Department for Environment Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for:

Candidatus Phytoplasma fragariae

September 2015

Summary and conclusions of the rapid PRA

Ca. Phytoplasma fragariae is a poorly understood plant pathogen whose full distribution and host range are unlikely to have been elucidated. It has been associated with moribund hazel (*Corylus*) at an outbreak in the UK, which triggered the initiation of this PRA. Without knowledge of the vector of the pathogen, risk assessment and management decisions are subject to high levels of uncertainty.

Risk of entry

The only pathway of entry assessed was plants for planting, as phytoplasmas are obligate parasites. This pathway is considered likely, due to the presence of the pathogen in Europe on widely traded material, but with low confidence as its full distribution and host range is unknown. As the vector is unknown, entry via this pathway could not be assessed.

Risk of establishment

If an insect vector is absent from the wider environment the disease may be self-limiting in the UK. However, establishment could occur in the absence of a vector by natural root grafts transmitting between trees. Though no spread has been observed at the outbreak site, establishment is rated as moderately likely due to the risk of establishment via root grafts or vegetative propagation. Confidence is low, because the vector is unknown.

Economic, environmental and social impact

The lack of reports concerning this pest suggests that impacts are small elsewhere, with medium confidence. Mortality rate in hazel in the UK has been very high, but there is no evidence of spread from the current site, thus economic, environmental and social impacts have been rated as small. Should a vector be introduced in the future, or spread from the current site become apparent, then environmental impacts could be large due to the importance of hazel as a native species.

Endangered area

If a vector is present, then the endangered area is wherever there is crossover between the vector and hazel. Clonal propagation of hazel and strawberries may also be endangered.

Risk management options

Because the pathogen is poorly understood, exclusion is very unlikely. Eradication or containment is only feasible if a vector is not present in the area where the disease is found, and can be achieved by destroying infected plants or preventing propagation. There should be a zero tolerance for the presence of the pathogen in propagating material of strawberry and hazel.

Key uncertainties and topics that would benefit from further investigation

There are a number of key uncertainties and areas where more research and information is required:

- Any instances of decline and mortality of hazel in the UK should be reported to the PHSI, as it is possible that the disease may be more widely spread than the outbreak in Surrey.
- The fact that the vector is unknown is a major source of uncertainty for the risk analysis. If the vector in Europe or China is identified in the future, the risk analysis should be revisited.
- The host range and distribution of *Ca.* Phytoplasma fragariae is likely to be incomplete.
- It is unknown if the high mortality rate in hazel in Surrey may be a result of a susceptible genotype (as the plants are all likely clones derived from the same mother plant), and thus not representative of the pest's impact in this host should it become widespread in the UK.

Images of the pest

Declining hazel (*Corylus avellana*) from the UK *Ca.* Phytoplasma fragariae outbreak, July 2015. Photo by Melanie Tuffen.

Is there a need for a detailed PRA or for a more detailed analysis of particular sections of the PRA? If yes, select the PRA area (UK or EU) and the PRA scheme (UK or EPPO) to be used.

When more information about *Ca.* Phytoplasma fragariae and its vector becomes available, further assessment may be warranted, but at this time it is very unlikely to provide additional information.

No	✓				
Yes		PRA area: UK or EU		PRA scheme: UK or EPPO	

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

Currently, *Ca.* Phytoplasma fragariae appears limited to copses of hazelnut trees in Surrey. The disease is expected to be self-limiting as there is no evidence of a vector and / or spread. Action would be justified on findings on *Ca.* Phytoplasma fragariae on commercially traded plants because of its impacts on hazel, particularly on material being used for propagation. Destruction of infected plants in the wider environment is not justified, because of the apparent limited spread capacity, but measures to contain the pest by preventing propagation of this material should be put in place and it would be advisable for outbreaks to continue to be monitored, to see if spread occurs.

Yes Statutory action	✓	No Statutory action	

Stage 1: Initiation

1. What is the name of the pest?

Candidatus Phytoplasma fragariae (16SrXII-E)

Special notes on taxonomy

Phytoplasmas cannot be cultured, and as a consequence their taxonomic names include "*Candidatus*" to indicate it is a well characterized organism, but uncultured. Much of phytoplasma taxonomy is based on analysis of the 16Sr gene – this analysis splits phytoplasmas into groups, and further analysis by molecular methods leads to classification into sub-groups. *Ca.* Phytoplasma fragariae is in group 16SrXII, subgroup E (16SrXII-E) (Valiunas *et al.* 2006). A phytoplasma will only be referred to as *Ca.* Phytoplasma fragariae if its 16SrXII gene shows 100% identity with the reference strain; otherwise it will be referred to as a *Ca.* Phytoplasma fragariae strain or *Ca.* Phytoplasma fragariae-like. For the purposes of this PRA, all reports of 16SrXII-E are taken into consideration. It is possible at a later date these may be re-classified into new *Candidatus* Phytoplasma species.

References in the literature to disease caused by group 16SrXII, but where no classification to sub-group has occurred, could be referring to incidences of *Ca.* Phytoplasma fragariae. However, there are several other widespread members of the 16SrXII and so these reports are not considered within the PRA, unless there is strong reason to suspect they may refer to *Ca.* Phytoplasma fragariae.

2. What initiated this rapid PRA?

The assessment was triggered by an outbreak of *Ca.* Phytoplasma fragariae at a nature reserve in Surrey, in order to see if continued statutory action against the pest is justified.

3. What is the PRA area?

The PRA area is the United Kingdom of Great Britain and Northern Ireland.

Stage 2: Risk Assessment

4. 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]?

Ca. Phytoplasma fragariae is not listed in the EC Plant Health Directive and is not recommended for regulation as a quarantine pest by EPPO, nor is it on the EPPO Alert List.

5. What is the pest's current geographical distribution?

The first record of *Ca.* Phytoplasma fragariae was from Lithuania in cultivated strawberry (Valiunas *et al.* 2006). It was later reported in Italy, having been detected in a survey of plants in the wider environment around phytoplasma infected vineyards (Filippin *et al.* 2008). More recently, it has been described as causing disease in China in potatoes (Cheng et al. 2015). Its current distribution suggests it is likely to be more widely distributed than currently reported, especially given that symptoms are similar to other phytoplasma diseases or unrelated pests.

In Italy, the phytoplasma was detected in *Cornus*. There is also a record of an uncharacterised 16SrXII phytoplasma infecting *Cornus* in France (Jarausch *et al.* 2001). This may refer to *Ca.* Phytoplasma fragariae, but it is not conclusive evidence that the pest is present in France.

Table 1: Distribution of *Ca.* Phytoplasma fragariae	
North America:	No records
Central America:	No records
South America:	No records
Europe:	Italy (Filippin *et al.* 2008), Lithuania (Valiunas *et al.* 2006), United Kingdom (Hodgetts *et al.* 2015)
Africa:	No records

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

[2] https://www.eppo.int/QUARANTINE/quarantine.htm

Asia:	China (Cheng *et al.* 2015)
Oceania:	No records

6. Is the pest established or transient, or suspected to be established/transient in the UK/PRA Area?

A *Ca.* Phytoplasma fragariae strain has been identified in diseased *Corylus avellana* (hazel) (Hodgetts *et al.* 2015), at a nature reserve in Surrey. Because the situation in Surrey is pertinent to the whole PRA, it is described in more detail below.

In 2006, the pest was identified in a *Cordyline* (an ornamental species with a palm like appearance) in Jersey, which was symptomatic and destroyed in order to protect other *Cordyline* plants in the vicinity – no testing of *Corydline* has occurred on Jersey since and the current status of the pest on the island is not known.

Special notes on the outbreak in *Corylus avellana* (hazel)

In 2012 poor health was noted in some of the hazel stools in a copse of hazel trees used for coppicing (approximately 0.8 ha) on a nature reserve in Surrey. In September 2014, a survey was carried out by the conservation society, looking at 8 plots of 8m radius laid out randomly in the survey area. All stools within the plots were counted and condition recorded. The total number of stools assessed was 184, of which 94 were found to be dead or dying, 61 were symptomatic with epicormic shoots and yellowing leaves and 29 were apparently healthy (Charlotte Davey, *pers. comm* 09.07.2015). The PHSI was contacted and the site examined. In addition to the yellowing of the leaves, some trees also showed cankers which were bleeding.

Samples of leaves and samples taken from cankers on two trees were sent for analysis. No bacteriological and mycological causes for the decline of the trees could be found, but some leaves tested positive for a *Ca.* Phytoplasma fragariae strain. No other cause has been found for the symptoms, but since Koch's postulates would be technically challenging to demonstrate with a phytoplasma, it cannot be said conclusively that symptoms seen are entirely caused by *Ca.* Phytoplasma fragariae, though it is strongly suspected to be the case. Further samples were taken from 8 trees around the one which tested positive, but only a few leaf samples could be submitted due to autumn leaf fall. All 8 were found positive for Ca. Phytoplasma fragariae. These 9 stools, and a one tree cordon sanitare (a block of 30 trees in total) were removed under statutory notice – cutting, burning and the regrowth being sprayed off.

The trees in this coppice were all planted at the same time, approximately 15 years ago, and originated from the same source. This is thought to be a nursery business that is now no longer trading, and thus it is not possible to trace the country of origin of the trees. Visual surveys in spring and summer 2015 strongly indicate that the whole 0.8 hectare is

infected with the exception of a few healthy hazel trees – these healthy examples appear to be more mature, and may represent trees that were already present on the site before it was planted as a hazel coppice. The total number of trees (living and dead / dying) at this site was estimated in the survey carried out by the conservation society at 920. This is based on the planting spacing, and numbers found in the sample plots. In addition, a small number of trees (approximately 10) from the same source were planted in woodland managed by the same conservation society approximately 7 miles away. The trees from the second site are showing the same symptoms and one has tested positive for *Ca.* Phytoplasma fragariae by molecular testing, but they have not been removed.

Clonal propagation is widely used for *Corylus* grown for nut production or ornamental production (Contessa *et al.* 2012, Damiano *et al.* 2005, Sadhu 1989) and a single infected mother plant could have produced numerous infected daughter plants. Though *Corylus* for forestry purposes is also grown from seed, the most likely scenario is that trees planted at both sites were clonally propagated from an infected mother plant and thus already infected at the time of planting, and disease has progressed over a 15 year period.

Both sites contain many other unrelated hazel trees, present before the infected trees were planted, in addition to other broadleaved trees. To date, no trees outside of the planted coppices are visually symptomatic, and there is no evidence of spread, even to trees in very close proximity (less than 5 metres) to the infected coppice. However, given how long symptom development has been assumed to have taken on the infected trees, and the difficulties in detecting phytoplasmas at low levels, it cannot be concluded with certainty that spread is not occurring.

Because of the high level of mortality seen in hazel, it is unlikely that *Ca.* Phytoplasma fragariae is widespread in hazel in the UK. However, as discussed in section 12, symptoms in other species are relatively minor. Further trace back of the infected hazel trees is not possible, and thus it is not known if this outbreak represents an introduction of *Ca.* Phytoplasma fragariae to the UK or if it may already be present at low levels in other hosts in the wider environment.

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

Ca. Phytoplasma fragariae has been recorded in a small but diverse number of hosts. Those recorded to date are summarised in Table 2. The full host range is very unlikely to have been elucidated, and to a certain extent will be determined by the insect vector(s) of the phytoplasma which is/are unknown.

China is the only country to date which has reported *Ca.* Phytoplasma fragariae from potato – though the closely related *Ca.* Phytoplasma solani is present in potato in much of Europe. The outbreak in the UK is the first time *Ca.* Phytoplasma fragariae has been reported from hazel.

All of the recorded hosts are grown in the UK and have economic and/or environmental value.

Table 2: Known hosts of *Ca.* Phytoplasma fragariae Scientific name	Common Name	Reference
Cordyline	Cordyline	(Stephen Thomas, *pers. comm.* 27.11.2014)
Cornus sanguinea	Common dogwood	(Filippin *et al.* 2008)
Corylus avellana	European hazelnut	(Hodgetts *et al.* 2015 *in press*)
Fragaria x ananassa	Strawberry	(Valiunas *et al.* 2006)
Sambucus nigra	Elder	(Filippin *et al.* 2008)
Solanum tuberosum	Potato	(Cheng *et al.* 2015)

8. What pathways provide opportunities for the pest to enter and transfer to a suitable host and what is the likelihood of entering the UK/PRA area?

Phytoplasmas are obligate parasites, requiring a plant or insect vector to survive. The only pathway of entry for phytoplasmas are plants for planting (not including seeds as phytoplasmas as not transmitted via seed), or the hitchhiking/natural spread of infectious vectors as the majority of phytoplasmas are transmitted in a persistent manner. As is discussed in section 9, the vector for *Ca.* Phytoplasma fragariae is entirely unknown and thus assessment of the pathway of infectious vectors is not possible. Transmission via seed potatoes is possible, but *Ca.* Phytoplasma fragariae is only present in potatoes in China which are prohibited from entry into the EU, so this pathway is not considered.

Plants for Planting

To date, *Ca.* Phytoplasma fragariae has been shown to be able to infect hosts from six plant families, and is likely to have many other hosts. The pest is present in two other EU countries and is very likely to be more widely distributed. Detection of the phytoplasma in early stages of infection via visible symptoms may be difficult. It can take many years for phytoplasma titres to build to a level in which symptoms are apparent and the phytoplasma is reliably detectable via molecular methods. In the outbreak in Surrey, it appears to have taken over ten years for symptoms to become apparent. This means that infected mother trees, which are asymptomatic, may be propagated from, thereby spreading the disease in nursery plants.

As described in section 6, it is likely that *Ca.* Phytoplasma fragariae was introduced to the sites on the planting material.

Since the pest is present in Europe, on hosts for which there is free movement of planting material, entry on plants for planting is rated as likely. Confidence is low, because of the paucity of data concerning the pest, its hosts, distribution and its vector.

Plants for planting	Very unlikely	☐	Unlikely	☐	Moderately likely	☐	Likely	☑	Very likely	☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑				

9. If the pest needs a vector, is it present in the UK/PRA area?

Phytoplasmas are spread by insect vectors. The vector of *Ca.* Phytoplasma fragariae is unknown and thus it is not known if a vector is present in the UK.

Phytoplasma vectors tend to be phloem feeding (Phytoplasmas are limited to the phloem) members of the Hemiptera, including leafhoppers (Cicadellidae), planthoppers (Fulgoromorpha) and psyllids (Psyllidae) – the largest number of vector species belong to the leafhopper subfamily Deltocephalinae (Wilson & Weintraub 2007). Other sap-sucking Hemiptera such as aphids or whitefly have not been shown to be phytoplasma vectors.

Ca. Phytoplasma fragariae is part of the 16SrXII group of phytoplasma. The closely related *Ca.* Phytoplasma solani (16SrXII-A) is mainly vectored by two members of the Cixiidae family of planthoppers: *Hyalesthes obsoletus* and *Reptalus panzeri,* which are both absent from the UK. However, there are also reports that *Ca.* Phytoplasma solani can be transmitted by leafhopper species from the family Cicadellidae, such as *Anaceratagallia ribauti* (Riedle-Bauer *et al.* 2008). Another member of 16SrXII include *Ca.* Phytoplasma australiense – which is vectored by the Cixiidae *Zeoliarus oppositus* and *Z. atkinsoni* (Winks *et al.* 2014). Vectors of the other subgroups in 16SrXII are unknown.

Based on the vectors of other 16SrXII phytoplasmas, it is most likely any efficient vector of *Ca.* Phytoplasma fragariae would belong to the Cixiidae. There are only 12 species of Cixiidae in the UK (Wilson *et al.* 2015), summarised in Table 3.

Table 3: List of Cixiidae known to occur in the UK taken from Wilson *et al.* 2015. The preferred hosts or environments are listed for each species and sources are as referenced – however Cixiidae are likely to at least occasionally feed on other hosts. Nymphs overwinter underground on the roots of hosts. Because of their cryptic lifestyle, their host range is less well understood than adults.

Species	Known preferred hosts/environment	UK status
Cixius caledonicus	Life history poorly understood (Kirby 1992).	Only recorded from Scotland (Kirby 1992) and possibly extinct (buglife 2015).
Cixius cambricus	Grasslands, with a preference for higher	Northern and western

	altitudes (Kirby 1992).	species, local and notable (Kirby 1992).
Cixius cunicularius	Deciduous woody plants (Nickel & Remane 2002), often associated with streams (Bantock & Botting 2013).	Widely distributed but uncommon (Bantock & Botting 2013).
Cixius distinguendus	Deciduous woody plants (Nickel & Remane 2002).	Common (Stewart & Bantock 2012).
Cixius nervosus	Deciduous trees and shrubs (Bantock & Botting 2013).	Widespread and common (Bantock & Botting 2013).
Cixius remotus	Hosts are unknown but seems to breed on vegetated shingle (Kirby 1992).	Southern coasts of Britain, notable and local species (Kirby 1992).
Cixius similis	*Betula* (birch), *Pinus* (pine), *Vaccinium* (Nickel & Remane 2002).	Local populations only (Stewart & Bantock 2012).
Cixius simplex	Shrubs (Nickel & Remane 2002) in a variety of habitats including woodlands and salt marches (Bantock & Botting 2013).	Southern and Central England and Wales (Bantock & Botting 2013).
Pentastiridius leporinus (*Oliarus leporinus*)	Salt marshes (Kirby 1992).	Southern coasts of England and Wales, rare and very local where found (Kirby 1992).
Reptalus quinquecostatus	Polyphagous, found in grassland and woody areas (Webb *et al.* 2013).	Widespread in south-east England (Webb *et al.* 2013).
Tachycixius pilosus	Deciduous trees and shrubs (Bantock & Botting 2013).	Widespread (Bantock & Botting 2013).
Trigonocranus emmeae	Lifecycle and host plants are poorly understood, but it described as “on moderately warm sites covered by vegetation of medium density, probably feeding on roots of shrubs” (Musik *et al.* 2013).	Records are scarce but widespread across the UK. A rare and notable species (Kirby 1992).

Of the Cixiidae known to occur in the UK (Table 3), only *R. quinquecostatus* has been potentially associated with phytoplasma disease. Its close relative *R. panzeri* vectors *Ca.* Phytoplasma solani, and *R. quinquecostatus* has been implicated as a potential vector of *Ca.* Phytoplasma solani in vineyards in Tuscany (Trivellone *et al.* 2005), and could transmit the phytoplasma into artificial feeding medium in the lab (Pinzauti *et al.* 2008). It remains unclear if *R. quinquecostatus* is a vector of *Ca.* Phytoplasma solani. However, even if it is a vector, it does not automatically mean it could vector the closely related *Ca.* Phytoplasma fragariae. It is also unclear if *R. quinquecostatus* requires deciduous trees to complete its lifecycle (Webb *et al.* 2013) and, thus, if it could act as a vector on woody hosts.

Though seemingly restricted to salt marshes in the UK, *P. leporinus* on the Continent is found on sugar beet and wheat where it transmits another phloem limited bacterial pathogen, *Candidatus* Arsenophonus phytopathogenicus (EPPO 2012).

However, lack of evidence as a known vector cannot be taken as evidence that other species in Table 3 are not capable of transmitting *Ca.* Phytoplasma fragariae, since this pathogen is so poorly studied. Furthermore, it is possible that *Ca.* Phytoplasma fragariae may be transmitted by phloem feeding leafhoppers or psyllid species (with the UK checklists containing a total of 296 Cicadellidae and 82 Psyllidae species).

10. How likely is the pest to establish outdoors or under protection in the UK/PRA area?

Because phytoplasmas are obligate parasites, in order to become established in the UK, at least one of the following conditions would need to be met: -

1) An insect vector is present

2) The disease becomes widespread in material used for vegetative propagation

3) An outbreak occurs in an area with a high potential for natural root grafts to occur between hosts

Unless one or more of these three conditions is fulfilled, the disease will be self-limiting.

There is no reported vector of *Ca.* Phytoplasma fragariae, and potential vectors are discussed in section 9 above. It is most likely to be a hemipteran insect from the family Cixiidae (one of the planthoppers). Since there are no Cixiidae usually associated with potatoes in the UK (Chris Malumphy, Fera, *pers. comm.* 21.07.2015), establishment in potato crops is very unlikely. However, there are Cixiidae associated with broadleaved trees, as well as a possibility of phloem feeding leafhoppers and psyllids acting as a vector. If one of these species is able to transmit *Ca.* Phytoplasma fragariae, then establishment would be very likely, since hosts are so widespread.

Hazel will form natural root grafts and an unrelated phytoplasma disease in hazel in Oregon is believed to have spread throughout a nut orchard by the formation of root grafts (Johson *et al.* 2000). Thus there is potential for establishment to occur in hazel in the UK via root grafts.

However, to date there is no evidence of spread from the current outbreak site in Surrey despite an abundance of suitable hosts very close by. This could indicate that no suitable vector is present and that root grafting to trees is not occurring – however there is still potential for natural root grafts to occur in the future and thus transmit the disease. The phytoplasma is also unlikely to become very widespread in propagated material, as mother plants would eventually become symptomatic and thus rouged out. However, a significant number of daughter plants may have been created by this point.

Establishment outdoors in the UK is rated as moderately likely, with low confidence, because the status of the vector in the UK is unknown. It is not rated as unlikely, because even if there is no vector present, there is still potential for establishment to occur due to spread via root grafts and unintentionally in vegetatively propagated material. However the formation of root grafts by infected hazel may be limited by the poor health of infected trees and their high mortality rate.

The known hosts of *Ca.* Phytoplasma fragariae include species that are grown under protection such as *Fragaria* (strawberry). Establishment under protection is very unlikely though, as the potential vector species of phytoplasmas are not usually found in protected cultivation, and there is no evidence of a UK vector. The pest could thus be eliminated easily by the destruction of infected plants.

Outdoors	Very unlikely	☐	Unlikely	☐	Moderately likely	☑	Likely	☐	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑			

Under Protection	Very unlikely	☑	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			

11. How quickly could the pest spread in the UK/PRA area?

To date, the only infected trees identified at the outbreak sites have been from the same consignment and thus it appears natural spread of the pest is very slow. However, there is low confidence associated with this rating, as the vector is unknown. Additionally, symptom development may be slow, and apparently healthy trees may actually already be infected. Though, it would be expected that given the trees have been *in situ* for approximately 15 years, some start in decline of surrounding trees would be detected if the pathogen had spread.

Spread with trade is rated as moderate pace. Although some known hosts are widely traded, such as *Fragaria*, declining plants would likely be rouged out, limiting the spread of the pest. There will be instances where, because hosts are initially asymptomatic, there may be some propagation or trade before symptoms become apparent.

Natural Spread	Very slowly	☑	Slowly	☐	Moderate pace	☐	Quickly	☐	Very quickly ☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑			

With trade	Very slowly	☐	Slowly	☐	Moderate pace	☑	Quickly	☐	Very quickly ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			

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

There are very few reports of *Ca.* Phytoplasma fragariae causing impacts. Symptoms on *C. sanguinea* and *S. nigra* in Italy were described as "typical phytoplasma symptoms" – namely leaf-roll, reddening/yellowing of leaves and witches' broom. It should be noted two of the three *S. nigra* trees were found to actually be infected with *Ca.* Phytoplasma solani (16SrXII-A), but the remaining tree and the *Cornus* plants were infected with *Ca.* Phytoplasma fragariae. In Lithuania, strawberry symptoms were described as "general stunting and yellowing of leaves" (Valiunas *et al.* 2006). It appears that *Ca.* Phytoplasma fragariae only has very small impacts in Europe.

In China, *Ca.* Phytoplasma fragariae like strains have been detected in potatoes – however many other phytoplasmas, including other members of the 16SrXII, are present in potatoes in China. The overall impact of phytoplasma disease in potatoes in China appears to be large, but the individual contribution of *Ca.* Phytoplasma fragariae-like strains, only reported for the first time in 2014 and 2015, seems to be small.

Overall impacts of *Ca.* Phytoplasma fragariae are rated as small, with medium confidence. The low level of reports of the pest is suggestive that it is not economically important in its current range, but the pathogen may be under-recorded especially given the apparent long latency period in some hosts.

Impacts	Very small	☐	Small	☑	Medium	☐	Large	☐	Very large ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			

13. What is the pest's potential to cause economic, environmental and social impacts in the UK/PRA area?

From the current site, there is no evidence that the pest has spread. Other potential reservoirs of the pest, such as herbaceous hosts, have been tested and were negative. Though it appears to have taken approximately a decade for severe symptoms to become apparent, some spread and start of decline in surrounding trees would still be expected if the phytoplasma was spreading.

This may suggest that the pest has no vector in the UK (or that no vector is present at that site) and that the infected plants may have been propagated from a single infected mother plant. As a consequence, the current outbreak may be self-limiting – that is, the remaining infected trees will either suffer mortality or recover, eliminating the pest from the site. If this

is the case, impacts are expected to be small in the UK. Economic impacts are rated as small rather than very small, as there may be other instances where the pathogen is propagated unwittingly into many daughter plants which later go on to develop disease and die. This could occur not only in hazel but in other hosts such as strawberry that may be vegetatively propagated. There is also potential for spread via natural root grafts.

Hazel is an important and widespread species in the UK – a key component in the woodland understory. It is also used widely in coppice, by individuals foraging for nuts, and is planted as an ornamental. Mass mortality of this species caused by *Ca.* Phytoplasma fragariae – even with the relatively long time scale it seems to take to occur in the UK - would have large environmental and social impacts. However, even with an efficient vector present in the UK, wide scale death of hazel may not occur. This is because it seems very likely that the hazel plants in question were all clonally propagated, and it is possible the dying plants in question were derived from a susceptible genotype, and that in the wider environment with more genetically diverse hazel tolerance to the disease may be higher. In addition, hazel is also widely planted in Europe where there is no mortality caused by *Ca.* Phytoplasma fragariae reported.

Because of the lack of evidence of spread from the current site, environmental and social impacts have been rated as small. Confidence in all of these impact ratings is medium, because the pathogen is so poorly understood and the vector is entirely unknown. If there is any evidence of spread detected in the future, then it would be appropriate to reassess the impact scores of this PRA.

Economic Impacts	Very small	☐	Small	☑	Medium	☐	Large	☐	Very large ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			
Environ - mental Impacts	Very small	☐	Small	☑	Medium	☐	Large	☐	Very large ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			
Social Impacts	Very small	☐	Small	☑	Medium	☐	Large	☐	Very large ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			

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

Ca. Phytoplasma fragariae cannot vector plant pathogens.

15. What is the area endangered by the pest?

If a vector is present, then the endangered area is wherever there is crossover between the vector and hazel, as this is the only species shown to be severely impacted by the pest. Clonal propagation of hazel and strawberries may also be endangered.

Stage 3: Pest Risk Management

16. What are the risk management options for the UK/PRA area?

Exclusion

Complete exclusion prospects for the pest are very poor. The phytoplasma is poorly understood, has been found in hosts from six different plant families with a high probability of more hosts being identified in the future. It is very likely to be more widely distributed in Europe and Asia than currently reported. In addition, any measures to exclude the pest may also need to include measures to exclude the infectious vector, depending on the vector-phytoplasma relationship. Since the vector is unknown, such measures cannot be assessed.

The current prohibition on the import of potatoes from outside of Europe should, however, exclude *Ca.* Phytoplasma fragariae from potato crops provided it does not become present in seed potatoes in Europe, or a vector is introduced that would feed on both broadleaved trees and potatoes resulting in transmission from trees to potatoes.

Eradication

As discussed within the pest risk assessment, it is possible that *Ca.* Phytoplasma fragariae will be self-limiting in the UK. If no vector is present, eradication will be achieved by preventing propagation from the currently infested hazel, which will eventually die and eliminate the disease. Any findings of the pest in other crops could be dealt with in a similar manner, with destruction of infested plants warranted on nursery material.

If a vector is present (and widespread) in the UK, then eradication from the wider environment is not feasible. The infected hazel has been planted for approximately 15 years at the two sites. The full host range is not known, and some species in the area may be acting as asymptomatic reservoirs of disease. If findings occur in new areas on

relatively recent plantings, destruction of infested trees may be warranted to eradicate from that area. If infection occurred at strawberry production it may be possible to eradicate by destruction of the plants, but if an efficient vector is present this could also be problematic as there is the possibility of other plants and trees acting as a reservoir for the disease.

Containment

If a vector is present and widespread, full containment will not be possible. Long distance spread of the pathogen can be prevented by not allowing vegetative propagation of hosts from outbreak sites. Seeds and timber are not known to be a pathway of transmission, so activities concerning these commodities could continue. To prevent spread by natural root grafts in hazel, particularly in coppices and orchards, healthy trees in close proximity to infected ones could be removed. This process could be expensive; hazel is a coppiced species and will regenerate easily. Phytoplasmas are present in the roots, and thus any regenerated material would also be infected, and so root systems would need to be killed by herbicide treatment. It would be advisable for outbreaks to continue to be monitored, to see if spread occurs.

Non-Statutory Controls

Because of the impacts seen on hazel, there should be a zero tolerance for the presence of the pathogen in propagating material. Growers should source certified material of a high plant health status. Although impacts appear to be lower in strawberry, use of certified stock should also be considered for this host, as this is likely to be of a higher quality and health status.

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