PPM, Point 7.3
09-15574

SUMMARY: PEST RISK ANALYSIS FOR *PHYTOPHTHORA RAMORUM*

This summary presents the main features of a Pest Risk Analysis (PRA) which has been conducted on *Phytophthora ramorum* as the key deliverable from the EU-funded RAPRA Project. The PRA was prepared according to the EPPO Standard '*Guidelines on Pest Risk Analysis: Decision-support scheme for quarantine pests*' version 07-13727 (PM 5/3 (3). This summary is based upon the template for the EPPO '*Report of a Rest Risk Analysis*', version 06-12731, now superceded by 08-13988. Elements of both versions are included.

Pest: *Phytophthora ramorum* Werres, De Cock and Man In't Veld.

PRA area: European Union (27 Member States).

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STAGE 1: INITIATION

Reason for doing PRA: To take account of the new experimental and economic data that have been generated for *Phytophthora ramorum* from the EU Sixth Framework Project '*Risk Analysis for Phytophthora ramorum*' (RAPRA), together with other new information. This new PRA builds on previous ones which were only partially valid. It will contribute to the review of the EU emergency phytosanitary measures.

Taxonomic position of pest: Kingdom – *Chromalveolata*; Phylum – *Heterokontophyta* (heterkonts or stramenopiles); Class – *Oomycetes*; Order – *Peronosporales*; Family – *Pythiaceae*; Genus – *Phytophthora*

STAGE 2: PEST RISK ASSESSMENT

Probability of introduction

Entry

Geographical distribution:

North America: The pathogen occurs in the wild in parts of western California and Oregon, USA. The first nursery findings were made in California in 2001, then subsequently in Oregon and Washington State. In 2004 two large California nurseries and one in Oregon shipped millions of potentially infected plants to over 1,200 nurseries in 39 US states: the pathogen was found in 22 of these states (177 nursery-related detections) by the end of that year. Eradication action was taken on these findings. Nursery findings have been made in the USA in subsequent years.

The pathogen has also been reported (under eradication) in British Columbia, Canada in a few nurseries (first finding in 2003) and some related residential plantings.

There are three known molecular lineages in North America, NA1, NA2 and EU1. NA1 is present in forests and in nurseries but to date lineages NA2 and EU1 have been found almost exclusively in nurseries.

EU and Europe: To date only lineage EU1 has been recorded in Europe. The pathogen has been reported from 19 EU countries, where it is under official control: Belgium, Czech Republic (eradicated nursery finding), Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Slovenia, Spain (including Mallorca), Sweden and the UK (all countries including the Channel Islands). It has also been recorded in Norway and Switzerland.

Area of origin: The origin or origins of *P. ramorum* is/are not known, but it is speculated that the pathogen may have originated somewhere in Asia; possibly Yunnan, Taiwan or the eastern Himalayas. *P. ramorum* is considered to be an introduced exotic pathogen in both North America and in Europe. The NA1 and NA2 lineages are likely to have a separate geographic origin to the EU1 lineage; this is based upon genetic analysis.

Major host plants or habitats:

The host range of *P. ramorum* in North America and Europe is very wide. It includes many important shrubs and trees of ornamental or environmental significance; a few herbaceous plant species are also reported as hosts. Currently, natural hosts occur in 37 plant families, with 75 plant genera and more than 130 plant species affected. Experiments have been undertaken to determine the potential host-range. A number of those predicted to be natural hosts have been found to be naturally-infected.

Which pathway(s) is the pest likely to be introduced on:

Eight main '*commodity types*' are identified in this PRA:

1. Plants for planting (excluding seeds and fruit) of known susceptible hosts;
2. Plants for planting (excluding seeds and fruit) of non-host plant species accompanied by contaminated, attached growing media;

3. Soil/growing medium (with organic matter) as a commodity;
4. Soil as a contaminant (e.g. on footwear, machinery, etc.);
5. Foliage or cut branches (for ornamental purposes) of susceptible foliar hosts;
6. Seeds and fruits of susceptible host plants;
7. Susceptible (isolated) bark;
8. Susceptible wood.

Probabilities of entry for each commodity type are assessed for four geographical origins where *P. ramorum* has been recorded: USA; Canada; non-EU European countries (Norway and Switzerland); and, the unknown area or areas of origin for *P. ramorum*. Although the origin is still unknown, based upon speculation that it may have entered Europe and the USA from parts of Asia, assessments of imports from China and Taiwan have been included in the assessment of the risk of entry.

Establishment

Plants or habitats at risk in the PRA area:

A large range of environmental and ornamental shrubs and trees are potentially at risk. There are many suitable habitats including: woodland (managed, semi-natural or natural), heathland, maquis (macchia) shrubland, and managed gardens (including those of heritage value), parks and public greens. Many of the potentially at-risk habitats are covered by the EC Habitats Directive (Council Directive 92/43/EEC). For trees, genera/species in the family Fagaceae with susceptible bark (especially *Quercus* and *Fagus*) are considered most at risk of developing potentially lethal stem cankers. This has already occurred on a limited scale in the PRA area.

Tree species with susceptible bark are only likely to be at high risk if they occur in close association with foliar hosts capable of supporting significant sporulation (e.g. *Rhododendron*, especially *R. ponticum*), or if they themselves are also foliar hosts (e.g. holm oak - *Quercus ilex*).

In southern Europe, plants in evergreen oak woodlands and laurel forests (laurisilva) are considered most at risk since establishment could occur on a range of foliar hosts which are known to have the potential to support sporulation of the pathogen. Maquis/matorral habitats could also be at risk where they contain susceptible host species (e.g. evergreen oaks or other susceptible species). *P. ramorum* has not been recorded in these habitats to date.

In northern Europe, heathland with *Calluna* and *Vaccinium* species, both of which are particularly susceptible in laboratory tests and have been shown to have a significant sporulation potential are also at risk. In Europe, species of these genera have been reported as hosts on nurseries, but not in European heathlands.

Climatic similarity of present distribution with PRA area (or parts thereof):	The area, or areas, of origin of *P. ramorum* are unknown. The pathogen is considered to have been introduced to North America where it has established in woodlands in the Pacific Northwest coast of the USA (California and southwest Oregon). These US areas have a Mediterranean climate that is *largely similar* in climate to European countries adjoining the Mediterranean. Other parts of Europe have less similar climates ranging from *not similar* to *slightly similar*. Climate matching, using CLIMEX, between Oregon/California and Europe indicates that the areas of north-west Spain, northern Portugal, south-west England, and parts of Italy and western Albania have the most similar climates; larger parts of the UK, Ireland, France, Belgium, the Netherlands, western Germany, Italy, the Adriatic coast of the Balkan peninsula, as well as north-west Turkey and east Bulgaria on the black sea coast, also have relatively good climate matches.
Aspects of the pest's biology that would favour establishment:	Establishment is favoured by the pathogen's very wide host range, capacity for asexual reproduction, ability to produce long-lived, thick-walled chlamydospores (resting spores) and, to survive for relatively long periods in soil and water. Asexual reproduction through the production of sporangia (spores involved in dispersal and infection) can occur under a wide range of environmental conditions (62–100% RH; >10°C and <30°C). The period from infection to production of infectious spores is relatively short. *P. ramorum* is heterothallic requiring opposite mating types to be present for sexual reproduction to occur. The current distribution of mating types (mainly A1 in Europe and A2 in North America) has not facilitated this, but this has not hindered the pathogens establishment and spread in (at least) some of the favourable areas of the USA (California and part of Oregon) and Europe. However, the mating system may be not be fully functional, so it is not certain that frequent sexual reproduction would occur should the opportunity arise. However recombination of genetic material might also occur through somatic hybridisation. Any progeny arising might have different adaptive characteristics to the parents. In the absence of controls, small populations of the pathogen are likely to become established. Other pathogens are unlikely to prevent establishment of *P. ramorum*. No natural enemies are known. The pathogen is favoured by certain nursery practices. Additionally, it can survive in growing media and can infect roots, largely asymptomatically. Cryptic infections and asymptomatic sporulation on aerial plant parts are also reported. This may favour spread in the nursery trade. *P. ramorum* cannot be detected based upon symptoms alone. In the absence of controls, it is likely to spread rapidly within trade networks that have scale-free network properties. Scale-free networks (those with super-connected nodes) have a lower epidemic threshold than other kinds of complex networks; in the absence of controls this favours rapid spread and establishment throughout the network, increasing the risk of wider spread in the environment.

Characteristics (other than climatic) of the PRA area that would favour establishment:	The host plants are widely distributed and traded in the PRA area as cultivated ornamental plants. There are numerous host plants in the natural or semi-managed environment. Soil type and pH do not affect the establishment potential of the pathogen directly. There are no chemical treatments that can consistently eradicate the pathogen on infected plants. However, there may be situations where fungicides could be used as part of an eradication and containment programme.
Which part of the PRA area is the endangered area:	With respect to susceptible hosts of cultivated shrubs and trees on nurseries the whole of the PRA area is potentially endangered wherever these occur because the pathogen is favoured by certain nursery practices. With respect to the semi-natural (including managed parks, gardens, public greens etc) or the natural environment, the parts of the PRA area that are most endangered based upon climatic factors alone (Figure A) are *Atlantic Central* and *Lusitanian* climatic zones; *Mediterranean* and *Atlantic North* climates are also potentially favourable, especially in coastal locations. (See Figure 13 of the PRA for distribution of the climatic zones). Although mild and wet climates are most likely to favour establishment and spread, the pathogen's ability to form long-lived chlamydospores enables it to survive Mediterranean climates with hot and dry summers, as demonstrated in California, and potentially also colder climates with cold winters. Areas with the most suitable climates coincide broadly with the areas that potentially have the most at-risk habitats. This is illustrated by the presence of potentially suitable broadleaved hosts/habitats in Figure B with some of the highest proportions occurring in the climatically favourable areas shown in Figure A. Heathland and maquis areas are not illustrated here but these also coincide with areas that appear to be climatically favourable. Those areas that are climatically favourable are only at risk where there are susceptible host plants that are capable of supporting sporulation. More detail is given below.

Potential Geographical Distribution of *Phytophthora ramorum* in Europe

The PRA for *P. ramorum* includes a range of climate-based risk maps in the probability of establishment section. Since these were created using different techniques and different parameters, it is not possible to combine them into one simple summary map of risk that represents the endangered area for *P. ramorum* hosts in Europe based on climate. It is also not possible to say that one technique or map is superior to another since validation of the methodology is not possible using the limited case data in Europe which is influenced by (a) the extent of the surveys for individual Member States and (b) by the pathogen being under statutory control, thus limiting its spread. Models using current pathogen distribution with climate matching are likely to predict a more limited distribution than those that do not. The climate-based risk map for Europe (Figure A) is based on the ranking system developed by Meentemeyer *et al.* (2004) to predict potential *P. ramorum* distribution in California. It uses climatic parameters that favour *P. ramorum*, with scores, ranks and weights assigned to precipitation,

maximum temperature, relative humidity and minimum temperature. This European risk map does not incorporate the host-species index of Meentemeyer *et al*. (2004) (which is based on epidemiological significance and sporulation potential of different plant species) used for California since there is a lack of high-resolution host data (individual host distribution and also host associations) for the whole of Europe. However, since trees are considered to be one of the most at-risk plant types, the areas of broadleaved woodland in Europe are also shown below (Figure B); these broadly coincide with the areas that are predicted as most climatically favourable. The most suitable climatic locations for establishment based upon Meentemeyer *et al*. (2004) are northern Portugal, north-western Spain, the southern tip of Spain, the Adriatic coast of the Balkan peninsula (e.g. western parts of Greece, Albania, Montenegro, Bosnia and Herzegovina, Croatia, Slovenia), south-western France, north-west France (Brittany), northern coastal Spain, southern Turkey and western UK and south-west Ireland. Those areas that are climatically favourable are only at risk where there are susceptible host plants that are capable of supporting sporulation.

Figure A. *P. ramorum* risk ranking model based on Meentemeyer *et al.* (2004) for Europe using the 10’ latitude/longitude resolution global climatology for December–May 1961–1990.

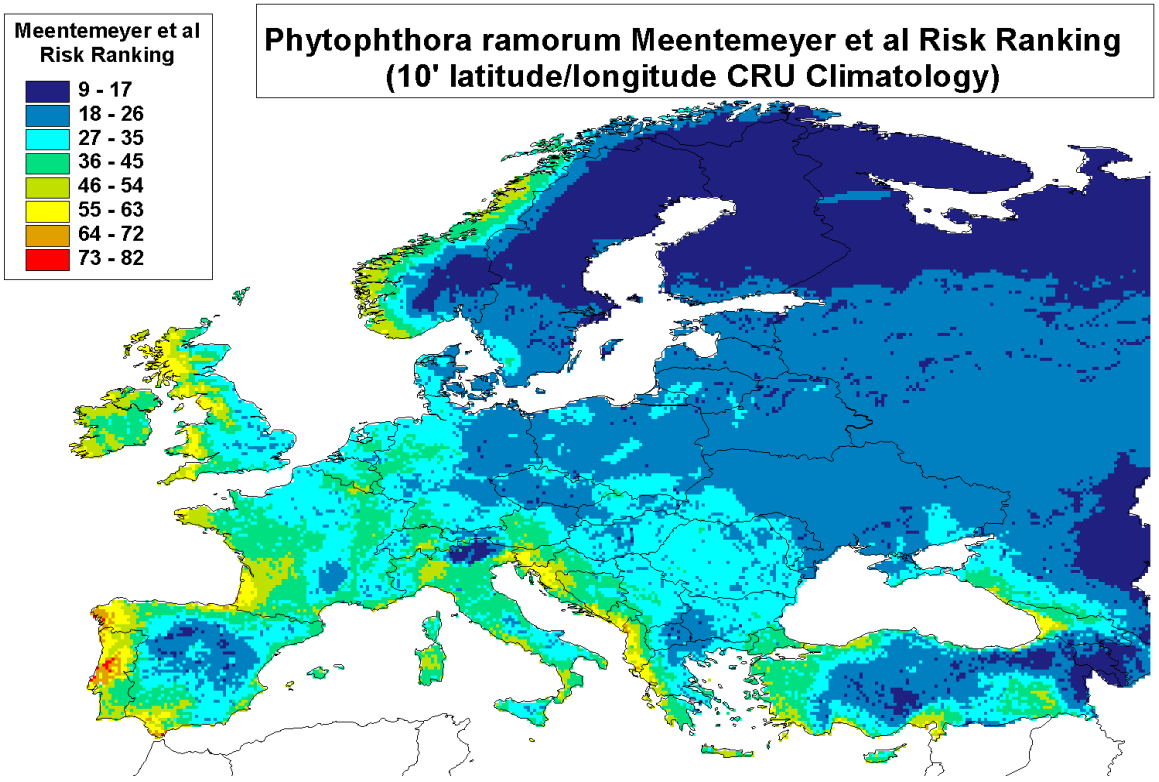
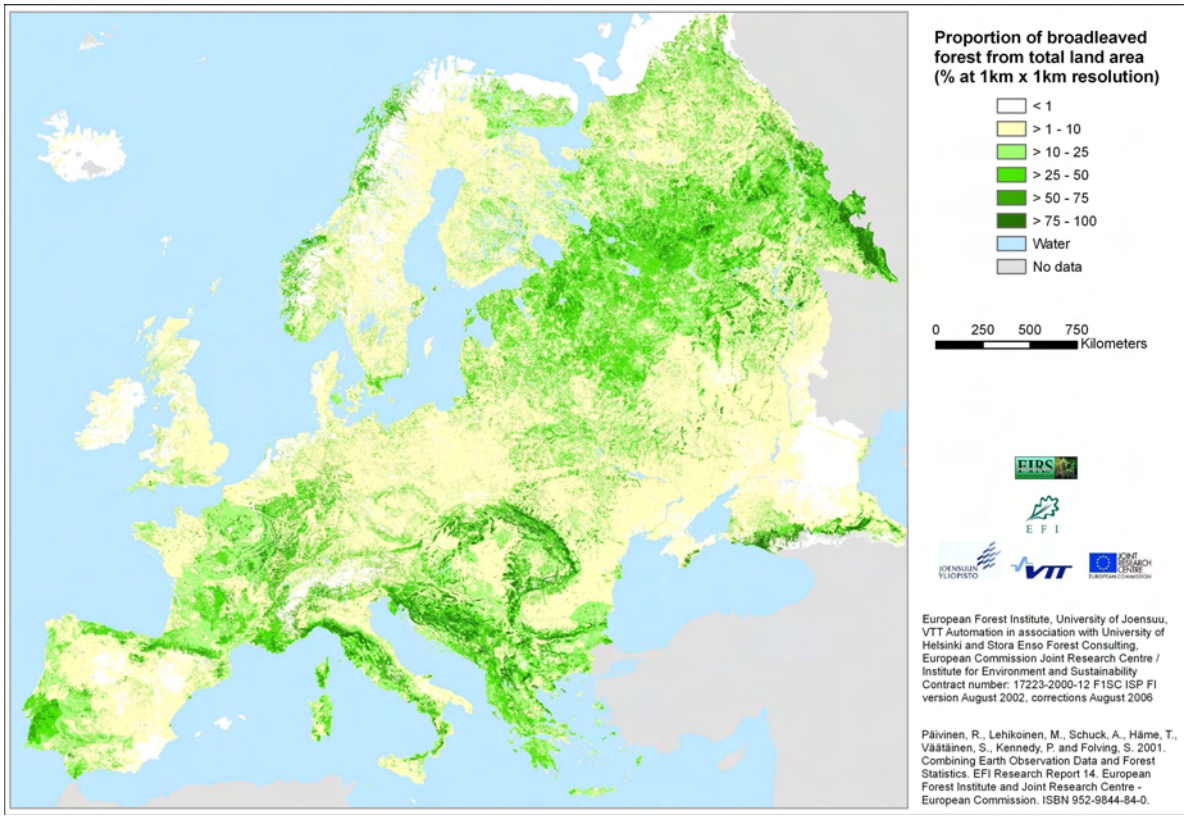


Figure B. Calibrated broadleaved forest map as a percentage of land area for Europe, produced by combining geographically referenced Earth observation data and forest statistics. Source: Päivinen *et al.* (2001 and Schuck *et al.* (2002).



Acknowledgement and disclaimer: This information is based on outputs from the project "Forest tree groupings database of the EU-15 and pan-European area derived from NOAA-AVHRR data", which was awarded by the European Commission, Joint Research Centre (Institute for Environment and Sustainability), to a consortium consisting of EFI, VTT Information Technology and the University of Joensuu under the contract number: 17223-2000-12 F1SCISPFI. The information contained herein has been obtained from or is based upon sources believed by the authors to be reliable but is not guaranteed as to accuracy or completeness. The information is supplied without obligation and on the understanding that any person who acts upon it or otherwise changes his/her position in reliance thereon does so entirely at his/her own risk. The European Commission nor the project consortium are responsible for its use in this publication and the content is at the sole responsibility of the end-user.

POTENTIAL ECONOMIC CONSEQUENCES

How much economic impact does the pest have in its present distribution:

Because *P. ramorum* is subject to official control in the countries where it is known to occur (19 EU Member States plus Norway and Switzerland; the USA and Canada) the direct economic impact that it has caused is not quantifiable and there is some uncertainty associated with the estimates. The scores assigned are subjective and individual Member States have/will vary in their assessment of the impact. However, the majority view is represented below based upon the limited evidence that is available.

The values that have been attributed to its impacts include the costs of phytosanitary measures and associated costs. However, in Europe the pathogen has a direct effect on the quality of nursery stock as well as the quality of plants in managed parks, gardens and public greens. Shrubs and trees in woodlands have become locally affected with some tree death in the UK and the Netherlands. In the USA the major impact has been environmental arising from massive tree death in coastal California and part of Oregon; the US and Canadian nursery trades have also subsequently become affected.

Nursery production: In the EU, surveys in Member States show that typically <5% of nurseries surveyed nationally have been affected by *P. ramorum.* The number of surveys that have been undertaken has varied by country and by year and some Member States have not supplied survey data. It is therefore difficult to know the true level of disease in the nursery trade and so estimations of impacts for the whole of the EU are not easy to determine. In the USA, *P. ramorum* has been found on nurseries in California, Oregon and more than 20 other states. In Canada, most recently, the 2007 national survey detected *P. ramorum* at 10 nurseries, all in British Columbia. In terms of yield, quality and control costs, excluding the cost of phytosanitary controls, the current impact on nursery grown ornamental species is thought to be **moderate** within the areas in which *P. ramorum* occurs in the EU, USA, and Canada. Including the costs of phytosanitary controls the impact is **major.** Losses in export markets arising from the presence of *P. ramorum* in the EU are not quantifiable but there are suggestions of losses for some Member States including the Netherlands, Germany and Belgium. Losses in exports (including intra-state trade) have also occurred in the USA and Canada.

Non-nursery findings: The number of Member State surveys have varied by year and by country (as per the nursery surveys). However, European countries that have reported findings of *P. ramorum* outside of nurseries (including managed parks, gardens, public greens, woodlands and forests) are Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, Slovenia, Spain, Switzerland and the UK. The countries where *P. ramorum* has been found in woodlands or other semi-natural/natural environments are France, Germany, Ireland, the Netherlands and the UK. The UK seems to be most intensively affected. Specific details about the current

impact of non-nursery findings have been difficult to obtain for all the European countries that have reported findings.

With respect to the natural and semi-natural environment, estimates have been made of the current (and future) impact of *P. ramorum* in three systems/scenarios in Europe (Kehlenbeck, 2008). In the '*northern European tree system*' (broadly-defined as trees with stem cankers in association with infected rhododendron in the Netherlands and the UK) the impact has been described as **moderate** and this is related to the environmental impact being limited to a few parts of the PRA area only with a relatively low number of infected sites. In the '*southern European tree system*', a hypothetical system based upon the presence of the infected foliar host *Q. ilex* (holm oak), the impact is **minimal** (zero) because the pathogen has yet to be introduced there.

There are other effects arising from findings in managed gardens. In the EU, managed parks and gardens are, or have been affected, in: Belgium, Denmark, Germany, Ireland, Luxembourg, the Netherlands, Slovenia, Spain, and the UK, as well as in the non-EU countries of Norway and Switzerland. The majority of findings have been in the UK and the Netherlands. The south-west of England is particularly badly affected where there is some impact on tourism due to the effect of the pathogen on the appearance of the plants and landscapes of the managed and historic gardens that contribute to the local economy.

In the USA, the major environmental impact of *P. ramorum* to date has been on the coastal woodland environment of California. Symptoms of *P. ramorum* were first reported on trees in California in the mid-1990s. Since then, it is estimated that over a million oak trees have been killed. Other species of woodland plants have suffered non-lethal foliar and shoot infections. Woodland in Curry County, Oregon, has also become affected. Knock-on effects resulting from loss of tree and understorey species include disruption to the ecology of the area, loss of recreational areas in woodland, dead trees increasing the risk of accelerated water run off, and, resultant soil erosion and sedimentation and endangering of certain plant species. There is a particular risk from forest fires due to dead trees.

Describe damage to potential hosts in the PRA area:

P. ramorum has already been found in the PRA area. It has affected the quality of plants in the nursery trade as well as those in parks, gardens (including heritage plants and gardens important to tourism), historic collections, public greens and woodlands. Limited tree mortality has occurred to date but this is at least partly because the pathogen has been under phytosanitary control since 2002 and therefore its full effect has been limited by attempts at containment and eradication. Heathland and maquis are yet to become affected, as well as ancient plant communities in southern Europe such as laurosilva habitats.

How much economic impact would the pest have in the PRA area:

P. ramorum is already present in the PRA area but subject to official control. It still has the potential to increase its host-range and to become more widespread in the nursery trade and in the natural and semi-natural environment than at present. The long-term potential for ecological damage is difficult to predict, especially if the pathogen adapts to new hosts or environments. There is the potential for the pathogen to affect timber production but this has not occurred to date in North America or Europe. The potential economic impacts have not been quantified for the PRA area as there are insufficient data to do so. The impacts will increase if controls are lifted.

If phytosanitary controls are maintained at the current level or increased/reduced, costs related to nursery production as well as managed gardens will continue to include:

- Surveillance and testing costs (National Plant Protection Organisation - NPPO)
- Administration and compliance costs including publicity (NPPO)
- Value of plants destroyed (grower, managed gardens)
- Costs of destroying plants (grower, managed gardens)
- Purchase of replacement plants to fulfill sales contracts (grower)
- Income loss from cropping restrictions (grower, managed gardens)
- Income loss from loss of sales due to effect on quarantined areas on reputation (grower)
- Income loss from impacts on tourism (managed gardens, businesses related to reductions in visitor numbers)
- Costs of alternative planting schemes (managed gardens)
- Equipment cleaning costs (grower, managed gardens)
- Facility cleaning costs (grower, managed gardens)
- Research and development costs including those needed to develop good management practices (EC, national government and levy bodies)

These costs are **major.**

Should phytosanitary controls be lifted globally the increase in production costs will principally fall on nurseries producing hardy ornamental nursery stock, and managed gardens.

These costs will include:

- Diagnoses and consultancy advice (grower, managed gardens)
- Loss of symptomatic plants (grower, managed gardens)
- Purchase of replacement plants to fulfill sales contracts (grower)
- Change in species grown or planted (grower, managed gardens)
- Additional control costs including fungicide costs and cultural control (grower, managed gardens)
- Implementation of production of healthy certified stock by the use of certification schemes
- Research and development costs (national government and levy bodies)

These costs are also **major.**

The impact that *P. ramorum* is likely to have on the yield/quality of cultivated ornamental species on nurseries in the EU without any control measures is likely to be **major.**

Although not crop plants, the impact that *P. ramorum* is likely to have on the quality of cultivated plants in managed gardens (especially heritage plants in gardens involved in tourism) in the EU without control measures is likely to be **massive**, but on a local-scale. Overall of the EU, the impact is likely to be **moderate.**

If controls are lifted, in the '*northern European tree system*' (described as trees with stem cankers in association with infected rhododendron) the environmental impact will increase as the pathogen becomes more widespread in the environment, increasing the number of infected foliar hosts that sporulate sufficiently to provide inoculum to infect tree stem hosts with subsequent tree mortality. This impact has the potential to be **major** on a local basis but **moderate** over the whole of the PRA area. In the '*southern European tree system*', should the pathogen be introduced, the impact would shift from minimal (zero) to **major** because the environment is considered to be highly favourable to the establishment of *P. ramorum*.

At risk habitats that are yet to become affected by *P. ramorum* include heathlands in northern Europe, as well as evergreen oak woodlands and laurel forests (laurisilva) and maquis/matorral habitats in southern Europe, but only where they contain susceptible host species that are capable of sporulating and favourable conditions for the pathogen. Should these areas become affected there will be knock-on effects on the ecology of the area.

The pathogen has yet to be found in timber plantations but should it do so, long-term, the impact may be **minor to moderate** in the absence of controls.

CONCLUSIONS OF PEST RISK ASSESSMENT

Summarize the major factors that influence the acceptability of the risk from this pest:

- *Phytophthora ramorum* is moving in trade in both North America and Europe
- The pathogen is favoured by some nursery practices. In the absence of phytosanitary controls it is likely to spread rapidly within the EU through the trade network
- It is very likely that the pest will survive or could remain undetected during existing phytosanitary measures
- Observations suggest that symptom expression may be suppressed by fungicide treatment.
- The pest is established in an area (Pacific Northwest of the USA) with similar climatic conditions (though not necessarily optimal for the pathogen) to some parts of the PRA area and causes serious economic damage in its area of establishment there (where it is considered to be an exotic introduction)
- It has a very wide host range and a reproductive strategy (asexual sporangia for dispersal and infection; long-lived chlamydospores for survival) likely to help establishment
- A large range of ornamental plants are at risk, both traded plants and those grown in heritage gardens, parks and public greens
- A large range of environmental shrubs and trees are potentially at risk across a range of habitats (e.g. woodland, heathland and maquis shrubland)
- The most at-risk habitats broadly occur in climatic areas that most favour the pathogen

Estimate the probability of entry:

In the absence of phytosanitary controls the overall probability of entry is considered to be **high**, mainly due to the wide host range and the ability of *P. ramorum* to persist in a variety of substrates (e.g. soil, growing media, bark, wood, foliage). The relative importance of the pathways is given below (based upon a 5 word ranking system where **very low** and **very high** are extremes):

In the absence of phytosanitary controls:

Plants for planting of susceptible hosts (excluding seeds and fruits) from the USA and the unknown area/areas or origin: **high risk.**

Plants for planting of susceptible hosts (excluding seeds and fruits) from Canada and the non-EU countries of Norway and Switzerland: **medium risk**.

Soil as a commodity from the USA, Canada, the unknown area/areas of origin, and non-EU countries of Norway and Switzerland: **medium risk.**

Susceptible isolated bark from the USA and the unknown area/areas or origin: **medium risk.**

Plants for planting of non-hosts (excluding seeds and fruits) accompanied by contaminated growing media from the USA, Canada, the unknown area/areas of origin and the non-EU countries of Norway and Switzerland: **low risk.**

Soil as a contaminant of travellers shoes and imported machinery, vehicles etc from the USA and the unknown area/areas of origin: **low risk.**

Susceptible wood from the USA and the unknown area/areas of origin: **low risk.**

Foliage or cut branches of susceptible hosts from USA, Canada, the unknown area/areas of origin, and non-EU countries of Norway and Switzerland: **very low risk.**

Seeds and fruits of susceptible hosts from the USA, Canada, unknown area/areas of origin, and non-EU countries of Norway and Switzerland: **very low risk.**

Susceptible isolated bark from Canada and the non-EU countries of Norway and Switzerland: **very low risk**

Susceptible isolated wood from Canada and the non-EU countries of Norway and Switzerland: **very low risk.**

Estimate the probability of establishment:

The probability of establishment in the PRA area is **high**.

A wide range of host plants is cultivated on nurseries in the EU. Outside of nurseries, managed parks and gardens growing susceptible host species have already become affected in parts of the EU. In some of these areas (e.g. parts

of the UK), containment with a view to suppressing the level of inoculum to protect susceptible trees and to reduce spread, has become necessary. This is because total eradication of the pathogen may not be possible in part of the PRA area. Some parts of the area have very favourable climatic conditions; certain nursery practices favour the pathogen; long-lived chlamydospores aid survival and establishment.

Estimate the potential economic impact:

The potential economic impact for the nursery trade is **high**.

Without controls the pathogen has the potential to spread further in the trade network and could potentially expand its host-range, which is already very wide. For cultivated plants, damage is principally to the quality of hardy ornamental hosts. Loss of exports may increase if third countries maintain requirements for imports of ornamental plants from the EU.

If controls are lifted, environmental impacts may become locally **major** but this may take some time (possibly decades) as this relies on further spread of the pathogen.

Social impacts will increase as a result of damage to plants in managed gardens that are visited by the public firstly impacting on visitor numbers and ultimately affecting the tourism industry where such gardens are part of that economy.

Costs borne by National Plant Protection Organisations will increase if increased phytosanitary controls are recommended in an effort to reduce further spread to the environment. However, there will be environmental benefits if controls focus on removal of foliar sporulating hosts that are invasive species such as *R. ponticum.*

Degree of uncertainty

Pathways

Although there are data available in the Eurostat Comext database for six of the eight pathways the level of uncertainty surrounding the data is **high** for Pathway (i) plants for planting (hosts), Pathway (ii) plants for planting (non-hosts) and Pathway (v) foliage/cut branches of susceptible hosts because the only named hosts in the database are rhododendron (including azalea) and roses and this is only for plants for planting. It is assumed that Pathway (ii) plants for planting (non-hosts) contains some susceptible hosts. The level of uncertainty for Pathway (iv) volume of soil as a contaminant is **high** because there are no data. The level of uncertainty for Pathway (vii) volume of susceptible bark is **high** because the data are part of a

general wood waste category in Eurostat with no named genera. The level of uncertainty is **high** for Pathway (iii) volume of soil/growing media as a commodity from non-EU European countries (Norway and Switzerland) as no data are available in the Eurostat database, as well as for Pathway (vii) susceptible bark and Pathway (viii) susceptible wood from these countries too, as no data were obtained.

Pathway (vi), the volume of seeds and fruits has **medium** to **high** uncertainty as only a few genera are named and these data refer to nuts and fruit only.

The only categories where the data on volumes of imports has **low** uncertainty are for Pathway (iii) soil as a commodity from Canada, USA, China and Taiwan as this is banned and Pathway (viii) susceptible wood from these countries as five of the known host genera are named in the Eurostat Comext database including *Quercus* spp.

Establishment

It is uncertain as to whether the mating system is fully functional and therefore what risks arise from the introduction of the A2 mating type into the EU.

The potential for adaptation to new hosts or environments is uncertain.

There is a lack of high-resolution data on host distribution for Europe. This has limited the determination of the endangered areas outside of nurseries.

The rate of spread in the absence of phytosanitary controls is uncertain.

The ability for asymptomatic root infections to become systemic is uncertain.

The significance of asymptomatic sporulation is uncertain.

The role of inoculum contaminating the growing media of plants that are traded is uncertain.

The suppression of symptoms by the use of fungicides (with fungistatic properties) is based upon observations.

The likelihood of eradication in non-nursery environments is uncertain.

Economic impact

The impact in the area or areas of origin is unknown, as this has yet to be identified. This has a high level of uncertainty.

The impact in the absence of phytosanitary measures is not known for the EU where measures have been in place since 2002.

The potential for hybridisation with other species of *Phytophthora* is uncertain.

The potential for timber plantations to become affected by *P. ramorum* is uncertain.

OVERALL CONCLUSIONS The pest fulfils the criteria of a quarantine pest. There is a risk of further entry (of known or new lineages and/or mating types), establishment and economic impact. The risk from the pest is considered not to be acceptable.

STAGE 3: PEST RISK MANAGEMENT

IDENTIFICATION OF THE PATHWAYS

Pathways studied in the pest risk management section

Pathway (i):
Plants for planting (excluding seeds and fruit) of known susceptible hosts that are permitted entry from the USA and Canada, or from undetermined third countries that represent the pathogen's, as yet unknown, area/s of origin. Plants for planting of known hosts from non-EU European countries where the pathogen occurs (Norway and Switzerland) are also a pathway.

Pathway (ii):
Plants for planting (excluding seeds and fruit) of non-host plant species accompanied by contaminated, attached growing media from the USA and Canada, or from undetermined third countries that represent the pathogen's area/s of origin. Plants for planting of non-host plant species with contaminated growing media from non-EU European countries where the pathogen occurs (Norway and Switzerland) are also a potential pathway.

Pathway (iii):
Soil/growing medium (with organic matter) as a commodity from the USA and Canada, or from the as yet unknown area/s of origin for *P. ramorum.* Soil/growing media as a commodity from non-EU European countries where the pathogen occurs (Norway and Switzerland) is also a potential pathway.

Pathway (iv) :
Soil as a contaminant (e.g. on footwear, machinery, etc.) from the USA and Canada, or from undetermined third countries that represent the pathogen's area/s of origin. Soil as a contaminant from non-EU European countries where the pathogen occurs (Norway and Switzerland) is also a potential pathway.

Pathway (v):
Foliage or cut branches (for ornamental purposes) of susceptible foliar hosts from the USA and Canada, or from undetermined third countries that represent the pathogen's area/s of origin. Foliage or cut branches of susceptible foliar hosts from non-EU European countries where the pathogen occurs (Norway and Switzerland) is also a potential pathway.

Pathway (vi):
Seeds and fruits of susceptible host plants from the USA and Canada, or from undetermined third countries that represent the pathogen's area/s of origin. Seeds and fruits of susceptible host plants from non-EU European countries where the pathogen occurs (Norway and Switzerland) is also a potential pathway.

Pathway (vii):
Susceptible (isolated) bark from the USA and Canada, or from undetermined third countries that represent the pathogen's area/s of origin. Susceptible (isolated) bark from non-EU European countries where the pathogen occurs (Norway and Switzerland) is also a potential pathway.

Pathway (viii):
Susceptible wood from the USA and Canada, or from undetermined third countries that represent the pathogen's area/s of origin. Susceptible wood from non-EU European countries where the pathogen occurs (Norway and Switzerland) is also a potential pathway.

Other pathways identified but not studied None

IDENTIFICATION OF POSSIBLE MEASURES

Pathway (i): Plants for planting (excluding seeds and fruit) of known susceptible hosts that are permitted entry from the USA and Canada, or from undetermined third countries that represent the pathogen's, as yet unknown, area/s of origin, and Norway and Switzerland

Measures related to consignments:
Detection of the pathogen in consignments by inspection and testing at export and/or import
Detection of the pathogen by inspection and testing during post-entry quarantine

Measures related to the crop or to places of production:
Pest freedom for the crop, place of production or area.
Domestic certification schemes if supported by testing of symptomatic material.

Other possible measures:
Surveillance and eradication in the importing country of the EU

Pathway (ii): Plants for planting (excluding seeds and fruit) of non-host plant species accompanied by contaminated, attached growing media from the USA and Canada, or from undetermined third countries that represent the pathogen's, as yet unknown, area/s of origin, and Norway and Switzerland

Measures related to consignments:

Physical removal of any surplus growing media just before export.

Measures related to the crop or to places of production:
In areas where the pathogen occurs, treatment (sterilisation) of the growing media prior to planting and prevention of reinfestation during the growing period.

Pest freedom for the crop, place of production or area (i.e. non-host plants to be produced away from host-plants to avoid contamination.)

Other possible measures:
Surveillance and eradication in the importing country of the EU.

Pathway (iii): <u>Soil/growing medium (with organic matter) as a commodity</u> from the USA and Canada, or from undetermined third countries that represent the pathogen's, as yet unknown, area/s of origin, and Norway and Switzerland

Measures related to consignments:
Depending upon the volume of material heat treatment could be considered but may not be practical. Testing may be feasible but may not detect low levels of the pathogen.

Measures related to the crop or to places of production:
Pest free crop, place of production or area. (This refers to the area from which the soil or growing media is collected).

Other possible measures:
Surveillance and eradication in the importing country of the EU.

Pathway (iv): <u>Soil as a contaminant</u> (e.g. on footwear, machinery, etc.) from the USA and Canada, or from undetermined third countries that represent the pathogen's, as yet unknown, area/s of origin, and Norway and Switzerland

Measures related to consignments:
Cleaning and (if feasible without damage to the machinery) disinfection of used machinery or vehicles imported from an area where *P. ramorum* occurs.

Measures related to the crop or to places of production:
Not applicable

Other possible measures:
Inspection of human traveller's footwear and possible treatment at the point of entry where travellers have entered from an area where *P. ramorum* occurs.

Pathway (v): <u>Foliage or cut branches</u> (for ornamental purposes) of susceptible foliar hosts from the USA and Canada, or from undetermined third countries that represent the pathogen's, as yet unknown, area/s of origin, and Norway and Switzerland

Measures related to consignments:
Detection of the pathogen in consignments by testing at export and post-entry (this is only applicable to known hosts and given the volume of material may not be feasible)
Removal of the pest from the consignment by suitable heat treatment (affects quality)

Measures related to the crop or to places of production:
Pest–free area for the crop, place of production or area.

Other possible measures:
Controls on recycling – this is unlikely to be practical except where known infected material is to be disposed of.

Surveillance and eradication in the importing country of the EU.

Pathway (vi): Seeds and fruits of susceptible host plants from the USA and Canada, or from undetermined third countries that represent the pathogen's, as yet unknown, area/s of origin, and Norway and Switzerland

Measures related to consignments:
Detection of the pathogen in consignments by inspection and testing at export and import
For contaminated seed lots, removal of the pest from seed consignments by physical removal of contaminating plant debris

Measures related to the crop or to places of production:
Pest-free crop, place or area of production

Other possible measures:
Surveillance and eradication in the importing country of the EU

Pathway (vii): Susceptible (isolated) bark from the USA and Canada, or from undetermined third countries that represent the pathogen's, as yet unknown, area/s of origin, and Norway and Switzerland

Measures related to consignments:
Limited end-use of known infected bark (i.e. not to be used in the nursery trade or the landscaping industry)

Note that current prescribed treatments for isolated bark of conifers in the EC Plant Health Directive requires either fumigation or heat treatment at 56°C for 30 minutes before it can enter the EU. The efficacy of this treatment against cankered bark is unknown as one study has suggested that a treatment at 56°C for 30 minutes might not be adequate to kill *P. ramorum* in wood of tanoak (*L. densiflorus*). The efficacy of other prescribed treatments is also unknown.

Measures related to the crop or to places of production:
Pest-free crop, place of production or area.

Other possible measures:
Surveillance and eradication in the importing country of the EU.

Pathway (viii): Susceptible wood from the USA and Canada, or from undetermined third countries that represent the pathogen's, as yet unknown, area/s of origin, and Norway and Switzerland

Measures related to consignments:

Limited end-use of known infected wood (i.e. not to be used in the nursery trade or the landscaping industry) (but the risk of establishment from such a use is extremely low.)

Note that one of the current prescribed treatments for wood of conifers and wood waste of various types in the EC Plant Health Directive requires heat treatment at 56°C for 30 minutes before it can enter the EU. The efficacy of this treatment against cankered wood is unknown as one study has suggested that a treatment at 56°C for 30 minutes might not be adequate to kill *P. ramorum* in wood of tanoak (*L. densiflorus*). The efficacy of other prescribed treatments is also unknown

Measures related to the crop or to places of production:
Pest freedom of the crop, place of production or area

Other possible measures:
Surveillance and eradication in the importing country of the EU.

EVALUATION OF THE MEASURES IDENTIFIED IN RELATION TO THE RISKS PRESENTED BY THE PATHWAYS

The risks presented by the pathways have been ranked from high to very low depending upon the type of commodity as well as the origin.

Degree of uncertainty

The area of origin or origins has not been identified and although it has been speculated to be Asia (possibly Yunnan, Taiwan or the eastern Himalayas) this is still not proven. Because of this it is not possible to regulate all of the pathways.

The efficacy of fungicide treatments for host plants is not 100%.

The potential for spread in asymptomatic roots of host plants is a possibility, but is not proven to have led to new findings.

The significance of asymptomatic sporulation is uncertain.

The potential for spread in growing media has not been shown to occur in practice, but it has the potential to do so.

It is not known whether there are imports of machinery or vehicles from area where *P. ramorum* occurs

It is not known whether areas where foliage or cut branches are harvested for export to the EU are affected by *P. ramorum*

There is no evidence of seed-borne infection to date so the potential for this to be a pathway is uncertain.

The evidence for fruit-borne infection is only experimental so

the potential for this to be a pathway is uncertain.

The efficacy of phytosanitary treatments that are routinely prescribed for bark and wood are not known but there is doubt as to the efficacy of 56ºC for 30 minutes.

The potential for spread from infected bark and wood to host plants is not known; spread from bark is more likely than from wood.

CONCLUSION:

Recommendation for possible measures:

The measures below do not account for pre-existing EC phytosanitary measures for *P. ramorum* or any measures that may have an impact on the risks posed by *P. ramorum* under the EC Plant Health Directive (2000/29/EC).

Because of the uncertainty surrounding the origin or origins of *Phytophthora ramorum* it is not possible to regulate the 8 main '*commodity types*' from this origin, albeit this continues to present a risk of entry of *P. ramorum* to the EU.

For foliage and cut branches, measures may only be necessary for areas where *P. ramorum* occurs if material is harvested there. This is likely to be only California and Oregon in the USA. Norway and Switzerland may only need to be regulated if the pathogen occurs in areas where foliage and cut branches are harvested and if these are exported to the EU. These measures could be recommended but the risk of establishment from this pathway is likely to be low.

It is thought that measures are not necessary for seeds and fruit of susceptible host plants as there are no records of infection in the field and plants with edible fruit that are likely to be traded are not hosts. There are no data to show that seed transmission is possible.

For susceptible bark, measures are only necessary for parts of the USA where *P. ramorum* occurs in woodlands and forests (California and Oregon) as there are no woodlands/forests affected in Canada, Norway or Switzerland.

For susceptible wood, measures seem not to be necessary because of the end-use of the material. If measures are maintained then they are only necessary for parts of the USA where *P. ramorum* occurs in woodlands and forests (California and Oregon) as there are no woodlands/forests affected in Canada, Norway or Switzerland

The recommended measures are listed below:

Pathway (i): Plants for planting (excluding seeds and fruit) of known susceptible hosts that are permitted entry from the USA and Canada, Norway and Switzerland	Phytosanitary Certificate (PC) and, if appropriate, Re-export Certificate (RC) *Measures related to consignments:* Detection of the pathogen in consignments by inspection and testing at export and/or import *or* Detection of the pathogen by inspection and testing

	during post-entry quarantine *Measures related to the crop or to places of production:* Pest freedom for the crop, place of production or area. Domestic certification schemes <u>if</u> supported by testing of symptomatic material. *Other possible measures* Surveillance and eradication in the importing country of the EU

Pathway (ii): <u>Plants for planting (excluding seeds and fruit) of non-host plant species accompanied by contaminated, attached growing media</u> from the USA and Canada, Norway and Switzerland	PC and, if appropriate, RC *Measures related to consignments:* Physical removal of any surplus growing media just before export. *Measures related to the crop or to places of production:* In areas where the pathogen occurs, treatment (sterilisation) of the growing media prior to planting and prevention of reinfestation during the growing period Pest freedom for the crop, place of production or area (i.e. non-host plants to be produced away from host-plants to avoid contamination) *Other possible measures* Surveillance and eradication in the importing country of the EU

Pathway (iii): <u>Soil/growing medium (with organic matter) as a commodity</u> from the USA and Canada, and Norway and Switzerland	PC and, if appropriate, RC *Measures related to consignments:* Depending upon the volume of material heat treatment could be considered but may not be practical. *Measures related to the crop or to places of production:* Pest free crop, place of production or area. (For the area where soil or growing media are collected) *Other possible measures* Surveillance and eradication in the importing country of the EU.

Pathway (iv): <u>Soil as a contaminant</u> (e.g. on footwear, machinery, etc.) from the USA and Canada, Norway and Switzerland	*Measures related to consignments:* Cleaning and disinfection of used machinery or vehicles imported from an area where *P. ramorum* occurs. *Measures related to the crop or to places of production:* Not applicable *Other possible measures* Inspection of human travellers footwear and possible treatment at the point of entry where travellers have entered from an area where *P. ramorum* occurs

Pathway (v): <u>Foliage or cut branches</u> (for ornamental purposes) of susceptible foliar hosts from the USA (Norway and Switzerland – but only if foliar hosts are affected where harvesting and export to the EU occurs)	PC and, if appropriate, RC *Measures related to the crop or to places of production:* Pest–free area for the crop, place of production or area. *Other possible measures* Controls on recycling for known infected material Surveillance and eradication in the importing country of the EU

Pathway (vii): <u>Susceptible (isolated) bark</u> from the USA	PC and, if appropriate, RC *Measures related to consignments:* Limited end-use of known infected bark (i.e. not to be used in the nursery trade or the landscaping industry) *Measures related to the crop or to places of production:* Pest-free crop, place of production or area

REFERENCES FOR SUMMARY

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