Contingency Planning for *Phytophthora ramorum* Outbreaks: Progress Report Work Package 7, EU RAPRA Project[1]

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Abstract

As part of the EU project "Risk analysis for *Phytophthora ramorum,* a recently recognised pathogen threat to Europe and the cause of Sudden Oak Death in the USA" (acronym RAPRA) outbreak scenarios are defined and existing strategies for eradication and containment of *Phytophthora ramorum* evaluated. Based on the current knowledge about disease epidemiology three types of outbreaks have been identified: the rhododendron system in northern Europe, a hypothetical system in southern Europe, and the nursery system. The logistic curve is suggested as a model to describe the geographical spread of *P. ramorum*.

Evaluation of existing strategies is subdivided into three categories: measures to prevent introduction, measures at nurseries and measures in the natural and semi-natural environment. Up until now there have been no indications that introductions have occurred in the EU from the U.S. However, in the U.S. there have been findings of the A1 mating type-European lineage at nurseries in Oregon and Washington State, suggesting another introduction has occurred at some time, either from Europe or another origin. Generally the measures at the nurseries are adequate, provided they are fully implemented. Since they have been in place there has been a sharp decline in the incidence of positive findings in the U.K. and the Netherlands. There are shortcomings in the measures for growing media, contact with the environment and uncertainties regarding the effect of contaminated irrigation water. Also information on the period before symptom development and optimal timing of inspection is incomplete. Evaluation of the measures in natural and semi-natural environment in the EU shows that if only a few plants are infected, eradication can be achieved. However, if large areas of rhododendron are infected control measures are required over a number of years and often containment is the maximum control attainable. Until now in the EU all infestations are in or linked to rhododendron. *P. ramorum* can be managed in the EU by managing rhododendron.

Key words: *Phytophthora ramorum*, outbreak scenario, evaluation, eradication, containment.

[1] A version of this paper was presented at the Sudden Oak Death Third Science Symposium, March 5–9, 2007, Santa Rosa, California.

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Introduction

The overall aim of the EU project "Risk analysis for *Phytophthora ramorum*, a recently recognised pathogen threat to Europe and the cause of Sudden Oak Death in the USA" (acronym RAPRA) is to develop a European pest risk analysis for American (U.S.) and European (EU) isolates of *P. ramorum*. The results should allow a review of the current EU phytosanitary policy. The tasks of the RAPRA project are clustered in work packages. In Work Package 7, "contingency planning for *Phytophthora ramorum* outbreaks", outbreak scenarios are defined and existing strategies for eradication and containment evaluated. With the production of technical guidelines for eradication and containment the work package will be completed. Work Package 7 is jointly carried out by Forest Research U.K., Central Science Laboratories U.K., Plant Health-Department for Environment Food and Rural Affairs, U.K., Federal Biological Research Centre for Agriculture and Forestry Germany, United States Department of Agriculture-Forest Service (USDA-FS) and the Netherlands Plant Protection Service.

Outbreak Scenarios

The outbreak scenarios are designed for European circumstances to assess the potential economic and environmental impacts by *P. ramorum* **(**Kehlenbeck 2007). Information on the actual situation was obtained through a questionnaire to the EU member states, and also from the annual *P. ramorum* survey reports submitted by the member states to the EU. Additional data was also provided by the U.K. and the Netherlands. Based on this information and knowledge of the principles involved in outbreaks (for example, host type, conditions for establishment and means of dispersal), three outbreak scenarios have been defined.

- The rhododendron system; exemplifies the situation in the temperate zone of northwest Europe with rhododendron as sole foliar (sporulating) host and a number of tree end hosts. Dispersal will take place within and between patches with sporulating host plants.
- A hypothetical system that exemplifies the situation in the Mediterranean climate zone of southwest Europe, with foliar (sporulating) tree and non-tree hosts and a number of tree and non-tree end hosts. The system is based on the assumption that there will be a driving force in the form of a sporulating foliar tree host. The spread can be over relatively large distances.
- A nursery system that exemplifies a generalised nursery with a variety of foliar and non-foliar host species arranged in uniformly planted beds in protected or semi-protected environment. The plants grow under favourable conditions. The disease spread can be over short to very large distances.

The nursery system and the two natural systems considered are interrelated via trade linked introduction pathways.

The logistic curve (S-curve) having an approximately exponential increase at the initial stage and a slow down and eventually a halt at later stage can be used as a model to describe the geographical spread of *P. ramorum* throughout an area with

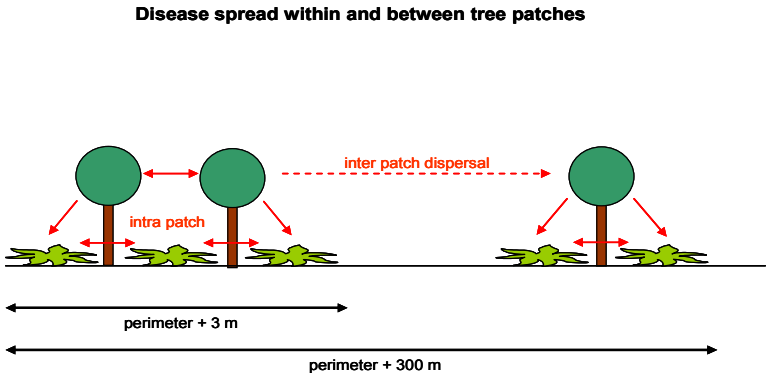

Figure 1—Schematic presentation of the hypothetical system in semi-open landscapes and forest with patches of foliar tree (e.g. *Quercus ilex*) and understory species and tree and non-tree end hosts; intrapatch disease spread by regular short distance dispersal of sporangia (eg. rainsplash); interpatch disease spread by incidental medium distance dispersal of inoculum (e.g.storm/rain splash).

patches of rhododendron or other sporulating foliar hosts capable of driving an epidemic under favourable climatic conditions. It is assumed that from the nurseries, infested plants are introduced in patches with rhododendron or other foliar hosts. The percentage of infested patches depends on the distance between the patches but also on the effectiveness of the measures (plant material free). Without measures within a patch, ultimately all the sporulating foliar hosts in that patch capable of maintaining an epidemic will be infested. The infestation level of other host plants will depend on the environmental circumstances. Until now the incidence of findings in other host plants is low.

Evaluation of Existing Strategies

The evaluation is subdivided into measures to prevent introduction, measures at nurseries and measures in the natural and semi-natural environment.

Preventing Introduction

In general the measures are directed to prevent introduction associated with the importation of susceptible plants, wood and bark. The danger of recombination between U.S. and EU isolates of *P. ramorum* increases the fear of introductions between North America and the EU. Up until now there have been no indications that introductions have occurred in the EU from the U.S. However, in the U.S. there have been findings of the A1 mating type-European lineage at nurseries in Oregon and Washington State and more recently in California (COMTF 2007), suggesting introductions have occurred at some time, either from Europe or another origin. Besides the U.S. and the EU 50 countries (IPPC 2007) have *P. ramorum* on their regulated pests lists or mentioned in their legislation.

Nurseries

The necessary information for the evaluation of the measures at the nurseries in the EU was obtained through questionnaires to the Member States, through in-depth studies at nurseries, from the EU *Phytophthora ramorum* working Group and in a

limited way from research results. Evaluation of the measures in the U.S. was confined to using the information to support the evaluation of the EU measures. Information on U.S. measures was obtained from the Animal and Plant Health Inspection Service (APHIS).

The results of the evaluation in Work Package 7 are very much in line with the results of the EU *Phytophthora ramorum* Working Group that met in May 2006. The Working Group convened to evaluate briefly the Member State survey and RAPRA research results and to make recommendations for improvement of the EU Commission Decision[3].

The measures are generally adequate when implemented fully. This is demonstrated by the sharp decline in the number of positive findings at the nurseries in two Member States. In England and Wales, from 2003 to 2006, *P. ramorum* positive inspections declined from 3 percent to less than 1 percent. In the Netherlands, over a similar time scale, findings reduced from 4 percent of the nurseries infected to less than 0.5 percent. However the number of infestations found in marketed lots by the receiving countries is not always in concurrence with the decline found at the producer's nurseries. One of the reasons might be the marketing of asymptomatic but infected plants.

There are shortcomings:

- Information from different Member States in the EU but also from the U.S. indicates infested soil and debris is a cause of infestations.
- Infection of nursery plants through contact with infestations in the semi-natural environment, but also inadequate inspections leading to the introduction of the pathogen at the nursery via infected planting material are reported as important factors.
- Infection spread via irrigation remains a point of attention. Research (Werres and others 2007) clearly indicates that *P. ramorum* can be spread with contaminated water and that infection via overhead irrigation is possible. Further studies are needed to investigate the conditions favouring infection and symptom development.

These points have also been raised at the EU Working Group, resulting in recommendations for adaptations to the EU regulation and technical guidelines (Slawson and others 2006). The EU Standing Committee on Plant Health accepted the recommendations of the EU Working Group in February 2007.

The evaluation of the measures currently in place made it clear that more research is required on the likelihood and circumstances under which infection can be initiated by infested soil and irrigation water. Also more information is needed on the lag period before symptom development and on the optimum timing for inspection.

[3] COMMISSION DECISION of 19 September 2002 to prevent the introduction into and spread within the Community of *Phytophthora ramorum* Werres, De Cock & Man in't Veld *sp. nov.* (notified under document number C – 2002 3380).

Natural and Semi-natural Environment

Until now in the EU all infestations are in or linked to rhododendrons. The EU Commission Decision requires only that the harmful organism should be contained. The EU Working Group on *Phytophthora ramorum* worked out the approach in technical guidelines (Slawson and others 2006**)**.

Experiences in both the U.K. and the Netherlands have shown that if only a few plants are infected, eradication can be achieved successfully. However where large areas of rhododendrons are infected, experience has shown that control measures are required over a number of years and even then, it is uncertain whether or not complete eradication is achievable (Slawson 2006). The inputs required for eradication are often substantial and of such long duration that they cannot be met.

Less effective but cheaper containment measures such as pruning back infected plants, chipping the debris and leaving this on site are often financially and socially more acceptable. Due to its acceptability, containment measures can often contribute more to the prevention of the spread than eradication measures.

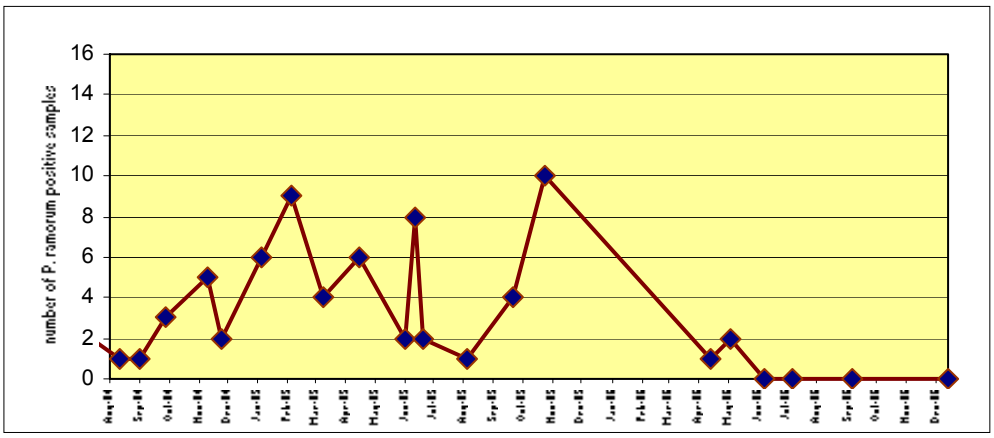

Figure 2— Survival of *Phytophthtora ramorum* in woodchips.

In an experiment in the Netherlands to monitor the persistence of *P. ramorum* after infected rhododendrons were cut down and chipped, it took 2 years before the pathogen could no longer be detected in the previously infested woodchips. An earlier trial in 2003/2004 in the Netherlands proved that it took 1.5 years before the pathogen could not be detected in the soil after removing infected rhododendrons. The additional risk of leaving infested woodchips at the site is limited, considering the short extra period the pathogen could be detected.

It is accepted in both the Netherlands and the U.K. that in cases where eradication cannot be achieved containment measures are taken, with the overall aim of preventing the spread of *P. ramorum*. In both countries it is concluded that these containment measures reduce considerably the risk of the pathogen spreading. Such containment measures in the natural and semi-natural environments are often very similar to the normal maintenance of intentionally planted rhododendrons.

The experiences in southern Oregon also show that eradication is difficult in the natural environment. Despite an intensive eradication campaign, over the last 2 years the number of newly found infested trees has increased (Kanaskie this volume).

However, in the infested area in northern California (Humboldt County) the spread has been considerable compared to the Oregon infested area. It is assumed that without treatment spread in Oregon would be similar to northern California. Maybe the conclusion is that even containment may not be possible and that slow in spread rate is the best that is achievable under conditions of established widespread outbreaks. In Humboldt County trials have been implemented to find an acceptable and affordable way to manage the disease. The trials include burning and removal of bay laurel and tanoak (COMTF 2006), but only after two years will it be possible to say whether the approach is successful. Undoubtedly, the impact of *P. ramorum* on the environment in California U.S. is much more serious than in the EU due to its conducive environment as well as a continuum of highly susceptible bole (tree) host and tree sporulators.

General Conclusions

The measures to prevent introduction of the pathogen in the EU have been successful. However the findings of A1 mating type-European lineage in the U.S. suggest an introduction at some time from Europe or another origin.

The measures at the nurseries in Europe are in general adequate. There has been a sharp decline in positive findings in the U.K. and the Netherlands. Shortcomings are reported in the measures for growing media and contact with the environment. Further studies are needed on the effect of irrigation water and there is lack of information on the period between infection and symptom development and on the optimal timing of inspection.

Until now in the EU all infestations found in the natural environment are in or linked to rhododendrons. Based on the information from the U.S. and the EU, for Europe some general conclusions can be drawn about strategies for eradication and containment. With small outbreaks, consisting of only a few plants, eradication can be successful as has been demonstrated in nurseries and the natural environment. If a larger outbreak has established itself however, often containment is the maximum achievable. Nevertheless, for Europe, *Phytophthora ramorum* can be managed by managing rhododendron. Considering the difficulties with eradication and containment, our main aim has to remain preventing introductions in new areas.

Acknowledgements

I would like to use the opportunity to express my gratitude and appreciation for the contributions of all the co-workers in the Work Package 7 of the EU RAPRA project named below. In the above presentation I have made use extensively of their specific contributions.

Paul van den Boogert, Plant Protection Service, Netherlands; Susan Frankel, USDA-FS, U.S.; Hans de Gruyter, Plant Protection Service, Netherlands; Hella Kehlenbeck, Federal Biological Research Centre for Agriculture and Forestry, Germany; Sharon Mattews-Berry, Peter Reed, Claire Sansford, Central Science Laboratory, U.K.; David Slawson, Plant Health and Seeds Inspectorate, U.K.; Joan Webber, Forest Research, U.K.

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