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Aromia bungii
Pest Report to support ranking of EU candidate priority pests

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Table of Contents

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 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 *Aromia bungii* the following documents were used as key references: pest risk analyses (PRAs) by EPPO (2014), CABI datasheet (2018) and the video by Regione Campania (Servizio Fitosanitario Regionale, 2019).

[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

Aromia bungii is a single taxonomic entity. The impact caused by *Aromia bungii* is mainly due to the feeding activity of larvae which bore into the wood soon after hatching, producing tunnels in the branches and the trunk (Gressitt, 1942). The galleries, that are in the cambium zone, stop the circulation of the sap, killing the associated tissues, weakening the tree (favouring secondary pest attacks), reducing the fruit production and finally killing the whole plant, in case of high-density infestations.

This pest has been frequently reported as preferring old, stressed or decayed trees, although observations in Italy indicate that it can also attack young and healthy trees.

Aromia bungii has a long-life cycle (2-4 years in Hebei Province, by Ma et al., 2007) with a duration depending on the climate, favouring the adaptation of this species to a wide range of conditions. Adults fly from May to September with the peak around June-July.

2.2 Host plants

2.2.1 List of hosts

This pest affects plants belonging to the genus *Prunus*. Most of the reports on other plant families and genera are not confirmed or lack supporting evidence (EPPO, 2014).

Appendix A provides the full list of hosts.

2.2.2 Selection of hosts for the evaluation

The main confirmed hosts are peach (*Prunus persica*), apricot (*Prunus armeniaca*), cherry (*Prunus avium*) and plum (*Prunus domestica*) trees. Other *Prunus* species of economic importance could be affected, if the host range observed during Italian and Japanese outbreaks is taken into account. For example, in Campania (Italy) *Prunus cerasifera*, a common rootstock of stone fruit (Griffo, 2016) and one almond tree (*Prunus dulcis*) were attacked.

The pest has been observed on tree species other than *Prunus*, including *Populus* spp., pomegranate (*Punica granatum*), olive (*Olea europaea*) but these species are not considered to be main hosts (EPPO, 2014). This statement is supported by observations made during EU outbreaks in Campania, where those plant species are monitored but never found infested (DRD 01-06-17[3]), as well as in Lombardy (Ciampitti, 2018), and Bavaria (Hoppe, 2018).

Wood production could also be affected since wild cherry (*P. avium*) provides one of the most valued timber products in EU and currently no management measures are required against wood pests of *Prunus*.

Distribution of main hosts: Peach and apricot are mainly located in the Mediterranean MSs (Spain, Portugal, Southern France, Italy, Slovenia, Croatia, Greece, Malta, Cyprus) but are also found in Slovakia, Czech Republic, Hungary, Austria, Romania, Bulgaria, in Germany as far as north as the Baltic Sea. Plum and cherry can be found in the same countries but also grow in the wild and in more northern countries

[3] Decreto Dirigenziale della Giunta Regionale della Campania. Aggiornamento "Piano d'azione regionale per la lotta al cerambicide *Aromia bungii*". Decreto No 1 del 01/06/2017

(UK, Belgium, the Netherlands, Denmark, Poland, Latvia, Estonia, southern parts of Norway and Sweden) (EPPO, 2014).

In Campania, larger and more mature trees seem to be more prone to attack (EPPO, 2014), as also confirmed by observations in Japan (Li et al., 2018; Yamamoto and Ishikawa, 2018).

In commercial orchards in Italy, peach trees are maintained for a relatively short time (about 10-15 years) whereas apricot, plum and cherry trees are kept for longer periods (more than 20 years).

In private gardens and amenity areas, trees are likely to remain for several decades and will be even more suitable for establishment of the insect.

In Campania, the pest has been only observed so far on *Prunus* fruit trees and not on ornamental *Prunus* species that are also present in the outbreak area. This is only based on 1 year of monitoring, since autumn 2012.

For the purpose of assessing the impact the *Prunus* hosts were grouped into three categories, based on the different production systems employed and the final use of the products (Table 1): (i) orchards (7 *Prunus* fruit-producing species), (ii) forests (4 *Prunus* hardwood producing species, especially *P. avium)* and (iii) ornamentals (all *Prunus* species).

Table 1: Classification of the *Prunus* hosts.

	Orchards	Forests	Ornamentals
Prunus spp.			X
Prunus armeniaca	X		
Prunus avium	X	X	
Prunus cerasifera	X	X	
Prunus cerasus	X	X	
Prunus domestica	X		
Prunus dulcis	X		
Prunus padus		X	
Prunus persica	X		

2.2.3 Conclusions on the hosts selected for the evaluation

Based on the different production systems employed and the final use of the products, the impact of *A. bungii* was assessed for different *Prunus* species: (i) in orchards (7 *Prunus* species), (ii) in forests (4 *Prunus* species) and (iii) as an ornamental (all *Prunus* species).

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. EU outbreaks occurred in 2011 near Kolbermoor (southern Bavaria, Germany) and in 2012 between Napoli and Pozzuoli (southern Italy) where *A. bungii* infested apricot, cherry, and plum trees (Anderson et al., 2013; EPPO, 2013a). Other isolated findings were declared in 2013 in the Lombardy region (EPPO, 2013b).

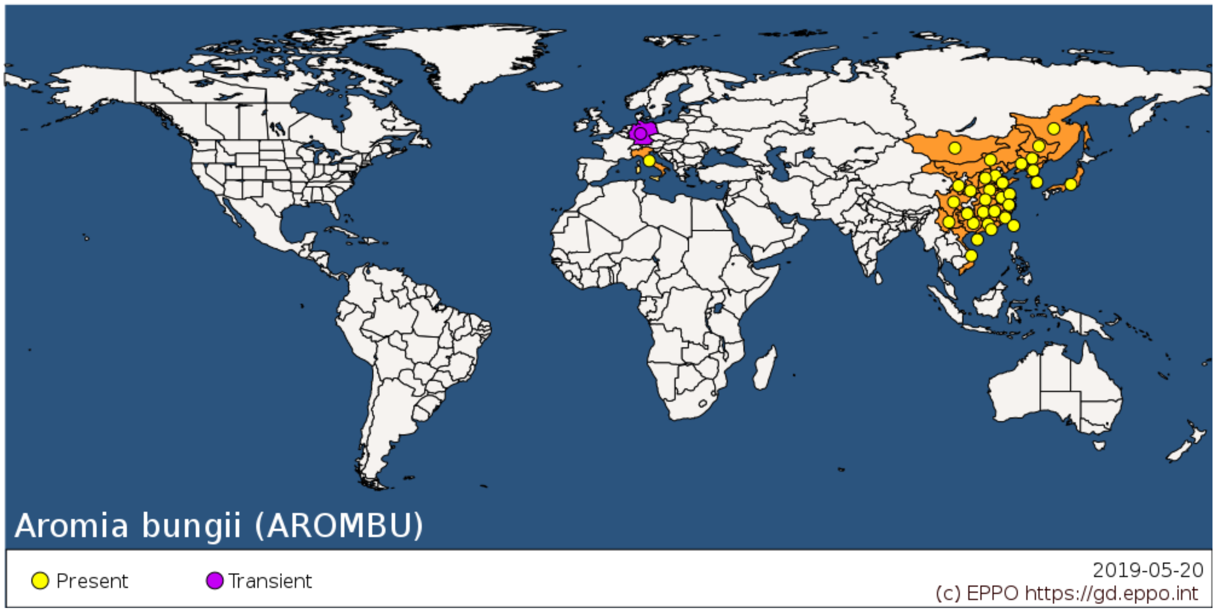

Figure 1 Distribution map of *Aromia bungii* from the EPPO Global Database accessed 20/05/2019.

2.3.2 Area of potential establishment

The lower temperature threshold for survival is unknown but adults can survive at 8°C in lab conditions for several weeks (EPPO, 2014). In natural conditions, most of the life cycle occurs within the tree, making the area of potential establishment for this pest very large.

A. bungii is present in Liaoning province (North-East China) where the annual average temperature is 6-9 °C with 140-160 days/year of frost-free period (Wen et al., 2010).

The pest distribution in China and Mongolia indicates that the northern limit is based on an annual number of accumulated degree-days (base 10°C) above 500, corresponding to hardiness zones from 4 to 13, even though the completion of the life cycle may take several years (EPPO, 2014, fig. 1 pag. 17). This thermal sum has been used to define the area of potential distribution in the EU. It covers almost the whole EU area, with southern Scandinavia as northern limit. In southern areas of the EU (where the accumulation of degree-days per year in base 10 is above 1000), the pest is likely to have a shorter life cycle, and may also have a higher reproductive capacity, similarly to that observed for *A. chinensis* (Adachi, 1988) and *A. glabripennis* (Keena, 2006).

2.3.3 Transient populations

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

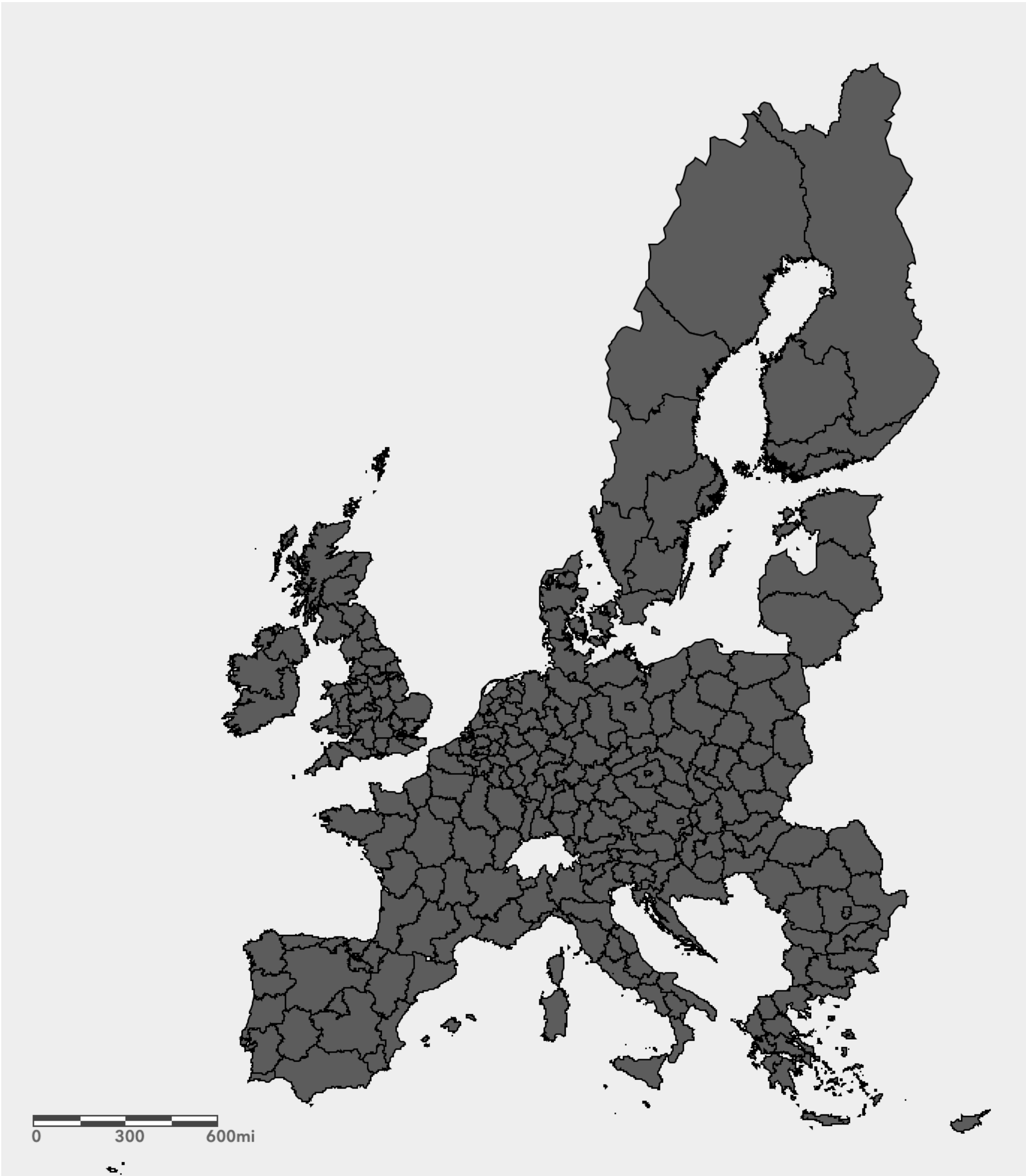

Figure 2 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/1jGria

2.3.4 Conclusions on the area of potential distribution

The area of potential distribution in this assessment corresponds to the part of the EU where the annual degree days (base 10°C) are greater than 500. All the current area of *Prunus* cultivation in this area was considered to be suitable for *A. bungii*. This includes everywhere but the extreme north of the EU in Sweden and Finland. However, since the NUTS2 regions are very large in this area and include some locations where degree days are above the threshold, all NUTS2 regions in the EU can be considered to be included in the area of potential distribution based on climate. No transient populations are likely to occur. In conclusion, the area of potential distribution of the pest is equivalent to the area where the main hosts occur in the EU. The mean abundance of the pest, the main driver of the pest impact, is considered to be the same throughout the whole area of potential distribution.

It is expected that the potential damage would be higher in the southern part of the assessment area where more *Prunus* orchards are present and where the pest may have a life cycle of 2 years (whereas it may be 3-4 years in the northern part), and therefore the pest is likely to build up larger populations more quickly in the southern part than in the northern part of the assessment area. However, for the purpose of the assessment the average impact is considered the same throughout the whole area of potential distribution (no gradient or zones are included in the assessment).

2.4 Expected change in the use of plant protection products

Some treatments applied in orchards against e.g., *Capnodis tenebrionis, Cossus cossus*, *Zeuzera pyrina*, or *Drosophila suzukii* could affect adults of *A. bungii* although they may not provide protection for the entire flight period. In addition, routine pest control tends to target fruit pests or defoliators, and not wood boring insects. Treatments against scale insects could affect eggs of *A. bungii* but once the young larva hatches from the egg and penetrates beneath the bark, it is very difficult to control the pest with insecticides. The period of egg-laying is very long and so repeated treatments (possibly every week) would be required over a long period to afford protection. A similar programme would be required to control adults.

The control measures currently applied against *C. tenebrionis* include the destruction and removal of damaged trees (Lichou et al., 2001) and the use of entomopathogenic nematodes such as *Steinernema carpocapsae* (del Mar Martinez de Altube et al., 2007), the same species tested in China against *A. bungii* (Liu 1993 and 1998). However, as these measures are not fully effective against *C. tenebrionis*, evidenced by its increasing damage in the Mediterranean countries (Bonsignore and Vacante, 2009), they could also have limited impact on *A. bungii*.

In Italian commercial stone fruit orchards insecticides are applied 6-8 times per season, especially for peach. This varies according to cultivars and pest pressure. Similar programmes are applied in other countries of the EU to control pests such as *Ceratitis capitata* and *Rhagoletis cerasi* (Diptera Tephitidae), aphid species (Hemiptera Aphididae), *Pseudaulacaspis pentagona*, *Diaspidiotus perniciosus*, and *Epidiaspis leperii* (Hemiptera: Diaspididae), *Parthenolecanium corni* and *Parthenolecanium persicae* (Hemiptera: Coccidae), *Grapholita molesta*, *Grapholita funebrana* and other Tortricid moths (Lepidoptera: Tortricidae); *Anarsia lineatella* (Lepidoptera: Gelechiidae); *Frankliniella occidentalis* and other Thysanoptera (Thysanoptera: Thripidae); other pests such as mites (Acari), sawflies (Hymenoptera: Tenthredinidae), and weevils (Coleoptera: Curculionidae) (EPPO, 2014).

In some countries (e.g. France, Spain), cherry and other *Prunus* species are grown under nets to protect them from rain, insects and/or birds. In a field experiment in southern France in cherry trees Charlot et al., 2013 showed that netting between fruit setting and early September had some efficacy against insects (EPPO, 2014).

EPPO (2014) also provides a list of EU generalist parasitoids and predators that could probably attack the different immature stages of *A. bungii*.

In conclusion, based on the table below, this pest belongs to Case "A" and category **0 for wood production** since no measures are available or feasible to control the pest. Case "D" and category **2** is appropriate **for fruit production and ornamentals** since integrated strategies, e.g. involving the removal of trees and netting would be required.

Table 2: Expected changes in the use of Plant Protection Products (PPPs) following *Aromia bungii* 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 scientific report on the applied methodology.

3.1.1.2. Specific scenario assumptions

- Although an average value of the yield loss is estimated at the EU level, it is expected that the potential damage would be higher in the southern part of the assessment area where more *Prunus* orchards are present and where the pest may have a life cycle of 2 years (whereas it may be 3-4 years in the northern part), and therefore the pest is likely to build up higher populations more quickly in the southern part than in the northern part of the EU.
- According to EPPO (2014) there could be an effect of competition with other wood borers (e.g. *Capnodis tenebrionis*) more likely in southern EU
- Since stressed trees are more prone to attack, good management practices will make the host less susceptible.
- The following aspect of the scenario are considered for orchards:
    - A new orchard is planted, the pest then enters and damages the plants, this causes losses in production because the tree produces less and/or because the tree has died.
    - The feeding activity could kill the tree with losses in fruit production but also in timber (particularly from wild cherry) production
    - Productive orchards: symptoms of infestations are visible, in productive orchards it is expected that at least part of infested trees is noticed and removed, effect of application of chemicals is expected to limit the pest population abundance
    - Orchards of plum, cherry, peach, apricot, almond are all equally suitable to *A. bungii*
- Forests (wood production)
    - Cycle for *Prunus* for wood production: 60-80 years (minimum 50), no chemical control, unlikely infested trees will be noticed
    - Damaged wood used for firewood is considered as a total loss
    - Yield loss in forest stands could result from (I) tree mortality as in trees that will not reach the time of harvest and (II) the damage caused to the trunk of the tree that makes the wood unmarketable
    - *Prunus* in mixed forests
    - An attacked tree is usually heavily infested
- Ornamental *Prunus* spp. (in urban areas and private gardens)

- Ornamentals planted in the urban areas are expected to have life cycles longer than 30 years

3.1.1.3. Selection of the parameter(s) estimated

The units for the assessment are different for the three categories of impact: (i) in orchards the impact on yield is assessed considering the mean percentage of production that is lost due to the activity of the pest, (ii) in forests the impact is assessed by considering the mean loss of wood production, (iii) for ornamental *Prunus* the impact is assessed by means of the reduction in tree life time caused by the pest (this reduction is considered as a proxy for the reduction in the ecosystem services provided by the ornamental trees).
Aromia bungii is borer, infested fruit trees produce less but there is no impact on the quality of the production. In forest and ornamental plantings attacked trees are usually heavily infested and the wood becomes unmarketable. In conclusion, quality losses are excluded for the assessment.

3.1.1.4. Defined question(s)

What is the percentage yield loss in productive orchards under the scenario assumptions in the area of the EU under assessment for *Aromia bungii*, as defined in the Pest Report?

What is the percentage yield loss in forest stands under the scenario assumptions in the area of the EU under assessment for *Aromia bungii*, as defined in the Pest Report?

What is the percentage yield loss in ornamental *Prunus* spp. in urban areas and private gardens under the scenario assumptions in the area of the EU under assessment for *Aromia bungii*, 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. Some general points were made:

- Cherry, almond, plum, apricot, peach are not expected to differ much in size
- Longer life cycle of the pest expected in the north
- Between planting and production a period of 3 years is required
- 20-25 years productive cycle (shorter in cherry)
- Frass is extruded 2 weeks after eggs are hatched
- Loss occurs when the presence of the pest is first noticed. Still, even in these circumstances, the whole plant is lost
- Depending on the location of the infestations, part of the wood could still be used, but only at the end of the productive cycle
- In forests mixed with *Prunus avium* in Lombardy where damage is > 40% all the trees are removed
- Cherry wood is mainly used for veneer, from minimum 60 year plantations, and mixed stands
- Time of tree decline after infection is short

- In commercial orchards in Italy, peach trees are maintained for a relatively short time (about 10-15 years) whereas apricot, plum and cherry trees are kept for longer periods (more than 20 years)
- In private gardens and amenity areas, trees are likely to remain for several decades and will be even more suitable for establishment
- In Campania (Italy), since the identification of the outbreak (2012), the pest was only observed on *Prunus* fruit trees and not on ornamental *Prunus* species that are also present in the outbreak area (Garonna et al., 2013; Decreto Dirigenziale 31 of 27 March 2019[4])

3.1.1.6. Uncertainties identified

The main uncertainty is due to the unknown preference of *A. bungii* for the different host species.

3.1.2. Elicited values for yield losses on *Prunus* orchards

What is the percentage yield loss in productive orchards under the scenario assumptions in the area of the EU under assessment for *A. bungii*, as defined in the Pest Report?

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

Table 3: The 5 elicited values on yield loss (%) on *Prunus* orchards

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	3%	4%	8%	20%

3.1.2.1. Justification for the elicited values for yield loss on Prunus orchards

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

The upper value of yield loss is estimated in a scenario that considers the following conditions:

- High pest population level
- Many infested orchards (85%)
- When there is a high proportion (50%) of trees infested in an infested orchard, the orchard must be replaced
- Most of the infestation is in young trees (leading to a reduction in production of 50%)
- The orchard is not managed properly
- The insect has a limited capacity to disperse

[4] Giunta Regionale della Campania. Decreto Dirigenziale 31 del 27/03/2019. Piano d'azione regionale per la lotta al cerambicide *Aromia bungii* – VI aggiornamento.

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

The lower value of yield is estimated in a scenario that considers the following conditions:

- The pest arrives at the end of the productive cycle and is established by only a few adults of *A. bungii* who give rise to offspring with a relatively long larval life cycle. Very few adults reach the orchard and there the spread remains low
- In commercial orchards, control of other pests also affects *A. bungii*
- Few orchards become infested (e.g., 40-80% from Japanese papers; in this case the level could be around 6%)
- Few infested trees in an infested orchard (10%)
- Most of the infestation is in old trees (leading to a reduction in production of 30%)
- Current practices are not favourable for the pest to reach high population levels in an orchard

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

The median value of yield loss is given by the fact that the expected impact won't reach very high values and the likely losses remain close to the low level.

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

The uncertainty is higher for lower values while there is more certainty that the curve won't reach the upper values.

3.1.2.2. Estimation of the uncertainty distribution for yield loss on Prunus orchards

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 *Prunus* orchard

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	1%					3%		4%		8%					20%
Fitted distribution	0.8%	1.0%	1.3%	1.7%	2.2%	2.7%	3.3%	4.5%	6.2%	7.4%	9.2%	11.7%	15.3%	19.3%	25.4%

Fitted distribution: Lognorm(0.059266,0.051055), @RISK7.5

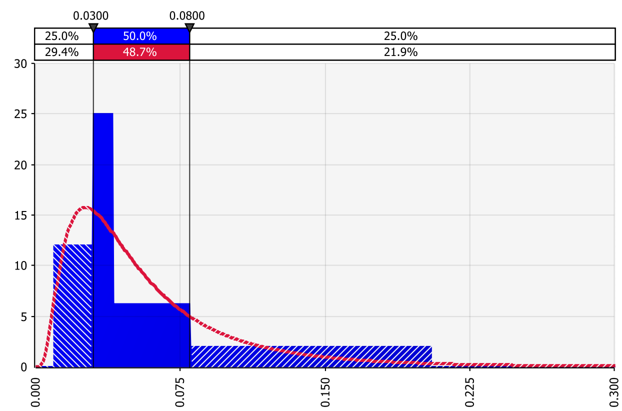

Figure 3 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on *Prunus* orchard.

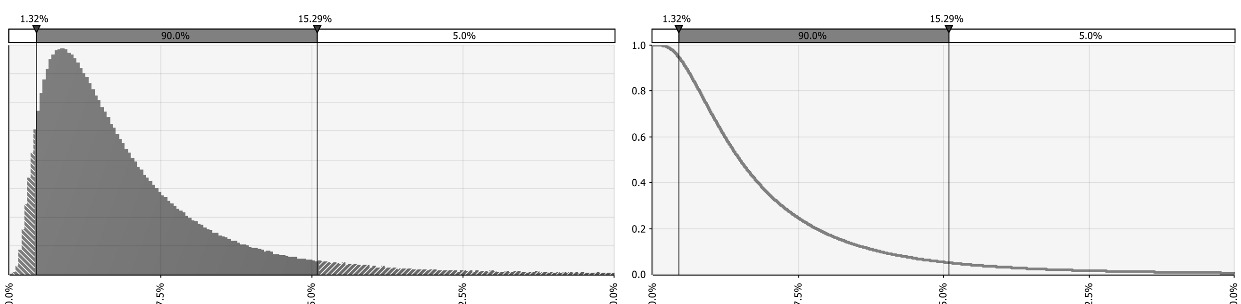

Figure 4 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on *Prunus* orchard.

3.1.3. Elicited values for yield losses on *Prunus* forests

What is the percentage yield loss in forest stands under the scenario assumptions in the area of the EU under assessment for *A. bungii*, as defined in the Pest Report?

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

Table 5: The 5 elicited values on yield loss (%) on *Prunus* forests

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	3.5%	6%	13%	30%

3.1.3.1. Justification for the elicited values for yield loss on Prunus forests

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

The upper value of yield loss is related to a scenario where:

- The initial infestation occurs in a cluster of *Prunus* trees in a mixed forest, with high chance to establish and damage the wood. In a forest stand there would be a high chance of an infestation not being identified
- Harvest in a forest is done only at the end of the production cycle so the population has time to build up locally without being noticed

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

The lower value of yield loss is related to a scenario where:

- The infestation is established by only a few adults of *A. bungii* who give rise to offspring with a relatively long larval life cycle
- The spatial distribution of the host could limit the capacity of the pest to cause damage, if for example the insect does not spread into a forest stand but stays at the edges
- An early infestation is recognised and removed before it spreads
- The population is not able to build high level of abundance

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

The median value of yield loss remains low as it takes into account the fact that cherry wood is of high value and is therefore expected to be generally monitored.

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

The uncertainty is maximum for lower values while certainty is higher around median.

3.1.3.2. Estimation of the uncertainty distribution for yield loss on *Prunus* forests

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 yield loss (%) on *Prunus* forests

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	1%					3.5%		6%		13%					30%
Fitted distribution	0.3%	0.6%	0.9%	1.6%	2.4%	3.4%	4.4%	6.7%	9.8%	11.9%	14.8%	18.3%	23.0%	27.6%	33.6%

Fitted distribution: Gamma(1.4206,0.060954), @RISK7.5

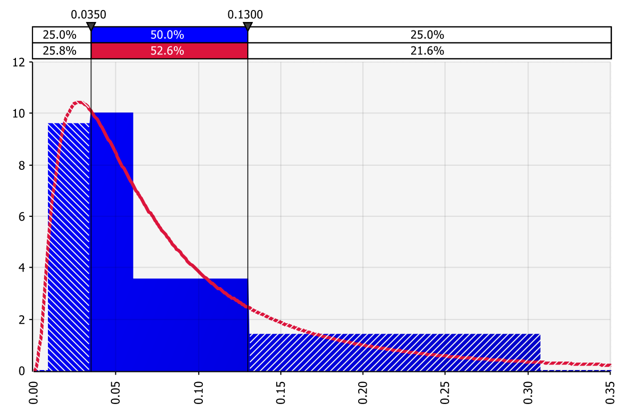

Figure 5 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on *Prunus* forests.

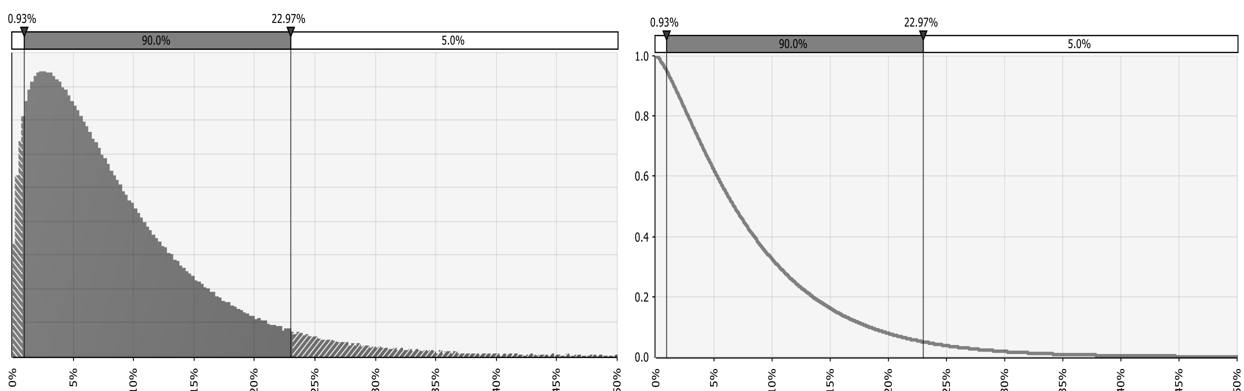

Figure 6 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on *Prunus* forests.

3.1.4. Elicited values for yield losses on ornamental *Prunus*

What is the percentage yield loss in ornamental *Prunus* spp. in urban areas and private gardens under the scenario assumptions in the area of the EU under assessment for *A. bungii*, as defined in the Pest Report?

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

Table 7: The 5 elicited values on yield loss (%) on ornamental *Prunus*

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	2%	8%	12%	18%	30%

3.1.4.1. Justification for the elicited values for yield loss on ornamental Prunus

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

The upper value of yield loss is given by early infestations. If in addition the pest reaches ornamental *Prunus* grown in marginal conditions (e.g. abandoned gardens, plants on private properties not regularly visited and not monitored by phytosanitary services) it has a higher probability to cause relevant damage before being identified.

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

The lower value of yield loss is the consequence of late infestations (or early infestations but immediately noticed with plant removal before spread happens) by a population with a longer development cycle. The spatial distribution of the host could also limit the capacity of the pest to cause damage, if for example there *Prunus* trees are widely dispersed.

Compared to forests the lower damage on ornamental *Prunus* could still be high due to the fact that ornamental plants, even in the best circumstances, are more likely to occur in stressful conditions and less likely to be supported by populations of natural enemies.

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

Compared to forests, trees in urban areas are highly controlled and immediately removed in case of pest attacks (in order to avoid falling), but more stressed and with less protected by natural enemies. Urban trees also have a shorter life span. Not all the trees will be infested at early stage.

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

The uncertainty is higher for values above the median, however there is a confidence around the median.

3.1.4.2. Estimation of the uncertainty distribution for yield loss on ornamental Prunus

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 yield loss (%) on ornamental *Prunus*

Percentile	**1%**	**2.5%**	**5%**	**10%**	**17%**	**25%**	**33%**	**50%**	**67%**	**75%**	**83%**	**90%**	**95%**	**97.5%**	**99%**
Expert elicitation	2%					8%		12%		18%					30%
Fitted distribution	1.4%	2.2%	3.2%	4.7%	6.2%	7.8%	9.3%	12.3%	15.6%	17.6%	20.1%	22.9%	26.2%	29.2%	32.7%

Fitted distribution: Weibull(1.939,0.14893), @RISK7.5

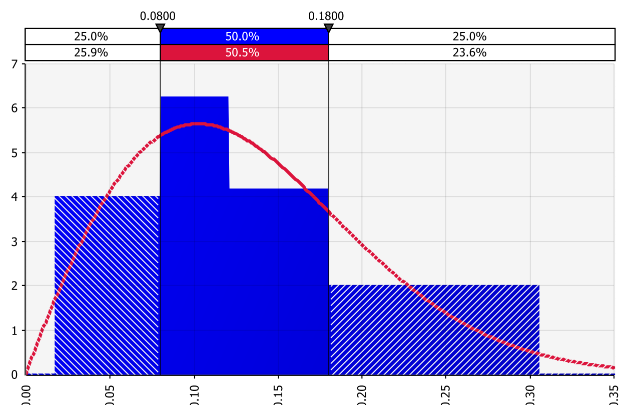

Figure 7 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on ornamental *Prunus*.

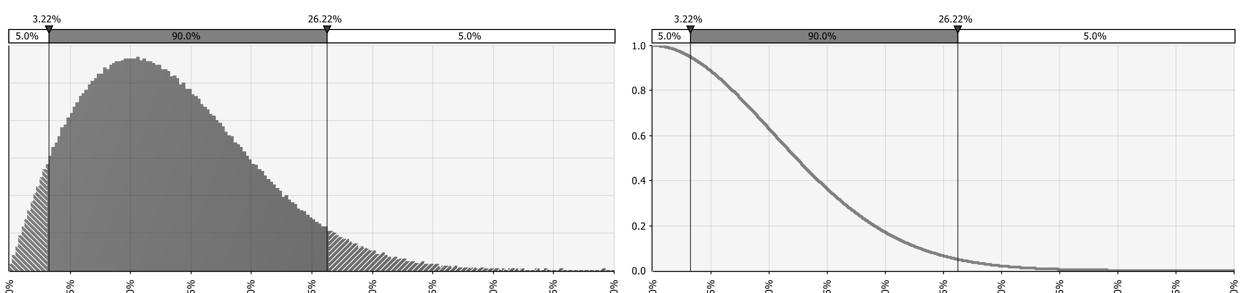

Figure 8 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on ornamental *Prunus*.

3.1.5. Conclusions on yield and quality losses

Based on the general and specific scenarios considered in this assessment, the proportion (in %) of yield losses is estimated to be

- 4.5% (with a 95% uncertainty range of 1-19.3%) in *Prunus* orchards
- 6.7% (with a 95% uncertainty range of 0.6-27.6%) in *Prunus* forests
- 12.3% (with a 95% uncertainty range of 2.2-29.2%) of ornamental *Prunus*

Quality losses have not been included in the assessment because they are considered as full losses and are included under the assessment of yield loss.

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 different priority pests are listed in the section 2.4.2.1 of the scientific report on the applied methodology.

3.2.1.2. Specific scenario assumptions

- Local displacement of logs is considered among the mechanisms of short distance dispersal
- Movement of adults for egg laying can contribute to local dispersal
- Starting points consisting of small clusters of trees infested with a number of individuals which induce some pressure to spread
- Populations have a 2-3 year cycle, based on the expected average life-cycle-length in the EU (i.e., 2-4 year cycles)
- The flight capacity is similar to *Anoplophora glabripennis* or *A. chinensis* EPPO (2014). These species share similar behaviour to *A bungii*, and spread is driven by search for hosts in the proximities

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.
Some general points were made:

- *A. bungii* is expected to behave very similar to *A. glabripennis*
- Scattered distribution of *Prunus* species could require *A. bungii* to travel further than *Anoplophora* for finding a new host
- The rate of expansion of Lombardy outbreak: 2 km in 6 years
- The rate of expansion of Campania outbreak: 5 km in 6 years
- Fukaya et al (2017) provide personal communications by Kiriyama about i) adults flying high (>10 m) in the field without capacity to turn quickly or to precisely control their flight courses, ii) their relatively rapid response to an approaching object while resting on a tree. The authors assume that *A. bungii* possesses relatively good eyesight and can use vision in addition to olfactory senses to find mates
- There are indications that adults may be hitch-hikers as some beetles were found in premises where goods have been imported (EPPO, 2014). On the other hand, human assisted short distance dispersal of eggs and larvae is considered unlikely: they may be present on and in cut branches. However, cut branches will probably be too small for the larvae to complete their development (EPPO, 2014).

3.2.1.6. Uncertainties identified

- Most likely duration of life cycle in the EU

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 spread rate on which the group agreed are reported in the table below.

Table 9: The 5 elicited values on spread rate (m/y)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	25	200	300	550	1,500

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 scenario for the upper value considers that: Climatic conditions are favourable for *A. bungii* it has short life cycle. Host availability is not limiting the spread, but hosts are of low density which creates pressure for insects to move. Higher population abundance can induce more competition and population pressure for dispersal. The high value scenario is well represented by a context placed in suburban landscape area.

The Naples Italy outbreak could be taken as an example of the worst-case scenario.

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

The scenario for lower value considers that:

The insect has a long lifecycle and a low population abundance. Overall *A. bungii* does not have a tendency to move far. Host plants are available and insects do not have to fly far to find hosts. This average takes into account orchard, forest and urban situation with a low population pressure and low competition.

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

According to available data (EU outbreaks) the average spread would be more towards lower values.

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

The precision is given by:

- Q1- More uncertainty in the lower values.
- Q3- More confidence in the median values.

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 10: 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	25					200		300		550					1,500
Fitted distribution	55	73	92	121	153	191	229	317	438	526	656	831	1,092	1,384	1,823

Fitted distribution: Lognorm(420.59,366.6), @RISK7.5

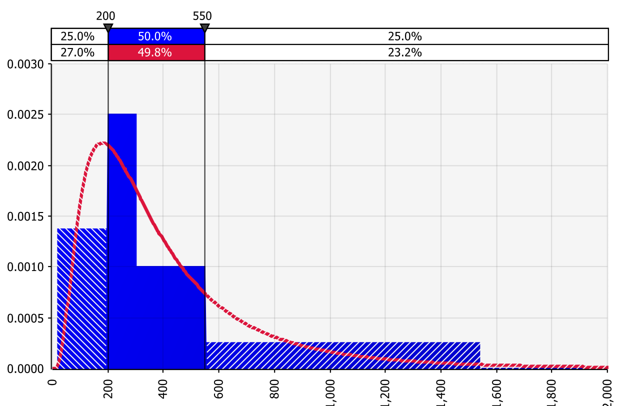

Figure 9 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

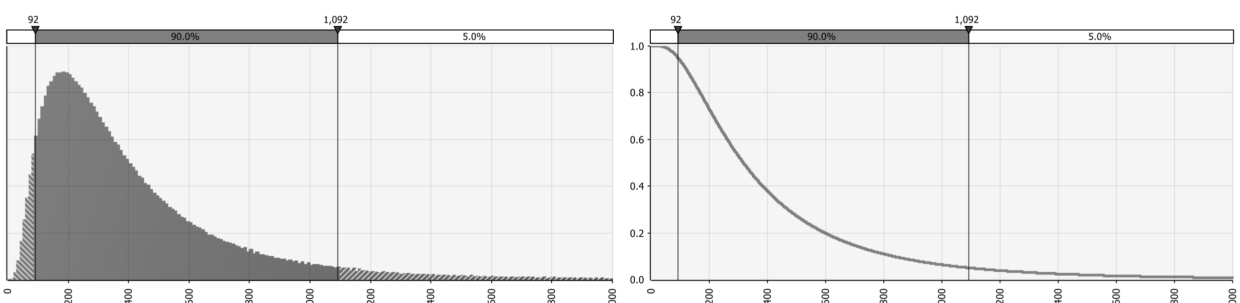

Figure 10 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

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. bungii* is around 300 m (with a 95% uncertainty range of 70 – 1,400 m).

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 different priority pests are listed in the section 2.4.2.1 of the scientific report on the applied methodology.

3.3.1.2. Specific scenario assumptions

Populations have a 2-3 year cycle, based on the expected average life-cycle-length in the EU (i.e., 2-4 year cycles).

- Time to detection takes into account the potentially different conditions in forests, orchards and urban areas

3.3.1.3. Selection of the parameter(s) estimated

The time for detection has been assessed as the number of months 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: months)

3.3.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.3 in Appendix B) selecting the data and references used as the key evidence for the EKE on spread rate. A few general points were made:

- Usually adults stay in the canopy and very rarely on the trunk, so they are difficult to see
- Frass is an important sign but easy to be confused with other pests
- Many years (5-6 years) passed before the outbreaks in Campania, Lombardy, Bavaria were detected
- Infested plants can survive
- A specific detection method is not needed to see and distinguish *A. bungii*

3.3.1.6. Uncertainties identified

No main uncertainties were noted.

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: months)

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

Table 11: The 5 elicited values on time to detection (months)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	4	30	48	72	120

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 estimated for a scenario where

- Adults stay in the canopy and are not easily detected
- The pest has long life cycle, low infestation rate and does not cause extensive tree mortality. These conditions are more typical of forests, wild or abandoned areas
- People find it difficult to detect the presence of the pest

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

The lower value is estimated for a scenario where

- The infestation is found shortly after eggs are laid
- These conditions are more typical of orchards or private gardens, where plants are frequently checked
- There is high awareness among the public and personnel trained to identify the insect exist. The initial infestation occurs in early summer. People would identify either adults or frass and contact the authorities. However, detecting larvae requires that the tree be felled

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

The median value takes into account an average situation among urban, orchard, forest areas. The estimated time to detection for the current EU outbreaks is considered.

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

The precision is mainly driven by the evidence of the symptoms and the uncertainty is higher for the extreme values.

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 12: Fitted values of the uncertainty distribution on the time to detection (months)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	4					30		48		72					120
Fitted distribution	5	8	12	17	23	30	36	48	62	71	81	93	108	121	137

Fitted distribution: Weibull(1.8278,59.228), @RISK7.5

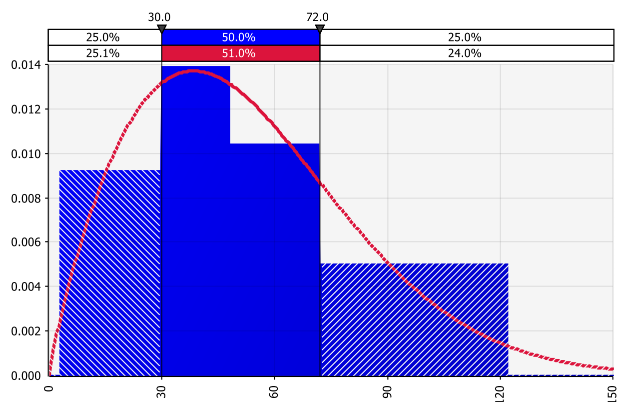

Figure 11 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

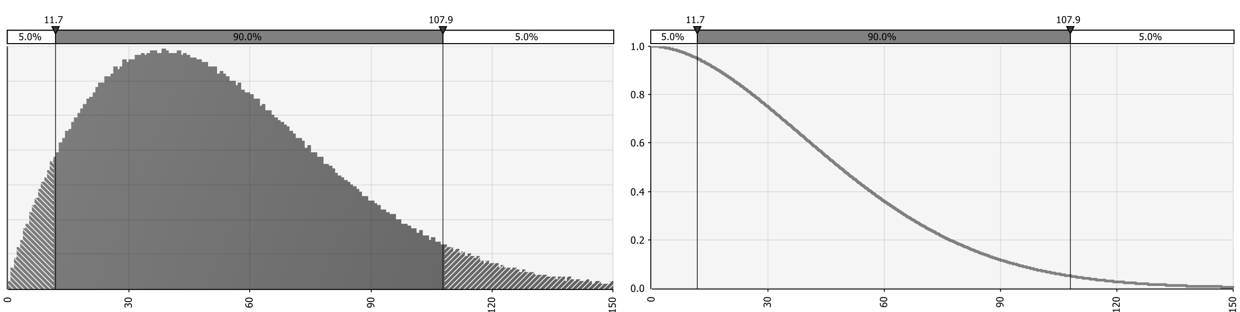

Figure 12 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

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 4 years (with a 95% uncertainty range of 8 months to 10 years).

4. Conclusions

Hosts selection

Based on the different production systems employed and the final use of the products, the impact of *A. bungii* was assessed for different *Prunus* species: (i) in orchards (7 *Prunus* species), (ii) in forests (4 *Prunus* species) and (iii) as an ornamental (all *Prunus* species).

Area of potential distribution

The area of potential distribution in this assessment corresponds to the part of the EU where the annual degree days (base 10°C) are greater than 500. All the current area of *Prunus* cultivation in this area was considered to be suitable for *A. bungii*. This includes everywhere but the extreme north of the EU in Sweden and Finland. However, since the NUTS2 regions are very large in this area and include some locations where degree days are above the threshold, all NUTS2 regions in the EU can be considered to be included in the area of potential distribution based on climate. No transient populations are likely to occur. In conclusion, the area of potential distribution of the pest is equivalent to the area where the main hosts occur in the EU. The mean abundance of the pest, the main driver of the pest impact, is considered to be the same throughout the whole area of potential distribution.

It is expected that the potential damage would be higher in the southern part of the assessment area where more *Prunus* orchards are present and where the pest may have a life cycle of 2 years (whereas it may be 3-4 years in the northern part), and therefore the pest is likely to build up larger populations more quickly in the southern part than in the northern part of the assessment area. However, for the purpose of the assessment the average impact is considered the same throughout the whole area of potential distribution (no gradient or zones are included in the assessment).

Expected change in the use of plant protection products

This pest belongs to Case “A” and category 0 for wood production since no measures are available or feasible to control the pest. Case “D” and category 2 is appropriate for fruit production and ornamentals since integrated strategies, e.g. involving the removal of trees and netting would be required.

Yield and quality losses

Based on the general and specific scenarios considered in this assessment, the proportion (in %) of yield losses is estimated to be

- 4.5% (with a 95% uncertainty range of 1-19.3%) in *Prunus* orchards
- 6.7% (with a 95% uncertainty range of 0.6-27.6%) in *Prunus* forests
- 12.3% (with a 95% uncertainty range of 2.2-29.2%) of ornamental *Prunus*

Quality losses have not been included in the assessment because they are considered as full losses and are included under the assessment of yield loss.

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. bungii* is around 300 m (with a 95% uncertainty range of 70 – 1,400 m).

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 4 years (with a 95% uncertainty range of 8 months to 10 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 Compendiumand 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**
Azadirachta	*indica*
Bambusa	*textilis*
Castanea	*mollissima*
Citrus	
Diospyros	*kaki*
Diospyros	*lotus*
Diospyros	*virginiana*
Juglans	*regia*
Olea	*europaea*
Populus	
Populus	*alba*
Populus	*tomentosa*
Prunus	*americana*
Prunus	*armeniaca*
Prunus	*avium*
Prunus	*cerasifera*
Prunus	*domestica*
Prunus	*domestics*
Prunus	*grayana*
Prunus	*japonica*
Prunus	*mume*
Prunus	*padus*
Prunus	*persica*
Prunus	*pseudocerasus*
Prunus	*salicina*
Prunus	*yedoensis*
Pterocarya	*stenoptera*
Punica	*granatum*
Pyrus	*bretschneideri*
Quercus	
Salix	
Schima	*superba*
Schima	*wallichii*
Zanthoxylum	*bungeanum*

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**
	Incidence	***Severity***	***Losses***		
			30% to 100% of the fruit trees		Liu et al. (1997) cited by EPPO, 2014. Only original language
Peach	Age dependent: from 3-4 years → 14% with 0.17 larvae/tree To 19–20 years→ 95% with 2.67 larvae/tree			Attacks not observed on trees of 1-2 year	Li et al., 2018
Ume and peaches	Infested sites	Attacked trees			Nakano et al., 2018 (Translation available)
	2015: 16/30 (53%)	130/864 (15%)			
	2016: 31/50 (62%)	256/1405 (18%)			
	2017: 69/162 (43%)	425/4832 (9%)			
Japanese cherry (Sakura, *Prunus serrulata*)	Infested sites	Attacked trees	Killed trees	More damages on trees with larger trunk which on the other hand resulted less vulnerable than smaller trees	Yamamoto and Ishikawa, 2018
	2015: 58% (7/12, of which 4/5 with control; 3/7 without control)	11% (24/206 of which 9/94 with control; 15/112 without control)	0%		
	2016: 75% (9/12, of which 4/5 with control, 5/7 without control)	20% (41/206, of which 18/94 with control and 23/112 without control)	0.5% (1/206, of which 1/112 without control)		
	2017: 83% (10/12, of which 5/5 with control, 5/5 without control)	40% (83/206, of which 38/94 with control, and 45/112 without control)	5% (10/206, of which 0/94 with control, 10/112 without control)		
Japanese apricot (Ume, *Prunus mume*)	Infested sites	Attacked trees	Killed trees		Yamamoto and Ishikawa, 2018
	2015: 0%	0%	0%		
	2016: 75%	20%	0%		
	2017: 75%	46%	8%		

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

Spread	Additional information	Reference
Spread rate depends from the proximity of favourable host trees: in absence of hosts, *A. glabripennis* tends to fly longer distances.	Spread rate of *A. glabripennis*, comparable to *A. bungii*, according to EPPO, 2014.	Smith et al., 2001
2-3 km per season	Spread rate of *A. glabripennis*, comparable to *A. bungii*, according to EPPO, 2014. Method: mass mark-recapture, which could provide an overestimation.	Smith et al., 2004
99.2% of the infestation within a radius of 400 m	Spread rate of *A. glabripennis*, comparable to *A. bungii*, according to EPPO, 2014	Cavagna et al., 2013
600 trees infested in 41 garden/orchard sites. The outbreak extends over an area of over 10 km in diameter with a single outlier located around 5 km outside of the main area. The orchards/gardens are scattered throughout the area	In Campania (IT), it is considered that *A. bungii* may have entered at least 5 years ago but given the scale of the outbreak, possibly much earlier. Result of a combination of natural and human-assisted spread.	EPPO, 2014

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

Reference	Case	Aspect	Results / evidence
Detection methods			
Van der Gaag et al., 2008	Surveillance of larvae	Effects on detectability	Hidden stages are very difficult to detect.
Burmeister et al., 2012	EU outbreaks	Effects on detectability	First specimen detected on July 2011 near Kolbermoor village in Upper Bavaria. Two other specimens were observed, including several bore holes. Supposed establishment since 2008 or 2009.
EPPO, 2014	Main symptoms: visual	Effects on detectability	Frass: extruded in large quantities by larvae, it can be observed on the branches or the stems, attached to the surface of the bark or on the surface of the ground. Young larvae start excreting frass about 2 weeks after hatching (very early) and from that moment it is extruded almost every day. The amount of frass increases with the size of the larva. It is very visible in orchards and private gardens. Exit holes (10-12 mm) are also visible. There are no oviposition scars since eggs are laid in crevices on the surface of the bark and they may be visible externally.
EPPO, 2014; DG SANTE, 2015	Traps effectiveness	Effects on detectability	Attractive liquid (sugar/vinegar mixtures) seem to be effective mainly when the relative humidity of the air is low, because adults look for water, otherwise it is a kind of trap more suitable to wood borers feeding on dead or decaying wood. In Italy, liquid food traps attracted many adults in some places but none in others (EPPO, 2014). It is not yet considered as a reliable or particularly effective technique to ensure detection.
Xu et al., 2017	Traps effectiveness	Effects on detectability	Preliminary results on a sex-aggregation pheromone attracting both males and females are promising.
EPPO, 2014	Main symptoms: visual	Effects on detectability	About 10cm: diameter of the most attacked branches, although observed also on thinner branches or stems, e.g. stems of 6 cm in Campania, a branch of 3-4 cm with a large gallery in China.
Jung et al., 2018	Main symptoms: visual	Effects on detectability	Observations on cherry trees in Korean urban areas: larvae entrance holes generally found from old trees above 30 cm

			in diameter at breast height, especially planted on dry environments, such as pavement roads, wood deck and so on.
Li et al., 2018	Main symptoms: visual	Effects on detectability	1– to 2–year–old peach trees not infested: larvae found on plants at least year old.
Li et al., 2018	Sampling technique	Effects on detectability	Given the fact that larvae show an aggregated spatial pattern and density dependent behaviour, in which aggregation increases with increasing population density, the authors suggest a sequential sampling formula based on 6 classes of age of trees (from 3 to 20 year old).
Yamamoto and Ishikawa, 2018	Main symptoms: visual	Effects on detectability	The highest damage position is rarely 2 m above the ground. Also, they are higher in those trees with longer period of damage.
Gregoire, 2018	Confusion with other pests	Effects on identification	The type of damage could be confused with *Cossus cossus* and *Zeuzera pyrina*, which are however moths.
	Confusion with other pests	Effects on identification	The autochthonous *Aromia moschata* is green where *A. bungii* is black and feeds on willow.
PSR Campania, 2013	Citizen science	Effects on detectability	Example on communication to general public.
Biology of the pest			
EPPO, 2014,	Behaviour	Effects on detectability	Egg laid mainly at 30 cm above ground level. There is no record of infestation in the roots. The larvae bore down the branches and the trunk under the bark or in the sap wood until pupation. The complete gallery can reach 50 to 60 cm in length. Pupation occurs in the heartwood.
Wang et al., 2007	Life cycle	Effects on incidence	325-357 eggs/female on average (ranging from 91 to 734) under artificial conditions
EPPO, 2014	Life cycle	Effects on incidence	about 700 eggs/female (with a maximum of 1200).
EPPO, 2014	Life cycle	Effects on incidence	The fecundity of females in the natural environment is not known but each female lay probably between 30 to 100 fertile eggs on few close trees (30 to 75 for Osphranteria coerulescens, another Callichromatini pest on fruit trees; Sharifi et al., 1970).
EPPO, 2014	Life cycle	Effects on detectability	Life cycle: 2-4 years. Adults life span: 10 days (Huang et al., 2012) 15-20 days (Garonna et al., 2013). They can be maintained alive in the laboratory in Petri dishes at 8°C for 2 months (with some food – peach fruit- available) (EPPO, 2014) Emergence and flight period of adults very long
	Adults	Effects on detectability	The adult beetles are 2.5-4 cm in length and their colour makes them relatively easy to find.
	Behaviour	Effects on detectability	Adults are active during the day.
EPPO, 2014	Larvae	Effects on detectability	The fully developed larvae are up to 4 cm in length. There may be several larvae in the main stem or branches. However, during the early stages of infestation, the presence of larvae might not be easy to detect, especially before the larvae have had an impact on the tree.