The Food & Environment Research Agency

Rapid Pest Risk Analysis for

Cryphonectria parasitica

This document provides a rapid assessment of the risks posed by the pest to the UK in order to assist Risk Managers decide on a response to a new or revised pest threat. It does not constitute a detailed Pest Risk Analysis (PRA) but includes advice on whether it would be helpful to develop such a PRA and, if so, whether the PRA area should be the UK or the EU and whether to use the UK or the EPPO PRA scheme.

STAGE 1: INITIATION

1. What is the name of the pest?

Cryphonectria parasitica (Barr, 1978) was originally described as *Diaporthe parasitica (Murrill, 1906)* and then as *Endothia parasitica (Anderson and Anderson, 1912). M*olecular phylogenetic methods have confirmed the taxonomic classification of *C. parasitica* (Myburg *et al*., 1999).

C. parasitica is a tree pathogen notable for the disease commonly known as chestnut blight, which primarily affects species of sweet chestnut including the American sweet chestnut (*Castanea dentata*) and European sweet chestnut (*C. sativa*). The pathogen has been referred to as the chestnut blight fungus.

2. What is the pest's status in the EC Plant Health Directive (Council Directive 2000/29/EC[1]) and in the lists of EPPO[2]?

Cryphonectria parasitica is listed in Annex II/AII of the EC Plant Health Directive (Council Directive 2000/29/EC). The subject of contamination listed is plants of *Castanea* and *Quercus* intended for planting, other than seed meaning that *Castanea* species are included in the EU Plant Passporting Scheme. *C. parasitica* is also listed in Annex IIB of 2000/29/EC with additional requirements for the movement of wood and bark of *Castanea* into and within Protected Zones which includes the UK (excluding the Isle of Man) (the Czech Republic, Ireland and Sweden are also Protected Zones). There are no Protected Zone requirements for plants for planting. At the beginning of 2013 UK national measures were introduced requiring prior notification of the movement of plants for planting of *Castanea* and *Quercus* into the UK from other EU member states through an amendment of the Plant Health (England) Order 2005(http://www.fera.defra.gov.uk/plants/plantHealth/).

C. parasitica is also on the EPPO A2 list

3. What is the reason for the rapid assessment?

Since November 2011 there have been a number of findings of *Cryphonectria parasitica* in the UK. It was first observed in sweet chestnut orchards in Warwickshire (confirmed 2011) and East Sussex (confirmed 2012), with (as of 16th April 2013) further confirmed findings at 1 nursery and 7 private residences. A risk assessment has been requested to help inform decisions on possible further strengthening of the Protected Zone requirements.

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[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000L0029:20100113:EN:PDF

[2] http://archives.eppo.int/EPPOStandards/PM1_GENERAL/pm1-02(21)_A1A2_2012.pdf

STAGE 2: RISK ASSESSMENT

4. What is the pest's present geographical distribution?

C. parasitica is native to eastern Asia and was introduced into North America over 100 years ago. It is recorded as present in:

Asia: Azerbaijan; China; Georgia (Republic of); India; Iran; Japan; Korea (Democratic People's Republic); Korea (Republic); Taiwan; Turkey (CABI CPC and EPPO PQR).

Africa: Tunisia (CABI CPC and EPPO PQR).

North America: Canada (British Columbia, Ontario); USA (Arkansas, California, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Tennessee, Texas, Virginia, Washington, West Virginia, Wisconsin) (CABI CPC and EPPO PQR).

Europe: Albania; Austria; Belgium; Bosnia-Herzegovina; Croatia; France; Germany; Greece; Hungary; Italy; Macedonia; Poland; Portugal; Romania; Russia (restricted: Black Sea coast and Caucasus); Serbia; Slovakia; Slovenia; Spain; Switzerland; Ukraine (CABI CPC, EPPO PQR).

Details of the first observations of chestnut blight in Europe can be found in Robin & Heiniger (2001).

The NPPO of the Czech Republic officially declared the eradication of *C. parasitica* in 2011 (EPPO PQR). The Netherlands report the pathogen as transient, under eradication (EPPO PQR). The UK status is present, under eradication.

5. Is the pest established or transient, or suspected to be established/transient in the UK?

The UK (including the Channel Islands, but not the Isle of Man) has Protected Zone status for *C. parasitica*. To maintain this status, and controls on movements of wood and bark, the UK is obliged to carry out annual surveys to demonstrate continued freedom from this disease. The surveys are conducted in sweet chestnut plantations in England and Wales (there are no commercial plantations of chestnut known in Scotland) and are mainly visual, but if the disease is suspected samples are taken. Surveys have been conducted annually since 2006 (Forest Research, 2006), with 17 permanent study plots consisting of 24 trees being surveyed. None of the trees in these study plots have shown any signs of *C. parasitica* (United Kingdom Protected Zone Surveys for Forestry Pests, 2012).

In November 2011, approximately 90 *C. sativa* (sweet chestnut) trees were found showing symptoms of *C. parasitica* on a farm in Warwickshire. This was confirmed as the first finding of this pathogen in the UK. The trees were planted at two sites on the farm. Eighty of the trees were found at the main site and had been planted in 2007 from stock imported from a French nursery. The remainder of the trees had been planted more recently and had been sourced from a UK nursery in Devon. This UK nursery had sourced their stock from the same French nursery that had supplied the farm in Warwickshire. All the stock at the UK nursery had been sold. The map below (Figure 1) shows the distribution of sites to which this stock had been sent.

Subsequent trace back through sales records of both the French nursery and the UK supplier by the Plant Health and Seed Inspectorate (PHSI) and the Forestry Commission (FC) has led to the identification of (as of April 2013) nine further sites where infected trees

have been found. Forestry Commission focussed on the distribution of consignments of more than 10 trees, leading to the finding of over 30 infected trees on a farm in East Sussex and 2 infected trees at a private residence in Herefordshire. Additionally the PHSI have, to date, traced infected trees to 7 private residences and one additional nursery, primarily in the southwest of England. In each case statutory action to eradicate *C. parasitica* has been taken, with the destruction of trees, surveys of the surrounding areas and further trace back in relation to the additional nursery. The vast majority of the trees supplied by the French nursery were sold mail order by several distributors and customer lists for deliveries prior to 2011 are difficult to obtain. To date 7 of the 13 2008/9 deliveries have been traced, 8 of the 9 2009/10 deliveries and 24 of the 40 2010/11 deliveries.

A table detailing all the UK findings and action taken up to April 2013 can be found in the Appendix.

There has additionally been suspicion of infection at a site in Cornwall, however results could not be confirmed from the samples. Further visits to this site are planned.

Following the first findings in the UK associated with imported trees from France, *Castanea* trees were held on entry. No disease symptoms were detected, and the plants were released for planting (PHSI pers. comm. and United Kingdom Protected Zone Surveys for Forestry Pests, 2012). In the last 12 months (as of April 2013) the PHSI have made 101 visits to 95 nursery and retail sites, making 170 inspections on *Castanea spp*., which includes plant passport inspections.

C. parasitica is currently present in the UK and under eradication (Fera, 2012).

Figure 1: Map showing the distribution of sweet chestnut trees following sale from the UK nursery. Courtesy of Forestry Commission.

6. What are the pest's natural and experimental host plants; of these, which are of economic and/or environmental importance in the UK?

A review of the host range of *C. parasitica* (CABI Crop Protection Compendium, 2013), identified species of *Castanea* and *Quercus* as the most important susceptible taxa.

The American chestnut (*C. dentata*) population comprising millions of trees has been nearly eradicated in central and eastern USA by *C. parasitica*, destroying what was previously a major component of hardwood trees in the region (Anagnostakis, 1987). When infecting the American chestnut, *C. parasitica* readily causes necrosis that girdles the trunk or major branches which leads to high mortality. Since roots are not affected some trees may survive as sprouted stumps though these eventually die back to the ground (Parker *et al.*, 1993). Other North American sweet chestnut species are also affected: *C. pumila*, *C. alnifolia*, *C. ashei*, *C. floridana*, *C. paupispina*.

Since *C. parasitica* was first reported in Europe in Italy in 1938 (Biraghi, 1946), the pathogen has produced significant disease, including mortality, in *C. sativa* (European chestnut) orchards and plantations throughout many regions of Europe. In Italy for example a survey of 30 sweet chestnut stands found severe disease and high mortality (Turchetti *et al.,* 1991). A more detailed account of the extent of the epidemic in Europe is provided in the impacts section of this PRA. The presence of a virus which can infect strains of *C. parasitica,* has been shown to reduce disease and promote canker healing (Robin and Heiniger, 2001). Reduced *C. parasitica* host virulence associated with the virus (termed hypovirulence), and the use of *C. parasitica* strains containing the virus as a potential means of disease control is considered in the impacts section of this PRA. *C. sativa* is, therefore, considered to be susceptible to *C. parasitica*, but less so than *C. dentata*.

Other non-European *Castanea* species referred to in CABI (2013) were reported to have a range of disease susceptibilities to *C. parasitica*. The Asian species of *Castanea*, including the Chinese chestnut, *C. mollissima*, the Japanese chestnut (*C. crenata*), Père David's chestnut (*C. davidii)*, Henry's chestnut (*C. henryi*) and Seguin's chestnut (*C. seguinii*) are all much less susceptible to the pathogen than the European or American sweet chestnuts, but none of these species is immune, despite having co-evolved with the pathogen.

Infection of Durmast or sessile oak (*Q. petraea*) by *C. parasitica* has been reported in Hungary, where mortality associated with the pathogen of up to 5.76% was recorded (Ilona *et al*., 2009). A Slovakian survey between 2003 and 2008 of seven localities which comprised mixed chestnut/oak trees detected cankers (which were less conspicuous than those affecting sweet chestnut) in up to 15.8% of *Q. petraea* and *Q. robur* trees (Adamcikova *et al*., 2010). *C. parasitica* has also been reported on *Q. petraea* in Switzerland (Bissegger and Heiniger, 1991). In Italy the pathogen has been noted on *Ostrya carpinifolia*, *Q. ilex*, *Q. pubescens* and *Alnus cordata* as well as *C. sativa*, however, only *C. sativa* trees were badly damaged (Turchetti *et al*., 1991). The paucity of reports of diseased oaks from Europe which were not associated with infected *C. sativa* suggests that European oak species are mainly incidental hosts. *Q. virginiana* and *Q. stellata* are the only oaks in North America to be seriously affected (CABI CPC, 2013).

Castanopsis spp., also a member of the family Fagaceae, is known to be a host, but the disease is much less severe than on chestnut.

As well as *O. carpinifolia*, and *A. cordata* reported hosts from other families include hickory (*Carya ovata*), maple (*Acer*) spp. and *Rhus typhina*, although on these species, only small, superficial cankers are formed, and the damage is not serious.

In the UK, the only known host on which the pathogen is likely to cause a major disease and damage is *C. sativa*. The distribution of *C. sativa* in the UK is shown in Figure 2, and no other *Castanea* species are recorded by the Botanical Society of the British Isles (BSBI). *C. sativa* is a major constituent of coppiced woodland in SE England and is also commonly found in hedgerows, wood-borders, parklands, gardens and amenity areas (Preston *et al*., 2002).

Castanea are sold by many nurseries in the UK, but again this is mostly *C. sativa*. RHS Plant Finder (http://apps.rhs.org.uk/rhsplantfinder/) records only a couple of nurseries which are supplying *C. dentata* and *C. crenata*, with *C. seguinii*, *C. henryi* and *C. pumila* entered as not having been supplied for several years.

The Forestry Commission (2012) reports that in Great Britain there are 28,200 ha of sweet chestnut in woodlands over 0.5 ha in size, a standing volume of 7,629,000 m^3 (3% of broadleaved trees) and 44.2 million trees.

Any chestnuts for human production in the UK are produced on too small a scale to register in international databases (Conedera *et al*., 2004; EFSA, 2010) and, as in France north of the river Loire, chestnut is only cultivated for timber and as a coppice tree (Cécile Robin, personal communication 15th April 2013).

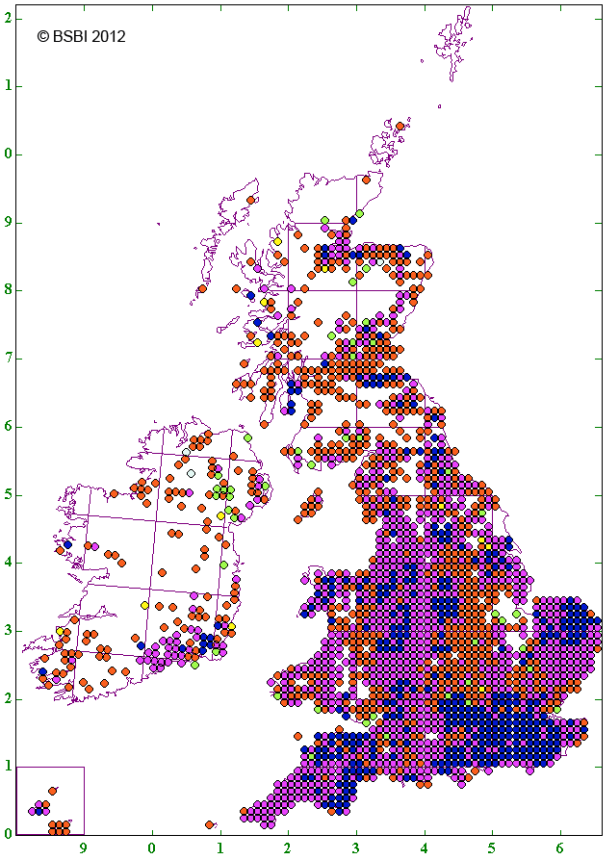

Figure 2. Distribution of *Castanea sativa* in Britain and Ireland. Source: http://www.bsbimaps.org.uk/atlas/

7. If the pest needs a vector, is it present in the UK?

No vector is required for this pathogen. However, conidiospores can be carried by insects, birds and mammals. See section 10.

8. What are the pathways on which the pest is likely to move and how likely is the pest to enter the UK? (*By pathway*):

Pathway 1: Host plants for planting, other than seed.

Evidence relating to the source of the UK findings indicates that this is a major pathway for introduction (rated very likely), with low uncertainty (see section 5).

Plants for planting of *Castanea* and *Quercus* moving within the EU need to meet the requirements set out in Annex IVAII of Council Directive 2000/29/EC. This states that plants for planting of *Castanea* and *Quercus*, other than seed, must be accompanied by an official statement that the plants either originate in areas known to be free from *C. parasitica* or that no symptoms of *C. parasitica* have been observed at the place of production or in its immediate vicinity since the beginning of the last complete cycle of vegetation. The UK also has a Protected Zone for *Cryphonectria parasitica*, however this applies only to the imports of wood and bark of *Castanea* and does not involve any further restrictions on the movement of plants for planting.

All symptoms on infected trees occur above ground. *C. parasitica* enters the host through fissures or wounds and grows in the cambium. The fungus can spread rapidly in infected bark, causing cankers that may eventually girdle the stem or branch. Branch points and graft sites are common sites of entry. The cambium under the infected bark is killed and the bark appears sunken or swollen. Above the girdling canker, leaves wilt and turn brown, while branches below may have healthy foliage. There may be several cankers on a single tree. When the bark is killed rapidly the stem is girdled without any callus formation, however the disease progress can be slower, with new layers of bark forming under affected areas, and swelling and subsequent cracking of the outer bark. Masses of yellow-orange to reddish-brown pustules, the size of a pin-head, develop on infected bark. These fruit bodies erupt through lenticels with long orange-yellow tendrils of spores developing in moist weather. Also characteristic is the formation of pale-brown mycelial fans in the inner bark, which can be seen if the outer bark is cut away (Forestry Commission, 2013).

However, there is evidence that there is likely to be a latent period between the time of infection and the emergence of symptoms on *Castanea*. Reports from France suggest that this may be up to six months (Guerin *et al*., 2000), while Cunnington & Pascoe (2003) using data from Australian post entry quarantine suggest it may take even longer for infection to be positively identified. They report that a consignment of *Castanea* plants arrived in Australia from France in March 1999. In August 2000 orange discoloration was observed on the stems, but no fungus material could be isolated. AQIS guidelines require chestnut nursery material be kept in post entry quarantine for a minimum of two years. The plants were due to be released from quarantine in April 2001 when more pronounced symptoms were observed and they were sampled again, this time with the identification of *C. parasitica*.

As well as the evidence of *C. parasitica* on UK and Australian imports of *Castanea*, there is also a report of the pathogen being found on *C. sativa* plants for planting entering Ireland, again originating in France (EPPO, 2010; Europhyt notification records).

Most plants for planting of *Castanea* and *Quercus* would be shipped bare-rooted in the dormant period, from October to March, when recent infections would not show diagnostic symptoms. Some containerised plants may be shipped during the spring and summer. The likelihood is, therefore that asymptomatic plants for planting could enter the UK and, even if inspected or sampled and tested on entry, the disease may not be picked up.

The numbers of potential host trees entering the UK are substantial. Since notification of imports was brought in at the beginning of 2013 there have (up to mid-April 2013) been 44 notifications by 26 nurseries, consisting of 18,367 *Castanea* plants for planting. Over the

same period there were notifications of the imports of 136,000 *Quercus* (PHSI notification data). Additionally, over a ten year period between 2002 and 2012, 35 *Castanea* consignments consisting of 102,480 trees were imported into the UK for forestry purposes (Forest Reproductive Material database). However, neither of these datasets covers trees which may have been brought in directly by individuals, for landscaping for roads and railways or urban industrial and domestic landscaping.

	Very unlikely	Unlikely	Moderately likely	Likely	Very likely
Plants for planting:	☐	☐	☐	☐	☑

Pathway 2 - Natural dispersal.

The rating for this pathway is given as unlikely, with moderate uncertainty.

Natural dispersal locally from an infected source is well documented for this and other similar pathogens. Ascospores (the sexual stage) are windborne (Heald and Studhalter 1915), while conidia (the asexual stage) ooze out of fruiting bodies and can be carried in water droplets or on the bodies of insects, birds and mammals (Craighead 1912; Studhalter 1914; Studhalter & Ruggles 1915; Sharf & DePalma, 1981; Smith, 2012). It is therefore only the ascospores that are likely to play a role in allowing the pathogen to enter the UK by long distance natural movement. However, this is difficult to assess because to date there is no published scientific evidence that long distance movement by this pathogen has occurred within mainland Europe or into the UK.

It is possible that the relatively slow spread of this pathogen in Europe may be related to a low likelihood of windborne spread. *C. parasitica* was reported for the first time in Europe in 1938, in Italy, although there is a suggestion it may have been introduced earlier and remained unnoticed (Guérin & Robin, 2003). It has since spread widely in Europe (see section 5), but not rapidly. It was first reported in France in the 1950s. In France the distribution of infected forest sites between 1989 and 2012 has been surveyed and mapped. The maps show the progression of the pathogen, especially in forests of northern France in the ten years between 1997 and 2006 (DSF-MAAF, 2013). The slow spread could be due to slow natural dispersal, although climate may also have an influence (Desprez-Loustau *et al*. 2007), with the changes over the last 20 years contributing to the establishment of the pathogen further north.

Although the hosts are widespread in mainland Europe, apart from in chestnut plantations, the trees generally grow at low density in the regions close to the UK (Conedera *et al*., 2004). This will limit the concentration of ascospores that are produced and could travel along the pathway at any one time.

	Very unlikely	Unlikely	Moderately likely	Likely	Very likely
Natural dispersal:	☐	☑	☐	☐	☐

Pathway 3 - Tree seed external contamination.

This pathway is rated as unlikely to moderately likely. Both boxes are ticked to show that there is moderate uncertainty.

There do not appear to be any recent references to the infection of nuts of *Castanea* (i.e. seeds) by *C. parasitica*. However, fruit (i.e. nuts plus the husk) of European and American chestnut have been found naturally infected by *C. parasitica* (Collins 1913; 1915; Gravatt *et al*. 1935; Jaynes & DePalma, 1984). The article by Jaynes and DePalma documents that an average of 14% of the nuts harvested from a planting of *C. dentata* with chestnut blight were infected. The infections were confined to the husk and shell of the seed and no effect on

seed germination or growth was noted. However, fruiting bodies were commonly produced. A New Zealand Risk Management proposal (2011) postulated that the infection could move on the outside of the seed, on the pericarps as the plumule develops into a shoot (MAF, 2011). The risk is that in moist conditions sporulation of the fungus present on the surface of the seed could occur and the new seedling or other nearby trees would become infected through wounds. The importation of host tree seed from an area where *C. parasitica* is present could, therefore, be a means of introducing the chestnut blight fungus.

	Very unlikely		Unlikely	✓	Moderately likely	✓	Likely		Very likely	
Tree seed external contamination:										

Pathway 4 – Wood and bark.

The pathway for this is rated as unlikely to moderately likely. Both boxes are ticked to show that there is moderate uncertainty.

The UK (except the Isle of Man) has a Protected Zone status for *Cryphonectria parasitica* and this requires that if **wood of *Castanea*** is imported from areas where the disease occurs, it must be de-barked or the timber have undergone kiln-drying to specified standards. These requirements should be sufficient to prevent entry to the rest of the UK by this pathway, provided 'in-transit' arrangements of any material to the Isle of Man are observed.

Similarly for **isolated bark of *Castanea*,** this must originate in areas known to be free from *Cryphonectria parasitica* or subjected to fumigation or other appropriate treatment to a specification laid down by the Article 18.2 procedure in 2000/29/EC, i.e. by the Standing Committee for Plant Health. It appears no treatments have been approved by this committee under this procedure in the past (*J Morgan pers comm*).

However, there is nothing in the legislation regarding wood of other potential hosts of *C. parasitica*.

It is believed that logs of *Castanea* carrying infected bark were the source for the introductions of *C. parasitica* into North America in approx. 1900 and into Europe in approx. 1938 (Anagnostakis, 1987). Hepting (1974) suggested that mycelium of *C. parasitica* survived in dried bark for up to 10 months.

	Very unlikely		Unlikely	✓	Moderately likely	✓	Likely		Very likely	
Wood and bark:										

Pathway 5 – Chestnuts for human and animal consumption.

This pathway is rated as very unlikely, medium level of uncertainty.

The primarycommodity for this pathway is seed of *C. sativa* imported from other European countries where the pathogen is established for human consumption. Much of this trade occurs in the late autumn and it is quite likely that spores will be contaminating the fruits during this period. However, chestnuts are primarily sold fresh, without the surrounding husk (Geisler, 2012), which reduces, though does not eliminate the likelihood of contamination. The likelihood of the chestnut seeds themselves carrying and transferring spores to growing trees is very low, even if the chestnuts are deemed inedible and discarded.

Sweet chestnut seed has been recommended for supplementary feeding of UK populations of red squirrel (*Sciurus vulgaris*) (http://jncc.defra.gov.uk/pdf/rs_supfeed_v5.pdf). This

practice may represent an enhanced risk of entry compared to other seed uses, since the red squirrel may inhabit areas with sweet chestnut. There is no data available as to the extent of the use of imported *C. sativa* nuts for feeding to red squirrel. The very low levels of potential infection carried on the surface of dehusked nuts is consistent with a pathway rating of very unlikely, however, considering the difficulty in precisely assessing this risk, the level of uncertainty scored for this pathway is raised to medium.

Pathway title:	Very unlikely	✓	Unlikely		Moderately likely		Likely		Very likely	

Pathway 6 - Foliar plant debris.

This pathway is rated as very unlikely, with moderate uncertainty.

There is a possibility that foliar debris may act as a vector for *Cryphonectria parasitica*, where spores are attached to leaf surfaces. The potential distance for spread via this pathway is unknown, but unlikely to be far. It is possible this may contribute to local spread.

Pathway title:	Very unlikely	✓	Unlikely		Moderately likely		Likely		Very likely	

9. How likely is the pest to establish outdoors or under protection in the UK?

C. parasitica infections have been detected on outdoor-grown *C. sativa* at a number of locations around the UK (see Appendix). These trees all originate from a nursery in France, either bought directly from this nursery or through a UK nursery which imported the plant material. To date no symptoms have been found on trees already growing in the UK, but, from the data gathered by the Forestry Commission and the PHSI, most of the infected plant material had been planted in either small numbers or in an area where there was little host material. The site in East Sussex is the exception and monitoring of the area is planned.

The pathogen is present in Canada, Belgium and Northern France and is no evidence to suggest that this pathogen could not establish in the wider environment in the UK given the opportunity (see section 11 for the endangered area).

The potential hosts of this pathogen are very unlikely to be grown under protection, and on this basis establishment indoors is rated as very unlikely, low uncertainty.

	Very unlikely		Unlikely		Moderately likely		Likely		Very likely	
Outdoors:										✓
Under protection:		✓								

10. How quickly could the pest spread in the UK?

Natural dispersal locally from an infected source is well documented for this and other similar pathogens. Ascospores (the sexual stage) are wind borne (Heald and Studhalter 1915), while conidia (the asexual stage) ooze out of fruiting bodies and can be carried in water droplets or on the bodies of insects, birds and mammals (Craighead 1912; Studhalter 1914; Studhalter & Ruggles 1915; Smith, 2012). Ascospores, despite being far more common than conidiospores in the air, were rarely found on insects. In North America, several insect species that wound bark tissues may vector the pathogen, including *Strophiona nitens* and *Ectoedema phleophaga*. Folivorous species such as *Leptostylus maculata* also carry

conidia. Compared with insects, the roles of birds and arboreal mammals in dissemination is less clear, although conidia are known to attach to both groups of animals from sporulating cankers (Heald & Studhalter 1914; Scharf & DePalma 1981). Insects in the UK with similar life cycles may vector the pathogen, including the bark beetles and borers *Taphrorychus villifrons*, *Scolytus intricatus*, *Platypus cylindrus* and *Agrilus biguttatus*.

There is a high risk of spread of *C. parasitica* inoculum between trees through the use of pruning tools that were not disinfected between individual trees. However, this method is likely to lead to only very localized spread.

In the USA the spread of *C. parasitica* was documented as proceeding at the rate of 37 km per year once the pathogen moved out of New York State, so that within 50 years about 3.6 million hectares of *C. dentata* were dead or dying (Anagnostakis, 1987). A similar rate of spread occurred in Italy in the 1940s.

C. parasitica was first reported in France in 1956, on *C. sativa* in the southeast (Rhone valley), although it was probably introduced earlier, and shortly after in the southwest (Basque country). It is still spreading northwards (Desprez-Loustau *et al*., 2007). French surveys of *Castanea* in forest stands in 1996-97 detected only three sites of infection in northern France. Over the last 15 years there has been an extension of the disease in the north of France, and, although occurrences of mortality are uncommon north of the river Loire, locally severely affected stands have been observed (Dominique Piou, Ministère de l'agriculture, France; *pers comm*).

Spread in the UK, is, therefore, highly likely. In trade spread to disparate locations around the UK is likely to be rapid, with the risk then being natural spread into the wider environment.

	Very slowly	Slowly	Moderate pace	Quickly	Very quickly
Natural spread:			✓		
In trade:				✓	

11. What is the area endangered by the pest?
Based on published information on the impacts of environment on disease development (e.g. Anagnostakis & Aylor 1984), all areas of the UK where sweet chestnut is grown are potentially suitable for infections to occur and canker to develop, however the concentration of hosts does decrease further north and is not known if there may be a northern limit on its spread.

A report by English Nature (2009) gives the following summary on *C. sativa*:
"Sweet chestnut - *Castanea sativa* was probably introduced into Britain over two millennia ago, since when its range has expanded steadily across southern England as a result of increasing domestication and naturalization. Initially valued for its nuts and timber properties, planting of pure chestnut stands for coppice accelerated sharply in the nineteenth century, in response to strong hop-growing and fencing markets. These plantations were often located on sites of semi-natural, broadleaved woodlands that were comprehensively cleared of competing woody species."
(http://www.swog.org.uk/wp-content/uploads/2009/03/627.pdf).

Many additional trees are located throughout the UK in large gardens and in parks in both urban and rural areas. Apart from *C. sativa*, other species of *Castanea* and *Castanopsis* are grown in arboreta, botanic gardens and parks.

Any chestnuts for human production in the UK are produced on too small a scale to register in international databases (Conedera *et al*., 2004; EFSA, 2010) and, as in France north of

the river Loire, chestnut is only cultivated for timber and as a coppice tree (Cécile Robin, personal communication 15th April 2013). However in recent years there does seem to have been a resurgence in interest in nut growing (PHSI, pers comm.) which may have led to an increase in imports of plant for planting for nut production.

Desprez-Loustau *et al*. (2007) investigated the potential distribution of *C. parasitica* with climate change based on a French survey in 1996-7 and a CLIMEX model. In this rapid PRA, we have had insufficient time to study this in detail. However, the paper suggests that the northwards spread of this species in France may be related to climate change because "*C. parasitica* occurrence is favoured by increased spring precipitation and warmer and drier summer climate." Although *C. parasitica* symtoms are known to be influenced by water stress (Gao and Shain., 1995) and temperature (Guérin *et al*., 2001), the extent to which this will limit its establishment and minimise impacts in the UK is unclear.

12. What is the pest's economic, environmental or social impact within its existing distribution?

C. parasitica attacks bark tissues producing cankers that can develop as sunken regions due to tissue collapse; damage to vascular tissues produces wilts and die backs distal to the canker. (Hebard *et al*., 1984). Ultimately chronic infections can girdle major branches or the trunk which can kill the tree. Although *C. parasitica* infections in *C. sativa* can be severe, the extreme scale of destruction of *C. dendata* in N. America has not been repeated in *C. sativa* in Europe.

C. parasitica can be infected with a double-stranded RNA virus known as (CHV-1) C*ryphonectria hypovirus* 1 (Hillman and Suzuki, 2004). Members of the hypoviridae (Nuss, 2005) induce changes to fungal physiology that lead to reduced fungal pathogenicity known as hypovirulence (Heiniger and Rigling, 1994; Hillman and Suzuki 2004.). CHV-1 is unusual in that its transmission to new hosts is mediated through hyphal fusion (anastomosis) between the infected hyphae and hyphae of the new host. The ability of two *C. parasitica* strains to fuse hyphae is dependent on the vegetative compatibility (vc) characteristics of the strains. Many vc types have been identified from European *C. parasitica populations* (Allemann *et al*., 1999). Successful transmission of the virus to a new host is therefore dependent upon the vc status of the infected strain and potential new host. The presence of CHV-1 in *C. parasitica* is associated with healing cankers and reduction in disease symptoms (Heiniger and Rigling, 1994). CHV-1 is most frequently isolated from areas where *C. parasitica* infection has been established over a long period (Bryner *et al*., 2012), and the virus is thought to have moderated the effects of the chestnut blight in the region (Zoinia, 1987). CHV-1 has been used successfully in Europe as a biocontrol agent (Soylu and Mert, 2009).

In the eastern USA the impact of the disease on the *C. dentata* population has been devastating, reducing the species in its natural range from what was once a major component of the hardwood canopy to dying sprouted stumps (Parker *et al.*, 1993). Although *C. dentata* was the cornerstone tree species of the region and made up to 25% of eastern USA forest the ecological impact of the loss of the species has been poorly recorded. Seven species of moth which depended on *C. dentata* became extinct (Orwig, 2002; Opler, 1978). The American chestnut tree has been replaced in forests by hickory (*Carya glabra*) and species of oak (McCormick and Platt 1980).

The American chestnut is a tall tree which can grow to large proportions and the loss of these great trees had a profound impact on the composition, nature and visual amenity of woodland in the region. Intrinsically, the near extinction of a species in its natural range comprising of billions of trees is a significant environmental loss which has caused great concern and a sense of loss by members of the public. Anxiety is made more acute by the threat posed by other pests and diseases to other tree species, eg the American elm (*Ulmus americanum*), which contribute to environmental quality and natural diversity of this region.

Since the first report of chestnut blight in Italy in 1938 (Biraghi, 1946) the disease has spread widely in sweet chestnut growing areas of Europe. *C. parasitica* infection rates of 67-99% have been reported in Italy (Amorini *et al*., 2001), which compares with 17-65% for Portugal (Braganca *et al*., 2009). In Portugal a survey of 185 sites revealed the disease had become widespread by 2005 (Braganca *et al*. 2005).

The first report of chestnut blight in Spain dates back to 1947 (Elorrietta Artaza 1949). The El Bierzo region is found in north western Spain, an area which produces 8000 tonnes of nuts per year. Recently, a large study of chestnut blight has been completed from the El Bierzo region (Tizado *et al*., 2012), *C. parasitica* strains from this region were reported to have a low incidence of hypovirulence (3% of infected trees). This extensive study used a detailed methodology for recording the extent of disease symptoms in 7240 trees located in 452 plots, which found that 90.7% of plots contained diseased trees with an estimated disease incidence of 78.5%. Mean mortality recorded as dead trees with symptoms of chestnut blight was 5.12% and 15.48% of plots were severely damaged. This study also concluded that the most important means of *C. parasitica* disease transmission in the El Bierzo region was mediated through graft and pruning injuries as a consequence of crop management. This study found that most infections (82.2%) were centred on the crown rather than the main stem, which was attributed to the use of management techniques involving pruning and grafting to lower branches.

In Germany the disease has been monitored since it was first reported in 1992. Between 2003 and 2010 the area containing infected sweet chestnut in the Rhine valley had increased 6-fold from 0.5% to 3%. In south-western Germany there is an increasing utilisation of *C. sativa* for high grade timber (Mettendorph, 2007). Peters *et al*. (2012) consider that the hot dry summer of 2003 could explain the rapid spread of the disease and the increase in symptom expression. In Slovakia chestnut blight was first reported in 1976 and, by 1998, had spread to 77 stands at 20 sites (Juhasova *et al*., 1999). In Slovenia chestnut blight was first reported in 1950 and, despite intensive disease management action, the disease spread and control measures were halted in 1969 (Jurc, 2002).

In France, it is considered that *C. parasitica* has now infected almost all areas where chestnut is present in France. There has been a very significant movement northwards and eastwards in the last 15 years. In northern France, mortality is still relatively rare but some plantations in NW France now have no commercial value (Dominique Piou, personal communication 15th April 2013).

In Belgium, although the disease is reported to be present (Belgium NPPO 2007, reported in EPPO PQR), no surveys have been carried out and neither the Plant Clinic at Walloon Agricultural Research Centre or the Institute for Agricultural and Fisheries Research in Flanders have ever received any samples infected with *Cryphonectria parasitica*, suggesting that the disease is not common (*pers. comm.* Anne Chandelier and Kurt Heungens, 2013).
This has been backed up by a researcher from the Flemish Research Institute for Nature and Forest (INBO), who, despite contacting other Flemish fungal experts, is unaware of any records of *C. parasitica* in the northern region of Belgium (*pers. comm*. Peter Roskams).

USA

Very small	Small	Medium	Large	Very large
☐	☐	☐	☐	☑

Europe

Very small	Small	Medium	Large	Very large
☐	☐	☑	☑	☐

13. What is the pest's potential to cause economic, environmental or social impacts in the UK?

Should the pathogen become established, economic impacts will be mainly to the chestnut timber industry (primarily coppice for fencing) and ornamental tree nurseries since there is no significant commercial nut production. Environmental impacts include reductions in food resource and habitat for associated organisms. Sweet chestnut is a dominant component of landscapes in the areas where large numbers of trees have been planted for coppicing, particularly Kent and Sussex, and their loss would cause considerable changes to the landscape. As a specimen tree, sweet chestnut is a long lived species which often reaches a large size. The tree is widely planted for aesthetic reasons in arboreta, parks and gardens where it is highly valued by the public who may also forage for the nuts in the autumn. The loss of these trees would have a social impact as it would reduce the environmental enjoyment of these areas by the public.

Sweet chestnut is a suitable broad-leaved substitute for ash on certain non-calcareous sites in lowland England and Wales. After oak and ash, sweet chestnut has been the next most common species planted on woodland creation schemes in England over the last 7 years. Although only 4% this could rise to around 10-20% as people seek to fill the void left by ash (*pers. comm.* John Morgan and Andrew Smith, 2013).

In mainland Europe, attenuation of the disease, when the hypovirus attacks the pathogen, has led to a decrease in damage (see section 12) over a period of time (10-20 years in central and southern France (Robin & Heiniger, 2001)). Although the situation is complex, chestnut blight is largely under control and tree mortality is often uncommon in Europe because of hypovirulence. The potential use of the hypovirus in the UK as a biocontrol strategy requires consideration. It is not clear whether the virus is currently present in the UK. Artificial introductions will require permissions from ACRE (the Advisory Committe on Releases to the Environment Committee). However, the more vegetative compatibility groups of the fungus there are (i.e. more tissue types), the more difficult it is for the virus to spread through the *C. parasitica* population, and more interventions may be needed to release the virus in different host genotypes.

Since it is very difficult to predict the short and long term role that hypovirulence will play if the pathogen became established in the UK, any choice of risk rating must be accompanied by considerable uncertainty. We have therefore rated impacts of the disease as medium-large with the expectation that in the early stages of any epidemic, impacts will be large.

Very small	Small	Medium	Large	Very large
☐	☐	☑	☑	☐

14. What is the pest's potential as a vector of plant pathogens?

C. parasitica is not known to vector other plant pathogens.

STAGE 3: PEST RISK MANAGEMENT

15. What are the risk management options for the UK? *(Consider exclusion, eradication, containment, and non-statutory controls; under protection and/or outdoors).*

Exclusion

Plants for planting requirements set out in Annex IVAI and IVAII of 2000/29/EC specify that plants of *Castanea* and *Quercus* intended for planting should originate in areas known to be free of *Cryphonectria parasitica* or that no symptoms should have been seen at the place of production or in its immediate vicinity since the beginning of the last complete cycle of vegetation (EC 2000).

There is evidence of *C. parasitica* having a long latency period on plants of *Castanea*. In post entry quarantine in Australia plants have been noted with symptoms which were still undiagnosable 16 months after import (Cunnington & Pascoe, 2003), and it can survive for at least 10 months in infected dried bark (Hepting, 1974). This evidence suggests that the current requirement that plants have been obtained from a place of production where the disease has not occurred either on the place of production or its immediate vicinity in the last complete cycle of vegetation may not be sufficiently rigorous. It is possible that newly introduced non-symptomatic infections could be present and the recent outbreaks in the UK in young planted trees introduced from the EU some years ago tends to support this..

It is considered that the risk of introduction from importation of seed is unlikely to moderately likely (section 8), as external contamination of seed by spores has been documented (Jaynes & DePalma, 1984) and it is possible that the infection could move on the outside of the seed on the pericarps as the plumule develops into a shoot (MAF, 2011). Therefore there may be a risk associated with imported seeds, however the current requirements for plants for planting in Annex IVAII exclude seeds. Although introduction of seed to the UK from other EU Member States is not substantial (J Morgan *pers. comm.*) it would be considered appropriate to extend requirements to include seeds, as plants for planting, in any proposed changes to the legislation.

To mitigate the risk associated with plants for planting the addition of protected zone requirements for plants for planting including seeds of *Castanea* is proposed. This could be achieved by the addition of requirements in Annex IVB of Directive 2000/29 which would require that plants for planting of *Castanea* entering the UK (including the Isle of Man) should originate in either an area known to be free for *C. parasitica* or one of the existing protected zones. The level of risk posed by other host plants in more uncertain, but restrictions on other host plants for planting, particularly *Quercus*, could also be considered.

In theory post entry quarantine could be used to allow the import of plants for planting from infested area. However plants would need to be maintained in quarantine for a minimum of two years, in order for any latent infections to be detected. Plants would need to be maintained inside enclosed glasshouses or growth chambers to prevent possible escape of the pathogen. This would be expensive, regular inspections would be required and contained conditions may not be conducive to symptom development. Therefore this option is not being proposed.

The UK (except the Isle of Man) has Protected Zone status for *Cryphonectria parasitica* with requirements in Annex IVB of 2000/29/EU that if **wood of *Castanea*** is imported from areas where the disease occurs, it must be de-barked or the timber have undergone kiln-drying to specified standards. These requirements should be sufficient to prevent entry into the UK. However as *Cryphonectria parasitica* has not been recorded in the Isle of Man it is proposed that the Isle of Man is included in the protected zone for the UK in future.

Similarly for **isolated bark of *Castanea***, this must originate in areas known to be free from *Cryphonectria parasitica* or subjected to fumigation or other appropriate treatment to a specification laid down by the Article 18.2 procedure in 2000/29/EC, i.e. by the Standing Committee for Plant Health. It appears no treatments have been approved by this committee under this procedure in the past (*J Morgan pers comm*).

Wood and bark of other potential host trees are not specified in the existing protected zone requirements. The level of risk posed by these is very uncertain, but restrictions on the movement of wood and bark of other hosts, particularly *Quercus*, could also be considered.

Chestnut fruit for human and animal consumption is considered unlikely as a pathway for entry of *C. parasitica* into the UK. There may be some risk associated with the surrounding soft 'husk' tissue but as trade in the nuts without the fleshy husk is the normal way chestnuts for consumption are traded the risk of transfer from chestnuts for consumption to growing trees is considered very unlikely, even if the nuts are being used as feed for red squirrels (section 8) and therefore regulation of this pathway is not considered necessary.

Eradication/Containment

Eradication could be achieved if infection was detected soon after import of the plants via the destruction of infected plants and all other plants from the same lot. There would also need to be a survey of hosts in the surrounding area over a minimum period of 2 years to ensure spread has not occurred prior to the identification of infection. Survey procedures for eradication purposes and the distance around an infected site that would need to be surveyed are currently being devised. It is also recommended that Forestry surveillance of *C. sativa* should be stepped up in the south of the UK, to demonstrate freedom form *C. parasitica*.

Non-Statutory control

Preventative fungicide treatments against infection do not appear to be being used in countries where the disease occurs, though there are some preliminary data indicating that the phosphite-based Agri-Fos fungicide used with the organosilicate surfactant Pentra-Bark in trunk bark wetting applications was effective in controlling advanced chestnut blight caused by the fungus in American chestnut. (Barilovits, 2009). However there is limited data to support this.

In the long term, breeding for resistance may help manage the disease on *Castanea sativa* in Europe and promising selections of canker-resistant hybrid *C. dentata* are undergoing field trials in New York State, USA (Thompson, 2012). The crosses between the American species *Castanea dentata* and the Chinese *C. mollissima* carrying resistance genes from the Chinese parent have shown resistance to the pathogen, whilst maintaining growth characteristics of the American chestnut.

Hypovirulence, the reduction of pathogen virulence as a result of virus infection of the fungus, (see section 12 above), may also contribute to a long term strategy to manage the disease in Europe (Heiniger and Rigling, 1994). However, it is not clear how, if *C. parasitica* did become established in the UK, this 'hypovirus' may also be brought to the UK. There would also need to be research to identify a suitable hypovirus strain and how it could be 'inoculated' into infected trees.

16. Summary and conclusion of rapid assessment.
(Highlight key uncertainties and topics that will require particular emphasis in a detailed PRA) General / overall summary and conclusion and then specific text on each part of assessment...

This evidence presented in this rapid assessment suggests that action is required to ensure the integrity of the UK's Protected Zone

Risk of entry: Six potential pathways have been identified

1. Host plants for planting other than seed is considered very likely, with low uncertainty despite the current legislation. This is due to the possibility of a latent period between the time of infection and emergence of symptoms.
2. Natural dispersal from other countries where establishment is known is considered unlikely, with moderate uncertainty. It is possible that the relatively slow spread of this pathogen in Europe may be related to a low likelihood of windborne spread. Also, although the hosts are widespread, apart from in chestnut plantations, the trees generally grow at low density in mainland Europe close to the UK. This will limit the amount of ascospores that are produced and could travel along the pathway.
3. Tree seed external contamination is considered unlikely to moderately likely with moderate uncertainty, due to the risk that infection on the husk and shell could produce fruiting bodies.
4. Wood and bark is considered unlikely to moderately likely with moderate uncertainty. The UK (with the exception of the Isle of Man) has Protected Zone status for *C. parasitica* on wood and bark of *Castanea*. However, there is nothing in the legislation regarding wood of other potential hosts of *C. parasitica*.
5. Chestnuts for human and animal consumption are considered a very unlikely pathway, with medium uncertainty
6. Foliar plant debris is considered a very unlikely pathway, with moderate uncertainty.

Risk of establishment: Very likely outdoors in the UK, very unlikely under protection. Low level of uncertainty.

Economic impact: Impact of *C. parasitica* in the UK is rated as medium-large with the expectation that in the early stages of any epidemic, impacts will be large. This rating is given high uncertainty due to the difficulties in predicting the short and long term role that hypovirulence will play if the pathogen became established in the UK.

Endangered area: Based on published information on the impacts of environment on disease development, all areas of the UK where sweet chestnut is grown are potentially suitable for infections to occur and canker to develop, however the concentration of hosts does decrease further north and is not known if there may be a northern limit on its spread.

Risk management: To mitigate the risk associated with plants for planting the addition of protected zone requirements for plants for planting including seeds of *Castanea* is proposed. This could be achieved by the addition of requirements in Annex IVB of Directive 2000/29 which would require that plants for planting of *Castanea* entering the UK (including the Isle of Man) should originate in either an area known to be free for *C. parasitica* or one of the existing protected zones. It is also proposed that the current Protected Zone legislation for bark and wood for *Castanea* be extended to include the Isle of Man. Restrictions on the movement of plants for planting, wood and bark of other hosts, particularly *Quercus*, could also be considered.
Eradication could be achieved if infection was detected soon after import of the plants via the destruction of infected plants and all other plants from the same lot. A survey of hosts in the surrounding area over a minimum period of 2 years would also be required, to ensure spread has not occurred prior to the identification of infection. Survey procedures for eradication purposes and the distance around an infected site that would need to be surveyed are currently being devised.

17. Is there a need for a detailed PRA? If yes, select the PRA area (UK or EU) and the PRA scheme (UK or EPPO) to be used. ***(for PH Risk Management Work stream to decide)*** ✓ ***(put tick in box)***

This Rapid Pest Risk Analysis is based on the current available data and literature. There remain uncertainties in the analysis, particularly regarding risks posed by hosts other than *Castanea*, whether there may be a northern limit on the potential spread of this pathogen and the short and long term role which hypovirulence could play in the UK. These uncertainties are, however, unlikely to be addressed by a more detailed PRA at this time.

No	✓

Yes		PRA area: UK or EU		PRA scheme: UK or EPPO	

18. Given the information assembled within the time scale required, is statutory action considered appropriate / justified?

Yes Statutory action	X	No Statutory action	

Statutory action against *Cryphonectria parasitica* is a requirement of the EU Plant Health Directive 2000/29/EC. The pathogen is listed in Annex II/AII of Council Directive 2000/29/EC and is not considered to be present in the UK. Currently the requirements are that plants of *Castanea* and *Quercus*, intended for planting, other than seeds, must be free of *C. parasitica* and originate either from a Pest Free Area, or from a place of production where no symptoms of the organism have been observed, including in the immediate vicinity, since the beginning of the last complete cycle of vegetation. However, evidence regarding the potential for there to be a significant latent period between the time of infection of *Castanea* and the emergence of symptoms suggests that the current requirements are not providing sufficient assurances of freedom when the material originates in a nursery which is not situated in a Pest Free Area. It is therefore recommended that the Protected Zone for the UK should be extended to include *Castanea* plants for planting, including seeds, with the requirement that any plants moving into and within Protected Zones should originate either from a Pest Free Area or a Protected Zone. It is also recommended that the UK Protected Zone should be extended to include the Isle of Man.

Should the pathogen enter the UK, eradication could be achieved if infection was detected soon after import of the plants via the destruction of infected plants and all other plants from the same lot. A survey of hosts in the surrounding area over a minimum period of 2 years would also be required, to ensure spread has not occurred prior to the identification of infection. Survey procedures for eradication purposes and the distance around an infected site that would need to be surveyed are currently being devised by the PHSI and Fera consultants. It is also recommended that Forestry surveillance of *C. sativa* should be stepped up in the south of the UK, to demonstrate freedom form *C. parasitica*.

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Appendix 1

Cryphonectria parasitica: **Information on findings in the UK to April 2013**

No.	Location	Source of trees and when planted?	When was disease confirmed and by whom?	Extent of infection: symptoms, mortality, % affected…	Eradicatory action taken?	When was action completed?	How were infected trees disposed of?	Any potential movement of infected trees / wood from site?	What survey work has been undertaken?	Plans for future survey work?
1	Farm, Warwickshire.	**Source for main site**: Nursery in France. Planted 2007 **Source for more recently planted site**: UK nursery (originally sourced from same French nursery). Planted 2011	Inspection of site Nov / Dec 2011 FR Diagnosis 2011	Data from 21st Dec 2011: 92 trees showing symptoms, 80 in main site and 12 in recently planted site.	Statutory Notice issued for destruction of all host material	31/03/12	On site burning	No	1.5km ground survey – very little host material in vicinity. Tests in a nearby English Woodland Grant Scheme site (10 year old planting) negative.	Monitor
2	Farm, East Sussex.	**Source**: UK nursery (originally sourced from same French nursery). 32 trees planted 2009 and 2010	Samples taken 02 February 2012 following traceforward from UK nursery. FR Diagnosis 2012	Variety of cultivars planted in orchard for nut production. 30% affected with death of <5 trees	Statutory Notice issued for destruction of all host material	31/03/12	On site burning	No	1.5 km ground survey – and inclusion in aerial survey due to large amount of host material in nearby wider environment.	Monitor via aerial surveillance due to large amount of host material.
3	Nursery, Devon.	Source: Nursery in France (same	Sample taken 21/9/2012		Statutory action required. Survey			Yes, via internet	Preliminary site	Revisit proposed

		source as Warwickshire finding).	following traceforward from French nursery. Fera diagnosis 19/11/2012		of susceptible hosts in vicinity to be conducted			sales. All supplier paperwork to be supplied to PHSI for further traceback	inspection carried out in November	for 2013 when surrounding area plants are in early leaf.

Additionally, findings have been made by traceforward of sales at 7 private residences in the UK, involving 16 trees. In each case Statutory action for destruction of all trees from the same lot has been required, with an assessment of the immediate site to see if other host trees are present and if wider surveillance is warranted.