Phytophthora ramorum and *Phytophthora kernoviae* in England and Wales - Public Consultation and New Programme[1]

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Abstract

Since the first reports in Great Britain (GB) of *Phytophthora ramorum* (2002) and *P. kernoviae* (2003), the death of a small number of infected trees and of heathland *Vaccinium* has been recorded. Initial policy against these pathogens was one of containment, with a view to eradication based on recommendations arising from Pest Risk Analyses (PRAs), whilst more evidence was gathered on their likely impact. Both pathogens have continued to spread slowly, mainly in the southern and western part of GB.

In 2008, a policy and science review, including a public consultation, was carried out in England and Wales, examining the current situation and options for future management of both pathogens. The consultation resulted in the conclusion that an increase in the current level of phytosanitary activity was required to reduce the potential risk of increased tree death and impacts to heathlands and heritage gardens in England and Wales.

A new 5 year programme of work aimed at reducing the risk of *P. ramorum* and *P. kernoviae* spreading further was launched by United Kingdom (U.K.) Ministers (March 2009); £4m was allocated for each of the first 3 years of the programme. Earlier research at woodland outbreak sites in southwest England showed that proactive clearance of sporulating hosts (whether infected or not), especially invasive *Rhododendron ponticum*, was effective in reducing pathogen inoculum and disease spread in woodlands, gardens and parks. This appears to have prevented further infection of trees at a number of woodland sites where clearance has been implemented. Consequently, future management in woodlands and the wider environment will include removal of infected and susceptible plants, and the identification and management of any new outbreaks. Activities will concentrate initially on high-risk, valuable sites, and vulnerable, ecologically important habitats.

Enhanced containment and eradication measures in infected gardens and nursery sites will also be undertaken, together with an education and awareness programme to build and disseminate best practice protocols, aimed at minimizing the risk that these pathogens pose.

A new research programme will improve our understanding of the two pathogens and the diseases they cause, enabling an update of the PRAs, thus informing programme activity, particularly with reference to disease control in a range of environments including heathland.

Introduction

Phytophthora ramorum and *P. kernoviae* are recently described plant pathogens that are considered to have been introduced separately to Europe and North America from

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an unknown origin or origins. *P. ramorum* was first confirmed in Great Britain (GB) in 2002, whilst *P. kernoviae* was first recorded in 2003. *P. ramorum* is present in 21 European countries (19 European Union (EU) Member States plus Norway and Switzerland). It is subject to emergency European Commission (EC) phytosanitary measures. Following an EU-wide Pest Risk Analysis (PRA) (Sansford and others 2009), the EC Standing Committee for Plant Health (SCPH) has provisionally agreed that *P. ramorum* should become listed as a harmful organism within the EC Plant Health Directive (2000/29/EC as amended), with phytosanitary measures yet to be defined and agreed. *P. kernoviae* is recorded in Great Britain (GB) and in Eire, as well as in New Zealand. A U.K. PRA for *P. kernoviae* (Sansford 2008) was also reviewed by the EC SCPH, and there has been provisional agreement that *P. kernoviae* should be subject to emergency EC phytosanitary measures, again yet to be defined and agreed.

In 2008, the Department for Environment, Food and Rural Affairs (Defra), the Forestry Commission, and the Welsh Assembly Government held a policy and science review on *P. ramorum* and *P. kernoviae*, including a public consultation. This examined the historic and current situation as well as the U.K. PRAs for both pathogens (Sansford and Woodhall 2007, Sansford 2008), and proposed options for management of these pathogens in the future. The public consultation offered three options: (i) continue to meet EC minimum requirements on the control of *P. ramorum* and remove all controls against *P. kernoviae* other than maintaining a ban on the movement of infected plants to other countries; (ii) undertake an enhanced programme of activity aimed at reducing the level of inoculum of both species to epidemiologically insignificant levels; (iii) continue containment/eradication activity with the objective of containing the spread whilst gathering further evidence prior to decisions on long-term action.

The third option was ruled out, principally because of the risk of the diseases moving into the exponential phase of the disease progress curve, thus increasing control costs and/or eliminating the potential of implementing option two. The majority of the responses to the consultation were in favour of option two or a variation of option two. The review and consultation recommended increasing current activity levels to reduce the risk of significant tree death and impact on heathlands, and identified the approaches to achieve this.

As a result of this review and consultation, and, its accompanying impact assessment and subsequent business case, a new Defra-funded "*Phytophthora ramorum* and *Phytophthora kernoviae* Disease Management Programme" was approved, to be delivered via Defra's Food and Environment Research Agency (Fera). This programme aims, amongst other objectives, to reduce pathogen inoculum to epidemiologically insignificant levels, by removing sporulating/potentially sporulating host plants from high-risk areas.

Risks (Great Britain)

In GB both *P. ramorum* and *P. kernoviae* are subject to an eradication/containment programme and so their full potential in terms of impact on the environment has not been realised. The west and southwest of GB seems particularly favourable to both pathogens in woodlands, heathlands and managed gardens.

In GB, *P. ramorum* and *P. kernoviae* cause leaf blights or dieback on a wide range of shrub hosts and some trees; these produce inoculum which can infect the stems of susceptible trees, causing bleeding bark cankers which can girdle and kill affected trees. Evergreen rhododendron (especially *Rhododendron ponticum*) is the main sporulating host that drives woodland epidemics, with beech (*Fagus sylvatica*) and some oak species (*Quercus* spp.) being particularly threatened by both pathogens. In GB, trees with bleeding bark cankers have, to date (summer 2009), all been in close proximity to infected rhododendron, particularly *Rhododendron ponticum*. Studies on the effect of *R. ponticum* clearance in infested woodlands, as part of recent research, has shown a reduction in inoculum levels and an apparent lack of infection of new trees within the study period. Recent surveys in GB woodlands have recorded sweet chestnuts (*Castanea sativa*) showing foliar symptoms (and stem cankers) caused by *P. ramorum*; as a sporulating host, this, as well as other species, can act as inoculum sources for infection of other trees. Ornamental plants and trees in heritage gardens can also be seriously affected, and those that are sporulating hosts will drive epidemics.

Heathland plants, especially *Vaccinium* species, are considered to be at high risk, having initially proven to be susceptible in laboratory experiments and subsequently becoming infected by both pathogens in GB. *V. ovatum* has been recorded as a natural host of *P. ramorum* in forests in North America, and in GB, *V. myrtillus* was recently found infected with *P. kernoviae* in woodland and heathland as well as with *P. ramorum* in heathland. *P. ramorum* has been found on nursery plants of *V. vitis-idaea* in GB and on *Calluna vulgaris* in Poland. The favourable climatic conditions in Cornwall have resulted in dramatic spread on sites with *V. myrtillus* and significant plant mortality. Both pathogens have the potential to cause further damage to GB heathland. For example, in Cornwall alone there is about 11 000 hectares of heathland within 10 km of currently infested sites.

Under GB conditions, both pathogens have the potential to produce spores all year round on rhododendron and possibly on other hosts which have not yet been studied. The clearance of sporulating hosts is likely to be the single most effective control measure to reduce disease spread in the wider environment (woodland, heathland, gardens, and parks), thus protecting vulnerable trees, shrubs, and heathland plants.

Outbreaks (England and Wales)

In England and Wales, between April 2002 and December 2008 there were 248 outbreaks of *P. ramorum* at 221 sites in locations other than nurseries, of which 84 have been eradicated (table 1). These woodland or garden/park sites are fairly widely distributed, but the highest incidence and severity of disease has been in the south and west of England and in south Wales (fig. 1). These areas of the country appear more favourable for the pathogen and for disease development, since they are mild and wet. Although the number of trees that are known to have developed bleeding cankers is low (approximately 28), it is increasing; a few trees have also developed bleeding cankers outside of the southwest region. Ornamental plants in historic gardens involved in tourism have been badly affected by the pathogen and some rare or historically important specimens or collections are now considered to be at risk. Visitors to some historic gardens have complained about the appearance of infected plants; gardens which rely on spring flowering rhododendrons and camellias to

attract visitors have been most affected. Nurseries have mainly been affected by the phytosanitary measures that have been implemented to try to prevent spread to the environment (see below). Between April 2002 and December 2008 in England and Wales there were 626 nursery outbreaks at 526 sites of which 541 have been eradicated (table 1).

Figure 1—Distribution of (non-nursery) outbreak sites for *P. ramorum* (pink dots) and *P. kernoviae* (blue dots) in England and Wales (2003 to 2008).

Between October 2003 and December 2008 there were 66 outbreaks of *P. kernoviae* in England and Wales on managed and unmanaged land, with an additional five outbreaks (at four sites) in nurseries and garden centres (table 1). All but five are subject to ongoing eradication or containment action.

Table 1—Outbreaks of *P. ramorum* and *P. kernoviae* in England and Wales between April 2002 and December 2008

Pathogen	Location	Total	Eradicated	Ongoing
Phytophthora ramorum	Nurseries and Garden Centres	626 (526 sites)	541	85
	Managed and Unmanaged Land	248 (221 sites)	84	164
Phytophthora kernoviae	Nurseries and Garden Centres	5 (4 sites)	4	1
	Managed and Unmanaged Land	66 (66 sites)	1	65

The number of new outbreaks recorded has been at a low annual frequency (and at similar levels between years) over this period (fig. 2). The most significant damage has again been in the southwest of England (Cornwall and one site in Devon) and at five sites in south Wales, with only one finding in a managed garden in northwest England. In September 2008, a site in Kent was found to be infested with *P. kernoviae* (this is thought to be an isolated site linked to plant movements from

Cornwall). Although the number of trees that have developed bleeding cankers is low (approximately 60), it is increasing, and a few trees with bleeding cankers have already died. As is the case for *P. ramorum*, ornamental plants and trees in managed gardens involved in tourism have been badly affected, and some rare or historically-important specimens continue to be at risk.

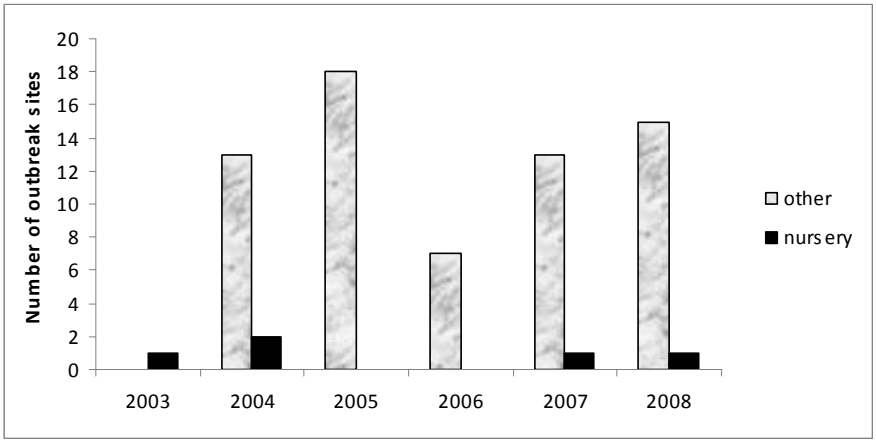

Figure 2—The number of outbreaks of *P. kernoviae* in nurseries and garden centres or other (managed and unmanaged land) sites in England and Wales in each year between 2003 and summer 2009.

The longer-term risk from both pathogens may increase if new isolates are introduced or if climatic conditions become even more favourable. If the pathogens are not controlled, it is not yet clear when or whether the whole of GB would become affected. However, in the absence of enhanced control measures, spread into and within the environment is predicted to increase. The scale of environmental damage is uncertain.

Movement of Infected Plants

The main means of long-distance spread in GB is thought to be by the movement of infected plants. However, there have been limited findings of *P. kernoviae* in the nursery trade, with the first GB findings being in woodland surrounding a nursery. Both pathogens are considered to be of exotic origin and introduced to GB on imported plants. Current EC measures for *P. ramorum* require that (a) official surveys be reported back to the EC at the end of the year and (b) import controls are imposed on all listed susceptible hosts imported from the U.S. (as well as on a separate list of species for susceptible wood), that there is a prohibition on imports of susceptible bark from the U.S. (same listed species as those for susceptible wood), and that there is internal movement controls in the EU (plant passporting) of *Rhododendron* (excluding *R. simsii*), *Viburnum*, and *Camellia* (the three most commonly affected traded genera in the EU), with statutory action to be taken on findings. These genera can only be moved from nurseries which have been officially inspected and found free from the disease, or where appropriate eradication measures have been taken. Consignments of these plants must be accompanied by plant passports (used already in the EU to manage risks from a number of other plant pests and pathogens). This aims to ensure that plants moved in trade are free of the pathogen and, if symptoms develop after movement, the infection can be traced back to the originating nursery and follow-up inspections carried out at sites which have

received plants from the same batch. There are no official EC measures in place for *P. kernoviae* but these are envisaged.

New *Phytophthora* Programme

The new Defra *Phytophthora* Programme will address the risks posed by the two pathogens through three main workstreams, namely: disease management and surveillance, awareness and behavioual change, and research.

The disease management and surveillance workstream will substantially increase the current level of phytosanitary activity, with the aim of clearing sporulating host plants (principally *R. ponticum*, but also other infected hosts) from known infested sites. The workstream may also involve removal of uninfected rhododendron or other potential sporulating hosts to protect vulnerable woodland and heathland, coupled with a national surveillance programme to monitor changes in disease distribution in England and Wales on a regular basis, and to identify and control new outbreaks. The scientific basis for this work will remain the comprehensive Pest Risk Analyses collating and interpreting published and unpublished research, but advantage will also be taken of the potential of modeling techniques developed recently in relation to *P. ramorum* outbreaks in California (Meentemeyer and others, these proceedings; Filipe and others, these proceedings; Vaclavik and others, these proceedings). Containment and eradication measures in infested parks and gardens will also be enhanced. An enhanced regime of checks and controls on commercial plant trade (nurseries) will be applied, and proactive management of high-risk sites will be encouraged.

The awareness and behavioural change workstream will primarily work with all stakeholder groups to develop and coordinate the drafting of joint codes of practice. These will improve biosecurity through better operational procedures both in management of established plants and through better buying and selling protocols. The lead for this work will be shared with stakeholders themselves to promote recognition of commercial as well as statutory plant health and biological requirements, and to facilitate uptake by industry. Initial work in this area has resulted in a suite of biosecurity protocols for heritage gardens developed by the National Trust (for England, Wales, and Northern Ireland) and representatives of the original Defra *Phytophthora* Programme (Wright and Slawson, these proceedings). A significant programme of work will also be undertaken to further raise awareness of the diseases amongst a broad range of stakeholder groups.

The science, policy, and operational needs of the disease management and surveillance, and the awareness and behavioural change workstreams will be supported by a research workstream. Research funding of up to £1.5 million is scheduled for the 5-year period of the Defra Programme, but to ensure that output is available to inform and guide the delivery of other elements of the wider programme, it will be front-loaded with annual funding of about £400,000 per year over the first 3 years of the programme. The research programme will aim to build upon previous work to refine further knowledge of pathogen and disease characteristics and spread in GB and develop tools for better containment and eradication in the future. In particular, there will be increased study into the impact of these pathogens on *Vaccinium* in the natural environment.

Measures of Success

If successful, the Defra *Phytophthora* Programme will result in an environment where trees and heathland are not generally threatened by *P. ramorum* or *P. kernoviae,* and where the commercial plant trade and historic and public gardens are applying codes of practice which reduce the risk of pathogen and disease spread through proactive biosecurity measures (which will benefit the control of these pathogens and others which are also present or may be introduced in the future). Thus, the social and environmental benefits that society enjoys from woodland and heathland, including sites of special scientific interest (SSSI) and visiting historic gardens, would be maintained.

At a high level, the disease management and surveillance workstream, if successful, would result in the protection of the wider environment from the risk of significant further tree and heathland infections. The eradication of long-lived spores (chlamydospores for *P. ramorum*) will be very difficult, as will eradication in heathland habitats, thus the aim is to control the risk of further new infections by reducing inoculum to levels which reduce the rate and potential for longer-distance spread to new sites. Success will be measured through national surveys of vulnerable sites and by measuring the percentage of new survey sites found to be infested. A reduction in the percentage of newly surveyed sites found to be infested would demonstrate a slowing of pathogen and disease spread.

The surveillance programme will aim to identify affected parks, gardens, woodlands, and heathlands through surveys, and to support the subsequent removal of all *R. ponticum* from these sites in England and Wales (currently estimated at approximately 450 ha) and potentially other known and potential sporulating hosts. The programme aims to complete the clearance of *R. ponticum* within the first 5 years of activity. Progress towards this total will be monitored and reported annually. A programme of surveillance and clearance of rhododendrons from uninfested high-risk sites which are valuable or ecologically important habitats will be developed.

With regard to the movement of *Phytophthora* in traded plants, the number of confirmations of infected material identified as a result of official inspections at nurseries and garden centres will be monitored, with the aim to achieve further reductions from the current 1 percent of material inspected. The results of recent monitoring has indicated that positive findings on nurseries have reduced from 3 percent to 1 percent of inspected material as a result of emergency action taken during the last 5 years.

Success of the awareness and behavioral change workstream will be measured by the degree to which the horticultural industry and historic and public gardens have developed suitable codes of practice which reflect improved biosecurity procedures and a responsible approach to disease management. The programme aims to co-ordinate activity across the sector to facilitate a joined-up approach. It is proposed that codes of practice should be in place within the first 3 years of the programme. In addition, the workstream aims to result in a better informed public about the pathogens/diseases, through an education and awareness campaign. This, combined with the industry codes of practice, will improve general disease awareness and management by the public.

A review of science to identify science gaps related to policy/management needs, priorities for a proactive research programme and strategy for commissioning new work will be completed during the first year of the research workstream. By year 3 of the programme it is intended that this will have contributed to refinement of our understanding of factors driving pathogen spread and disease development, and to a better understanding of risk to heathland environments; as well as comparative risks between *P. ramorum* and *P. kernoviae*. Improved disease management or control methods are intended to be established for heathland environments, together with improved approaches for socio-economic evaluations of the impacts of both pathogens and cost-benefit analyses of the measures.

Discussion

The principal objective of this programme is to support the development and maintenance of a healthy, resilient, productive, and diverse natural environment. Disease control under this programme is especially targeted to protect trees and native heathland from further infection. The main method of disease control is the removal of *R. ponticum*, a non-native invasive weed, which will also contribute to an increase in biodiversity by allowing native species to repopulate (as has been recorded in a test site in Cornwall). *P. kernoviae* has spread rapidly through *V. myrtillus* in heathland environments and is thought to have the potential to spread rapidly to other heathland sites (many of which are denoted as SSSIs). *P. ramorum* was more recently recorded on *V. myrtillus* in woodland in GB. The diseases will not only impact on the susceptible plant species, but also on the rare vertebrate and invertebrate species for which they provide a unique habitat. The U.K. has 20 percent of the world's lowland heath and approximately 75 percent of the total resource of upland heath. The U.K. government has a public service agreement target for 95 percent of the area of sites of SSSIs in England to be in 'good condition' by 2010. Much of the heathland resource is notified as SSSI and these habitats form a significant proportion of the total SSSI area. Disease control will help to maintain these SSSIs.

The impacts of these pathogens and the diseases they cause will principally be felt in rural areas (generally those associated with tourism). Infection in parks and gardens open to the public, and in heathland areas, could affect visitor numbers through the loss of plants that attract the public. In some areas of the country (particularly the southwest), local economies are highly dependent on the tourism generated by these gardens and landscapes.

The new *Phytophthora* programme will also increase the general awareness of plant disease and good biosecurity measures in the nursery and garden centre trade and of consumers. This will contribute to sustainable patterns of consumption and production and support the further development of a thriving farming and food sector, with an improving net environmental impact.

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