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Pest Risk Analysis for

Lycorma delicatula

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This risk assessment follows the EPPO Standard PM PM 5/5(1) *Decision-Support Scheme for an Express Pest Risk Analysis* (available at http://archives.eppo.int/EPPOStandards/pra.htm) and uses the terminology defined in ISPM 5 *Glossary of Phytosanitary Terms* (available at https://www.ippc.int/index.php).
This document was first elaborated by an Expert Working Group and then reviewed by the Panel on Phytosanitary Measures and if relevant other EPPO bodies.

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Photo: *Lycorma delicatulaadult*. Courtesy: Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org

Pest Risk Analysis for *Lycorma delicatula* (Hemiptera: Fulgoridae)

This PRA follows EPPO Standard PM 5/5 *Decision-Support Scheme for an Express Pest Risk Analysis*. For the determination of ratings of likelihoods and uncertainties, experts were asked to provide a rating and level of uncertainty individually during the meeting, based on the evidence provided in the PRA and on the discussions in the group. Each EWG member provided anonymously a rating and level of uncertainty, and proposals were then discussed together in order to reach a final decision.

PRA area: EPPO region
Prepared by: EWG on *Lycorma delicatula*
Date: 1-4 February 2016

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Prior to the EWG, the PRA was reviewed and comments provided by the following experts: Lawrence Barringer and Sven-Erik Spichiger (Pennsylvania Department of Agriculture, USA).

All personal communications in this PRA were obtained in January/February 2016. There is limited published information on some aspects relating to *Lycorma delicatula*, in particular regarding observations from Pennsylvania. Consequently this PRA relies heavily on the knowledge of experts from countries where the pest occurs, and contains many personal communications.

Following the EWG, the PRA was further reviewed by Dominic Eyre (UK; EPPO Panel on Quarantine Pests for Forestry) and by the following PRA core members: Alan MacLeod (UK), Dirk Jan van der Gaag (The Netherlands), José Maria Guitian Castrillon (Spain), Silvija Pupelienė (Lithuania), Nursen Urstun (Turkey), Guillaume Fried (France), Ahmet Uludag (Turkey).

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Summary of the Pest Risk Analysis for *Lycorma delicatula* (Hemiptera: Fulgoridae)

PRA area: *EPPO region*

Describe the endangered area: The endangered area is considered to be where the host *Ailanthus altissima* is present. There is an uncertainty on the host status of a number of other plants, and whether the pest may be able to sustain populations on those in the absence of *A. altissima*, which would widen the endangered area. This is the case, among others, for *Vitis vinifera*. Overall it is not expected that the climate will be a limiting factor for the establishment of the pest.

Main conclusions

Overall assessment of risk: L. delicatula is present in China, Taiwan and Vietnam, and was introduced into the Republic of Korea, Japan and the USA (Pennsylvania). Feeding activity can cause withering of the foliage, and attacked trees may develop weeping wounds on their trunks; stunting and plant mortality may occur in heavy infestations (e.g. on *Vitis vinifera*). In China, it is overall not considered a major pest, but damage has been reported in forestry (on *A. altissima*), and on various fruit species (e.g. *Actinidia*, *Malus*, *Prunus*). In the Republic of Korea, it causes damage to *Vitis vinifera*. In Pennsylvania, it is present in a limited area and subject to quarantine. No economic damage has been observed to date, but it is considered by the Pennsylvania Department of Agriculture as a potential threat for many species, such as grapevine, apple, stone fruits, nurseries and the hardwood timber industry. Information is lacking from other countries where the pest occurs.

The risk of entry for all pathways is mostly linked to the presence of egg masses (generally difficult to detect). Likelihood of entry was assessed as being:

- *moderate to high* for woody plants for planting (except seeds) of known hosts of diameter above 1 cm (*moderate* for other woody plants of diameter above 1 cm)
- *moderate* for all roundwood and sawn wood, for wood packaging material (this rating also applies to such material treated according to ISPM 15 because egg masses can be laid after treatment) and man-made items/inert objects (it is suspected that *L. delicatula* was introduced in Pennsylvania with stones imported from China).
- *low to moderate* for wood chips, hogwood (in the terms of EPPO Study on on wood commodities, see section 8 and Annex 3), processing wood residues (except sawdust and shavings), and bark (of a size exceeding 2.5 x 2.5 cm in two dimensions).

L. delicatula is likely to establish at least in areas where *A. altissima* is present. It may have an economic impact on grapevine (known impact in the Republic of Korea), and possibly on other fruit trees, urban trees, and forest or plantation trees. Eggs will be difficult to detect while nymphs and adults may be more easily detected. Some control options are available (such trapping of nymphs, scraping of egg masses, chemical control) and others are under evaluation, especially in the USA. If introduced, it may spread to many places through human assisted pathways. It will be difficult to eradicate and contain (requiring controls on the movement of a wide variety of plants, commodities and items).

Phytosanitary measures to reduce the probability of entry: Risk management options were determined for woody plants for planting, round wood and sawn wood, wood chips, hogwood, processed wood residues, bark. Wood packaging material, man-made items and inert objects are discussed.

Phytosanitary risk for the *endangered area* (*Individual ratings for likelihood of entry and establishment, and for magnitude of spread and impact are provided in the document*)	High ☐	**Moderate** ☒	Low ☐
Level of uncertainty of assessment (*see Q 17 for the justification of the rating. Individual ratings of uncertainty of entry, establishment, spread and impact are provided in the document*)	High ☐	**Moderate** ☒	Low ☐

Other recommendations: *L. delicatula* is believed to be a good example for which citizen science could be applied and a larger community be involved in early detection (large insect, colourful).

Stage 1. Initiation

Reason for performing the PRA: *Lycorma delicatula* is a polyphagous pest originating from Asia, which was first found in Pennsylvania (USA) in 2014. In the 2000s, it was introduced into the Republic of Korea where it rapidly spread, showing invasive behaviour and causing damage to vineyards. Considering the fact that *L.delicatula* can attack many woody plants of economic importance in the EPPO region, and that it has clearly shown invasive behaviour in its introduced range, the EPPO Secretariat decided to add it to the EPPO Alert List (EPPO, 2015a). The Panel on Phytosanitary Measures suggested *L. delicatula* as a priority for PRA, which was confirmed by the Working Party on Phytosanitary Measures in June 2015.

The EPPO standard PM 5/5 *Decision-Support Scheme for an Express Pest Risk Analysis* was used, as recommended by the Panel on Phytosanitary Measures. Pest risk management was conducted according to the EPPO Decision-support scheme for quarantine pests PM 5/3(5) (detailed in Annex 4).

PRA area: EPPO region (map at www.eppo.org).

Stage 2. Pest risk assessment

1. Taxonomy

Taxonomic classification. Kingdom: Animalia / Phylum: Arthropoda / Class: Insecta / Order: Hemiptera/ Suborder: Auchenorrhyncha / Family: Fulgoridae / Genus: *Lycorma* / Species: *delicatula* (White, 1845) Subspecies: *jole* and *operosa* (Bourgoin - Flow, 2016).
Previous names. *Aphaena delicatula*, *Lycorma delicatulum* (Bourgoin - Flow, 2016)

Common names. English**:** spotted lanternfly (USA, Barringer, 2014); spot clothing wax cicada (China, Korea; Han et al., 2008; Lee et al., 2011); Chinese blistering cicada (University of California, 2015).
Other languages (transcriptions used in English articles): 'chu-ki', 'hong-liang-zi', 'hua-gu-liang', 'ban-yi-la-chan' (Chinese); 'ggot-mae-mi' (Korean) (Han et al. 2008; Lee et al., 2009).

Due to the large distribution of the pest in very different climatic zones, the existence of subspecies or cryptic species of *L. delicatula* cannot be excluded. In particular, two subspecies were described in the past: *Lycorma delicatula jole* Stål, 1863 and *Lycorma delicatula operosa* (Walker, 1858). Their validity needs to be re-checked (T. Bourgoin, pers. comm.).

There are only three other *Lycorma* species, all from Asia: *Lycorma imperialis* (White, 1846), *Lycorma meliae* Kato, 1929 and *Lycorma olivaceae* Kato, 1929 (Bourgoin - Flow, 2016).

2. Pest overview

2.1 Short overview

Adults and nymphs feed on phloem tissues of host plants, extracting sap with their piercing and sucking mouthparts. *L. delicatula* excretes large amounts of honeydew on which sooty moulds can develop. Feeding activity can cause withering of the foliage, and attacked trees may develop weeping wounds on their trunks. In the Republic of Korea, *L. delicatula* is considered to be a serious pest of grapevine, and when infestations are severe, stunting and plant mortality may occur. Egg masses (30-50 eggs) are laid on the bark of trees, under loose bark or on various surfaces (such as bricks, stones, dead plants) and are covered in a yellowish brown waxy deposit (resembling mud). There are 4 larval instars (nymphs). The first three nymphal instars are black with white spots but the 4th instar develops red patches in addition to the white dots. Nymphs start climbing up the trees after they emerge. Adult males are 20.5-22.0 mm long (from head to end of folded wings) and females are 24.0-26.5 mm long. Forewings are greyish with black spots and their tips are reticulated. Part of the hind wing is red with black spots and the rest is white and black. The abdomen is yellowish with black bands.

Pictures can be found on the Internet: www.pda.state.pa.us/spottedlanternfly ; http://hojae.net/520 ; http://justsixlegs.blogspot.fr/2014/12/new-invasive-pest-in-us-spotted.html; http://www.forestryimages.org/search/action.cfm?q=lycorma; or in CFIA (2015).

2.2 Additional details needed for the PRA

Biological considerations

Life cycle

In the part of its distribution where it has been studied (i.e. China, the Republic of Korea, Japan and the USA), *L. delicatula* has one generation per year and overwinters as eggs. Egg may diapause during overwintering in northern areas [of China]. Nymphs emerge in spring and adults emerge in late summer. In Jincheon (Republic of Korea), nymphs were observed from late May to August and adults from late July to November (Lee et al., 2011). Adults die off when the weather gets cold towards the end of the year (November in Han et al., 2008; Tomisawa et al., 2013). In Pennsylvania, the dates in 2015 (first full life cycle since detection) were delayed by 2 weeks compared to Park et al. (2009). Park et al. (2009) illustrates the presence of life stages in the Republic of Korea during the year as follows (note: a different symbol was used for each stage of development):

Stage	Dec.~Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.
Egg	○○○	○○○	○○○				○	○○○	○○○
1st Nymph		□	□□□	□□					
2nd Nymph			■■	■■■	■				
3rd Nymph				◇◇◇	◇◇◇				
4th Nymph				◆	◆◆◆	◆◆			
Adult					◎◎◎	◎◎◎	◎◎◎	◎◎◎	

Fig. 2. Life cycle of *Lycorma delicatula*.

Data on the duration of the life cycle available from the literature are presented in Annex 1.

No information was found on the life cycle in warmer areas such as Southern China. The EWG considered that there was an uncertainty on whether the pest may have several generations in warmer areas, and on whether eggs may stay in diapause during more than 1 year if conditions were not appropriate (there is no evidence of this to date).

Egg-laying.

Eggs are laid on woody plants or other material. Substrates for egg-laying, are referred by several publications as ‘smooth’ (e.g. Barringer, 2014; Kim et al., 2011a). However, although *L. delicatula* appears to preferentially lay eggs on surfaces with as little topography as they find, they will settle for any surface with a small patch (approximately 2.5 cm or larger) that is relatively smooth (L. Donovall, personal observation), such as inner surface of bark fissures on trees with deep fissures in the bark.

- **Woody plants**

Eggs are laid on woody plants (herbaceous plants would not provide the size and stability needed for egg-laying), including non host plants (all details on hosts are given in section 7). Eggs may be found on small or large plants, and on different parts of the plant. Kim et al. (2011a) found ootheca of *L. delicatula* to a height of 1-3 m, even 13 m on some branches of some *Prunus* trees whose bark was rough lower on the tree. The trees that were surveyed and carried eggs measured 8-36 cm diameter. On inclined tree branches, oothecae were found on the lower side or in hollow places. In a survey on *A. altissima* in China, Cai and Wu (2013) observed eggs mainly in branches. Tomisawa et al. (2013) observed egg masses at various heights on branches and trunks of large trees (>10 m), most located in the lower half of the trees. In Pennsylvania, egg masses were not present on the lower trunk on larger trees with rougher bark, but rather in the upper trunk and branches. Smaller smooth-barked trees had egg masses from the ground to the crown. Some egg masses were found on small-diameter branches, but only when the population of *L. delicatula* was very high. On rough bark trees, if the inner surfaces of the bark fissure were deep-enough or if there was enough space between fissures where the bark was smoother, egg masses could be found at breast height on large trees (L. Donovall, pers. comm.).

Eggs may be found on trunks and branches even down to 1 cm diameter (based on observations in the Republic of Korea and Pennsylvania; M. Park and L. Donovall, pers. comm.). However, it was noted during surveys in Pennsylvania that woody plants larger than 15-cm diameter at breast height were preferred.

For the purpose of this PRA, it is considered that *L. delicatula* may be present on woody plant material of different sizes, if the diameter is above 1 cm.

- **Inert objects**

A wide variety of inert objects that may carry egg masses are mentioned in Pennsylvania Department of Agriculture (2015) (see also section 16). Umemura et al. (2013 – Japan) and Zhai et al. (2014 – China) mention eggs on buildings, and Cai and Wu (2013 – China) on cables near tree crowns. It has been observed

that gravid females may fall from trees and lay eggs on other material. On stones, dunnage and debris, in Pennsylvania it was observed that size did not matter – only that the surface was more-vertically oriented and very stable (i.e. less-likely to be disturbed by environmental events). Colour is probably a factor in the choice of egg-laying substrates (red-brown-greys) (L. Donovall, pers. comm.).
It is considered in this PRA that eggs may occur on substrates other than plants.

Dispersal.
The exact mechanisms of host search are not known (e.g. olfactory etc.), but *L. delicatula* is known to aggregate both as nymphs and as adults, in the latter case probably using vibrations to communicate through the substrate (tree) to find partners for mating, as in all planthoppers. The aggregation mechanism for nymphs is not yet known but vibrations and chemical communication are probably involved.
Nymphs and adults crawl and jump. When they encounter physical obstacles or are dislodged by wind or other individuals (Choi et al., 2012), they may fall or jump to another place. As nymphs age, they are less easily dislodged and fall less (Kim et al., 2011a). Adults may jump 1.0-1.3 m (Chou, 1946). They are weak flyers (Pennsylvania Department of Agriculture, 2015) and prefer to move up trees by walking (Kim et al., 2011a).
Recorded flying distances are short: limited to 2 m (Tomisawa et al., 2013); seldom beyond 3.3 m (Chou, 1946); in Pennsylvania, flights of up to 20 m were observed following disturbance in favourable terrain and wind (L. Donovall, pers. comm.). As adults live several months, they would disperse at longer distances by successive movements during their lifetime. Data on this is very limited, but in the USA, in a delimiting survey, single or few adults were found 200 m from known infested *A. altissima* (L. Donovall, pers. comm.). Based on the biology of the pest, it is also not excluded that emerging adults may be able to fly longer distances in order to find food.
The flight capacity of adults is important in relation to spread (section 11), and to determine the size of buffer zones in case of containment/eradication (section 16.2) and distance from infested areas for pest free areas (Annex 4). There is no specific data available for *L. delicatula*, nor for any other similarly large Fulgoridae. The EWG, with further pers. comm. from two other planthopper specialists (S. Wilson, University of Central Missouri, and J. Urban, NC Museum of Natural Sciences), concluded that the flight capacity of adults during their lifetime can be hypothesized to be similar to that of similar-bodied insects in other families (or orders) with similar life histories, and that comparison with *Anoplophora glabripennis* (Coleoptera: Cerambycidae; for which data is available) can be used. *A. glabripennis* has a similarly large, bulky body size and apparently similar movements and patterns of spread by flight; large-bodied Fulgoridae have a slow, almost upright flight style, similar to that of large insects such as *A. glabripennis*. Consequently *A. glabripennis* is referred to in section 16 (containment/eradication) and Annex 4 (for PFA).

Feeding.
Nymphs and adults suck sap from vascular bundles of branches, trunks or leaf petioles. In a survey on *A. altissima*, adults were observed mostly on leaves and branches (Cai and Wu, 2013). In Japan, nymphs were observed on leaves, young shoots, rachis, moving to branches and trunks during their development, and adults mostly on trunks and also on branches.

Temperature requirements.
The developmental threshold temperature was determined to be 11.13°C (Park, 2015). Regarding survival of overwintering eggs, Park et al. (2011) reports on experiments on overwintered eggs exposed to -15, -20 and -25°C for different exposure times (12 h, 24h, 3 d, 5 d, 7 d). Eggs were collected, chilled at 5°C, exposed to low temperatures, and then kept at room temperatures. They conclude that -25°C is around the critical temperature (no hatching obtained for any exposure time). Some eggs exposed at -20°C for 12h or 24 h hatched. At -15°C, site and exposure time affected hatching.
In Pennsylvania, emergence in the infested area occurred following average temperatures of -4.4°C between 01-12-2014 to 30-04-2015, and -10.5°C between 01-01-2015 and 28-02-2015, with a lower temperature of -22.2°C. In Jilin province in China, the coldest temperature recorded in history was -44°C, in an area where *L. delicatula* occurs (Changbaishan Mountain).
Kim et al. (2011a), comparing sunny and rainy days, mention that precipitation may have an effect on egg hatching.

Detection
Symptoms.
The pest is likely to be found on *A. altissima* or close-by (on a variety of hosts). Trees develop weeping wounds (Barringer, 2014), leaving a trail of sap on the trunk. Large quantities of honeydew may be observed

on leaves. Sooty moulds develop on the honeydew excreted by the insect. Similar symptoms are expressed on other plants. USDA (2014a) note that adults and nymphs often gather in large numbers on plants and are easier to spot at dusk or at night as they migrate up and down the trunk of the plant. During the day, they tend to cluster at the base of the plant if there is adequate cover, or in the canopy. Egg masses can be found on woody plants and inert objects (see above). Eggs are generally difficult to detect. This is because they may be in hidden places, and the ease of detection also depends on the colour contrast between the substrate and the eggs (eggs are whitish when just laid, and becoming brownish when older). Eggs are generally easier to detect on trees than on other substrates. Guidelines on the detection of egg masses and inspection tips are available from the page of Pennsylvania Department of Agriculture (http://www.agriculture.pa.gov/Protect/PlantIndustry/spotted_lanternfly/Pages/default.aspx).

Trapping.
There are no species-specific traps. Trials are being conducted in the USA on attractants (preliminary results show that an ester and an alcohol are more effective). Lee and Park (2013) investigated extracts of *A. altissima* as potential attractants for *L. delicatula*, and found that *A. altissima* chloroform fraction could be a potential candidate. It is not known if extracts are now available and used in practice for trapping.
Sticky traps may be used to capture individuals as they climb from the ground onto stems. In Pennsylvania, brown sticky traps have been effective to capture nymphal instars; adults may be strong enough to leave the adhesive (L. Donovall, pers. comm.). Choi et al. (2012) showed that brown sticky traps were more effective than blue and yellow sticky traps.

Identification
Detailed morphological descriptions are given in Lieu (1934) in English, Chou (1946) and Chou et al. (1985) (both in Chinese). Molecular methods have been developed for the purpose of genetic studies of populations' origins (e.g. Song et al., 2012; Park et al., 2012; Kim et al., 2013). However, molecular methods are normally not necessary for the identification of the pest.

3. Is the pest a vector? **Yes** **No** ✓

One publication reports *L. delicatula* as a vector of 'persimmon witches' broom disease' in China (Zu et al, 1992). However this report has never been confirmed and the causal agent of the disease has not been identified. The EWG considered that this report is doubtful.

4. Is a vector needed for pest entry or spread? **Yes** ☐ **No** ✓

5. Regulatory status of the pest
L. delicatula is not listed as a quarantine pest by EPPO countries (EPPO, 2016 - EPPO Global Database). It was added to the EPPO Alert List in 2015. *L. delicatula* was not found in the lists of regulated pests for other countries found on www.ippc.int.
In the USA, an internal quarantine was put in place in Pennsylvania in 2014 with restrictions on the movement of many items (Pennsylvania Department of Agriculture, 2015; see also section 16).

6. Distribution
L. delicatula is present only in Asia and in Pennsylvania (USA). Several publications mention that *L. delicatula* is native to 'China, Japan, India and Vietnam' (e.g. Chou et al, 1985; Barringer, 2014); however, evidence of its native status was found in the literature only for China. *L. delicatula* is known to have been introduced to the Republic of Korea and to Pennsylvania. Its native or introduced status in other Asian countries where it occurs is not clear.

Table 1. Distribution of *L. delicatula* (details and uncertainties below the table)

Region	Distribution	References and additional details
EPPO region	Absent	
North America	**USA**: Pennsylvania (Berks, Bucks, Montgomery, Chester counties)	First found in September 2014 on *Ailanthus altissima* in Berks country (Barringer, 2014; Barringer et al., 2015), under quarantine. Found so far on *A. altissima* and wild *Vitis*. Established in Berks, Bucks, Montgomery and Chester counties (Dara et al., 2015; L. Donovall, pers. comm.).
Asia	**China** (native)	**Anhui** (Li et al., 1997), **Beijing** (Choi et al., 2014), **Chongqing** (Chen et al., 2010), **Fujian** (Yu, 2011), **Gansu** (Zheng et al., 2009 – i.e. Tianshui in the southern part), **Guangdong** (Li et al., 1997), **Guangxi** (Zhang and Zhao, 1996), **Guizhou** (Li, 2011), **Hainan** (Zhang and Zhao, 1996),

Region	Distribution	References and additional details
		Hebei (Choi et al., 2014), **Henan** (Cai and Wu, 2013; Ding et al., 2006), **Hubei** (Kim et al., 2013 citing Xiao, 1992 & Hua, 2000; Ding et al., 2006), **Hunan** (Zhou, 1992; Chen et al, 2010), **Jiangsu** (Li et al., 1997), **Jiangxi** (Peng et al., 2004), **Jilin** (Zhang and Zhao, 1996; Liu et al, 2015), **Liaoning** (Zhang and Zhao, 1996; Wang, 2012), **Ningxia** (Zheng, 2015), **Shaanxi** (Choi et al., 2014), **Shandong** (Choi et al., 2014), **Shanghai** (Kim, 2013), **Shanxi** (Wang et al., 2000 ; Ding et al., 2006), **Sichuan** (Li et al., 1997), **Tianjin** (Choi et al., 2014), **Xinjiang** (Forest Pest Control and Quarantine Bureau of Xinjiang Uygur Autonomous Region. 2014); **Xizang** (Tibet; Zhang and Zhao, 1996); **Yunnan** (Wang et al., 2000; Ding et al., 2006), **Zhejiang** (Li et al., 1997).
	Japan	Tomisawa et al. (2013), Umemura et al. (2013)
	Korea Rep.	First finding in 2004; a first report made in the 1930s was a misidentification of *Limois emelianovi* (Han et al., 2008).
	Taiwan	Li et al. (1997)
	Vietnam	Pham (2009)

Comments on the distribution

- **China**. *L. delicatula* has been known in China since as early as 500 BC (Liu, 1939). It was originally mainly in Shandong, Shanxi and Hebei, and more common in the North than in the South; and might then have spread to other areas (Liu, 1939; Kim et al., 2013). Regarding provinces not listed above, there are Internet records for Qinghai (Forest Pest Control and Quarantine Station of Qinghai Province, 2015). The only provinces where *L. delicatula* is not recorded are Heilongjiang and Inner Mongolia. See Figure 1.
  Figure 1. Distribution in China
  In blue, records in Table 1; in orange, internet record only. Whole provinces are marked, not detailed distribution within provinces.

- **Japan**. *L. delicatula* is present in Japan at least in Honshu. It was first found in Ishigawa Prefecture (Komatsu city; Tomisawa et al., 2013) in 2009. It has then spread within Ishigawa and to the neighbouring Fukui Prefecture (first finding in 2013; Umemura et al., 2013). There is an uncertainty regarding the current situation in other Japanese regions. For example Han et al. (2008) mentions Honshu, Kyushu, Okinawa Honto Is, Kim et al. (2013) that the pest was reported sporadically since the 1930s from Okinawa, Honshu and Kyushu, before being found in Ishigawa. The general catalogue of Hemiptera (Metcalf, 1947) refers to Loo-Choo isl., which is part of Ryukyu, and to Okinawa. These records are not reflected in recent publications (Tomisawa et al., 2013; Umemura et al., 2013) or the Internet (general search). It is not clear whether the pest has disappeared and has been reintroduced at the end of 2000s.
- **Republic of Korea**: *L. delicatula* was first found in 2004, and has since expanded its distribution from the West to the South and to the East, including northeast (Han et al. 2008; Kim et al., 2011a; Choi et al., 2012 Park, 2015). Spread between 2006 and 2010 is illustrated by maps in Han et al. (2008), Kim et al.

(2013), Park (2015). Spread occurred within 7 years (Park, 2015). The pest now occurs throughout the country (except for Jeju Island in the South). The pathways of introduction and spread of *L. delicatula* are not fully known (Kim et al., 2011c). It is not believed to have reached Korea through natural spread, and the hypothesis has been made of its introduction on imported products (as adults or egg masses) (Kim et al., 2013). Studies found similarity between Korean populations and Chinese populations north of the Yangtze river (morphological – Kim, 2013; molecular - Kim et al., 2013). There may have been several introductions as populations with different genetic background were found (Park et al., 2013; Park, 2015). Spread within Korea occurred through movement to adjacent zones, but also long-distance spread, most probably linked with human-assisted pathways. Climate change (milder winters) and lack of natural enemies have been hypothesised as causing the increased abundance and spread of the pest in Korea (Choi et al., 2014). The presence of a mountain chain has caused only a minor delay in spread to the East of the country (Park, 2015).

- **Vietnam**. Pham (2009) seems to indicate that the distribution in Vietnam is unclear, but that specimens are kept in the National History Museum in London. Constant (2014 – project description) notes that it 'could be present/spreading in North Vietnam'.
- **USA, Pennsylvania only**. The pest was first found in September 2014 in Berks County on *A. altissima*. The infestation was believed to be 2-3 years old (Barringer et al., 2015). Large numbers of individuals are reported in the outbreak area. Surveys have been conducted and, as of 21 December 2015, the infested area includes a few townships in nearby Bucks, Montgomery and Chester Counties. Isolated findings (one individual only and no additional findings during follow-up visits) at a few sites in Lehigh and Northampton counties (L. Donovall, pers. comm.). Trapping counts and maps are updated on the following page: http://www.agriculture.pa.gov/Protect/PlantIndustry/spotted_lanternfly/Pages/default.aspx).

Uncertainties/doubtful/invalid records

- **India.** Indicated in EPPO Global Database as 'absent, unreliable' based on Atkinson (1885) (doubtful record in Assam). India is mentioned in many publications, including old and recent ones. However, reports for India are doubtful as not recently confirmed. There is another *Lycorma* species in that area (*L. imperialis* White).
- **Laos**, **Cambodia**. Pham (2009) focuses on Vietnam, but gives records for other countries, including Laos and Cambodia. No other reference to these countries was found.
- **Myanmar (Burma)**. EOL (2015) mentions that *L. delicatula* was described by White (in 1845) from Moulmein in 'Burma' (southern part of Myanmar). However, Han et al. (2008) note that it was described by White from Nankin, China. No other reference to Myanmar/Burma was found. This report is considered invalid.

For the purpose of this PRA, the pest was considered to be absent from these countries.

7. Host plants, associated plants and their distribution in the PRA area

L. delicatula is polyphagous, with hosts in many families including many of agricultural or forestry importance. Different life stages may be associated with different plants. 'Hosts' are considered in this PRA as those supporting feeding of nymphs or adults; plants on which only eggs are recorded (sometimes also listed together with 'hosts' in the literature) are considered as 'associated plants'. Annex 2 gives a list of hosts and associated plants, with countries and life stages associated, where available.

There is a certain uncertainty associated with the separation between 'hosts' or 'associated plants':

- plants on which nymphs and adults were observed are considered as hosts, even if feeding has not been explicitely recorded, because it is considered likely that the pest was on many of these plants in order to feed (although there may be some plants that were used by adults only for egg-laying).
- plants on which the presence of *L. delicatula* has been reported but without details of the pest's life stages are considered as hosts.
- when only egg masses were recorded, the plant is considered as an 'associated plant' but there is an uncertainty on whether other life stages may also be associated with the plant (but have not been recorded so far).

Several elements related to hosts are important in the context of this PRA:

- *Ailanthus altissima* is a key host in the life cycle of *L. delicatula*, and is the preferred host at all locations (Chou, 1946; Park et al., 2009; Tomisawa et al., 2013; Barringer et al., 2015). The presence of *A. altissima* is important for the prevalence of the pest (M. Park, pers. comm.). However, some hosts in Annex 2, on which damage has also been noted, are important hosts in the PRA area, such as *Vitis*, fruit trees. In addition, the pest has been recorded in some countries causing serious damage on species that are ornamental plants in the PRA area, such as *Parthenocissus quinquefolia*, *Phellodendron amurense*, *Toona sinensis*. Finally, recent observations in the USA showed high populations on forest genera, such as *Acer* or *Betula*, although their significance in the life cycle of *L. delicatula* is not known yet.

- The pest can complete its life cycle on *A. altissima*. However even the preferred hosts may not be sufficient for completion of the life cycle, and it may need to feed on other plants during its life cycle (Park, 2015). A similar concept seems to be expressed in Tomisawa et al. (2013), who mention that only *A. altissima* and *Melia azeradach* are 'hosts', but citing others as 'not hosts but adults depend upon'.
- It is currently not known if there are any other hosts on which the pest may complete its life cycle. For *Vitis vinifera*, two small-scale cage experiments were conducted in the USA and Korea (M. Park and L. Donovall, pers. comm.) to study the development of *L. delicatula*. Individuals died at the 1st or 2nd nymphal instars. It is not known if this was because *V. vinifera* does not support the complete life cycle of the pest, or whether mortality was due to abiotic conditions. Further experiments are planned in the USA.
- Other than for *A. altissima*, the role of the recorded hosts is not known (feeding at earlier stages versus feeding at later stages or to complete the life cycle). Preference for feeding on certain plants is not fully understood and different hypothesis are made, such as sugar composition of the plant (Lee et al., 2009), the presence of toxic chemicals (Kim et al., 2011a) or population levels (Pennsylvania Department of Agriculture, 2015).
- The host preference becomes narrower during *L. delicatula* development. Earlier nymphal instars seem to feed rather indiscriminately on many plants (including trees, shrubs and herbaceous plants). The 1st to 3rd nymphal instars have a wider range than 4th instars, and adults seem to have a strong host preference for feeding just before egg-laying (Kim et al., 2011a). Some hosts on which adults are recorded feeding are not recorded for egg-laying (Barringer et al., 2015; Kim et al., 2011a), and there are many plants on which eggs were recorded, but not feeding (see Annex 2). Other than possibly the nutritional content of the plant, the availability of suitable surfaces for females is important for egg-laying. In Pennsylvania, adult feeding and egg-laying are strongly associated with *A. altissima*, although in high populations females may lay eggs on other plants or materials (L. Donovall, pers. comm.). In China, eggs are observed on other plants and materials close to *A. altissima* also in situations of low population density (Wang X.Y., pers. comm.).
- *L. delicatula* has been found on new species of woody plants where it has been introduced (over 20 new species have been recorded from Pennsylvania). It is considered likely in this PRA that it may be associated with other woody species where it occurs or that it may attack other such plants if introduced in the EPPO region.
- Although the pest has been recorded on several herbaceous species, this seems to be due to the living and feeding habits of early nymphal instars (falling/climbing on nearby plants). The pest is as likely to be associated as nymphs to any other herbaceous species than to the herbaceous plants in Annex 2. Late nymphal instars and adults are not associated with herbaceous plants.
- The EWG considered it unlikely that conifers are hosts (i.e. for feeding). Two Cupressaceae, *Platycladus orientalis* and *Juniperus* (*Sabina*) *chinensis*, are on the host list (with adult feeding and egg-laying reported); however, this represents only a minor proportion of all hosts on which *L. delicatula* has been reported, despite the fact that conifer species are common where the pest is present. In addition, two species are recorded as uncertainties in Annex 2. *Pinus strobus* is mentioned in University of Delaware (2015) in a general list (without indication of life stages). In Kim et al. (2011b), *P. strobus* and *P. densiflora* were surveyed for the presence of eggs and nymphs (among 13 species); eggs were not found, and nymphs were found on 12 of the 13 species studied (without indication of which). *P. densiflora* was used in laboratory experiments on the survival of nymphs and adults on plant parts (Lee et al., 2009), but was not favourable to *L. delicatula*. In addition eggs were found on the bark of *P. tabuliformis* and *P. thunbergii* (Wang X.Y., pers. comm.), but eggs may be laid on many different substrates other than hosts. Consequently, there is currently no evidence that *Pinus* spp. are hosts.

Almost all hosts and associated plants in Annex 2 are present in the PRA area in many different environments, and *A. altissima* is widespread. Details on the presence of hosts are given in section 9.2.

8. Pathways for entry

General considerations on pathways linked to the biology of the pest:

- Based on experience in different countries, eggs can be laid on woody plants or on inert objects (see Pest overview), for the later particularly those under infested trees. In the egg stage, the pest can be present on host plants and as a hitchhiker on other plants, plant products and inert objects.
- Nymphs and adults feed on the leaf petioles, twigs, branches and trunks of their host plants.

- The state of the plant material (e.g. wood) does not matter for the eggs (e.g. even if the material dries out), as eggs may also be laid (and survive), on inert surfaces such as stone. However, if nymphs are produced during transport and storage, they would need to find suitable material to feed on. Otherwise the survival of nymphs and adults is normally limited to a few days without feeding. If the temperature drops below the development threshold, adults (and perhaps nymphs) may be able to survive without feeding during a longer period (for a general reference for insects, see Lee and Denlinger, 1991). However, nymphs and adults are not expected to survive on commodities other than fresh host material. If they are produced on a host other than a preferred host, their survival may also be limited and restricted on their ability to find fresh host to suck sap.
- Due to their wider host preferences, it may be easier for early nymphal stages to find a suitable host than for late nymphal stages and adults. There is an uncertainty on whether adults, in the absence of their preferred host *A. altissima*, would be able to transfer to a less-preferred one and complete their life cycle (for introductions in the USA and Korea Rep., *A. altissima* was present). In experiments (Lee et al., 2009), adults had a limited survival on other plants, but did survive for some days. Information available on the life cycle seem to show that adults live for about 2-3 months before eggs are laid; there is no information on whether they could survive only on non-preferred hosts during such period.
- Nymphs move mostly by crawling or jumping and adults also by flying. Transfer to a host would presumably require that suitable host plants are closeby (see 'dispersal' in *Pest overview*), but nymphs are probably not strongly limited due to their polyphagy. For pests to transfer from infested imported commodities, the commodity would need to be kept outdoors close to potential hosts or, if indoors, there would need to be hosts in the facility (e.g. nursery, botanical glasshouse). It is not known whether nymphs/adults would be more actively searching hosts if suitable plants are not present in the immediate vicinity, for example adults flying more (longer or more frequently).

8.1 Pathways studied

Plants and plant products may be a pathway. Given the knowledge of hosts (see section 7), this PRA in the study of pathways considers that:
- The pest as nymphs or adults is most likely to be found on host plants.
- However, eggs may be associated with any woody plant.
- Nymphs may be associated with any herbaceous plants, and this is not limited to the herbaceous species in Annex 2.
- Egg masses may be associated with various wood products.

Man-made items/inert items were also studied, taking into account that eggs masses are reported on other substrates than plants (Barringer, 2014; Pennsylvania Department of Agriculture), and given the many items included in the internal quarantine restrictions being implemented in Pennsylvania. Imports of stones from China are suspected to be the source of the incursion in Pennsylvania (the focus of the outbreak is a stone importer and distributor) (pers. comm. in http://www.dontmovefirewood.org/gallery-of-pests/spotted-lanternfly.html).
The following pathways are considered and defined in the tables below:
- plants for planting (except seeds)
- cut branches
- round wood and sawn wood
- wood chips, hogwood, processing wood residues (except sawdust and shavings), and bark
- wood packaging material
- other man-made items/inert items (defined in the pathway)

For all pathways and at the scale of the PRA area, it is not considered that the current phytosanitary requirements in place in the PRA area are sufficient to prevent the introduction of *L. delicatula*. Although some prohibitions would prevent introduction on some commodities to at least part of the PRA area (e.g. plants for planting of *Vitis*), and while some requirements would ensure that the commodity is free from the pest, there are many other commodities that are not regulated. In the Tables below, examples of prohibition or inspection are given; they are taken from EU regulations (as these apply to many EPPO countries, and it was not possible in this express PRA to fully analyse the regulations of all EPPO countries). Similarly, the current phytosanitary requirements of EPPO countries, currently in place on the different pathways, are not fully detailed in this PRA, but were taken into account when looking at management options. EPPO countries would have to check whether their current requirements are appropriate to help prevent the introduction of the pest.

8.1.1 Pathways for plants

Table 4. Plant pathways: plants for planting (except seeds), and cut branches

Pathway	**Plants for planting (except seeds)**	**Cut branches**
Coverage	Known hosts in Annex 2, other woody plants, herbaceous plants	As for plants for planting
Pathway prohibited in the PRA area?	Partly (only for some hosts and for some EPPO countries). e.g. EU: *Vitis*, *Quercus* with leaves, *Populus* with leaves (N-Am), *Castanea* with leaves ; *Rosa* other than dormant plants free from leaves, flowers and fruit for USA); *Malus*, *Pyrus* and *Prunus* (all from Asia; other than dormant plants free from leaves, flowers and fruit for USA),.	Partly (only for some hosts and for some EPPO countries) e.g. EU: *Castanea*, *Populus* and *Quercus*, with leaves, *Quercus* with leaves, *Populus* with leaves (N-Am), *Castanea* with leaves ; *Malus*, *Pyrus* and *Prunus* (all from Asia; other than dormant plants free from leaves, flowers and fruit for USA.
Pathway subject to a plant health inspection at import?	Most probably partly in many EPPO countries. e.g. EU: all. There are specific requirements targeting all plants for planting, trees and shrubs, *Castanea*, *Quercus*, *Fraxinus*, *Juglans ailantifolia*, *Juglans mandshurica*, *Ulmus davidiana* and *Pterocarya rhoifolia*, *Betula*, *Platanus*, *Ulmus*, *Populus*, *Sorbus*, *bonsais*	Partly. e.g. EU : *Populus*, *Betula*, *Fraxinus*, *Juglans ailantifolia*, *Juglans mandshurica*, *Ulmus davidiana*, *Pterocarya rhoifolia*, *Castanea*, *Quercus Acer saccharum* (USA), *Prunus*
Pest already intercepted?	Not known	Not known
Most likely stages that may be associated	Eggs on any woody plants for planting of diameter above 1 cm (including associated plants in Annex 2). Any woody plant may be suitable for egg-laying, but it is likely that, to become infested, these plants should originate in an area where *Ailanthus altissima* also occurs. Nymphs and adults on woody host plants Nymphs only on herbaceous plants (not limited to those in Annex 2). Nymphs and adults jump readily, and association is less likely than for eggs. For woody plants, nymphs and adults may also emerge during transport and storage.	Eggs on branches of diameter above 1 cm. Nymphs and adults jump readily, and are likely to leave when branches are cut and processed. However, nymphs may emerge during transport and storage.
Plants concerned	The pest (as eggs, nymphs, adults) is more likely to be associated with its known hosts. It can be associated with any woody plants as eggs, including those in Annex 2. It may also be associated to any herbaceous plants as nymphs, but this is less likely.	Regarding woody plants, there are probably few species used as cut branches. Possibly *Salix* and *Vitis*.
Important factors for association with the pathway	In China and the Republic of Korea, the pest is present in a large number of areas where hosts occur. In the USA it is only known in one state and under quarantine. Detection of eggs is difficult. If the level of infestation is high, nymphs and adults may be observed (as the pest aggregates). For herbaceous plants, in an area of high level of infestation where known hosts also occur (especially *A. altissima*), it is not excluded that any herbaceous plant may carry nymphs. Even where control measures are applied, these would not ensure freedom from the	As for plant for planting, but the material would be subject to a higher level of scrutiny during consignment preparation.

Pathway	Plants for planting (except seeds)	Cut branches
	pest.	
Survival during transport and storage	Likely for eggs. For nymphs and adults, survival is more likely on known hosts. Survival on non-preferred hosts was shown by Lee et al. (2009) to be much shorter than on *A. altissima* and *V. vinifera*.	Likely for eggs. (nymphs and adults not considered likely to be associated – see above)
Trade	There is no detailed data on the trade of plants for planting. Some hosts are prohibited to at least a part of the PRA area (at least the EU), including *Vitis*. However, the host list includes a large number of ornamental trees, and the trade of such plants for planting worldwide is huge. Eurostat provides data for imports of broad categories of plants, but quantities are given as weight, which is not informative for the purpose of this PRA. During the EPPO Study on Plants for Planting (EPPO, 2012a), partial data on imports of plants for planting was received from a few EPPO countries. The genera imported as plants for planting cover a large number of hosts or associated plants of *L. delicatula*. Quantities varied between few plants to hundred thousands (*Acer*, *Actinidia*, *Ligustrum*, *Syringa*, *Zelkova*), to several hundred thousands (*Rosa*, *Buxus*). - The trade of the host genera was much larger with China than with the USA, and only minor for other countries where *L. delicatula* occurs - Some species are known to have been (at least in part) imported as bonsais, such as *Acer*, *Betula*, *Camellia*, *Ligustrum*, *Syringa*, *Zelkova*. Given the number of hosts involved, the volume of trade may be high.	No information on the trade of host plants as cut branches. There were data on imports of foliage and branches (undefined species, but other than Christmas trees) with 22230 t from the USA; 139 t from China, 4,5 t from Vietnam, >1 t from Japan).
Transfer to a host	Plants for planting will be planted in favourable conditions for their development. Transfer of the pest to another host will depend where the plants will be used. Because of the climbing-falling behaviour of the pest, suitable hosts should be located close to the imported plants. This is most likely if the plants for planting are used outdoors, or in facilities containing large numbers of plants (e.g. nurseries, botanical glasshouses).	Cut branches are likely to be used indoors. However, they may be discarded outdoors, where emerging nymphs may find suitable hosts.
Likelihood of entry a nd uncertainty (ratings: low, moderate, high)	- Woody plants for planting of known hosts >1 cm: **moderate to high** (**high**uncertainty) - Other woody plants above >1 cm: **moderate** (**moderate** uncertainty) - Herbaceous plants: **low** (**low to moderate** uncertainty) - Woody plants for planting <1 cm: **low** (**low** uncertainty)	- Cut branches of diameter >1cm: **low** (**moderate** uncertainty)

8.1.2 Wood pathways

For wood pathways, the main risk is related to the presence of egg masses. The EPPO study on wood commodities (EPPO, 2015b; or 'EPPO Study' below) defines several wood commodities (see definitions in Annex 3), which were used to determine the wood pathways to be studied in this PRA. Similar commodities relevant for the entry of *L. delicatula* were grouped as follows:

- Roundwood and sawn wood (Table 5)
- Wood chips, hogwood, processing wood residues (except sawdust and shavings) and bark (Table 5)
- Wood packaging material (Table 6)

*S*awdust and shavings, as well as other wood commodities in the EPPO Study are considered not likely to carry *L. delicatula* and are listed under 8.2.

For all commodities concerned, egg masses may be on different species, including non-hosts. Whether the commodity is composed of one species or several does not significantly influence the risk. Similarly, egg masses may be laid on bark before harvest, but they may also be laid on harvested products, with or without bark after processing. Consequently no difference in the risk was made for commodities with or without bark. Egg masses may be laid on material of a diameter above 1 cm, and may therefore be associated with any wood before harvest.

The EPPO Study provides a preliminary assessment of pest risk associated with wood commodities for different types of pests depending on the initial material used to produce the commodity. However, this could not be used here:

- The categories of arthropods chosen do not apply to *L. delicatula* (for which the concern is egg masses on the wood).
- There is currently no indication of the type of material coming into the EPPO region (apart from the categories, overlapping with those of the EPPO Study, for which trade statistics exist). The existence of a trade into the EPPO region is important to the risk. As there is no data corresponding to the new EPPO categories, the PRA relied on existing statistical data (from Eurostat - i.e. using existing CN customs codes). It is recognized that this overlaps with EPPO wood commodities.

Some uses not mentioned in the EPPO Study were added below, and their relative importance ordered differently.

Table 5. Round wood and sawn wood of deciduous species/ Wood chips, hogwood, processing wood residues (except sawdust and shavings) of deciduous species

Pathway	Roundwood and sawn wood	Wood chips, hogwood, processing wood residues (except sawdust and shavings), and bark
Coverage	This pathway intends to cover all types of roundwood and sawn wood, including with or without bark. The understanding of sawn wood is as per definition in ISPM 5. Roundwood includes logs, but also other types of material. Whole trees including branches, twigs, possibly stumps, may be harvested (e.g. as fuel wood). In addition, part of the EPPO commodity 'harvesting residues' is a type of roundwood (when in the form of top of trees, branches, twigs etc.). - *composition*: Consignments of roundwood (as logs) would generally be of one species. Harvesting residues (in the form of roundwood) arise from the harvest of logs and may initially be from one species, but it is not known if they would be grouped with others from other origins when traded (e.g. as fuel wood). Roundwood intended for other purposes (e.g. fuel wood, production of chips) may sometimes contain a mixture of species.	*Note (except sawdust and shavings) is not repeated below to simplify, but is intended throughout this pathway.* Where harvesting residues are in another form than roundwood (e.g. residues from squaring), the EPPO study considers that they would either be left on-site or be transformed on-site, in which case they become another commodity (e.g. wood chips, hogwood). All these commodities may be used for different purposes, such as pulp, fibreboard production, energy purposes, mulch. - *composition.* depending on the intended use, wood chips are produced from one or a mixture of species. This is not known for other wood commodities, but would presumably be the same. Most bark traded on its own probably arises from conifers, although some deciduous bark seems to be available (such as walnut bark used as mulch - EPPO, 2015c; PRA on thousand cankers disease). → consignments may include a mixture of species.

Pathway	Roundwood and sawn wood	Wood chips, hogwood, processing wood residues (except sawdust and shavings), and bark
	- *presence of bark*: round wood (as logs) and sawn wood may be traded with or without bark. Other types of roundwood may have bark attached. Some types of roundwood may also contain leaves. - *size*. Logs would normally be of a large size. Both for harvesting residues (in the form of roundwood) and any material sold as fuel wood, the material may be of variable size (including branches, top of trees, branches, twigs etc.). - *intended use*. Such commodities may be used for construction, energy purposes or processed (such as chips, pulp, fibreboard etc.). For this pathway, trade data is available 'fuel wood as logs, billets, twigs, faggots or similar forms' (EU CN code 44011000) and for logs; this would cover together logs or whole trees that would be sold as firewood, and one type of harvesting residues (that may contain branches, twigs, etc.). According to the EPPO Study, it also covers bark.	- *presence of bark.* wood chips or hogwood may be produced from different types of initial material (e.g. wood with or without bark, post-consumer scrap wood etc.). Processing wood residues (except sawdust and shavings) are residues from round and sawn wood, e.g. off-cuts, and may have bark attached. → at least part of these commodities may include some bark. - *size.* wood chips are produced through a shredder using a round-hole sieve that defines the dimension of chips (e.g. <2.5 cm) on two sides (not the third). The European Standard on solid fuel (Alakangas, 2010; CEN, 2011) identifies four classes of wood chips according to size; in the largest class, 75% of wood chips should be comprised in the range 16-100 mm, and 6% can measure 200-350 mm. Hogwood or processing wood residues have no size requirement. → even wood chips can be quite large. The size of all these commodities would vary. - *intended use*. Although use of the wood commodities as mulch is that presenting the highest risk (as facilitating transfer of pests to nearby trees), this is a minor use of such commodities. Energy and fibreboard production would be the main uses of such products. The intended use of bark may vary, from energy purposes to mulch, but there is no information on this, nor on the trade of bark into the EPPO region. There is limited information to study this pathway. For this pathway, trade data is available for 'deciduous wood chips', 'coniferous wood chips', and 'wood waste and scrap (whether or not agglomerated in logs, briquettes or similar forms (excl. sawdust and pellets)'. These categories overlap several EPPO commodities, but they are the only data available and were therefore used. As per EPPO Study, ''wood chips' likely covers hogwood. 'Wood waste and scrap (whether or not agglomerated in logs, briquettes or similar forms (excl. sawdust and pellets)' would cover processing residues, as well as other commodities that do not present a risk; it would also cover deciduous but also coniferous wood.
Pathway prohibited in the PRA area?	No	No
Pathway subject to a plant health inspection at import?	Partly. e.g. EU: *Acer saccharum*, *Fraxinus*, *Juglans ailantifolia*, *Juglans mandshurica*, *Ulmus davidiana*. *Pterocarya rhoifolia* (kiln-drying), Quercus, Betula, Platanus, Populus, conifers.	Partly. e.g. EU ('chips, particles, sawdust, shavings, wood waste and scrap') Betula, *Fraxinus*, *Juglans ailantifolia Juglans mandshurica*, *Ulmus davidiana*, *Pterocarya rhoifoliai*, Acer saccharum (USA), Betula, Populus (Americas), Quercus (USA), Platanus (USA), conifers; bark of *Castanea*, *Quercus* (from N-Am), *Acer saccharum* (from N-Am), *Populus* (Americas).

Pathway	Roundwood and sawn wood	Wood chips, hogwood, processing wood residues (except sawdust and shavings), and bark
Pest already intercepted?	Not known	Not known
Most likely stages that may be associated	Eggs may be associated with wood of any tree species from infested areas, with or without bark. Nymphs and adults are not likely to remain associated with wood. However, nymphs may emerge during transport and storage.	Some eggs may survive processing. Females are not expected to lay eggs on already processed material. Nymphs may emerge during storage or transport.
Plants concerned	Any wood from any species from an infested area may carry eggs.	As for wood
Important factors for association with the pathway	Handling and processing may destroy or remove eggs. However if not stored in a protected area during the egg-laying time frame, egg-laying may occur on this material. Raw roundwood with bark still attached would also pose a risk.	Eggs are at the surface of the bark and may be destroyed or scraped away during processing. It is not known if they would survive (without being crushed) in the mass of the commodity. A study on wood chips in the USA showed no survival on chips of 2.5 x 2.5 cm in two dimensions (L. Donovall pers. comm). This was considered as the minimum size under which no eggs would survive processing (including for bark)
Survival during transport and storage	Likely for eggs. Eggs are expected to survive even if the wood is stored for a period and dessicates (they are also associated with inert substrates). If nymphs emerge, they are unlikely to survive transport and storage (as they would not be able to feed) Recently laid eggs are easier to observe, but older egg masses are difficult to detect.	All such commodities may be stored in big piles. In particular, the temperature in the core of the bulk for wood chips may become high (e.g. 60 C) due to composting effect. Eggs may be destroyed at high temperatures. Temperatures in the periphery of the pile are expected to be much lower and seldom lethal. In addition, eggs may be crushed within the mass of the material. Consequently, only part of the consignment/pile is likely to present conditions that would allow survival of eggs. If nymphs emerge during transport, they are unlikely to survive transport and storage (as they would not be able to feed). Detection of eggs is difficult
Trade	Regarding firewood ('logs, billets, twigs, faggots or similar forms as in the EU CN code 44011000) Eurostat indicates imports into the EU of 106 t from the USA, 63 t from China and 22 t from Vietnam in 2014. FAO Stat provides data for all industrial roundwood (wood in the rough - (coniferous or non-coniferous excl. tropical wood), as well as for sawn wood (coniferous and non-coniferous excl. tropical wood). In 2013, there were major imports from the USA of both coniferous (over 985000 m3) and deciduous (non-tropical) roundwood (over 790.000 m^3) and minor imports from China (ca. 6000 and 4000 m^3, also 130 m^3 deciduous from Japan and 8 m^3 from the Rep. of	No data was found regarding the trade of bark. Regarding other commodities, data on trade of wood chips and wood waste are available in USA, EU trade statistics (USDA-FAS, 2014; Eurostat – used for EPPO, 2015c) and FAO Stat. - <u>wood chips</u> 'Wood chips and particles' (coniferous and deciduous - FAO Stat) were imported from the USA in 2013 to 21 EPPO countries, but the large majority to Turkey. There were minor imports from China, Korea Rep. and Japan. USDA-FAS (2014) indicated increased imports of deciduous wood chips (4401220000) to the PRA area in 1998-2013, with over 180.000 metric tonnes in 2013. Turkey was by far the largest importer (ca. 120.000 metric tonnes) followed

Pathway	Roundwood and sawn wood	Wood chips, hogwood, processing wood residues (except sawdust and shavings), and bark
	Korea). Imports of sawn wood from the USA amounted in 2013 to over 70000 m3 for coniferous wood and over 460000 m^3 for deciduous. There were minor imports from other countries where *L. delicatula* occurs, from China (conifer: 4000 m^3; deciduous: 16600 m^3), from Japan (175 m^3 and 200 m^3) and Korea Rep (1 and 4 m^3).	by France (23.000 metric tonnes) and Germany (12.000 metric tonnes). Although the intended use of the wood chips are not known, these countries also happen to be major producers of fibreboard and particle-board; IBS, 2014). Exports to Turkey greatly increased again in 2014 (x3, reaching 345,368 metric tonnes). In 2013, a number of other countries imported smaller quantities, and imports increased considerably between 2012 and 2013 for some countries. EU trade statistics (Eurostat) for 1998-2013 indicate similar trends from the USA. In addition in 2014, there were imports of 'deciduous wood chips and particles' (covering hogwood - EPPO Study), over 55 t from China, 103 t from Vietnam, 110 t from Korea Rep. - '<u>Wood waste and scrap (whether or not agglomerated in logs, briquettes or similar forms (excl. sawdust and pellets)'</u> (corresponding to 'post-consumer scrap wood' according to EPPO Study, but possibly also part of 'processing wood residues' and 'harvesting residues'). USDA-FAS (2014) indicated a trade of waste wood (including sawdust - 4401300000 in 1998-2011; 4401.39.0000 in 2012-2013) in small quantities mainly to the UK, the Netherlands and Germany. The volumes and importing countries seem to vary a lot, with the Netherlands having imported over 200.000 metric tonnes in 2010 and in 2011, and the UK over 130.000 metric tonnes in 2011. For Eurostat, in 2014 there were imports from the USA (>9700 t), and minor quantities from China (>126 t), Vietnam (> 20 t) and <10 t from Japan and Korea Rep. Products for ground cover (mulch), which clearly present the highest risk, likely constitutes a small part of imports.
Transfer to a host	Wood is often stored outdoors. Nymphs would have to crawl to plants to feed, and they may be able to feed on many plants. However, late nymphal instars would eventually have to find hosts. Wood is often stored close to forest or trees, and this is not considered impossible. However, it is not known how far the nymphs would be able to crawl to find their hosts.	Transfer would be similar as for wood. In addition, the intended use of the commodities would also influence transfer. Transfer would be facilitated if the commodities are used outdoors (e.g. ground cover, mulch), where they may be located at the base of plants, i.e. facilitating the finding by emerging nymphs. However, this is a limited use of wood chips or hogwood. Bark used outdoors (especially as mulch) may be close to suitable host plants. The majority of wood chips (or hogwood or processed wood) imported into the EPPO region would be intended for processing (e.g. fibreboard, pulp) or energy. Transfer would be possible only if they are stored outdoors for a sufficient period prior to processing, allowing emergence, and close to host plants. It is commonly the case in the PRA area that large quantities of wood chips are stored close to forests. However, even if eggs hatch, only nymphs that are at the surface of the material may be able to exit the bulk. They would have to crawl to find hosts, at a long distance as the

Pathway	Roundwood and sawn wood	Wood chips, hogwood, processing wood residues (except sawdust and shavings), and bark
		piles would not be located just at the base of growing plants.
Likelihood of entry and uncertainty (ratings: low, moderate, high)	**Moderate** (**moderate** uncertainty)	Wood chips and bark < 2.5 cm x 2.5 cm in two dimensions: **low** (**low** uncertainty) All others in this pathway: **low to moderate** (**moderate** uncertainty)

Table 6. wood packaging material

Pathway	Wood packaging material
	Pennsylvania Department of Agriculture (2015 – inspection tips) mentions dunnage. In the infested area in Pennsylvania, pallets are selected as training material on which eggs can be found easily. If eggs are laid on trees/wood used to produce wood packaging material, they are likely to be destroyed during the different processes. In addition, treatments in ISPM 15 *Regulation of wood packaging material in international trade* (FAO, 2009) should be effective in destroying eggs of *L. delicatula*. ISPM 15 requires that all wood packaging material moved in international trade should be debarked and heat treated (either 56°C for 30 min at the core if using a conventional steam or dry kiln heat chamber; or 60 °C for 1 minute throughout the entire profile of the wood if using dielectric heating) or fumigated with methyl bromide (and stamped or branded with a mark of compliance). These treatments are internationally considered adequate to destroy insects and nematodes present in wood packaging material at the time of treatment. However, the pest may also become associated with wood packaging material (treated or not), if such material is kept outdoors close to host plants, during the egg-laying period. Such eggs may be eliminated/scraped away during further handling, but if not they are likely to survive transport. Transfer would require that the wood packaging material is kept outdoors at destination, close to host plants. The association with such material is less likely than for woody plants of known hosts and transfer would require special circumstances; however, there are very large quantities of wood packaging material moving in trade.
Likelihood of entry and uncertainty (ratings: low, moderate, high)	**Moderate** (**moderate** uncertainty**)**

8.1.3 Other man-made items/ inert items

Based on observations available from the USA, objects having been produced or stored outdoors where the pest occurs may carry egg masses. This potentially covers a wide range of items (see section 16 and Pennsylvania Department of Agriculture, 2015, incl. quarantine measures). The items in Table 7 were selected based on the items mentioned in the USA, and looking at trade data to determine which items may be relevant in international trade to the EPPO region.

Table 7. Other man-made items / inert items

Pathway	Man-made items
Coverage	At the moment, evidence is available that eggs have been transported in international trade on stones (initial location in Pennsylvania at a stone importer's yard) and a dead adult was found on a steel consignment (interception in the USA). For other material, there is only suspicion that they may act as a pathway. In the USA, surveys are conducted on some imported items, such as new cars, to identify potential pathways (L. Donovall, pers. comm.). Entry on this type of material is through hitch-hiking. Eggs may be carried on a wide range of inert objects that have been stored outdoors close to host plants, such as packaging (other than wood packaging material – separate pathway), stones, containers, road and building construction material (incl. bricks, pipes), vehicles, machinery and industrial equipment (e.g. forest, agriculture, mining, building materials, industrial equipment). It is not possible to give a complete assessment of all such items that may be traded into the PRA area from areas where *L. delicatula* occurs.
	Pathway prohibited in the PRA area? No
	Pathway subject to a plant health inspection at import? most likely not. Note: The EU Decision 2013/92/EU of 18 February 2013 (EC, 2013) provides for plant health checks of the wood packaging material associated with certain types of stones from China (to a level of 15 or 90% depending on the stone type), but this does not apply to the stones themselves.
	Pest already intercepted? Not known for egg masses. A dead adult was intercepted in the USA in a consignment of steel.
Most likely stages that may be associated	Only eggs. If nymphs emerge during transport or storage, they are unlikely to survive (see below) Nymphs or males adults would not become associated to such items at origin, and would leave/fall if disturbed. Females may be present on the items at the time of egg-laying, but they are also likely to leave/fall if disturbed.
Important factors for association with the pathway	Association would require that the items are kept outdoors close to hosts at the time when egg-laying takes place. It is not necessary to have a high population for egg-laying on other material than plants. It has been observed that gravid females may fall from trees and lay eggs on other material. Longer exposure at origin would increase the likelihood of association. (see also section 2 for details on egg-laying)
Survival during transport and storage	Likely for eggs. If nymphs emerge during transport in a closed environment, their survival would be limited to a few days (not able to feed; survival <5 days if water is available; Lee et al., 2009) and they would not develop into adults. The interception of a dead adult in a consignment of steel (above) seems to indicate that an adult was able to become associated with the consignment. However, adults are unlikely to survive (not able to feed; survival <3 days if water is available; Lee et al., 2009). It is therefore not considered likely that live adults be present at destination and transfer to hosts.
Trade	It is not possible to evaluate the trade of all possible inert objects. However, it is known that there is a trade of such objects, such as: **Stone.** Data was found in Eurostat (EU28). There is a trade of stones from countries where the pest occurs, especially granite, sandstone, marble and travertine, 'porphyry and other stones', and minor imports of limestone. From countries where *L. delicatula* occurs, the pattern of imports was similar in 2011-2014, with the largest imports from China, substantial imports from the USA and Vietnam, and minor irregular imports from Japan and the Korea Rep. In 2014, the total quantities were >47100 m^3 from China, >9100 m^3 from the USA, >3700 m^3 from Vietnam, >8 m^3 from Japan and >4 m^3 from Korea (approximative due to

Pathway	Man-made items
	conversion of kg in m^3). **Containers**. High numbers of containers move around the world, although most would not be exposed to the pest. **Used vehicles and machinery**. There are imports of used vehicles to EU28 reported from countries where *L. delicatula* occurs. Road tractors for semi-trailers from the USA (also Japan and China); agricultural and forestry tractors mostly from Japan (also USA and Vietnam, to a lower extend China and Korea Rep.); vehicles for passengers from the USA (also Japan, Korea and China, and to a lower extend from Vietnam); vehicles for merchandise transport from the USA (also Japan, China and Korea Rep.); Trailers for living or camping mostly from the USA (also minor from China). The quantities indicated in Eurostat are not clear (it is not clear if the 'supplementary quantity' relates to a number of units), and the value in Euros was looked at. There may also be a movement of vehicles (driven, not imported) from Asia to the EPPO region, but it is probably quite limited by distance, except possibly to Far-East Russia (no data was sought).
Transfer to a host	Nymphs would have to crawl to plants to feed, and they may be able to feed on many plants. However, late nymphal instars would eventually have to find hosts. It is not known how far the nymphs would be able to crawl to find their hosts. Objects carrying eggs should therefore be stored or used outdoors at destination, in areas where host plants are available. This may be the case for stones or other items above. Vehicles and machinery would move and may become exposed to plants. Used vehicles may be washed before being sold, which may dislodge egg masses.
Likelihood of entry and uncertainty (ratings: low, moderate, high)	**Moderate** (**moderate** uncertainty)

Rating of the likelihood of entry	*Low* ☐	***Moderate to high*** ✓	*High* ☐
Rating of uncertainty	*Low* ☐	***Moderate*** ✓	*High* ☐

8.2 Unlikely pathways:

- *Fruit of hosts*. *L. delicatula* does not feed on fruit in nature. In addition, both nymphs and adults jump readily when disturbed, and are unlikely to remain associated with fruit at harvest. Grapes are not a pathway in Biosecurity Australia (2011, PRA on grapes from Korea to Australia). *Uncertainty*: low.
- *Sawdust and shavings (one part of processing wood residues), processed wood material, post-consumer scrap wood* (see definitions in Annex 3). EPPO Study (EPPO, 2015b) assesses the risk as being low for all pests. Although the Study does not cover a case similar to *L. delicatula*, this would also apply. Such wood material is processed to a level that would not allow survival of the pest (incl. eggs). If processed wood material or post-consumer scrap wood is stored outdoors, eggs might become associated, but this is considered unlikely. *Uncertainty*: medium.
- *Furniture and other objects*. Only eggs may be associated. Handling during fabrication would dislodge any material remaining at the surface of the wood used to make such objects (e.g. by brushing, finishing etc.), including egg masses. It is unlikely that such objects are stored in the open in conditions favourable to egg-laying by *L. delicatula*. *Uncertainty*: low.
- *Seeds, bulbs and tubers, grain, pollen, stored plant products, soil and growing medium*. No life stages are associated with these. *Uncertainty*: low.
- *Natural spread* is unlikely from countries where the pest occurs. *L. delicatula* does not occur in N-East China, which has a common border with Russia. It has been present in China for many centuries and such spread has apparently not occurred. The capacity for natural spread is also limited, as adults and nymphs mostly crawl and jump, at limited distance. *Uncertainty*: low.
- *Movement of individuals, shipping of live Fulgoridae, e.g. traded by collectors. L. delicatula* is a colourful insect and may circulate between hobbyist entomologists, but is most likely sent dead. This pathway is also difficult to regulate as such. *Uncertainty*: low.

9. Likelihood of establishment outdoors in the PRA area

9.1 Climatic suitability

L. delicatula occurs in a very wide range of climates, from very cold to very warm, and also dry climates. There may be populations that are more adapted to different climates. However, overall it is not expected that the climate will be a limiting factor for the establishment of the pest.

It is suspected that a cold period in winter may be necessary (possibly below the development threshold of the pest, i.e. 11°C). However there is no data, and it seems that the pest also occurs in areas where such temperatures would not be recorded.

9.2 Host plants

Nearly all recorded host plants (as well as associated plants) occur in the PRA area (see Annex 2), either in the wild or in a wide variety of environments, including in commercial cultivation (*Vitis vinifera*, *Actinidia chinensis*, all fruit trees incl. *Prunus*), gardens (fruit trees, ornamentals), urban areas (street trees, parks, such as *A. altissima*, *Platanus*, *Broussonetia papyrifera*, *Parthenocissus quinquefolia*, *Acer*, *Phyllostachys heterocycla)*, forest or plantations (e.g. *Robinia pseudoacacia*, *A. altissima*, *Populus*, *Prunus*, *Salix*, *Ulmus*).

Adults have a more restricted host preference. Details on a few hosts are given below. Among the main hosts, *A. altissima* and *Vitis* are widespread in the PRA area. If *A. altissima* does not occur, there is an uncertainty on whether adults would find hosts to complete the life cycle and whether it would establish long-term viable populations.

Ailanthus altissima was introduced into Europe in the 18th century. It has been used extensively as a street tree, and is naturalized in many countries. It is also grown in plantations (EEA, 2006), and has become invasive in some countries. Its precise distribution and density within EPPO countries is not known. However, it is widespread and invasive in most (probably all) Mediterrean countries of the EPPO region; in many places there are large stands with many individuals; it is known to occur in areas of grapevine production, at least in the Mediterranean areas of Europe (Fried 2012; G. Fried, ANSES, France, pers. comm.). Kowarik and Saumel (2007) note that it can invade borders of agricultural fields, meadows, vineyards and old fields; in Gard (south of France), about 17% of habitats of *A. altissima* are encroaching into agricultural fields and vineyards (while over 58% are roadsides). No source was found that gives a complete picture of the distribution of *A. altissima* in the EPPO region; however, the maps available reflecta large distribution in the EPPO region (see maps below; for France, an interactive map is given in FCBN, 2016).

Figure 2. Countries where *A. altissima* is present (EPPO Global Database)
Note: the map is less complete for regions other than EPPO (in particular, *A. altissima* is known to occur in China, Korea Rep. and the USA, where it is a host of *L. delicatula*).

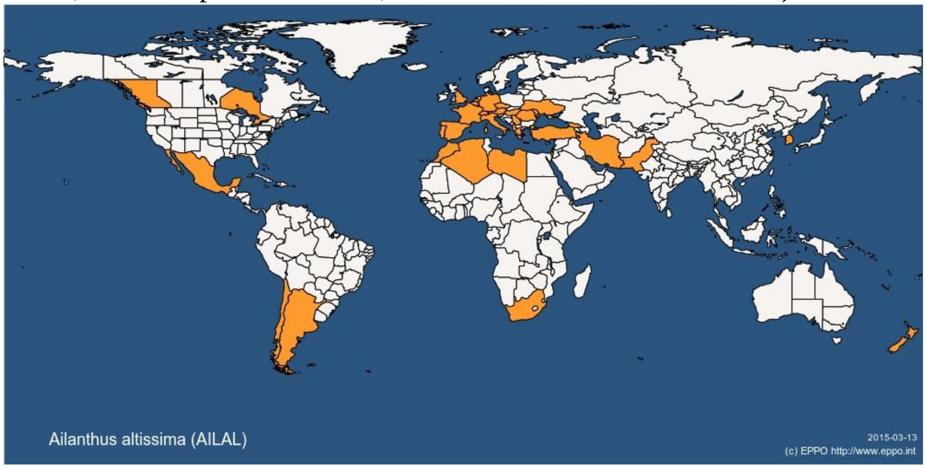
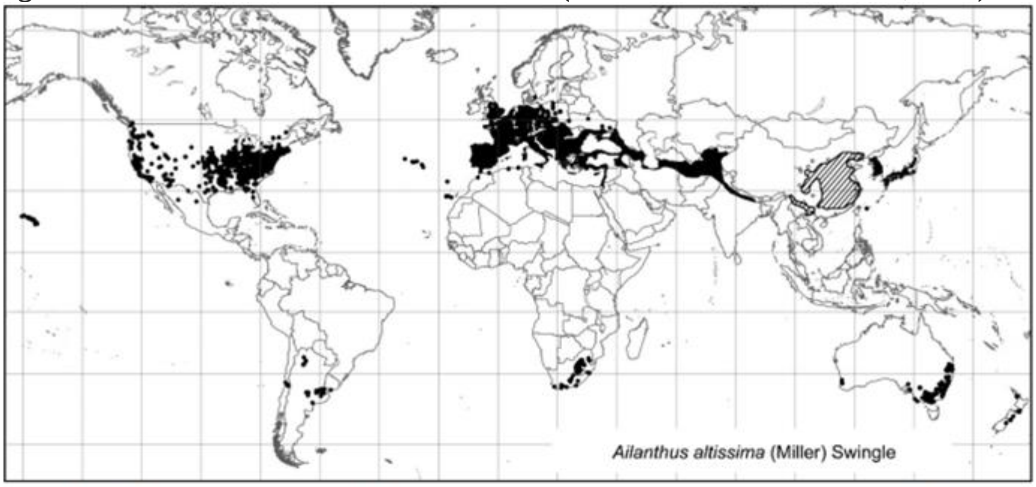
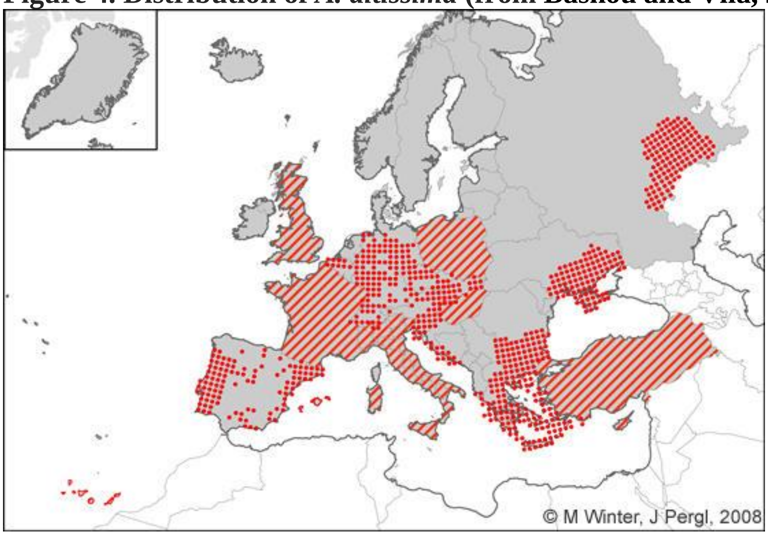


Figure 3. Detailed distribution of *A. altissima* (from Kowarik and Saumel, 2007)



Range of *Ailanthus altissima*, with a differentiation of the native Chinese range (hatched; including possible early range expansions within China), and of the secondary world-wide distribution (black) resulting from the range expansion since the introduction of *Ailanthus* to Europe in the 1740s (distribution data compiled and mapped by E. J. Jäger & E. Welk, AG Chorology, Institute for Biology Halle/Saale).

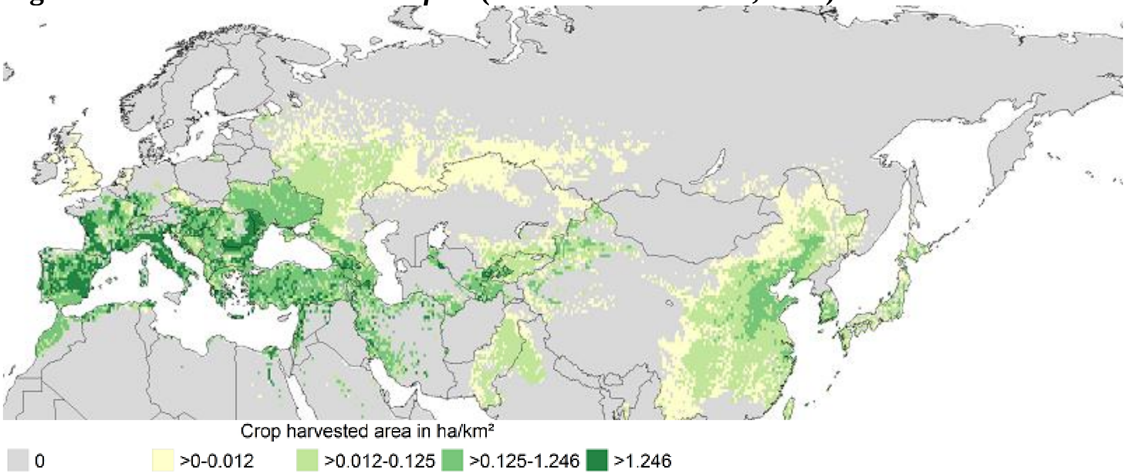
Figure 4. Distribution of *A. altissima* (from Basnou and Vila, 2006 - Daisie)



Known in country Known in CGRS square

***Vitis* spp.** *Vitis vinifera* is a major and high value crop in the EPPO region. Main areas of cultivation are indicated on the map below (from modelling). *Vitis vinifera* is also increasingly grown in Northern locations (e.g. Denmark). A large number of other *Vitis* spp. are present in the PRA area, in the wild or cultivated, for fruit or as rootstocks. *V. amurensis*, a known host of *L. delicatula*, is cold tolerant and used on its own or as hybrids with *V. vinifera* in areas less favourable to *V. vinifera* (http://www.mustila.fi/en/plants/vitis/amurensis).

Figure 5. Distribution of *Vitis vinifera* (from Monfreda et al., 2008)



Among other hosts, ***Actinidia*** are grown in the southern part of the EPPO region, with the largest cultivation areas in Italy and Turkey (EPPO, 2012b), ***Malus*** and ***Prunus*** spp. are grown throughout the region (with ***P. serotina*** also for plantations), ***Pyrus*** are also widely grown, and ***Punica granatum*** is grown in grown mostly in the Mediterranean Basin, Near East and Central Asia. Some ***Juglans*** species occur naturally in the PRA area (*J. regia*, *J. nigra*, *J. mandshurica*) and, as well as many other *Juglans* spp., are also grown commercially (for wood or nuts) and as amenity trees (parks, gardens). ***Quercus***, ***Salix*** and ***Populus*** are present in the wild, as ornamentals and in forests (EPPO, 2013b), ***Populus koreana*** and ***Betula platyphylla*** occur in the wild in the Russian Far-East (EPPO, 2000), ***Platanus*** spp. are used extensively as street trees and ornamentals, ***Robinia pseudoacacia*** is widespread (planted especially for energy production purposes, also as street trees and ornamentals, and also occurs in forests; invasive in some habitats - EPPO, 2013b, citing sources), ***Camellia sinensis*** is cultivated from Turkey to Southern Russia and Central Asia (EPPO, 2013b), and there is a starting (and prized) production in Scotland, ***Liquidambar orientalis*** is grown as a forest species in the South West of Turkey (Euforgen, 2009).

Rating of the likelihood of establishment outdoors	*Low* ☐	*Moderate* ☐	***High* ✓**
Rating of uncertainty	*Low* ☐	***Moderate* ✓**	*High* ☐

10. Likelihood of establishment in protected conditions in the PRA area

L. delicatula is mostly a pest of woody plants, including grapevine, which are normally not grown under protected conditions in the PRA area. However, bonsais and ornamental plants may be grown in protected conditions, e.g. in nurseries or botanical gardens. Establishment would require that host plants are present in the protected conditions, or that *L. delicatula* is able to leave those to search for hosts.

Rating of the likelihood of establishment in protected conditions	***Low* ✓**	*Moderate* ☐	*High* ☐
Rating of uncertainty	***Low* ✓**	*Moderate* ☐	*High* ☐

11. Spread in the PRA area

L. delicatula generally moves at short distance by walking and jumping, as well as flying (see details in *Pest Overview*). At medium and long distance it is readily carried by human-assisted pathways. If *A. altissima* is not present in the area of introduction, it is not clear if this would have an effect on spread (i.e. triggering more active movement to explore the area and try to find preferred hosts). Spread by wind is not mentioned in publications, and may only aid over short distances (see details in *Pest Overview*).

Once introduced in Korea Republic, the pest has spread over the country (except for Jeju Island) within 7 years, most probably linked with human-assisted pathways. In the USA, detection is recent (2014; possibly present since 2012) and it has spread locally (in an area of 20 by 20 km); quarantine measures are applied.

Once it is introduced into the EPPO region, many items may carry egg masses, including plants and plant products, and other items (see section 16). These would add to the pathways that exist in trade. Natural spread from each individual outbreak would be slow. Natural spread is not likely to play a role in rapid spread.

Rating of the magnitude of spread	*Low* ☐	***Moderate to high*** ✓	*High* ☐
Rating of uncertainty	***Low to moderate*** ✓	*Moderate* ☐	*High* ☐

12. Impact in the current area of distribution

Nature of the damage

L. delicatula causes direct damage to plants by feeding, with large numbers of individuals that may feed on the same plant. Direct damage is by sucking plant sap, and indirect damage by producing honeydew on which fungi and sooty moulds may grow, causing reduced photosynthesis. At the base of trees, mould develops on sap flowing from wounds. Direct damage may result in wilting and death of twigs (Han et al., 2008), but also in death of branches and plants (Chou, 1946). Mortality is also reported as a result of fungal infection (Chou, 1946 – *Teichospora oxystomoides* mentioned). *L. delicatula* may cause wilting and death of twigs of *A. altissima*. In Korea, direct mortality of grapevine plants was observed (M. Park, pers. comm.).

In the USA there is a concerned that weakening of plants by *L. delicatula* may favour infestations by other insects (L. Donovall, pers. comm.). This has not been observed in the Republic of Korea on grapevine (M. Park, pers. comm.).

Impact in different countries

- In China, *L. delicatula* is overall not a major pest (Wang XY, pers. comm.):
  - In forestry, it is currently generally minor and may be serious only on *A. altissima* in a few regions. In the 1940s, *L. delicatula* was a serious pest of forestry when *A. altissima* was used for plantings (in Guanzhong, now corresponding to part of central Shaanxi and W Henan) (Chou, 1946). For Southern China, Li et al. (1997), list it as a pest of forestry plantations, on acacia and *Toona sinensis*; this does not seem to correspond to the current situation (Wang XY, pers. comm.). Although mentioned as a forestry pest, damage was so far observed only on *A. altissima*. Consequently, it cannot be compared with other major forest pests such as *Lymantria dispar*.
  - It is reported attacking various fruit species, such as apple, grapevine, kiwifruit, pomegranate, peach, apricot, plum, hawthorn, cherry, as well as *Zanthoxylum bungeanum* (pepper trees) (Wang, 2008, Zheng et al., 2009, Hou 2013, Zhai et al 2014; Qi et al 2007, and XY Wang, pers. comm.). No specific pest control is applied in orchards and vineyards, but general treatments applied against insect pests seem to provide protection. The frass (honeydew) covers twigs and leaves of seedlings or trees, on which mould may grow, which may eventually lead to the death of seedlings or reduced tree growth. It seems to have gained importance in recent years on fruit crops. It is a pest of urban trees in Weifang, Shangdong China (Xie, 2012).Regarding grapevine, no reports of serious outbreaks of *L. delicatula* were found in the literature; the pest may not be present in main grapevine-production regions (e.g. Xinjing); management practices may maintain the pest at a low level (Wang X.Y., pers. comm.). In addition, natural enemies occur, and they contribute greatly to the suppression of *L. delicatula* populations (Wang XY, pers. comm.).
  - *L. delicatu*la was assessed as a possible natural enemy for the control of *A. altissima,* but not retained due to its broad host range including fruit and other economically important trees (Ding et al., 2006).
- In the Republic of Korea, it causes direct and indirect damage on grapevine leading to the decline in quality and yield of grapes, and the species is subject to control. Kim et al. (2013) mentions that it is a serious pest of grapevine causing substantial economic damage (citing Shin et al., 2010; Lee et al., 2011). Kim et al. (2011a) mention that the density of *L. delicatula* is high in urban areas on *A. altissima*. Direct mortality of grapevine plants was observed (M. Park, pers. comm.).
  Some expert information indicates that attempts to eradicate *L. delicatula* by destroying *A. altissima* may have triggered its passage onto grapevine and peach (GoodFruitGrower, 2015 citing US scientist citing Korean sources). However, it was also observed that when *A. altissima* was removed close to grapevine (30 m), populations of *L. delicatula* (occurring at low density) were also reduced in grapevine (M. Park,

pers. comm.). The effect of removal of *A. altissima* is thought to differ depending on the density of *L. delicatula* (M. Park, pers. comm.): in low density, the populations of *L. delicatula* were greatly reduced when *A. altissima* was removed; in high density, some experts support that the pest moved to grapevine and peach when *A. altissima* was removed.
No data is available on a possible correlation between the density or distribution pattern of *A. altissima*, and damage on grapevine. *A. altissima* is widespread and naturalized in the Republic of Korea; it is planted as street trees and cultivated for young leaves for consumption. It is commonly growing in the vicinity of vineyards. The presence of *L. delicatula* in grapevine often seems linked to the presence of *A. altissima* in the vicinity; however, there are cases where this association is less clear and this is not fully elucidated. (M. Park, pers. comm.).

- In Pennsylvania, the pest has not caused economic damage to date, but is present only in a limited area and subject to quarantine. It has been found on *A. altissima*, as well as on wild *Vitis* (Barringer et al., 2015). Aggregation has been observed only on *A. altissima*. The pest has not been observed on *Vitis vinifera* plants to date, but at the end of 2015 some adults were caught for the first time on netting above grapevine plants (L. Donovall, pers. comm.). It is considered as a potential threat especially for grapevine and fruit trees (apple and stone fruit), nurseries, and hardwood timber industry (Pennsylvania Department of Agriculture, 2015). In 2015, high numbers of individuals were caught on *Salix* (L. Donovall, pers. comm.), as well as on *Acer* and *Betula* (G. Setliff, pers. comm.) with weeping observed on *Acer* and *Betula* (indicating a certain damage).
- In Japan, there was one major outbreak in 2009, mainly on *A. altissima* (Tomisawa et al., 2013). The pest is spreading but no further information on damage was found.
- For Vietnam, no information on damage was found.

No mention of environmental impact was found. Regarding social impacts, *L. delicatula* is reported to cause nuisance by entering houses (Han et al., 2008). In the Republic of Korea, grapevine is generally grown commercially on small plots and, when the first outbreaks occurred, some farmers uprooted grapevine plants (M. Park, pers. comm.). 'Social problems' are mentioned in Song et al. (2013) (no details available on their nature). In some cases, large aggregations on urban trees nearby *Ailanthus* trees probably affect their aestethic value, even when not killing the trees. Finally, in the USA large quantities of honeydew were observed to attract large numbers of stinging insects. In addition, effects on honey quality from hives located close to infestations are being tested, and the possible toxicity (health effect) of *Ailanthus* sap is not known yet (L. Donovall, pers. comm.).

Existing control measures
Physical methods: trapping can be used to capture nymphs as they climb on plants (Kim et al., 2011a; sticky traps at the based of preferred hosts at the activity period). This may protect the plants on which such traps are installed but does not control the pest. In Pennsylvania, brown sticky traps have been effective to capture nymphal instars; adults may be strong enough to leave the adhesive (L. Donovall, pers. comm.). Such brown sticky traps around the trunks are being used in a voluntary programme to trap the pest (Pennsylvania Department of Agriculture, 2015). Control also relies on scraping of egg masses using egg-scraping cards (effective both as an outreach tool and control method). It is estimated that over 17.000 egg masses were reported destroyed by the public in 2015 using these cards. The control programme also includes removal of some *Ailanthus* trees (with herbicide treatment to prevent sprouting), and maintenance of some other *Ailanthus*, treated with the systemic insecticide dinotefuran, to act as trap trees. Experiments are planned on wrapping trees with burlap (or Hessian; woven fabric made from plant fibers) treated with egg-effective pesticide to prevent emergence.

High pressure water jets have been used in China on trees to destroy egg masses (Chen, 1996, Zheng, 2015). It may be possible to also use that on inert objects such as stones. In China, coating of the base of trees with lime-based white wash is used against a range of pests, including against feeding and oviposition of *L. delicatula* (Zheng, 2015).

Studies were conducted on the repellency of natural oils (only lavender oil showed some effects; Yoon et al. 2011). This may ensure that individual plants are not attacked, but the pest could climb on others.

Chemical control. In the Republic of Korea, control has relied on insecticide applications in and around grapevine. Applications target adults after harvest. Egg masses are also removed by scraping during winter. The following active ingredients are reported in the literature as used in China and the Republic of Korea against nymphs and adults (in bold: active ingredients approved in the EU): **deltamethrin**, fenitrothion,

imidacloprid, clothianidin (Park et al., 2009), **dimethoate** (Cai and Wu, 2013) **etofenprox** + diazinon, **chlorpyrifos**, **etofenprox**, dinotefuran (Hong et al. 2013). In laboratory experiments against 1st and 2nd nymphal instars, the following were also effective (in addition to some mentioned above): methidathion, phenthoate, bensultap, furathiocarb, **bifenthrin, esfenvalerate, acetamiprid, thiamethoxam**, chlorfenapyr, **spinosad** (Shin et al., 2010). In the USA, testing will be conducted on **bifenthrin, pymetrozine, flupyradifurone** ('sivanto', TM) and **fipronil** (impregnated paper bands). Shin et al. (2010) investigated treatments of eggs, and only **chlorpyrifos** provided mortality.

Natural enemies. Natural enemies have been identified in China, but are not yet used in biocontrol (e.g. *Dryinus browni* (Yan et al, 2008); *Dryinus lycormae* (Dong, 1983, 1987, Yang, 1994); *Anastatus orientalis*, (Yang et al, 2015a, Kim et al, 2011b, Choi et al., 2014)). *Anastatus orientalis* is investigated both in the Republic of Korea and the USA as a potential biological control agent, because of high rates of parasitism of eggs. In Beijing, the average rate of parasitism of eggs reached 33% (Choi et al., 2014).

Rating of the magnitude of impact in the current area of distribution	*Low* ☐	*Moderate* ✓	*High* ☐
Rating of uncertainty	*Low* ✓	*Moderate* ☐	*High* ☐

13. Potential impact in the PRA area

Will impacts be largely the same as in the current area of distribution? **Yes** /No

Grapevine is likely to be affected, both for the quantity and quality of the grapes, as in the Republic of Korea. The economic impact on grapevine in the PRA area may be higher than at origin due to the high economic value of the crop in many countries because grapes are used for wine-making, high-quality table grape and raisins. However it is likely that control can be implemented, like in Korea.

Grapes exports will probably not be affected as it is widely accepted to not be associated with fruit. The pest may also affect a large number of hosts that are important in the region for fruit production (e.g. apple, stone fruits, kiwi), as urban trees (e.g. *Platanus*, *Acer*), as forest or plantation trees (e.g. *Quercus*, *Betula*, *Populus*). In addition, *L. delicatula* may impact different species than at origin (as observed in Pennsylvania – see Annex 2).

IPM is widely used in the EPPO region for grapevine and fruit trees, and would be disrupted. Organic farming is likely to be more affected. No biocontrol agent is readily available for use against this pest (work is ongoing in the Republic of Korea, the USA and China).

Chemical control seems to be effective to control the pest in China and the Republic of Korea. However, it cannot be assumed that the current routine chemical treatments in orchards and vineyards of the EPPO region would provide control of this pest.

Some host mortality has been reported where *L. delicatula* occurs, but it is not known if similar impacts will occur in the PRA area (they have not been observed in Pennsylvania so far).

As for any new introduction and also because there are no Fulgoridae in the PRA area, there will be no natural parasites (whereas in China parasitism rates reach 30%). Predators, from the same families, are likely to be comparable in the PRA area and where the pest occurs; however *L. delicatula* contains toxic substances and it is not known how this would impact predation, especially in newly infested areas.

The pest is not expected to have major effects on *A. altissima* (which is on the EPPO List of Invasive Alien Plants) because of the resilience of this species (as observed where *L. delicatula* occurs).

One major uncertainty is whether damage would occur in the absence/low presence of *A. altissima*, and how the presence of *A. altissima* in the EPPO region compares to that in the Republic of Korea. Only general data was available to compare the presence of *A. altissima* in the Republic of Korea and in the EPPO region in the vicinity of grapevines (see section 9 and 12). However, *A. altissima* is known to occur in areas of grapevine production in the EPPO region (section 9).

Rating of the potential impact in the PRA area	*Low* ☐	*Moderate* ✓	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ✓	*High* ☐

14. Identification of the endangered area

The endangered area is considered to be at the minimum where *A. altissima* is present. This is illustrated in Figures 3 and 4 (section 9.2), but the area concerned is probably wider as the maps date from 2007 and 2008 and *A. altissima* is still spreading. The risk would be greater in areas of greater density of *A. altissima*.

However, there is an uncertainty on whether the pest may be able to sustain populations on other hosts in the absence of *A. altissima*, which may widen the endangered area.

15. Overall assessment of risk

L. delicatula may enter on woody plants, wood products and various other commodities. It is likely to establish at least in areas where *A. altissima* is present. Without phytosanitary measures, it may have an economic impact on grapevine, and possibly on other fruit trees, urban trees, and forest or plantation trees. Eggs will be difficult to detect while nymphs and adults may be more easily detected. Some control options are available and others are under examination. If introduced, it may spread to many places through human assisted pathways. Options to reduce the risk of entry are discussed below.

Stage 3. Pest risk management

16. Phytosanitary measures

16.1 Measures on individual pathways

The pathways with a risk of introduction are woody plants for planting (except seeds), round wood and sawn wood, wood packaging material as well as man-made items and inert objects. In addition wood pieces and bark (above a certain size) may also present a risk.

Pathways for plants and plant products were studied in Annex 4, and measures are proposed for: plants for planting; round wood and sawn wood; wood chips, hogwood, processed wood residues (except sawdust and shavings), as well as bark. For plants for planting, the likelihood of entry was assessed to be higher for hosts than for non-hosts, and the PPM proposed to focus measures on known hosts, noting that non-host plants would be covered by visual inspection arising from regulation.

Possible pathways *(in order of importance))*	**Measures identified**
Woody plants for planting (except seeds) of known hosts	PFA (details in Annex 4) + stored and transported in conditions preventing egg-laying (through PFAs, or outside of the pest flying period, or enclosed). Or Pest-free production site (details in Annex 4) + stored and transported in conditions preventing egg-laying (through PFAs, or outside of the pest flying period, or enclosed). Or Complete physical isolation (EPPO Standard) + Packaging should be free from the pest + stored and transported in conditions preventing egg-laying (through PFAs, or outside of the pest flying period, or enclosed). Or Plants of a diameter <1 cm
Round wood and sawn wood	PFA (details in Annex 4) + storage and transport in conditions preventing egg-laying (through PFAs, or outside of the pest flying period, or enclosed). Or Treatment (heat treatment or irradiation) + storage and transport in conditions preventing egg-laying Or Squaring to entirely remove the wood surface + storage and transport in conditions preventing egg-laying
Wood chips, hogwood, processed wood residues, bark	Chips or bark: cutting to a size below 2.5 x 2.5 cm in two dimensions Or PFA (details in Annex 4) + transport in conditions preventing egg-laying (through PFAs, or outside of the pest flying period, or enclosed). Or Heat treatment + storage and transport in conditions preventing egg-laying

The PPM supported that it was not possible to require phytosanitary measures for other material for which the risk relates to the presence of eggs (i.e. hitchhiking); however, regulating the pest would also imply that such material should be free from the pest.
- Wood packaging material in international trade should be treated according to ISPM 15. In the case of *L. delicatula*, the risk relates to the contamination of such material by eggs after it has been treated according to ISPM 15 (see section 8). The only possible measure would be to require storage of ISPM 15-treated wood packaging material in conditions preventing egg-laying; however, this was not considered practical. The risk would nevertheless be reduced by visual inspection performed in the framework of the regulation of such material.
- Other man-made items and inert objects (such as stones, containers, used vehicles - mentioned in section 8; and any others) are not normally targets for phytosanitary measures in the EPPO region and they may not fall under the responbility of NPPOs. However, the risk may be reduced by visual inspection arising from regulation. NPPOs should also consider raising awareness of exporters and importers In addition, in the framework of inspections carried out on wood packaging material carrying stones, originating from areas where the pest is present, special attention should be paid to the possible presence of egg masses on these stones. It was also noted that two draft ISPMs are in preparation that could cover part of the risk of entry of this pest (on containers, and on used vehicles, machinery and equipment).

16.2 Eradication and containment
For eradication to be successful, early detection is essential. For *L. delicatula*, outreach and education would be valuable to ensure that the pest is detected early (large adults, colourful). This may target the public (citizen science) but also importers of relevant items (such as plants and stones – see section 8.1.3). Eradication would require extensive information to the local area and monitoring (survey targeting hosts) in order to delimit the infested areas. Monitoring would require locating areas where *A. altissima* is present. Control measures should be implemented (see section 12), as well as quarantine measures to prevent movement of egg masses on plant material and inert objects. Feasibility would depend on the size of the area.

In Pennsylvania, eradication is being attempted. As part of the programme, single detections outside of the infested area are considered as regulatory incidents and monitored during 3 years (allowing possible build-up of populations) in order to confirm whether the pest has been eliminated.

Containment would be facilitated by the fact that the pest is not very mobile, and natural spread would be slow, even if measures should be in place to avoid spread with many items (see below). However, the pest is nevertheless likely to progress by 'jumps' within the region on potentially many materials. Removing *A. altissima* (which is also an invasive plant in some countries) may be helpful to avoid building up of populations, but it may not be sufficient as there are many other potential hosts.

Containment would require a quarantine such as that implemented in Pennsylvania (Pennsylvania Department of Agriculture, 2015), encompassing the movement of a large variety of plants, plant products and man-made items. The internal quarantine in Pennsylvania restricts the movement of the following material:

- living stages of *L. delicatula*
- brush, debris, bark, or yard waste
- landscaping, remodeling or construction waste
- logs, stumps, or any tree parts
- firewood of any species
- grapevines for decorative purposes or as nursery stock
- nursery stock
- crated materials
- outdoor household articles including recreational vehicles, lawn tractors and mowers, mower decks, grills, grill and furniture covers, tarps, mobile homes, tile, Stone, deck boards, mobile fire pits, any associated equipment and trucks or vehicles not stored indoors.

Citizen collaboration is also sought, and a checklist provided for verifying absence of egg masses prior to moving items, as diverse as (extracts): vehicles (bicycles, boats and their trailers, campers, motorcycles, snowmobiles); outdoors items (e.g. tents, backpacks, cardboard or wooden boxes, plant containers, propane or oil tanks, outdoor furniture); building materials (incl. bricks, pipes, tools, machinery); garden items (e.g. dog houses, grills, tools, lawnmowers); children toys (incl. play houses, pools, bicycles).

Such quarantine (requiring declaration by persons moving items) would require public engagement and resources to implement and control. Such a policy would also need to apply to very many industries/sectors.

Comparison with *Anoplophora glabripennis* was thought to be appropriate in relation to flight capacity (see details in *Pest overview*). The size of buffer zones around infested areas could therefore also be similar to that used against *A. glabripennis* (EPPO (2013c) on official control), i.e. at least 2 km. However, it should also be noted that the EWG considered that, for a PFA, a distance of 200 m from an infested area would be appropriate to keep out 95% of the population. The size of buffer zone for eradication may be adjusted to specific situations and risk.

Given the current knowledge of hosts, a worst-case scenario would be if the pest was introduced in an area of grapevine production where *A. altissima* also occurs and it can survive outdoors.

17. Uncertainty

- whether there are subspecies (with different climatic requirements)
- location of the pest in the southern part of its distribution (South of China, Vietnam); presence in India, Laos, Cambodia
- Biology:
  Number of individuals required to establish a viable population in PRA area
  Number of generations in warmer climates
  Whether diapause of eggs would allow the pest to survive more than one year
  Whether a cold period is necessary for hatching (facultative or obligatory diapause)
  Whether adults would survive for longer periods in some climates
  Reproduction rate
  Ability to disperse: flight distance, crawling distance of nymphs
  Relative importance of human-assisted spread versus natural spread in the absence of measures
  Minimal size of the substrate for oviposition
  Whether predators in the PRA region are able to predate on *L. delicatula*
  Clarification regarding the only record as vector
  Number of larval stages (four recorded; 5 for other Fulgoridae)
- Hosts:
  Whether plants other than *A. altissima* support the complete life cycle (incl. if the pest arrives in an area where *A. altissima* does not occur);
  Other hosts than those listed and which life stages they support (incl. conifers);
  Mechanisms for host attraction and host preference
- Trade (volumes, species traded for the different pathways)
- Active substances for treatments against eggs.
- Traps and lures that are species-specific (versus currently sticky bands)

18. Remarks

More information will become available in the coming years as there is extensive research being carried out in the USA.

L. delicatula is believed to be a good example for which citizen science could be applied and a larger community be involved in early detection (large insect, colourful).

This is a case with many pathways not usually subject to phytosanitary regulations in the EPPO region.

19. References (including for Annexes) (all websites mentioned were accessed in August 2015)

Alakangas E. 2010. The European Standard EN 14961 for Wood Chips and Hog Fuel. Forest Bioenergy Conference. VTT Technical Research Centre of Finland.

Bai J. 2004. Control of the four pest of Ailanthus altissima in summer. Flower Plant & Penjing, (9), 25-25(In Chinese).

Barringer LE, Donovall LR, Spichiger S-E, Lynch D, Henry D. 2015. The first New World record of Lycorma delicatula (Insecta: Hemiptera: Fulgoridae). Entomological News, Volume 125, Number 1, June 2015

Barringer LE. 2014. Pest Alert. Spotted Lanternfly Lycorma delicatula (WHITE) (Hemiptera: Fulgoridae). Pennsylvania Department of Agriculture

Basnou C, Vilà M. 2006. *Ailanthus altissima*. Delivering Alien Invasive Species Inventories for Europe. http://www.europe-aliens.org/pdf/Ailanthus_altissima.pdf

Biosecurity Australia. 2009. Draft import risk analysis for fresh apple fruit from the People's Republic of China. Biosecurity Australia, Canberra.

Biosecurity Australia. 2011. Draft non-regulated import risk analysis report for table grapes from the Republic of Korea. Department of Agriculture, Fisheries and Forestry, Canberra.

Bojnanský V, Fargašová A. 2007. Atlas of Seeds and Fruits of Central and East-European Flora: The Carpathian Mountains Region. Springer Science & Business Media.

Bourgoin T. 2016. FLOW (Fulgoromorpha Lists on The Web): a world knowledge base dedicated to Fulgoromorpha. Version 8, updated 2016-02-08. http://hemiptera-databases.org/flow/

Cai HX, Wu XZ. 2013. Occurrence and control of Lycorma delicatula in Ailanthus altissima in Jiaozuo, China. Proceedings of Chinese Society of Plant Protection, 11th National Congress of the members and academic year in 2013, Shandong, China. October 22-25, 2013. Pp 146-149 (in Chinese).

CEN. 2011. European Standard EN 961-4. Solid biofuels — Fuel specifications and classes. Part 4: Wood chips for non-industrial use

CFIA. 2015. Spotted Lanternfly (Lycorma delicatula). Canadian Food Inspection Agency. http://www.inspection.gc.ca/plants/plantprotection/insects/spottedlanternfly/eng/1433365581428/1433365581959

Chen B, Li TJ, He ZB. 2010. Insects in Chongqing Municipality. Beijing: Science Press, p59. (in Chinese)

Chen B. 1996. Test on high pressure water spray gun smashing egg masses of Lycorma delicatula. Beijing Garden (3): 37-38(In Chinese).

Chen HY, Wang YJ. 2010. Integrated control techniques of grape pests. China Friuts and Vegetables, 3: 32-32. (In Chinese)

Chen JF. 2011. Cultivation and comprehensive utilization of tree of heaven. Forest By-Product and Speciality in China, 3: 61-63. (In Chinese)

Choi DS, Kim DI, Ko SJ, Kang BR, Park JD, Kim SG, Choi KJ. 2012. Environmentally-friendly Control Methods and Forecasting the Hatching Time Lycorma delicatula (Hemiptera: Fulgoridae) in Jeonnam Province. Korean J. Appl. Entomol. 51(4): 371-376.

Choi MY, Yang ZQ, Wang XY, Tang YL, Hou Z, Kim JH, Byeon YW. 2014. Parasitism rate of egg parasitoid Anastatus orientalis (Hymenoptera: Eupelmidae) on Lycorma delicatula (Hemiptera: Fulgoridae) in China. [in Korean]. Korean Journal of Applied Entomology 53(2), 135-139.

Chou I, Lu JS, Huang J, Wang SZ. 1985. Economic Insect Fauna of China, Fasc. 36, Homoptera: Fulgoroidea. Beijing: Science Press, pp104-119. (in Chinese)

Chou I, Lu JS, Huang J, Wang SZ. 1985. Economic Insect Fauna of China. Fasc. 36. Homoptera: Fulgoroidea. Science Press, Beijing, China, 3, 5, 7, 112. (In Chinese)

Chou I. 1946. A study on Lycorma delicatula White (Hemiptera: Fulgoridae). Entomologia et ARS, 1(2-4):31-54. (In Chinese).

Constant. 2014. Project title: A step further in the Entomodiversity of Vietnam (part V). Project description. GTI calls. Available at http://www.taxonomy.be/gti_calls/grants_awarded/grants-obtained-rbins-researchers-2014/constant-and-grootaert-vietnam/projects/gti-project_vietnam-constant-2014.pdf/download/en/1/GTI-Project_Vietnam-Constant-2014.pdf?action=view.

CropIPM.com. 2009. Online Database. Lycorma delicatula. http://www.cropipm.com/Html/2002_03_11/104022_107862_2002_03_11_109657.html

Dai ZX. 2012. Control measures of disease and insect pests on kiwi fruit. The Farmers Consultant, 3: 24. (In Chinese)

Dara SK, Barringer L, Arthurs SP. 2015. Lycorma delicatula (Hemiptera: Fulgoridae): A New Invasive Pest in the United States. J. Integ. Pest Mngmt. (2015) 6(1): 20; DOI: 10.1093/jipm/pmv021

Ding J, Wu Y, Zheng H, Fu W, Reardon R, Liu M. 2006. Assessing potential biological control of the invasive plant, tree-of-heaven, Ailanthus altissima. Biocontrol Science and Technology, Volume 25, Issue 11.

Dong JF. 1983. Studies on the biology of Dryinus sp., a hymenopterous parasitoid of Lycorma delicatula White (Homopt: Fulgoridae). Natural Enemies of Insect, 5(4): 228-230. (In Chinese)

Dong JF. 1987. Rearing method of Dryinus lycormae Yang. Henan Science & Technology, (1): 17-18.

Du C, Zhao HY, Gao HH, Li JF, Luo K, Hu ZQ, Hu XS. 2011. Arthropod community reestablishment and niche of the main groups in kiwifruit orchards. Acta Ecologica Sinica, 31(11): 3246-3254. (In Chinese)

Du XW, Zhao XQ, Zhou YQ, Chen GD, Wang JC. 2010. Prevention and control of major diseases and insect pests in the South West of Henan Province. Deciduous fruits, 42(5): 32-34. (In Chinese)

EC. 2013. Commission Implementing Decision 2013/92/EU of 18 February 2013 on the supervision, plant health checks and measures to be taken on wood packaging material actually in use in the transport of specified commodities originating in China (notified under document C(2013) 789).

EEA. 2006. European forest types. Categories and types for sustainable forest management reporting and policy. EEA Technical report No 9/2006

EOL. 2015. Lycorma delicatula. Encyclopedia of Life [online database]. http://eol.org/pages/241504/details

EPPO List of IAP. 2015. EPPO List of Invasive Alien Plants. Available at www.eppo.int.

EPPO. 2000. Distribution of the main forest trees and shrubs on the territory of the former USSR. Working document for the Panel on Quarantine Pests for Forestry. 00/7806

EPPO. 2009. EPPO Standard 10/8(1). Disinfestation of wood with ionizing radiation. EPPO Bulletin, 39: 34–35.

EPPO. 2012a. EPPO Technical Document No. 1061, EPPO Study on the Risk of Imports of Plants for Planting EPPO Paris. www.eppo.int/QUARANTINE/EPPO_Study_on_Plants_for_planting.pdf

EPPO. 2012b. Final pest risk analysis for Pseudomonas syringae pv. actinidiae. EPPO, Paris. http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_bacteria/12-18034%20Express_PRA_PSA.pdf

EPPO. 2013a. Pest risk analysis for Oemona hirta. 13-18692. www.eppo.int

EPPO. 2013b. Pest Risk Analysis for Apriona germari, A. japonica, A. cinerea (13-18692). www.eppo.int
EPPO. 2013c. EPPO Standard PM 9/15 (1) *Anoplophora glabripennis*: procedures for official control. EPPO Bull, 43: 510–517. doi:10.1111/epp.12064
EPPO. 2015a. Lycorma delicatula on EPPO Alert List. http://www.eppo.int/QUARANTINE/Alert_List/alert_list.htm
EPPO. 2015b. EPPO Technical Document No. 1071, EPPO Study on wood commodities other than round wood, sawn wood and manufactured items. EPPO Paris. https://www.eppo.int
EPPO. 2015c. EPPO PRA for Thousand cankers disease (Geosmithia morbida and Pityophthorus juglandis). http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm
EPPO. 2015d. EPPO PRA for Polygraphus proximus. http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm
EPPO. 2016. EPPO Global Database (available online). https://gd.eppo.int
Euforgen 2009. Distribution map of oriental sweet gum (Liquidambar orientalis). Org; http://www.euforgen.org/fileadmin/templates/euforgen.org/upload/Documents/Maps/JPG/Liquidambar_orientalis.jpg
Eurostat. European Statistics. European Commission. http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/
FCBN. 2016. Federation des conservatoires botaniques nationaux, France. http://siflore.fcbn.fr/?cd_ref=80824&r=metro (A. altissima) http://www.fcbn.fr/
Feng H. 2000. Anniversary calendar on Kiwifruit pest prevention, Northwest Horticulture, (6): 38-39. (In Chinese)
Feng P. 2012. Control techniques of Lycorma delicatula on grape. Hebei fruits, (5): 45-45. (In Chinese)
Feng ZT. 2003. Cultivation techniques of precocious new cultivar kiwifruit-YU-2. Northern fruits. 2: 20. (In Chinese)
Forest Pest Control and Quarantine Bureau of Xinjiang Uygur Autonomous Region. 2014. A Field Guide to the Forest Insect Pests of Xinjiang. Beijing: China Forestry Publishing House, p296. (in Chinese)
Forest Pest Control and Quarantine Station of Qinghai Province. 2015. Occurrence of Lycorma delicatula in Minhe County, September 30th, 2015. [http://www.forestpest.org/senfang/News/dfxx/qinghai/2015-09-30/Article_418949.shtml]
Fried G. 2012. *Guide des plantes invasives*. Collection "L'indispensable guide des…fous de Nature!" (ed. G. Eyssartier). Editions Belin, France. 272 p.
Gao YM. 1993. Study on high yield cultivation technique of Chinese pepper (Zanthoxylum bungeanum). Economic Forest Researches, 11(S1): 255-261. (In Chinese)
Ge CY. 2008. The control methods of grape pest in North of Anhui. Modern Agricultural Science and Technology, 16: 147-148. (In Chinese)
GoodFruitGrower. 2015. Lanternfly targeted for eradication. Efforts to eliminate the invasive spotted lanternfly will begin this spring in Pennsylvania. Good Fruit Grower, USA. http://www.goodfruit.com/lanternfly-targeted-for-eradication/
Han JM, Kim H, Lim EJ, Lee S, Kwon YJ, Cho S. 2008. Lycorma delicatula (Hemiptera: Auchenorrhyncha: Fulgoridae: Aphaeninae) finally, but suddenly arrived in Korea. Entomological Research 38 (2008) 281–286.
He HP, Gong LZ, Gu X, Wang FR. 2007. Occurrence and control measures of Lycorma delicatula on grapes in Wuhan area. Fruit Growers' Friends, 3: 36-36. (In Chinese)
Hong EY, Kim SK, Lee SH, Lee YS, Lee JW, Kim GH. 2013. Control effect using insecticides and environmental-friendly agricultural materials against spot clothing wax cicada , Lycorma delicatula (Hemiptera: Fulgoridae) at the vineyard. 2nd Global Conference on Entomology, November 8-12, 2013, Kuching, Sarawak, Malaysia, scientific programme containing abstracts.
Hong HL, Li BB. 1994. Occurrence and control of major insect pests on Chinese kiwi fruit. Hubei Plant Protection, 3: 17-18. (In Chinese)
Hou ZR. 2013. Study on the Lycorma Delicatula and Egg Parasitoids. Master's Thesis of Chniese Academy of Forestry
IBS. 2014. Opportunities for Canadian wood producers to expand their market share in Turkey. Prepared for Natural Resources Canada. Final Report, Istanbul, May 13, 2014. http://www.IBSResearch.com
IPPC. 2015. Report of the Tenth Session of the Commission on Phytosanitary Measures, 16-20 March, 2015. www.ippc.int
Kim H, Kim M, Kwon DH, Park S, Lee Y, Huang J, Kai S, Leec H-S, Honge K-J, Jang Y, Lee S. 2013. Molecular comparison of *Lycorma delicatula* (Hemiptera: Fulgoridae) isolates in Korea, China, and Japan. Journal of Asia-Pacific Entomology, Volume 16, Issue 4, December 2013, Pages 503–506.
Kim H. 2013. Morphometric Analysis of Wing Variation of Lantern Fly, Lycorma delicatula from Northeast Asia. Korean J. Appl. Entomol. 52(4): 265-271 (2013).
Kim HJ, Kim MY, Kwon DH, Park SW, Lee YR, Jang HY, Lee SH, Lee SH, Huang JH, Hong KJ, Jang YW. 2011c. Development and characterization of 15 microsatellite loci from Lycorma delicatula (Hemiptera: Fulgoridae). Animal Cells and Systems; 2011. 15(4):295-300.
Kim IK, Koh SH, Lee J-S, Choi WI, Shin S-C. 2011b. Discovery of an egg parasitoid of Lycorma delicatula (Hemiptera: Fulgoridae) an invasive species in South Korea. Journal of Asia-Pacific Entomology 14 (2011) 213–215.
Kim JG, Lee E-H, Seo Y-M, Kim N-Y. 2011a. Cyclic Behavior of Lycorma delicatula (Insecta: Hemiptera: Fulgoridae) on Host Plants. J Insect Behav. 24:423-435.
Kowarik I, Saümel I. 2007. Biological flora of Central Europe: Ailanthus altissima (Mill.) Swingle. Perspectives in Plant Ecology, Evolution and Systematics 8: 207–237
Lee J-E, Moon S-R, Ahn H-G, Cho S-R, Yang J-O, Yoon C, Kim G-H. 2009. Feeding Behavior of Lycorma delicatula (Hemiptera: Fulgoridae) and Response on Feeding Stimulants of Some Plants. Korean J. Appl. Entomol.48(4): 467～477.
Lee K-Y, Kim S-K, Kim, I-H, Kim K-S. 2011. Seasonal Occurrence of Spot Clothing Wax Cicada, Lycorma delicatula(Hemiptera: Fulgoridae) and It's Control Efficacy Using EFAM at the Vineyards. The Korean Journal of Pesticide Science. Volume 15, Issue 3, 2011, pp.303-309.

Lee RE, Denlinger DL (eds). 1991. Insects at low temperature. Chapman and Hall. 513 pages.
Lee S-J, Park S-C. 2013. Attraction effect against Lycorma delicatula, antioxidant activity and local irritation test of Ailanthus altissima extract. Korean J Vet Res(2013) 53(4) : 231~237
Li JB, Song XG, Xue JP. 2009. The biological characteristics and occurrence regularity of Lycorma delicatula on grape in Huaibei. Modern agricultural science and technology, 22: 137-138. (In Chinese)
Li JH, Li XT, Li SQ. 2013. The occurrence and control of Semanotus bifasciatus and Lycorma delicatula in cypress trees. Modern Agricultural Science and Technology, 37-38. (In Chinese)
Li LY, Wang R, Waterhouse DF. 1997. The distribution and importance of arthropod pests and weeds of agriculture and forestry plantations in Southern China. ACIAR, Canberra (AU), 185 pp.
Li SM. 2006. Fast Extraction, Fatty Acid Composition Analysis and Purification of α-Linolenic Acid from Insects, Thesis for Doctor Degree Northwest A & F University, 27. (In Chinese)
Li SZ. 1578. Compendium of Materia Medica. (In Chinese)
Li ZZ. 2011. Catalog of wild animals in Guizhou. Guizhou Science and Technology Publishing House Co., Ltd, p103. (in Chinese)
Lieu K. 1934. External Morphology and Internal Anatomy of a Lantern-fly, Lycorma delicatula White. 1933 Year Book of Bureau of Entomology, Hangzhou, Zhejiang, 1934, (3): 1-25.
Liu DG. 2011. Prevention and control of Lycorma delicatula. Science and Technology of Tianjin AgroForestry, 6: 9. (In Chinese)
Liu G. 1939. Some extracts from the history of entomology in China. Psyche, 46: 23-28.
Liu T, Fan ST, Yang YM, Ai J, Liu YX. 2015. Investigation on occurrence regularity and integrated control of diseases and pests in grape Garden of Ji'an. Sino-overseas Grapevine & Wine, 2:49-51. (In Chinese)
Ma YN, Sun BL, Jia GH, Wang KY. 2010. The occurrence and control of wax cicada insect pests in pomegranate garden, Modern Agricultural Science and Technology, 12: 167-167. (In Chinese)
Mei X, Cui L, Han B. 2011. A survey on species of major pests and natural enemies in tea plantations in Lishui region. Journal of Anhui Agricultural University, 38(3): 328-332
Metcalf Z. P. 1947 - General catalogue of the Hemiptera. Fasc.IV Fulgoroidea, Part 9 Fulgoridae. IV-9: 276 pp. Smith College, Northhampton (Mass.) (United States of America).
Mi HB, Zhang G, Liu B. 2007. Main technologies of pest management on Shannxi organic Kiwi production. Academic Periodical of Farm Products Processing. 3: 85-87. (In Chinese)
Monfreda, C., Ramankutty, N. & Foley, J. A. 2008. Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000, Global Biogeochemical Cycles, 22, 1-19.
Ni TL, Li FS, Li ZY, Wang M. 2004. The main diseases and insect pests of Ailanthus altissima and control methods. Forest Science & Technology, 29(6): 24-25. (In Chinese)
Park JD, Kim M-Y, Lee S-G, Shin S-C, Kim J, Park I-K. 2009. Biological Characteristics of Lycorma delicatula and the Control Effects of Some Insecticides. Korean J. Appl. Entomol, 48(1): 53-57.
Park M, Kim K-S, Lee J-H. 2012. Isolation and characterization of eight microsatellite loci from Lycorma delicatula (White) (Hemiptera: Fulgoridae) for population genetic analysis in Korea. Mol Biol Rep (2012) 39:5637–5641
Park M, Kim K-S, Lee J-H. 2013.Genetic structure of Lycorma delicatula (Hemiptera: Fulgoridae) populations in Korea: implication for invasion processes in heterogeneous landscapes. Bulletin of Entomological Research / Volume 103 / Issue 04 / August 2013, pp 414-424
Park M, Kwon Y-J, Yoo J-W, Lee J-H. 2011. Cold hardiness of overwintering eggs of five Lycorma delicatula (White) populations in South Korea. International symposium on celebration of the 50th anniversary of the korean society of applied entomology. 12-14 May 2011, Hongcheon.Gangwon-do, Republic of Korea.
Park M. 2015. Overwintering ecology and population genetics of Lycorma delicatula (Hemiptera: Fulgoridae) in Korea. PhD Thesis. February 2015. Seoul National University.
Pei ZH, Wang YA. 2001. Comprehensive prevention and control of major pests of kiwifruit occurred in the south slope of the Funiu Mountain. Deciduous Fruits, 33(1): 53-54. (In Chinese)
Peng LH,Yang MX,Gui AL. 2004. Insect fauna analysis of Matou mountain natural reserve in Jiangxi. Acta Agriculturae Universitatis Jiangxiensis, 26(4): 507-511.
PennState Extension. 2015. Host Plants Used by Spotted Lanternfly. http://extension.psu.edu/pests/spotted-lanternfly/news/2015/host-plants-used-by-spotted-lanternfly
Pennsylvania Department of Agriculture. 2015. Spotted Lanternfly. Data sheet with links. http://www.agriculture.state.pa.us
Pham HT .2009. [A checklist of the family Fulgoridae (Homoptera: Auchenorrhyncha: Fulgoroidea) from Vietnam]. Proceedings of the 3rd National Scientific Conference on Ecology and Biological Resources (Hanoi, VT, 2009-10-22), 317-321 (in Vietnamese).
Qi HX, Zhang JZ, Qi YS, Wang TK, Li SM. 2007. Research of the pests in free-pollutant culture wine grape orchard. Northern Horticulture, 8, 202-204. (In Chinese)
Qiu YS, Fan YG, Yang WQ. 1991. Study on investigation of oviposition habits of lycorma delicatula and control method. Plant Protection, 17(2): 14-16. (In Chinese)
Qiu YS, Fan YG, Yu SZ. 1994. Preliminary study on comprehensive control of Grape Black Pox. Journal of Nanjing Agricultural Technology College, 10(3): 9-13. (In Chinese)
Shi YR. 2007, Research on the cultivation techniques of high quality and hazard-free wine grape. Thesis for Master Degree Northwest A & F University: 10-11. (In Chinese)
Shin, Y. H., S. R. Moon, C. Yoon, K. S. Ahn, and G. H. Kim. 2010. Insecticidal activity of 26 insecticides against eggs and nymphs of Lycorma delicatula (Hemiptera: Fulgoridae). Korean Journal of Pesticide Science 14:157–163.

Song MK, Lee KY, Hong ST, Kim SD, Lee GJ, Hwang S, Park HH, Kim GH. 2013. The pest control role of NCPMS, National Crop Pest Management System, in the Republic of Korea. 2nd Global Conference on Entomology, November 8-12, 2013, Kuching, Sarawak, Malaysia, scientific programme containing abstracts.

Song N, Liang A-P, Bu C-P. 2012. A Molecular Phylogeny of Hemiptera Inferred from Mitochondrial Genome Sequences. PLoS ONE 7(11): e48778.

Struik PC, Amaducci S, Bullard MJ, Stutterheim NC, Venturi G, Cromack HTH. 2000. Agronomy of fibre hemp (Cannabis sativa L.) in Europe Industrial Crops and Products 11 (2000) 107–118.

Tomisawa, A, Ohmiya S, Fukutomi H, Hayashi K, Ishikawa T. 2013. [Biological notes on Lycorma delicatula (White) (Hemiptera, Fulgoridae) in Ishikawa Prefecture, Japan]. Japanese Journal of Entomology 16(1), 3-14 (in Japanese).

Umemura S, Itoh K, Inoue M,　Genno M, Sakurai C. 2013. [The first record of *Lycorma delicatula* (White) in Yoshizaki, Awara City, Fukui Prefecture Bulletin of the Fukui City Museum of Natural History，No.60，67-68.]

University of California. 2015. Dara SK. Spotted lanternfly (Lycorma delicatula) is a new invasive pest in the United States. Pest News. eNewsletter about endemic and invasive pests in California. http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=15861

University of Delaware, 2015. GENUS LYCORMA STÅL, 1863. Online data sheet. http://ag.udel.edu/research/planthoppers/families/species/Lycorma.htm

USDA. 2014a. Pest Alert. Spotted Lanternfly (Lycorma delicatula). APHIS 81-35-024, Issued November 2014.

USDA. 2014b. Treatment Manual. 06/2014-111.

USDA-FAS. 2014. USDA Foreign Agricultural Service's Global Agricultural Trade System. http://apps.fas.usda.gov/GATS/default.aspx

Wang HB, Wang XD, Wang BL, Liu FZ. 2011. Key techniques for the early cultivation of grape plant- Integrated control of diseases and insect pests. Sino-oversea Grapevine & Wine, 2: 33-37. (In Chinese)

Wang KR, Lu DL, Yang SA. 2006. Sap of Broussonetia papyrifera can control vegetable pests. Journal of Changjiang Vegetables, 12:42. (In Chinese)

Wang SB. 2008. Studies on the Pest Species in Apple Orchard of Tianshui and the Biology of Aphis Citricola Van Der Goot. Master's Thesis of Northwest A&F University

Wang SZ, Wang FX, Xuan LF. 2000. Fauna Study of Fulgoroidea of Hainan Province. Acta Agriculturae Boreali-Sinica, 15: 157-161. (In Chinese)

Wang XC, Peng JD, Wu DY. 2015. Investigation on the Occurrence of Lycorma delicatula on Eight Species of Landscape Trees in Hengshui Lake Wetland. Hubei Agricultural Sciences 54(9): 2010-2013. (In Chinese)

Wang Z. 2005. Artificial cultivation techniques of Phellodendron amurense. Practical Forestry Technology, 8:18. (In Chinese)

Wang ZG. 2012. Forest Pests Integrated Management Technology of Fuxin, Liaoning. Shenyang: Shenyang Science & Technology Press, P114-115. (in Chinese)

White A. 1845. Descriptions of a new genus and some new species of Homopterous Insects from the East in the collection of the British Museum. Annals and Magazine of Natural History. London 15: 34-37.

Wu BG. 2012. Preliminary investigation and control of the pests on kiwi fruit. Sichuan Agricultural Science & Technology, 7: 45-45. (In Chinese)

Xiao GR. 1992. Forest Insects of China (2nd edition). Beijing: China Forestry Publishing House. 169-170. (In Chinese)

Xie GK. 2012. Damage and Preventive Measures on Sapping Pests of Garden Trees in Weifang City. Proceedings of 2012 Annual Meeting of the International Federation of Landscape Architects (IFLA) Asia-Pacific Division. pp. 930-933.

Xue YT, Jiao RL. 2002. Occurrence and control of grape pests in Greenhouse. Shanxi Friuts, 4: 29. (In Chinese)

Xue YT. 2004. Non pollution Control technology of grape pests. Shanxi Agriculture, 2: 34-35. (In Chinese)

Yan JH, Ding SM, Qin XB, Wang FR, Bo LL. 2008. Studies on the biology of Dryinus browni Ashmead. Shandong Forestry Science and Technology, 178: 16-18. (in Chinese)

Yang C. 1994. Descriptions of Dryinus lycormae sp. n. and its biological notes (Hymenoptera Dryinidae), pp. 37-42 In X. Shen and Z. Shi [eds.], Fauna and Taxonomy of Insects in Henan vol. I (1994). Chinese Press Agric. Sci. & Tech., Beijing, P R. China. 351 pp.(in Chinese)

Yang R, Wang YA, Zhang K, Hao Y. 2015b. Study on the occurrence and control of Lycorma delicatula on grape in areas of Lanzhou." Gansu Agr. Sci. and Techn, 4: 87-88.(In Chinese)

Yang ZQ, Choi WY, Cao LM, Wang XY, Hou ZR. 2015a. A new species of Anastatus (Hymenoptera: Eulpelmidae) from China, parasitizing eggs of Lycorma delicatula (Homoptera: Fulgoridae). Zoological Systematics, 40: 290-302.

Yoon CM, Moon SR, Jeong JW, Shin YH, Cho SR, Ahn KS, Yang JO Kim GH. 2011. Repellency of lavender oil and linalool against spot clothing wax cicada, Lycorma delicatula (Hemiptera: Fulgoridae) and their electrophysiological responses. Journal of Asia-Pacific Entomology, 14(4):411-416.

Yu DY. 2011. Pests of Plum in Fujian Province and Their Integrated Management Technology. Xiamen: Xiamen University Press. (in Chinese)

Yuan F, Hua BZ, Yang CJ, Zhang YL, Lei YX, Zhao SF. 1997. An Investigation of Tobacco Insect Fauna in Shaanxi Province and Its Classification System. Acta Universitatis Agriculturae Boreali-Occidentalis. 25(2): 27-36. (In Chinese)

Zhai YL, Gao JS, Yan LL, Zhang JL. 2014. [Occurrence of Homoptera insects in Prunus armeniaca species, and control methods]. Entomological Research in Centre China, 10: 223-227.

Zhang HH, Xue QT, Zhuo YG. 1994. Cultivation model of high quality and high yield of kiwi fruit. Special Wild Economic Animal and Plant Research, 3: 43-44 (In Chinese)

Zhang J. 2013. The cultivation of kiwi fruit in the Funiu mountain area. Hebei Friuts, 3, 57. (In Chinese)

Zhang JJ, Cheng GL. 2000. Occurrence and control of pest on grape in early spring. Yantai Fruits, 1: 26. (In Chinese)

Zhang SM, Zhao YX. 1996. The Geographical Distribution of Agricultural and Forest Insects in China. Beijing: China Agriculture Press, p50. (in Chinese)

Zhang WJ. 2001. Investigations on the insect pests of American Black Walnut in Henan Province. Forest Pest and Disease, 1:38-39 (In Chinese)

Zhang XF, Li T, Zhang CX, Zhang JY, Zhang XX, Hu CL. 2002. The effect of controlling garden insect with Jingyebao. Shanxi Forest Science & Technology, 1:14 (In Chinese)

Zhao J, Wang JX, Song FC, Sun FP, Yang LF. 2001. Key techniques for improving the survival rate of seedling kiwifruit, Yantai Friuts, 3: 37-38. (In Chinese)

Zhao ZW. 2006. Non-pollution integrated control technology of grape pests. China fruits & vegetables, 2: 30-30.

Zheng JW, Du J, Liu Q, Wang SB, Li YP, Wu JX. 2009. Investigation on insect pest and plant diseases damaging apple trees and their dynamics in Tianshui, Gansu. Acta Agriculturae Boreali·occidentalis Sinica, 18(2): 293—298.

Zheng YQ. 2015. An analysis on causes of outbreak of Lycorma delicatula in Yinchuan City and countermeasures for its prevention and control. Ningxia Journal of Agricultural and Forestry Science & Technology, 56(8): 53-54. (in Chinese)

Zhou SJ. 1992. *Lycorma delicatula*. In: Peng JW (Ed). Iconography of Forest Insects in Hunan, China. Changsha: Hunan Science & Technology Press, P112. (in Chinese)

Zhu YC, Lu RH, Yu FJ. 1997. Grape production and cultivation technology in plastic sunlight greenhouse. Gansu Agri. Sci. & Tech. 2: 25-26

Zu XS, Liu QF, Jin LP. 1992. Studies on the persimmon witches' broom disease: III vectors. Hebei Fruits, (2): 31-33. (in Chinese)

Zu XS. 1992. Studies of Persimmon Proliferation Disease. Hebei Fruits, 3: 23-26

ANNEX 1. Duration of life stages and life cycle in different publications

	Duration	**DD**	**Conditions and reference**
Egg	55.9, 26.8, 21.6 d (means)	355.4 DD needed to reach nymph.	15, 20, 25 C with 14L:10D (Choi et al., 2012 – presumably lab experiment) [hatching rate 61.9, 57.8, 30.4%] Egg development stopped at 8.14 C (based on the developmental rate expressed as a linear equation)
			Developmental threshold temperature was 11.13 °C (Park, 2015)
1st nymph	18.8 d (mean)		On *Parthenocissus quinquefolia* at room temperature; Park et al. (2009)
		271	Thermal constant for peak population on *A. altissima* (Park, 2015)
2nd nymph	20.9 d (mean)		On *Parthenocissus quinquefolia* at room temperature; Park et al. (2009)
		492	Thermal constant for peak population on *A. altissima* (Park, 2015)
3rd nymph	20.8 d (mean)		On *Parthenocissus quinquefolia* at room temperature; Park et al. (2009)
		620	Thermal constant for peak population on *A. altissima* (Park, 2015)
4th nymph	22.2 d (mean)		On *Parthenocissus quinquefolia* at room temperature; Park et al. (2009)
		908	Thermal constant for peak population on *A. altissima* (Park, 2015)
Adult	3 months or more Up to 4 months		Tomisawa et al. (2013) CropIPM.com (2009)

Note: Lee et al. (2009) in experiments on longevity of adults and nymphs on different material mention longevities that are much shorter than above for nymphs and adults, but reasons are not known (article in Korean - seems to have been carried out in the laboratory on plant parts separated from trees).

ANNEX 2. Hosts and associated plants of *L. delicatula*

'Hosts' are considered in this PRA as those supporting feeding of nymphs or adults; plants on which only eggs are recorded (sometimes also listed together with 'hosts' in the literature) are considered as 'associated plants'. See general uncertainties in section 7 of this PRA.

The table below indicates the life stages found on the plant and whether feeding was reported (where available), as well as countries.

E = egg masses/egg-laying recorded (plant considered as 'associated plant' – see general uncertainties in section 7)
N or A = nymphs or adults recorded (plant considered as 'host' – see general uncertainties in section 7)
F = feeding recorded (plant considered as 'host'). Note: the host list in Park et al. (2009) assesses the number of individuals on various plant species, and this was not taken below as an evidence of feeding.
If all these fields are blank, this information was not available in the publications mentioned (plant considered as 'host' – see general uncertainties in section 7).

Notes

- Regarding presence in the PRA area, where 'ornamental' is indicated without a reference, availability was checked in the PPP-Index (http://www.ppp-index.de/).
- Hosts in Crop.IPM.com (2009) and Wang et al. (2000) [both in Chinese] were translated. They were included below only if the genus was not already listed, and only if there was no ambiguity in the translation. Other hosts from these publications are listed as uncertainties below the table. Many details are extracted from other Chinese publications in Chinese; the references are not available to the EPPO Secretariat.
- 'herbaceous' is indicated in the comments column for relevant hosts.
- PennState Extension (2015) is a literature review and does not relate only to Pennsylvania.
- The table was also cross-checked with compilations prepared by Lawrence Barringer (Pennsylvania Dept of Agriculture).

Name	Presence in PRA area (Yes/No)	E	N or A	F	Comments
Acacia	Yes, wild, ornamental (EPPO, 2013a)				Southern China (Li et al., 1997)
Acer buergerianum	Yes, ornamental				China (Chou, 1946; Xiao, 1992)
Acer mono	Yes, wild (Far-East) (EPPO, 2000), ornamental				China (Chou, 1946; Xiao, 1992)
Acer palmatum	Yes, forestry (forestry.gov.uk), ornamental, bonsai	X	X	X	Korea (egg laying) (Kim et al., 2011a), Japan (general search), confirmed feeding and egg-laying (PennState Extension, 2015), USA (captures on sticky bands) (G. Setliff, pers. comm.)
Acer platanoides	Yes, wild, ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Acer rubrum	Yes, ornamental	X	X		USA ('resting/aggregating', egg laying) (Barringer et al., 2015), USA (captures on sticky bands) (G. Setliff, pers. comm.)
Acer saccharum	Yes, ornamental		X	X	USA (feeding) (Barringer et al., 2015); Korea (as *Acer saccharinum*) (Kim et al, 2011a), USA (captures on sticky bands) (G. Setliff, pers. comm.)
Actinidia chinensis	Yes, fruit (esp. as *A. deliciosa*, previously var. of *A. chinensis*)		X	X	Korea (nymph) (Park et al., 2009); China (feeding, adults and nymphs; Du et al., 2010, Pei and Wang, 2001; Zhang et al., 1994; Zhang, 2013; Dai, 2012; Wu, 2012; Zhao et al., 2001;Cai and Wu, 2013; Feng, 2003; Hong and Li, 1994; Yuan et al., 1988; Li, 2006; Mi et al., 2007; Feng, 2000; Yuan et al., 1997; Du *et al.,* 2011).
Ailanthus altissima	Yes, ornamental, plantations; considered invasive in some countries (EEA, 2006; EPPO List of IAP)	X	X	X	Korea (adult, nymph: Park et al., 2009; egg laying: Kim et al., 2011a), Japan (Tomisawa et al., 2013); USA (Barringer *et al.,* 2015); China (Chou, 1946; Ni et al. 2004; Liu, 2011, Zheng, 2015, Li, 1578; Lieu, 1934; Chou et al., 1985; Wang *et al.*, 2015; Bai, 2004; Chen, 2011; Pei and Wang, 2001; Cai and Wu, 2013; Dong, 1983; Yuan *et al.*, 1997; Du *et al.*, 2011; Wang *et al*. 2000; Liu, 1939; Li *et al.*, 2013).
Albizia julibrissin	Yes, ornamental				China (Chou, 1946; Chou et al., 1985)
Alcea (*Althaea*) *rosea*	Yes, ornamental		X		**Herbaceous**. China (Lieu, 1934 – habitat, nymphs)
Alnus hirsuta	Yes, wild (Far-East, Siberia) (EPPO, 2000), ornamental		X		Korea (nymph) (Park et al., 2009).
Amelanchier canadensis	ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Angelica dahurica	Wild (Far-East and Siberia)		X		**Herbaceous** (probably nymphs only). Korea (nymph)

Name	Presence in PRA area (Yes/No)	E	N or A	F	Comments
					(Park et al., 2009)
Aralia cordata	Yes, ornamental		X		**Herbaceous** (probably nymphs only). Korea (nymph) (Park et al., 2009)
Aralia elata	Yes, ornamental		X		**Herbaceous** (probably nymphs only). Korea (nymph) (Park et al., 2009)
Arctium lappa	Wild		X		**Herbaceous** (probably nymphs only). Korea (nymph) (Park et al., 2009)
Betula lenta	Ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Betula papyrifera	Ornamental, plantations?		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Betula platyphylla	Yes, wild (Siberia, Far East) (EPPO, 2000)	X	X	X	Korea (adult, nymph) (Park et al., 2009). confirmed feeding, egg-laying (PennState Extension, 2015)
Betula platyphylla var. japonica	Yes, wild (Far-East) (EPPO, 2000)	X			Korea (egg laying) (Kim et al., 2011a)
Broussonetia papyrifera	Yes, ornamental (EPPO, 2013b)				China (CropIPM.com, 2009 as构树)
Buxus microphylla	Yes, ornamental, incl bonsai				China (Chou, 1946; Chou et al., 1985)
Callistephus chinensis	Yes, ornamental		X		**Herbaceous** (probably nymphs only). China (Crop IPM, 2009 as 翠菊)
Camellia sinensis	Yes, cultivated for leaves (tea) (EPPO, 2013b), ornamental		X		China (probably nymphs or adults, Mei et al., 2011)
Cannabis sativa	Yes for fiber (Struik et al., 2000)		X		**Herbaceous** (probably nymphs only). China (Chou, 1946; Chou et al., 1985)
Carya glabra	ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Carya ovata	ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Castanea crenata	Fruit, wood, rootstock, ornamental (EPPO, 2013a); wild (SE Russia, S Ukraine, W Transcaucasus (EPPO, 2000)	X			University of Delaware, 2015 (in a general list of hosts). Egg-laying (PennState Extension, 2015)
Catalpa bungei	Yes, ornamental				China (Chou, 1946; Chou et al., 1985)
Cedrela fissilis	Yes, ornamental		X		Korea (adult, nymph) (Park et al., 2009)
Celastrus orbiculatus	Yes, ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Colutea arborescens	Yes, ornamental				China (Chou, 1946)
Cornus	Yes, wild, ornamental (EEA, 2006)		X		USA ('resting/aggregating') (Barringer et al., 2015)
Cornus controversa	Yes, ornamental		X	X	University of Delaware, 2015 (in a general list of hosts). Confirmed feeding (PennState Extension, 2015)
Cornus kousa	Yes, ornamental (EPPO, 2013b)		X	X	University of Delaware, 2015 (in a general list of hosts); confirmed feeding (PennState Extension, 2015)
Cornus officinalis	Yes, ornamental		X	X	University of Delaware, 2015 (in a general list of hosts); confirmed feeding (PennState Extension, 2015)
Diospyros kaki	Yes, fruit	X			China (egg-laying; Zu, 1992)
Elaeagnus umbellata	Yes, ornamental		X	X	University of Delaware, 2015 (in a general list of hosts). confirmed feeding (PennState Extension, 2015)
Epilobium angustifolium	Yes, wild		X		**Herbaceous** (probably nymphs only). China (Crop IPM, 2009, as 柳)
Evodia (=*Tetradium*) *danielii*	Yes, ornamental	X	X	X	Korea (adult, nymph) (Park et al., 2009) Korea (egg laying, adult feeding) (Kim et al., 2011a)
Fagus grandifolia	Yes, ornamental	X			USA (egg-laying) (Barringer et al., 2015)
Ficus carica	Yes, fruit, ornamental				China (Cai and Wu, 2013)
Firmiana simplex	Yes, ornamental		X		Korea (nymph) (Park et al., 2009); China (Chou, 1946; Chou et al., 1985)
Fraxinus	Yes, wild, forestry, ornamental	X			Korea Rep. (eggs, M. Park, pers. comm.)
Fraxinus americana	Yes, ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)

Name	Presence in PRA area (Yes/No)	E	N or A	F	Comments
Glycine max	Yes, cultivated		X		**Herbaceous** (probably nymphs only) China (as大豆, Wang et al., 2000; Chou et al., 1985)
Hibiscus	Yes, ornamental				CropIPM.com, 2009
Juglans	Yes, fruit, forestry, ornamental				China (CropIPM.com, 2009 as 核桃)
Juglans hindsii	Not known		X	X	China (Zhang, 2001 – adult and nymph feeding)
Juglans major	Not known		X	X	China (Zhang, 2001 – adult and nymph feeding)
Juglans mandshurica	Yes, wild (Far East, EPPO, 2000), ornamental		X		Korea (nymph, adult) (Park et al., 2009)
Juglans microcarpa	Not known		X	X	China (Zhang, 2001 – adult and nymph feeding)
Juglans nigra	Yes, wild (naturalized), forestry, ornamental		X	X	China (Zhang, 2001 – adult and nymph feeding); Korea (nymph) (Park et al., 2009), USA (captures on sticky bands) (G. Setliff, pers. comm.)
Juglans sinensis (syn. of *Juglans regia* var. *orientis)*	Not known. (*J. regia* is present - fruit, forestry, wild)		X		Korea (nymph) (Park et al., 2009)
Juniperus (*Sabina*) *chinensis*	Yes, ornamental		X	X	China (Li et al., 2013)
Ligustrum lucidum	Yes, ornamental				China (Chou, 1946; Chou et al., 1985)
Liriodendron tulipifera	Yes (ornamental, EPPO, 2013a)	X	X		USA (egg-laying) (Barringer et al., 2015), USA (captures on sticky bands) (G. Setliff, pers. comm.)
Maackia amurensis	Yes, ornamental		X		Korea (nymph) (Park et al., 2009)
Magnolia kobus	Yes, ornamental		X		Korea (nymph) (Park et al., 2009)
Magnolia obovata	Yes, ornamental		X		Korea (nymph) (Park et al., 2009)
Mallotus japonicus	Yes, ornamental		X	X	Japan [not considered as hosts but 'adults depend upon'] (adult feeding ; Tomisawa et al., 2013)
Malus	Yes, fruit, ornamental		X	X	China (adults? Han et al., 2008 citing others; Biosecurity Australia, 2009; Zheng et al., 2009, Wang, 2008)
Malus pumila	Yes, fruit, ornamental	X	X	X	Korea Rep. (eggs, M. Park, pers. comm.); China (Zheng et al., 2009 – nymph and adult feeding); PennState Extension, 2015 (in a list of hosts, no details on life stages)
Malus spectabilis	Yes, ornamental				China (Chou, 1946, Chou et al., 1985)
Melia azeradach	Yes, ornamental (EPPO, 2013b)		X	X	China (Chou, 1946 ; Chou et al., 1985; Yang et al., 2014 (feeding) [through pers. comm.]); Japan (nymphs, adults; Tomisawa et al., 2013)
Metaplexis japonica	Yes, wild? (Far-East), ornamental		X		Korea (nymph) (Park et al., 2009)
Morus alba	Yes, ornamental, fruit, feed (EPPO, 2013b)		X		Korea (nymph) (Park et al., 2009)
Morus bombycis	Yes, ornamental, fruit, feed (EPPO, 2013b)		X		Korea (nymph) (Park et al., 2009)
Nicotiana	Yes				China (as tobacco, Yuan et al., 1997)
Nyssa sylvatica	Yes, ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Osmanthus	Yes, ornamental				China (CropIPM.com, 2009)
Parthenocissus quinquefolia	Yes, ornamental		X	X	Korea (adult, nymph) (Park et al., 2009), China (T. Bourgoin, pers. comm.)
Paulownia kawakamii	Ornamental?				China (Xiao, 1992)
Paulownia shensiensis (=*P. tomentosa* var. *tsinlingensis*)	Not known				China (Chou, 1946; Chou et al., 1985)
Phellodendron amurense	Yes, ornamental	X	X	X	Korea (adult, nymphs) (Park et al, 2009; Kim et al, 2011a); USA (feeding) (Barringer et al., 2015); China (Wang, 2005, Chen, 1996)
Philadelphus schrenckii	Yes, ornamental		X		Korea (nymph) (Park et al., 2009)
Phyllostachys heterocycla	Yes, ornamental				China (Zhao, 2006)
Picrasma quassioides	Yes, ornamental		X		Korea (adults, nymphs) (Park et al., 2009)
Platanus occidentalis	Yes, ornamental	X	X		USA (egg-laying) (Barringer et al., 2015), (as 'sycamore', adult feeding and egg-laying; USDA, 2014a), USA (captures on sticky bands) (G. Setliff,

Name	Presence in PRA area (Yes/No)	E	N or A	F	Comments
					pers. comm.)
Platanus orientalis	Yes, ornamental (EPPO, 2013a), plantations		X		Korea (adults) (Han et al., 2008); China (Chou, 1946; Chou et al., 1985)
Platycarya strobilacea	Yes, ornamental				China (Chou et al., 1985)
Platycladus orientalis	Yes, ornamental		X	X	China (Li et al., 2013)
Populus alba	(native) Yes, forestry, wild (EPPO, 2013a, EEA, 2006), ornamental	X			Korea (egg laying) (Kim et al., 2011a)
Populus grandidentata	Not known		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Populus koreana	Yes, wild (Far East), (EPPO, 2000), ornamental		X		Korea (adult) (Park et al., 2009)
Populus simonii	Yes, wild (Kazakhstan), (EPPO, 2000), ornamental				China (Chou, 1946)
Populus tomentiglandulosa	Not known		X		Korea (adults) (Han et al., 2008)
Populus tomentosa	Not known				China (Wang et al., 2015)
Prunus armeniaca	Yes, for fruit	X	X	X	China (Chou, 1946; Zhai et al, 2014 as apricots, major damage; Chou et al., 1985, also eggs)
Prunus cerasus (Cerasus)	Yes, for fruit				China (Chou et al., 1985)
Prunus mume	Yes, ornamental, incl. bonsai (le-prunus-mume.over-blog.com)		X	X	China (Han et al., 2008 citing others; adults?). Confirmed feeding (PennState Extension, 2015)
Prunus persica	Yes, fruit		X	X	China (Chou, 1946 Han et al., 2008 citing others; adults?; Chou et al., 1985). Confirmed feeding (PennState Extension, 2015)
Prunus salicina	Yes, fruit		X	X	China (Han et al., 2008 citing others, adults?; Chou, 1946; Chou et al., 2015). Confirmed feeding (PennState Extension, 2015)
Prunus serotina	Yes, plantations (EEA, 2006). Considered invasive in some countries (EPPO List of IAP)	X	X		USA ('resting/aggregating', egg laying) (Barringer et al., 2015), USA (captures on sticky bands) (G. Setliff, pers. comm.)
Prunus serrulata var. spontanea	Yes, ornamental	X			Korea (egg laying) (Kim et al., 2011a)
Prunus x *yedoensis*	Not known	X			China (Chou, 1946; Chou et al., 1985); Korea (egg laying) (Kim et al., 2011a)
Pterocarya stenoptera	Yes, ornamental (EPPO, 2013b)		X		Korea (nymph) (Park et al., 2009), China (Chou, 1946)
Punica granatum	Yes, fruit, ornamental (EPPO, 2013b)	X	X	X	China (Hou, 2013 as pomegranate, major damage = adults?; Ma et al., 2010, nymphs, adults, eggs, feeding)
Pyrus	Yes, fruit, ornamental	X	X	X	China (Yang et al., 2015b)
Quercus	Yes, forest, ornamental, wild (EPPO, 2013b)				China (Chou, 1946; Chou et al., 1985)
Quercus acutissima	Yes ornamental	X			Japan (egg laying) (Tomisawa et al., 2013)
Quercus aliena	Yes, ornamental		X		Korea (nymph) (Park et al., 2009)
Quercus montana (syn. *Q. prinus*)	Yes, ornamental	X	X		USA (egg-laying) (Barringer et al., 2015) USA (captures on sticky bands) (G. Setliff, pers. comm.)
Quercus rubra	Yes, ornamental, plantations		X		USA (captures on sticky bands + nymphs feeding) (G. Setliff, pers. comm.)
Rhus javanica	Not known		X		Korea (nymph) (Park et al., 2009)
Rhus typhina	Yes, ornamental				China (Wang et al., 2015)
Rhus (*Toxicodendron*) *verniciflua*	Yes, ornamental		X		Korea (nymph) (Park et al., 2009)
Robinia pseudoacacia	Yes, ornamental, forest, plantations (widely naturalized and invasive in some countries) (EPPO, 2013a, EEA, 2006)	X	X	X	China (Chou, 1946; Chou et al., 1985) Wang et al. 2000 (as 洋槐) ; Japan (egg laying) (Tomisawa et al., 2013). Confirmed feeding (PennState Extension, 2015; Yang et al., 2014 [through pers. comm.]).
Rosa hybrida	Yes, ornamentals, incl. flower crops		X		Korea (nymph) (Park et al., 2009)
Rosa multiflora	Yes, ornamental, also considered as invasive in some		X		Korea (nymph) (Park et al., 2009)

Name	Presence in PRA area (Yes/No)	E	N or A	F	Comments
	countries?				
Rosa rugosa	Yes, ornamental, also considered as invasive in some countries		X		Korea (nymph) (Park et al., 2009)
Rubus crataegifolius	Yes, wild (Far-East) (www.agroatlas.ru), fruit, ornamental, honey plant		X		Korea (nymph) (Park et al., 2009)
Salix	Wild, ornamental, forest (EPPO, 2013a)	X	X	X	USA (feeding) (Barringer et al., 2015), (feeding and egg-laying) (USDA, 2014a), USA (captures on sticky bands) (G. Setliff, pers. comm.)
Salix babylonica	Yes, ornamental, wild		X		China (Lieu, 1934)
Salix matsudana	Yes, ornamental (EPPO, 2013a)		X	X	China (Lieu, 1934); USA (feeding) (Barringer et al., 2015). Confirmed feeding (adult) (PennState Extension, 2015)
Salix udensis	Yes, wild (Far East) (EPPO, 2000)		X	X	USA (feeding) (Barringer et al., 2015). Confirmed feeding (adult) (PennState Extension, 2015)
Sassafras albidum	Yes, ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Sophora japonica	Yes, ornamental (EPPO, 2013a)	X			China (eggs, low hatching rate; Chou, 1946; CropIPM.com, 2009 as国槐)
Sorbaria sorbifolia	Yes, wild (Far-East – Wikipedia), ornamental		X		Korea (nymph) (Park et al., 2009); China (Chou, 1946; Chou et al., 1985)
Sorbus commixta	Yes, wild (Far-East – Wikipedia), ornamental		X		Korea (nymph) (Park et al., 2009)
Styrax japonicum	Yes, ornamental	X	X	X	Korea (nymph, adult) (Park et al., 2009); Japan [not considered as hosts but 'adults depend upon'] (egg laying and adult feeding) (Tomisawa et al., 2013); USA (feeding) (Barringer et al., 2015). Confirmed feeding (adult, nymph; PennState Extension, 2015)
Styrax obassia	Yes, ornamental		X	X	Korea (nymph) (Park et al., 2009). Confirmed feeding (adult, nymph; PennState Extension, 2015)
Syringa vulgaris	Yes, ornamental (EPPO, 2013a)	X			Korea (egg laying) (Kim et al., 2011a)
Tamarix chinensis	Yes, ornamental				China (Wang et al., 2015)
Tilia americana	Yes, ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Toona (*Cedrela*) *sinensis*	Yes, ornamental	X	X	X	Korea (adult, nymph) (Park et al., 2009); China (Chou et al., 1985; Li et al., 1997; Chou, 1946). Confirmed feeding, egg-laying (PennState Extension, 2015)
Ulmus pumila	Yes, wild (Far East, Siberia) (EPPO, 2000), ornamental				China (Chou, 1946; Chou et al., 1985)
Ulmus rubra	Yes, ornamental		X		USA (captures on sticky bands) (G. Setliff, pers. comm.)
Vitis amurensis	Yes, fruit, ornamental, wild, breeding (PPP-Index, 2015, http://www.mustila.fi/en/plants/vitis/amurensis; Bojnanský and Fargašová, 2007)		X		Korea (adult, nymph) (Park et al., 2009); China (Liu et al., 2015)
Vitis sp.	Yes, wild, fruit, ornamental, breeding, rootstock (Bojnanský and Fargašová, 2007)		X	X	USA (wild *Vitis, feeding*) (Barringer et al., 2015); China (as葡萄, Wang et al., 2000; CropIPM.com, 2009, Qi et al., 2007), USA (captures on sticky bands) (G. Setliff, pers. comm.)
Vitis vinifera	Yes, fruit, ornamental	X	X	X	Korea (eggs, adult, nymph) (Park et al., 2009; M. Park, pers. comm.). Confirmed feeding, egg-laying (PennState Extension, 2015); China (eggs, nymphs, adults, feeding; Chou, 1946; He et al., 2007 ; Feng, 2012; Yang et al., 2015b; Shi, 2007; Qiu et al., 1991; Feng, 2012; Lieu, 1934; Chou et al., 1985; Wang et al., 2006; Zhu et al., 1997; Zhang et al., 2002; Yang et al., 2015; Wang et al., 2011; Qi et al., 2007; Chen &Wang, 2010; Xue and Jiao, 2002; Xue, 2004; Zhao, 2006; Zhang and Cheng, 2000; Qiu et al., 1994; Ge, 2008; Li et al., 2009).

Name	Presence in PRA area (Yes/No)	E	N or A	F	Comments
Zanthoxylum bungeanum	Not known	X	X	X	China (Gao, 1993)
Zelkova serrata	Yes, ornamental, bonsai (EPPO, 2013a)	X			Korea (egg laying) (Kim et al., 2011a)

Uncertainties on hosts:

- The following hosts from Crop.IPM.com (2009 – in Chinese) are uncertain: Begonia, Prunus davidiana, Bambusoidae, Photinia.
- *Pinus densiflora*, *Hibiscus syriacus*, *Pyrus calleryana* were used in experiments on the survival of nymphs and adults on plant parts (Lee et al., 2009). These species were not favourable to *L. delicatula* and were not added to the host list above (although repeated in general lists of host, e.g. University of Delaware, 2015)
- *Pinus strobus* is mentioned in University of Delaware (2015) without indication of the life stage. In Kim et al. (2011b), *P. strobus* and *P. densiflora* were surveyed for the presence of eggs and nymphs (among 13 species); eggs were not found, and nymphs were found on 12 of the 13 species studied (without indication of which). For reasons explained in section 7, *Pinus strobus* and *P. densiflora* were not listed in the host list above.

ANNEX 3. Definitions used in the EPPO Study on wood commodities (EPPO, 2015b)

Table 1 - including existing definitions from ISPM 5 *Glossary of Phytosanitary Terms* for wood commodities and definitions developed as part of the Study

Commodity	Definition	Origin of definition
Bark (as a commodity)	Bark separated from wood	Glossary (ISPM 5)
Firewood except sawn wood, processing wood residues, wood chips, hogwood, processed wood material and post-consumer scrap wood	See 'round wood' definition	
Harvesting residues	Wood material consisting of any parts of trees left on the site after round wood harvesting	Proposed under the Study
Hogwood	Wood with or without bark in the form of pieces of varying particle size and shape, produced by crushing with blunt tools such as rollers, hammers, or flails	Proposed under the Study
Manufactured wood items	To be added when defined under the ISPM (under development) on 'International movement of wood products and handicrafts made of wood'	
Post-consumer scrap wood	Wide variety of wood material from ex-commercial, industrial and domestic use made available for recycling	Proposed under the Study
Processed wood material	Products that are a composite of wood constructed using glue, heat and pressure, or any combination thereof	Glossary (ISPM 5)
Processing wood residues	Parts of wood and bark that are left after the process of transforming round wood into sawn wood and further transformation of sawn wood	Proposed under the Study
Round wood	Wood not sawn longitudinally, carrying its natural rounded surface, with or without bark	Glossary (ISPM 5)
Sawn wood	Wood sawn longitudinally, with or without its natural rounded surface with or without bark	Glossary (ISPM 5)
Wood chips	Wood with or without bark in the form of pieces with a definable particle size produced by mechanical treatment with sharp tools	Proposed under the Study

ANNEX 4. Consideration of pest risk management options

The table below summarizes the consideration of possible measures for the pathways plants for planting, round wood and sawn wood, and wood pieces and bark (based on EPPO Standard PP 5/3)

Option	Woody plants for planting	Round wood and sawn wood	Wood pieces and bark	General considerations
Existing measures in EPPO countries	No	No	No	The measures in place are not sufficient to prevent the risk of entry of the pest at the scale of the whole EPPO region.
Options at the place of production				
Visual inspection at place of production	Not alone. Trapping may help detect the pest, but would not be sufficient for low populations. Insufficient for eggs.	Timber yard/sawmills, or forest. Not relevant for forest. Not alone for sawmills. Inspection at sawmills may be possible but would not be sufficient on its own. Detection of eggs is difficult	Timber yard/sawmills, or forest. Not relevant for forest. Not alone for sawmills. Inspection at sawmills may be possible but would not be sufficient on its own. Detection of eggs is difficult	Eggs are difficult to see. There are non-specific trapping methods for nymphs/adults (brown sticky traps).
Testing at place of production	No	No	No	Not relevant.
Treatment of crop	Not alone Not reliable to guarantee pest freedom. It may be used in combination with others in a systems approach.	Not relevant for forest trees	Not relevant for forest trees	Using sticky bands at the base of trees at an appropriate period may allow capturing some individuals, especially nymphs. However, it has been observed in Pennsylvania that adults may be strong enough to leave the sticky bands. In addition, nymphs and adults may jump from plant to plant. Such trapping would not be sufficient Pesticide treatments may be applied but would not be sufficient to eliminate the pest.
Resistant cultivars	No	No	No	Not relevant.
Growing the crop in glasshouses/ screenhouses	Yes 'complete physical isolation' can be used (see EPPO Standard [in preparation]). Regular inspections should be carried out.	Not relevant for forest trees	Not relevant for forest trees	

Option	Woody plants for planting	Round wood and sawn wood	Wood pieces and bark	General considerations
Specified age of plant, growth stage or time of year of harvest	Yes. Eggs are not laid on material <1 cm diameter	No The risk relates to egg masses. Harvesting and exporting wood between emergence and egg-laying would ensure absence of egg masses. However, determining the precise period would be difficult. There is also an uncertainty on whether eggs may stay in diapause for more than 1 year if conditions are not appropriate (however there is no evidence of this to date).	No The risk relates to egg masses. Harvesting and exporting wood between emergence and egg-laying would ensure absence of egg masses. However, determining the precise period would be difficult.	
Produced in a certification scheme	No	No	No	Not relevant for an insect.
Pest free production site	Yes (growing under complete physical isolation) Yes Pest free production site outdoors (in areas of low populations, in a system approach involving trapping, control measures and inspections, and control on the movement of people, material and conveyances). The pest-free production site should be surrounded with a 200-m buffer zone without *A. altissima* (with regular surveillance and inspection).	Not feasible for forest trees (difficult to maintain in forest environment)	Not feasible for forest trees (difficult to maintain in forest environment)	If the pest is present in high populations in the vicinity, a pest free production site probably could not be maintained outdoors, as nymphs or adults could move to the site when falling from a host and searching for another.

Option	Woody plants for planting	Round wood and sawn wood	Wood pieces and bark	General considerations
Pest free area	Yes	Yes	Yes	PFA as described in ISPM 4. A PFA will require the use of traps. Specialized identification capacities should be available, but nymphs and adults are quite characteristic. The pest has a limited natural spread, but may progress locally by human-assisted movement on various materials. There should be control on movement of all host fruit and plants, other hosts, equipment and packaging, etc. as well as relevant man-made items in and out of the area. Egg masses may be transported on a wide variety of such items (see e.g. list in section 16.2), and such controls may be difficult to implement in practice. Consequently maintaining PFAs may not be feasible in some circumstances. Regarding natural spread, the EWG considered (based on the flight distance of an adult, on expert observations and knowledge, and on comparison with *Anoplophora glabripennis*) (see *Pest overview*) that a distance of 200 m from an infested area would be appropriate for 95% of the population.
Options after harvest, at pre-clearance or during transport				
Visual inspection of consignment	Not alone	Not alone	Not alone	Nymphs and adults are easy to see but eggs are difficult to detect
Testing of commodity	No	No	No	Not relevant.
Treatment of the consignment	No. It may be possible (e.g. dipping or systemic insecticides) but no data is currently available	Not alone (avoid reinfestation). Treatment would need to be effective on eggs. **Heat treatment.** Yes, would kill the eggs (as well as any other life stage). No specific treatment study was found, and there is no information on the maximum temperature for	For chips and bark: not alone (avoid reinfestation). Other 'wood pieces' are probably low value, and treatments may not be cost-effective). **Heat treatment.** The same schedule as for wood should	<u>Measures not retained for any commodity:</u> **Pesticides** Eggs are covered and would not be reached by insecticides. **Cold treatment** to eliminate eggs would require a temperature of at least -25 C. It is not feasible for plants for planting and cut branches, and it is not known if it can be used as a phytosanitary measure for wood.

Option	Woody plants for planting	Round wood and sawn wood	Wood pieces and bark	General considerations
		survival of eggs. For *L. dispar* egg masses on logs, USDA (2014b) requires 56°C for 30 min. **Irradiation**. Ionizing radiation may be used (EPPO Standard PM 10/8).	work, but it should be applied to the core of the material/bulk. **Processing/cutting to a specified size** (below 2.5 cm x 2.5 in two dimensions). Experiments in the USA have shown no emergence from eggs on wood chips cut down to that size.	**Fumigation**. - *sulfuryl fluoride*: difficulty in penetrating insect eggs (USDA, 2014b) - *methyl bromide*: phase-out in 2015 For wood: **Chemical pressure impregnation.** Normally used against diseases. **Kiln-drying alone** (to reduce the moisture content of the wood to e.g. 20%). This would not be sufficient to kill the eggs, unless a sufficient temperature is attained (and then it becomes a heat treatment). **Submergence treatment.** No information found. **Dielectric heating** (EPPO, 2015b, for harvesting residues). No specific data found. **Vapour heat treatment.** No information found. Note: this is being investigated in the USA against thousand cankers disease. **Solarization.** In experiments on solarisation of *Juglans*, inner bark temperature reached 50-60°C at the top of the logs, 30-40°C at the bottom (EPPO, 2015c). This may be sufficient to kill the eggs and emerging nymphs (with a sufficient exposure time). It is not known if this could be used as a phytosanitary measure. **Insecticide impregnated nets** (EPPO, 2015d). These have been experimented against other insects, and would kill nymphs and adults. However, there is no specific data, and it is not known if it could be used as a phytosanitary measure (plus conditions and duration of treatment are not known). **For chips: Produced from treated wood.** It is not known if this is common practice and it is

Option	Woody plants for planting	Round wood and sawn wood	Wood pieces and bark	General considerations
				not included in the table of section 16. **Processing** is covered in the next row.
Pest only on certain parts of plant/plant product, which can be removed	No Eggs may be present on the bark	Not alone (avoid reinfestation) **Squaring to entirely remove the wood surface**. Would remove all bark, i.e. all eggs.	No Wood chips could be producedfrom debarked wood, thereby ensuring that eggs are removed first by debarking and then by processing into wood chips. However, it is not known if this is a common practice.	**For wood, debarking** and **processing into sawn wood** would not remove all bark, and would not be sufficient to remove all eggs.
Prevention of infestation by packing/handling method	For relevant measures, suitable packing/handling methods should be used to prevent egg-laying. Packaging should be free from the pest	Not alone.For relevant measures, suitable packing/handling methods should be used to prevent egg-laying during transport and storage (in conditions preventing egg-laying (e.g. net, warehouse). **Isolation/storage.** According to current knowledge, the pest has one generation per year. The possibility that wood may be stored for a sufficient period in appropriate conditions, so that all eggs hatch and adults die out, was considered. However this was eventually not considered an appropriate option. There is an uncertainty on whether eggs can diapause for more than one year (although there is currently no evidence of this) and the duration of such isolation would be difficult to determine.	No. It is unlikely that adults lay eggs on such commodities, and prevention of egg-laying is not necessary. **Isolation/storage** As for wood	Commodities may already be infested. When other measures have been applied suitable packing/handling methods should be used to prevent egg-laying. Commodities should be be stored and transported in conditions preventing infestation (through PFAs, or outside of the pest flying period, or enclosed).
Options that can be implemented after entry of consignments				

Option	Woody plants for planting	Round wood and sawn wood	Wood pieces and bark	General considerations
Post-entry quarantine	Yes Possible in theory for plants (but may not be practical/cost-effective).	Not relevant	Not relevant	
Limited distribution of consignments in time and/or space or limited use	No. Difficult to implement in practice	No	No. Difficult to implement in practice	Consignments may be imported where the pest cannot survive outdoors. However, it occurs in a wide range of climates, and there is limited knowledge on the conditions under which it may not survive outdoors.
Surveillance and eradication in the importing country	Difficult to implement in practice	No. Too difficult in forests	No. Too difficult in forests	In the part of the EPPO region where the pest cannot establish outdoors (not precisely defined), infested consignments could in theory be imported. This would require a good surveillance system (although this will be challenging as there is no species-specific traps). Eradication is considered possible in limited conditions.