Annexes

Annex 1

Disease spread model

Phytophthora ramorum and *Phytophthora kernoviae*: local and national timescales for disease epidemics

The term '*epidemic*' describes the change in the amount of disease with time and space. For plant diseases, the amount of disease is measured either as the number of plants or plant parts affected (incidence) or the amount of plant tissue affected (severity), or a combination of both. Plant disease epidemics can be fast, slow or negative (if there is a decrease in disease with time). Associated with the temporal change in the amount of plant disease, is a change in the spatial distribution of lesions on individual plants or of infected plants in the environment.

In areas where a pathogen and its host or hosts have coevolved over long periods of time, they often are in equilibrium and there is little alteration in the amount of disease with time. The exception to this is when environmental changes or disturbance trigger a change in pathogen behaviour.

For pathogens that have been introduced to a new geographical area, such as the introduction of *Phytophthora ramorum* and *Phytophthora kernoviae* to GB, many of the newly exposed hosts have only limited resistance to counter infection. However, at the local level (garden/woodland etc), at the beginning of the epidemic, only small numbers of individual plants will be affected (low incidence) and disease severity will vary. Usually, disease development is very slow because there is relatively little inoculum, and this initial period is known as the '*lag phase*' of the epidemic. Frequently during this phase, a new introduction remains undetected because only a few plants are infected, and the symptoms are difficult to detect or easily confused with other abiotic/biotic disorders. With favourable environmental conditions combined with ready availability of susceptible hosts, infective inoculum can gradually build-up so the disease increases in severity and incidence (around the original introduction point). Eventually the disease becomes more widespread and can be very damaging once the epidemic has reached what is known as the *'exponential phase'* of the epidemic. The final *'slowing down'* or '*decline*' of the epidemic will only occur when there is no new host material available or the environmental conditions become unfavourable to the pathogen. The three phases of this type of disease epidemic are shown in Figure 1.

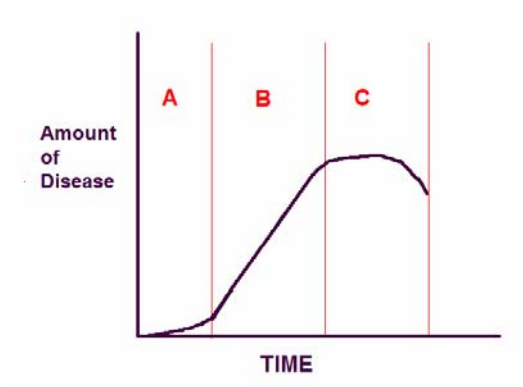

Figure 1. Epidemic growth curve.
A = Lag phase, B=Exponential phase, C= Slowing down or decline phase.
For both *P. ramorum* and *P. kernoviae*, favourable environmental conditions (particularly in the west of Britain) and abundant, susceptible host material (rhododendron), has lead to the rapid

build-up of disease in individual woodlands and gardens in south-west Britain. Over the last 3-5 years therefore, the disease trajectory for both pathogens has entered the exponential phase in some local areas. As a consequence of this, not only rhododendrons but also trees have now become infected with a potentially lethal disease. On a national scale, in terms of the number and distribution of affected hosts, the development of the epidemic is currently still in the lag phase for both *P. ramorum* and *P. kernoviae*. Although host material, especially invasive *Rhododendron ponticum* is available throughout GB, and favourable environmental conditions are also widespread, so far neither pathogen has spread much beyond the south and west of the country. Long distance movement of infected plant material is the most likely route by which these pathogens will be distributed to new areas and as disease builds in each of these, producing increasing quantities of inoculum, it is likely that these diseases will progress to the exponential phase on a wider scale. Thus, on a national scale, the lag phase is likely to be lengthy, especially under the current regime of phytosanitary controls. There is also a two stage process in which both pathogens must build up on rhododendron before enough inoculum is available to infect and kill susceptible tree species. It could be decades therefore, before the diseases move into the exponential phase on the wider scale.

Phytophthora alni

Many parallels can be drawn with another new *Phytophthora* disease on trees, caused by a pathogen which was recently named as *Phytophthora alni*. This *Phytophthora* disease of alder (*Alnus*), was first discovered in Britain in 1993 where it is now widespread. It causes a root and collar rot which can result in rapid girdling and killing of trees. The disease is found along river ('*riparian*') systems as well as in some orchard shelterbelts and woodland plantings. It has also spread across much of Europe from Sweden to France, causing much local mortality in some areas. See: http://www.forestresearch.gov.uk/website/forestresearch.nsf/ByUnique/INFD-737HUN

In GB alone, it is now estimated that more than 20% of riparian alders have been damaged or killed by the disease since its discovery. The first surveys in 1995, revealed that around 5% of riparian alders were already infected in southern England, and even at that time it was considered that the pathogen may have been present in Britain for 20-30 years in the lag phase prior to detection. It is now established on most river systems in the south and midlands of England and also Wales, more recently extending into the north of England and Scotland, causing damage to riparian ecosystems.

The alder pathogen differs from *P. ramorum* and *P. kernoviae* because it is not a uniform species but a swarm of hybrids between two exotic *Phytophthora* species. The circumstances of the hybridisation remain obscure, but plant nurseries are most likely to have provided the environment for the origin of the new species. *Phytophthoras* are frequently found in nurseries and the increasing interest in exotic plants and the difficulty of ensuring that imported stock is free from pathogens has meant that these often include *Phytophthora* species previously geographically separated from each other. Man's commercial activities can result in mixing of *Phytophthora* species and plant species that may originate from all over the world. This, combined with the use of disease suppressive chemicals, could have encouraged the process of hybridisation. Certainly there is strong evidence that *P. alni* is disseminated on alder plants that have become infected in the nursery; in Germany it has been found on the root stocks of alder in three out of four commercial nurseries that were tested.

Once again, several features have probably contributed to the invasive behaviour of the alder *Phytophthora*. Long distance international movement of the parent pathogens has probably occurred via the trade of infected but symptom-free plants. In addition, one spore type of *Phytophthora* species (zoospores) is free-swimming, and therefore adapted to dispersal in water. The hybridisation event that led to the creation of *P. alni* also allowed it to exploit a new host genus not previously susceptible to *Phytophthora*.

Inspection costs

Table 1: - Option 1: EU minimum – Site time required for surveillance programme

	Premises	Visits	Site time (hours)
Nursery trade [1]			
Plant passporting (wholesale) nurseries	450	960 [2]	832 [3]
National survey of nurseries and garden centres	1,500	1,690 [4]	1,211 [5]
Parks, gardens and woodland			
National survey [6]	300	391 [7]	2,124 [8]
			4,167

Notes:

1. EU decision requires surveys of "cultivated" plants and appropriate procedures aimed at eradicating *P. ramorum* if found. Visits both to wholesale nurseries and to retailers are considered to fulfil this requirement. Extra resource required against *P. kernoviae* specifically has not been included.

2. EU decision requires two visits to all plant passporting (wholesale) nurseries (900). Plus an additional five extra visits to 12 premises at which the pathogens might expect to be detected based on the latest data which indicate that *P. ramorum* was detected at around 2.5% of commercial premises inspected (60 visits).

3. Site time based on average visit time of 52 minutes.

4. Based on one visit to ~ 1,500 premises plus an additional five visits to 38 premises at which the pathogens might expect to be detected based on the latest data which indicate that *P. ramorum* was detected at around 2.5% of commercial premises inspected (190 visits).

5. Site time based on average visit time of 43 minutes.

6. EU decision requires surveys of "uncultivated/unmanaged" plants and appropriate measure at least to contain *P. ramorum* if found. This survey may include parks, gardens, woodland and heathland.

7. Based on one visit to 300 sites (300 visits) plus on average an additional 7 visits to 13 sites at which the pathogens might expect to be detected based on the latest data which indicate that *P.ramorum* was detected at around 4.3% of such sites inspected (91 visits).

8. Site time based on average visit time of 5 hours and 26 minutes.

Table 2: - Option 2: Increased activity – Site time required for surveillance programme

	Premises	Visits	Site time
1. Nursery trade [1]			
1.1 Plant passporting	450	1,992 [9]	1,726 [3]
1.2 National survey of nurseries and garden centres	1500	3,437 [10]	2,463 [5]
1.3 Port survey [11]	9	50	568 [12]
2. Parks, gardens and woodland			
2.1 National survey [6]	1,800	2,724 [13]	14,800 [8]
			19,557

Notes:

9. Based on 4 visits to all plant passporters (1,800) targeted in the spring and autumn when experience has shown the pathogens to be more active. Additional visits will be required to 12 premises at which the pathogens might expect to be detected based on the latest data which indicate that *P. ramorum* was detected at around 2.5% of commercial premises inspected as follows: monthly visits to 8 sites (96 visits) and fortnightly visits to the 4 highest risk sites (96 visits).

10. Based on two visits to ~ 1,500 premises (3,000). Additional visits will be required to 38 premises at which the pathogens might expect to be detected based on the latest data which indicate that *P. ramorum* was detected at around 2.5% of commercial premises inspected as follows: five visits to 25 sites (125 visits) and fortnightly visits to the 13 highest risk sites (312 visits).

11. Maintain programme of 50 visits to monitor EU trade entering ports.

12. Site time based on average visit time of 11 hours and 21 minutes.

13. Based on one visit to 1,800 sites (1,800 visits). Plus monthly additional visits to 77 sites at which the pathogens might expect to be detected based on the latest data which indicate that *P.ramorum* was detected at around 4.3% of such sites inspected (924 visits).

Table 3: - Costing of the various regimes

	Site time (hours)	Estimated total time (hours) [14]	Estimated total number of staff [15]	Estimated total number of additional staff	Cost (£k) [16]
Current regime	12,630	50,520	32	21.5 (see table 4a for details)	1,104
EU minimum Option 1	4,167	16,668	10.5	0 (see table 4b for details)	537
Short-term increase Option 2	19,557	78,228	48	38.5 (see table 4c for details)	1,855

Notes:

14. Total time estimated on the basis that for each hour spent on-site, there is one hour travel, one hour specific administration and one hour general administration.

15. Estimated number staff obtained by dividing the total time by the number of hours in a working year (215 working days x 7.4 hours in a day = 1,591 hours).

16. Costs calculated using PHSI's Memorandum Trading Account process, which includes the following costs; salaries and allowances, ERNIC, superannuation costs, accommodation overhead, central services and local overheads, travel and subsistence.

17. For all options, there is additional management and administration time, both of which are assumed met from within current resources.

Table 4(a): - Estimated total number of additional staff – Current Regime

Location	Staff
Polwhele	SPHSI x 1 PHSI 1 x 2 SO surveyors x 10 AO admin = 1
Temporary SO surveyors in rest of country including: London Region North Region South East Region South West Region Wales & West Midlands Region	 1 2 1 1.5 2
Total	21.5

Table 4(b) - Estimated total number of additional staff – EU Minimum

Location	Staff
Polwhele	PHSI 1 x 1 SO surveyors x 5
Beverley & East Midlands Region Cambridge Region London Region North Region South East Region South West Region Wales & West Midlands Region	PHSI 1 x 0.25 PHSI 1 x 0.25 PHSI 1 x 0.5 PHSI 1 x 1 PHSI 1 x 0.5 PHSI 1 x 1 PHSI 1 x 1
Total	10.5

Table 4(c) - Estimated total number of additional staff – Short term increase

Location	Staff
HQ	Grade 7 x 1 EO/AO x 1.5
Polwhele	SPHSI x 1 PHSI 1 x 3 SO surveyors x 10 AO admin = 2
South West - Devon	PHSI 1 x 1 SO surveyors x 2
Wales & West Midlands - Swansea	PHSI 1 x 1 SO surveyors x 5 AO admin = 1
South West - Hampshire	SO surveyors x 2
North – esp. Cheshire/Cumbria/Lancs/Yorkshire	SO surveyors x 2
Other PHSI Regions South East/London/Cambridge/East Midlands	SO surveyors x 6
Total	38.5

Clearance area and costs

Clearance cost is estimated at between £7,000 and £10,000 per hectare depending on accessibility of the site and assuming disposal of cleared material is by burning on site. (although costs on one site have exceeded £17,000/ha)

If burning on site is not an option and landfill is required the cost per tonne to land fill is c£325/tonne. Each hectare may produce between 4 and 40t (depending on density) of material for disposal. 10% not burnable.

For the purposes of this Impact Assessment an average of £8,000 per hectare has been used.

P. kernoviae

- 45 on-going outbreaks in wider environment (~37 in Cornwall a 5 in South Wales)
- Area to be cleared: ~310ha assuming a 10% spread over clearance period = 341ha.
- Clearance of c68ha per year over 5 years
- Cost per ha £8,000
- Cost per year £550,000
- Total cost = £2.7m
- Year 6 – 10 clearance of an additional ha per year cost £500,000
- Grand total £3.2m

P. ramorum

- 112 on-going outbreaks in wider environment of *P.ramorum* only
- Much smaller scale generally; usually sporadic plants around parks and gardens
- Area to be cleared: 112 sites x 1ha = 112ha assuming a 20% spread over clearance period = 135ha.
- Clearance of c45 ha per year over 5 years
- Cost per ha £8,000
- Cost per year £220,000
- Total cost = £1.08m
- Year 6 – 10 clearance of an additional 10ha. per year
- Cost per year £80,000
- Total costs £480,000
- Year 11 – 20 clearance of 5ha per year
- Cost per year £40,000
- Total costs £240,000
- Grand total £1.8m

Diagnostic Costs

Predicitive diagnostic costs for SOD based on 3 proposed strategies

Visits	**FY 06/07**	**Status quo**	**EU minimum**	**Short term increase**
Plant passporting	1,132	1,132	960	1,992
Nursery survey	2,417	2,417	1,690	3,437
Port survey	51	51	0	50
Parks survey	1,725	1,725	391	2,724
Total	5,325	5,325	3,041	8,203
% change wrt 06/07		No change	57.1% decrease	154% increase
Lab samples	2,965	2,965	1,693	4,566
LFDs	7,636	7,636	4,360	11,759
Costs	(£000)	(£000)	(£000)	(£000)
Lab samples costs - MOU funded	99	99	99	99
Lab samples - emergency funding	91	97.6	14	204
Total lab sample costs	190	197.6	113	303
LFD costs - MOU funded	24	24	24	24
LFD costs - emergency funded	24	25	4	52
Total LFD costs	48	49	28	76
Total diagnostic costs (LFD + Lab.)	238	247	141	379

Cost to nursery and garden centre industry of destruction and quarantine of plants

Average costs are notoriously difficult as there is no average nursery, however the generic examples are quoted below.

Costs are calculated based on 9cm liner (young plant) pots at 11x11 to the sq.m=
121 x 12m (a bit allowed for paths) = 1,452 plants at 60p = £871.20

Saleable 15 litre containers of Rhododendrons at 8 plants per sq.m = 8 x 12m at £10 = £960

A 10m quarantine zone presents much larger difficulties. Small numbers of suspect plants may be found leading to a large area of plants being quarantined and unavailable for sale. If the crop is being grown for a contract or a specific sell by date governed by flowering time etc., then the crop can be wasted after the quarantine period, and the point could be reached where it is more economic to destroy the entire crop and get a new crop established than it is to try and save small numbers of suspect plants over a long period. In other words, losses in the destruction or quarantine zones are not the whole financial story, and it must not be overlooked that a 30m zone includes all potentially susceptible species and not just the one in which the disease has been found. 3 months is almost irrelevant as a time scale, a crop in annual production has been significantly delayed and in most cases it will be the wrong time to start a new crop. Actual cost can be identified by multiplying up the figure for 6.35m. In the majority of cases plants will have to be bought in to replace those destroyed in order to complete the relevant contract/sales demand. On garden centres there is the potential for a very costly loss of reputation if sales beds are quarantined.

Historic garden costs

Written Q&A from: the National Trust

What effect would different control levels above have on historic gardens?

Less: Uncertainty over how to manage the disease on site, unclear picture of true spread, no clear advice, potential for greater spread, less research.

Same: Gradual understanding of how to manage the disease, snapshot of disease spread, on call advice, monitoring not enough, not enough controls on plant movement.

More: Better monitoring and control, may prove confrontational due to the passion surrounding historically significant collections if the option was very robust in its approach to the two diseases. Better controls and protocols surrounding plant movement.

The National Trust is the owner of over 200 gardens across the UK, some of which already have seen the effects of the disease. In response to this the Trust is currently developing a Position Statement on *Phytophthora ramorum* and *Phytophthora kernoviae* which will clearly set out the organisations views and recommendations to Defra on implications of the disease and actions and control measures that need to be taken

Would increased disease levels in gardens reduce visitor numbers? If so by what number? 10%, 25% 50 %?

A snapshot estimate might be 10% if the levels of infection create visible damage to our collections and or garden character. The risk of negative publicity and as a consequence any loss in public confidence could have a significantly larger impact on visitor numbers.

If a garden with a important plant collection were to lose say 60-80% of its collection, this may well have a major impact on visitor numbers over a longer period of time.

And for how long would the numbers be reduced?

Until temporary solutions could be found and a program of proactive marketing, a period of approximately 5 years could be a guide timescale this would allow for any temporary planting to mature and counteract any loss of reputation and interest. It should be noted that rebuilding public confidence could take much longer.

Would the reduction be seasonal or all year round?

If the impact was on gardens that rely on a collection of plants with predominantly spring interest, this would not only have a seasonal impact but would have a wider affect on visitor numbers and therefore finances. Much would be depend on what plant species were affected, any loss of public confidence or any associated negative publicity. Other sites which rely on susceptible species as part of their historic design may have longer term reductions in visitor numbers as a consequence.

Have visitor numbers already reduced on infected sites?

Not at present but some sites have received a few isolated comment cards from visitors feeding back ' poor condition and bare areas in need of planting'.

How might the reputations of historic gardens be affected by high levels of disease?

It could cause a lack of confidence in how plant collections are being managed and a concern that not enough is being done to inform and protect visitors from carrying the disease away with them. There may also be an adverse affect on the income generated by plant sales and possibly even loss of membership income from any relevant organisations (NT, RHS) if members strongly believed their organisation wasn't fulfilling their garden conservation obligations.

Would there be a clearance cost over and above the normal maintenance costs if susceptible species were removed /replaced with non susceptible species?

Yes there would be a significant increase which would need careful planning. A conservation plan would be required to help determine management and planting proposals that would address a future without susceptible species for those sites affected. A conservative estimate of such a plan would be in excess of £25,000 per site (depending on complexity) and then a program of propagation to safeguard the more valuable specimens then replanting over a period of time. The issues surrounding long term storage of these plants would also need careful consideration as would increased cost from additional marketing needs. The loss to the nation may well be significant as some of the specimens will be of important historic significance. The historical character, design or 'sense of place' may be lost forever resulting in a wider range of reputation and management issues.

Heathland Data

Extract from *P. kernoviae* PRA

"Britain and Ireland together support *ca.* 20% of the world's lowland heath and the UK supports 2-3 million hectares of upland heath, which represents *ca.* 75% of the total resource. All upland and lowland heathland types are classified ad Annex 1 habitats under the European Habitats Directive (Council Directive 92/43/EEC; UK regulations Statutory Instrument SI 2007/1842). (J. Perry, Countryside Commission for Wales, *personal communication*, 2008). The potential impact that *P. kernoviae* may have if it establishes in these habitats is not known as it is not known how damaging it could become there. *Vaccinium* is clearly environmentally important and even if it is not killed by *P. kernoviae*, removal or wide-scale cutting of *Vaccinium* to reduce the risk of pathogen spread will impact on a range of species, even if they spend part of their life-cycles elsewhere, with consequent repercussions through the food chain over a wide area."

For more detail please see full Pk PRA http://www.defra.gov.uk/planth/pra/forest.pdf

Annex 8

Special note regarding Cornwall: At present the majority of known infection of both *P. ramorum* and *P. kernoviae* in gardens and the wider are within Cornwall. Cornwall has been in receipt of EU Objective 1 aid to '*promote the development and structural adjustment of regions whose development is lagging behind'.* Significant money has been directed into the development of the Cornwall tourist industry particularly in marketing the 'Gardens of Cornwall'. The 'Gardens of Cornwall' project reports a £23.6m annual increase in income to the region as a direct result of the historic gardens.