow the same disease pattern as <i>P. ramorum</i> and are often circular in appearance and also often have a purple halo around the circumference of the lesion. <i>P. kernoviae</i> is another fungal pathogen that causes similar symptoms to those of <i>P. ramorum</i> on rhododendron. On <i>Vaccinium myrtillus</i>: <i>Vaccinium myrtillus</i> is susceptible to <i>P. ramorum</i> and infection among plants spreads through open heath and causes extensive dieback. Symptoms include leaf necrosis, blackened shoots and dieback. <i>P. kernoviae</i> also infects <i>V. myrtillus</i> and produces symptoms that are almost identical to those of <i>P. ramorum</i>. <i>V. myrtillus</i> is also susceptible to other <i>Phytophthoras</i>. <i>V. myrtillus</i> will exhibit dieback if its roots are affected by pathogens or abiotic factors. <i>V. myrtillus</i> is also susceptible to a fungal rust disease caused by <i>Calyptospora goeppertiana</i>, which causes deformation and browning of shoots ('witches' brooms') and a reduction in leaf size. On sweet chestnut: Foliar symptoms include wilting, and leaves with 'water-soaked' or discoloured margins. The petioles of infected leaves may also be blackened, with the discoloration extending along the midrib of the leaf. Infected leaves can be shed prematurely and may be present beneath affected trees. Other symptoms of <i>P. ramorum</i> infection on sweet chestnut include profuse epicormic growth at the base of the stem, often with retained symptomatic foliage. Infected trees can also display a progressive year-on-year decline. Lesions can develop on the bark of infected sweet chestnut trees. Other <i>Phytophthora</i> species such as <i>P. cinnamomi</i> and <i>P. cambivora</i> can infect and kill roots of sweet chestnut trees and cause cankers on the base of infected trees leading to dieback in the crown. Pathogenic fungi such as <i>Cryphonectria parasitica</i> (causes chestnut blight; a priority pathogen which is notifiable) and <i>Gnomoniopsis smithogylvii</i> can also cause cankers on the bark of sweet chestnut trees leading to
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	dieback in the shoots and branches. On the bark of other broadleaved trees such as beech: The symptoms on broadleaved trees such as beech, oak and southern beech are mainly bark lesions which exude fluid from infected areas. The exudate is often a dark colour which can dry to a crust on the outer bark of the tree. The inner bark underneath bleeding areas is discoloured (usually brown) and dying. There may be many, or just a few, lesions on a single tree with the size of the lesions varying. The lesions are usually found on the lower stem, but are occasionally up to a few metres above ground level. <i>P. ramorum</i> lesions do not extend below the soil line and do not appear to infect root systems. When the lesions become extensive on, or girdle, the main stem, the tree will die. Bleeding lesions on the stems and branches of broadleaved trees can result from infection by honey fungus (<i>Armillaria</i> spp.) and other <i>Phytophthora</i> species such as <i>P. pseudosyringae</i> and <i>P. kernoviae</i>. Bleeds on oak trees may also result from acute oak decline (an Observatree priority disease). However, acute oak decline bleeds tend to be a very dark brown and originate from between cracks in bark plates at heights of 1 metre plus, whereas <i>Phytophthora</i> bleeds on oak tend to be more black/purple and originate randomly from areas of the lower stem.
Timing	On larch: Yellowing or gingering of needles will often be the first visible sign of infection and can be observed when the larch is bearing needles from May to October. The foliar symptoms associated with the pathogen sporulating (e.g. wilting shoot tips, purple/black needles and premature needle drop) are most likely to be seen at the beginning of the autumn, in September and October. During the winter, retained needles indicating sudden death of branches or some or all of the crown, may be visible. Lesions/bleeding cankers on the stems and branches can be present all year round but may be easier to see in the winter when the foliage is absent. On <i>Rhododendron ponticum</i>: Leaf lesions, wilt and shoot and twig cankers may be visible all year round.

	On <i>Vaccinium myrtillus</i>: Symptoms can be seen all year round. On sweet chestnut: Symptoms on the leaves can be observed throughout summer until the leaves fall in the autumn. Bark cankers may be visible all year round. On the bark of other broadleaved trees such as beech: Lesions and bleeds can be observed on branches and stems all year round but may be easier to see in the winter when leaves are absent.
Biosecurity	<i>P. ramorum</i> spreads through soil, organic matter, mists and rainsplash. Transportation and movement of infected plants is also a key means of long-distance spread. Precautions such as cleaning and disinfecting footwear and tools before and after a site visit are essential and can be a legal requirement in outbreak areas to prevent further spread. Remember to check clothing such as collars, inside boots, hoods and outer pockets too. Keep vehicles on hard tracks and ensure that they are kept clean so that they are easier to disinfect when necessary and check them over for any plant material before leaving an infected site. In larch, rhododendron and <i>V. myrtillus</i> infected areas, tree needles/leaves and soil are the main risks, especially if they are wet. Surface water such as puddles also increases the risk of spread. Even after felling and removal of infected larch trees, infective spores may still persist on needles and in the soil.
Reporting requirements	If you find this disease, please report it through Tree Alert (https://treealert.forestresearch.gov.uk). In Northern Ireland please report via the TreeCheck website (www.treecheck.net) or phone app, or by emailing planthealth@daera-ni.gov.uk For traded plants and any non-tree hosts please email planthealth.info@apha.gov.uk (England & Wales), or hort.marketing@gov.scot (Scotland).

Based on information available in December 2017.

Signs and symptoms on larch



Photograph: Forestry Commission England Tree Health team

Impact of *Phytophthora ramorum* on larch at a landscape scale. The healthy trees are bright green in colour and the infected trees are a grey-brown colour.

Signs and symptoms on larch



Photograph: Clive Brasier, Forestry Commission

Japanese larch trees (*Larix kaempferi*) infected with *Phytophthora ramorum*.

Signs and symptoms on larch



Photograph: Barnaby Wylder, Forestry Commission England Tree Health team

Dieback of Japanese larch (*L. kaempferi*) caused by *Phytophthora ramorum*. Individual branches or complete crowns can be affected.

Signs and symptoms on larch



Photograph: Suzanne Sancisi-Frey, Forest Research

Epicormic growth can occur among dead branches of larch trees infected with *Phytophthora ramorum*.

Signs and symptoms on larch



Photograph: Suzanne Sancisi-Frey, Forest Research

Epicormic growth occurring among dead branches and extending down the stems of larch trees infected with *Phytophthora ramorum*.

Signs and symptoms on larch



Photograph: Barnaby Wylder, Forestry Commission England Tree Health team

Profuse resin production associated with *Phytophthora ramorum* bark lesions. Here the resin is fresh and translucent.

Signs and symptoms on larch



Photograph: Ben Jones, Forestry Commission England Tree Health team

Profuse resin bleeds are associated with *Phytophthora ramorum* lesions on the stem and branches. The resin here has dried out to a white crust.

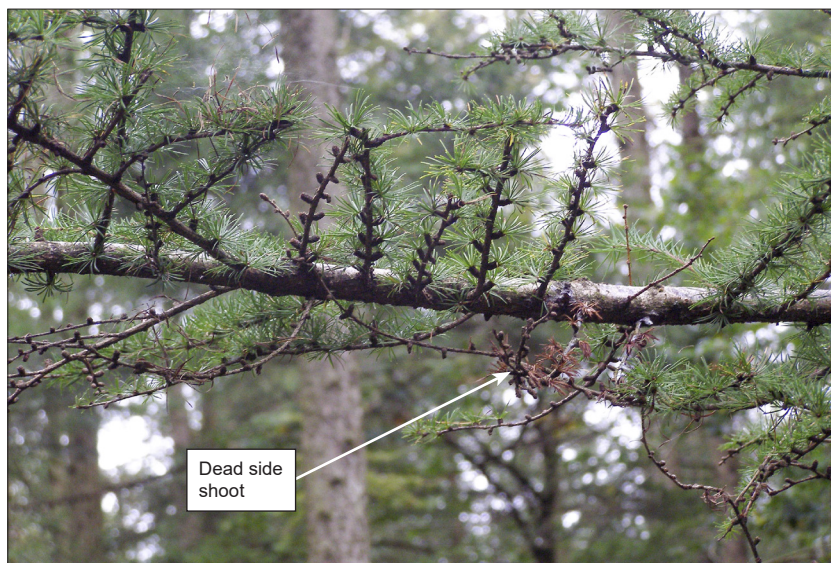
Signs and symptoms on larch



Photograph: Isobel Cameron, Forestry Commission

Resin exudation on a larch branch as a result of *Phytophthora ramorum* infection of the bark. Here the resin has dried to a white crust but is more subtle and less obvious.

Signs and symptoms on larch

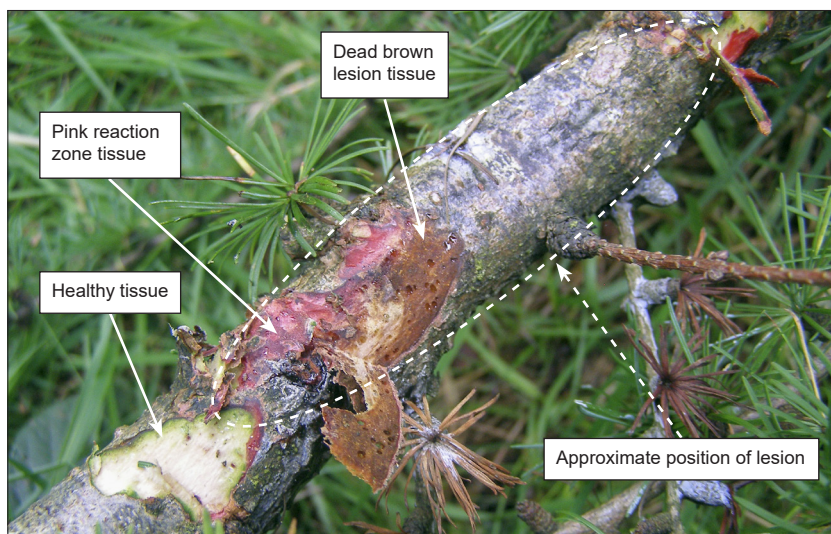


Sometimes symptoms can be subtle such as this dead and discoloured side shoot associated with a *Phytophthora ramorum* lesion on a side branch of an infected larch tree.



Phytophthora ramorum lesion on a side branch of an infected larch causing the discoloration and death of side shoots. Resin production is associated with the lesion.

Signs and symptoms on larch



Photograph: Suzanne Sandis-Frey, Forest Research

An infected larch side branch showing discoloration and death of side shoots. The outer bark has been removed to show the brown dead tissue of the lesion, the red/pink reaction tissue characteristic of a *Phytophthora ramorum* lesion and the healthy tissue beyond the lesion.



Photograph: Barnaby Wylder, Forestry Commission England Tree Health team

Foliage of larch becomes discoloured when stems or branches are girdled by *Phytophthora ramorum* lesions.

Signs and symptoms on larch



Photograph: Johnny Hathaway, Forestry Commission

Foliage of larch becomes discoloured when stems or branches are girdled by *Phytophthora ramorum* lesions.

Signs and symptoms on larch



Photograph: Ben Jones, Forestry Commission England Tree Health team

Foliar symptoms of *Phytophthora ramorum* on larch associated with sporulation of the pathogen.



Photograph: Mick Biddle, Forestry Commission England Tree Health team

Wilt and dieback of fresh growth. Distinct wilting/greying needles (often only retained towards tips of shoots).

Signs and symptoms on larch



Photograph: Barnaby Wylder, Forestry Commission England Tree Health team



Photograph: Ben Jones, Forestry Commission England Tree Health team

Grey/purple coloration of larch needles infected by *Phytophthora ramorum* and associated with sporulation of the pathogen. Note that frost damage can also cause needles to become discoloured and shoots to wilt and die.

Signs and symptoms on Douglas fir



Photograph: Ben Jones, Forestry Commission England Tree Health team

Phytophthora ramorum stem infection on a young Douglas fir leading to death of the top of the tree.

Signs and symptoms on Douglas fir



Photograph: Alan Ockenden, Forestry Commission England Tree Health team

Phytophthora ramorum stem lesion on a young Douglas fir.

Signs and symptoms on western hemlock



Photograph: Ben Jones, Forestry Commission England Tree Health team

Phytophthora ramorum infection on western hemlock foliage.



Photograph: Suzanne Sancisi-Frey, Forest Research

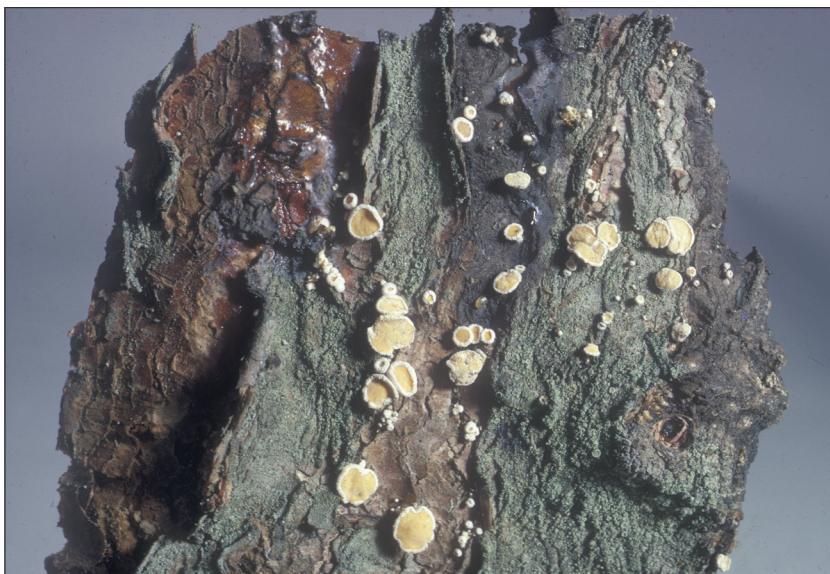
Dead shoot tips on western hemlock caused by *Phytophthora ramorum*.

Look-alike signs and symptoms on larch



Photograph: David Rose, Forestry Commission

Symptoms of larch canker (*Lachnellula willkommii*) on a side branch of infected larch.



Photograph: Barry Lambdown, Forestry Commission

Larch canker fruiting bodies (1–4 mm).

Look-alike signs and symptoms on larch



Photograph: Barry Lambsdown, Forestry Commission

Larch canker on stem showing sooty coloured resin exudation, fruiting bodies and stem deformation.

Look-alike signs and symptoms on larch



Photograph: Robert Strouts, Forestry Commission



Photograph: Robert Strouts, Forestry Commission

The fungal pathogen *Allantophomopsis pseudotsugae* (previously known as *Phacidium coniferarum*) causes the death of twigs and small branches in larch trees (the photos here show symptoms on an Atlas cedar, *Cedrus atlantica*; however, the symptoms in larch look the same).

Look-alike signs and symptoms on larch



Photograph: Robert Strouts, Forestry Commission

The fungal pathogen *Allantophomopsis pseudotsugae* causes the death of twigs and small branches in larch trees (the photo here shows symptoms on an Atlas cedar; however, the symptoms in larch look the same).

Look-alike signs and symptoms on larch



Photograph: Forestry Commission

Signs and symptoms of larch woolly aphids (*Adelges laricis*). Needles are discoloured and shoots become defoliated. Note the white woolly secretions on needles.



Photograph: Tony Anderson, Forestry Commission

Signs and symptoms of larch woolly aphids. Note the white woolly deposits on the needles.

Look-alike signs and symptoms on larch



Photograph: Forestry Commission



Photograph: Forestry Commission

Signs and symptoms of the larch case-bearer (*Coleophora laricella*). The needles become discoloured and die from the needle tip.

Look-alike signs and symptoms on larch



Photograph: Myler Crooke, Forestry Commission

Larch trees that have been infested with the bark boring beetle *Ips cembrae*.

Look-alike signs and symptoms on larch



Photograph: Thelma Wood, Forestry Commission

Galleries of the bark beetle *I. cembrae* in European larch (*L. decidua*).

Look-alike signs and symptoms on larch



Photograph: Forestry Commission

Signs and symptoms of a needle cast disease on larch caused by the fungal pathogen *Meria laricis*.

Look-alike signs and symptoms on larch



Photograph: Forestry Commission

Signs and symptoms of a needle cast disease on larch caused by *M. laricis*. Note that the needles at the tip of the shoots look green and healthy while the needles along the remainder of the shoot have died.

Signs and symptoms on *Rhododendron ponticum*



Photograph: Ben Jones, Forestry Commission England Tree Health team

Early *Phytophthora ramorum* infection on *Rhododendron ponticum*. Note the wilting leaves.



Photograph: Everett Hansen, Oregon State University

Typical shoot dieback and wilting rhododendron leaves caused by *Phytophthora ramorum* infection.

Signs and symptoms on *Rhododendron ponticum*



Photograph: Suzanne Sancisi-Frey, Forest Research

Wilting rhododendron leaves caused by *Phytophthora ramorum* infection.

Signs and symptoms on *Rhododendron ponticum*



Photograph: Barnaby Wylder, Forestry Commission England Tree Health team

Shoot dieback and wilting rhododendron leaves caused by *Phytophthora ramorum* infection. Note the bent over (shepherd's crook) appearance of the shoot, which occurs as the shoot dies back from the tip.

Signs and symptoms on *Rhododendron ponticum*



Photograph: Suzanne Sandisi-Frey, Forest Research

Typical symptoms of a *Phytophthora ramorum* infection on a rhododendron leaf. The infection has entered the leaf both via the petiole and the leaf tip where water collects.



Photograph: Suzanne Sandisi-Frey, Forest Research

Typical symptoms of a *Phytophthora ramorum* infection on a rhododendron leaf. The infection has entered the leaf via the petiole and is progressing along the midrib.

Look-alike signs and symptoms on *Rhododendron* spp.



Photograph: RHS, Horticultural Science



Photograph: Suzanne Sancisi-Frey, Forest Research

Leaf blotch on rhododendron can be caused by a number of different organisms such as *Gloeosporium rhododendri* and *Septoria* spp.

Signs and symptoms on *Vaccinium myrtillus*



Photograph: Barnaby Wylder, Forestry Commission England Tree Health team

Woodland *Vaccinium myrtillus* infected with *Phytophthora ramorum*.

Signs and symptoms on *Vaccinium myrtillus*



Photograph: Barnaby Wylder, Forestry Commission England Tree Health team

Woodland *Vaccinium myrtillus* infected with *Phytophthora ramorum*.

Signs and symptoms on *Vaccinium myrtillus*



Photograph: Barnaby Wylder, Forestry Commission England Tree Health team

Woodland *Vaccinium myrtillus* infected with *Phytophthora ramorum*.

Signs and symptoms on *Vaccinium myrtillus*



Photograph: Ben Jones, Forestry Commission England Tree Health team

Infected woodland *Vaccinium myrtillus* showing symptoms that are typical of *Phytophthora ramorum* and *Phytophthora kernoviae*.

Signs and symptoms on *Vaccinium myrtillus*



Photograph: Ben Jones, Forestry Commission England Tree Health team

Infected woodland *Vaccinium myrtillus* showing symptoms that are typical of *Phytophthora ramorum* and *Phytophthora kernoviae*.

Signs and symptoms on sweet chestnut



Photograph: Mick Biddle, Forestry Commission England Tree Health team

Severe crown dieback on sweet chestnut trees caused by *Phytophthora ramorum*.

Signs and symptoms on sweet chestnut



Photograph: Barnaby Wylder, Forestry Commission England Tree Health team

Prolific epicormic growth, with brown and wilting hanging foliage caused by *Phytophthora ramorum*.

Signs and symptoms on sweet chestnut



Photograph: Mick Biddle, Forestry Commission England Tree Health team

Wilting, 'water-soaked' and discoloured foliage on epicormic shoots at the stem base of a *Phytophthora ramorum* infected sweet chestnut tree.

Signs and symptoms on sweet chestnut



Photograph: Mick Biddle, Forestry Commission England Tree Health team



Photograph: Forest Research

Sweet chestnut leaves infected with *Phytophthora ramorum* showing discoloured midribs.

Look-alike signs and symptoms on sweet chestnut



Photograph: Helen Carter, Forestry Commission England Tree Health team

Clusters of dead leaves on a young sweet chestnut infected with a fungal pathogen (*Cryphonectria parasitica*) which causes chestnut blight.

Look-alike signs and symptoms on sweet chestnut



Photograph: Forestry Commission England and Tree Health team

Severe dieback in the crown of a sweet chestnut tree that is infected with *Phytophthora cinnamomi*.

Signs and symptoms on the bark of broadleaved trees



Photograph: Forestry Commission England Tree Health team

Stem bleeding caused by *Phytophthora ramorum* on beech.

Signs and symptoms on the bark of broadleaved trees



Photograph: Forestry Commission England and Tree Health team

Stem bleeding caused by *Phytophthora ramorum* on beech. Note the bleeding can occur quite high on the stem.

Signs and symptoms on birch



Photograph: Ben Jones, Forestry Commission England Tree Health team

Birch tree infected with *Phytophthora ramorum*.

Look-alike signs and symptoms on the bark of broadleaved trees



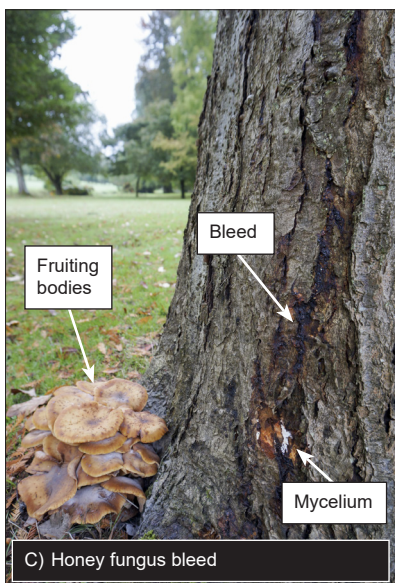
A) Bacterial wetwood

Photograph: Sandra Denman, Forest Research



B) *Phytophthora pseudosyringae* bleed on beech

Photograph: Ana Pérez-Sierra, Forest Research



C) Honey fungus bleed

Photograph: Ana Pérez-Sierra, Forest Research



D) Acute oak decline bleed

Photograph: Forestry Commission

Other pathogens can also cause bleeds on the bark of broadleaved trees such as bacteria (A), other *Phytophthora* spp. (B), honey fungus (C) and acute oak decline (D).

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Observatree aims to create a tree-health early-warning system using citizen science.

Observatree is a partnership project led by Forest Research, the research agency of the Forestry Commission. Project partners are the Animal & Plant Health Agency (APHA), Department for Environment, Food & Rural Affairs (Defra), Fera Science Ltd, the Forestry Commission, the National Trust, Scottish Forestry, the Welsh Government and the Woodland Trust. Supporting the project is Natural Resources Wales. The first four years of this project was 50% funded by the EU's LIFE programme.

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This booklet forms part of a set that supports Observatree volunteers when out looking for priority pests and diseases. It supplements face-to-face training and is not intended as a full or detailed description. It will also be useful for others who have some knowledge of the particular pest or disease and understand how to look for these. Further information is available online from the websites listed below:

www.observatree.org.uk

www.forestresearch.gov.uk/tools_and_resources/fthr/pest-and-disease-resources/

www.gov.uk/guidance/prevent-the-introduction-and-spread-of-tree-pests-and-diseases

<https://planthealthportal.defra.gov.uk>