Department for Environment Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for:

Corythucha arcuata

November 2018

Summary and conclusions of the rapid PRA

This rapid PRA is an update of one produced in 2007 and shows that the oak lace bug has the potential to add strain to trees and ecosystems which are already under threat from other pests and environmental factors. This pest has been present in Europe for some time, but in recent years its distribution has either expanded, or its population levels have increased so there is greater evidence of the potential effects of this pest, though still many uncertainties. The ratings for establishment potential and economic impact remain unchanged, however, more evidence of the potential of this pest to move on wood and wood products has led to a raising of the risk of entry, and evidence from Europe suggests that this pest may have a greater potential environmental impact than previously rated.

Risk of entry

Although oak trees are the preferred host, there are a number of other tree species that can be potential hosts, and therefore entry has been assessed accordingly.

Entry on plants for planting has been assessed as **moderately likely** with **medium confidence**. The oak lace bug is most likely to be associated with plants for planting when overwintering under loose bark scales and in crevices. Most plants imported into the UK are likely to be young trees, with few bark crevices. Larger trees do represent a significant

risk, as it would be difficult to determine if they were pest free, however the numbers are likely to be fewer.

Entry on wood and wood products with bark associated has been assessed as **likely** with **medium confidence**. These are considered as higher risk due to the potentially larger volumes of plant material entering the UK from areas where the oak lace bug is established.

Hitchhiking on transport mechanisms has been assessed as **moderately likely** with **low confidence**, due to the current location of outbreak sites and the barrier of the sea in crossing.

Risk of establishment

The temperate climate of the UK is not thought to be a barrier to this pest's establishment outdoors, and this is rated as **likely** with **high confidence**.

Establishment under protection is **unlikely** with **high confidence** due to the limited hosts under protection.

Economic, environmental and social impact

Economic impacts have been rated as **small**, with **medium confidence**, as it is thought that impacts on the nursery trade, where populations may be more likely to be controlled, and on wood production would not to be as high as in the areas of Europe where the pest has established.

Environmental impacts have been rated as **medium**, due to the lower chance of eradication in a forest environment and cumulative effect of this pest on the health of UK woodlands and iconic amenity trees. There is **low confidence** due to the current speculative nature of the cumulative impacts.

Social impacts have been rated as medium, with medium confidence, as oaks are iconic in the UK, and public concern over a pest of oaks is likely.

Endangered area

Oak trees across the whole of the UK. While other tree species on which the oak lace bug has been found are considered potential pathways into the UK there is insufficient data to suggest they are themselves endangered.

Risk management options

The implementation of a Protected Zone in the UK, is a potential option for exclusion of this pest.

The effectiveness of eradication and containment measures in the event of a UK outbreak is likely to depend on where the outbreak is first found, and how quickly. If found at a nursery, or in the vicinity of wood importers soon after import, and on a small number of trees then effective chemical treatment may be possible. Should the pest be first detected in the wider environment, such as in an oak wood, eradication potential is considered less likely, largely due to the practicalities of treating larger trees in a large area, where there may be many potential hosts.

There are no current biological control options which have been tested for large scale use.

Key uncertainties and topics that would benefit from further investigation

- Potential impacts in the UK: the UK has a temperate climate, unlike areas where the pest has currently established in Europe, and so population levels may be unlikely to reach the same levels. However, it lacks native parasitoids and predators which help to keep the population numbers at a lower level in North America.
- More research into potential biological control methods
- Research into the environmental impacts on infested trees: what is the impact of early leaf loss and reduced photosynthesis, e.g. effects on growth and acorn production and susceptibility to other pests.
- The relative importance of hosts other than *Quercus* – are these only hosts in cases of high population concentrations? How favoured are *Quercus* in comparison?

Images of the pest

	
Oak lace bug adult © Gyögy Csoka (Hungary)	Oak lace bug eggs hatching © Gyögy Csoka (Hungary)

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.

This PRA has utilised all known current information sources. If more information which has a bearing on key areas of this analysis became available then this PRA would be revised and updated accordingly.

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?

[The text below is a recommendation by the risk analyst which requires approval by PHRG]

Yes Statutory action	✓	No Statutory action	

Stage 1: Initiation

1. What is the name of the pest?

Corythucha arcuata (Say) Tingidae: Hemiptera – Oak Lace Bug.

Synonym = *Corythuca arcuata*. Note the alternative spelling of the genus, without an “h” towards the end.

French common name: punaise reticulée du chêne.

2. What initiated this rapid PRA?

This is an update of a PRA published in 2007. Since this date the pest has expanded its distribution in Europe, and there is more information on its host range and impacts. There is concern that this pest may spread to the UK, and further consideration of potential management measures to mitigate this are considered in this PRA.

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]?

Pest is not listed in the EC Plant Health Directive and is not recommended for regulation as a quarantine pest by EPPO, nor is it currently on the EPPO Alert List. It was formerly on the alert list but removed in 2007 following a conclusion from an Italian PRA that its spread could not be stopped (Bernardinelli, 2003).

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

[2] https://www.eppo.int/ACTIVITIES/quarantine_activities (accessed 22 October 2018)

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

Corythucha arcuata is native to North America, and was first reported in Europe in northern Italy in 2000, although the size of the area over which it was found suggests that its introduction had been considerably earlier (Bernardinelli, 2000; Bernardinelli, 2001). It has since either been separately introduced to or spread to other areas of Europe, either from Italy, or from Turkey, where it was discovered in 2003. The distribution, and dates of first findings outside North America, detailed below comes from the EPPO Global database (https://gd.eppo.int), unless otherwise referenced, however, given the length of time till first discovery in Italy, and observations that the lace bug is not easy to spot when in low numbers, it is highly possible that the distribution of this pest is already wider than is recorded here.

Table 1: Distribution of *Corythucha arcuata*, with dates of the first reports in countries where it has been introduced

North America:	Canada (Manitoba, Ontario, Québec); USA (Alabama, Minnesota, Nebraska, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Vermont, Virginia, West Virginia).
Central America:	Absent
South America:	Absent
Europe:	Albania (2016) (Berta *et al*., 2018)[1], Bosnia & Herzegovina (2017), Bulgaria (2012), Croatia (2013) (Hrašovec, 2013), France (2017), Greece (2018) (pers comm. Dr Dimitrios Avtzis), Hungary (2013), Italy (2000), Romania (2016), Russia (2015), Serbia (2012), Slovakia (2018) (Zubrik *et al*., in press), Slovenia (2016) (Jurc & Jurc, 2017), Switzerland (2002) (Dioli *et al*., 2007; Forster *et al*., 2005)
Africa:	Absent
Asia:	Iran (2005); Turkey (2003)
Oceania:	Absent

[1] This reference is from a map in a presentation. Original reference to this has not been found and for this reason Albania is marked as tentative on the map below

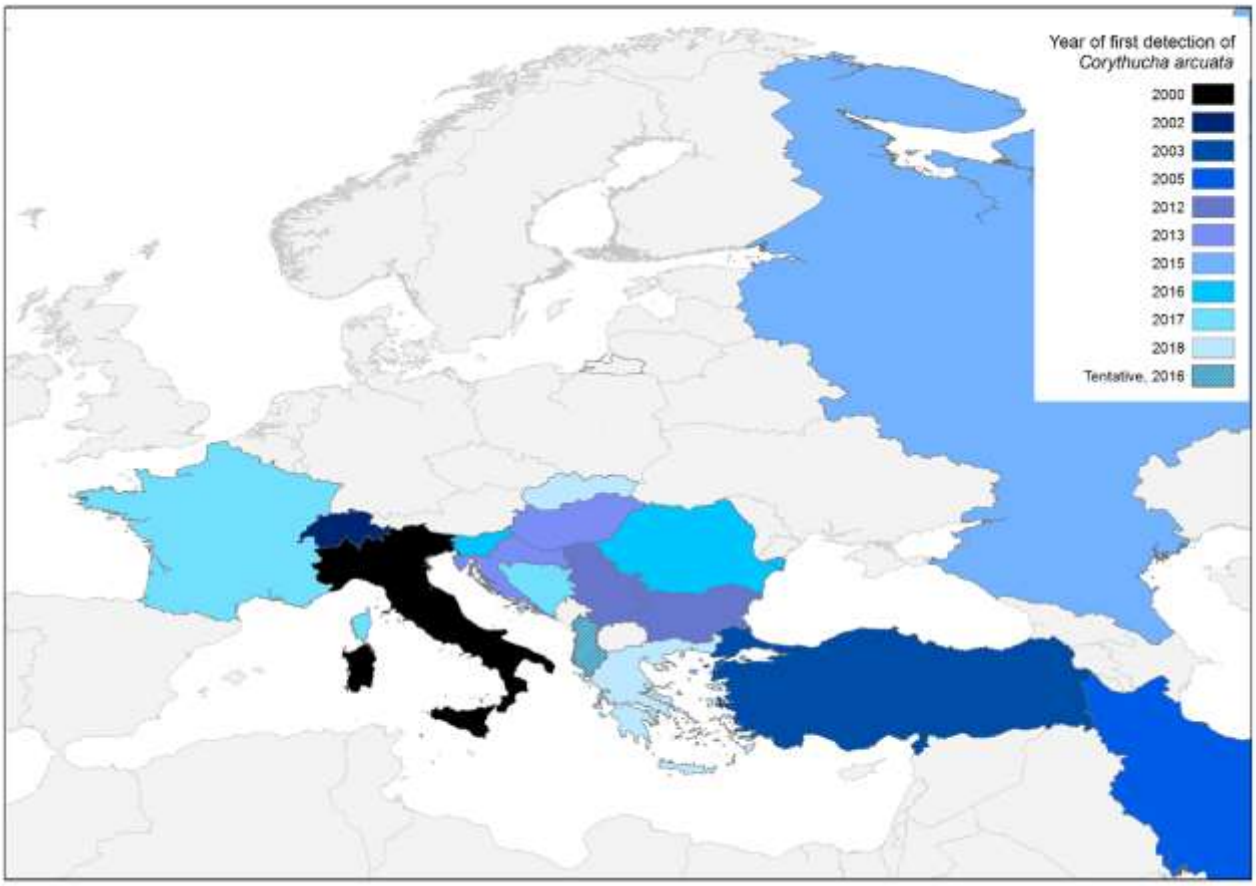

Figure 3. Map showing presence of *C. arcuata* in Europe – with guide to first year of detection.

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

The pest is currently absent from the PRA area, and there have been no recorded interceptions or outbreaks.

An outbreak of a related species, *Corythucha ciliata*, a pest of *Platanus* (plane trees), was detected in the vicinity of a nursery in the UK in 2006. Following treatment, and no further findings, this pest has been declared absent from the UK.

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?

Records taken from those compiled by Csóka *et al* (2017) unless otherwise referenced. The grading of the symptoms in Table 2 is also based on Csóka *et al* (2017), and is based on the most severe reported. Reports do vary between countries, and many reports do not distinguish between severity of attack on species.

Table 2: Hosts species which have been reported by countries or mentioned in literature.					
Host species	**Symptoms very common, and often abundant**	**Symptoms common, sometimes abundant**	**Symptoms or record rare/ occasional**	**Country report originated**	**Reference(s)**
Acer campestre			✓	Hungary	
Acer laetum			✓	Russia	Neimorovets *et al*. (2017)
Acer saccharinum			✓	USA – known to overwinter	Connell & Beacher, 1947
Carpinus betulus			✓	Hungary	
Castanea dentata			✓	USA	Drake and Ruhoff, 1965
Castanea sativa	✓			Croatia, Hungary	
Corylus avellana			✓	Hungary	
Corylus colurna			✓	Hungary	
Cotinus coggygria			✓	Hungary	
Fagus sylvatica			✓	Hungary	
Kerria japonica			✓	Hungary	
Koelreuteria paniculata			✓	Hungary	
Liquidambar styraciflua			✓	USA – known to overwinter	Connell & Beacher, 1947
Lysimachia punctata			✓	Hungary	
Malus sylvestris			✓	Croatia, USA	Drake and Ruhoff, 1965 (USA, *Malus*); Milan and Nikola (2017) (Croatia)
Prunus avium			✓	Russia	Neimorovets *et al*. (2017)
Prunus serrulata			✓	Hungary	
Prunus serotina	✓			Hungary	
Prunus spinosa			✓	Hungary	
Pyrus			✓	USA	Drake and Ruhoff, 1965
Quercus alba	✓			Hungary, Italy, USA	Connell & Beacher, 1947 (for USA)

Table 2: Hosts species which have been reported by countries or mentioned in literature.					
Host species	**Symptoms very common, and often abundant**	**Symptoms common, sometimes abundant**	**Symptoms or record rare/ occasional**	**Country report originated**	**Reference(s)**
Q. cerris	✓			Bulgaria, Croatia, Hungary, Italy, Romania, Serbia	Chireceanu *et al*. (2017)
Q. frainetto	✓			Bulgaria, Croatia, France, Hungary, Italy, Romania	EPPO reporting Service (2018) (France)
Q. hartwissiana	✓			Bulgaria, Russia	Neimorovets *et al*. (2017) (Russia)
Q. ilex			✓	Croatia	
Q. imbricaria			✓	Hungary	
Q. libani	✓			Hungary	
Q. macranthera		✓		Hungary	
Q. macrocarpa			✓	Hungary, USA	Connell & Beacher, 1947 (for USA)
Q. montana			✓	USA	Connell & Beacher, 1947
Q. muehlenbergii			✓	USA	Drake and Ruhoff, 1965
Q. pedunculiflora	✓			Bulgaria, Romania, Russia	Neimorovets *et al*. (2017) (Russia)
Q. petraea	✓			Bosnia-Hertzegovina, Bulgaria, Croatia, France, Hungary, Italy, Romania, Serbia, Switzerland, Turkey	EPPO reporting Service (2018) (France)
Q. prinoides			✓	USA	Drake and Ruhoff, 1965
Q. pontica		✓		Hungary	
Q. pubescens	✓			Bulgaria, Croatia, Hungary, Italy, Russia, Turkey	Neimorovets *et al*. (2017) (Russia)
Q. robur	✓			Bulgaria, Croatia, France, Hungary, Italy, Romania,	EPPO reporting Service (2018) (France)

Table 2: Hosts species which have been reported by countries or mentioned in literature.					
Host species	**Symptoms very common, and often abundant**	**Symptoms common, sometimes abundant**	**Symptoms or record rare/ occasional**	**Country report originated**	**Reference(s)**
				Russia, Serbia, Slovenia, Turkey	
Q. rubra			✓	USA	Drake and Ruhoff, 1965
Q. virgiliana	✓			Turkey	
Robinia pseudoacacia			✓	Hungary, Russia	Neimorovets *et al*. (2017)
Rosa canina		✓		Hungary, USA	Drake and Ruhoff, 1965 (USA, *Rosa*)
Rubus caesius	✓			Hungary	
Rubus ideaus				Italian experimental study only	Bernardinelli, 2006
Rubus ulmifolius				Italian experimental study only	Bernardinelli, 2006
Sorbus aria			✓	Hungary	
Sorbus torminalis			✓	Hungary	
Tilia cordata	✓			Hungary	
Tilia platyphyllos	✓			Hungary	
Ulmus glabra			✓	Hungary	
Ulmus minor		✓		Croatia, Hungary, Russia	Milan and Nikola (2017) (Croatia); Neimorovets *et al*. (2017) (Russia)

Pests highlighted in yellow are those on which the oak lace bug has been recorded in the USA.

A study (still in press) has been carried out in stands, botanical gardens and arboreta of many European countries. Almost all Eurasian oak species are suitable hosts and may suffer severe infestation levels, except evergreen ones (*Q. coccifera* and *Q. ilex*). North American white oaks are also suitable hosts, however, North American red oaks (e.g. *Q. coccinea*, *Q. palustris* and *Q. rubra*) do not appear to be suitable, and records on these do seem to be rare (pers. comm. Dr G Csóka).

8. Summary of pest biology and/or lifecycle

The oak lace bug is native to North America. Studies in Delaware have reported two and a partial third generations, with some second generation females laying eggs in sufficient time for individuals of the third generation to reach adulthood before normal leaf-fall.

The eggs are nearly elliptical in outline, 0.56mm long by 0.24mm diameter and laid in irregularly arranged groups or clusters on the under surface of the leaf of the host plant, with eggs often being added to clusters on subsequent days, or by different individual females. Number of eggs laid has been recorded ranging from 15 to more than 100 per female (Milan and Nikola, 2017). The duration of each of the first four nymphal stages is reported as 2 -3 days, with the fifth instar stage lasting 6-7 days. From egg to adult full development takes 4-6 weeks.

Adults overwinter beneath loose bark scales on trunks and larger limbs of living trees, and also under bark scales on logs (Connell & Beacher, 1947). Overwintered adults move to leaves as soon as they begin to appear in the spring.

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?

Plants for planting

The first recorded finding of *C. arcuata* in Italy was made in one of the parks near Milan (Bernardinelli & Zandigiacomo, 2000), and studies soon after showed that the highest populations were found around the Milan area (Bernardinelli, 2000). Hence, it has been suggested that the introduction may have been through the planting of infested plants that had been imported. Eggs are likely to be associated with foliage, and so the import of dormant plants reduces the risk of movement of eggs, which may be hard to spot. However, as the adults are known to overwinter under the loose bark scales of oak tree trunks and larger branches (Connell & Beacher, 1947; Csóka *et a*l., 2017), even the import of leafless specimen trees could bring the pest into the UK.

However, most plants which are imported into the UK are likely to be young trees, with few bark crevices and a lower likelihood of association with overwintering oak lace bugs. While larger specimen plants are moved, either as rootballs or heavy potted specimens the numbers are likely to be fewer. These larger trees do, however, represent a significant risk as it would be very difficult to determine if these trees were pest free, and the trees are more likely to be moved straight to planting sites. It is also worth noting that oak trees, other than *Quercus suber*, with a girth at 1.2 m above the root collar of 8 cm or more do have requirements with respect to oak processionary moth (*Thaumetopoea processionea*), including inspections, which may help reduce the likelihood of importing the oak lace bug

as well. This only applies to oak trees, however, and not other potential hosts, and as the oak lace bug is not a listed pest, would not prevent the import of these trees.

Quercus plants with leaves are prohibited from Non-European countries (Annex III, Plant Health Directive 2000/29/EC), however this would not prohibit the movement of dormant *Quercus* from North America, on which oak lace bugs could be overwintering cryptically. Volumes from Europe, are, however, likely to be higher. Data on imports of all potential host species is not available, however, the table below (Table 3), documents data relating to *Quercus* imports from the EU notified from April 2017 – March 2018, a total of 2619 consignments, consisting of 196107 plants. In March 2018, as an example, 3 consignments, a total of 8 plants, were imported from France, while 89 consignments, a total of 1320 plants were imported from Italy. Other imports during that month were from countries where the oak lace bug is currently unknown, however, it is worth noting that there is an industry practice of sending young trees down to Italy for 1-2 years to enable them to put on size more quickly, before they are re-lifted and returned north to countries such as Germany and the Netherlands, for a final year of finishing before being sold. Specific data on the number of trees being moved in this way is unavailable, however the oak lace bug has not, to date being found in more northern European countries. Data on specific sizes is inconsistently recorded.

Overall, the risk from plants for planting has been rated as likely, with low confidence. This is largely taking into account the uncertainty over the volume of larger trees likely to be entering. If more specific data becomes available which suggests that this volume is smaller then the risk and uncertainty may be lowered.

Table 3: Data on number of *Quercus* consignments and plants notified to PHSI (2017-2018) (APHA, 2018)

Month	Number of consignments notified as arriving in that month	Number of plants
April	155	11677
May	102	2282
June	53	935
July	51	544
August	62	405
Sept	83	906
October	164	3554
November	517	41696
December	270	25297
January	347	39451
February	426	39808
March	388	29552

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

Confidence	High Confidence ☐	Medium Confidence ☐	Low Confidence ☑

Wood and wood products

Although oak trees are the preferred host, there are a number of other tree species that can be potential hosts, and therefore movement of wood of any species considered an overwintering host could be considered a pathway.

The movement of wood and wood products has become the focus of attention through the measures being implemented by the Croatian authorities to try and reduce the spread of the oak lace bug within Croatia. Wood and wood products which could be associated with the lace bug could be logs, wood with bark still associated and wood chips which include bark. Wood with bark removed is not being considered as there is no known association of the pest with this part of the host plants, however it is worth noting that processes to remove bark are unlikely to be perfect and therefore wood with any bark still remaining would still be considered a risk. Oak lace bugs are known to overwinter in crevices in the bark and so any plant material which is known to be a host on which the lace bug overwinters could potentially be a pathway of entry. The information available on the level of association the oak lace bug has with different hosts varies between countries, but specific data on overwintering hosts is not currently available.

Due to the uncertainties regarding overwintering hosts, the quantities and frequency of import of wood and wood products of concern from the countries where the oak lace bug has been confirmed is unclear. In terms of oak firewood, 27 tonnes were reported as imported from Canada in 2017. There are no other notified records of similar imports from countries known to have the oak lace bug, but these figures are likely to be an underestimate as unregistered imports of firewood entering the UK cannot be ruled out. There were much larger quantities of oak timber in the rough (see Table 4), which is wood which has been sawn and air dried, but is likely to carry residual bark. However data on other potential host pathways is not available.

There is higher confidence relating to the risk of wood and wood products than plants for planting, due to the potential larger volumes of the plant material entering.

Table 4: UK imports of *Quercus* timber in the rough (courtesy of FC, 2018)

	Three year average (2015-2017) - kg	2018 (Jan – Aug) - kg
Czech Republic	16,099	
Finland	13,575	
France	1,219,001	1,145,255
Germany	2,985	137,613
Irish Republic	1,434,129	914,559
Italy	100,401	
Latvia	26,057	
Netherlands	20,472	44,355

Table 4: UK imports of *Quercus* timber in the rough (courtesy of FC, 2018)		
	Three year average (2015-2017) - kg	2018 (Jan – Aug) - kg
Poland	65,963	
Sweden		37,531
Moldova	3,876	
Canada	84,633	
United States	112,735	25,048
Total	**3,099,926**	**2,304,361**

Wood and wood products	Very unlikely	☐	Unlikely	☐	Moderately likely	☐	Likely	☑	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			

Hitchhiking

Hitchhiking on several mediums of transport has been mentioned by different countries as the likely means of rapid spread within states and between neighbouring countries. At present this pathway is of lower risk to the UK than it may be in the future due to the distance from the nearest outbreak site, currently in southern France, and the barrier of the sea in crossing. However, as the oak lace bug moves across Europe, this pathway is likely to increase in likelihood and concern, as it is difficult to mitigate against.

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

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

No vector is required. This is a free living organism.

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

Although *C. arcuata* has to date not been found in more temperate regions in Europe, the presence in the UK of known host plants and the pest's distribution in the USA (across

many of the northern and eastern states, and into southern Canada), suggests that the pest would have no problem establishing and overwintering in the UK. Following the pest's introduction to Hungary, work was carried out to look at how the relatively cold winter of 2016-2017 affected the mortality of the overwintering lace bugs. The study sampled 4770 lace bugs from 5 locations. The survival rate was 63.6%, further suggesting that cold winters themselves are not likely to limit areas of potential establishment (Csepelényi *et al*. (2017a)).

In Delaware, USA, where it is native, *C. arcuata* is known to have two and a partial third generation per year, with some adults from the second generation and those from the third overwintering (Connell & Beacher, 1947). In Italy, with the warmer climate, *C. arcuata* can complete three generations a year and have a partial fourth (Bernardinelli, 2000). In South East European countries with mild winters and hot summers, up to three generations per year have been recorded (Csóka, *et al*. (2017).

In the UK the pest would be more likely to follow the lifecycle pattern from the north eastern states of the USA, which has a more comparable climate (i.e. two complete generations per year and a partial third).

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

Host plants are not commonly grown in protected environments, although a few, such as Acers may be kept under protection on nurseries, and cherries may be grown in protected environments. On this basis establishment under protection is considered unlikely with high confidence. The first records in Hungary were found to be in arboretum and botanical gardens, but communication with the author of the first finding report confirms they were found outdoors and not under protection (Csóka, *et al*., 2013).

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

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

Although the oak lace bug was discovered in Europe in 2000, it had likely been present for many years prior to its discovery. Initial information on potential rates of spread were, therefore, very limited and suggested that spread may not occur quickly, however it may also relate to the oak lace bug being very difficult to detect at low population densities, and first findings in an area possibly only being made some time after the pest had been introduced.

Recent information from Croatia and Hungary suggests that the rate of spread may be higher than previously thought. In Hungary the species was first detected in 2013 in limited areas, and in five years it had spread widely across the country (Csepelényi *et al*., 2017b). In Croatia the link has been made between spread, the presence of roadways and high pest population levels, although whether the spread being recorded in Croatia is down to the movement of logs, timber and wood chips or natural spread assisted by movement of road traffic is difficult to be certain. However, evidence from Croatia does show that new areas of infestation have been found in the vicinity of traffic rest stops, main junctions, large processing plants and border crossings, all of which suggest that movement via the traffic or the commodity that the traffic is carrying is a significant factor. It had also been previously reported from Italy and Bulgaria that the pest's movement was thought to be favoured by road traffic (Bernardinelli, 2000; Dobreva, 2013), and the link has also been made in Slovenia (pers comm. Rebecca McIlhiney). Additionally, it is speculated the oak lace bug was a hitchhiker on rail traffic in Slovenia and Russia (Jurc & Jurc, 2017; Neimorovets *et al*., 2017).

Croatian authorities report that they are slowing the spread of the oak lace bug through adopting the Croatian Order (Berta *et al*., 2018; Croatian Ministry of Agriculture, 2017). This includes owners and holders of plants being required to control and monitor the health status of the plants that they grow or produce, and inform forest inspectors of any occurrence of the oak lace bug. It also specifies that any transfer or transportation of wood of *Quercus robur* and *Quercus petraea* which has completely or partially retained its natural round surface (with or without bark), and planting material of the same specified species should be limited for two years. Further species are listed (*Quercus cerris*, *Q. pubescens*, *Q. rubra*, *Carpinus betulus*, *Castanea sativa* and *Malus sylvestris*) for which relocation is permitted from the place of production to the place of processing by transfer or transportation via the shortest route, and wood of these species should be treated to reduce the natural surface area and contain less than 20% moisture before transportation. If these preliminary reports are accurate it would link the movement of the pest more firmly with trade.

Natural spread	Very slowly	☐	Slowly	☑	Moderate pace	☐	Quickly	☐	Very quickly ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			
With trade/transport	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?

Oak lace bugs feed on the lower surface of the leaves and large populations can cause yellowing and browning of the foliage, leading to premature leaf drop. This reduces the

vigour and growth of affected trees (University of Minnesota Extension, 2018). Weakened trees are likely to be more susceptible to other pests and diseases as well as other stress factors such as drought (Connell & Beacher 1947; Bernardinelli, 2000).

In the USA *Corythucha arcuata* is well known in forests, and is a common pest of ornamental trees and shrubs. It is of particular importance to amenity trees as the discoloration and premature leaf fall reduces their ornamental value. In the forests natural enemies are usually effective, but control measures need to be taken early on shade and ornamental trees, while the insect is in its first generation and before visible scarring occurs (Shetlar, 2011; Connell & Beacher, 1947).

In Italy it is known to have caused damage in parks and is seen as a threat to both woodland and amenity trees (Bernardinelli & Zandigiacomo, 2000). When present in large numbers the oak lace bug can reduce the value of amenity trees as discoloration and premature leaf drop reduces their aesthetic ornamental value. However, despite the length of time since its introduction into Italy, no significant damage has been recorded there (Ministero delle politiche agricole, alimentary e forestali, 2018).

In Hungary the oak lace bug has rapidly spread since its introduction in 2013, with severe infestations causing 100% discolouration of the foliage as early as late June. To date long term consequences of this reduction in photosynthesis are not yet known, but it is difficult to see how this early discolouration could have no negative effects on a trees health and growth status, especially if repeated in consecutive years (Csepelényi *et al*., 2017b and pers. comm. with Dr G Csóka, 2018). There are also preliminary results suggesting that the acorn crop is negatively affected by severe infestation, which, along with the decrease in quality of oak leaves, may have consequences for wildlife and the natural regeneration of oak trees (Pers comm. Dr G Csóka, 2018). In Croatia the main impacts have been on forest areas. Data from the Croatian PRA (Milan and Nikola, 2017) suggested that there had been a drop in photosynthesis index for the part of the PRA area where the oak lace bug is established. There is concern in Croatia that the oak lace bug could decrease the growth and quality of the timber in affected forests and that impacts could be higher due to cumulative effects of this, other pests and abiotic factors.

It is also worth noting here that there are some potential human health concerns with oak lace bug. Publications have already been made about the dermatological effects caused by the plane lace bug *Corythucha ciliata*, biting humans. In most cases people do not report a reaction to the bite, but in some cases it causes skin lesions, although these appear to clear up quickly. The oak lace bug is thought to cause similar symptoms (Dutto & Bertero, 2013; Izri *et al.*, 2015.

Overall, *C. arcuata* is not considered a significant pest in its native range in North America, and although it has been present in Italy for some time prior to its discovery in 2000 it had not been considered a significant pest in Europe until reports of damage from Croatia and Hungary in the wider forestry environment. There are concerns in Europe over the population levels reached in some European countries and the cumulative impacts these

pests could have on forests which are already under other stresses. However, the pest itself does not cause host mortality.

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?

The potential impacts in the UK are the area of greatest uncertainty. Croatia and Hungary have both reported rapid spread of the oak lace bug and large population build up. This may be connected to the hot summers in these regions allowing the number of generations to exceed those found in more temperate parts of North America, and this, with the lack of native parasitoids and predators (only occasional predation e.g. by ladybirds has been noted in Hungary – pers comm. Dr G Csóka), has led to a build-up in the populations of oak lace bugs in its invasive habitat (Csóka, *et al*., 2017). What is not clear is the effect that it is likely to have in more temperate regions of Europe, including the UK. There is still a risk of populations being higher than in comparable areas of North America because of the lack of natural predators and parasitoids, however the cooler UK climate is likely to limit the number of generations the pest can complete in a year which may limit the impacts in the UK. This does not, however, rule out the possibility of impacts in the UK during a hot summer when trees are more likely to be stressed already. Whether these impacts would be greater than those of pests already present in the UK is unknown.

Economic impacts on the nursery trade, where populations may be more likely to be controlled, and on wood production are not thought to be as high as in the areas of Europe where the pest has established. However, social and environmental impacts are considered as potentially higher, due to the difficulty of spotting an outbreak due to the effects of native bugs which cause similar damage, the lower chance of eradication in a forest environment, and the cumulative effect of this pest on the health of UK woodlands and iconic amenity trees. There is concern that if the oak lace bug established in the UK it could be another factor contributing to oak decline, especially in areas of the country where these trees are already threatened by other invasive pests. There are also uncertainties about the long term effects of the oak lace bug on seedlings and young stands, on the crops of acorns produced by affected trees and on populations of native species which rely on oaks for their habitat and food – both acorns and herbivores which feed on the leaves. There is low confidence with the environmental rating in particular due to the possibility of lower impacts due to the UK climate, and the current speculative nature of the cumulative impacts, in terms of both time and how trees would cope with this and other pests.

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	☐				

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

Corythucha arcuata has not been recorded as a vector of plant pathogens, however, due to the oak lace bug being invasive there is a possibility of it coming into contact with a pathogen not previously encountered and acting as a vector.

16. What is the area endangered by the pest?

Oak trees across the whole of the UK. Oaks are common in the UK, in woodlands, parklands, agricultural and urban environments, as well as private gardens. They form an important part of the landscape and many individual specimens are considered iconic. While other tree species on which the oak lace bug has been found are considered potential pathways into the UK there is insufficient data to suggest they are themselves endangered.

Stage 3: Pest Risk Management

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

Exclusion

One possible option for exclusion from the UK is the implementation of a Protected Zone.

To implement a Protected Zone requirements for the import of plants for planting and wood of oak would be needed. Possible requirements would be:

Plants of *Quercus*, intended for planting, other than fruits and seeds

(a) the plants have been grown throughout their life in places of production in countries where *Corythucha arcuata* is not known to occur, or
(b) the plants have been grown throughout their life in an area free from *Corythucha arcuata* established by the national plant protection organisation in accordance with relevant International Standards for Phytosanitary Measures, or
(c) the plants have been produced in nurseries which, including their vicinity, have been found free from *Corythucha arcuata* on the basis of official inspections and official surveys carried out at appropriate times, or
(d) the plants have been grown throughout their life in a site with complete physical protection against the introduction of *Corythucha arcuata* and have been inspected at appropriate times and found to be free from *Corythucha arcuata*.

Wood of *Quercus*

(a) The wood shall be bark free, or
(b) Official statement that the wood:
(i) Originates in areas known to be free from *Corythucha arcuata*.
or
(ii) has undergone kiln-drying to below 20 % moisture content, expressed as a percentage of dry matter, achieved through an appropriate time/temperature schedule. There shall be evidence thereof by a mark 'Kiln-dried' or 'KD' or another internationally recognised mark, put on the wood or on any wrapping in accordance with current usage.

There is no actual evidence of the effect of kiln drying on the species *C. arcuata*. However, it has been included as a possible option due to its inclusion on the protected zone for bark beetles.

Eradication / Containment

The effectiveness of eradication and containment measures in the event of a UK outbreak is likely to depend on where the outbreak is first found, and how quickly. If found at a nursery, or in the vicinity of wood importers soon after import, and on a small number of trees then effective chemical treatment may be possible. There is precedent for this from a similar non- native species, *Corythucha ciliata*, the plane lace bug. In Autumn 2006, *C. ciliata* was discovered on two nurseries in Bedfordshire on *Platanus* trees imported from France and Italy. The trees were large and although pesticide treatment (Bifenthrin) was applied it was assumed that the plane lace bug would establish in the vicinity. The lace bug was even entered as present on the UK Plant Health Risk Register. However, subsequent searches of the areas where the lace bug was first discovered have shown no evidence that the plane lace bug ever established, and the pest is considered to have been eradicated from the UK.

Should the pest be first detected in the wider environment, such as in an oak wood, eradication potential is considered less likely, largely due to the practicalities of treating larger trees in a large area, where there may be many potential hosts. Removal and destruction of infested trees is unlikely to be effective due to the range of hosts and types

of material (e.g. dead wood as well as live wood) the lace bug could be present on, and may be more destructive than the pest itself. In Croatia, the view is that natural spread to adjacent forest areas cannot be stopped with current available pest controls. Use of highly effective chemicals is not allowed in forest areas according to FSC standards and, in Croatia, no significant natural enemies have been reported (Berta *et al*. 2018). Croatian authorities have put in place official measures to try and prevent the spread of the oak lace bug to new locations. These include:

- Restrictions on movement of planting material
- Restrictions on movement of wood products

Reports from Croatia have been that the spread has been slowed by these measures, but new areas of infestation have been still found. If the oak lace bug was found in the UK, similar measures to those above could be imposed on planting material and wood products with bark as part of containment strategies. However, reports from other European countries where the oak lace bug has established do suggest that human road / rail travel in general can aid the spread of this pest, so how much impacts on the rate of spread such measures would have is unclear.

There is ongoing research into different control mechanisms, including looking at entomopathogenic fungi. Ten of these were tested in laboratory conditions in 2013 with *Beauvaria bassiana* causing the highest mortality against both nymphs and adults (Sönmez, *et al*., 2017). This seems to have potential for development as a biological control agent against *C. arcuata*, however the usage of this may be more appropriate for amenity trees and nurseries rather than forests, where the number and area or coverage of affected trees may be greater. It's potential application does not seem to have been tested more widely.

Non-statutory controls

Gardeners and nursery owners in the USA are advised to use a variety of methods to remove lace bugs these include;

- High pressure water spray
- Insecticidal soaps and oils
- Broad spectrum pesticides

However, in the USA oak lace bugs are not generally considered to affect plant health (University of Minnesota Extension, 2018). This is probably largely due to the number of native predators, including syrphid larvae; two mirid bugs, *Hyaliodes vitripennis* and *Deraeocoris nebulosus,* and the anthocorid *Orius insidiosus* (which is used in IPM)*,* (Connell & Beacher, 1947; Wheeler et al., 1975), but, apart from syrphid larvae, none of these appear to be naturally present in the UK, and the syrphid species in the UK are likely to be different from most of the US syrphid fauna (Schaefer & Panizzi, 2000). It is unknown whether any of the US native predators would be suitable for release in the UK, but the

three bugs named above are known as general predators and would be unlikely to be suitable (Chouinard, *et al*., 2006; Wheeler *et al*., 1975; Wikipedia: *Orius insidiosus*, 2018).

Raising awareness of this pest may also be useful, as this aids in the identification of findings early. In the UK this pest is already one of the Observatree priority pests, highlighting the pest with citizen science, and nurseries and forestry have already been alerted through a Defra pest alert.

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