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Anoplophora chinensis 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 *Anoplophora chinensis* the following document was used as a key reference: the pest risk analysis by van der Gaag et al. (2008).

[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

Anoplophora chinensis is a single taxonomic entity. *Anoplophora malasiaca* was recognized as a junior synonym of *A. chinensis* in 2002 (Lingafelter and Hoebke, 2002), and this needs to be taken into account with the literature predating 2002, where *A. chinensis* and *A. malasiaca* are differentiated. In some papers *A. malasiaca* is reported as a subspecies of *A. chinensis*.

The adults feed on leaves and young bark of various trees, but the main impact is caused by the larvae, which disrupt nutrient and water transport in attacked trees by damaging the vascular system; this causes structural weakness and in consequence may lead to tree death. The pest colonizes healthy trees but can attack the same tree repeatedly over a long period of time. The female deposits about 70 eggs one week after copulation, under the bark of the trunk up to 60 cm above the soil level and also in the roots, but very rarely in branches. The larva tunnels under the bark and enters the woody tissues. Pupation takes place in the wood and a circular exit hole can be observed in the trunk after the adult leaves the tree. In tropical and subtropical regions, a single generation per year is observed but occasionally the life cycle takes two years. In the Netherlands, three years may be required to complete its life cycle (van der Gaag et al., 2008).

2.2. Host plants

2.2.1. List of hosts

A. chinensis is a polyphagous pest and can attack plants of more than 70 plant taxa belonging to more than 20 families: van der Gaag et al. (2011) provide the full list in Appendix I of their article.

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

The list of hosts indicated by van der Gaag et al. (2011) includes only those plant species on which *A. chinensis* was found able to complete the life cycle. Due to the large number of hosts, the authors concluded that all woody deciduous plants are potential hosts of *A. chinensis*, although with different levels of susceptibility. Hérard and Maspero (2018) identified the following 17 genera as the preferred hosts in Lombardy, after 16 consecutive years of observations in the infested area: *Acer*, *Aesculus*, *Betula*, *Carpinus*, *Corylus*, *Cotoneaster*, *Crataegus*, *Fagus*, *Lagerstroemia*, *Malus*, *Platanus*, *Populus*, *Prunus laurocerasus* (only this species of *Prunus*), *Pyrus*, *Quercus*, *Rosa*, and *Ulmus*. The frequency distribution of *A. chinensis* attacks in Lombardy evidenced a strong preference for *Acer* spp. (36%) with differences in preference at species level (Cavagna et al., 2013).

In Italy, the preference for *Tilia*, *Platanus*, *Fagus* is higher in *A. chinensis* than in *A. glabripennis*.

Anoplophora chinensis is also a pest of *Citrus* in Japan.

2.2.3. Conclusions on the hosts selected for the evaluation

Taking into account the very large number of host species and the similarity of the damage that can occur, four groups were identified based on the habitats/production systems in which they occur: forests for hardwood production (e.g. *Fagus*), trees in urban/suburban areas, *Citrus* for fruit production and *Malus*, *Prunus* and *Pyrus* for fruit production.

2.3. Area of potential distribution

2.3.1. Area of current distribution

Anoplophora chinensis is native to China, Japan and North Korea and was introduced to USA and Europe. Figure 1 provides an overview of the current area of distribution of the pest. Outbreaks have occurred in the EU since 2001 in several EU MSs: Italy (2000), Netherlands (2001; 2004), France (2003), UK (2005), Croatia (2007), Germany (2008), Lithuania (2008), and Denmark (2011).

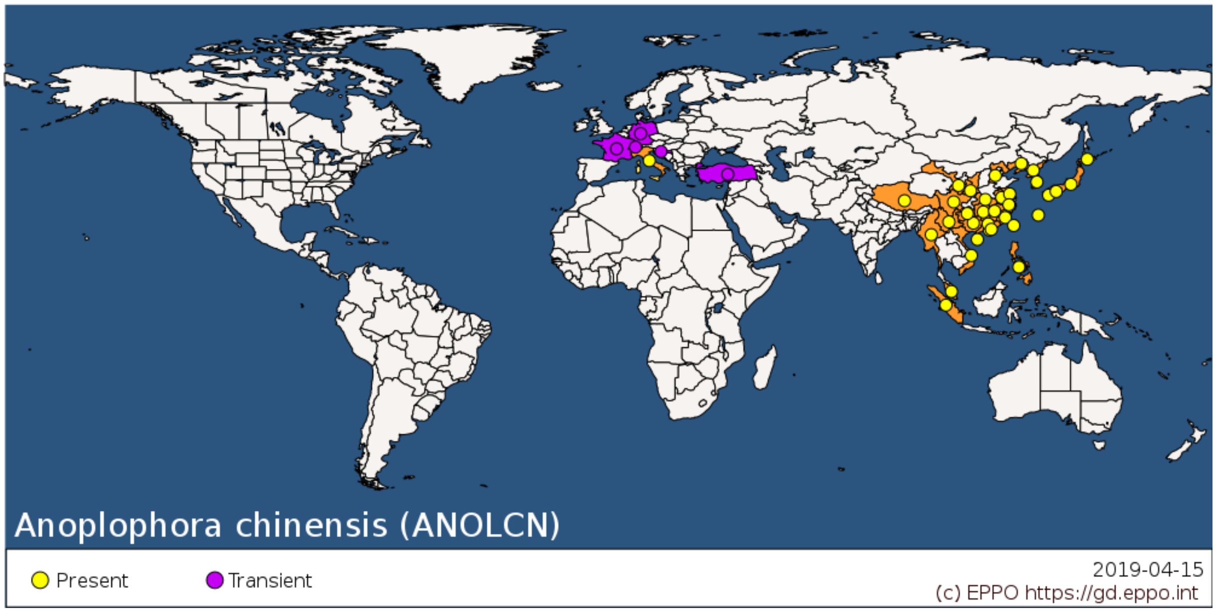

Figure 1 Distribution map of *Anoplophora chinensis* from the EPPO Global Database accessed 15/04/2019 (EPPO, online).

2.3.2. Area of potential establishment

The CLIMEX model based on Robinet et al. (2012) was used to define the area of potential distribution. The resulting Figure 2 shows that all of the EU is suitable for establishment except for the north of Sweden and the north of the United Kingdom.

2.3.3. Transient populations

Anoplophora chinensis 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

All the current area of the EU was considered to be suitable for *A. chinensis* (except for the north of Sweden and the UK, Figure 2) and was therefore used as the area of potential distribution in this assessment.

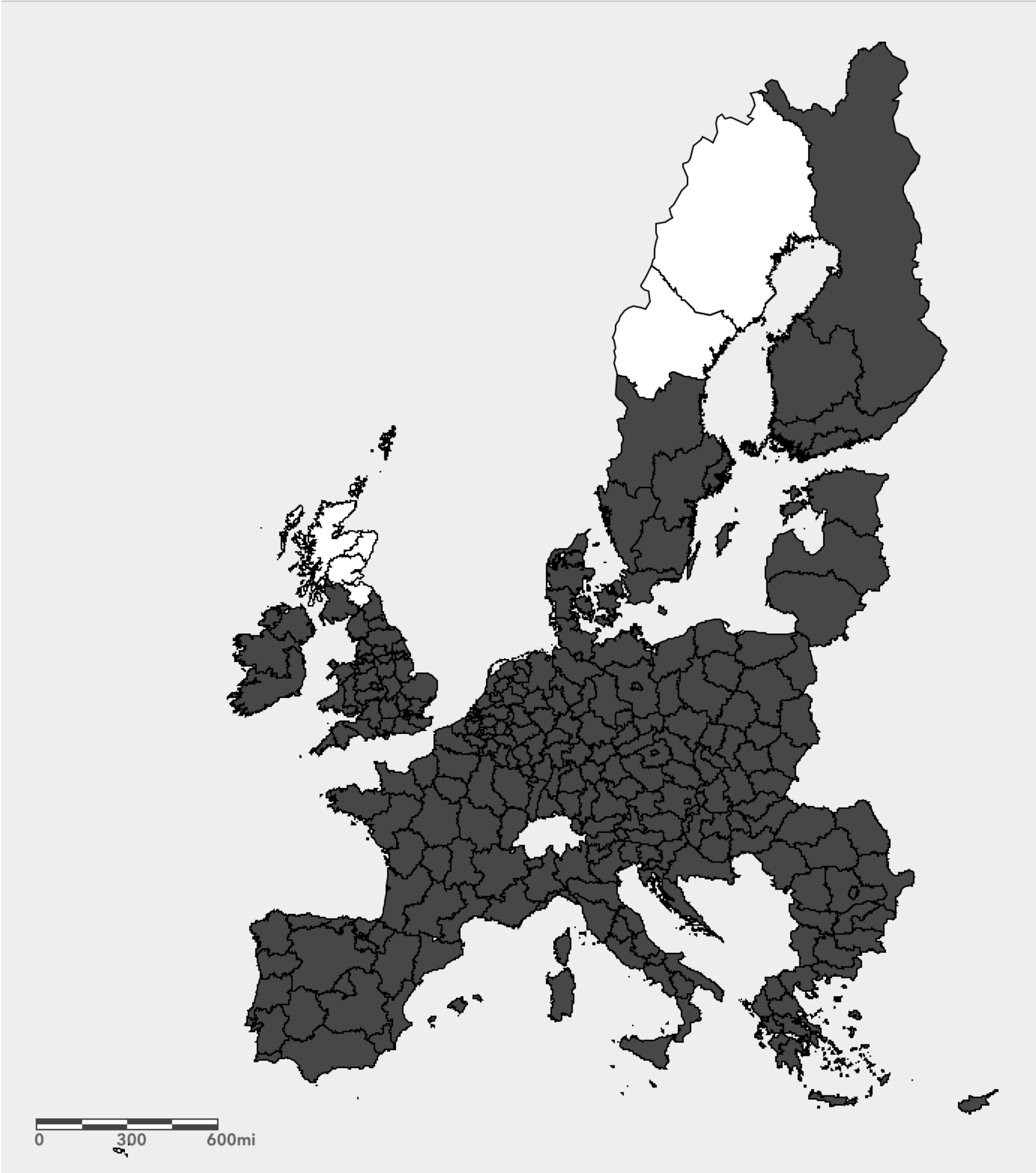

Figure 2 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/0OWaCf

2.4. Expected change in the use of plant protection products

No control strategies are appropriate *for A. chinensis* apart from tree felling and destruction of the host since trunk injection methods require further development and the adults are too difficult to trap.

In conclusion, based on the table below, this pest belongs to Case "A" and category **0** since no measures are available or feasible to control the pest.

Table 1: Expected changes in the use of Plant Protection Products (PPPs) following *Anoplophora chinensis* 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

- Infested plants or parts of plants are removed.
- Yield losses include both dead trees and the removal of affected parts of a tree.
- Quality losses are not assessed because infested trees or parts of trees will only be used for low value wood products and therefore count as total losses.
- Damage in urban areas is assessed by considering that these affect small populations of hosts that are not growing in optimal conditions.
- Due to the fact that in woodlands *A. chinensis* is a “forest-edge pest”, the area where impacts could occur is just a proportion of the overall area of potential establishment
- In urban areas current practices include the removal of infested plants (because they are dead and/or due to pest detection even when the tree is still alive) and their subsequent replacement.
- Outside forests, the mortality takes into account a stable tree population that is based on the replacement of dead plants.
- In urban areas the replacement rate corresponds with yield loss.
- The removal of infested plants is considered to be an uncertainty.
- total yield loss does not correspond to the infestation rate because damaged wood can still be sold at a lower value and damaged plant parts can be removed.
- The final product for forests is hardwood (the production of secondary products, e.g. woodchips, is not taken into account).
- Species composition: the population of hardwood forest plants is composed of all potential hosts relevant for wood production in a proportion that reflects the situation at the EU level.
- For urban areas an average lifespan of a tree of 60-80 years is taken into account
- Two possible scenarios are considered for the yield losses:
    - The tree does not reach the optimal size for harvesting.
    - The tree reaches the optimal size for harvesting but part of the wood has to be discarded because it is damaged.

- *Malus*, *Pyrus*, *Prunus* orchards: only yield loss is considered (as % of weight of production). Lost trees are replaced. Production cycle is no longer than 15-20 years. Attacked trees die and are replaced but there is a long period (3-5 years) before the new plant becomes productive. Fruits may be smaller because of stress during the early phase of infestation.
- *Citrus* orchards are more likely to be attacked in Japan than *Malus*, *Pyrus* and *Prunus*. The production cycle is longer, up to 30 years, compared to *Malus*, *Pyrus* and *Prunus*. No replacement of trees is assumed to occur in *Citrus* orchards.
- Time for development of the pest is not taken into account as we consider the time will be long enough to observe the impact.
- Population density might be reduced by insecticides applied in the orchards. Timing of pesticides application might be not the same for other pests compared to *A. chinensis*.

3.1.1.3. Selection of the parameter(s) estimated

In forest plantations the EKE is based on the mortality of trees caused by *A. chinensis*, since it is assumed that infested trees do not reach the normal size for harvesting. The estimation of mortality is not affected by any replanting. It is assumed that even damage only to the outer layers of the tree will cause total loss of hardwood production. The use of reduced quality trees, e.g. by downgrading its final use from hardwood to pulp wood or firewood, has not been evaluated.

In urban and suburban areas, the EKE is based on the percentage loss in ecosystem services.

Although in the EU outbreaks damages on *Prunus* species, other than *P. laurocerasus*, have never been observed, the Working Group included this genus among those potentially affected in commercial orchards, based on the existing evidence in the area of origin (Sjöman et al., 2014).

For *Citrus*, *Malus*, *Prunus* and *Pyrus*, the EKE is based on losses in fruit production.

3.1.1.4. Defined question(s)

What is the percentage yield loss in hardwood production under the scenario assumptions in the area of the EU under assessment for *Anoplophora chinensis*, as defined in the Pest Report?

What is the percentage loss in ecosystem services in urban and suburban areas under the scenario assumptions in the area of the EU under assessment for *Anoplophora chinensis*, as defined in the Pest Report?

What is the percentage yield loss in citrus production under the scenario assumptions in the area of the EU under assessment for *Anoplophora chinensis*, as defined in the Pest Report?

What is the percentage yield loss in *Malus, Pyrus* and *Prunus* production under the scenario assumptions in the area of the EU under assessment for *Anoplophora chinensis*, 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. Comparisons with *A. glabripennis* and some general points were noted:

- Differently from *A. glabripennis*: exit hole is at the bottom of the trunk and there is a preference for isolated trees or trees in rows
- Low population densities still produce a high impact (Faccoli, 2018)

3.1.1.6. Uncertainties identified

- Compared with *A. glabripennis*, infestations are easier to detect but more difficult to eradicate (due to the need for root removal)
- It is more polyphagous than *A. glabripennis* and therefore the impact is expected to be higher in urban areas
- The main uncertainties refer to the impact on *Citrus*, *Malus, Prunus* and *Pyrus* orchards: very few information can be found in literature and inconsistent observations are collected in the area of origin and in the EU outbreak (e.g. no impact on *Prunus* spp. have been observed yet in Italy, other than on *P. laurocerasus*).

3.1.2. Elicited values for yield losses of hardwood in forest plantations

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

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

Table 2: The 5 elicited values on yield loss (%) on forests hardwood production:

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	0%	1.5%	2.5%	4%	10%

3.1.2.1. Justification for the elicited values for yield loss of hardwood in forest plantations

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

The upper value depends on the fact that *A. chinensis* is a more aggressive species than *A. glabripennis* but it prefers isolated trees and the climate in the area of potential distribution is not as suitable as in its native range.

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

The lower value takes into account the fact that *A. chinensis* does not seem to be a forest pest and prefers warmer climates compared to *A. glabripennis*.

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

The median value is mainly justified by the fact that at least half of hardwood production is in central EU where the climate is not very suitable for *A. chinensis*.

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

The precision reflects the uncertainty in the values lower than median and the low probability of high values.

3.1.2.2. *Estimation of the uncertainty distribution for yield loss of hardwood in forest plantations.*

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 3: Fitted values of the uncertainty distribution on the yield loss (%) in forest plantations

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	0%					1.5%		2.5%		4%					10%
Fitted distribution	0.3%	0.4%	0.6%	0.8%	1.1%	1.5%	1.8%	2.5%	3.4%	4.0%	4.7%	5.7%	6.9%	8.0%	9.5%

Fitted distribution: Gamma(2.161,0.01374), @RISK7.5

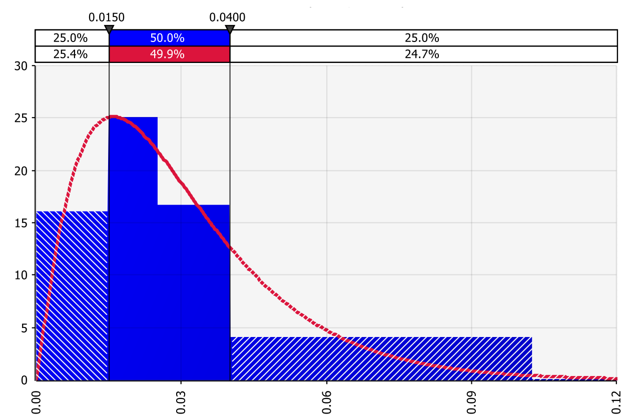

Figure 3 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss in forest plantations.

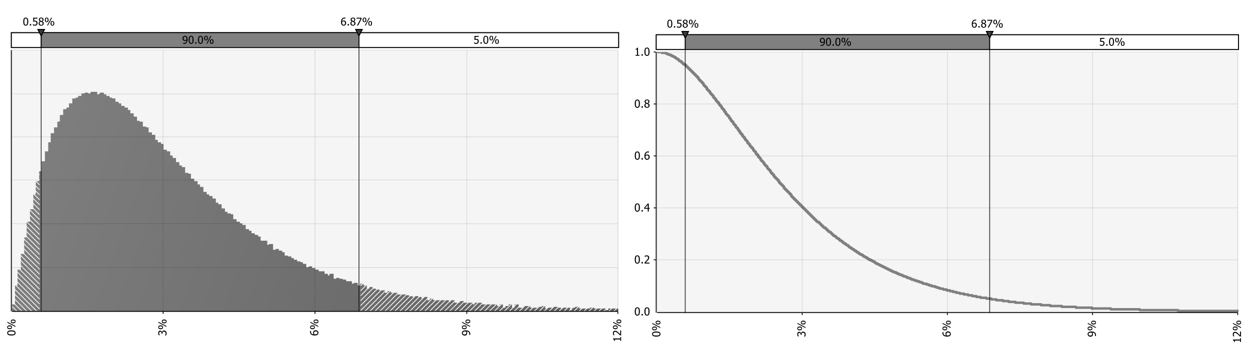

Figure 4 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss in forest plantations.

3.1.3. Elicited values for losses to ecosystem services in urban and suburban areas

What is the percentage loss in ecosystem services in urban and suburban areas under the scenario assumptions in the area of the EU under assessment for *A. chinensis*, as defined in the Pest Report?

The five elicited values on losses in ecosystem services in urban and suburban areas on which the group agreed are reported in the table below.

Table 4: The 5 elicited values on losses in ecosystem services (%) in urban and suburban areas

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	5%	13%	20%	30%	60%

3.1.3.1. Justification for the elicited values for losses to ecosystem services in urban and suburban areas

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

The upper value takes into account a scenario where

- The pest is present at high population density
- The attacked tree species are among the most susceptible
- Survey activity occurs and is effective, but the detection capacity is low
- The high mortality rate causes a high replacement rate with younger plants, therefore reducing the level of ecosystem services provision

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

The lower value is based on a scenario where

- The pest is present at low population density
- The attacked tree species are among the most resistant, or at the end of their life cycle (so the ecosystem service losses are limited)
- Survey activity occurs and is effective with a high detection capacity
- The attacked trees are replaced with plants that are still old enough to provide a level of ecosystem services level that is almost equal to that of the removed tree
- When attacked trees are removed, this gives a longer life span to the remaining trees, since they are no more at risk of attack

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

The damage is expected to be higher in urban areas than in forests, as this pest favours small and stressed plants. However, the pest is easier to detect and the surveillance activity in urban areas is more effective and is easier than for *A.glabripennis*, due to the position of exit holes at the base of the trunk. The attacked trees can still survive consecutive years of attack, particularly when trees are mature and when population densities are low. The impact is expected to be a little higher than for *A. glabripennis* due to the difficulty of removing the roots of affected trees.

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

Uncertainty is mainly located on the upper side of the curve. There is a little bit more uncertainty compared with *A. glabripennis*.

3.1.3.2. *Estimation of the uncertainty distribution for loss in ecosystem services in urban and suburban areas*

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 5: Fitted values of the uncertainty distribution on the loss (%) in ecosystem services in urban and suburban areas

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	5%					13%		20%		30%					60%
Fitted distribution	5%	6%	7%	9%	11%	13%	15%	20%	26%	30%	35%	40%	47%	52%	59%

Fitted distribution: BetaGeneral(1.6087,6.7072,0.04,1), @RISK7.5

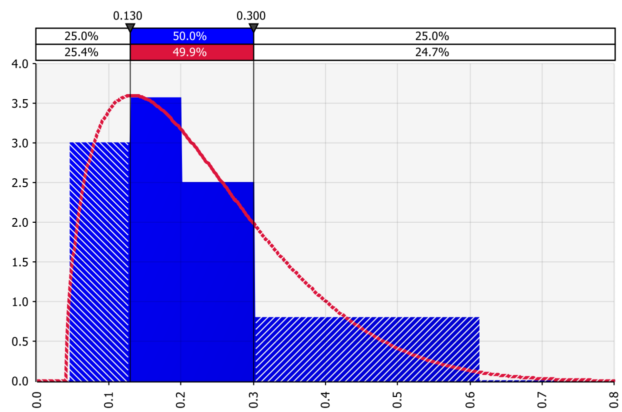

Figure 5 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss in urban and suburban areas.

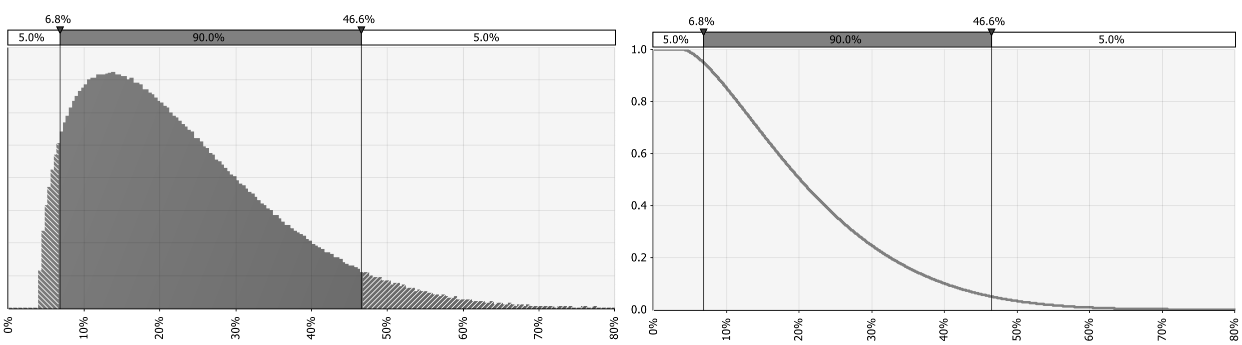

Figure 6 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss in urban and suburban areas.

3.1.4. Elicited values for yield losses on *Citrus*

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

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

Table 6: The 5 elicited values on yield loss (%) on *Citrus*

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	6%	8%	12%	25%

3.1.4.1. Justification for the elicited values for yield loss on Citrus

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

The upper value depends on the fact that *A. chinensis* also attacks young trees. Trees die in a few years. In Japan 25% had been attacked in some locations. The value is based on a consideration of two different scenarios in each orchard: either with low productive young trees or highly productive older trees. Insecticide treatment is not effective because of the method and time of application.

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

The lower value takes into account the fact that few infestations in the later phases of the life of the orchard are observed. The population density is low. Few trees, mainly at the edge of the orchard, are infested reducing overall impact. We assume that insecticides will control the population.

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

The median value is justified by the fact that the timing and density of the attacks is mainly in the middle of the expected production cycle of citrus trees and some control methods are in place. The tree may not be reattacked.

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

The precision reflects the lower uncertainty for values below the median and higher uncertainty for values above the median.

3.1.4.2. Estimation of the uncertainty distribution for yield loss on Citrus

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 7: Fitted values of the uncertainty distribution on the yield loss (%) on *Citrus*

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	1%					6%		8%		12%					25%
Fitted distribution	2.5%	3.0%	3.5%	4.3%	5.0%	5.8%	6.6%	8.3%	10%	12%	14%	16%	19%	23%	27%

Fitted distribution: Gamma(2.161,0.01374), @RISK7.5

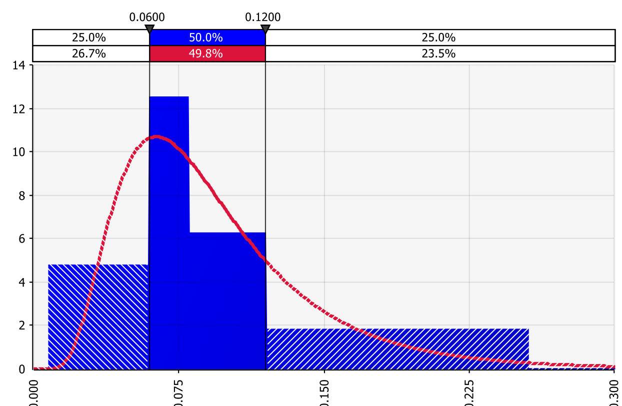

Figure 7 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on *Citrus* sp.

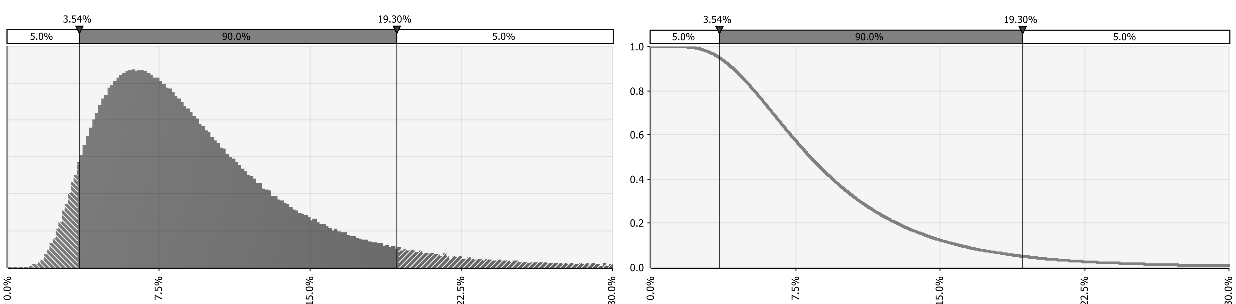

Figure 8 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on *Citrus* sp.

3.1.5. Elicited values for yield losses on *Malus, Pyrus, Prunus*

What is the percentage yield loss in *Malus, Pyrus* and *Prunus* production under the scenario assumptions in the area of the EU under assessment for *A. chinensis*, as defined in the Pest Report?

The five elicited values for yield loss on *Malus, Pyrus* and *Prunus* on which the group agreed are reported in the table below.

Table 8: The 5 elicited values on yield loss (%) on *Malus, Pyrus, Prunus*

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	4%	6%	12%	20%

3.1.5.1. Justification for the elicited values for yield loss on Malus, Pyrus, Prunus

The assessment of the impact on *Malus, Prunus* and *Pyrus* was conducted in comparison with the impact assessed for *Citrus.* In both cases the Working Group acknowledged the limited evidence in support to the EKE.

It is expected that the replacement of trees will reduce the impact.

The climatic conditions in the area of *Malus, Prunus* and *Pyrus* production are less suitable for *A. chinensis* than those in *Citrus* productive regions. *Malus*, *Pyrus* and *Prunus* are expected to be less susceptible to *A. chinensis* than *Citrus*.

Treatments are not expected to be effective.

3.1.5.2. *Estimation of the uncertainty distribution for yield loss on Malus, Prunus* and *Pyrus*

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 9: Fitted values of the uncertainty distribution on the yield loss (%) on *Malus, Prunus* and *Pyrus*

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	1%					4%		6%		12%					20%
Fitted distribution	0,5%	0,9%	1,3%	2,0%	2,8%	3,7%	4,6%	6,6%	9,2%	11%	13%	16%	19%	23%	27%

Fitted distribution: Gamma(2.161,0.01374), @RISK7.5

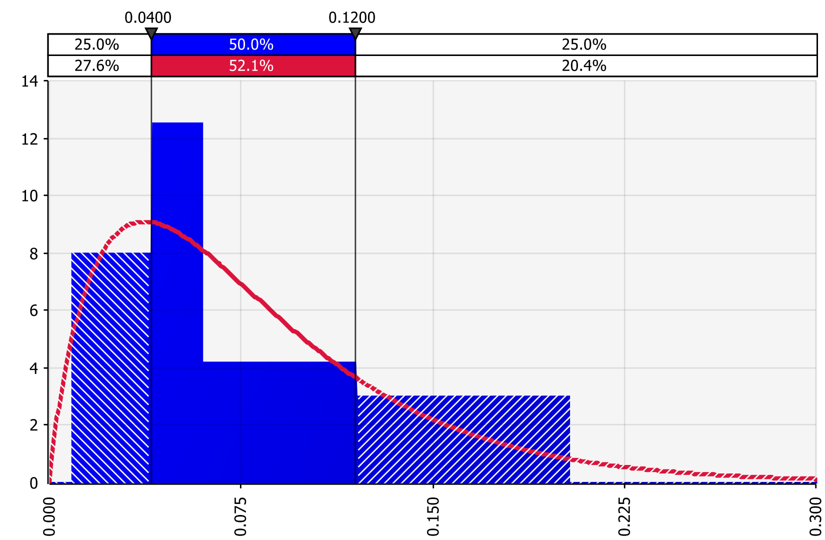

Figure 9 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on *Malus, Prunus* and *Pyrus*.

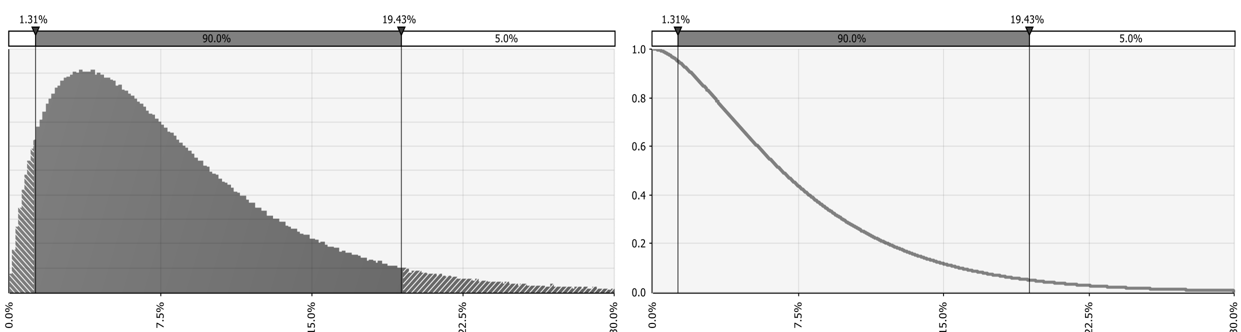

Figure 10 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on *Malus, Prunus* and *Pyrus*.

3.1.6. Conclusions on yield and quality losses

Based on the general and specific scenario considered in this assessment, the proportion (in %) of losses (here with the meaning of reduction in fruit production or hardwood production and the loss of ecosystem services) is estimated to be

- 3% (with a 95% uncertainty range of 0-98%) on forest trees
- 20% (with a 95% uncertainty range of 6-52%) on ecosystem services in urban and suburban areas
- 8% (with a 95% uncertainty range of 3-19%) on *Citrus*
- 7% (with a 95% uncertainty range of 1-23%) on *Malus, Pyrus, Prunus*

Quality losses have not been included in the assessment.

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 the section 2.4.2.1 of the Methodology Report (EFSA, 2019).

3.2.1.2. Specific scenario assumptions

- A population with a 2 year cycle is considered based on the average EU situation (1-3 year life cycle)
- In case of forest management, the common practice of gathering the cut logs inside the forest along a forest road is included in the short distance spread and taken into account in the spread rate. In case of urban infestations, since the material resulting from pruning is either shredded on the spot or gathered in a waste facility/storage area which could be far from the infestation location, this component is not considered in the assessment of the natural spread rate
- Due to limited knowledge about the host preferences of the pest, the different host species are not considered to influence the spread rate
- Hitchhiking is excluded as it is a major component of human assisted spread in urban situations
- The spread rate is assessed as a single parameter which takes into account the difference in conditions between forest and urban areas

3.2.1.3. Selection of the parameter(s) estimated

The spread rate has been assessed as the number of metres per year. Values are assessed by comparing the results with *A. glabripennis.*

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. The key evidence was obtained from:

- van der Gaag et al. (2008) and Hérard and Maspero (2018)
- Cavagna et al. (2013)

3.2.1.6. *Uncertainties identified*

- Influence of the difference in forest structures between urban plantations and natural and managed forests
- The effect of host preference
- unknown biases in the capture mark, release experiments
- less experimental evidence compared to *A. glabripennis*

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

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	10	120	200	300	2000

3.2.2.1. *Justification for the elicited values of the spread rate*

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

The upper value is based on *A. glabripennis* results with additional experimental evidence (flight mill studies) assuming similar behaviour.

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

This value is estimated as being lower than *A. glabripennis* due to the fact that *A. chinensis* is observed to favour smaller trees (therefore also potted plants) that often grow at higher densities.

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

The median value of 200m is based on van der Gaag et al. (2008).

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

The higher uncertainty is given for lower values due to missing evidence. The 3rd interquartile is mainly based on Cavagna et al. (2013).

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 11: 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	10					120		200		300					2000
Fitted distribution	28	42	57	77	99	123	145	194	260	308	382	489	669	904	1337

Fitted distribution: Loglogistic(0,194.48,2.3836), @RISK7.5

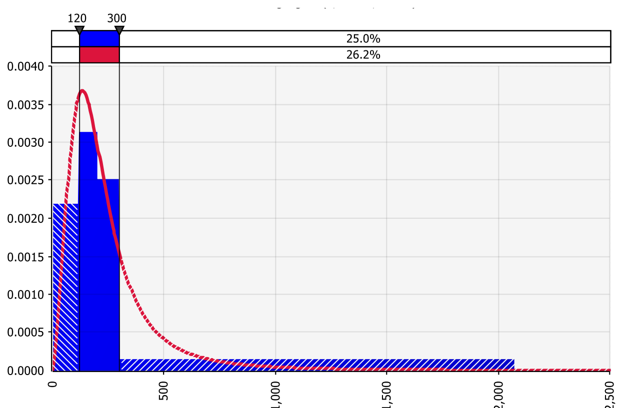

Figure 11 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

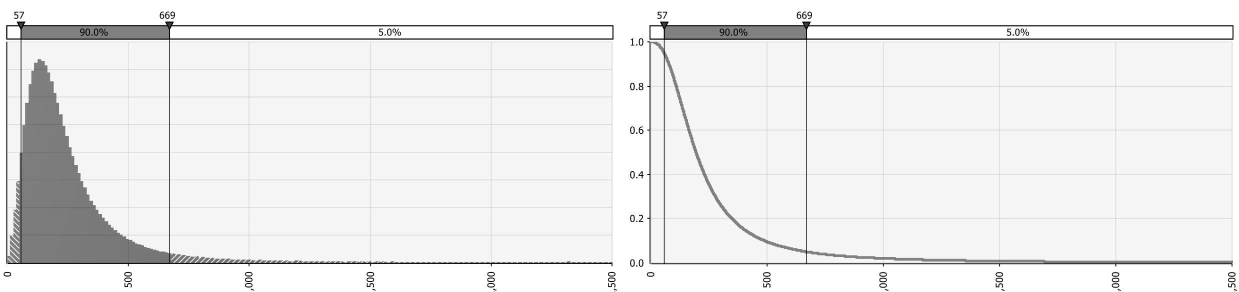

Figure 12 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

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. chinensis* is approximately 194 m (with a 95% uncertainty range of 42 – 904 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 priority pests are listed in the section 2.4.2.1 of the Methodology Report (EFSA, 2019).

3.3.1.2. Specific scenario assumptions

No specific assumptions are introduced for the assessment of the time to detection.

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.

The time to detection is assessed separately for forest and urban areas conditions.

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

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:

- Adults and exit holes are very visible and easy to spot even for the general public
- The exit holes at the base of the trunks and on roots are easier to observe than for *A. GLABRIPENNIS*
- Strangi et al. (2017) provides useful evidence from Italian outbreaks
- Tree recovery by forming calluses over exit holes could mask pest presence and delay symptom expression (Sabbatini et al., 2012)

3.3.1.6. *Uncertainties identified*

- The extent to which the different behaviour of *A. chinensis* (which, unlike *A. glabripennis*, also attacks young trees) will influence the time to detection.

3.3.2. Elicited values for the time to detection in urban areas and orchards

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 12: The 5 elicited values on time to detection (years) in urban areas and orchards

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	2	4.5	5.5	6.5	10

3.3.2.1. *Justification for the elicited values of the time to detection in urban areas and orchards*

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

The upper value of 10 years takes into account the uncertainties related to the values provided by Strangi et al. (2017): the two extremes of 8 and 15 years in this paper are equally uncertain.

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

The lower value of 2 years is based on the assumption that exit holes can be seen after 2 years of development (van der Gaag et al., 2008).

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

The median value of 5.5 years takes into account the assumption that *A. glabripennis* is harder to spot and for that pest a median value of 7 years was defined.

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

The precision indicates a high level of confidence around the median value.

3.3.2.2. *Estimation of the uncertainty distribution for the time to detection in urban areas and 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 13: Fitted values of the uncertainty distribution on the time to detection (years) in urban areas and orchards

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	2					4.5		5.5		6.5					10
Fitted distribution	2.1	2.5	2.9	3.3	3.7	4.0	4.3	4.9	5.6	6.1	6.7	7.4	8.5	9.8	11.6

Fitted distribution: Loglogistic(0,4.946,5.3906), @RISK7.5

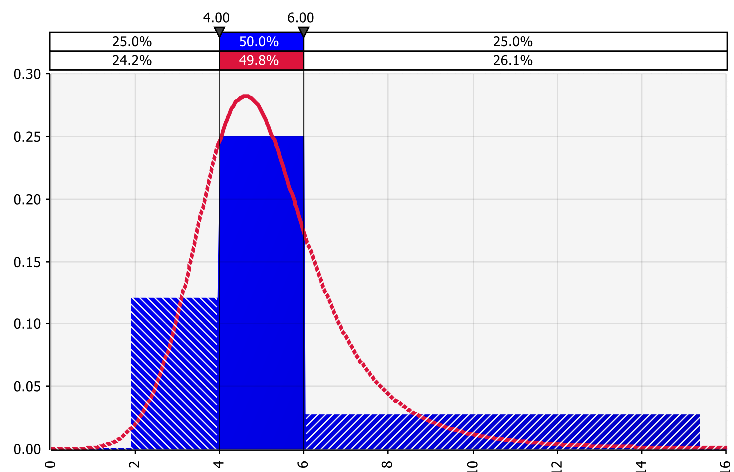

Figure 13 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection in urban areas and orchards.

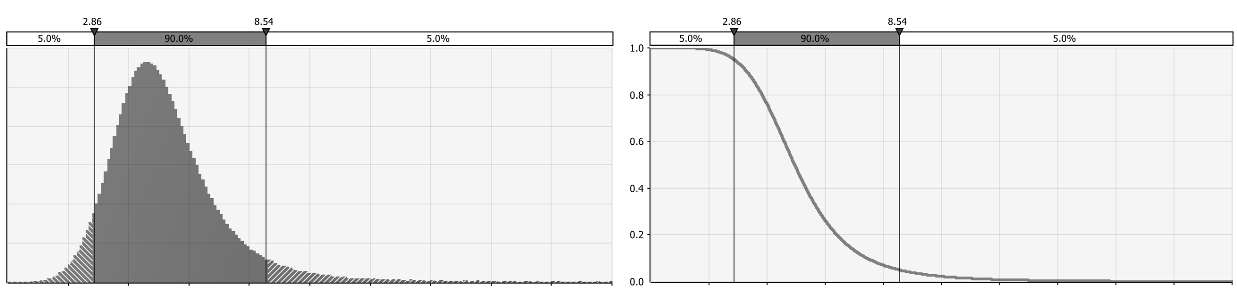

Figure 14 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection in urban areas and orchards.

3.3.3. Elicited values for the time to detection in forests

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 14: The 5 elicited values on time to detection (years) in forests

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	2	7	8	10	12

3.3.3.1. Justification for the elicited values of the time to detection in forests

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

The upper value is obtained by comparing the same pest in urban areas (where it will be detected faster) and with *A. glabripennis* which presents less visible symptoms.

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

The lower value of 2 years is based on the assumption that exit holes can be seen after 2 years of development (van der Gaag et al., 2008).

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

The median value takes into account the greater difficulty in detecting the symptoms in forests compared to urban areas.

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

The precision is lower for the upper values.

3.3.3.2. Estimation of the uncertainty distribution for the time to detection in 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 15: Fitted values of the uncertainty distribution on the time to detection (years) in forests

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	2					7		8		10					12
Fitted distribution	2.7	3.5	4.2	5.1	5.9	6.6	7.3	8.4	9.4	9.9	10.4	10.9	11.4	11.7	12.0

Fitted distribution: BetaGeneral(4.109,2.1962,0,12.5), @RISK7.5

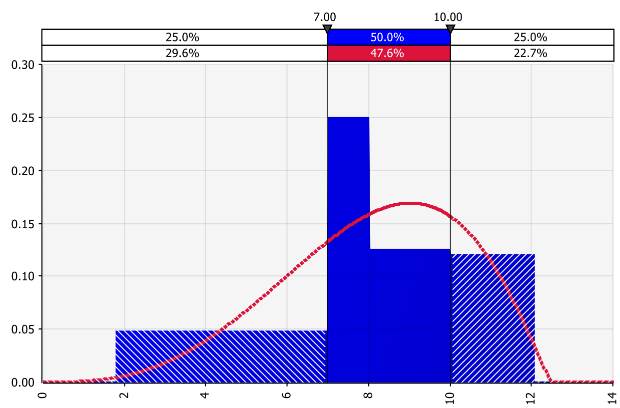

Figure 15 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection in forests.

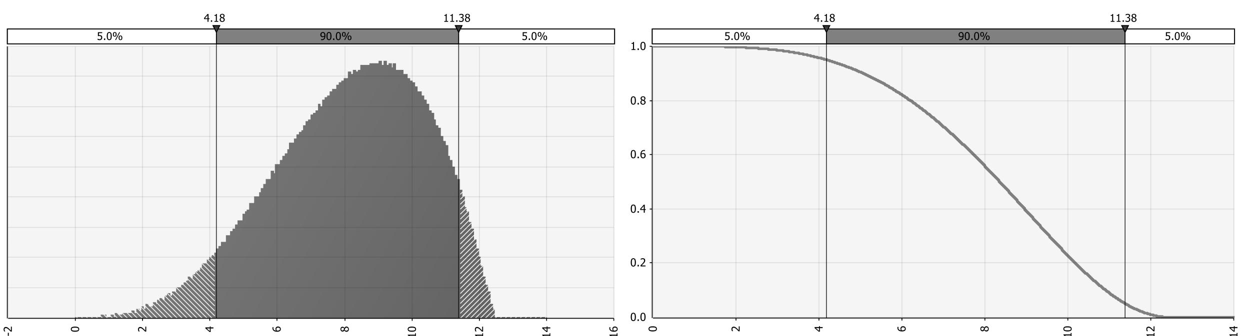

Figure 16 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection in forests.

3.3.4. 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:

- 4.9 years (with a 95% uncertainty range of 2.5 to 9.8 years) in urban areas and orchards (*Citrus, Malus, Pyrus* and *Prunus*)
- 8.4 years (with a 95% uncertainty range of 3.5 to 11.7 years) in forests.

4. Conclusions

Hosts selection

Taking into account the very large number of host species and the similarity of the damage that can occur, four groups were identified based on the habitats/production systems in which they occur: forests for hardwood production (e.g. *Fagus*), trees in urban/suburban areas, *Citrus* for fruit production and *Malus*, *Prunus* and *Pyrus* for fruit production.

Area of potential distribution

All the current area of the EU was considered to be suitable for *A. chinensis* (except for the north of Sweden and the UK) and was therefore used as the area of potential distribution in this assessment.

Expected change in the use of plant protection products

This pest belongs to Case "A" and category **0** since no measures are available or feasible to control the pest.

Yield and quality losses

Based on the general and specific scenario considered in this assessment, the proportion (in %) of losses (here with the meaning of reduction in fruit production or hardwood production and the loss of ecosystem services) is estimated to be

- 3% (with a 95% uncertainty range of 0-98%) on forest trees
- 20% (with a 95% uncertainty range of 6-52%) on ecosystem services in urban and suburban areas
- 8% (with a 95% uncertainty range of 3-19%) on *Citrus*
- 7% (with a 95% uncertainty range of 1-23%) on *Malus, Pyrus, Prunus*

Quality losses have not been included in the assessment.

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. chinensis* is approximately 194 m (with a 95% uncertainty range of 42 – 904 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:

- 4.9 years (with a 95% uncertainty range of 2.5 to 9.8 years) in urban areas and orchards (*Citrus, Malus, Pyrus* and *Prunus*)
- 8.4 years (with a 95% uncertainty range of 3.5 to 11.7 years) in forests.

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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 (CABI, 2018) and the EPPO Global Database (EPPO, online). 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
Acacia	*decurrens*
Acacia	*mearnsii*
Acer	
Acer	*negundo*
Acer	*palmatum*
Acer	*pictum*
Acer	*saccharinum*
Aesculus	*hippocastanum*
Albizia	*julibrissin*
Alnus	
Alnus	*alnobetula*
Alnus	*firma*
Alnus	*hirsuta*
Alnus	*pendula*
Aralia	*cordata*
Atalantia	
Betula	
Betula	*platyphylla*
Broussonetia	*papyrifera*
Cajanus	*cajan*
Carpinus	
Carpinus	*laxiflora*
Carya	*illinoinensis*
Castanea	
Castanea	*crenata*
Castanopsis	*cuspidata*
Casuarina	
Casuarina	*equisetifolia*
Casuarina	*stricta*
Citrus	
Citrus	*aurantiifolia*
Citrus	*aurantium*
Citrus	*deliciosa*
Citrus	*junos*
Citrus	*limon*
Citrus	*limonia*
Citrus	*maxima*

Citrus	*natsudaidai*
Citrus	*nobilis*
Citrus	*paradisi*
Citrus	*reticulata*
Citrus	*reticulate*
Citrus	*sinensis*
Citrus	*unshiu*
Cornus	
Corylus	*avellana*
Cotoneaster	
Crataegus	
Cryptomeria	*japonica*
Elaeagnus	*umbellata*
Eriobotrya	*japonica*
Fagus	
Fagus	*crenata*
Ficus	
Ficus	*carica*
Fortunella	*margarita*
Hedera	*rhombea*
Hibiscus	
Hibiscus	*mutabilis*
Juglans	
Juglans	*mandshurica*
Lagerstroemia	
Lagerstroemia	*indica*
Lindera	*praecox*
Litchi	*chinensis*
Litchi	*sinensis*
Mallotus	*japonicus*
Mallotus	*philippensis*
Malus	
Malus	*domestica*
Malus	*pumila*
Melia	*azedarach*
Morus	
Morus	*alba*
Persea	*thunbergii*
Pinus	*massoniana*
Platanus	
Platanus	*acerifolia*
Platanus	*occidentalis*
Platanus	*orientalis*
Poncirus	*trifoliata*
Populus	
Populus	*alba*
Populus	*maximowiczii*
Populus	*nigra*
Populus	*sieboldii*
Populus	*tomentosa*
Prunus	*armeniaca*

Prunus	*mume*
Prunus	*pseudocerasus*
Prunus	*yedoensis*
Psidium	*guajava*
Punica	*granatum*
Pyracantha	*angustifolia*
Pyrus	
Pyrus	*communis*
Pyrus	*pyrifolia*
Pyrus	*ussuriensis*
Quercus	*acutissima*
Quercus	*glauca*
Quercus	*petraea*
Quercus	*serrata*
Rhus	*javanica*
Rhus	*verniciflua*
Robinia	*pseudoacacia*
Rosa	
Rosa	*multiflora*
Rosa	*rugosa*
Rubus	*microphyllus*
Salix	
Salix	*babylonica*
Salix	*gracilistyla*
Salix	*integra*
Salix	*jessoensis*
Salix	*laevigata*
Salix	*sachalinensis*
Sapium	*sebiferum*
Sophora	
Styrax	*japonica*
Styrax	*japonicus*
Ulmus	
Ulmus	*davidiana*
Ulmus	*pumila*
Vaccinium	
Vernicia	*fordii*
Woody	*plants*
Zanthoxylum	
Ziziphus	*mauritiana*

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**	**Uncertainty**
	Incidence	***Severity***	***Losses***			
Acer			*Acer saccharinum* trees are heavily attacked and usually die either due to secondary infections or directly due to the high number of larval tunnels in the wood. Other *Acer spp.* and *Fagus sp.* are also heavily attacked often leading to the death of the tree but only when they have (many) roots surfacing above the ground.	Italy, Lombardia	van der Gaag et al., 2008	
Acer palmatum and *A. negundo*			A total of 52 larvae that bored holes into the sapwood of six young trees consumed on average nearly 27 (26.98) percent of the stemwood, 12 (11.94) cm in length. Trees weakened by larval attack become readily susceptible to wind damage as the proportion of holes in the wood increases.	Outbreak in Trabzon 2016. Young trees of *Acer palmatum* and *A. negundo* 1.9-10.4 cm in diameter.	Eroglu et al.,2017	Information taken from abstract, article in Turkish
Citrus			On average 19.3% (10% to 52%) of the sampled trees had new exit holes that occurred in 1987. The mean number of emergence holes per tree bearing the holes varied from 2.2 to 5.9. Average frequency of trees with emergence holes (1987 and older) in all six regions was 66%.	300 *Citrus* trees from 6 different orchards (50 in each region) were randomly sampled. All orchards were managed with conventional pest control practices.	Mitomi et al., 1990	Information taken from abstract, article in Japanese
Corylus avellana			*Corylus avellana* shrubs are heavily attacked leading to the death of the shrub or to the death of individual branches. Other host trees and shrubs in Lombardy are generally attacked to a lower extent and usually do not die or at least not within a few years.	Italy. Lombardia	van der Gaag et al., 2008	

Many species	Number of infested and sensitive plants			Table 1 in the original article	Roselli et al., 2013 (p. 23)	

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

Spread	**Additional information**	**Reference**
Identification of main means of spread		
Natural spread	*A. chinensis* is present in Lombardy (Italy). Beetles of *A. chinensis* probably behave like beetles of the related species *A. glabripennis* in that they usually do not fly over long distances, usually less than 400 m	van der Gaag et al., 2008
Natural spread	Only one study is known to have investigated dispersal of *A. chinensis*. In a mark-recapture study, a few beetles were found at a distance of more than 2 km from the initial point of release (unpublished data referred to in Adachi, 1990; no details were given about this study by the author).	van der Gaag et al., 2008
Natural spread	More information is available about dispersal distance of the related species *A. glabripennis*. In mark-recapture studies of this beetle, marked beetles were found at distances of more than 1 or 2 km (Smith et al., 2001 and 2004). However, most beetles of *A. glabripennis* remained near the tree from which they emerge (Sacco, 2004). In the infested area in Chicago, 99% of trees with egg-deposit sites were within about 400 m (1/4 mile) of the nearest tree with one or more exit holes	van der Gaag et al., 2008; Smith et al., 2001 and 2004; Sacco, 2004
Natural spread	At high population densities *A. chinensis* may fly more than 2 km and may spread more rapidly (Adachi, 1990). However, it is likely to take several years for populations to build up to high densities at new outbreak sites in the EU.	van der Gaag et al., 2008
Natural spread	This geostatic study (Methods 1 and 2) demonstrates that all new infestations of *Anoplophora chinensis* can be found within a radius of 500 m in an urban environment and within a radius of 663m in an agricultural Environment (Cavagna et al., 2013).	Cavagna et al., 2013
Human assisted spread	*A. chinensis* could spread by human assistance in several ways a) By trade of infested trees b) As a contaminant on transport vehicles c) By movement of infested wood	van der Gaag et al., 2008
Natural and human assisted spread	Authors describe the progression of the discoveries of infested areas in Lombardy between 2000 and December 2017. This may not represent the natural spread of the pest because the gradual increase in surveillance efforts may have detected sites that had been infested in previous years.	Hérard and Maspero, 2018

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

Category of factors	Additional information	Reference
Biology	In *A. malasiaca*, some marked adults were recaptured in places more than 2 km from their release point. Such relatively large flight potential may result in frequent migration.	Adachi, 1990
Biology	The life cycle in EU is 2 year, and the characteristic holes in trees can be seen after 2 years of larva development.	van der Gaag et al., 2008
Detection	It also usually takes 5-10 years before a tree will die due to attack by the pest or due to secondary infections (experiences in the infested area in Lombardy).	van der Gaag et al., 2008
Detection	Formation of callus on the exit holes makes them invisible in after some years.	Sabbatini et al., 2012
Detection	The oldest (outbrake) one was detected in Parabiago (Lombardy, Northwest of Italy) in 2000 even if the first introduction had probably occurred 10 or 15 years before.	Strangi et al., 2017
Detection	Another outbreak of A. chinensis was detected in 2008 in Rome (Region Lazio) but dendrochronological analysis of fully wood-enclosed adult exit holes showed that the actual year of introduction might date back to 2002.	Strangi et al., 2017
Detection	Similarly, in Galciana (Tuscany, Central Italy), the infestation of *A. chinensis* was detected in 2014, but dendrochronological analysis evidenced that the first year of introduction could date back to 2009 (Strangi, personal communication).	Strangi et al., 2017