

The Ramorum Conundrum

Recently found for the first time in conifers, *Phytophthora ramorum* is on the march

Six years ago Britain came face to face with an alien plant pathogen which threatened to change the landscape on an even greater scale than did Dutch elm disease three decades earlier. England's 'Hearts of Oak' which saved the day against the King of Spain and Napoleon Bonaparte were now the assumed targets of *Phytophthora ramorum* ripping through oak forests in the Pacific North West. The first infected tree found in the United Kingdom in 2003 was a 200-year-old southern red oak (*Quercus falcata*) in East Sussex – like the pathogen, a non-native species.

All eyes switched to the Pacific North West where native oaks, including tan oak (*Lithocarpus densiflora*), coastal live oak (*Quercus agrifolia*) and Californian black oak (*Quercus kelloggii*) were being killed in their millions across north western California and Oregon. Initial bark infection developed into a systemic necrosis, girdling the bole and killing 80 per cent of infected trees along the way. The adopted North American name 'sudden oak death' was seized on by the UK media and irreverently shortened to 'SOD', as Britain anticipated a massacre of its native white oaks *Quercus robur* (pedunculate oak) and *Quercus petraea* (sessile oak).

In the event, pathogen and disease in the UK turned out to be an enigma. It was reported from Germany and Netherlands as early as 1993, two years before the first tree succumbed in North America, but confined to *Rhododendron* and *Viburnum* in nurseries. The first indi-

cation that UK trees may succumb was the infection of container-grown yew (*Taxus baccata*) in 2002. By 2003 there were already 350 reported cases on a wide range of species in UK nurseries and garden centres including *Camellia*, *Pieris* and *Syringa* (lilac), as well as *Rhododendron* and *Viburnum*.

By 2004 native British oaks were still free of infection, while other thin-barked relatives in the *Fagaceae* (beech family) were infected. That said, the speed and spread of infection and rate of terminal decline was generally lower than seen in North America. Common beech (*Fagus sylvatica*), Turkey oak (*Quercus cerris*), holm oak (*Quercus ilex*), sweet chestnut (*Castanea sativa*), horse chestnut (*Aesculus hippocastaneum*) and common ash (*Fraxinus excelsior*) were added to the list of naturally infected trees.

Natural infections were also recorded on an ever-widening range of ornamental shrubs including *Kalmia*, *Magnolia*, *Leucothoe*, witch hazel (*Hamamelis virginiana*), Winter's bark (*Drimys winteri*) and *Vaccinium* species (eg bilberry and cowberry). The known natural host range now covers 130 species in 75 genera spread across 37 plant families. Research has shown virtually all species, including conifers, can be infected under laboratory conditions.

Mycological evidence indicated the pathogen entered the UK on infected plant material from Europe, not North America, while taxonomists have separately decided (on DNA evidence) that the



Pictures courtesy Forest Research

Shoot-tip die-back on holm oak caused by *Phytophthora ramorum*.

Phytophthora genus, with all its species including *ramorum*, is not a true fungus and should be taken out of the plant kingdom 'Fungi' and placed in the 'Chromista' (algae).

Varied symptoms on an increasingly wide range of species representing trees, shrubs and ground cover plants showed 'sudden oak death' as an unnecessarily narrow and restrictive name. More appropriate and meaningful are a trio of terminologies:

- 'Ramorum bleeding canker' after the discoloured lesions on the trunks of trees which issue dark coloured ooze rich in brown tannins
- 'Ramorum leaf blight' that describes dark necrotic areas on the leaves of some trees (eg holm oak), shrubs and herbaceous plants
- 'Ramorum die-back' caused by shoot/stem infection leading to tip wilt and die-back in rhododendron.

Two pathogens, several strains

The best course of action would have been to ban all imports of at least *Rhododendron* and *Viburnum*

immediately after the first European outbreaks in 1993, but this would be contrary to the spirit and law of the European Union. The EU charter is based on free trade in goods, services and labour, additionally coming to cover 'free' trade in pests and diseases. The establishment of a Statutory Order by the UK government relating to specified plant material from the United States following the first identification of *P. ramorum* on *Viburnum tinus* in 2002 was in vain because the disease came in through the 'back door' from Europe.

Mycologists established two mating types, the European A1 mating type and the North American A2 mating type. Each was then confined to its respective region and UK infections were of the A1 mating type. The European strain, redesignated EU1, now occurs in North America with two newly designated 'native' strains NA1 and NA2. NA1 is present in forests and nurseries but NA2 and EU1 are virtually exclusive to nurseries.

The origin of *P. ramorum* is unknown but the strongest speculation suggests Asia, with Yunnan, Taiwan or the eastern Himalayas the most likely areas. Africa is the 'dark continent' for human diseases but Asia has rapidly assumed this role for exotic plant pests and diseases.

Searches in Cornwall during 2003 identified an additional and completely different species alongside *P. ramorum*, sometimes on the same shrub or tree and causing similar symptoms. The newly named *Phytophthora kernoviae* had a much narrower host range though proved to be more pathogenic (aggressive).

Foliar infection template

Phytophthora species infecting trees is nothing new for the UK but the ability of *P. ramorum* to

The ideal gift for Christmas

Our readers loved John Cooper's *Woodsmen's Tales*. Now they have been gathered together into one volume.

116 A4 pages packed with over 70 short stories, photos and cartoons by Gordon Songer.

Price £10.99 + £2.75 p& p. (All proceeds to charity.)

For your copy, call 01903 691034, 07932 151297, email chris.cooper36@ntlworld.com, visit, <http://awoodmanstale.yolasite.com/> or send a cheque payable to Chris Cooper to 110 Boxgrove, Goring-by-Sea, West Sussex BN12 6LX



form infection templates on leaves and produce spores, subsequently spread in air currents and onto the bark of trees, has presented a new and dangerous disease dimension for forestry and arboriculture. Formation of infection templates on the leaves of evergreen shrubs like *Rhododendron* has proved instrumental in the spread of infection to nearby trees and development of the disease as a bark necrosis and canker. Sporulation strategy is another strong point for the pathogen. Combined production of asexual sporangia for dispersal and immediate widespread infection, alongside long-lived chlamydospores (also asexual) for survival, clearly assists disease spread and establishment of the bleeding canker phase on trees. *Phytophthora*, as the primary infective pathogen, paves the way for secondary invaders like *Armillaria* which help to 'finish the job'.

The key template host for *P. ramorum* and *kernoviae* is *Rhododendron ponticum*, an alien and invasive under-storey shrub widely spread throughout UK woodlands, especially in western maritime regions like the Cornish peninsula where these moisture-loving *Phytophthorae* are established. Early mycologists called *Phytophthora* the 'water-fungus' due to its moisture dependence for infection, spore production and spore dissemination.

Infected *Rhododendron ponticum* bushes with leaf necrosis, shoot-tip wilt and die-back symptoms, hold the key to disease spread in the wider-UK woodland environment, just as California bay laurel/Oregon myrtle (*Umbellularia californica*) did in North America. Leaves of other shrubs like lilac produce more spores but, unlike *Rhododendron ponticum*, are not evergreen or widely found as under-storey shrubs in natural woodland.

Early signals showing similar scenarios could develop for naturally occurring ground cover plants were flagged up when naturally infected *Vaccinium* species were found in nurseries. The first confirmed finding on *Vaccinium* in the wild was recorded on bilberry (*V. myrtillus*) in January 2009 in Staffordshire. It opened possibilities for disease spread from wild ground cover plants to trees as well as emphasising the ability of the pathogen to spread beyond south and west of the country.

Pest pathways for *P. ramorum*

A 2009 report (Deliverable Report 28) from EU Sixth Framework Project

RAPRA documented eight pathways as main routes for *P. ramorum* introduction. They are:

- Vegetative planting material of known susceptible hosts
- Vegetative planting material of non-host plant species but with attached contaminated growing media
- Soil or other growing media (containing organic matter) marketed as commodities
- Contaminated soil on footwear, machinery, vehicle tyres etc
- Foliage and cut branches of susceptible foliar hosts sold for ornamental purposes
- Seeds and fruits from susceptible plant hosts
- Bark isolated from susceptible trees and used in amenity or horticultural sectors
- Wood and timber from susceptible trees

Not everything is in its favour

P. ramorum clearly has many factors in its favour but also some 'Achilles' heels' limiting infection rate, spread and damage in UK forestry. Native English oaks have escaped. The pathogen appears to perform most efficiently as a wound parasite, although laboratory tests on mature logs of beech, red oak, native oaks, Sitka spruce and Douglas fir show wounding is not essential for infection.

Bark thickness of English native oak offers physical protection while thinner-barked species, related or not, are more prone to penetrative wounding and therefore infection. Related thin-barked species in the 'Fagaceae' family, such as common beech, and sweet chestnut, have succumbed, with beech the most commonly and rapidly infected by *P. kernoviae* as well as *P. ramorum*. An infected mature beech first found in Unity Wood at Scorrier in Cornwall in 2005 had died by 2007, which is quick, even measured against bacterial bleeding canker of horse chestnut.

Other thin-bark trees of different plant families, including sycamore, common ash and horse chestnut, have similarly succumbed. The same situation clearly prevailed in the Pacific North West where relatively thin-barked North American native oaks have been 'slaughtered' over a 15-year period with over 2 million trees killed so far. And especially tan oak which, in spite of its common name, appears closer botanically and structurally to sweet chestnut rather than English white oaks.

That said, trees are essentially at risk only if admixed with under-



(Left) The stem of a Turkey oak bleeding with tarry ooze as a result of inner bark necrosis caused by *Phytophthora ramorum*. (Right) Exposed *Phytophthora ramorum* lesion on Turkey oak.

storey susceptible shrubs with high spore production capacity, which is why broadleaf woodland with *Rhododendron ponticum* under-storey is the natural/semi-natural forest environment most at risk. Moreover, aerial dissemination of spores has only been recorded when the propagules are carried in airborne water droplets. Contrary to earlier belief, there is recent evidence of commercial softwood forests being at risk, and research shows conifers, including Douglas fir and Sitka and Norway spruce, are all susceptible to infection under laboratory conditions. Resin production in conifers is nevertheless considered to offer a measure of protection against natural infection.

The ideal climate for *Phytophthora* is mild maritime conditions along the western seaboard of the British Isles and especially Cornwall where the disease is most entrenched. That said it should not be viewed purely as a Cornish problem because outbreaks have subsequently been recorded in Devon and Wales. Since 2007 *P. ramorum* has been identified in Scotland in garden sites on a wide range of ornamentals and *P. kernoviae* also in Scotland on *Rhododendron*. *P. ramorum* was discovered in a Northern Ireland domestic garden in August 2007. The Forestry Commission has since delineated the most *Phytophthora*-prone area of the UK as a swathe from western Scotland down to the Cornwall/Devon peninsula, and across England south of a line from the Bristol Channel to the Thames Estuary.

Containment not control

Plant nurseries have borne the brunt of disease, damage and financial loss through continuing international trade in a wide range of suscepti-

ble ornamental plants, and heritage gardens too, especially in Cornwall with wide plant collections, including highly prized *Rhododendrons*, *Camellias*, *Viburnums* and other susceptible evergreen shrubs, with the potential for spread through plant propagation and high visitor numbers. Moreover, heritage gardens invariably contain broadleaf woodland with *Rhododendron ponticum* as the main under-storey shrub.

Containment has correspondingly concentrated on phytosanitary controls in nurseries and plant propagation units and removal of *Rhododendron ponticum* as an under-storey shrub from woodlands, especially within or near heritage garden sites. *Rhododendron* removal is helping to contain the disease but is logistically difficult and expensive with estimates in the region of £8000/hectare.

The official view is *P. ramorum* (and *kernoviae*) are here to stay but subject to suppression providing existing 'containment controls' are at least maintained. The forestry sector has so far escaped but recirculating infection within the nursery trade and endemic infection in heritage gardens could ultimately threaten mature trees in the wider environment, whether in forest plantations, natural or semi-natural woodlands or hedgerows.

The disease continues to circulate within the North American, European and UK nursery industries with infected material from Asia still an unknown quantity. The main phytosanitary controls and quarantine measures for plant material coming into the EU occur at the point of entry in any one of its 27 member countries but movement within thereafter is subject to more minimal restriction.

Dr Terry Mabbett