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Agrilus anxius
Pest Report to support ranking of EU candidate priority pests

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1. Introduction to the report

This document is one of the 28 Pest Reports produced by the EFSA Working Group on EU Priority Pests under task 3 of the mandate M-2017-0136. It supports the corresponding Pest Datasheet published together on Zenodo[1] and applies the methodology described in the Methodology Report published on the EFSA Journal (EFSA, 2019).

This Pest Report has five sections. In addition to this introduction, a conclusion and references, there are two key sections, sections 2 and 3.

Section 2 first summarises the relevant information on the pest related to its biology and taxonomy. The second part of Section 2 provides a review of the host range and the hosts present in the EU in order to select the hosts that will be evaluated in the expert elicitations on yield and quality losses. The third part of Section 2 identifies the area of potential distribution in the EU based on the pest's current distribution and assessments of the area where hosts are present, the climate is suitable for establishment and transient populations may be present. The fourth part of Section 2 assesses the extent to which the presence of the pest in the EU is likely to result in increased treatments of plant protection products. The fifth part of section 2 reviews additional potential effects due to increases in mycotoxin contamination or the transmission of pathogens.

In Section 3, the expert elicitations that assess potential yield losses, quality losses, the spread rate and the time to detection are described in detail. For each elicitation, the general and specific assumptions are outlined, the parameters to be estimated are selected, the question is defined, the evidence is reviewed and uncertainties are identified. The elicited values for the five quantiles are then given and compared to a fitted distribution both in a table and with graphs to show more clearly, for example, the magnitude and distribution of uncertainty. A short conclusion is then provided.

The report has two appendices. Appendix A contains a host list created by amalgamating the host lists in the EPPO Global Database (EPPO, online) and the CABI Crop Protection Compendium (CABI, 2018). Appendix B provides a summary of the evidence used in the expert elicitations.

It should be noted that this report is based on information available up to the last day of the meeting[2] that the Priority Pests WG dedicated to the assessment of this specific pest. Therefore, more recent information has not been taken into account.

For *Agrilus anxius*, the following documents were used as key references: pest risk analyses (PRAs) by EPPO (2011) and Norway (VKM, 2012).

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[1] Open-access repository developed under the European OpenAIRE program and operated by CERN, https://about.zenodo.org/

[2] The minutes of the Working Group on EU Priority Pests are available at http://www.efsa.europa.eu/sites/default/files/wgs/plant-health/wg-plh-EU_Priority_pests.pdf

2. The biology, ecology and distribution of the pest

2.1. Summary of the biology and taxonomy

Agrilus anxius is a single taxonomic entity. Its larvae feed primarily on plant tissue (phloem and cambium found under the bark) of birch, cutting off the flow of water and nutrients to the tree. Initial symptoms of an infestation appear in the upper crown of the tree: leaves are often yellow and sparse, and branch dieback occurs. The dieback progresses downwards towards the base (bole) of the tree each year. In addition, holes of 0.5 cm in diameter are produced when the adult beetle eats its way out from under the bark (Carlos et al., 2002).

2.2. Host plants

2.2.1. List of hosts

Agrilus anxius has been observed attacking many *Betula* species in North America. The level of susceptibility of the different birch species varies considerably, as summarised in Table 1 (extracted from p. 20 of EPPO, 2011). In that table EPPO indicates also the level of uncertainty, as different authors provided inconsistent conclusions for certain *Betula* species. For all those species not mentioned in the table, as not present/not grown in North America, but present in the EU, there is uncertainty concerning the expected level of damage.

Table 1: Summary table of some *Betula spp.* species susceptibility (from EPPO, 2011, p. 20).

***Betula* species**	**Origin**	**Susceptibility according to Miller et al. (1991), Katovich et al., (2005), Santamour (1999), Nielsen et al. (2011) and Herms (2002)**
B. jacquemontii	Asia	Highly susceptible
B. pubescens	Europe	Highly susceptible (low uncertainty)
B. pendula	Europe	Highly susceptible (low uncertainty)
B. maximowicziana	Asia	Highly susceptible (low uncertainty)
B. szechuanica	Asia	Highly susceptible (low uncertainty)
B. alleghaniensis	North America	Moderately susceptible if stressed (low uncertainty)
B. lenta	North America	Moderately susceptible if stressed (low uncertainty)
B. papyrifera	North America	Moderately susceptible if stressed (low uncertainty)
B. populifolia	North America	Moderately susceptible if stressed (low uncertainty)
B. platyphylla	Asia	Highly susceptible (medium uncertainty)
B. davurica	Asia	Highly susceptible (medium uncertainty)
B. nigra	North America	Rarely attacked (low uncertainty)

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

Agrilus anxius attacks birch trees (*Betula* spp.). It has been observed to cause greater damage on the European species *B. pendula* and *B. pubescens* than on North American species, among which river birch (*B. nigra*) does not appear to be a host (Nielsen et al., 2011).

The EPPO PRA (EPPO, 2011) states that *A. anxius* is considered to be a secondary pest of highly stressed trees in North America (Haack, 1996; Santamour, 1990); however, *A. anxius* has been observed killing also healthy trees, when they belonged to species non-coevolved with the pest, as in the case of European and Asian *Betula* species (Miller et al. 1991; Nielsen et al., 2011).The two European species listed in Table 1 (*B. pendula* and *B. pubescens*) are classified as “highly susceptible” with “low uncertainty”. These two species are the main representatives of the genus in the EU, followed by *B. nana* and *B. humilis* (Beck et al., 2016). No evidence is available concerning the capacity of *B. nana* and *B. humilis* to host *A. anxius*. In the risk assessment area, *B. pendula* and *B. pubescens* are widespread and important in uncultivated habitats and as amenity trees, except in southern Europe (Beck et al., 2016).

Birch is particularly important as a commercial crop in Scandinavia and, in forest ecosystems, it is the most abundant deciduous tree species. Patterson (1993) described how in Scandinavian spruce plantations, naturally generating birch trees increase the biodiversity of birds and lichens, while Kennedy and Southwood (1984) calculated that 334 insect species (including leaf miners, gall formers, sap feeders, and chewers) have been recorded feeding on birch in Britain, the third highest amount of any native tree.

Beck et al. (2016) provide a detailed overview of the economic and environmental importance birch species in the EU,

2.2.3. Conclusions on the hosts selected for the evaluation

Betula pendula and *B. pubescens* were assessed together for impact since they are both known to have high susceptibilities and are both widespread and common in the EU. Since there is no information on the susceptibility of the two other European birch trees, *B. nana* and *B. humilis*, and both have a more restricted and scattered distribution, and particularly occur in montane and alpine zones (Beck et al., 2016), they have not been included in the EKE on impact.

2.3. Area of potential distribution

2.3.1. Area of current distribution

Figure 1 provides an overview of the current area of distribution of the pest. In the EU no outbreaks have yet been reported.

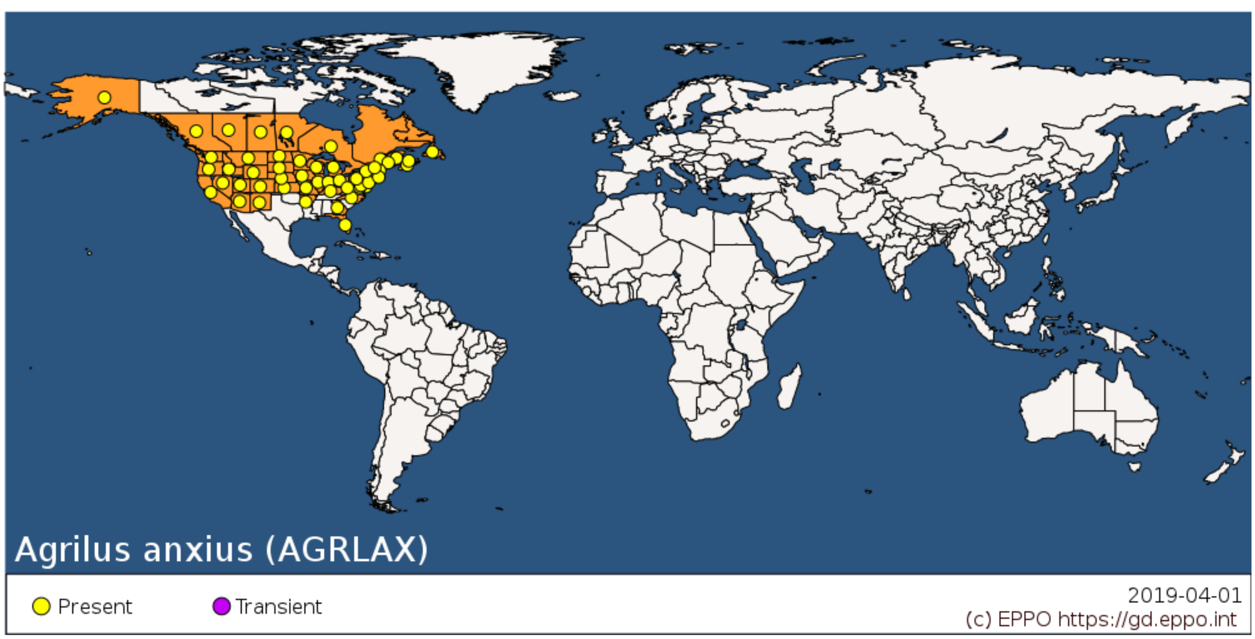

Figure 1 Distribution map of *Agrilus anxius* from the EPPO Global Database accessed 01/04/2019.

2.3.2. Area of potential establishment

The current area of distribution of *A. anxius* covers several different types of climates that can be also found in the EU (figure 2 in EPPO, 2011). Its current range in North America now extends beyond the natural distribution of its host plants into the southern and western United States following the introduction of birch species as amenity trees in these areas (Muilenburg and Herms, 2012). However, the pest risk analysis (PRA) by EPPO (2011) indicates that *A. anxius* is not likely to develop in most of Norway (except the southern Coast), Northern Sweden and Finland, where the degree-day accumulation is between 0 and 250 and this corresponds approximately with the limit of distribution of *B. pendula* according to EUFORGEN (EUFORGEN, online). The EPPO PRA (2011) was reviewed by the Norwegian Scientific Committee for Food Safety (VKM, 2012) and they found that the endangered area was probably underestimated due to the coarse resolution of the climatic grids which could not capture all areas having a degree-day accumulated temperature between 0 and 250. The maps have a 10-minute latitude × 10-minute longitude spatial resolution, and either lack data (the same problem as found by Peel et al., 2007) or may be unrepresentative, e.g. due to the steep altitude gradient along the west coast of Norway.

Betula pubescens has a more northerly and easterly distribution than *B. pendula*.

The confirmed potential hosts *B. pendula* and *B. pubescens* occur naturally throughout the EU but are rarely found in southern regions such as the Iberian Peninsula, southern Italy and Greece.

Since stressed trees are more prone to attacks by *A. anxius*, the warmer EU zones are considered be at greatest risk, although northern areas would also be at risk due to the higher density of birch.

The NUTS2 zones related to the area of potential establishment were defined by combining by eye:

- The EU chorology maps for *Betula pendula* and *B. pubescens* from the European Atlas of Forest Tree Species by JRC (San-Miguel-Ayanz et al., 2016)
- Maps of *Betula* distribution from Flora Europea as included in the EPPO PRA on *Agrilus anxius* (EPPO, 2011)
- *Betula* distribution maps in France from the Atlas de la Flore de France (FCBN, 2016)
- *Betula* distribution maps in Spain from Anthos. Sistema de información sobre las plantas de España (Anthos, online)
- *Betula* distribution maps in Italy from Flora Italiana (Schede di botanica, online)
- *Betula* distribution maps in Greece from Flora of Greece (HBS, online)

2.3.3. Transient populations

Agrilus anxius is not expected to form transient populations in the EU (for "transient" see the definition in EFSA, 2019).

2.3.4. Conclusions on the area of potential distribution

The area of potential distribution of *A. anxius* (Figure 2) is equivalent to the area where the main hosts (i.e. *Betula* spp.) occur in the EU. The mean abundance of the pest, the main driver of pest impact, is considered to be the same throughout the area of potential distribution.

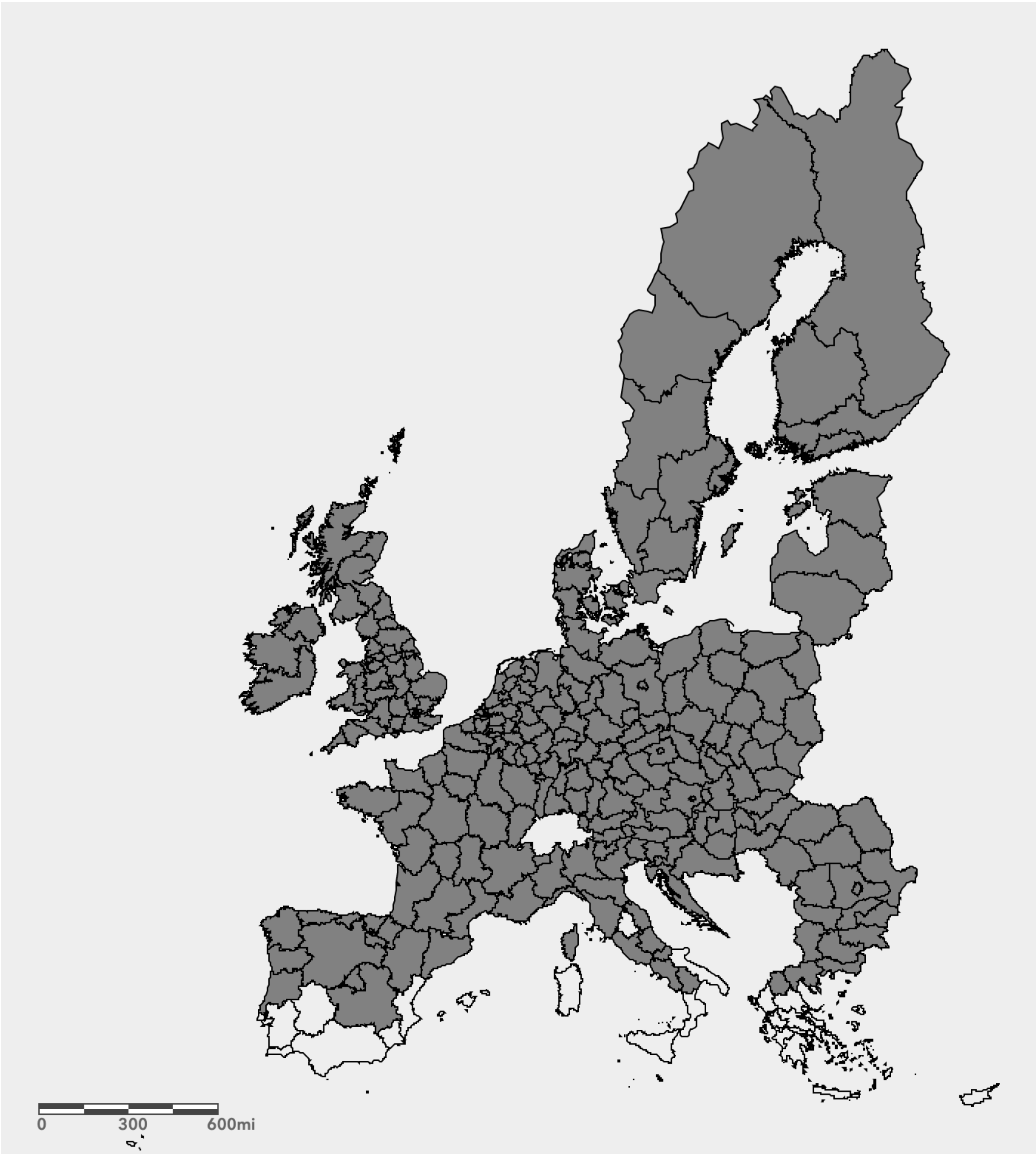

Figure 2 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/05DXKP

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2.4. Expected change in the use of plant protection products

No cultivation practices in forests will limit the presence of this pest (EPPO, 2011) and, when symptoms are observed, nothing can be done except by removing and destroying the plant. The only treatments likely to be applied are post-harvest processing procedures. The application of a targeted insecticide regime could only work effectively in nurseries (EPPO, 2011). Due to the fact that no effective treatments with plant protection products (PPPs) are currently available, the most suitable PPP indicator is Case "A" and the category is "0" based on Table 2.

Table 2: Expected changes in the use of Plant Protection Products (PPPs) following *Agrilus anxius* establishment in the EU in relation to four cases (A-D) and three level score (0-2) for the expected change in the use of PPPs.

Expected change in the use of PPPs	**Case**	**PPPs indicator**
PPPs effective against the pest are not available/feasible in the EU	**A**	**0**
PPPs applied against other pests in the risk assessment area are also effective against the pest, without increasing the amount/number of treatments	B	0
PPPs applied against other pests in the risk assessment area are also effective against the pest but only if the amount/number of treatments is increased	C	1
A significant increase in the use of PPPs is not sufficient to control the pest: only new integrated strategies combining different tactics are likely to be effective	D	2

2.5. Additional potential effects

2.5.1. Mycotoxins

The species is not known to be related to problems caused by mycotoxins.

2.5.2. Capacity to transmit pathogens

The species is not known to vector any plant pathogens.

3. Expert Knowledge Elicitation report

3.1. Yield and quality losses

3.1.1. Structured expert judgement

3.1.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.1.1 of the Methodology Report (EFSA, 2019).

3.1.1.2. Specific scenario assumptions

- Susceptible hosts are living trees that would be killed by *A. anxius*
- There are no differences in terms of pest preferences and host vulnerability for the EU *Betula* species
- The potential severity of impacts is considered to be the same in all the different climatic zones in the area of potential establishment
- The amount of stress that a birch tree is suffering is not expected to influence substantially its vulnerability to an *A. anxius* attack
- The assessment considers the commercial and non-commercial plantations of the European birch species and does not take into account the potential losses to other ornamental and non-native birch species which are less widely grown
- There is a uniform age distribution of birch trees, from very young to the end of the rotation in the area of potential establishment
- The estimation of yield loss of *A. anxius* is done by comparison with the EKE (yield loss) values on *A. planipennis*

3.1.1.3. Selection of the parameter(s) estimated

The assessment focuses on trees for hardwood and veneer production. As high value production it can be assumed that even damages to the outer layers of the tree will cause total loss of the hardwood and veneer production. Nevertheless, the quality of the timber may only be partly affected. The use of reduced quality *Betula*, e.g. for pulp wood or firewood, has not been evaluated as it is considered to be very low. Additionally, since an infested tree will decline fast, the EKE was restricted to the mortality of trees caused by *A. anxius* in total, assuming that the infested tree will not reach the normal size for harvesting. The effect of replanting infested trees on yield loss is assumed to be minor.

3.1.1.4. Defined question(s)

What is the percentage yield loss *Betula* trees under the scenario assumptions in the area of the EU under assessment for *Agrilus anxius*, as defined in the Pest Report?

3.1.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.1 in Appendix B) selecting the data and references used as the key evidence for the EKE on impact. Two general points were made:

- All the evidence concerning impacts that is available comes only from the native range of the pest

- When comparing potential impacts with *A. planipennis* it is important to appreciate that *Betula* trees have a stronger wound response mechanism, e.g. callus formation, than *Fraxinus* trees

3.1.1.6. *Uncertainties identified*

- *A. anxius* behaviour on European birch species has only been observed in North America
- *A. anxius* has not invaded other countries, so its invasive potential is unknown.
- Some of the dead tree may still provide some yield if the trunk is large enough
- the presence and effectiveness of natural enemies in the EU

3.1.2. Elicited values for yield losses

What is the percentage yield loss of *Betula* trees under the scenario assumptions in the area of the EU under assessment for *Agrilus anxius*, as defined in the Pest Report?

The five elicited values on yield loss on *Betula* trees on which the group agreed are reported in the table below.

Table 3: The 5 elicited values on yield loss (%) on *Betula* spp.

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	50%	65%	80%	85%	95%

3.1.2.1. *Justification for the elicited values for yield loss on Betula* spp.

Reasoning for a scenario which would lead to high yield loss (99th percentile / upper limit)

The upper value of yield loss is based on the assumption that *A. anxius* behaves as *A. planipennis* but that, compared to ash, birch has stronger defence mechanisms.

Reasoning for a scenario which would lead to low yield loss (1st percentile / lower limit)

The lower value of yield loss is based on control by natural enemies (e.g. wasps, woodpeckers, etc.) in the EU and by the potential variability in the tolerance/resistance of birch populations to *A. anxius* attack.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

The median value of yield loss is slightly higher than that expected for *A. planipennis* due to the general higher uncertainty concerning the level of impact on EU birch species.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

The precision is mainly affected by the potential defensive response that could influence the expected impact on the left side of the curve.

3.1.2.2. Estimation of the uncertainty distribution for yield loss on Betula spp.

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 4: Fitted values of the uncertainty distribution on the yield loss (%) on *Betula* spp.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	50%					65%		80%		85%					95%
Fitted distribution	50%	52%	55%	59%	63%	67%	71%	77%	83%	86%	90%	93%	95%	97%	98%

Fitted distribution: BetaGeneral (2.1392,1.6113,0.45,1), @RISK7.5

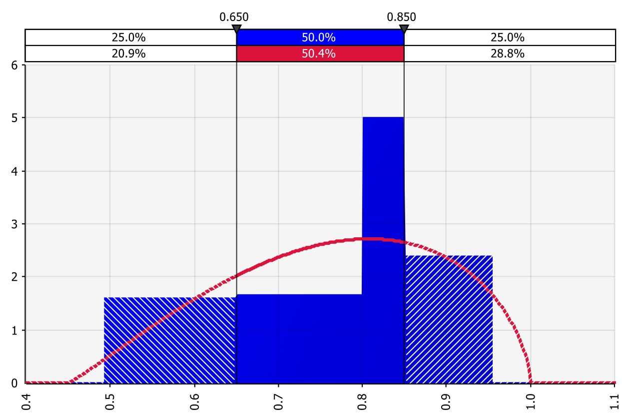

Figure 3 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on *Betula* spp.

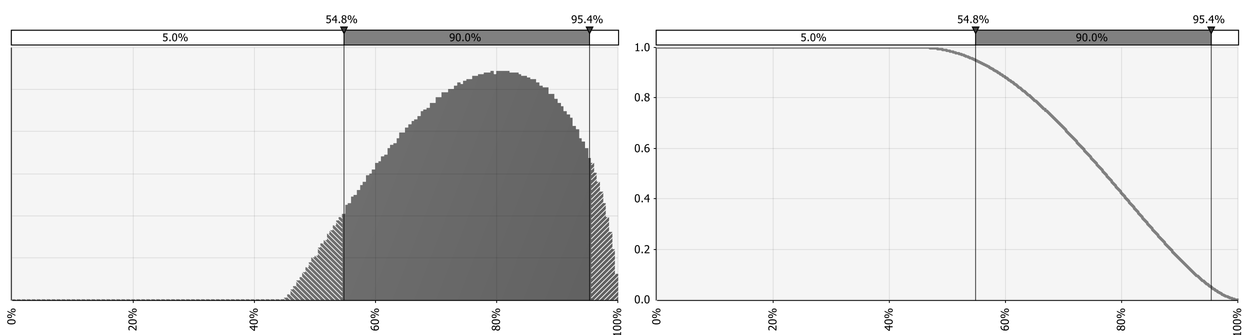

Figure 4 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on *Betula* spp.

3.1.3. Conclusions on yield and quality losses

Based on the general and specific scenarios considered in this assessment, the proportion (in %) of yield losses (here with the meaning of mortality rate) is estimated to be 77% (with a 95% uncertainty range of 52 - 97%).

3.2. Spread rate

3.2.1. Structured expert judgement

3.2.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in section 2.4.2.1 of the Methodology Report (EFSA, 2019).

3.2.1.2. Specific scenario assumptions

- There is no shortage of suitable hosts
- Different birch species do not influence the spread rate
- Hitchhiking is excluded as it is not confirmed to be a major component of spread
- The estimation of spread rate of *A. anxius* is done by comparison with the EKE (spread rate) values on *A. planipennis*

3.2.1.3. Selection of the parameter(s) estimated

The spread rate has been assessed as the number of metres per year.

3.2.1.4. Defined question(s)

What is the spread rate in 1 year for an isolated focus within this scenario based on average European conditions? (units: m/year)

3.2.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.2 in Appendix B) selecting the data and references used as the key evidence for the EKE on spread rate. One general point was made: when interpreting the literature, it is important to take into account the fact that the distribution of *Betula* in the EU is different from that in North America.

3.2.1.6. Uncertainties identified

- There is a very limited number of studies on spread, one of the two papers refers to another *Agrilus* species, *A. planipennis*
- The contribution of local displacement of logs to short distance dispersal
- Little is known about the dispersal of this species

3.2.2. Elicited values for the spread rate

What is the spread rate in 1 year for an isolated focus within this scenario based on average European conditions? (units: m/year)

The five elicited values on the spread rate on which the group agreed are reported in the table below.

Table 5: The 5 elicited values on spread rate (m/y)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	50	750	1,000	3,000	8,000

3.2.2.1. Justification for the elicited values of the spread rate

Reasoning for a scenario which would lead to wide spread (99th percentile / upper limit)

The upper value takes into account the fact that *A. planipennis* has a larger size than *A. anxius*: this influences the estimate of its spread capacity.

Reasoning for a scenario, which would lead to limited spread (1st percentile / lower limit)

The lower value of spread rate is lower than *A. planipennis* due to the smaller size of the adults, in addition host plant availability in the EU is higher than in North America and so the need for long flights could be less likely in the EU.

Reasoning for a central scenario, equally likely to over- or underestimate the spread (50th percentile / median)

The median value of *A. anxius* is close to *A. planipennis*, again influenced by the different adults' size.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

The precision is given by the higher uncertainty than for *A. planipennis*: the curve is flatter than for *A. planipennis*.

3.2.2.2. Estimation of the uncertainty distribution for the spread rate

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 6: Fitted values of the uncertainty distribution on the spread rate (m/y)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	50					750		1,000		3,000					8,000
Fitted distribution	16	42	89	190	336	541	773	1,348	2,168	2,754	3,584	4,634	6,063	7,495	9,393

Fitted distribution: Gamma (0.94924,2093), @RISK7.5

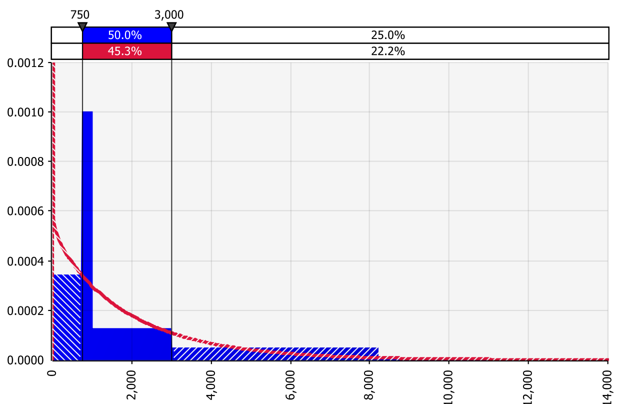

Figure 5 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

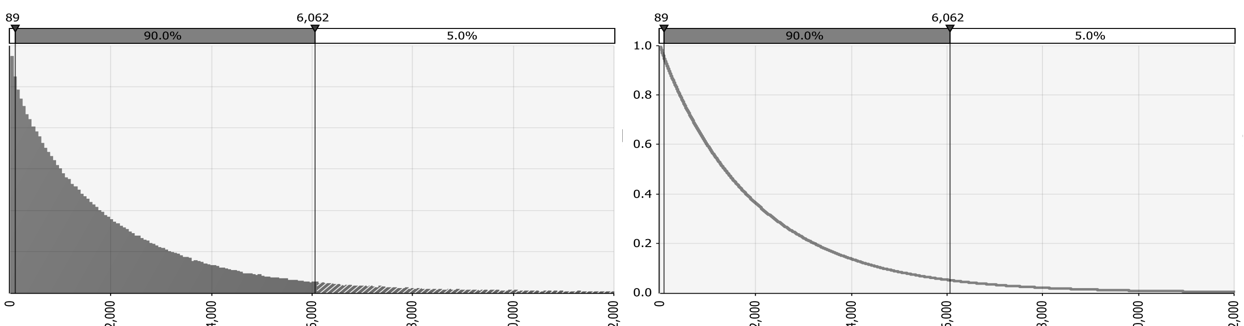

Figure 6 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

3.2.3. Conclusions on the spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *A. anxius* is 1.3 km (with a 95% uncertainty range of 42 m to 7.5 km).

3.3. Time to detection

3.3.1. Structured expert judgement

3.3.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.2.1 of the Methodology Report (EFSA, 2019).

3.3.1.2. Specific scenario assumptions

- The isolated population not known to be established is a small population of beetles emerged all at the same time
- Different birch species do not influence the expression of symptoms

3.3.1.3. Selection of the parameter(s) estimated

The time for detection has been assessed as the number of years between the first event of pest transfer to a suitable host and its detection.

3.3.1.4. Defined question(s)

What is the time between the event of pest transfer to a suitable host and its first detection within this scenario based on average European conditions? (unit: years)

3.3.1.5. Evidence selected

- There is a lower risk of confusing symptoms with other pests than for *A. planipennis* (where Chalara ash dieback could cause misidentifications)
- There is a lower level of awareness of birch pest damage than of ash damage by the general public, therefore the likelihood of symptoms identification is lower
- EU birch species would die faster than US species (Nielsen et al., 2011)
- Birch trees have stronger defense mechanisms against borer' attacks than ash trees
- The estimation of time to detection for *A. anxius* is done by comparison with the EKE (time to detection) values on *A. planipennis*

3.3.1.6. Uncertainties identified

- Forests surveys are done every 4 years everywhere in the EU
- The average size of EU birch trees compared to American trees is unknown

3.3.2. Elicited values for the time to detection

What is the time between the event of pest transfer to a suitable host and its first detection within this scenario based on average European conditions? (unit: years)

The five elicited values on time to detection on which the group agreed are reported in the table below.

Table 7: The 5 elicited values on time to detection (years)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	4	7	10	14	18

3.3.2.1. Justification for the elicited values of the time to detection

Reasoning for a scenario which would lead to a long time for detection (99th percentile / upper limit)

The upper value is given by the fact that symptoms are easier to recognise than for *A. planipennis* (no other pests produce the same kind of damage) but this is counterbalanced by the fact that a large part of Northern EU forests are not expected to be inspected as frequently.

Reasoning for a scenario which would lead to a short time for detection (1st percentile / lower limit)

The lower value for time to detection is due to the fact that *A. anxius* is less visually attractive than *A. planipennis* for the general public. The invasion starts from the top of the tree and goes down with time, making holes visible only on big trees after some years. The expression of symptoms can be slower than *A. planipennis*.

Reasoning for a central scenario, equally likely to over- or underestimate the time for detection (50th percentile / median)

The median value is related to the fact that *A. anxius* has received less attention. However, EU *Betula* species are more susceptible than US *Betula* species.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

The precision is mainly driven by the fact that the curve includes very different situations: from urban areas to parks and forests.

3.3.2.2. Estimation of the uncertainty distribution for the time to detection

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 8: Fitted values of the uncertainty distribution on the time to detection (years)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	4					7		10		14					18
Fitted distribution	3.3	3.7	4.1	4.9	5.9	7.0	8.1	10.3	12.5	13.7	15.0	16.2	17.2	17.9	18.4

Fitted distribution: BetaGeneral (1.3141,1.5198,3,19), @RISK7.5

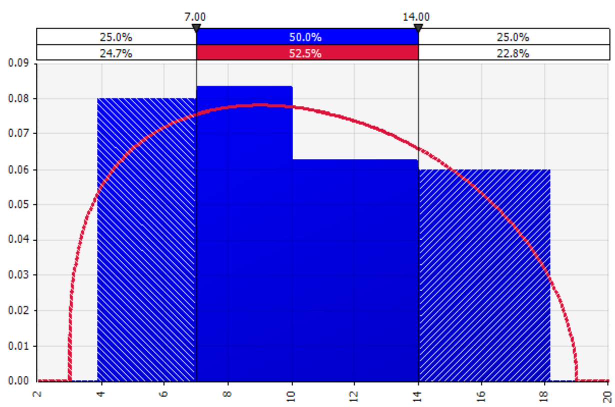

Figure 7 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

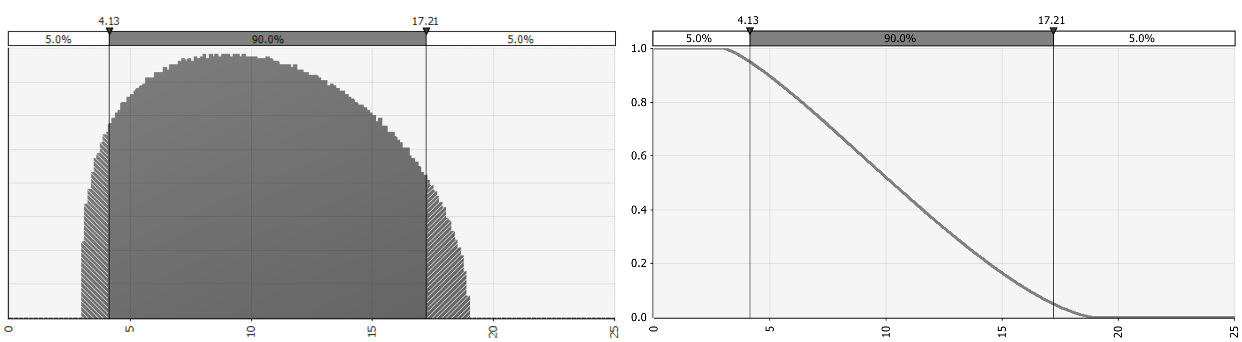

Figure 8 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

3.3.3. Conclusions on the time to detection

Based on the general and specific scenarios considered in this assessment, the time between the event of pest transfer to a suitable host and its detection is estimated to be approximately 10 years (with a 95% uncertainty range of 3.7 - 18 years).

4. Conclusions

Hosts selection

Betula pendula and *B. pubescens* were assessed together for impact since they are both known to have high susceptibilities and are both widespread and common in the EU. Since there is no information on the susceptibility of the two other European birch trees, *B. nana* and *B. humilis*, and both have a more restricted and scattered distribution, and particularly occur in montane and alpine zones (Beck et al., 2016), they have not been included in the EKE on impact.

Area of potential distribution

The area of potential distribution of *A. anxius* is equivalent to the area where the main hosts (i.e. *Betula* spp.) occur in the EU. The mean abundance of the pest, the main driver of pest impact, is considered to be the same throughout the area of potential distribution.

Expected change in the use of plant protection products

Due to the fact that no effective treatments with plant protection products (PPPs) are currently available, the most suitable PPP indicator is Case “A” and the category is “0”.

Yield loss of birch trees

Based on the general and specific scenarios considered in this assessment, the proportion (in %) of yield losses (here with the meaning of mortality rate) is estimated to be 77% (with a 95% uncertainty range of 52 - 97%).

Spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *A. anxius* is 1.3 km (with a 95% uncertainty range of 42 m to 7,5 km).

Time for detection after entry

Based on the general and specific scenarios considered in this assessment, the time between the event of pest transfer to a suitable host and its detection is estimated to be approximately 10 years (with a 95% uncertainty range of 3.7 - 18 years).

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Appendix A – CABI/EPPO host list

The following list, defined in the Methodology Report (EFSA, 2019) as the full list of host plants, is compiled merging the information from the most recent PRAs, the CABI Crop Protection Compendium and the EPPO Global Database. Hosts from the CABI list classified as 'Unknown', as well as hosts from the EPPO list classified as 'Alternate', 'Artificial', or 'Incidental' have been excluded from the list.

Genus	Species epithet
Betula	
Betula	*albosinensis*
Betula	*alleghaniensis*
Betula	*dahurica*
Betula	*ermanii*
Betula	*lenta*
Betula	*maximowicziana*
Betula	*nigra*
Betula	*occidentalis*
Betula	*papyrifera*
Betula	*pendula*
Betula	*platyphylla*
Betula	*populifolia*
Betula	*pubescens*
Betula	*utilis*

Appendix B – Evidence tables

B.1 Summary on the evidence supporting the elicitation of yield and quality losses

Susceptibility	Infection	Symptoms	Impact	Additional information	Reference	Limitation/uncertainties
	Incidence	***Severity***	***Losses***			
Betula pendula	Table 2: comparison of average number of larvae/100 cm^2 of inner bark between bole and branches for each vigour class	165 new emergence holes on class 5 trees Stems at class 2 can improve to class 1			Ball and Simmons, 1980	Only studied after 1 year
Betula pubescens	6/22 trees attacked in 10 years				Santamour, 1990	
Betula pendula *Betula pubescens*	European species were colonized by bronze birch borer at a faster rate and to a greater degree than North American species. 2 year after first inoculum: 97% of *B. pendula* colonised, 3 years after first inoculum: 90% of *B. pubescens*	Also, larval development (in terms of adult emergence holes on trunks of infested trees) was more successful in European species.	Mortality rate 100% 5-6 years after inoculum.	20-yr common garden experiment, initiated with 2-year-old seedlings. Randomized complete block study Infestation occurs by artificial inoculum with infested logs 2-3 years after plantation	Nielsen et al., 2011	The density in the experiment was lower than in the commercial plantation but likely denser than in the natural environment. No forestry management was applied. The climate is comparable to northern Europe except for the hotter summer temperature. Young birches are not affected as stems below 2 cm diameter and scions below 1 cm are very unlikely to be infested
Betula papyrifera		Site 1: 13% Site 2: 25%	Site 1: 62% Site 2: 0	Northern Michigan, Plants under stress and close to senescence (58-59 years old)	Jones et al., 1993	It is not possible to distinguish between the effect of climate and pests

B.2 Summary on the evidence supporting the elicitation of the spread rate

Spread	**Additional information**	**Reference**
16 to 32 km/year		Federal Register, 2003
2.8 km/day at > 1.5 m/sec	Adults spread capacity of *A. planipennis* (approximation suggested in EPPO, 2011)	Taylor et al., 2007

B.3 Summary on the evidence supporting the elicitation of the time to detection

Reference	**Case**	**Aspect**	**Results / evidence**
Detection methods			
EPPO, 2011	Survey methods	Effects on detectability	No effective pheromone trapping tools available. No effective monitoring tools
EPPO, 2011	Reproduction	Effects on incidence	25-50 eggs/female with an expected high survival rate
		Effects on detectability	Oviposition 7-10 days after adults' emergence. Eggs hatch in 2 weeks.
		Additional information	Eggs are laid on the bark
	Life cycle	Effects on incidence	1 (in stressed hosts) or 2 (in vigorous hosts) year life cycle
		Effects on symptoms expression	When prepupae have been submitted to a suitable cold period, development starts again, and pupae form in the pupal chamber. Once the appropriate degree-days have accumulated, pupation ends and adults emerge.
		Effects on detectability	4 larval instars, prepupae and pupae likely to survive in wood even if bark is removed Adult emergence generally over a 10-week period between late spring and early summer
		Additional information	Its mostly hidden life stages could delay detection till a population is already well-established
Barter, 1957	Life cycle	Effects on incidence	1 or 2 depending on the climate
Muilenburg and Herms, 2012	Life cycle	Effects on detectability	Emergence occurs in 10-12 weeks (relatively synchronized) with a peak 2-4 weeks after first emergence

Rutledge and Keena, 2012	Reproduction preferences	Effects on expected survival and reproduction rates	BBB males > successful at transferring a spermatophore > EAB males, with BBB males succeeding in 47/48 attempts > 43/52 attempts of EAB. 45% of singly mated EAB females failed to lay any eggs > 12% of singly mated BBB. BBB shows also < mate discrimination than EAB
EPPO, 2011	Transfer capacity	Effects on incidence	If conditions are suitable for emergence, adults, which are good flyers, can reach a host in the vicinity
Muilenburg and Herms, 2012	Transfer capacity	Effects on incidence	Fecundity depends on the host plant upon which the female has fed
		Effects on symptoms expression	Tree defoliation caused by adults feeding is negligible
Carlos et al., 2002	Transfer capacity	Effects on detectability	Rust coloured sap oozing and staining the bark along with swelling and bumps where the tree has healed inside. The "D" shaped exit holes of one-fifth of an inch in diameter can be found near the base of infested limbs and the trunk.
EPPO, 2011	Population dynamics	Effects on detectability	*A. anxius* is present typically at low density, although in this situation some trees might still be heavily infested.
		Additional information	they are generally first observed years after they have become established and spread
Jones et al., 1993	Population dynamics	Effects on detectability	Outbreaks are infrequent in space and time
Barter, 1957	Population dynamics	Effects on symptoms expression	~ 23 days adults life span during which the eat continuously. 4-7 days survival in absence of food
Anderson, 1944	Behaviour	Effects on incidence	about 6.5 prepupae + adults per m^2 of bark in felled *B. papyrifera*
		Effects on detectability	Not a very aggressive pest: strong preference for the most decadent trees.
		Additional information	The author suggests that when this pest is found in dying trees it should not be considered necessarily the primary cause of the death.
Akers and Nielsen, 1990	Behaviour	Effects on detectability	*A. anxious* can survive on a number of non-larval plant species.
		Additional information	Beetles longevity varies with host and between years
Ball and Simmons, 1980	Behaviour	Effects on detectability	Larval density in boles > in branches
		Additional information	*Betula pendula*
Haack, 1996	Behaviour	Effects on incidence	Often 2-3 years of successive attacks are needed before a given branch or trunk section dies
		Effects on detectability	Adults often reattack the same tree until it dies, attacking from year to year only those portions that are still living at the time of oviposition.

		Additional information	Global warming expected to exacerbate trees mortality where *A. anxius* is present
Host conditions during the period of potential detection			
EPPO, 2011	Host size	Effects on detectability	In the USA, larvae have not been reported to colonize trees with main stem diameter < 2 cm, but have been observed to bore from larger stems and branches into branches as small as 1 cm diameter
	Nursery plants	Effects on symptoms expression	Symptoms are often not visible until after adults have emerged
		Effects on detectability	Larvae, prepupae and pupae can survive but adults would not reproduce
		Additional information	Transport and storage of living plants
Muilenburg and Herms, 2012	Host vigour	Effects on symptoms expression	Weakened trees express the maximum symptoms severity in terms of larval density and number of emergence holes
Ball and Simmons, 1980	Host vigour	Effects on incidence	Class 3 trees are much more susceptible to *A. anxius* attacks
		Effects on detectability	First successful larval penetration in the main stem
		Additional information	*Betula pendula*
Muilenburg and Herms, 2012	Host species	Effects on symptoms expression	Colonisation patterns may be different in more resistant versus more susceptible species. i.e. in European species observed random vertical colonization of the stem while in North American species colonisation happened in the upper parts of the stem first.
		Additional information	Tree mortality as a combination/interaction of predisposing factors + inciting factors + contributing factors
Nielsen et al., 2011	Host species	Effects on incidence	European and Asian *Betula* spp. colonised faster than *B. papyrifera* and *B. populifolia* (North America) and with higher % of trees with emergence holes. From 24% of colonised *B. papyrifera* emerged adults and from 48% of *B. populifolia.*
		Additional information	many larvae die before emerging as adults, and the vast majority of trees survived to colonisation, proving a certain level of tolerance