Phytophthora ramorum ... ten years on

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10 YEARS have now passed since *Phytophthora ramorum* was first confirmed in the UK. What have we learnt in that time and what could the future hold for us?

First let's take a step back for those few remaining people who can consider themselves fortunate not to have come across this virulent plant disease, and just remind ourselves of the pathogen that is now very much 'at large' throughout the UK but particularly in the West.

WHAT IS *PHYTOPHTHORA RAMORUM*?

Phytophthora are fungus-like disease pathogens; they belong to a group of organisms known as oomycetes. Oomycetes were thought until recently to be fungi as they spore and have hyphae but DNA analysis in the 1990s indicated that they were more closely related to the algae groups (diatoms and brown algae in particular). They are in a separate taxonomic kingdom, part of the algae community 'Chromista', as opposed to a fungi kingdom member. Therefore *Phytophthora* are known as being 'fungal like'.

RHODODENDRONS GROWING AT THE NATIONAL TRUST PLANT CONSERVATION CENTRE

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WHERE DID IT COME FROM AND WHAT HAS HAPPENED IN THE LAST 10 YEARS?

One of the first references to *Phytophthora ramorum* was along the west coast of the USA in the 1990s where a close relation of the UK strain of *Phytophthora ramorum*, had been, and is still, devastating the American Tan Oak population, along with many other species.

The disease was first noted in the UK in 2002, initially intercepted by our Plant Health Inspectors mainly on *Viburnum* and *Rhododendron* within the horticultural trade, but it quickly became apparent after initial surveys that infected plants planted out into private and public gardens had spread the disease to other susceptible species and existing mature stock. *P. ramorum* spores were found to be aerially dispersed within water particles and as the host list of affected plants grew (now amounting to over 150 species) so did our concern over the future of so many of our much loved garden taxa. Would this be the demise of growing rhododendrons as we know it, what will we do without these plants we love so much and perhaps have taken for granted as being with us forever? Most of the questions emulated from the fact that at that time our understanding and knowledge of the pathogen was sadly lagging behind the pace of change and speed that these new hosts were being confirmed, also compounded by the discovery

of a new but similar *Phytophthora* later named *Phytophthora kernoviae* after the area it was first found (Cornish for Cornwall is 'kernow').

As the (now) two diseases took hold in the wetter west of the UK (climatic maps predicted these areas were of higher risk due to favourable conditions for the disease, particularly higher rainfall) and our ability to locate and identify them improved, we started to realise that our native flora could also be threatened, with some key plant species being highly susceptible. So a targeted campaign against the invasive and highly susceptible disease host *Rhododendron ponticum* began, but this came too late to protect the native heath species *Vaccinium myrtillus* (Bilberry) which was found to be highly susceptible and at great risk. As a consequence it has suffered from a number of outbreaks, particularly in Cornwall, with very limited management options within the challenging terrain.

The previous Government realised that these growing issues were going to need a large injection of new money to support better understanding via research, and more robust actions aimed at slowing the spread of this quarantine organism from its seemingly relentless march through natural and heritage environments, not forgetting the impacts and costs that the UK's nursery industry affected by the disease were having to bear alone.

In the spring of 2009 a further £25 million of new funding support was agreed and a 5 year programme commenced to: slow the spread of the disease, protect heathlands and other valuable plant communities, improve our understanding and provide us with management options.

Part of these new funds were directed towards increasing the numbers of Plant Health Inspectors available to survey and take action against the disease and support affected owners if the pathogen was confirmed present on their site.

It should be remembered that *P. ramorum* (also *P. kernoviae*) continue to be notifiable diseases covered by specific legislation under the Plant Health Act and, specific to *Phytophthora ramorum*, the Plant Health Order 2004 (England) and (Forestry 2005) aimed to prevent the spread of this harmful organism. This means there is an obligation to take action if found; no action is still not an option.

It was perhaps inevitable that more trained eyes surveying would mean more outbreaks confirmed, so numbers of hosts and new outbreaks continued to rise.

Then a real step change of the worst kind occurred in 2009 when a number of dead and dying Japanese Larch (*Larix kaempferi*) were found in the South West, and once the difficult task of isolating the pathogen was overcome, *Phytophthora ramorum* was eventually confirmed to be the cause. This was a very worrying development because it meant that we had a tree which was both highly susceptible and a major sporulating host. This meant that long distance spore dispersal was quite possible and that P. ramorum had in effect created a full circle from nurseries into gardens into the natural environment which then threatened nurseries. By this time the nurseries had less incidence of the disease because of fewer interceptions; this was due to better practice, awareness and restrictions on known high risk trade pathways reducing interception figures in the trade to as low as 0.2 % of all targeted inspections recently reported.

Why did it take so long for larch to become affected? Among many theories, one is that weather events such as rainfall and wind in the preceding years allowed a build-up of inoculum to reach levels which could trigger tree-to-tree spread via spore distribution without the aid of any man-made pathways of within 100m locally to between 1–3km from infected stands of trees. After some rather rapid research focussed on larch it was found that a single infected larch needle could have as many as 2000 spores, each capable of releasing around 10 zoospores, each of these capable of starting a new outbreak. To put this into context a *Rhododendron ponticum* leaf with a 4cm^2 lesion can produce 8 sporangia, each containing perhaps 8-10 zoospores, each of these capable of starting a new infection. To date the losses of larch are quite significant and it was estimated that over 3 million larch trees had been felled or placed under statutory

notice by the end of 2011 in England and Wales alone. The situation is very much ongoing as this goes to print. The Forestry commission (FC) working with the Food and Environment Research agency (FERA) are applying a strict policy of control measures in an attempt to slow down the speed of distribution, in that all host trees within a 150m radius of the infected tree are felled and any timber then needing extracting will need to satisfy biosecurity protocols, as will the processing facilities licensed to accept infected material. The key then is to ensure this material cannot re-enter the horticulture industry as a growing medium or mulch which might then cause new outbreaks.

The economic cost of a major disease outbreak such as *Phytophthora ramorum* is hard to quantify, but in an estimate prior to its discovery on Larch, Defra placed the full economic impact on the UK between £20 million and £30 million (Defra, 2008). In the National Trust alone the direct cost to the organisation since 2005 is around £1million.

This all sounds a little bleak when first read, but I do think we have a much better understanding about how we might live with *P. ramorum*. I am prepared to be challenged in my personal view that a magic cure will not appear, at least not yet, for *P. ramorum*, it now being too widespread. However *P. kernoviae* is still fairly confined, always remembering that any disease that has escaped outside of the confines of a nursery or glasshouse becomes a very difficult if not impossible challenge to eradicate, especially one that can produce such long-lasting survival spores (chalamaedospores) as *P. ramorum* can; such spores are thought to have a dormancy lifespan in excess of 5 years.

LESSONS LEARNED

When we challenged the way we manage our gardens it quickly became apparent that our plant records were far from perfect, and that our garden management lacked basic hygiene and good husbandry – especially evident when resources become stretched.

The National Trust committed (with support in the form of sponsorship from Yorkshire and Clydesdale Bank) to survey, map and record our most valuable plant collections, developing a new, user-friendly database for our garden teams. The objective of this was to gain a better understanding of which plants were threatened or needing safeguarding via propagation.

PLANT SURVEYS & *PHYTOPHTHORA*

The undertaking of plant surveys within the National Trust's garden and parks over the past five years was initially to discover what we owned, such knowledge would give us a better understanding of how to best maintain and safeguard the collection, which is considered one of the biggest, if not *the* biggest under single ownership. But with the onslaught from the threat of *Phytophthora* and other diseases it soon become apparent that this would also be a way of knowing what our resources are for working and coping with the threat of such natural adversities.

To date we have surveyed almost half of the properties within our care; thankfully this includes most of those with major plant collections. The task has been challenging and a steep learning curve for all concerned but fortunately we have been able to adjust and adapt the methodology as appropriate when new issues occurred. If individual properties haven't the resources available to undertake the survey work themselves, we have built up a strong team of experienced professionals within the organisation to take on the work; they fully understand the tasks and their importance towards plant conservation.

Surveying and mapping a plant collection usually results in a good baseline on which to build future records, however, gardens with more significant collections of rhododendrons, such as Rowallane, Mount Stewart, Trengwainton and Bodnant, all needed a more expert eye to analyse the data and provide a clearer picture of which plants should receive priority attention.

For one property, under the imminent threat of *Phytophthora* in its tree canopy, we adapted the GPS recording form to allow for extra information to be added which would give us a better picture of our immediate conservation requirement should the worst happen. The extra data recorded included the current health condition of the plants, the impact from the removal of the offending trees including the

THE NATIONAL TRUST PLANT CONSERVATION CENTRE, relocated during 2012 to a new biosecure site

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root plates and the plant's value in the wider picture of plant conservation. The other, and perhaps the most important information gathered, was judging whether the plant would survive in its new micro-climate once the canopy was removed.

Developing and tailoring these skills means we are now in a better position to manage the conservation needs of our plant collection by knowing the locations of vulnerable subjects. We can now implement a propagation programme which will enable us to perpetuate threatened subjects in more suitable areas of the country which have escaped or are less susceptible to the threat from *Phytophthora* etc. We accept that some subjects run the risk of being lost for ever but at least we will know that we did the best we could and have a detailed knowledge of their existence.

HOW DO WE SAVE OUR GARDENS' PLANT HERITAGE?

This was one of the questions we asked ourselves and in response to the difficulties posed by plant movement restrictions on an infected site we've had to become more inventive in finding appropriate solutions.

The National Trust's own Plant Conservation Centre took on the challenge even when local *Phytophthora ramorum* issues made it a necessity to move the whole operation to a new, more biosecure site, away from a garden and highly susceptible trees that might put these highly valuable plants at risk.

As part of the survey process we often use a conservation flow chart as a method of assessing a plant's conservation value and giving it a score that would steer the urgency of any propagation requirement.

However, if a garden is under a Plant Health Notice preventing the spread of *P. ramorum*, we require written permission from the Food and Environment Research Agency before moving any material from site; if the plant is infected or near infection, safeguarding via propagation is a significant challenge at the least.

Our first port of call especially for rhododendrons is Ros Smith based at Duchy College, Camborne in Cornwall and the micropropagation facility Ros runs is still the only FERA-licensed facility to process infected material.

MICROPROPAGATION OF RHODODENDRONS

There has been considerable success after building up extensive knowledge through experience of the many pitfalls in trying to get this material to respond. The conservation programme has been focussing on historic and rare rhododendrons under threat by age, disease and climatic stresses.

Started in 2005 in order to conserve historic rhododendrons in Cornish gardens, the technique used involves the laboratory production of tiny plantlets from small pieces of plant material, such as vegetative buds and shoots and floral buds too. This is done initially by using a dilute solution of bleach then, by successive selection, the resulting plantlets are cleaned of *Phytophthora*. These are grown in a nutrient jelly with added plant growth hormones which allows manipulation of the way that plants grow.

***RHODODENDRON* 'MORVAH' (BOLITHO HYBRID) EX DUCHY MICROPROP c.5 YEARS OLD.** Planted as part of an ADAS/FERA trial at a Cornish garden in an area which had known *P. ramorum* positive plants. Note the viburnum, which had been identified as *P. ramorum* positive and now in severe decline. Could the increased vigour ex-microprop provide the rhododendron with increased resistance to *ramorum*?

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Plantlets are returned to the National Trust Plant Conservation Centre (PCC) in Devon at the rooting stage, for acclimatisation and growing on; other organisations can receive them at a later stage of development. Although many plants are produced from a small amount of material, it takes a minimum of two years to produce rooted plantlets. Over 900 rhododendron species and cultivars are being or have been micropropagated since the programme began, sent from 37 gardens, parks and arboreta around the UK. The success rate is around 95% but could be higher if floral buds are collected at the best stage of development. It is known that at least ten of the mother plants are no longer alive and many others will have been rescued from certain loss. There is great satisfaction in returning micropropagated plantlets following the receipt, through the post, of an almost dead twig with the accompanying note 'This was all that was left, it was cut down and put on the bonfire before we realised it was important!'

Magnolias and camellias are among other susceptible plants that can be micropropagated; however research is ongoing to produce rooted plantlets at the final stage of propagation; it is so frustrating to have shoots which will not initiate roots, though it is only a matter of time.

THE NATIONAL TRUST PLANT CONSERVATION CENTRE (PCC) – AFTERCARE

Once Ros has worked her magic in the lab it's down to the PCC to gradually wean the new plantlets off from the agar gel and into compost. This we do by gently washing the agar from the roots and potting up individually into 6cm pots which are then placed into a sealed cabinet to mimic the conditions they were growing in. Gradually we allow more and more air whilst still misting overhead, until the lid is taken completely off. After a period of about 6 months we pot them into a 1ltr air pot (www.superoots.com/) where they are grown on in a shade tunnel until being moved into a 3ltr air pot, cut back and then placed onto our drip system where the water uptake is regulated. This whole process can take a minimum of 4 years to complete but at the end a slice of our country's plant heritage has been saved for

future generations to enjoy. Some of our most precious rhododendrons from Cornish gardens have been rescued in this way, for example *Rhododendron macabeanum*; this was the original Frank Kingdon-Ward plant that flowered for the first time in this country. Prioritised due to its unique plant heritage it was one of the first to be saved in this way and has now been spread to other gardens to help safeguard its future.

WITH A GARDEN UNDER RESTRICTIONS, WHAT HAPPENS TO OTHER GENERA WHICH NEED PROPAGATION?

This is where we move our propagation expertise onto site, the first port of call being our plants' database to check which plants are important; from then on it can be a race against time to propagate plants before they die or are destroyed.

We know we cannot move the young plants from an infected site but the hope is that they may be more resilient to re-infection, or at least can be planted out after all other host plants have been removed; unfortunately this is the only option open to us until we get a negative result for *Phytophthora* from the site.

We propagate by seed, cuttings or, in the case of *Magnolia*, grafting on a hot-pipe system. Generally speaking we use either a *M. campbellii* or *M. kobus* rootstock depending on requirements; due to the nature of the plants we deal with it's not always possible to propagate from the best material.

This is what makes it more rewarding when you have success, the resulting new plant may not look like a 'cat walk model' but it has potential and any resulting new growth will be re-propagated to produce a plant that is worthy of being planted out.

Success has been achieved in this way at various sites in the southwest; any equipment we set up on an infected site will then stay there for future use.

PRACTICAL ACTIONS

During the last few years the term 'biosecurity' has become part of new vocabulary within our gardens and synonymous with preventing the entry or spread of diseases such *P. ramorum*. This term covers a whole range of aspects of garden management from *sensible* purchasing to general good husbandry and hygiene; healthy plants are less likely to succumb to disease, therefore good cultural husbandry such as trying to match a plant to its preferred location, soil type and conditions is likely to help.

Avoiding planting into previously infected areas is a requirement of a Statutory Plant Health Notice: 'no susceptible plant is to be planted within 3m of an infected plant for 4 years.' Having *Phytophthora ramorum* confirmed means you need to understand how plants might become infected by spores remaining in or on the soil, for example, one pathway might be lower leaves in contact with soil or rain splash, therefore measures such as removing the lower leaves or mulching around the plant to prevent soil splashing on to leaves may help.

Planting with sufficient space around is also essential to ensure good air movement so that humidity, which this pathogen thrives on, is reduced.

Throughout the last seven years there has been a targeted campaign against *Rhododendron ponticum*, the reason being that it is known to be a highly susceptible sporulating host of both *Phytophthora ramorum* and *Phytophthora kernoviae*. In total, 600 hectares have been cleared in the UK; many would say that this has a double benefit due to the invasive habit *R. ponticum* displays in certain situations .

Something we can all do is to improve garden hygiene since pests and pathogens are readily spread around a garden on soil and plant debris attached to footwear, tools (e.g. pruning knives, secateurs, saws etc.) or on tractors and other vehicles or machinery. Keeping paths well-drained and clear of soil and plant debris will also slow the movement of diseases around a site.

Our gardens have a limited palette of chemicals to play with these days partly due to our commitment to more greener practices, but we in the NT recommend the use of products such as 'Jet 5' which is recommended for general purpose disinfectant tasks, or 'Cleankill Sanitising Spray' which helps to form a barrier against pathogens such as *P. ramorum*.

Poor irrigation and watering practice will also provide pathways for disease so if possible use a source of water that is free from pests and diseases. But if water is collected on-site, ideally it should be treated in some way to destroy pathogens. Methods might include, for larger sites and nurseries, slow sand filtration – this has been proved to be completely effective at removing pathogens such as *Phytophthora* species (including *P. ramorum*) from water. However, it is expensive. Alternative cheaper systems include ultra-violet light, chlorination or ozone.

Dealing with plant waste in a sensible manner is another weapon against the spread of *Phytophthora*. Ideally, plant waste should be collected and kept secure prior to disposal and not subject to dispersal during windy conditions. Acceptable methods of disposal include composting, burning and, although not very eco-friendly, deep burial at an approved landfill site. Composting, if done correctly with sustained temperatures of over 55°C, will also kill many pests and pathogens, including *P. ramorum*.

Last, but no mean least, is the need to improve awareness via education at all levels. The essential need for better garden hygiene and pest and disease recognition and prevention has slipped. My personal view is that it is partly because of the vast increase in other tasks expected of the professional gardener these days such as health and safety, interpretation, budget management and so on. If we are to truly make a difference longer term we need to in-bed these practices back into our day-to-day garden management.

So, simple recommendations might be: that garden staff (gardeners, volunteers etc) should receive basic training in the main pests and diseases of plants relevant to their garden. The general condition and health of plants should be monitored regularly so that problems are spotted early and prompt remedial action can be taken. Report all suspicious symptoms to Fera or The Forestry Commission (it is a legal requirement to notify all suspect findings of quarantine pests and pathogens to Fera).

HORIZON SCANNING

The risk from new harmful organisms is increasing at an exponential rate due to a variety of reasons such as increases in global trade (including plants), also the ease with which we ourselves can travel around the world. There are more exotic sources and more exotic plants/food than ever before. We are routinely importing larger plants and increasing the demand for cheap plants and food. A stretched plant health system built on visual inspection and known risks (ie already on a interception list) can only exacerbate the situation.

The pathways for these harmful organisms are obvious: allowing them to move from country to country puts at risk trees and plants within the historic, natural and urban environments, together with commercial trade or food production.

So, although this article covers *P. ramorum*, the lessons and techniques we have learnt can be applied to other threats, both known and unknown.

Although not currently a notifiable organism (covered by legislation) there have been significant losses of horse chestnut (*Aesculus hippocastanum*) trees from Chestnut Bleeding Canker. Similarly, we need to establish a clearer picture of how Acute Oak Decline is affecting our most iconic tree species, the English Oak (*Quercus robur*).

Box blight continues to affect our native box (*Buxus sempervirens*) and garden plantings. Red Band Needle Blight is now affecting pines throughout much of the UK and Fuchsia Gall Mite has been found in gardens throughout the south and southwest during 2011.

New pests and diseases that also pose a great risk to our green assets are: Ash Dieback (*Chalara fraxinea*) is the most recent and perhaps the most deadly arrival, posing a very serious risk to another of our great natives, *Fraxinus excelsior*; Citrus and Asian Longhorn Beetles (ALB) – in 2012 there was an outbreak of ALB, one of the world's most devastating tree pests, in the southeast of England, thought to have arrived on imported wooden packaging material from the Far

***RHODODENDRON* 'JOHNNIE JOHNSTON'** is another microprop success that has safeguarded this rare and beautiful double pink maddenia hybrid
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East; Emerald Ash Borer, already around the Moscow area; and *Phytophthora lateralis, Phytopthora austrocedrae,* Chestnut Blight and Oak Processionary Moth are all part of this cheery new bunch here already or heading our way.

So what if anything can we do? I say: challenge ourselves to what we might do in our own small way to reduce this risk. A key part of the Government's new Tree Health & Plant Biosecurity Action Plan focuses on behaviour change and increasing public awareness, alongside increasing research, practical actions and improving import controls. I ask how many people reading this article understand what plant material they are permitted to bring back with them from trips abroad or take overseas with them, but conversely, I am sure many will have heard about the strict biosecurity procedures imposed if visiting New Zealand. For us it's a less than clear picture as we have a large boundary in terms of plant health, being part of the EU. This in itself would not solve all the problems we face but does form part of a complex jigsaw, which includes supporting our own growers and thinking about the need to protect and enhance the diverse nature of our ornamental and natural plant communities. Personally, I would prefer to lead by example and play my own part rather than just expect others to do the work for me in protecting the plants and places that are so special to me.

MORE INFORMATION AND HOW YOU CAN HELP

National Trust
http://www.nationaltrust.org.uk/what-we-do/what-we-protect/gardens-and-parks/
FERA
http://www.fera.defra.gov.uk/plants/plantHealth/pestsDiseases/phytophthora/pRamorum/
The Forestry Commission
http://www.forestry.gov.uk/pramorum
FERA. Best Practice Protocols
http://www.fera.defra.gov.uk/plants/plantHealth/treeHealth.cfm
Plant Network
http://plantnetwork.org/category/links/plant-health-links/
Duchy College
http://www.cornwall.ac.uk/duchy/index.php?page=_News&subpage=_Latest_News&pagetype=item&refer=home&newsid=3026

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