Department for Environment Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for:

Pseudomonas avellanae

April 2022

Summary and conclusions of the rapid PRA

The production of this rapid PRA was requested as a result of the risk register entry for *Pseudomonas avellanae* from 2020. In addition, this bacterium is currently listed as a Regulated Non-Quarantine Pest (RNQP) on *Corylus avellana* in GB legislation, but due to its absence from the UK, it does not meet the specifications of an RNQP.

This rapid PRA shows:

Pseudomonas avellanae is a bacterial pathogen which infects hazel (*Corylus avellana*) and is the causal agent of hazelnut decline and dieback. Disease caused by *P. avellanae* was first reported in 1976 in northern Greece and has caused severe damage to hazelnut orchards in both northern Greece and central Italy. Despite these severe impacts its distribution has remained restricted to these areas. *Pseudomonas avellanae* has the potential to be very damaging to UK populations of hazel, with trees growing on highly acidic soils at significantly greater risk.

Risk of entry

Hazel is the only host associated with *P. avellanae* and this pathogen has not been isolated from nuts taken from infected trees. Therefore, the only pathway assessed for risk of entry and transfer to a suitable host was infected propagating material. To date there have been no interceptions of *P. avellanae* in the UK. The scale of imports of hazel plants

from either Greece or Italy are unknown but likely to be small, so the risk of entry has been rated as **moderately likely** with **low confidence**.

Risk of establishment

As *P. avellanae* only appears to be present and result in severe disease and outbreaks in areas with highly acidic soils (pH <5.0), a combination of both hazel presence and acidic soils are needed for establishment. This is difficult to assess, however there are large swathes of highly acidic soil across the UK particularly across upland areas, and in many of these areas hazel is present. This suggests that the likelihood of establishment outdoors is **likely**, this is rated with **medium confidence**. The likelihood of establishment under protection has been rated as **very unlikely** with **high confidence** because hazel is extremely hardy and therefore not grown under protection.

Economic, environmental and social impact

Potential economic impacts have been rated as **small** with **medium confidence**. Hazelnut decline through an outbreak of *P. avellanae* could severely damage hazelnut production and potentially make the land unsuitable for this purpose in the future. The disease could also impact the trade of hazel for hedgerows and woodlands; and affect the coppicing of woodlands. The exact values associated with these trades and industries are unknown.

The environmental impacts from this disease have been rated as **large** due to the widespread distribution of hazel in the UK and its prevalence in rare habitats such as Atlantic hazelwoods. This has been rated with **low confidence** because of the uncertainty with the conditions associated with disease outbreaks. These conditions are thought to include the prevalence of spring frosts and highly acidic soils, which have been associated with previous European outbreaks.

Social impacts have been rated as **medium**. Landscapes and ornamental settings containing hazel across the UK would be altered if severe declines were to occur, reducing the population’s enjoyment of them. A **medium confidence** has been attributed to this score due to the uncertainty about the extent of damage this disease could cause in the UK and how hazel trees in isolation could be affected.

Endangered area

The exact areas endangered in the UK are uncertain. In the current areas affected by *P. avellanae*, outbreaks occur on highly acidic soils, therefore hazel growing in acidic soils are at the highest risk. *Pseudomonas avellanae* has only been found to use hazel as a host, therefore we can be confident it is only hazel at risk from this bacterium.

Risk management options

The continued exclusion of *P. avellanae* is the best option for managing the risk. As of 1st January 2021, a 100% inspection rate is required for all plants for planting imported from the EU. This should help with the exclusion of this disease because it is only known to occur in Greece and Italy. However, this exclusion is not guaranteed due to the possibility of latently infected material not being identified at inspection.

Key uncertainties and topics that would benefit from further investigation

The volume of trade of hazel from the EU, particularly Greece and Italy where the disease occurs, is a major uncertainty. More data should become available because since 1st January 2021 pre-notification of plants for planting from the EU and accompanying phytosanitary certificate are required, however due to free movement within the EU it may not be always possible to know the original origin of material. This is a result of the UK leaving the EU. Additional uncertainties lie in the optimum conditions required for disease progression and the overlap of hazel distribution and highly acidic soils in the UK.

Images of the pest

Figure 1. A, Early canker on hazel stem. B, Hazel showing dieback of stems as a result of *Pseudomonas avellanae* infection. C, Vascular staining on hazel stem. D, Infected hazel amongst non-infected hosts. Images courtesy of Marco Scortichini (Personal Communications).

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 EPPO) and the PRA scheme (UK or EPPO) to be used.

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

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

This disease has caused significant damage to hazel trees in northern Greece and central Italy. There are high degrees of uncertainty surrounding the likelihood of establishment in the UK and disease severity. The UK has both climatic and soil conditions shown to be favourable to the pathogen's spread, disease development and host susceptibility in its current range. There is a risk, therefore, that this disease could establish and cause damage in the UK, so statutory action is considered appropriate.

Yes Statutory action	✓	No Statutory action	

Stage 1: Initiation

1. What is the name of the pest?

Pseudomonas avellanae (Bacteria, Pseudomonadaceae).

Pseudomonas avellanae was first described as the pathovar *Pseudomonas syringae* pv. *avellanae* (Psallidas, 1993). Later molecular analyses resulted in *P. s*. pv. *avellanae* being reclassified as the separate species, *P. avellanae* (Janse *et al.*, 1996). Further studies comparing Greek and Italian strains have identified two distinct phytopathogens; *P. s.* pv. *avellanae* which has only been isolated in Italy and *P. avellanae* which has been isolated in both Greece and Italy (Scortichini *et al.*, 2015).

Common names for the disease caused by this pathogen include hazelnut decline, stem dieback of hazelnut and bacterial canker of hazelnut (EPPO, 2001; Scortichini, 2002; CABI, 2021).

In the literature European hazelnut (*Corylus avellana*) and filbert (*C. maxima*) are often used interchangeably. However, filbert is a different species which is not known to be infected by *P. avellanae*. In the UK, cultivated hazelnuts are often referred to as cobnuts, particularly in Kent.

2. What initiated this rapid PRA?

Pseudomonas avellanae is listed as an RNQP on *Corylus avellana*. However, it is only reported to be present in two European countries: Italy and Greece. Therefore, *P. avellanae* does not meet the requirements for an RNQP in GB because of its absence from the UK. To assess the risk posed by *P. avellanae*, the pathogen was added to the UK Plant Health Risk Register in 2020. As a result of this Risk Register entry, *P. avellanae* was recommended for regulation as a quarantine pest and a PRA requested to better understand the potential risk it poses to the UK. This rapid PRA will help inform decisions on whether statutory action 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 plant health legislation, and in the lists of EPPO[1]?

The legislation for Great Britain is The Plant Health (Phytosanitary Conditions) (Amendment) (EU Exit) Regulations 2020[2]. The legislation which applies to Northern Ireland is the EU legislation: 2019/2072 and 2016/2031[3].

Pseudomonas avellanae is listed in Annex IV of Commission Implementing Regulation (EU) 2019/2072 as an RNQP on *Corylus avellana* (hazelnut). *Pseudomonas avellanae* is also listed in Annex 4 of The Plant Health (Phytosanitary Conditions) (Amendment) (EU Exit) Regulations 2020 as an RNQP on *C. avellana*.

This pest is not included in EPPO's A2 list of pests recommended for regulation, nor is it on the EPPO Alert list.

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

In 1976 a destructive decline of hazelnut (*Corylus avellana*) in northern Greece was observed. In this area plantations of the Turkish cultivar Palaz were almost completely devastated within a few years (Scortichini, 2002). Later similar declines and symptoms (Fig. 1) were observed in central Italy and considered severely damaging to hazel cultivars Tonda Gentile Romana and Nocchione. In Italy the disease is known as "moria" (decline and death) (Gentili *et al.*, 2008; Frutos, 2010; Scortichini *et al.*, 2015). Surveys in 1996-1998 identified *P. avellanae* causing symptoms in wild *C. avellana* trees in central Italy (Scortichini *et al.*, 2000). Damage reported in this survey included completely wilted *C. avellana* trees growing adjacent to hazelnut orchards and wilted twigs in those growing in forests away from orchards. Therefore, it is still a concern that *P. avellanae* could spread amongst susceptible wild populations of *C. avellana* even if damages are not as severe as in cultivated *C. avellana*.

The causal agent of these declines was first described as *Pseudomonas syringae* pv. *avellanae*, but later molecular work elevated it from pathovar to species level and it was renamed *P. avellanae*. Despite the severity of *P. avellanae* outbreaks in central Italy and northern Greece, which in some cases have caused hazelnut production to cease, the spread of this disease has remained restricted to these areas. The common link between areas which have witnessed severe outbreaks is the soil pH; both areas have highly acidic soil pH levels of <5.0 (Scortichini *et al.*, 2006). Alongside low pH levels, a high aluminium

[1] https://www.eppo.int/ACTIVITIES/quarantine_activities

[2] https://www.legislation.gov.uk/uksi/2020/1527/contents/made

[3] The latest consolidated versions can be accessed via a search on https://eur-lex.europa.eu/

content (>20%) can result in an increased susceptibility of hazel trees (Scortichini, 2010). Furthermore, the plant genotypes used and cultural practices in hazelnut production in central Italy are homogenous across orchards, but some have suffered decline and others have not (Lamichhane *et al.*, 2016). This highlights the influence that soil conditions have on where outbreaks of this disease occur rather than cultivation practices.

There are suggestions in the literature that *P. avellanae* has been found in Denmark, however these are not confirmed (Scortichini *et al.*, 2000; Griesbach, 2020). This suggests that either *P. avellanae* is not present in Denmark or is present but due to environmental conditions persists without causing major damage and has not been formally detected. The pathogenicity or even benefits of a plant-bacteria interaction can depend on environmental conditions. These appear to play an important role in the *C. avellana – P. avellanae* relationship (Passera *et al.*, 2019). This PRA only reflects confirmed findings of this pathogen from Greece and Italy, however its range could be larger (Table 1.).

Table 1: Distribution of *Pseudomonas avellanae*	
North America:	Absent
Central America:	Absent
South America:	Absent
Europe:	Greece, Italy
Africa:	Absent
Asia:	Absent
Oceania:	Absent

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

Pseudomonas avellanae has not been recorded in the UK and is not suspected to be present. Additionally, no interceptions have been recorded by the Plant Health and Seeds Inspectorate in England and Wales.

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?

Pseudomonas avellanae has only been recorded to use hazel (*Corylus avellana*) as a host (Psallidas, 1993). Hazel occurs in both wild and cultivated settings across the UK. Commercial hazelnut production in the UK is minor with the majority of nut orchards in Kent, with lower levels of production in Sussex and Suffolk. Most hazelnuts are now imported, however a future expansion in hazelnut production should not be ruled out with ongoing projects trying to revitalise the UK hazelnut industry, such as 'The Cobnut Project' funded by the Winston Churchill Memorial Trust.

The coppicing of hazel is widely used in the UK as both a management strategy for woodlands and for gathering a crop of woodland produce. This crop has many uses including traditional fencing panels made by weaving the coppiced hazel. Hazel is also an important component of hedgerows across the lowlands of the UK. Together these create important social value, environmental value and shape the rural landscape of the UK.

Hazel is native to the UK and extremely widespread. In Great Britain there is an estimated 87,000 hectares of woodlands where the principal species is hazel (Forestry Commision, 2021). Hazel helps sustain wildlife: leaves provide food for caterpillars and managed coppiced woodlands provide habitats for butterflies and ground nesting birds. Early in the year male catkins are an invaluable source of pollen for bees, and nuts produced in autumn sustain squirrels, dormice and other small mammals and birds. Further north in restricted areas of the west coast of Scotland, hazel develops into Atlantic hazelwoods, a highly diverse, ancient habitat (NatureScot, 2021). Within this hazelwood habitat a mix of distinct grasses, flowering plants, mosses and lichens are found, highlighting the wide-ranging environmental importance of hazel in supporting UK biodiversity.

8. Summary of pest biology and/or lifecycle

Pseudomonas avellanae is a gram-negative bacterium. The following summary describes the lifecycle of *P. avellanae* and the resultant symptoms on hazel when grown on highly acidic soils.

Pseudomonas avellanae results in the development of cankers on the branches and trunk of infected hazel throughout autumn months, with infected bark turning reddish-brown (Fig. 2A) (Scortichini, 2002). These cankers exude a bacterial ooze which provides a source of inoculum for secondary infection and additional infections on nearby hosts. *Pseudomonas avellanae* does not infect and cause necrotic spots on leaves or nuts, a symptom of hosts often observed with other closely related *Pseudomonas* species (Scortichini, 2002). Instead when hazel sheds its leaves in autumn, generating numerous leaf scars across its branches, a combination of rain splash and wind-disseminated inoculum from nearby symptomatic hosts is transferred to these scars before they are fully healed (Scortichini,

2010). It has also been suggested that inoculum could be spread by scolytinae beetles, this is discussed further in section 10. Once the bacterium has entered through leaf scars or other wounds it then overwinters under the bark within parenchymal and xylem tissues. Over winter, symptoms of *P. avellanae* infection can be observed on the blossoming male inflorescences of hazel catkins. Diseased catkins either produce low amounts of pollen or wilt before producing any.

Figure 2. Typical symptoms caused by *P. avellanae* in a hazelnut orchard in Italy. **A**, bacterial canker on the trunk. **B**, twig dieback noticeably causing necrosis in individual twigs. **C**, branch dieback. Images courtesy of Marco Scortichini (Scortichini, 2002).

In the spring, female inflorescences do not enlarge properly and may become necrotic and have reduced fertility. As the growth of hazel commences, *P. avellanae* systemically migrates throughout the tree via the phloem, spreading from points of infection to other branches and into the root system (Scortichini & Lazzari, 1996). Spring frosts can also cause wounds to open through the cracking of bark on branches and trunks of hazel, creating further opportunities for infection and re-infection by *P. avellanae* (Lamichhane *et al.*, 2016). Increased colonisation events through leaf scars and frost cracks by *P. avellanae* results in an increased disease severity the following growing season. Failure to break bud or delayed leaf emergence can be seen in diseased specimens; leaves may also be a pale green colour or wilt and die on some branches. In contrast to other pathogenic *Pseudomonas* spp. there is no evidence of epiphytic populations of this pathogen on the surface of leaves and branches (Scortichini, 2010).

The most severe symptoms of *P. avellanae* are observed during the summer months when sudden wilting of leaves and twigs occurs can occur (Fig. 2B). This progresses to branches and even entire trees, often resulting in tree mortality (Fig. 2C). Dead leaves can stay attached to the tree for a long period, long after they would usually fall in the autumn. If disease onset is severe an individual infected in the autumn can die the following summer. Symptomless suckers can develop from damaged trees, however these have a high probability of carrying the bacterium and should not be used for propagation (Loreti *et al.*, 2009). It is also worth noting that even when diseased trees have been removed from a site, any hazel trees which are replanted are more than likely to become reinfected with *P. avellanae* (Lamichhane *et al.*, 2016).

9. 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?

Infected propagating material:

The import of hazel plants for planting provides the greatest risk pathway for entry of this pest. Previous work has indicated that large-scale spread of the disease can occur through the distribution of suckers for propagation which appear symptomless but are latently infected with *P. avellanae* (Scortichini, 2010). The scale of imports of hazel from Italy and Greece is unknown as a result of free trade within the EU which can make it uncertain which plants originated in Italy or Greece. A Certification scheme for hazelnut has been published by EPPO, which describes the production of pathogen-tested propagation material of hazelnut (EPPO, 2004). *Pseudomonas avellanae* is mentioned in this certification scheme, with nuclear-stock plants visually inspected for the presence of this pathogen. However, with the knowledge that *P. avellanae* can be present in plant material without displaying symptoms, this is not a guarantee that propagation material certified by this scheme is free from the pathogen (Lamichhane *et al.*, 2016). There have been no interceptions of *P. avellanae* in the UK and planting materials from the EU have required a physical inspection at a rate of 100% since 1st January 2021. Imported hazel are likely to be planted near other individuals whether this be in nut orchards, hedging, woodlands, ornamental settings, or rewilding landscapes. The combination of these factors makes this pathway **moderately likely** due to latent infection. Many unknowns, including a lack of information about the quantity of hazel imports, make it difficult to assess the risk of entry, so a **low confidence** score has been attributed to this pathway.

Pseudomonas avellanae has not previously been isolated in nuts from infected trees, therefore this has been ruled out as a potential pathway (Scortichini, 2002; Janse & Scortichini, 2008).

	Very unlikely	Unlikely	Moderately likely	Likely	Very likely
Infected propagating material	☐	☐	☑	☐	☐

Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑

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

Pseudomonas avellanae does not require a vector, however it is suggested that its spread could be enhanced by several genera of scolytinae beetles. These are only potential vectors because, although *P. avellanae* has been isolated from both adults and larvae of scolytinae beetles, their role in vectoring the disease has not been conclusively demonstrated (Scortichini, 2002). Scolytinae beetles such as *Anisandrus dispar* and *Xyleborinus saxesenii* are attracted to the terpenes released by symptomatic trees. Both of these beetle species are present in the UK, so could pose a risk of contributing to the spread of *P. avellanae* if it enters the UK. In general beetles are much more widely reported to vector viruses and fungal pathogens than bacterial pathogens, however they should not be ruled out as they still have the potential to vector bacterial pathogens (Wielkopolan *et al.*, 2021).

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

Hazel is widely distributed across the UK and present in a wide range of environments, including forest understoreys, hedgerows, cliffs, valleys, riverbanks and limestone pavement (Enescu *et al.*, 2016).

Hazel is tolerant of soil pH across a wide range, although hazel visibly infected with *P. avellanae* has only been observed on highly acidic soils. Therefore, it is likely that if *P. avellanae* was to establish in the UK it would only establish and cause severe disease symptoms to hazel growing on highly acidic soils. In Great Britain, highly acidic soils (Fig. 3) are mainly associated with specific habitats in upland areas including acid grassland, bog and heathland (Emmett *et al.*, 2010). These areas include Exmoor, Dartmoor, Brecon Beacons, Snowdonia, North York Moors, Yorkshire Dales, Lake District, North Pennines, Northumberland and vast swathes of the Scottish Highlands and Islands. These areas do not contain nut orchards for hazelnut production, however some will contain wild hazel which is characteristic of a number of upland vegetation types (Averis *et al.*, 2004).

The occurrence of spring frosts are thought to provide opportunities for infection and are common throughout the UK, with the total number of annual frosts increasing in prevalence with latitude (Fig. 4). The number of annual frosts across the UK are comparable to areas of central Italy and Northern Greece where *P. avellanae* outbreaks have occurred. Despite the UK having similar levels of frosts in comparison to areas in

Northern Greece and central Italy affected by *P. avellanae* summer temperatures are lower in the UK. Symptoms caused by *P. avellanae* such as dieback occur during summer months, which imply this is when the bacterium is in its most active state. It may be possible that the cooler UK summers are less suitable for the bacteria's proliferation and consequently disease progression and severe symptom expression.

The likelihood that *P. avellanae* could establish outdoors has been scored as **likely** due to the abundance of both *C. avellana* and acidic soils in the UK. This is scored with a **medium confidence** due to uncertainty of whether *P. avellanae* could establish in other areas without acidic soils and remain symptomless. Asymptomatic infection has been demonstrated in *C. avellana* in Italy when in close proximity to symptomatic individuals (Scortichini & Marchesi, 2001). There is additional uncertainty around whether UK summers are hot enough for disease progression.

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

Hazel is an extremely hardy tree which is normally only grown outdoors, therefore the chance of *P. avellanae* establishing under protection has been scored as **very unlikely** with **high confidence**.

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

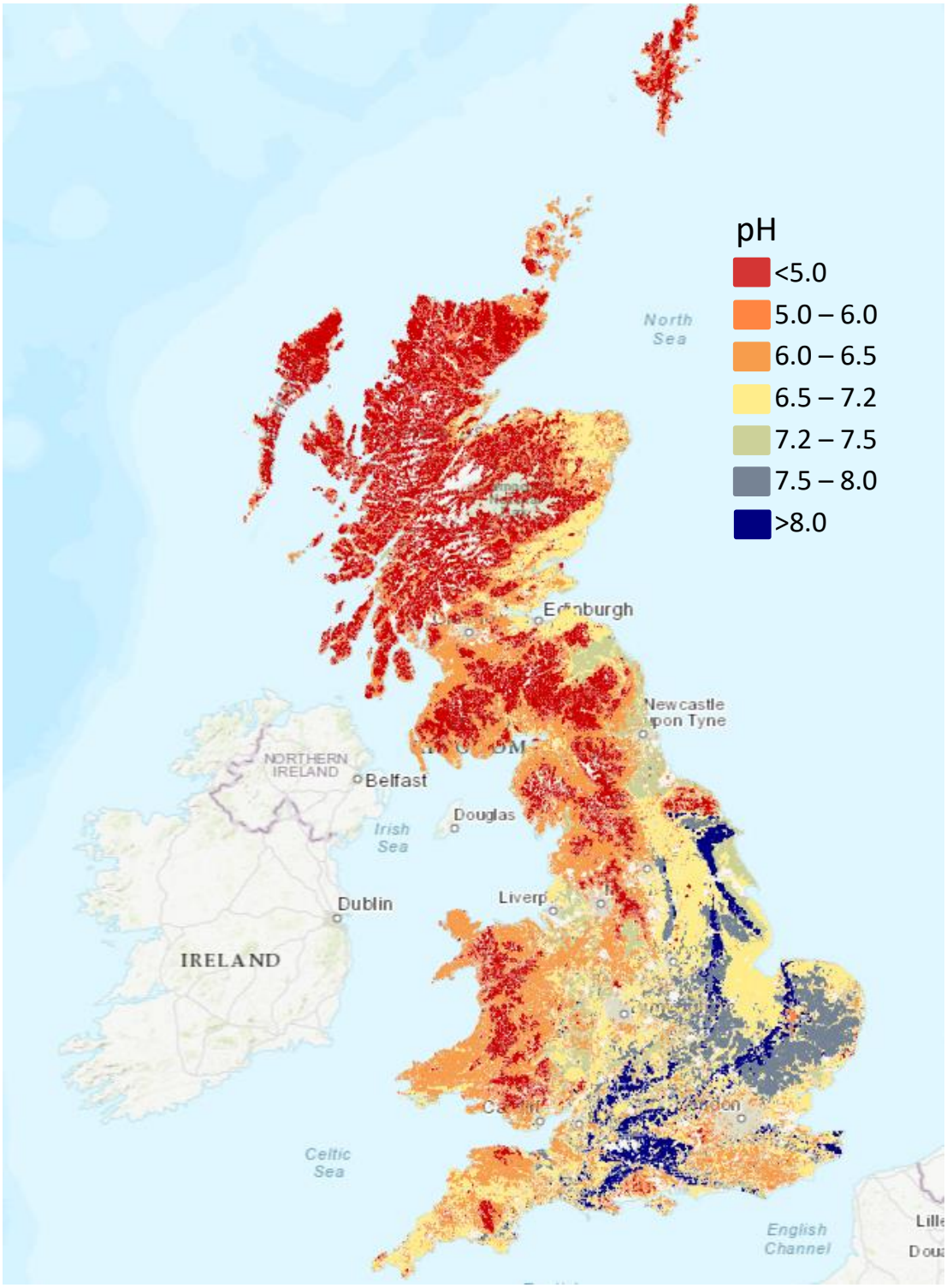

Figure 3. Soil pH across Great Britain with inserted legend showing colours representing pH bands (UKSO, 2022).

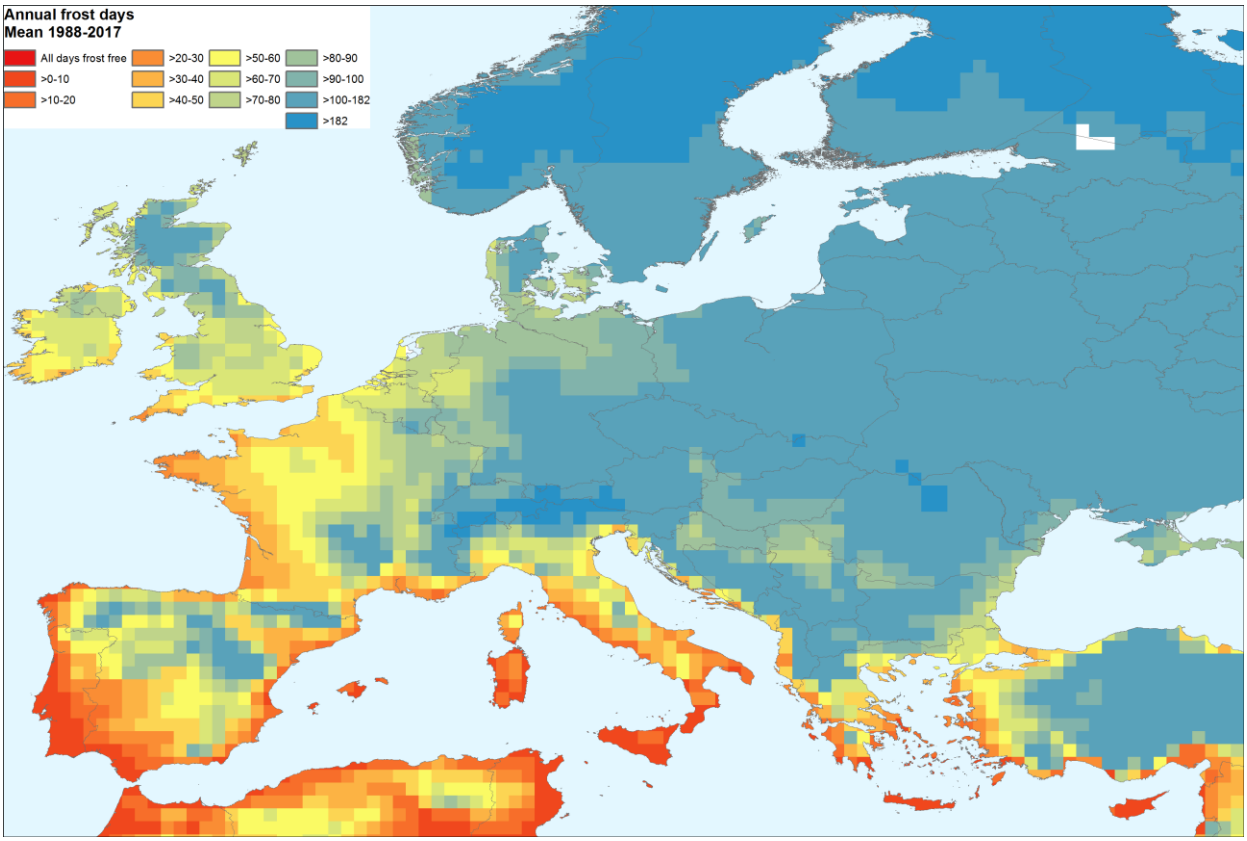

Figure 4. Map of Europe displaying the mean number of annual frost days between 1988 and 2017 (Korycinska, 2019).

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

There is a high level of uncertainty about how rapidly *P. avellanae* could spread throughout the UK. Previous outbreaks of *P. avellanae* have shown that once established and under favourable conditions it can destroy large swathes of cultivated hazel. However, despite these outbreaks covering thousands of hectares of land they have remained restricted in their distribution after many decades presumably due to the specific soil conditions required for disease proliferation and severe symptom expression.

Several factors are thought to enhance the susceptibility of *C. avellena* and contribute to the spread of *P. avellanae,* and these are all present in the UK. The occurrence of spring frosts (Fig. 4) potentially creating entry wounds for *P. avellanae* have been suggested as a contributor to the rate of spread. Rain splash contributes to the spread of the pathogen, particularly in autumn when leaf scars are open. Autumn in the UK typically brings more rainfall than other seasons across the UK which could contribute to the spread of *P. avellanae*. Uninfected hazel trees downwind of an infected individual have an increased likelihood of becoming infected than those upwind (Scortichini, 2002). Therefore, the proximity of an infected host to uninfected potential hosts is an important factor in the rate

of spread of this bacterium. This implies that situations where hazel is under cultivation, such as nut orchards or hedgerows, may have an increased rate of spread compared to more natural settings. Spread of *P. avellanae* could also be exacerbated by the presence of scolytinae beetles, potential vectors of this bacterium.

Hazel is relatively abundant in the UK and so are acidic soils, therefore the pace of natural spread of *P. avellanae* has been rated as **moderate**. However, due to the uncertainty of the overlap of hazel and acidic soil distribution this has been scored with a **low confidence**.

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

Hazel is commonly sold in the UK for hedging so the introduction of infected stock could lead to infections in gardens and field margins with existing hosts. This movement of infected hazel cuttings and nursery stock would facilitate a rapid and long-distance dispersal of *P. avellanae*. After initial infection hazel can be symptomless which exacerbates the potential for transmission (Scortichini, 2010). Although it has not been demonstrated, cutting of hedgerows and coppicing could further facilitate the spread of the pathogen with the pathogen transferred from host to host on the equipment used. Therefore, the rate of spread in the trade has been scored as **very quickly** but with **low confidence** because of the uncertain levels of trade volumes and any new locations would need to possess the required conditions for disease progression.

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

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

It is estimated that *P. avellanae* has caused the mortality of in excess of 40,000 trees in central Italy (Scortichini, 2002). In 2002 it was estimated that the yearly cost of the disease was US$1.5 million, and a national law was put in place to compensate farmers for the damage caused by the disease. Areas totalling over 3,000 hectares have been abandoned in the Italian province of Viterbo since the first appearance of *P. avellanae* (Lamichhane *et al.*, 2016). This represents a **large** economic impact and has been scored with **high confidence**.

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

Pseudomonas avellanae has been detected in wild hazel. Impacts have been noted as being more severe when in close proximity to infected hazelnut orchards, however the same wide scale dieback has not been reported so the environmental impact is scored as **small** with **medium confidence**.

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

The social impact of *P. avellanae* has been large for a small number of individuals such as the farmers whose livelihoods have been damaged. In some cases, this may have resulted in the displacement of people as land is no longer viable for hazelnut production. Due to the small number of individuals affected by this, the social impact has been rated as **small** but with **low confidence**, as the impact on these individuals may have been significant.

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

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

As mentioned in part 11, outbreaks of *P. avellanae* are strongly associated with acidic soils of pH <5.0. Consequently, severe damage by *P. avellanae* is likely to be limited to *C. avellana* populations growing in highly acidic soils. The main areas of highly acidic soils in the UK span Wales, North West England and Scotland, therefore in these areas *P. avellanae* is more likely to result in damaging symptoms if sufficient hosts are present.

Hazelnut decline caused by *P. avellanae* could severely damage the small pockets of hazelnut production in Southern England on acidic soils. This would have detrimental effects on the hazelnut/cobnut industry potentially making land unusable for this purpose. Soils in these areas are acidic, however whether they are acidic enough for *P. avellanae* to take hold is unknown. Therefore, potential economic impacts of *P. avellanae* for hazelnut production are large and areas of production are within endangered areas. However, given the size of the hazelnut industry across the UK, the economic impact for the entirety of the UK is predicted to be small. Additional small economic impacts would be caused if areas of hazel used for coppicing were damaged by *P. avellanae*. Therefore, the potential economic impact has been scored as **small** with **medium confidence**.

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

Hazel is a common tree in the wider environment throughout the UK, in some cases it is the main species in Atlantic hazelwoods habitat, whilst in other habitats it is more minor contributing to understorey growth and it can also act as a pioneer species. Hazel is a very valuable species to wildlife providing food for a range of species in the habitats it occupies and also contributing to ecosystem services across its habitats. If *P. avellanae* reached these areas, some of which will have the highly acidic soils which might promote severe outbreaks of this pathogen, a **large** environmental impact would be seen. Due to both the uncertainty about the overlap of highly acidic soils and hazel distribution and also the potential impacts on wild hazel this has been scored with **low confidence**.

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

As previously discussed, this disease can be very destructive to hazel and this could alter the landscapes within the UK. In the UK lowlands, hazel is used for hedging and the crop from coppices is used for fences and other structures. Due to large scale changes to wider UK landscapes and ornamental settings which could occur, the social impact has been scored as **medium** with **medium confidence**.

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

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

There is no potential for this bacterium to act as a vector for further plant pathogens.

16. What is the area endangered by the pest?

The exact area endangered by *P. avellanae* is uncertain. To establish in GB, *P. avellanae* needs its host, *C. avellana*, which limits its distribution. In addition, the previously discussed prevalence of hazelnut decline on acidic soils could further limit the area endangered.

Stage 3: Pest Risk Management

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

Exclusion

The use of disease-free propagation material is the primary means of reducing the risk of importing *P. avellanae* into the UK. There is no evidence of *P. avellanae* being dispersed via infected hazelnuts, so propagation material remains the only pathway. Controls on imported *C. avellana* plants from the EU started on 1st January 2021. *Corylus avellana* is subject to a physical and identity check at a frequency of 100% in GB. In the initial stages of disease development hazel can be infected asymptomatically with *P. avellanae*. This applies to suckers taken from infected trees or material moved during the winter months, which is the tree planting season (Loreti *et al.*, 2009). Therefore, it is possible that *P. avellanae* could escape detection even with these controls in place. Sourcing material from pest free areas may be one way of mitigating against this risk.

Eradication and Containment

If *P. avellanae* was to be detected in the UK, statutory action would be taken to destroy infected stock. Early detection of infection may be inhibited by the potential for *C. avellana* to be asymptomatically infected. Therefore, by the time *P. avellanae* is formally detected it may have already spread to some degree. If there is a possibility that the pathogen has spread, measures could be taken to destroy hosts (*C. avellana*) over a certain area and place restrictions on the movement of these to prevent additional spread.

Non-Statutory Controls

Despite there being no recorded interceptions of *P. avellanae* in the UK, good hygiene practices should be followed for hazel propagation. These include the use of disease-free stock with an awareness of the stock's origin, regular inspection of stock and prompt removal and testing of any symptomatic plants. This should allow growers to notice an outbreak early if it occurs.

Additional good practices include having separate areas on site to quarantine new or suspected infected stock, reducing the chance of *P. avellanae* spreading to existing stock. These non-statutory controls should help complement statutory controls on *C. avellana* plants for planting.

18. References

Averis A, Averis B, Birks J, Horsfield D, Thompson D & Yeo M (2004) *An Illustrated Guide to British Upland Vegetation*. Joint Nature Conservation Committee pp.

CABI (2021) Pseudomonas avellanae (stem dieback of hazel nut). Available at: https://www.cabi.org/isc/datasheet/45001 (accessed 30/12/2021).

Emmett BA, Reynolds B, Chamberlain PM, Rowe E, Spurgeon D, Brittain SA, Frogbrook Z, Hughes S, Lawlor AJ, Poskitt J, Potter E, Robinson DA, Scott A, Wood C & Woods C (2010) Soils Report from 2007. Centre for Ecology & Hydrology.

Enescu CM, Houston Durrant T, de Rigo D & Caudullo G (2016) Corylus avellana in Europe: distribution, habitat, usage and threats. In *European Atlas of Forest Tree Species* (San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T & Mauri A eds.), Luxembourg, p. e015486+.

EPPO (2001) Pseudomonas avellanae (PSDMAL). Available at: https://gd.eppo.int/taxon/PSDMAL (accessed 30/12/2021).

EPPO (2004) Certification scheme for hazelnut. In *EPPO Bulletin*, pp. 149-153.

Forestry Commision (2021) Forestry Statistics 2021: A compendium of statistics about woodland, forestry and primary wood processing in the United Kingdom.

Frutos D (2010): Bacterial Disease of Walnut and Hazelnut and Genetic Resources. *Journal of Plant Pathology* **92** (1), S1.79-S71.85.

Gentili A, Mariotti E, Vincenzi A, Mazzaglia A, Heydari A, Schaad NW, Varvaro L & Balestra GM (2008): Dieback (Moria) of Hazelnut: Isolation and Characterization of two potential biocontrol agents. *Journal of Plant Pathology* **90** (2), 383-386.

Griesbach JA (2020) Hazelnut Bacterial Canker Pseudomonas avellanae Pest Risk Assessment. Oregon Department of Agriculture.

Janse JD, Rossi P, Angelucci L, Scortichini M, Derks JHJ, Akkermans ADL, De Vrijer R & Psallidas PG (1996): Reclassification of Pseudomonas syringae pv. avellanae as Pseudomonas avellanae (spec. nov, the Bacterium Causing Canker of Hazelnut (Corylus avellana L.). *Systematic and Applied Microbiology* **19** (4), 589-595.

Janse JD & Scortichini M (2008) Pseudomonas avellanae (Psallidas) Janse et al. Bacterial canker of hazelnut (Corylus avellana).

Korycinska A (2019) Annual frost days of Europe map 1988-2017. Unpublished analysis of Harris et al. (2020) Available at: https://crudata.uea.ac.uk/cru/data/hrg/

Lamichhane JR, Bartoli C & Varvaro L (2016): Extensive Field Survey, Laboratory and Greenhouse Studies Reveal Complex Nature of Pseudomonas syringae-Associated Hazelnut Decline in Central Italy. *PLoS One* **11** (2), e0147584.

Loreti S, Gallelli A, De Simone D & Bosco A (2009): Dectection of Pseudomonas avellanae and the bacterial microflora of hazelnut affected by 'moria' in central Italy. *Journal of Plant Pathology* **91** (2), 365-373.

NatureScot (2021) Atlantic hazelwood. Available at: https://www.nature.scot/landscapes-and-habitats/habitat-types/woodland-habitats/scotlands-rainforest/atlantic-hazelwood.

Passera A, Compant S, Casati P, Maturo MG, Battelli G, Quaglino F, Antonielli L, Salerno D, Brasca M, Toffolatti SL, Mantegazza F, Delledonne M & Mitter B (2019): Not Just a Pathogen? Description of a Plant-Beneficial Pseudomonas syringae Strain. *Front Microbiol* **10** 1409.

Psallidas PG (1993): Pseudomonas syringae pv. avellanae pathovar nov., the bacterium causing canker disease on Corylus avellana. *Plant Pathology* **42** 358-363.

Scortichini M (2002): Bacterial Canker and Decline of European Hazelnut. *Plant Disease* **86** (7), 704-709.

Scortichini M (2010): Epidemiology and predisposing factors of some major bacterial diseases of stone and nut fruit tree species. *Journal of Plant Pathology* **92** (1).

Scortichini M, Ferrante P, Cozzolino L & Zoina A (2015): Emended description of Pseudomonas syringae pv. avellanae, causal agent of European hazelnut (Corylus avellana L.) bacterial canker and decline. *European Journal of Plant Pathology* **144** (1), 213-215.

Scortichini M & Lazzari M (1996): Systemic Migration of Pseudomonas syringae pv. avellanae in Twigs and Young Trees of Hazelnut and Symptom Development. *Journal of Phytopathology* **144** (4), 215-219.

Scortichini M & Marchesi U (2001): Sensitive and Specific Detection of Pseudomonas avellanae using Primers based on 16S rRNA Gene Sequences. *Journal of Phytopathology* **149** 527-532.

Scortichini M, Marchesi U, Angelucci L, Rossi MP & Dettori MT (2000): Occurrence of Pseudomonas avellanae (Psallidas) Janse et al. and related pseudomonads on wild Corylus avellana trees and genetic relationships with strains isolated from cultivated hazelnuts. *Journal of Phytopathology* **148** 523-532.

Scortichini M, Natalini E & Marchesi U (2006): Evidence for separate origins of the two Pseudomonas avellanae lineages. *Plant Pathology* **55** 451-457.

UKSO (2022) UKSO Map Viewer. UK Soil Observatory. Available at: http://mapapps2.bgs.ac.uk/ukso/home.html (accessed 22/02/2022).

Wielkopolan B, Jakubowska M & Obrepalska-Steplowska A (2021): Beetles as Plant Pathogen Vectors. *Front Plant Sci* **12** 748093.

Name of Pest Risk Analysts(s)

Aaron Hoyle

This publication is available via the UK Plant Health Information portal https://planthealthportal.defra.gov.uk/

This PRA has been undertaken following IPPC International Standards for Phytosanitary Measures (ISPMs 2 and 11) and it provides technical evidence relating to the risk assessment and risk management of this pest.

Any enquiries regarding this publication should be sent to us at

The Chief Plant Health Officer

Department for Environment, Food and Rural Affairs

Room 11G32

Sand Hutton

York

YO41 1LZ

Email: plantpestsrisks@defra.gov.uk