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ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

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Pest Risk Analysis for

Agrilus planipennis

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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).
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Pest Risk Analysis for *Agrilus planipennis*

This PRA follows EPPO Standard PM 5/5 *Decision-Support Scheme for an Express Pest Risk Analysis*

Prepared by: Expert Working Group (EWG) on *Agrilus planipennis*
Date: 28-31 January 2013

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This PRA was reviewed by the EPPO Panel on Phytosanitary Measures on 2013-03-05/07

Summary of the Express Pest Risk Analysis for *Agrilus planipennis*			
PRA area: EPPO region			
Describe the endangered area: *Fraxinus* spp. are present throughout the EPPO region, including Russia, the southernmost part of Finland, Norway, and Sweden, although *Fraxinus* is more widespread (and with a larger number of species) in the north, central and eastern parts of the EPPO region. Impact is likely to occur throughout the natural and planted range of ash in the EPPO region.			
Main conclusions *Overall assessment of risk:* The likelihood of entry is considered as moderate, and the likelihood of establishment as high. Where it is introduced, the pest is likely to cause major losses and environmental impact, and some social effects. Long-distance spread will be via human-assisted pathways, although natural spread will happen but at a slower pace. Where *A. planipennis* is introduced, it will have massive impact, and eradication or containment will be difficult and costly, and very unlikely to be successful. *Phytosanitary Measures:* the pest should be recommended for immediate action in the PRA area. Measures were identified for the following pathways: wood, wood waste, wood chips, plants for planting, bark, furniture and cut branches.			
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: • ***Surveys are recommended to confirm the pest status*** • ***The EWG recommends research several following topics (see Q. 18)***			

Content

Stage 1. Initiation

Reason for performing the PRA:
Agrilus planipennis Fairmaire, 1888 (Coleoptera: Buprestidae) originates from Far-East Asia and is primarily a pest of *Fraxinus* (ash). It was detected in North America (USA and Canada) in 2002 and in the European part of Russia (Moscow region) in 2005. It is a serious pest of *Fraxinus* where it has been introduced outside its native range. It has caused extensive ash mortality in North America and in the Moscow area and is spreading in all introduced areas.

A. planipennis was added to EPPO A1 List of pests recommended for regulation in 2004, based on a PRA performed during the EPPO Panel on Quarantine Pests for Forestry in 2003. The short PRA report was finalized in 2004 (EPPO, 2004) to support this recommendation. *A. planipennis* was transferred to the A2 list in 2009, after its introduction and establishment in European Russia. When considering the measures recommended for *Agrilus anxius*, which has a similar biology and for which an EPPO PRA was performed in 2011 (EPPO, 2011), the Panel on Phytosanitary Measures noted that some measures were not consistent with those required against *A. planipennis*. The EPPO Working Party on Phytosanitary Regulation agreed in June 2012 that import measures for *A. planipennis* should be reviewed. At its meeting in October 2012, the Panel on Phytosanitary Measures decided that a more complete PRA should be prepared, especially to reconsider pest risk management in view of recent advances in *A. planipennis* research, and to obtain more information on spread, host plants, and the situation in Russia. The Secretariat decided to prepare this PRA according to the EPPO Standard PM 5/5 *Express Pest Risk Analysis*, to focus on available new information, and in particular to consider the current situation facing EPPO members, elements presenting a higher uncertainty and pest risk management.

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

Stage 2. Pest risk assessment

1. Taxonomy

Taxonomic classification. Domain: Eukaryota; Kingdom: Metazoa; Phylum: Arthropoda; Class: Insecta; Order: Coleoptera; Family: Buprestidae; Genus: *Agrilus*; Species: *planipennis* Fairmaire, 1888.

Synonyms. Jendek (1994) synonymized *Agrilus feretrius* Obenberger, 1936 (type Taiwan), *Agrilus marcopoli* Obenberger, 1930 (type China) and *Agrilus marcopoli ulmi* Kurosawa, 1956 (type Japan) with *A. planipennis* (type China) based on adult morphology.

It is important to note that the host range of *A. planipennis* (and its former synonyms) varies from country to country. In North America and European Russia where it has been introduced, *A. planipennis* has only been reported to complete its life cycle on *Fraxinus* spp. Similarly, in China it has only been reported on *Fraxinus* (Yu, 1992; Liu *et al.*, 2003) However, in Korea, *Ulmus davidiana* var. *japonica* is the only host listed by Ko (1969), while in Japan the reported hosts include *Fraxinus mandshurica* var. *japonica, Juglans mandshurica, Pterocarya rhoifolia* and *Ulmus davidiana* (Haack *et al*., 2002 citing others). The EWG did not find any host records for *Agrilus planipennis* (or *A. feretrius*) in Taiwan. One possible explanation for *Juglans, Pterocarya* and *Ulmus* species being reported as hosts of *A. planipennis* in Japan may be that the Japanese population represents a distinct sub-species (the former *A. marcopoli ulmi*), or that these host records represent collections of adults on non-host plants (Lyons and Scarr, 2010). Finally, recent genetic analyses of some Asian and North American *A. planipennis* populations by Bray *et al.* (2011; see under section 6) showed higher similarity among Chinese, Korean, and North American populations, compared with Japanese populations. Similarly, genetic analysis of North American, Chinese, Far-East Russian and Moscow populations of *A. planipennis*, all of which are found on *Fraxinus* spp., showed high similarity (Y. Baranchikov, unpublished).

Common names. emerald ash borer (EAB); agrile du frêne (French).

2. Pest overview

2.1 Biology of the pest

The life cycle and biology of the pest are detailed in an EPPO data sheet (EPPO, 2005). An illustration of the location of the different life stages is given in Appendix 1 (extracted from Robertson and Andow, 2009). De Groot *et al.* 2006, Lyons *et al.* (2007) and EABINFO (2012, under "how to identify EAB") provide illustrated guides to the pest, signs and symptoms of infestation, and possible confusion with similar species in North America. The main elements relevant for this PRA are summarized below.

Life stages (Haack *et al.*, 2002; EPPO, 2005 citing others; Petrice & Haack, 2006; Chamorro *et al.* 2012)
Eggs. Eggs are laid individually or in small groups on the bark surface, usually inside bark cracks and crevices (68-90 eggs per female; Haack *et al.*, 2002). The pest normally oviposits on live trees; it has been observed to occasionally oviposit on freshly cut ash logs, although larvae emerging from such eggs rarely complete their development (Petrice & Haack, 2007, citing others; Anulewicz *et al.* 2008).
Larvae. There are four larval instars. First-instar larvae tunnel through the bark to the cambium. Larvae then feed in the inner bark and outer sapwood. They produce galleries (up to 26-32 cm long), which are S- shaped and filled with frass.
Pupae. Pupal cells are located in the outer sapwood or in the outer bark, at the end of the larval gallery. When the bark is thin, pupae are predominantly found in the sapwood. However, when the bark is thick, more pupal cells are located in the outer bark.
Adults. After eclosion, the adults remain under the bark for 1-2 weeks ("callow adults") and then exit through D-shaped holes (3-4 mm wide). Adult emergence usually begins after accumulation of 230-260 degree-days base 10°C (Brown-Rytlewski and Wilson 2005). In the Great Lakes area of North America, adults are most active between May and August. Adults feed on the foliage of their host throughout their lives, starting to feed and fly soon after emergence. Adults are active during the day and rest on foliage at night. When conditions are not favourable for flight, adults rest in bark cracks and on foliage. In laboratory experiments under favourable conditions, female adults lived an average of 63 days (range 28-120) and laid an average of 74 eggs (range 1-307), whereas male adults lived an average of 43 days (range 12-83) (LS Bauer and DL Miller, unpublished).

See EPPO (2005) for details on morphology, which can be summarized as follows:

Stage	Colour/shape	Size
Eggs	light to brownish yellow, oval-shaped	1 x 0.6 mm
Mature larvae	creamy white	26–32 mm long
Pupae	creamy white	10-14 mm long
Adults	metallic blue-green, elongated	8.5-14.0 mm long and 3.1-3.4 mm wide

Life cycle (Haack *et al.*, 2002; EPPO, 2005 citing others; Petrice & Haack, 2006; Wei *et al.*, 2007)
Infestation of large trees normally starts in the canopy. However, infestation progresses down the tree and in the later stages of infestation, the base of the tree and surface roots can be infested. Infestation tends to start at a place where diameter is 5-10 cm (T Scarr, personal communication). In saplings, the trunk is attacked first.
A. planipennis generally has one generation per year, although some individuals may require two years In situations where development lasts one year, adults begin to emerge in late spring or early summer, larvae develop in summer and autumn, the pest overwinters as fourth instar larvae or prepupae, and pupation occurs in spring of the following year. In situations where two years are required to complete one generation, young larvae (first to third instars) overwinter in the cambial area and resume feeding in spring of the following year. These individuals overwinter a second time as fourth instars or prepupae, and then pupate and emerge as adults the next year. The proportion of individuals completing their development in more than one year depends on when the eggs were laid during the summer months, and the local climate and host condition. For example, Siegert *et al.* (2010 citing others) mention that prolonged larval development is more common in healthy trees and when there are low densities of *A. planipennis* infesting a tree.

Temperature thresholds and tolerance levels
Limited data on temperature thresholds and tolerance levels were found (to cold or heat). Given its current distribution in North America and European Russia, and its home range in Asia, it is clear that *A. planipennis* can survive temperatures well below the freezing point in winter. Crosthwaite *et al.* (2011), in laboratory

studies, found that the average lethal temperature was –30°C for prepupae. Venette and Abrahamson (2010), testing larvae collected from infested trees, found an average lethal temperature of –25°C. The EWG noted that the pest has established in the Moscow region where winter temperatures often reach below –30°C. Wang *et al.* (2010) stated that a cold period may not be necessary for the pest to complete its life cycle, although some period of cold does speed emergence. Sobek-Swant *et al.* (2012) suggested that extreme warm spells in mid-winter followed by extreme cold periods could be lethal to overwintering *A. planipennis*, but that this situation may rarely occur in nature.
No data were found on the minimal temperature requirements for adult emergence and flight. Wang *et al.* (2010) noted that adults are active in strong sunlight and at temperatures > 25°C. In laboratory experiments, *A. planipennis* adults commonly flew at room temperatures of 23°C (Taylor *et al.*, 2010).

2.2 Detection

Detection is mentioned here as it is relevant especially in relation to spread (section 11) and phytosanitary measures (section 16).

Signs and symptoms of infestation (Haack *et al.*, 2002; EPPO, 2005; de Groot *et al.* 2006; CFIA, 2012a; USDA-APHIS, 2012a)

- D-shaped exit holes produced by emerging adults
- Larval galleries, which are typical for the genus *Agrilus*.
- Symptoms of infested trees: yellowing then premature browning of the foliage, thinning of crowns, dying of branches, longitudinal bark splits with larval galleries underneath, epicormic branches and shoots often along the lower trunk, dead branches.
- Woodpecker injury is commonly observed in North America and European Russia on infested trees. Woodpeckers remove small patches of bark or create small holes in the bark to extract developing *A. planipennis.* On heavily infested trees, woodpeckers in search of *A. planipennis* can flake off large areas of outer bark, which can accumulate at the base of the tree. This also leaves the trunk with large areas of light brown or whitish bark after the flakes of bark have been removed.
- Dieback and dead trees.

All life stages (except adults) are hidden (eggs in bark cracks; larvae, prepupae and pupae in the bark or sapwood, callow adults in the bark or sapwood), making their detection difficult (e.g. USDA-APHIS, 2012b). Infested trees do not present clear symptoms until they are heavily attacked. Symptoms may not be noticeable for 2-3 or more years after initial attack, particularly if the infestation begins in the upper part of the tree (Ryall *et al.*, 2010). Although D-shaped exit holes produced by emerging adults are present after the first year of infestation, they may be few in number and they are usually initially situated high in the canopy (i.e. not easily visible) on larger trees. First emergence, and therefore the appearance of D-shaped holes, will be delayed if the individuals develop over more than one year. In subsequent years of infestation, symptoms on infested trees as listed above may be more easily observed. Symptoms on trees may also be initially confused with ash decline or symptoms of diseases. At further stages of infestation, D-shaped exit holes and larval galleries may be observed throughout the trunk. Woodpecker injury (bark flaking or holes) may be observed, as they search for and extract larvae. Ultimately, dieback and mortality of infested trees will be observed.

Detection methods

There is no reliable single method to detect low level populations of *A. planipennis*. Monitoring usually relies on several methods, most commonly a combination of trapping, visual inspection of trees, and branch or tree sampling. For example, for surveys in 2013, USDA-APHIS (2012b) recommends the use of traps, associated with visual survey for ash trees exhibiting certain signs and symptoms, and destructive sampling techniques on those trees presenting them (e.g. bark peeling). The draft EPPO Standard PM 9 on *A. planipennis* (EPPO, under development) for situations of eradication and containment, recommends the use of traps and biosurveys (with wasps that specialize in hunting buprestids).

Trapping. Trapping relies on a combination of visual and olfactory stimuli, using sticky traps or trap trees. Chemical attractants enhance the performance of trapping, but traps are only likely to attract insects in the nearby vicinity (Ryall, 2010).

- *Sticky traps with attractants*. Numerous studies have been conducted to determine the optimal combination of trap colour, shape, attractant and placement. Traps should be placed on ash trees. Ryall *et al.* (2010) note that trap catches signify that adults are in the general area, but do not provide information on the infestation status of individual trees.
    - *Trap colour*. Attractive colours include purple and a light shade of green (Poland & McCullough, 2010, citing others, EPPO, under development). These colours are the principal ones used in practice today (Pureswaran & Poland, 2009 citing Francese *et al.*, 2005; Francese *et al.*, 2010; McCullough *et al.*, 2011b; Poland *et al.*, 2011; Ryall 2010, USDA-APHIS, 2012b). Purple traps appear to be more effective when placed below the canopy, while green traps appear to be more effective in the canopy.
    - *Trap shape*: prism traps seem preferred (e.g. Ryall, 2010; USDA-APHIS, 2012b). Sticky bands are mentioned as another option in EPPO (under development, PM9). Other shapes are being investigated (e.g. multifunnel, Francese *et al.*, 2011).
    - *Lures*. Attractants contain leaf volatiles or volatiles from ash bark, with the following being used alone or in combination: manuka oil, phoebe oil,and (*Z*)-3--hexenol (green leaf volatile; Grant *et al.*, 2011; Ryall *et al.*, 2012). Manuka oil and phoebe oil both contain attractive volatiles found in ash bark, and are usually used with the (Z)-3-hexenol green leaf volatile lure and purple prism traps hung below the canopy. The (Z)-3-hexenol green leaf volatile lure can also be used by itself in green prism traps placed in the canopy (Ryall 2010). There are two pheromones (a contact and a more long-distance compound). The latter (3Z-lactone) has been used for trapping in combination with (*Z*)-3-hexenol, and appears to increase trap catch (Grant *et al.*, 2011; Ryall *et al.*, 2012).

For 2013 surveys in the USA, USDA-APHIS (2012b) recommends the use of purple prism sticky traps with manuka oil and (*Z*)-3-hexenol. For surveys in Canada, green prism traps with (Z)-3-hexenol placed in the leafy canopy of ash trees are used in surveys (Scarr *et al.*, 2012). In 2012 and 2013, the Canadian trapping program recommends a portion of these traps are also baited with the 3Z-lactone pheromone together with the (Z)-3-hexenol green leaf volatile (T.Scarr, personal communication).

- *Trap trees*. Girdled trees were widely used initially in North America before more efficient traps were developed. Nevertheless, some communities in the USA still use girdled ash trees for monitoring and lowering *A. planipennis* populations (TM Poland, personal communication). Trees are girdled using herbicides or mechanically prior to adult flight, and later are felled and stripped of their bark to look for galleries and larvae (McCullough *et al.*, 2009a,b; Crook & Mastro, 2010; Ryall. *et al.*, 2011, citing others). Girdled ash trees with sticky bands have also been used (Petrice *et al.*, 2009). The use of girdled trees is labour intensive, time consuming and destructive (Marshall *et al.*, 2011, citing others). By using a model, Marshall *et al.* (2011) determined that labor costs can be reduced by starting to remove the bark on a sections of the trunk that are 8-12 cm diameter. The draft EPPO standard PM 9 (EPPO, undated), does not rely on girdled trees for monitoring. The EPPO Panel on Forestry considered that the use of girdled trees is not acceptable for the purpose of first detection of *A. planipennis* as it involves killing ash trees, and it was not mentioned amongst the monitoring methods.

Branch and tree sampling

- *Branch sampling* (Ryall *et al.*, 2010 and 2011). This method is particularly useful for detecting *A. planipennis* before signs and symptoms appear on the trees. The province of Ontario, several municipalities, and some First Nations in Canada, as well as a few USA muncipalities, use this method for delimitation surveys and to determine the severity of an infestation in a specific area. It is thought to be especially valuable for open-grown ash trees. In Ryall *et al.* (2011), sampling is done by selecting open-grown trees of 20-50 cm diameter at breast height, removing 2 branches of 5-8 cm diameter from mid-crown and peeling the bark from the first 50 cm from the base in order to inspect for galleries.
- *Bark peeling of a window of bark on a live tree*. This method is used in combination with traps and visual surveys to detect infestations in individual trees. Suspect trees are sampled by removing bark from a 10 x 10 cm window at breast height, and looking for immature stages or signs of infestation (Ryall *et al.*, 2011, citing others). This method is damaging for the tree, and is likely to be effective only for high infestation levels. If the section of the trunk to be sampled is selected based on bark splitting, woodpecker feeding, or sunken portions of the bark, this method can be used to confirm if such symptoms are caused by *A. planipennis*. Infestations discovered when using bark windows are likely to be 3-4 years old (Ryall *et al.*, 2011).
- *Felling and inspection of trees.* This method is used for delimiting surveys and confirmation of infestation when the pest is captured in traps. Trees may be felled and the bark removed to look for galleries and

immature life stages (Lyons *et al.*, 2007). This method has been retained in the draft EPPO standard PM9 (under development) for surveying around infested trees.

Visual inspection. The signs and symptoms of infestation described above may be observed, but are not conspicuous at early stages of colonization. Visual inspection is most effective after the trees have been infested for 3-4 years (Lyons and Scarr, 2010). De Groot *et al.* (2006) give a visual guide to detecting *A. planipennis*. Serpentine (S-shaped) larval galleries are typical of species in the genus *Agrilus* and may be observed when bark is removed. There are a few Buprestidae (including *Agrilus* spp.) that infest ash in the EPPO region, but they are rare. Consequently, if *Agrilus*-like galleries and D-shaped exit holes are observed on ash in the EPPO region, the presence of *A. planipennis* should be suspected. Visual inspection may also be carried out on ash logs and firewood (Marshall *et al.*, 2011, citing others) and other commodities. Lyons *et al.* (2007) describe visual inspection methods (using binoculars or telescopes for the higher parts of the trunk) and crown surveys.

Biosurveillance

Biosurveillance methods using wasps or dogs are currently under research and development, and have not been yet used operationally for monitoring of *A. planipennis*.

- Wasps that specialize in hunting buprestids, such as *Cerceris fumipennis* (Hymenoptera, Sphecidae), were recently identified as a potential surveillance tool for *A. planipennis* in North America (Marshall *et al.*, 2005). Careless *et al.* (2009 and http://www.cerceris.info) describe it as a promising method pending further research. Some projects were conducted in Canada and the USA in 2009-2011 to locate *C. fumipennis* colonies. In North Carolina, studies were carried out to collect prey of *C. fumipennis* as they returned to their nest, and it was found to be an effective tool for documenting regional buprestid diversity (Swink *et al.*, 2013). This method is mentioned as a monitoring tool in the draft EPPO standard PM 9 (EPPO, under development), recognizing that in order to be used in the EPPO region it would first necessitate the determination of the relevant European species of buprestid-hunting Hymenoptera and development of procedures for their use.
- In Minnesota, a pilot project was initiated in 2012 to train dogs to detect ash and *A. planipennis* in forest conditions, including in firewood and piles of mulch. In Europe, dogs have been successfully trained and used in various conditions for the detection of *Anoplophora glabripennis* and *A. chinensis* (Hoyer-Tomiczek, 2012).

Aerial surveys

- Low level aerial surveys have been conducted in Michigan (USA) and Ontario (Canada) to detect *A. planipennis* infestations. Using both helicopters and fixed-wing aircraft, technicians have been able to identify ash trees from the air and record GPS coordinates for symptomatic trees (i.e. ash trees exhibiting thin crowns, chlorotic foliage, or tree mortality or decline) (Ryall 2010). In most cases, follow up ground checks showed that there were too many other factors (e.g. flooding, drought, off-site plantings, leaf drop from anthracnose, ash yellows, or winter dieback) that cause symptoms similar to *A. planipennis* to make this a useful tool for operational detection of trees infested by *A. planipennis* (T. Scarr, personal communication).
- While aerial surveys have not proven to be efficient for detecting trees infested by *A. planipennis*, aerial mapping is used to record tree decline and mortality. Ground checks are then used to verify that the ash tree decline or mortality has been caused by *A. planipennis* (Scarr *et al.*, 2012).

Remote sensing

- Hyperspectral imaging has been investigated by one municipality as a means of identifying ash trees to create an ash tree inventory. The eventual goal was to be able to determine a specific spectral signature that could be used to detect ash trees infested with *A. planipennis* (McNeil 2010). While this technology has been used by a municipality to estimate its ash inventory, it has to yet be proven effective for detecting trees infested with *A. planipennis*.

In all cases, positive identification of *A. planipennis* is required to confirm the presence of the pest. Lyons *et al.* (2007) give a protocol for specimen collection. A detailed identification guide is provided at: http://www.emeraldashborer.info/files/eab_id_guide.pdf. A large number of photographs may be found on the internet and in the literature, especially Lyons *et al.* (2007), CFIA (2012a), de Groot *et al.*, 2006, USDA-APHIS (2012a).

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

5. Regulatory status of the pest

A. planipennis is on the EPPO A2 List of pests recommended for regulation. In the EPPO region, *A. planipennis* is regulated in the EU (Annex II/A1), Switzerland, Serbia, Turkey (source: EPPO collection of phytosanitary regulations and summaries, www.ippc.int). In the EU, measures are required for wood, plants for planting, wood chips and bark (details in Appendix 2 under 7.10 of each pathway). It is not regulated in Russia, Kazakhstan, Uzbekistan, Belarus, or Ukraine.

In other regions, *A. planipennis* is listed as a regulated pest for Canada, Chile (as *Agrilus* spp.), Jamaica, Peru, and USA (www.ippc.int; this list is not exhaustive and it may be regulated in more countries). Canada and USA have specific measures in place for the movement of regulated articles of ash between and within their two countries (see Appendix 2 on pest risk management, questions 7.10).

6. Distribution

Continent	*Distribution*	*Comments on the pest status*	*Reference*
Africa	Absent		
America	Present in North America:		
	• Canada (Ontario, Quebec)	Introduced, restricted distribution, under official control. Up-to-date information in CFIA (2012a) based on extensive official surveys.	CFIA (2012a)
	• USA (Connecticut, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, Wisconsin)	Introduced, restricted distribution, under official control. Up-to-date information and map in EABINFO (2012), based on extensive official surveys.	EABINFO, 2013
	Absent in Central and South America		
Asia	Present:		
	• China (Hebei, Heilongjiang, Jilin, Liaoning, Neimenggu (=Inner Mongolia), Shandong, Tianjin, Xinjiang, Sichuan, Beijing).	Present, no details. Uncertainties: Wang *et al.* (2010) note that EAB was not found in surveys in Shandong and Inner Mongolia in 2004, and also that the record in Xinjiang needs further confirmation.	PQR, 2012; Wei *et al.*, 2007 citing Wei *et al.*, 2004. Chamorro *et al.*, 2012.
	• Japan (Hokkaido, Honshu, Kyushu, Shikoku) (see uncertainty under *taxonomy)*	Present, no details.	PQR, 2012
	• Korea Democratic People's Republic (see comment below)	Present, no details.	PQR, 2012
	• Korea, Republic (see comment below)	Present, no details.	PQR, 2012
	• Russian Far East: Khabarovsk, Primorskiy	From Vladivostok to Dzhonki village in Khabarovsk Kray. See map in Baranchikov *et al.* (2011). Common (Duan *et al.*, 2012a)	Baranchikov *et al.* (2011)
	• Taiwan (see uncertainty under *taxonomy* and comment below)	Present, no details.	PQR, 2012
Europe	• Russia (Moscow region, Smolensk region)	Introduced, restricted distribution but spreading. Most recent description in Baranchikov and Kurteev (2012)	Izhevskii and Mozolevskaya, 2010; Baranchikov *et al.*, 2011; Baranchikov and Kurteev, 2012
Oceania	Absent		

Comments on the distribution:

- *A. planipennis* is native to northeastern China, Korea, Japan, the Russian Far-East and Taiwan (Haack *et al.*, 2002) (with some uncertainty as reported under *taxonomy*). It has been introduced into North America and into the European part of Russia (e.g. Haack *et al.*, 2002; Baranchikov *et al.*, 2008). Introduction is estimated to have occurred about a decade prior to first detection in both North America (Siegert *et al.*, 2008) and European Russia (Baranchikov *et al.*, 2011, citing Izhevskiy, 2007).

- **Korea**. Older records often mention simply "Korea" (Ko, 1969). Some recent papers have documented the occurrence of *A. planipennis* in the Republic of Korea (= South Korea) (Bray *et al.*, 2011), but not the Democratic Republic of Korea (= North Korea).
- **Laos**. Jendek and Grebennikov (2011) reported the presence of *A. planipennis* in Laos. However, later Jendek and Chamorro (2012) described these individuals as a new species, ***Agrilus tomentipennis. Therefore, the reference in*** Jendek and Grebennikov (2011) that *A. planipennis* ***is present in Laos*** should not be considered valid.
- **Mongolia**. References to Mongolia appear in several publications. However, there is uncertainty on whether this record is valid due to the near absence of *Fraxinus* in Mongolia (Y Baranchikov, personal communication). In addition, it is possible that references in the literature to the country "Mongolia" were actually references to the Chinese province of Inner Mongolia (Gould *et al.*, 2005).
- **North America**: Based on the genetic analysis of several North American and Asian *A. planipennis* populations, Bray *et al.* (2011) concluded that the North American populations were most similar to Chinese populations, especially those from the Tianjin/Hebei region of China.
- **Russia**:
  - In the European part of Russia, the pest has been spreading since its discovery in 2005 (see details under 11. spread). In 2012, killed ash trees were found 250 km west of Moscow (Baranchikov and Kurteev, 2012). Given that the pest needs several years to kill trees, it is likely that it is already present further west.
  - In Far-East Russia (where *A. planipennis* is native), the pest has not been found south of Sakhalin Island, despite the presence of native stands of *F. mandshurica* (Baranchikov *et al.*, 2011).
  - In southern Siberia and central Urals, surveys were conducted in 2009-2010 on *F. pennsylvanica* in several cities (Siberia: Tomsk, Novosibirsk, Krasnoyarsk, Abakan, Ulan-Ude and Central Urals: Yekaterinburg), and *A. planipennis* was not found (Baranchikov *et al.*, 2011).
- **Taiwan:** When the *A. planipennis* was suggested for inclusion in the Annexes to the Directive 2000/29/EC (in 2008), Taiwan commented that *A. planipennis* has never been detected in Taiwan based on general surveys. However as Taiwan did not provide detailed technical information to the EU Commission to support this statement, the country was not considered free from the pest (G. Cardon, EU Commission, pers. comm., 2013).

7. Host plants and their distribution in the PRA area

A. planipennis is a pest of Fraxinus species. Other hosts are also reported but only in Japan and Korea (see below and section 1 Taxonomy).

Host scientific name (common name)	Presence in PRA area (see also 9.1)	Comments	Reference (for host status)
Fraxinus americana	Yes	Species of North American origin. In former USSR, cultivated in C.E.Russia (East), S.E. Russia (East), S.Siberia (West); Ukraine; Uzbekistan (EPPO, 2000); infested in China (Liu *et al.* 2003)	Haack *et al.* (2002)
Fraxinus angustifolia	Yes	Native in Europe and some other parts of the EPPO region. Complete development obtained in field trials	Anulewicz and McCullough (2012)
Fraxinus chinensis	Yes	Species of Asian origin. Note: according to Wallander (2008 & 2012), *F. chinensis* comprises the subspecies *F. chinensis* subsp. *chinensis* and *F. chinensis* subsp. *rhynchophylla* (of which *F. japonica* and *F. rhynchophylla* are synonyms)	Wang *et al.* (2010, citing Hou 1986 & Yu 1992)
Fraxinus excelsior	Yes	Native in Europe and some other parts of the EPPO region. Widespread in natural environments, and widely planted; details in 9.	European Russia: Baranchikov *et al.*, 2008; Izhevskii and Mozolevskaya, 2010; in Canada: Lyons and Scarr,

Host scientific name (common name)	Presence in PRA area (see also 9.1)	Comments	Reference (for host status)
			2010
Fraxinus japonica	?	Species of Asian origin. Note: *F. japonica* and *F. rhynchophylla* are both synonyms of *F. chinensis* subsp. *rhynchophylla* (Wallander, 2008 & 2012)	EPPO (2005)
Fraxinus lanuginosa	?	Species of Asian origin.	EPPO (2005)
Fraxinus latifolia	Yes	Species of North American origin. *F. latifolia* is considered as a subspecies of *F. pennsylvanica* according to Wallander, 2012. Cultivated in S.E.Russia and Ukraine (EPPO, 2000)	Anulewicz and McCullough (2012)
Fraxinus mandshurica	Yes	Species of Asian origin. In former-USSR, listed as naturally occurring in S Far East, and cultivated in C.E.Russia, S.E.Russia, S.Siberia, Ukraine (EPPO, 2000)	Wang *et al.* (2010, citing Hou 1986 & Yu 1992)
Fraxinus nigra	Yes	Species of North American origin. In former-USSR, listed as cultivated in C.E.Russia; Georgia (EPPO, 2000)	Haack *et al.* (2002)
Fraxinus nigra x mandshurica	?	Hybrid of species of North American / Asian origin	Chen & Poland, 2010
Fraxinus ornus	Yes	Native in Europe and some other parts of the EPPO region. Complete development obtained in field trials	Anulewicz and McCullough (2012)
Fraxinus oxycarpa	Yes	Note: according to Wallander (2008 & 2012), *F. oxycarpa* and *F. angustifolia* are synonyms)	Anulewicz and McCullough (2012)
Fraxinus pennsylvanica	Yes	Species of North American origin; Plantations, ornamentals; In former-USSR, listed as cultivated in C.E.Russia, S.E.Russia; Belarus; Moldova; Ukraine (EPPO, 2000), also S.Siberia (West); Central Asia (as *F. lanceolata*); infested in China (Liu *et al*. 2003)	Haack *et al.* (2002), Baranchikov *et al.*, 2008
Fraxinus profunda	?	Species of North American origin (present in swamps, endangered)	Lyons and Scarr, 2010, citing Czerwinski *et al.*, 2007;
Fraxinus quadrangulata	Yes	Species of North American origin; In former-USSR, listed as cultivated in Uzbekistan (EPPO, 2000)	Hausman *et al.*, 2010; Bray *et al.*, 2011; Lyons and Scarr, 2010, citing Czerwinski *et al.*, 2007; Tanis and McCullough, 2012
Fraxinus rhynchophylla	Yes	Species of Asian origin. Occurring naturally in S.Far East (EPPO, 2000). In former-USSR, cultivated in Ukraine (EPPO, 2000) Note: *F. japonica* and *F. rhynchophylla* are both synonyms of *F. chinensis* subsp. *rhynchophylla* (Wallander, 2008 & 2012)	Wang *et al.* (2010, citing Hou 1986 & Yu 1992)
Fraxinus uhdei	Probably not?	Tropical ash (native to Mexico). Considered as invasive e.g. in Hawai (CABI compendium, 2012).	Anulewicz and McCullough (2012)
Fraxinus velutina	Yes	Species of North American origin; In former-USSR, listed as cultivated in Ukraine (EPPO, 2000); infested in China (Liu *et al.* 2003)	Baranchikov *et al.*, 2008; Lyons and Scarr, 2010, citing Liu, 2003; Wei *et al.*, 2007

Comments on hosts:

- In Canada and the USA, all *Fraxinus* species that have been exposed so far were susceptible to *A. planipennis*, but with differences in susceptibility and vulnerability (see below). Due to the wide range of new *Fraxinus* spp. already attacked in addition to hosts in its native area, the EWG considered all *Fraxinus* spp. as potential hosts. This applies in particular to two other native species in the EPPO region: *F. raibocarpa* and *F. xanthoxyloides* (see details under 9). *Fraxinus chinensis* (as *F. chinensis* subsp. *rhynchophylla*), *F. japonica* and *F. rhynchophylla* are considered as synonyms (Wallander, 2008 & 2012). Most information found for this PRA regarding the Asian species of *Fraxinus* relates to *F. chinensis* or *F. mandchurica*, in particular in reference to susceptibility.
- There are differences in susceptibility of *Fraxinus* spp. The Asian species *F. mandshurica* and *F. chinensis* are known to be susceptible to *A. planipennis* only if stressed (Rebek *et al.*, 2008), and other Asian species are also expected to be susceptible when in stressed conditions. The North American species and European species are infested even if healthy. Differences in susceptibility are minor for North American species, except for *F. quadrangulata* which has been shown to be significantly less susceptible (lower rates of attack) and less vulnerable (lower rates of mortality) (Lyons & Scarr, 2010; Tanis & McCullough, 2012).

- Details on the presence in the EPPO region of native *Fraxinus* spp. (*F. excelsior*, *F. ornus*, *F. angustifolia*, *F. raibocarpa* and *F. xanthoxyloides*) and exotic *Fraxinus* spp. are given under 9.1.

In Japan, the following species were reported as hosts of *A. planipennis* (as *A. marcopoli ulmi* – see uncertainty under taxonomy) (Haack *et al.*, 2002; Baranchikov *et al.*, 2008). It should be noted that in studies conducted in USA (e.g. Anulewicz *et al.*, 2006, 2008), *A. planipennis* did not develop on non-ash species tested (including some *Juglans* and *Ulmus* species). In addition the EWG contacted 2 experts of *Agrilus* species (Mr Hirokazu Fukutomi (Japan, via Dr Kojiro Esaki) and Dr Eduard Jendek (CFIA, Canada). Mr Fukutomi considered that the non-*Fraxinus* host records for *A. planipennis* in Japan are incorrect. Dr Jendek agreed with Mr Fukutomi's opinion and underlined that host status for these non-*Fraxinus* species were never supported by actual larva-to-adult rearing records. These experts suggest critical revision of the host records given in Akiyama & Ohmomo, 1997 and Sugiura, 1999.

Host scientific name (common name)	Presence in PRA area	Comments	Reference (for host status)
Juglans ailanthifolia (syn. *J. mandshurica* var. *sieboldiana, J. sieboldiana)*	Yes	Species of Asian origin. In former-USSR, listed as cultivated in C.E.Russia, S.E.Russia; Baltic countries; Belarus; Moldova; Ukraine (EPPO, 2000)	Haack *et al.* (2002, citing Akiyama and Ohmomo, 1997 and Sugiura, 1999)
Juglans mandshurica	Yes	Species of Asian origin. Occurring naturally in S.Far East (EPPO, 2000). In former-USSR, listed as cultivated in Russia (NE, CE, SE), S.Siberia; Moldova; Baltic countries; Belarus; Ukraine; Transcaucasus	Haack *et al.* (2002)
Pterocarya rhoifolia	?	Species of Asian origin.	Haack *et al.* (2002)
Ulmus davidiana	?	Species of Asian origin	EPPO (2005)
Ulmus japonica (= *Ulmus davidiana* var. *japonica)*	?	Species of Asian origin	Haack *et al.* (2002, citing Akiyama and Ohmomo, 1997 and Sugiura, 1999)
Ulmus propinqua (= *Ulmus davidiana* var. *japonica)*	Yes	Species of Asian origin. Occurring naturally in Siberia (NE, SE), Transbaïkalia, Far East (N & S) (EPPO, 2000, listed as *U. japonica = U. propinqua).* In former-USSR reported as cultivated in C.E.Russia (St-Peterburg), S. Siberia; Kazakhstan (EPPO, 2000)	EPPO (2005)

- *Ulmus propinqua* and *U. japonica* are subspecies of *U. davidiana* according to ARS-GRIN and the PlantList. Consequently, only *U. davidiana* has been covered when assessing pathways.
- *Ulmus parvifolia* is regulated by the EU in relation to *A. planipennis*. This record originates from the CABI Crop Protection Compendium, but this was later considered as erroneous and removed from the CABI datasheet (L. Mcgillivray, CABI, pers. comm., 2013). This species is not considered further in this PRA.
- *Pterocarya fraxinifolia* is mentioned as a host by EFSA (2011) based on EcoPort, 2008 (web-based wiki and database). The original source of this record was not found. This species is not listed amongst the hosts of *A. planipennis* on EcoPort at 30 January 2013 (EcoPort, 2013). This species is not listed as a host above and is not considered further in this PRA.

8. Pathways for entry

A. planipennis has already been shown to move on certain pathways. In North America, infested crating, dunnage or pallets are suspected for the first introduction. Since then, *A. planipennis* has spread naturally and through human-assisted pathways, such as infested ash logs, firewood and nursery plants (USDA-APHIS, 2010, citing Herms, 2009). USDA-APHIS (2011) also identifies other potential pathways as follows: lumber, chips, mulch (composted and uncomposted). It should be noted that export of ash plants and plant products from regulated areas in USA and Canada is currently restricted.

For all the wood pathways, it should be noted that *A. planipennis* does not greatly affect the quality of the hardwood because it generally infests the bark and the outer sapwood (Brashaw *et al.*, 2012).
All reported host plants are considered in the pathways for entry. Nevertheless, it should be noted that the probability of entry with *Juglans mandshurica*, *Pterocarya rhoifolia*, *Ulmus davidiana* is likely much lower (if they are indeed hosts – see uncertainty in section 7) as *A. planipennis* has only be reported on these species in its native range in Korea and Japan and trade of these species is probably very low.

Possible pathways *(in order of importance)*	Short description explaining why it is considered as a pathway	Pathway prohibited in the PRA area? Yes/No	Pest already intercepted on the pathway? Yes/No
Wood with or without bark of *Fraxinus* spp., *Juglans mandshurica*, *Juglans ailanthifolia, Pterocarya rhoifolia*, *Ulmus davidiana* from where the pest occurs	This pathway includes round wood, wood with bark (including debarked wood), bark-free wood, and firewood. Ash has a wide range of uses (see under 9.1). Regarding firewood, *Fraxinus*, *Ulmus* and *Juglans* are listed as a species used and traded for firewood in Canada (http://www.inspection.gc.ca/plants/plant-protection/directives/forestry/d-01-12/eng/1323828428558/1323828505539). Firewood has been identified as an important pathway for the spread of the pest in North America, including long-distance spread (Robertson & Andow, 2009, Haack *et al.*, 2010, USDA-APHIS, 2010). Biological considerations. All life stages of *A. planipennis* may be associated with the wood at origin, at any time of the year, but would need to survive cutting and processing of the wood. In particular, wood of which the bark and 2.5 cm of outer sapwood have been removed will not carry the pest. The association is most likely in cases of high population levels (and such wood may not be chosen for export). The risk of moving firewood is thought higher than other types of wood, in particular in the first year after felling. Adults may emerge from the wood up to 1-2 years after felling (Petrice and Haack, 2007). It is likely that late larvae, pupae and callow adults would be able to survive and complete their development on cut wood. These stages are less likely to be affected by desiccation and could survive and emerge, even if the bark has been removed. Ash is widespread in the EPPO region, and adults emerging from wood at the destination would likely find a host (especially where *F. excelsior* or North American species of ash are grown). Trade (Appendix 3) • *Round wood*. No specific data were found for *Fraxinus*, *Juglans* and *Ulmus*. There seems to be a relatively minor trade of round wood of deciduous temperate species from some countries where *A. planipennis* occurs to the EPPO region (see Tables 1, 3 and 6). The highest volume is imported by Finland from Russia. There are no data on whether this includes ash wood. • *Sawn wood*. There is some trade of sawn wood of *Fraxinus* from USA, Canada and Russia, although not in high volumes (tables 2, 4, 7 and 8) • *Firewood.* There is some trade of fuelwood (which includes firewood and other commodities such as wood pellets), mostly from Russia to Sweden (and to a lesser extent Finland and Denmark) (Table 5) (although it is not known whether ash is used for such wood). There is no official control for such wood in Russia. Whether massive imports of such firewood may occur in the future for the purpose of energy production is unknown. Fuelwood currently represents the lowest volume of wood for bioenergy (Lammers *et al.*, 2012). The risk of entry will increase when the pest increases its range in North America and Russia. Likelihood of entry on the pathway: moderate Uncertainty: medium - volume, proportion of ash in hardwood imports, frequency of import (per month) in the PRA area, timing of imports, distribution of the commodity throughout the PRA area, end-use of the wood.	No	Yes (in USA and Canada, on *Fraxinus*)
Plants for planting of *Fraxinus* spp., *Juglans mandshurica, Juglans ailanthifolia, Pterocarya rhoifolia*, *Ulmus davidiana* originating from where the pest occurs.	This pathway considers ash plants for planting traded as nursery plants for forest or amenity uses. Bonsais are also considered although no specific mention of *A. planipennis* on ash bonsais was found (http://www.bonsai4me.com/species_guide.html lists *F. excelsior* as a bonsai). *A. planipennis* is documented to have been transported long distances in nursery stock within North America (USDA–APHIS, 2010). Canada and USA have measures in place for ash plants for planting originating from areas regulated for *A. planipennis* in the other country (CFIA, 2012c) Biological considerations. All life stages of the pest may be associated with plants for planting at origin throughout the year, and are likely to survive transport.	No	Yes (in USA and Canada on *Fraxinus*)

<table>
<tr><td></td><td>The EWG envisaged whether material below a certain diameter would not present a risk of carrying the pest. Canada (CFIA, 2011) makes stricter requirements for branches > 1.5 cm diameter from regulated areas in the USA (although smaller branches are also regulated). However, the pest has been found on material of all sizes, including on material as small as 1 cm in diameter (Timms, et al., 2006 citing Lyons; RA Haack, T Scarr and Y Baranchikov, personal communications). The EWG concluded that there is no information allowing a minimum diameter of host material to be defined that could be infested by A. planipennis, and considered that material of any diameter may be infested by the pest.

Trade: Fraxinus plants are not differentiated from other ornamental or forest trees in trade statistics. However, from data provided by FR, IT, DE, NL in 2010 (not complete), there seems to be a minor volume of trade of Fraxinus plants for planting from Canada, USA and China. Data is missing on whether Fraxinus plants for planting are traded to other countries in the PRA area from China, USA or Canada, or from areas where the pest occurs in Russia to the rest of the EPPO region.

Imports of Fraxinus plants for planting (in number of units, origin to destination)
<table>
<tr><th>Species</th><th>2008*</th><th>2009</th><th>2010</th></tr>
<tr><td>Fraxinus spp.</td><td>120 Canada to NL</td><td>600 China to NL
208 USA to DE</td><td>1000 China to NL
20 USA to DE</td></tr>
<tr><td>F. americana</td><td></td><td></td><td>245 USA to DE
200 USA to IT</td></tr>
<tr><td>F. mandshurica</td><td></td><td></td><td>100 USA to DE</td></tr>
<tr><td>F. pennsylvanica</td><td></td><td>649 USA to DE</td><td>520 USA to DE</td></tr>
</table>
*Some data available only for NL, FR
The EWG is aware that there is a large import volume of plants for planting from other continents (especially Asia), and if trade volumes of plants for planting of Fraxinus increase, this would increase the risk.

Likelihood of entry on the pathway: moderate

Uncertainty: medium
- association of the pest in North American, Russian and Chinese nurseries for plants for export
- data on trade, frequency of movement, distribution of imported plants for planting throughout the PRA area, size of plants.</td><td></td><td></td></tr>
<tr><td>Waste wood originating from where the pest occurs</td><td>Waste wood (including the EU category “waste wood and scrapwood” (EU, 2012) may be of lower quality than wood chips. Wood chunks are used in wood industry but not mentioned in custom codes for trade. They are usually not screened and are much bigger in size than wood chips (e.g. cubes that are 5 cm or 10 cm on a side) (EPPO, 2011). Such materials pose a risk at least as high as for wood chips (as the probability of survival of larvae and pupae in chunks is more likely than in chips, and that quality of the wood may be lower).

Biological consideration. All life stages may be associated at origin with waste wood especially in the presence of bark, at any time of the year. However, the possible processes associated with wood waste are likely to reduce the concentration of the pest.

Trade (Appendix 4). There is a trade of waste wood (44013080) (the data does not differentiate softwood and hardwood). Finland (and to a lesser extent Germany, Denmark and Sweden) imported major volumes from Russia in 2010-2011.

The probability of entry on this pathway depends on, besides volume, the wood processing methods and time of the year. If the trade of such wood for energy purposes increases, the risk would be greatly increased. The risk of wood waste is considered similar to that of wood due to the low quality of the wood and large dimensions of wood pieces.
Likelihood of entry on the pathway: moderate

Uncertainty: medium
- proportion of ash in waste wood</td><td>no</td><td>no</td></tr>
</table>

	- volume, frequency of import and timing of imports into the PRA area, distribution throughout the PRA area *- whether wood waste would be stored for some time on arrival and in which conditions*		
Hardwood wood chips originating from where the pest occurs	Canada and USA have measures in place for ash bark and wood chips originating from areas regulated for *A. planipennis* in the other country (USDA-APHIS, 2010; CFIA, 2012b) (and also other measures for other bark and wood chips categories). The main commodity covered by this pathway is hardwood wood chips. *Fraxinus*, *Ulmus, Pterocarya* or *Juglans* may be used, alone or in mixture with other species, for producing wood chips. Wood chips might be imported for pulpmills, energy production, fiberboard production or as mulch. Mixed hardwood wood chips might contain a limited amount of wood of these species, which would lower the likelihood of association with the pathway. Wood chips are often produced from lower quality trees, which increases the risk of infestation. In addition, ash trees may be commonly processed into wood chips in situations where large volumes of dead ash trees killed by *A. planipennis* are available and cannot be used in other ways. There is a wide variation in the size of wood chips (details on this aspect may be found in the EPPO PRA on *Agrilus anxius*). The European Standard on solid fuel (Alakangas, 2010; CEN, 2011) identifies four classes of wood chips according to particle size (i.e. passing through a round-hole sieve of the specified 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. Biological consideration. All life stages may be associated at the origin with wood chips especially in the presence of bark, at any time of the year. However, the process of producing wood chips, i.e. grinding and chipping, is likely to reduce the concentration of the pest. A small percentage of larvae of *A. planipennis* have been shown to survive the chipping process (McCullough *et al.*, 2007). In this study no survival was found on wood chips produced by chipping or grinding machines with a 2.5 cm sieve. However, these wood chips were significantly smaller than 2.5 cm in two dimensions (see Appendix 2, question 7.24 for this pathway). The commercial production of wood chips may result in larger chips. Living *A. planipennis* fourth larval instars, prepupae, pupae, callow adults and adults may be present in wood chips produced with screens greater than 2.5 cm (McCullough *et al.*, 2007; Roberts & Kuchera, 2006). Chipping would expose the wood surface to drying, but fourth larval instars, prepupae, pupae, callow adults and adults may be able to survive. Earlier larval instars will not be able to complete their development in the chips. Not much research has been performed up to now regarding the minimal dimensions of wood chips that would support the pest. Further consideration is given to the size of wood chips under the phytosanitary measures section (under 16). During storage and transport lethal temperatures may be reached within the core (through composting), and some individuals will be killed. Transfer would be most likely if the wood chips are shipped soon after production and stored outdoors (i.e. allowing time for the pest to complete development), or used for mulch. Trade (Appendix 4) There is a trade of hardwood wood chips from some countries where the pest occurs. Turkey has become a major importer of wood chips (Lammers *et al.*, 2012) from both the USA and Canada (Tables 1 and 2), and in 2011-2012 it imported most of the hardwood wood chips exported by Canada (Table 1). Finland is a major importer of hardwood wood chips from Russia (Table 3). The probability of entry on this pathway depends on, besides volume, the processing and storage methods, and time of the year for import. If the trade of wood chips for energy purposes increases, the risk would be greatly increased. Although the volume of trade is quite high, survival (of the processes and in transport) would not be as likely as for wood. Likelihood of entry on the pathway: low/moderate Uncertainty*:* medium *- whether imported wood chips originate from trees killed by the beetle (i.e. low quality wood with potentially high concentration of pest)*	No	Yes (in USA and Canada)

	- proportion of ash in hardwood chips imports *- volume, frequency of imports (per month) in the PRA area, timing of imports, distribution throughout the PRA area* *- whether chips would be stored for some time on arrival and in which conditions* *- whether imported wood chips are used as mulch.*		
Wood packaging material (including dunnage) containing *Fraxinus* spp., *Juglans mandshurica*, *Juglans ailanthifolia*, *Pterocarya rhoifolia*, *Ulmus davidiana*	Wood packaging material (including dunnage) accompanies other commodities. Since the adoption of ISPM 15 (*Regulation of Wood Packaging Material in International Trade,* FAO, adopted in 2002 and revised in 2009), all wood packaging material moved in international trade should be debarked and then heat treated or fumigated with methyl bromide and stamped or branded, with a mark of compliance. If wood packaging material is debarked and treated in accordance to ISPM 15, this should destroy the pest (methyl bromide fumigation, or heat treatment at 56° C for 30 minutes throughout the entire profile of the wood including the core). With conventional heat treatment, if the temperature reaches 56°C for 30 min at the core, it is likely that insects in the outer sapwood will be exposed to higher temperatures. Some concerns were raised in the past about the efficacy of the ISPM 15 heat treatment against *A. planipennis*. Although there is still debate on whether the schedule of 56°C for 30 minutes is appropriate for *A. planipennis* in wood (see details in Appendix 2), the combination of debarking and heat treatment required by ISPM 15 is considered adequate for wood packaging material. The *International Forestry Quarantine Research Group* (IFQRG) concluded in 2010 that the combination of debarking and heat treatment of 56°C for 30 minutes for wood packaging material was adequate for *A. planipennis*. (note that the conclusions of EFSA (2011) do not apply to wood packaging material). Untreated (or incorrectly treated) wood packaging material (incl. dunnage) will present a risk. Recent findings showed the presence of living pests in ISPM 15-marked wood packaging material, indicating possible improper treatment or non-compliance (EPPO, 2012a and 2012b) Due to the volume of wood packaging material in circulation in trade, the risk posed by untreated wood packaging material or failure of treatment may be high. No specific data were found on whether *Fraxinus*, *Juglans*, *Pterocarya* or *Ulmus* are used for the production of wood packaging material (including dunnage). In North America wood packaging material is suspected to be the source for the introduction of *A. planipennis* (first recorded, in 2002; Haack *et al.*, 2002) and the source of several interceptions of *Agrilus* spp. (Haack *et al.,* 2002), but these records date from before the passage of ISPM 15 in 2002 (FAO, 2009). Likelihood of entry on the pathway: if treated according to ISPM 15 very low; if untreated, high Uncertainty: low	No	No?
Bark and objects made of bark of *Fraxinus* spp., *Juglans mandshurica*, *Juglans ailanthifolia,* *Pterocarya rhoifolia*, *Ulmus davidiana*	No data were found on whether the bark of the species concerned is used to produce bark or bark objects, or whether such commodities are traded to the EPPO region. The EU regulates this pathway, as well as Canada and USA for ash bark chips originating from regulated areas of the other country. Canada and the USA also regulate domestic movement of bark chips originating from regulated areas within their respective countries (USDA-APHIS, 2010; CFIA, 2012b). Biological considerations. Larvae may be present at the interface between the bark and sapwood, eggs in the bark, and some pupal chambers and callow adults or adults in the bark. Young larvae and eggs are not likely to survive. Late stage larvae, pupae, callow adults and adults are likely to survive. It is noted that bark can also have some wood attached, and this would increase the risk (increased probability of association and survival). Likelihood of entry on the pathway: moderate with high uncertainty Uncertainty: high *- Whether bark ash is used for such commodities.*	No	No

	- volume, frequency and timing of imports in the PRA area, distribution throughout the PRA area *- Whether processing of the bark will significantly reduce* A. planipennis *survival*		
Furniture and other objects made of untreated wood of *Fraxinus* spp., *Juglans mandshurica*, Juglans ailanthifolia, *Pterocarya rhoifolia*, *Ulmus davidiana* originating from where the pest occurs	Late larval stages, prepupae, pupae and callow adults could be present if untreated, air dried, or bark-covered sapwood is used (e.g. rustic furniture with bark attached). However, it is expected that wood used to make such objects would have been left to dry for a time before processing, and the life stages would have been exposed to desiccation, although Petrice and Haack (2007) showed emergence of *A. planipennis* adults from firewood after 2 years. Furniture made of low quality wood presents a higher risk. The risk of entry from this pathway was considered as lower than that for wood with bark (as fewer life stages may be associated, and the wood may not be as fresh). It was not possible to find trade data for this commodity, nor if these species are used for producing such objects. However, because it presents a risk, measures were included under 16. Likelihood of entry on the pathway: low Uncertainty: medium	No	No
Natural spread	Natural spread from the European part of Russia to other countries of the PRA area is likely to happen: there is a continuum of ash present from the Moscow region westwards, and the adults can fly. Details on spread are given in section 11. In the presence of hosts, most individuals remain within a few hundred meters of their emergence site. 10 km per year is the current estimate of spread westwards from the Moscow region (Baranchikov and Kurzeev, 2012), and there are approximately 200 km from the westernmost finding of the pest in Russia and the border of Belarus. Consequently, it is considered here that natural spread to other countries in the EPPO region is not likely to happen in the immediate future. It is more likely that the pest will be introduced before that through human-assisted pathways, and also spread through these pathways. Natural spread will be an important parameter in case of future introductions in other countries of the EPPO region. Likelihood of entry on the pathway from Russia into other EPPO countries: low in the medium term Uncertainty: medium (distribution in the European part of Russia)	No	-
Cut branches of *Fraxinus* spp., *Juglans mandshurica*, Juglans ailanthifolia, *Pterocarya rhoifolia*, *Ulmus davidiana* originating from where the pest occurs	Canada regulates this pathway (CFIA, 2012b). Biological considerations. Cut branches used for ornamental purposes could carry all life stages of the pest. Cut branches are likely to have a small diameter. Only late immature life stages would be able to complete their life cycle in cut branches. In addition, the quality of the plant material would degrade over time Trade. No evidence was found of imports into the PRA area or exports from where the pest occurs. Although Canada regulates this product (with different requirements for branches < and > 1.5 cm diameter), there is no known trade of this product between Canada and the USA (T. Scarr personal communication). While there may be limited trade in hardwood branches, the risk may occur when branches left after tree harvesting or sanitation are transported to landfill or co-generation sites. This pathway was identified as being possible, but presuming a very small trade volume, and low pest survival, entry was considered unlikely. However, because it presents a risk and it is regulated by Canada, measures were included under 16. Likelihood of entry on the pathway: low Uncertainty*:* medium - trade volume	No	No
Hitchhiking	Hitch-hiking on vehicles is mentioned as a form of human-assisted dispersal (Buck & Marshall, 2008). It is a possible pathway for introduction of the pest into other countries of the PRA area from the European part of Russia, especially into the closest country, Belarus. Infestations in Russia have been observed along highways. In Canada, infested trees and the pest have been found at rest-stop locations along highways at about 150 km from the nearest area known to be infested, suggesting that the pest may have hitchhiked with vehicles (T Scarr, personal communication). Hitchhiking could also play a role in local spread of the	No	-

	pest within the PRA area following future introductions. Likelihood of entry on the pathway: moderate for Belarus Uncertainty: medium		
Movement of individuals, shipping of live beetles, e.g. traded by collectors.	*A. planipennis* is a colourful and shiny insect and may circulate between hobbyist entomologists, but it is most likely to be traded once dead. This pathway would be difficult to control. Likelihood of entry on the pathway: very low Uncertainty: low This pathway was not considered further in this PRA.	No	-

Note on pathways that are not considered relevant for this pest:

- **Fresh leaves of *Fraxinus* spp.** This pathway is regulated by Canada from material originating in regulated States of the USA (PFA or ash leaves less than 2.5 cm in any two dimensions). These measures are targeting the presence of adults. The EWG did not consider this as a relevant pathway. There is also no indication that there is trade in fresh leaves of *Fraxinus* spp. This pathway was not considered further in this PRA.
- **Processed wood material of *Fraxinus* spp., *Juglans mandshurica, Juglans ailanthifolia, Pterocarya rhoifolia, Ulmus davidiana* and commodities made of this (composites of wood constructed with glue, heat and pressure, or combinations thereof), wood pellets, sawdust**. Such wood material would be processed to a degree that would not allow survival of eggs on the bark or larvae and pupae in the wood. It should be noted that wood pellets are the main commodity traded for wood for energy purposes (Lammers *et al.*, 2012).
- **Seeds of *Fraxinus* spp., *Juglans mandshurica, Juglans ailanthifolia, Pterocarya rhoifolia, Ulmus davidiana***. Life stages of *A. planipennis* are not associated with seeds.

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

The risk of entry can change over time if the pest expands its range, if trade changes or if the current official control in North America is not maintained due to further expansion of the pest distribution.

9. Likelihood of establishment outdoors in the PRA area

9.1 Host plants in the EPPO region

The main concern raised by *A. planipennis* is to *Fraxinus*, and so *Juglans*, *Ulmus* and *Pterocarya* have not been considered in detail here, although a range of species in these genera occur in the EPPO region, both in the wild and as ornamentals. The Asian species identified as hosts in these genera would mostly be used as ornamentals in the EPPO region. A large number of other species in the genera *Ulmus* and *Juglans* are recorded as occurring naturally or cultivated in the former USSR (see Appendix 5).

Regarding *Fraxinus* spp., native and exotic species are widespread in the PRA area, in forests (including plantations) and as amenity trees (landscape, parks, private gardens, bonsais). They occur in a variety of habitats, such as forests, riparian areas and cities. A large number of *Fraxinus* spp. are available as ornamentals (e.g. RHS, 2012) including native, North American and Asian species.

Ash occurs naturally from the south portions of Scandinavian countries (Sweden, Finland and Norway) to North Africa and the Middle East. It is not known whether native species other than *F. excelsior* will be hosts of *A. planipennis*. However, given that this pest has already attacked several *Fraxinus* spp. from outside its area of origin, these other *Fraxinus* spp. are considered below. In the UK, it is estimated that there are ca. 130 000 ha of predominently ash tree woodland (5.5% of all woods) as well as around 12 million ash trees outside woods and forests (http://www.forestry.gov.uk/website/forestry.nsf/byunique/infd-5nlcmt).

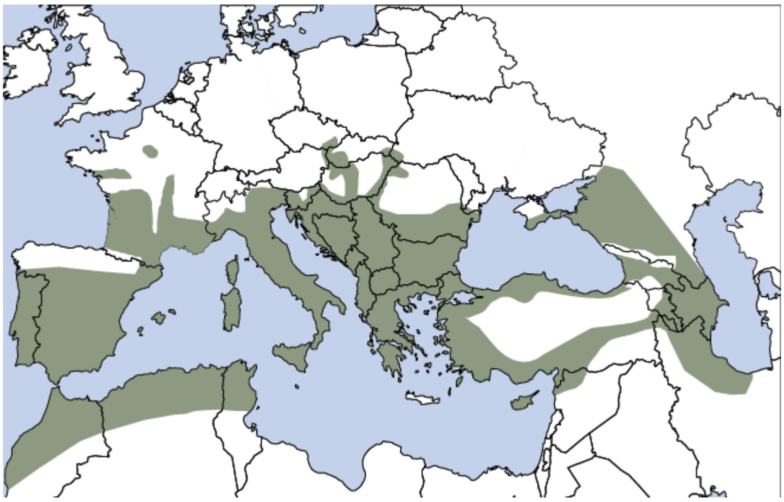
Ash wood has many uses, including for the production of furniture, veneer, flooring, doors, composite wood, panelling, tool handles and sport equipments (http://www.ahec.org/hardwoods/guide/ash.html, Brashaw *et al.*, 2012). *F. xanthoxyloides* is used as fodder in North Africa (El Aich, 1998). Ash has a keystone role in floodplain forest ecosystems in Europe, acts as a pioneer species in woodland recolonization, such as in marginal and mountaineous areas of Europe suffering from rural abandonment. Finally ash trees have a cultural and aesthetic value (see under social impact).

Native *Fraxinus* in the PRA area (except Far East, where some Asian species are native)
Apart from the Asian species that may be native in Far-East Russia, the following species are native to the EPPO region (Wallander, 2008 & 2012): *F. excelsior*, *F. angustifolia*, *F. ornus*, *F. raibocarpa* and *F. xanthoxyloides*. In particular *F. excelsior*, *F. angustifolia* and *F. ornus* are widespread components of mixed deciduous forests in Europe as far east as the Caucasus (Pautasso *et al.*, 2013).

- *F. excelsior* is the main ash species in the EPPO region, with a wide distribution eastwards to the Volga River in Russia, and southwards to the Mediterranean area. *F. excelsior* is a keystone species throughout temperate Europe, and commonly planted as a plantation and ornamental tree. It occurs in a wide diversity of environments (including riparian to mountain, steep slope stands, pioneer to mature and old growth woodland, nutrient rich to poor soils; Pautasso *et al.*, 2013). *F. excelsior* is also used as bonsai.

Map: natural distribution of *F. excelsior* in Europe (souce: Fraxigen, 2005)

- *F. angustifolia* occurs mostly in the southern part of the region, including in North Africa. In addition, in former USSR, *Fraxinus angustifolia* occurs naturally in Ukraine and Transcaucasus (Mountains). EPPO (2000) also mentions a number of species that are considered as synonyms or subspecies of *F. angustifolia* by Wallander (2008 & 2012), such as: *F. syriaca* from Turkey to Central Asia (Wallander, 2012), also Israel (Karschon, 1953) and cultivated in Ukraine (EPPO, 2000); *F. oxycarpa*, *F. pallisiae* and *F. ptacovskyi (= F. pojarkoviana)* occurring naturally in Ukraine and Transcaucasus mountains, S.E. and Central Europe (*F. oxycarpa* also cultivated in Ukraine) (Wallander, 2012; EPPO, 2000); *F. sogdiana* occurring naturally in Central Asia (Kazakhstan, Khirghistan, Tadjikistan, Uzbekistan) and considered as near-threatened (Eastwood *et al.*, 2011; Wallander, 2012).



Map: Natural distribution of *F. angustifolia* in Europe (souce: Fraxigen, 2005)

- *F. ornus* occurs mostly in the central and southern EPPO region. It is also recorded as being cultivated in S.E.Russia, Moldova and Ukraine (EPPO, 2000).

Map: Natural distribution of *F. ornus* in Europe (souce: Fraxigen, 2005)

- *F. raibocarpa* is a Central Asian species (Wallander, 2008). In former-USSR, it is recorded to occur in S. Siberia (mountains); Central Asia (mountains); Kazakhstan (mountains) (EPPO, 2000), and is cultivated in Ukraine.
- *F. xanthoxyloides* is native to North Africa.

In France in 2010-2011, the following numbers of forest seedlings were sold, respectively internally and for export: *F. excelsior* - 194 673 and 36900; *F. angustifolia* 7475 and 18 000 (IRSTEA, 2011).

Exotic *Fraxinus* in the EPPO region

In the EPPO region, exotic *Fraxinus* spp. (e.g. *F. pennsylvanica*, *F. velutina*, *F. nigra*, *F. americana*, *F. mandchurica*) are used for plantations or as ornamentals, including in cities (e.g. *F. pennsylvanica*, *F. velutina*; Baranchikov *et al.*, 2008; Wang *et al.*, 2010; Yurchenko, 2010). The American species *F. pennsylvanica* is planted for timber and shelter in central and south-eastern Europe. Exotic ashes are used throughout the PRA area, including in the area of origin of the pest (Duan *et al.*, 2012a, citing others). EPPO (2000) mentions two North American species of *Fraxinus* spp. not yet known as hosts, as being cultivated in former-USSR: *Fraxinus caroliniana* in Ukraine (Crimea), and *Fraxinus latifolia* (*F. oregona*; a subspecies of *F. pennsylvanica* according to Wallander, 2012) in S.E.Russia and Ukraine (Crimea).

9.2 Climatic conditions

The climate classification of Köppen-Geiger indicates that the pest is present in many different types of climates, which are also present in the EPPO region. *A. planipennis* has a wide distribution, which encompasses most climates found in the PRA area. *A. planipennis* spends a large part of its life cycle protected from extreme changes in climatic conditions (i.e inside the trunk). It may also develop over longer periods of time if conditions are not favourable. The distribution of *A. planipennis* is probably more dependent on the presence of hosts than on local climatic conditions. Cold temperatures do not seem to be a limiting factor for the survival of the pest in winter (see details under 2.), and it occurs in cold areas such as northeastern USA, central Canada, the Moscow region and northeastern China.

9.3 Managed environment

Fraxinus spp. are widely present in environments that are managed to a certain extent in the PRA area, such as nurseries for ornamental or forest trees; ornamental species in gardens and amenity areas; and forested areas. No information was sought on such managed areas, but it was not considered that active management would prevent establishment. Forests, forest tree nurseries and amenity areas may be subject to certain management practices such as pruning, thinning and fertilization, but this is not expected to prevent establishment. In ornamental nurseries, the level of management is likely to vary across the EPPO region, but it is presumed that trees would be grown outdoors and not protected from egg-laying adults. Possible current routine management practices (e.g. thinning, weed control, fertilization, insecticide treatments) are unlikely to affect pest establishment. Even if insecticides are applied against other pests, they may only partially control *A. planipennis* populations but are unlikely to prevent its establishment.

It is not considered that establishment of *A. planipennis* would be prevented if only Asian *Fraxinus* spp. were used (if there are any such areas), given that all ash species have a certain susceptibility. *F. excelsior* is susceptible to *A. planipennis* and is the dominant ash species in European forests. The native species *F. angustifolia* and *F. ornus* are also susceptible. Some North American species are extensively used in plantations. Avoiding stress to trees would also not be sufficient to avoid establishment as the pest may attack healthy trees. In addition, several species of *Fraxinus* in the EPPO region are currently under stress because of ash dieback disease associated with the fungus *Chalara fraxinea* (see under impact).

9.4 Biological considerations

A. planipennis may have a longer life cycle to adapt to the environmental conditions and the conditions of its host, and may develop over two years (i.e. it would not need to emerge the first year in order to survive). It has a moderate fecundity, each female producing 68-90 eggs (Haack *et al.*, 2002). Mercader *et al.* (2009) suggest that short distance dispersal of adults, which is observed where there are sufficient ash trees, is likely to enhance establishment from a single introduction (by maintaining a higher local population density).

A. planipennis has already spread and successfully established itself outside its original area of distribution in North America and the European part of Russia. It has adapted to new *Fraxinus* spp. which were not native to its area of origin.

The following factors, normally reviewed when assessing establishment are considered either not relevant or not likely to have an effect on the establishment of *A. planipennis*:

- Alternate hosts and other essential species. *A. planipennis* does not need an alternate host or another species to complete its life cycle.
- Other abiotic factors. No such factor that could have an impact on establishment was identified.
- Competition and natural enemies. Although some natural enemies are present, and competition may also occur, it is not considered that this would be sufficient to prevent establishment.

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

Fraxinus, *Juglans*, *Pterocarya* and *Ulmus* are mostly grown outdoors, including nursery plants.

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

Uncertainty:
- Whether bonsais of these tree species are produced and imported into the PRA area.

11. Spread in the PRA area

A. planipennis spreads naturally and through human-assisted pathways.

11.1 Natural spread

A. planipennis is a strong flier. Adults typically fly in 8-12 meter bursts, but long distance flight of more than one kilometer is possible (Haack *et al.*, 2002, citing Yu 1992, Minemitsu Kaneko, Japan Wildlife Research Center, Tokyo, Japan, personal communication). Flight distances of 0.3-19.3 km were reported, with maximal dispersal of 1.37 km in an intensive quarantine zone (Vannatta *et al.*, 2012, citing Raupp, 2010 and Sargent *et al.*, 2010). In flight-mills (Taylor *et al.*, 2010) the average flight was >3km, with 20% of mated females able to fly >10 km in 24 h, and 1% > 20 km. The maximum distance covered was 7.2 km in 4 days. Taylor *et al.* (2010, citing Sawyer, 2007) note that the 800 m ash-free zone which was used in the past in eradication attempts in the USA is not sufficient as some individuals would fly further to find their hosts.

However, when ash trees are available, the spread is minimal, and most adults would fly less than 100 m. In two newly-colonized sites (with a linear distribution of ash trees), Mercader *et al.* (2009) found most larvae (88.9% and 90.3% for each site) on trees within 100 m of the emergence points of the adults, and 100% and 97.8% within 300 m of the emergence points. One larva was found at a distance of 750 m at one site and 240 m at the other; there may have been longer dispersal, given that sampling was conducted up to 750-800 m from the original emergence sites.

In sites with more heterogeneous distribution of ash, sampling conducted up to 800 m showed that females did not disperse randomly. At short distances, 0-200 m from the origin, the pest spread more towards areas of relatively abundant ash than towards areas of low ash density. There was no influence of the prevailing wind direction or size or the tree (Siegert *et al.*, 2010).

Mercader *et al.* (2011a) state that spread of *A. planipennis* is difficult to assess, because the edge of a population will often be unknown (low densities of the pest are difficult to detect). Over 90% of eggs were found on trees within 500 m of the emergence point. This may lead to pockets of high densities of *A.*

planipennis surrounded by large areas with very low densities (making it difficult to detect new infestations). The attempts to reduce pest populations by cutting large numbers of infested or potentially infested trees may reduce the resources available to the pest and increase the local spread rate (Mercader *et al.*, 2011b).

11.2 Human-assisted pathways

A. planipennis was introduced into North America and Russia through human-assisted pathways. Within North America, various pathways have been shown to spread the pest, at short or longer distances, especially nursery plants, logs with bark, and firewood (see 6). Hitchhiking on vehicles could also contribute to the spread (see 2. entry).

11.3 Estimates of spread and expected spread within the EPPO region

Prasad *et al.* (2010) estimated the spread (natural and short-distance movement assisted by humans) in the USA in 1998-2006 to be 20 km per year. In the European part of Russia, having investigated the western edge of the spread of *A. planipennis*, Baranchikov & Kurteev (2012) estimate the spread rate at 10 km per year since its introduction. The pest is expected to spread slowly but continuously from where it occurs in the Moscow region to countries further west. Since its introduction (end of the 1980s-beginning of the 1990s), *A. planipennis* has spread 250 km west of Moscow. The distance between Moscow and Belarus (the closest country westward) is approximately 400-450 km. Baranchikov & Kurteev (2012) estimate that *A. planipennis* will reach the western border of Russia at the latest by 2020 (presumably by a combination of natural and human-assisted spread).

Human-assisted spread may lead to multiple establishment areas in different parts of the EPPO region, from which spread would in turn occur naturally and through human assisted means (including hitch-hiking, as shown in North America). The pest is difficult to detect (see under 2), and the pest may be well established before any action can be taken.

Because the pest is not likely to spread naturally to most EPPO countries in the next decade, and because there is a greater risk of human-assisted spread, pest risk management options are considered for all commodity pathways identified.

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

12. Impact in the current area of distribution

A. planipennis causes serious direct damage by killing ash trees, resulting in loss of forest products, and losses in timber sales (McKenney *et al.*, 2012 citing others). *A. planipennis* has a preference for stressed trees in its native range, although it also attacks healthy trees especially in its introduced range. It also has environmental impacts (ecosystem services, landscape). Finally, social impacts have also occurred (need for removal of trees, effects on culture and traditions, decreased property value, effects on aesthetics through loss of ornamental trees in the landscape, loss of noise reduction effects, loss of effects against wind, impact on human health, loss of benefits of urban shade (e.g. resulting in increased air conditioning costs) (Kovacs *et al.* 2010; Lyons & Scarr, 2010).

A. planipennis does not greatly affect the quality of the hardwood because it only infests the bark and the outer sapwood (Brashaw *et al.*, 2012). In areas where it is regulated, the end uses of the wood and possibilities for sale are more restricted. It also kills trees prior to maturity and may necessitate further additional processing. Where massive mortality has occurred, the market for ash products has become depressed.

Some of these effects are described below.

Death of trees

This has been reported for all *Fraxinus* spp. in the introduced range. In the USA in Michigan and Ohio alone, *A. planipennis* has killed tens of millions of ash trees (Mc Cullough *et al.*, 2011). In forests in Ohio, Michigan and Pennsylvania, ash mortality in areas studied reached nearly 100 % regardless of initial ash density, size, habitat, or diversity; a forest stand can progress from nearly all healthy trees to nearly all dead ash trees within 6 years (Knight *et al.* 2010). Similar levels of near 100% tree mortality have occurred in Ontario, Canada, some 63 000 hectares of woodlots and forested areas affected by the end of 2011 (Scarr *et al.*, 2012) It has also killed trees in European Russia, and caused mortality of North American *Fraxinus* species planted in Far-East Russia and China. Liu *et al.* (2003) indicate that, in China, "*Fraxinus americana* is no longer planted in China and *F. pennsylvanica* occurs only in localized areas because of past *A. planipennis* attack". In North America, *A. planipennis* has infested and killed trees in open settings and forests. Tree death occurs in 1-4 years of colonization, and may occur in 1-2 years in outbreak situations. Situations from healthy to almost complete mortality have been observed within 6 years (i.e. 5 years from first trapping, or 4 years from first observation of exit holes). *A. planipennis* is killing healthy trees on high quality sites (Rebek *et al.*, 2008, citing others).

Potential future damage and projected costs

Costs of removal, replacement and treatment have been estimated by studies in the USA and Canada.

In the USA, using simulations of spread in 2009-2019, Kovacs *et al.* (2010) estimated that these costs would concern more than 17 million trees (on developed land) for 25 States and amount to EUR 7.9 billions (USD 10.7 billion) (the total number of ash trees on developed land in these States was estimated to be 37.9 million).

In Canada, McKenney *et al.* (2012) estimated costs of removal and replacement to be EUR 195-868 million (265-1177 million Canadian dollars) depending on spread and treatment) for 30 years (332-1476 million EUR (451-2001 million Canadian dollars) when including backyard trees), estimating that there are 545 000 ash trees in Eastern Canada and 684 000 in Western Canada only in communities ("street" trees).

Environmental impact

Attacks by *A. planipennis* in riparian forests (along streams and ponds), ravines and wetlands may have environmental effects. Ecosystem services may be affected such as water regulation, shore stability, reduction of erosion. Death of trees in riparian environments is likely to affect water quality by leading to increased run-off of nutrients and contaminants, together with higher organic matter inputs into water bodies. Degradation of habitats sustaining biodiversity (e.g. effects on ash specialists; Gandhi and Herms, 2010), impacts on biodiversity in agricultural landscapes and destruction of ecocorridors for other species may also occur (Lyons & Scarr, 2010; McKenney *et al.*, 2012). Initial attempts to eradicate *A. planipennis* by removing ash trees within 800 m of infested trees has led to further disturbance caused by changes in abiotic factors (e.g., higher light environment and increased soil compaction), which can lead to secondary spread of invasive plant species (Hausman *et al.*, 2010).

Social impacts

Donovan *et al.* (2013) noted increased human mortality related to cardiovascular and lower-respiratory-tract illnesses in counties infested with the emerald ash borer in USA. *A. planipennis* threatens American Indian traditions, which rely on the use of ash wood for many purposes (Willow, 2011; EABINFO, 2012). It has also had an impact on the usual mode of using firewood in recreation areas in North America due to the restrictions on the movement of firewood into and out of regulated areas.

Possible options for control

The control measures applied in North America are applied mostly to amenity trees and not in forests (to the exception of the recent attempts to release natural enemies). The control methods aim at reducing the populations of the pest.

Chemical control

Chemical control is used mostly for high-value trees (e.g. urban trees, ornamentals). Because the USA and Canada each have their own independent pesticide registration systems, products registered in one country may not be registered or available in the other country. Combining the various approaches together, the following methods are used in North America (Herms *et al.*, 2009, referred to by EAB 2012 and CFIA 2012a; MDA, 2011; RA Haack and T Scarr, personal communications):

(1) systemic insecticides as soil injections or drenches (imidacloprid, dinotefuran) (also Rebek *et al.*, 2008; Smitley *et al.*, 2010);

(2) systemic insecticides as trunk injections (emamectin benzoate, once every 2-3 years; azadirachtin once every 2 years, imidacloprid annually) (also McKenzie *et al.*, 2010; McCullough *et al.*, 2011a). Trunk injections of emamectin benzoate and azadirachtin are currently the only methods that protect the trees for more than one year. They have proven to be very effective. Some trunk injury is incurred during the injection process but trees recover when treated with emamectin benzoate or azadirachtin.
(3) systemic insecticides as lower trunk sprays (dinotefuran; also imidacloprid McCullough *et al.*, 2011a)
(4) protective cover sprays that are applied to the trunk, main branches, foliage targeting adults and young larvae (permethrin, bifenthrin, cyfluthrin, carbaryl) (2 applications at 4-weeks interval; they need to be timed with adult activity, which is not easy to determine due to the absence of specific trapping methods).
The efficacy of imidacloprid when used as soil or trunk injections varies according to the formulation of the product (Herms *et al.*, 2009).

Injections or sprays are considered as valid methods to protect high-value trees and to prevent beetles from emerging from cut trees (McCullough *et al.*, 2011a, Petrice & Haack, 2006; Herms *et al.*, 2009). In forested areas, chemical insecticidal control is neither economically viable nor environmentally desirable (Poland, 2007). Some municipalities in Canada are treating hazard trees along trails and some trees in riparian areas using stem injections (T Scarr personal communication). Trunk or soil systemic injections or soil drenches could be used to prevent tree infestations (100% effective) or kill *A. planipennis* already present in trees (not 100% effective except for emamectin benzoate) (Petrice & Haack, 2006). The efficacy of systemic products will also depend on the size of the trees.

Microbial insecticides have also been investigated (*Beauveria bassiana*, *Metarhizium anisopliae*, Baranchikov *et al.*, 2008 citing Liu & Bauer, 2006; Castrillo *et al.*, 2010; Wang *et al.*, 2010). However, they do not seem to be recommended in practice; a formulation of *Beauveriana bassiana* was ineffective under high pest pressure (Herms *et al.*, 2009).

Biological control
An extensive amount of work in classical biocontrol has been done in North America on mass-rearing and release of parasitoids to reduce the populations of *A. planipennis*. Three parasitoids were collected in China, massed-reared and released in the USA (the larval parasitoids *Spathius agrili* and *Tetrastichus planipennisi*, and the egg parasitoid *Oobius agrili*). All three appear to be established in the USA (Duan *et al.* 2012a,b; Gould *et al.* 2012; RA Haack, personal communication). The impact of these species on the populations of *A. planipennis* is not yet known.

A number of other parasitoids reared from *Agrilus* are being investigated, such as *Spathius galinae* (originating from the Russian Far-East) (Yang *et al.*, 2012a; Belokobylski *et al.*, 2012). Several native species were also found attacking *A. planipennis* in North America (e.g. *Leluthia astigma* Kula *et al.*, 2010; *Atanycolus* spp. Duan *et al.*, 2012b; *Isaria farinosa* and *Purpureocillium lilacinum* [fungi] Johny *et al.*, 2012) and China (e.g. *Sclerodermus pupariae*, Yang *et al.*, 2012b). Lyons and Scarr (2010) report highly variable parasitism rates by several native and exotic parasitoid species (e.g. *Atanycolus planipennis*¸ *Phasgonophora sulcata*, and *Balcha indica*) ranging from 1.2% to 40.7%. The reasons for the variablity have not yet been determined, but the highest rates seem to occur after several years of *A. planipennis* infestation and after tree mortality has begun. These parasitoids are still being investigated for their use in augmentive or inundative biocontrol programs.
Entompathogic fungi have been investigated by searching for species attacking *A. planipennis* in trees and identifying strains that may be used in biocontrol programs (Lyons and Scarr 2010). A method for inoculating adult male *A. planipennis* in the field with a strain of *Beauveria bassiana* with the goal of eventually inoculating and killing adult females is now being explored (Lyons *et al.*, 2012). The potential for this method to actually reduce *A. planipennis* and protect ash tree health is not yet known, and the work is still quite experimental.

Woodpeckers are predators of *A. planipennis* in North America, European part of Russia and Asia (e.g. Wang *et al.* 2010, Duan *et al.*, 2010; Baranchikov *et al.*, 2008). In North America, the level of mortality caused by woodpeckers varies and their potential for control is limited by the territorial behaviour of the birds. Some studies observed high levels of mortality to late larvae, prepupae and pupae in North America (Duan *et al.*, 2010 citing Cappaert *et al.* 2005, Lindell *et al.* 2008). Duan *et al.* (2010) report mortality rates of 95% in some sites for large larvae and pupae, but as low as 3 % in other cases. Duan *et al.* (2012a) note that they are unlikely to be an important factor to regulate populations in Far-East Russia.

Management practices
The following management practices are mentioned in North America to limit the impact of the pest and its spread. However, these practices would not be sufficient to control the pest.

- *Disposal of infested ash material.* Grinding, chipping and heating can be used to kill immature stages in infested wood (McCullough *et al.*, 2007). Sprouting ash stumps produce foliage that support adults, and live stumps and larger sprouts may be colonized. Petrice & Haack (2011) recommend treatment with herbicide (triclopyr) to prevent sprouting of ash stumps. Alternatively, cutting stumps low to the ground (< 2.5 cm) would prevent most colonization.
- *Regular surveys and removal of infested trees*. In urban environments threatened by *A. planipennis*, the strategy used is to no longer plant ash trees, and start planting other tree species that will replace ash trees that will be killed by the pest (Lyons and Scarr, 2010).
- *Woodlot management prior to infestation.* In woodlots and forested areas composed of hardwoods or mixedwood forests with 30% or more ash components, Streit *et al.* 2012 recommend gradually reducing the ash component over several years through selective tree removal followed by natural regeneration or underplanting. This favours other species of trees, and controls the size and frequency of stand openings. It thereby encourages preferred non-ash trees species, and discourages invasive plants from moving in.

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

The pest is likely to have major direct economic losses, environmental impact and social impact, by causing high mortality of ash in the PRA area in landscapes, gardens, nurseries, urban areas, and forests. If the insect were to become established in the PRA area, the impacts in the PRA area would be expected to be similar to those in the European part of Russia or those in North America. The pest is difficult to detect (see under 2), and it might take several years before symptoms show, leading to a build up of pest populations.
In addition, *A. planipennis* is not possible to control on a wide scale. Control methods used in North America are detailed under 12. It would be difficult to apply control measures in forests in the PRA area, and amenity areas are also minimally managed. Control measures may provide adequate control in specific situations, such as in nurseries or on high-value ornamental trees, but would not prevent damage completely. The use of insecticides against *A. planipennis* may be effective but could be costly and have undesirable side effects. For practical and environmental reasons, the EPPO draft Standard on official control of *A. planipennis* (undated) recommends that chemical control is used in exceptional cases only (protection of historical and precious trees in public places). It is expected that control by natural enemies and woodpeckers that are present in the PRA area would not provide adequate control (Moraal, 2011). Mass-rearing and release of parasitoids may provide a control option to reduce the populations of *A. planipennis*, but needs further investigations and the appropriate authorizations before release.

Direct impact: death of trees: high
The pest is likely to cause high mortality of ash throughout the EPPO region, along with huge economic losses.

The native species *F. excelsior*, *F. angustifolia* and *F. ornus* are susceptible to *A. planipennis*, and several North American species, known as especially susceptible, are also used in the EPPO region as plantation trees or ornamentals. The susceptibility of other European species (*F. raibocarpa* and *F. xanthoxyloides)* is unknown but it is likely that they will also be susceptible.

As in North America, *A. planipennis* is likely to kill both healthy and stressed ash trees. In addition, in the EPPO region, several *Fraxinus* spp. are currently under threat of ash dieback, due to the fungus *Chalara fraxinea*. This disease stresses and ultimately kills ash trees. *Chalara fraxinea* has been spreading across Europe since the end of the 1990s (Webber & Hendry, 2012; Pautasso *et al.*, 2013) and is present throughout Poland, Denmark, Austria, Slovakia, and Germany. *F. excelsior* is especially threatened (Pautasso *et al.*, 2013). Ash is sometimes heavily attacked; for example, Webber & Hendry (2012, citing others) mention 80% of ash stands in Poland were affected by the fungus and over 30000 ha of *F. excelsior* stands in Lithuania were affected by ash dieback by 2002, resulting in mortality of approximately 60% of all ash stands in the country. Attacks by *Chalara fraxinea* may lead to increases in the damage by *A. planipennis* by weakening or stressing the trees and making them more attractive to *A. planipennis*.

Environmental impacts: high

In addition to the major environmental effects mentioned under 12 (e.g. biodiversity, ecosystem processes), *A. planipennis* will add to the stress of *Fraxinus* spp. where *Chalara fraxinea* occurs. It will attack the native species *F. excelsior* and may attack the other native *Fraxinus* spp. (although their host status is currently unknown). It may also attack endangered species e.g. *F. sogdiana* (a subspecies of *F. angustifolia*; Wallander, 2012) in Central Asia (Eastwood *et al*., 2009).

Fraxinus is used in the EPPO region in sensitive environments, such as riparian and mountains areas, for example for water management, conservation purposes, and prevention of erosion. These environments will be affected. Any pesticide use may have an impact on the environment. Lyons & Scarr (2010) note that imidacloprid (one of the insecticides recommended against *A. planipennis*) may inhibit leaf litter decomposition processes, and may also have an effect in ecologically sensitive areas (along waterways, wetlands, etc.). In forests, possible measures (cutting-down infested trees, clear cuts) may affect ecosystem functioning.

Social impact: locally high

There may be similar impacts on human health as observed in the USA (Donovan *et al*., 2013). Establishment of *A. planipennis* may result in potential loss of certain recreational areas, such as parks or forests. Infested trees in gardens, cities and amenity areas will first affect the aesthetic value of amenity trees, and may also have to be felled and replaced. Decrease of property value may occur. Loss of shade trees around buildings will result in reduced aesthetics and higher air conditioning costs.

In addition, *Fraxinus* has a cultural significance in European countries. Ash is present in the Northern European folklore as: Yggdrasil, the World Tree that holds the universe together in the Norse mythology; three of the five legendary guardian trees of Ireland; and as possessing a range of protective and healing properties in the British folklore. The bark of ash trees was used in the past, among others, against malaria (Pautasso, 2013; Hulden, 2011). Attacks to *F. xanthoxyloides* will reduce the fodder resources available (El Aich, 1998). Finally, in Ireland, ash wood has been used throughout the history for making hurleys (sticks used in the Gaelic sport hurling). Approximately 350 000 hurleys are produced each year, about 65 per cent of which are made from imported ash. *Chalara fraxinea* and measures put in place against it have raised concerns on whether such production can continue, and the introduction of *A. planipennis* would also have an impact on hurley manufacture (Teagasc, 2006; Irish Times, 2012).

Costs likely to be incurred by the introduction of *A. planipennis* (other than direct costs linked to the impacts above)

- General costs: surveillance and monitoring, eradication and containment efforts.
- In forests: additional costs would be incurred by pest surveillance (including sampling), removal of infested trees and destruction or processing, sanitation practices where applicable, and possible phytosanitary measures applied to wood for export specifically for *A. planipennis*.
- In nurseries: control operations, destruction of infested trees, loss of markets for trees already in production, initial costs of shifting to producing alternative species.
- In landscapes and gardens: additional costs of surveillance, removal of infested trees and destruction, cost of replacing trees.
- Possible loss of export markets
- Research: natural enemies, wasps for biosurveys, pesticides, host susceptibility
- Mass-rearing and release of natural enemies (including risk assessment prior to release) and wasps for biosurveys.
- Outreach and education are especially important for *A. planipennis* to ensure the cooperation of the public in extensive eradication or containment programmes.

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

Rating of the magnitude of impact in the area of potential establishment	*Low* □	*Moderate* □	*High* ✓
Rating of uncertainty	*Low* ✓	*Moderate* □	*High* □

14. Identification of the endangered area

Fraxinus spp. are present throughout the EPPO region, including Russia, the southernmost part of Finland, Norway, and Sweden, although *Fraxinus* is more widespread (and with a larger number of species) in the north, central and eastern parts of the EPPO region. Impact is likely to occur throughout the natural and planted range of ash in the EPPO region.

15. Overall assessment of risk

The likelihood of entry is considered as moderate, and the likelihood of establishment as high. Where it is introduced, the pest is likely to cause major losses and environmental impact, and some social effects. Long-distance spread will be via human-assisted pathways, although natural spread will happen but at a slower pace. Where *A. planipennis* is introduced, it will have massive impact, and eradication or containment will be difficult and costly, and very unlikely to be successful. Phytosanitary measures have therefore been considered for all the commodity pathways identified.

Stage 3. Pest risk management

16. Phytosanitary measures

The EWG discussed which plant genera should be recommended for phytosanitary measures at import. *A. planipennis* attacks only *Fraxinus* spp. in North America and Russia, and has not been found to develop in other genera to date even after 99% or more of the ash trees in an area have been killed. From Japan and Korea, there are records that *Juglans mandshurica*, *Juglans ailanthifolia*, *Pterocarya rhoifolia*, *Ulmus davidiana* are hosts (see section 7). Other host records from Japan and Korea may indicate that the *A. planipennis* populations in Korea and Japan represent a subspecies, but some experts now consider that some the original host records reported in Japan and Korea are doubtful (see section 7). However, the EWG recommends a precautionary approach and suggests that measures applied to *Fraxinus* species also be applied to *Juglans mandshurica, Juglans ailanthifolia, Pterocarya rhoifolia, Ulmus davidiana* from Japan, the Republic of Korea, and the Democratic Republic of Korea.
The following management measures were identified for the different pathways. The pathways for wood, wood waste, wood chips, plants for planting and bark are considered in details in Appendix 2. Measures for furniture and cut branches were taken among those identified for other pathways. These measures are recommended for an importing country where the pest is not present. If the pest is present other measures may be considered (e.g. heat treatment).

Possible pathways *(in order of importance)*	Measures identified
Plants for planting of *Fraxinus* spp., *Juglans mandshurica*, *Juglans ailanthifolia*, *Pterocarya rhoifolia*, *Ulmus davidiana*	- PFA - see requirements below - growing under insect proof conditions (very specific conditions; officially controlled facilities, equivalent to quarantine facilities)
Wood with or without bark of *Fraxinus* spp., *Juglans mandshurica*, *Juglans ailanthifolia*, *Pterocarya rhoifolia*, *Ulmus davidiana*	- PFA - see requirements below - treatment (ionizing radiation) - removal of bark and 2.5 cm of outer sapwood in authorized facilities
Firewood	- PFA - see requirements below - treatment (ionizing radiation) - removal of bark and 2.5 cm of outer sapwood in authorized facilities
Waste wood	- PFA + storage and transport to prevent contamination by adults under control of the NPPO
Wood chips	- PFA + storage and transport to prevent contamination by adults under control of the NPPO

Bark and objects made of bark of *Fraxinus* spp., *Juglans mandshurica*, *Juglans ailanthifolia, Pterocarya rhoifolia*, *Ulmus davidiana*	- PFA - see requirements below
Wood packaging material (including dunnage) containing *Fraxinus* spp., *Juglans mandshurica*, *Juglans ailanthifolia*, *Pterocarya rhoifolia*, *Ulmus davidiana*	-Treated according to ISPM 15
Furniture and other objects made of untreated wood of *Fraxinus* spp., *Juglans mandshurica*, Juglans ailanthifolia, *Pterocarya rhoifolia*, *Ulmus davidiana*	- made from wood originating in a PFA (see requirements below) - treatment (ionizing radiation) - made from wood whose bark and 2.5 cm of outer sapwood has been removed in authorized facilities
Cut branches of *Fraxinus* spp,. *Juglans mandshurica*, *Juglans ailanthifolia*, *Pterocarya rhoifolia*, *Ulmus davidiana*	- PFA - see requirements below

The following requirements are recommended to establish and maintain a PFA for *A. planipennis*:

- A minimum distance of 100 km between the PFA and the closest known area where the pest is known to be present..
- To establish and maintain the PFA, detailed surveys and monitoring should be conducted in the area in the two years prior to establishment of the PFA and continued every year. Specific surveys should also be carried out in the zone between the PFA and known infestation to demonstate pest freedom. The surveys should be targeted for the pest and should be based on appropriate combination of trapping, branch sampling and visual examination of host trees.
- Surveys should include high risk locations, such as places where potentially infested material may have been imported.
- There should be restrictions on the movement of ash material (originating from areas where the pest is known to be present) into the PFA, and into the area surrounding the PFA, especially the area between the PFA and the closest area of known infestation.

Eradication and containment

A. planipennis is extremely difficult to eradicate. The pest may fly long distances (see section 11. Spread) and detection is difficult (see under 2).

In North America, attempts to eradicate *A. planipennis* have not been successful. In particular, attempts to reduce *A. planipennis* populations by cutting large numbers of infested trees may reduce the ash resource available to the pest but may increase local spread (Mercader *et al.*, 2011b). It is also known that the pest can fly long distances in the absence of its host, and that the 800 m ash-free zones which were used in earlier eradication attempts were not sufficient (Taylor *et al.*, 2010). The insect appears to been able to fly from Michigan across the Detroit and St. Clair rivers into Ontario, indicating that waters bodies 1-3 kilometers in width are not a barrier to *A. planipennis*. Strategies are being developed in North America to slow the natural dispersal, population build up and local progression of ash mortality, in a context of established populations at sites that are relatively isolated from major infestations (SLAM project, Poland & McCullough, 2011). This involves:

- surveys to determine pest distribution and densities
- inventories and surveys for ash abundance and distribution,
- activities to suppress populations by removing infested trees (before adult emergence), insecticide treatments, ash utilisation or removal (harvesting for timber or firewood). Biological control was not yet a part of SLAM projects at that stage.
- regulatory measures,
- public information and outreach campaigns (support of residents and land owners).

This strategy was considered well-suited to isolated outlier sites.

In the EPPO region, the experience acquired in North America has been used to develop procedures for official control for the containment and eradication of *Agrilus planipennis* (draft EPPO Standard PM9 on *Agrilus planipennis*).[1]

17. Uncertainty

The main uncertainties are as follows:

- uncertainties on *Agrilus planipennis* taxonomy, especially in Korea, Japan, and Taiwan
- exact distribution and host range in the native range and in Russia (but this will only add to the risk already identified)
- appropriate heat treatment schedule to ensure nearly 100% mortality
- mode of production and size of wood chips in commercial facilities and survival of the pest
- volume of imports to the EPPO region of the different host commodities

18. Remarks

The EWG recommends research on the following topics, and encourages completion prior to any further expansion of *A. planipennis* within the EPPO region outside of Russia.

- Heat treatment schedules for ash logs and wood products to eliminate *A. planipennis.*
- Surveys for native natural enemies of *Agrilus* beetles within the EPPO region.
- Surveys for buprestid-hunting wasps in the EPPO region similar to the sphecid wasp *Cerceris fumipennis* in North America,
- Development of improved detection methods or tools
- Assessment of the efficacy of wood chipping and grinding under operational conditions for reducing the risk of *A. planipennis* being introduced in wood or bark chips
- Evaluating the susceptibility and vulnerability of ash species native to the EPPO region to attack by *A. planipennis*.
- Elucidating the tolerances of *A. planipennis* to the high air temperatures it may encounter in the southern parts of the EPPO region, and to the low air temperatures in the northern parts of the EPPO region.

[1] See Standard PM 9 (document 13-18592) under agenda point 8.4.1 presented for approval.

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Appendix 1. Relevant illustrative pictures (for information)

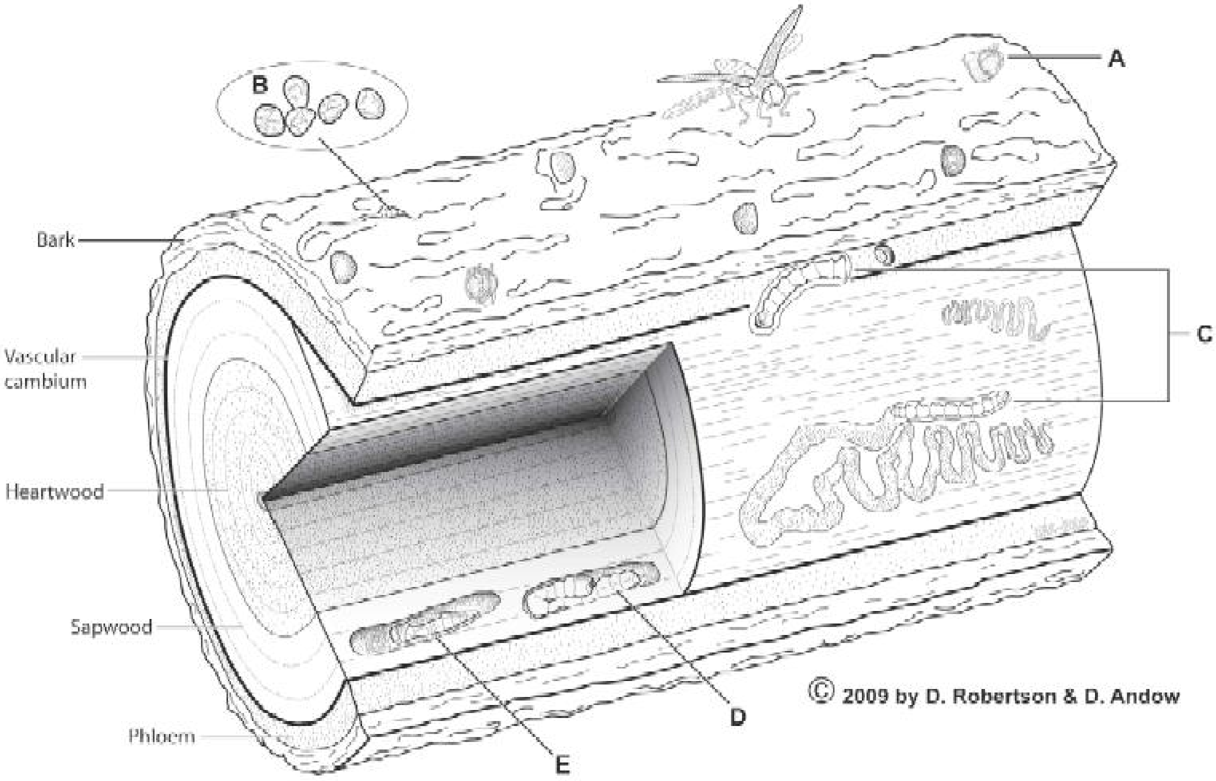

Illustration of *A. planipennis* biology (from Robertson and Andow, 2009)
Emerald ash borer biology. A: Adults typically emerge from ash (*Fraxinus* spp.) trees from May through August leaving 3-4mm wide D-shaped exit holes (Brown-Rytlewski and Wilson 2005, Haack *et al.* 2002). After approximately 5-7 days of extensive feeding on ash foliage, mating begins (Poland and McCullough 2006).
B: Females lay approximately 50-90 eggs during their lifetime (3-6 weeks), deposited individually in bark crevices along the trunk and lower portions of major branches (Haack *et al.* 2002, Poland and McCullough 2006).
C: Eggs hatch within 2 weeks at which time larvae begin feeding on the inner bark (phloem) and outer sapwood (xylem) of ash trees from midsummer through autumn, leaving serpentine-shaped galleries packed with frass (Cappaert *et al.* 2005, Haack *et al.* 2002, Poland and McCullough 2006).
D: After 4 larval instars, completed in autumn, most EAB overwinter as prepupae in cells excavated about 1 cm deep into the sapwood or outer bark (Cappaert *et al.* 2005, Haack *et al.* 2002, Poland and McCullough 2006). E: Pupation occurs the following spring (April thru May), with adult emergence occurring about 3 weeks later (Cappaert *et al.* 2005, Poland and McCullough 2006). In low-density populations or colder regions, multi-year development may occur with young larvae overwintering in the cambial region, completing development the following summer, and then emerging after overwintering for a second time (Cappaert *et al.* 2005, Haack *et al.* 2002, Poland and McCullough 2006).

Appendix 2. Detailed Stage 3: Pest Risk Management

7.01 - Is the risk identified in the Pest Risk Assessment stage for all pest/pathway combinations an acceptable risk?
no

7.02 - Is natural spread one of the pathways?
yes

7.03 - Is the pest already entering the PRA area by natural spread or likely to enter in the immediate future?
no
The pest is present in the region of Moscow, and is spreading westwards. See section 11. Although it may reach other countries of the PRA area in some years (Baranchikov and Kurteev, 2012 estimated that it will reach the western border of Russia in 2020), the pest is more likely to reach the rest of the PRA area through human-assisted pathways in the short-medium term.

Pathway 1: Wood of *Fraxinus*

7.06 - Is the pathway that is being considered a commodity of plants and plant products?
yes

7.09 - If the pest is a plant, is it the commodity itself?
no (the pest is not a plant)

7.10 - Are there any existing phytosanitary measures applied on the pathway that could prevent the introduction of the pest? (if yes, specify the measures in the justification)
no
Level of uncertainty: **medium**
There are already efficient measures in place in some EPPO countries (see below) but not for all of them (e.g. Eastern Europe). The following requirements were found in the EU Directive and EPPO collection of phytosanitary regulations/summaries:

EU	Wood (round or squared) of *Fraxinus*, *Juglans mandshurica*, *Ulmus davidiana*, *Ulmus parvifolia* and *Pterocarya rhoifolia*, including wood which has not kept its natural round surface, from Canada, China, Japan, Mongolia, Republic of Korea, Russia, Taiwan and USA	(a) origin in a PFA; or (b) squared so as to remove entirely the round surface.
Israel (Israel, 2009a)	wood	debarked and the consignment should undergo vapour treatment, with either phosphine or methyl bromide
Turkey (Turkey, 2007)	imported industrial wood, logs and roots Timber of non-coniferous species	fumigated or should be stripped of their bark. a) their bark stripped and they shall be free from harmful organisms; b) have undergone kiln-drying to below 20% moisture content, expressed as a percentage of dry matter, achieved through an appropriate time/temperature schedule

The fact that the wood is debarked or treated to prevent the introduction of the pest. The questions of section 7 of PM 5/3 are systematically answered to reevaluate measures in place and identify measures for countries which do not yet have any.

For reference, Canada and USA regulate their trade with each other as follows:

Canada (CFIA, 2012b) regulates the following commodities from regulated States in the USA:

- *Firewood*: prohibited
- *Ash logs (= round wood, with or without bark) and branches > 1.5 cm in diameter*:
  - Import, processing and safe disposal of waste material in Low Risk Season only (October 1-March 31): permit
  - Prohibited the rest of the year
- *Ash lumber (=sawn wood, round or not, with or without bark)*
  - Low Risk Season only (October 1-March 31): Permit and delivered to approved facility
  - PC + "harvested/produced in a county where *A. planipennis* is not known to occur based on official surveys." OR "bark free including the vascular cambium (to a depth of 2.5 cm), free of *A. planipennis* and free of signs of *A. planipennis* (exit holes or serpentine galleries)." OR "heat treated to attain a minimum core temperature of 56°C throughout the profile of the wood (including the core) for a minimum of 30 minutes."
- *Ash branches < 1.5 cm in diameter*: PC + " no more than 1.5 cm in diameter and harvested in a county where *Agrilus planipennis* is not known to occur based on official surveys."

USA (USDA-APHIS, 2012d)

- *Firewood*: heat treated (HT) at 60 °C (minimal core temperature) for 60 minutes
- *Ash logs* and *ash lumber with pieces of bark attached*:
  - from counties regulated for *A. planipennis:* PC and either "debarked and vascular cambium removed to a depth of 1.27 cm during the debarking process." Or "fumigated with methyl bromide T404-b-1-1" or "heat treated at a temperature of at least 71.1 °C for a minimum of 75 minutes as specified in T314-a" or "kiln dried - T404-b-4".
  - from counties not regulated for *A. planipennis* but located within a regulated province or territory: PC + "The articles in the shipment were produced/harvested in a county where *A. planipennis* does not occur, based on official surveys."
  - from provinces/territories not regulated for EAB: importer document that certifies that the articles are not from an area known to be infested by EAB
- *Ash lumber without bark*: no requirements.

Options at the place of production

7.13 - Can the pest be reliably detected by visual inspection at the place of production

no

Level of uncertainty: **low**

Detection of low level populations would be difficult (see under 2). The insect develops inside the trees.

7.14 - Can the pest be reliably detected by testing at the place of production?

no

Level of uncertainty: **low**

Sampling can be done on trees, but this does not guarantee that the pest would be detected.

7.15 - Can infestation of the commodity be reliably prevented by treatment of the crop?

no

Level of uncertainty: **low**

Treatment is not possible in forests.

7.16 - Can infestation of the commodity be reliably prevented by growing resistant cultivars?

no

Level of uncertainty: **low**

All ash species are believed susceptible to some degree. No resistant species or cultivar of ash has been identified.

7.17 - Can infestation of the commodity be reliably prevented by growing the crop in specified conditions (e.g. protected conditions such as screened greenhouses, physical isolation, sterilized

growing medium, exclusion of running water, etc.)?

no

Level of uncertainty: **low**

This is not relevant for forestry.

7.18 - Can infestation of the commodity be reliably prevented by harvesting only at certain times of the year, at specific crop ages or growth stages?

No

Level of uncertainty: **low**

Only late larval stages, pupae and callow adults are likely to survive in cut wood. However, all stages of the pest might be present on the bark or in the wood throughout the year. So, even when most larvae would be in the early instars, there might be some mature larvae or pupae from the previous generation in the trees at harvest.

7.19 - Can infestation of the commodity be reliably prevented by production in a certification scheme (i.e. official scheme for the production of healthy plants for planting)?

no

Level of uncertainty: **low**

Not relevant for forestry.

7.20 - Based on your answer to question 4.01, select the rate of spread.

high rate of spread (>10 km per year)

Level of uncertainty: **low**

Possible measure: pest-free place of production or pest free area

7.21 - The possible measure is: pest-free place of production or pest free area
Can this be reliably guaranteed?

yes

Level of uncertainty: **low**

In Russia or North America, the pest is not present throughout the range of ash, and it may be possible to establish and maintain a PFA, according to ISPM 4. This is also an option at the moment in the EU requirements. To provide a high level of assurance of pest freedom, the following requirements are recommended to establish and maintain a PFA for *A. planipennis*:

- A minimum distance of 100 km between the PFA and the closest known area where the pest is known to be present..
- To establish and maintain the PFA, detailed surveys and monitoring should be conducted in the area in the two years prior to establishment of the PFA and continued every year. Specific surveys should also be carried out in the zone between the PFA and known infestation to demonstate pest freedom. The surveys should be targeted for the pest and should be based on appropriate combination of trapping, branch sampling and visual examination of host trees.
- Surveys should include high risk locations, such as places where potentially infested material may have been imported.
- There should be restrictions on the movement of ash material (originating from areas where the pest is known to be present) into the PFA, and into the area surrounding the PFA, especially the area between the PFA and the closest area of known infestation.

Pest-free place of production is not a possible option. Due to the biology of the pest, and that detection is difficult (especially at early stages), it would not be possible to guarantee that a place of production is free from the pest. This is consistent with the experience in North America where the requirements between USA and Canada are based on regulated areas.

Options after harvest, at pre-clearance or during transport

7.22 - Can the pest be reliably detected by a visual inspection of a consignment at the time of export, during transport/storage or at import?

No

Level of uncertainty: **low**
The cryptic nature of the pest (life stages can be in the wood) makes it difficult to detect without inspecting the whole consignment. If bark is attached, it would have to be peeled off to detect the pest. Visual inspection could allow detection of some signs of infestation (e.g. larval galleries, exit holes – see under 2), but would not be sufficient. Mechanical debarking may obscure galleries, which would reduce reliability of visual inspection. Finally only a percentage of consignments would be visually inspected.

7.23 - Can the pest be reliably detected by testing of the commodity (e.g. for pest plant, seeds in a consignment)?
no
Level of uncertainty: **low**
There are methods that can detect wood-boring larvae in wood, branches, stems or roots (e.g. x-rays, acoustic methods, systematic destructive sampling, trained dogs, see Goldson *et al.*, 2003) but they are not fully developed, and they cannot be applied currently.

7.24 - Can the pest be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)?
yes as stand-alone measure
Level of uncertainty: **low**
Possible measure: specified treatment of the consignment

EPPO recommends two treatments for wood with or without bark against wood-related insects (including Buprestidae):

- Ionizing radiation: see EPPO Standard PM 10/8 *Disinfestation of wood with ionizing radiation*, EPPO (2008c). In EU (under development, relating to *A. anxius*), this treatment is retained with a minimum absorbed dose of 1 kGy throughout the wood.

- Heat treatment until the core temperature reaches at least 56°C for at least 30 minutes (EPPO Standard PM 10/6 *Heat treatment of wood to control insects and wood-borne nematodes*, EPPO (2008a)). There has been much debate in recent years regarding the efficient temperature and duration of heat treatment for *A. planipennis* in wood (see Appendix 6 for background).

- Nzokou *et al.* (2008), in a study on kiln and microwave heat treatments of logs, had a few *A. planipennis* survivor at 55°C and 60°C for 30 minutes.
- In another study with *A. planipennis*, heat treatment at 56°C (or 60°C) for at least 30 minutes was not 100% effective (Goebel *et al.*, 2010); however treatments in this study measured temperature at 2.5 cm into the firewood (i.e. where the pest is present) but not at the core.
- The *International Forestry Quarantine Research Group* discussed this issue (Lisbon, 2010-09-27/10-01) on the basis of recent research. The IFQRG concluded that the current schedule of 56°C for 30 minutes was adequate for ash and *A. planipennis.* In a study on heat treatment of wood, *A. planipennis* did not survive heat treatment of 56°C for 30 minutes at the core (RA Haack and TR Petrice, unpublished data). In experiments of Sobek *et al.* (2011), all *A. planipennis* life stages did not survive treatment at 56°C for 30 minutes at the core.
- Myers *et al.* (2009) estimated that an internal temperature of the wood of 60°C for 60 minutes was considered a minimum for a safe treatment to control *A. planipennis* in firewood. The USDA-APHIS treatment schedule for firewood T314-a was changed to 60°C core temperature for 60 minutes (USDA-APHIS, 2011). However efficacy of this treatment to allow import of wood from USA was considered by EFSA, and was not considered sufficient (EFSA, 2011).
- EFSA received another proposal by the USA (71.1 °C for 60 min), but this schedule could not be evaluated due to the lack of data (EFSA, 2012).

The EU did not retain heat treatment as an option for wood against *A. planipennis*, Canada uses the original schedule (56 °C for 30 minutes) and USA uses 60°C for 60 minutes for firewood but 71.1°C for 75 minutes for logs and lumber (USDA-APHIS, 2012c).

There are different opinions among the EWG members on what is the best duration and temperature for heat treatment for *A. planipennis*. Further research should be considered to identify the best temperature and duration of treatment for wood for the appropriate level of protection against *A. planipennis*. Heat treatment is not considered as a management option on its own at this stage because the minimal requirements have not been established.

The EWG also concluded that heat treatment at 56 °C for 30 minutes could not be recommended as a stand-alone measure for wood with bark to ensure 100% mortality. However, the EWG considered heat treatment at 56 °C for 30 minutes appropriate when used on debarked wood. The reasons for this difference are that the bark and cambial region will be removed during debarking (along with a high proportion of any *A. planipennis* individuals present), mechanical injury will kill other individuals, and debarking gives a greater guarantee of adequate heat penetration of the outer sapwood.
Taking into account all the above information including the EFSA opinion on the heat treatment, the Panel on Phytosanitary Measures considered that this combination of measures provides a lower level of protection and cannot be recommended for imported material from infested areas.
- Methyl bromide fumigation will be effective but only if there is no bark, see EPPO Standard PM 10/7 *Methyl bromide fumigation of wood to control insects,* EPPO (2008b). Fumigation is retained as an option for the USA (schedule T404-b-1-1). However, it is generally considered in EPPO that this option was not suitable given that this fumigant is now forbidden in EU countries, and EPPO should not encourage methyl bromide fumigation for non-essential uses.

- Sulfuryl fluoride fumigation (Barak *et al.,* 2010) was found effective at temperatures above 15.6°C. The EWG was not aware of commercial use of sulfuryl fluoride fumigation on wood.

- Kiln-drying. Kiln drying (schedule T404-b-4) is retained as an option for the USA. However, kiln-drying and microwave treatment experiments on logs by Nzokou *et al.* (2008) did not give 100% efficacy. Finally EUPHRESCO (2010) found that kiln-drying was not effective at eliminating all pests, unless the temperature reached 56 °C in the core for at least 30 minutes (See http://www.euphresco.org/downloadFile.cfm?id=664).

7.25 - Does the pest occur only on certain parts of the plant or plant products (e.g. bark, flowers), which can be removed without reducing the value of the consignment?
yes
Level of uncertainty: **low**
Possible measure: removal of bark and outer sapwood

Eggs are laid on the bark, early larval stages occur just below the bark in the cambial region, and 4th instar larvae, prepupae, pupae, and callow adults may occur in the outer sapwood. Both bark and the outer sapwood would need to be removed to ensure that the pest is not present. This would affect the value of wood with bark, such as veneer logs.

The current EU requirement is that the wood should be squared so as to remove entirely the round surface of the original log. This typically leads to the removal of 1.5 cm of sapwood which is why the depth does not need to be specified. It should be noted that there is a risk that pests could survive along the edges of squared wood because less sapwood would be removed at the edge. The current USA requirement is removal of the bark and an additional 0.5 inch (1.27 cm) of sapwood. The current Canada requirement is for bark free wood including the vascular cambium (to a depth of 2.5 cm) (combined with free of *A. planipennis* and free of signs of *A. planipennis*) (see 7.01).

Consequently the EWG proposes the following measure: removal of the bark and also of 2.5 cm of the outer sapwood. The facilities for undertaking the removal of the sapwood should be authorized by the NPPO, and there should be official inspections prior to export to verify compliance and absence of signs of infestation.

7.26 - Can infestation of the consignment be reliably prevented by handling and packing methods?
yes as stand-alone measure
Level of uncertainty: **low**
Possible measure: specific handling/packing methods

A long period of storage before export would ensure that no live stages of the pest are present in the wood. It may be considered that no adults will emerge 2 years after cutting (Petrice & Haack, 2006, Petrice & Haack, 2007). The pest cannot reinfest and develop in cut wood. Tarping of cut wood is not considered an effective control, and in fact under some circumstances the tarped wood maintained high humidity and actually favoured development, and increased emergence (Petrice & Haack, 2006).

If the wood is stored before export under suitable conditions for *A. planipennis* development for a minimum of 2 years under the control of the NPPO, this would ensure that the pest would emerge before export but there might be an impact on the quality of the wood.

The Panel on Phytosanitary Measures considered that given the difficulty to control the application of this measure in practice, it was not an appropriate option for imported material. However, the Panel on Quarantine Pests for Forestry considered that it may be applicable in the case of the outbreak in the EPPO region because the NPPO will be able to control the movement and use of the wood.

Options that can be implemented after entry of consignments

7.27 - Can the pest be reliably detected during post-entry quarantine?
no
Level of uncertainty: **low**
Post-entry quarantine is not practical for wood.

7.28 - Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the PRA area, or limited periods of entry, and can such limitations be applied in practice?
no
Level of uncertainty: **medium**

Wood for processing (e.g. furniture, pulpmills, fuel wood for energy production) could be imported to approved facilities under the control of the NPPO during periods of the year outside of the flight period of *A. planipennis*. The appropriate period will depend on the origin, destination and storage conditions. For example, Canada identifies the low risk season for imports from regulated areas in the USA as October 1-March 31.

Imported material would need to be processed before temperatures would allow emergence and flight of the pest.

This measure will be possible only if the end use can be guaranteed and verified. It would not be possible for firewood used by individuals, which might be stored before use. Waste or by-products from this wood should also be managed before the next flight period in such a way as to prevent adult emergence. The specifications of the requirements (including the allowed period of import) need to be done on a case by case basis depending on the origin and the country of destination.

The Panel on Phytosanitary Measures considered that given the difficulty to control the application of this measure in practice, it was not an appropriate option for imported material. However, the Panel on Quarantine Pests for Forestry considered that it may be applicable in the case of an outbreak in the EPPO region because the NPPO will be able to control the movement and use of the wood and define the flight period of the pest.

7.29 - Are there effective measures that could be taken in the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts?
no
Level of uncertainty: **low**
Surveillance might allow detection of *A. planipennis*, but detection is likely to occur when the pest is already established (see under 2.).

7.30 - Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?

yes

Q.	Standalone	Systems Approach	Possible Measure	Uncertainty
7.20	X		pest free area	low
7.24	X		specified treatment of the consignment (irradiation)	low
7.25	X		removal of parts of plants from the consignment	low

7.31 - Does each of the individual measures identified reduce the risk to an acceptable level?
yes
Level of uncertainty: **low**
For wood with or without bark:
- PFA
- treatment (ionizing irradiation)
- removal of bark and of 2.5 cm of the outer sapwood

7.34 - Estimate to what extent the measures (or combination of measures) being considered interfere with international trade.
Level of uncertainty: **low**
Measures are already in place in the EU regarding *A. planipennis.* Measures might affect the quality of the wood (removal of the outer sapwood). Trade in ash wood seems quite small, so interference would not be major.

7.35 - Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.
Level of uncertainty: **low**
Treatment for low quality wood may not be cost-effective. Removal of outer sapwood would result in loss of some of the product.

A. planipennis would be very difficult to eradicate, and contain if introduced, therefore it is essential to take measures to prevent its introduction.

7.36 - Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences?
Yes, as in 3.31

Pathway 2: Waste wood and wood chips

7.06 - Is the pathway that is being considered a commodity of plants and plant products?
yes

7.09 - If the pest is a plant, is it the commodity itself?
no (the pest is not a plant)

7.10 - Are there any existing phytosanitary measures applied on the pathway that could prevent the introduction of the pest?
no
Level of uncertainty: **low**

There are some measures in place in some EPPO countries (see below) but not for all of them (e.g. Eastern Europe). There is no measure in place that would prevent introduction for the whole EPPO region. The following requirements were found in the EU Directive and EPPO collection of phytosanitary regulations / summaries:

EU	Wood chips obtained in whole or part from *Fraxinus*, *Juglans mandshurica*, *Ulmus davidiana*, *Ulmus parvifolia* and *Pterocarya rhoifolia* from Canada, China, Japan, Mongolia, Republic of Korea, Russia, Taiwan and USA	(a) origin in a PFA; or (b) processed into pieces of not more than 2.5 cm thickness and width.
Israel (Israel, 2009a)	Wood chips	PC + (1) The woodchips do not include bark; (2) The consignment has undergone a vapour treatment with methyl bromide in accordance with the requirements detailed in the treatment manual (exposure for 16 hours, at 48g/m^3 at 21°C or more, or at 80g/m^3 at 10-20°C)
Turkey (Turkey, 2007)	woodchips of broadleaved (hardwood) trees	produced from wood that has been fumigated or stripped of its bark, or has been dried to below 20% moisture content, expressed as a percentage of dry matter.

Even if inspection was carried out, it is unlikely to detect the pest, as:
- wood chips might contain several tree species
- signs of presence of the pest in wood (e.g. galleries) would not be easy to observe.
Sampling rates for a possible detection of such pests in wood chips have not been defined but large samples would be needed to be confident that *A. planipennis* is not present (Økland *et al.*, 2012).

For reference, Canada and USA regulate their respective imports of wood chips as follows:

USA (USDA-APHIS, 2012d) for ash wood chips or bark chips from Canada:

- From counties regulated for *A. planipennis*. Chips larger than 1 inch in diameter: prohibited.
- From counties regulated for *A. planipennis*. Chips 1 inch or less in diameter: permit and PC.
- from counties not regulated for *A. planipennis* but located within a regulated Province or Territory: accompanied by an Import Permit (IP) and a Phytosanitary certificate (PC) with an additional declaration (AD) stating that “The material in this consignment was produced/harvested in a county where emerald ash borer (*Agrilus planipennis*) does not occur, based on official surveys
- from provinces or territories **not** regulated for *A. planipennis*: accompanied by an importer document that certifies that the articles are **not** from an area known to be infested by *A. planipennis*

Canada (CFIA, 2012b) for ash wood/bark chips from regulated areas of the USA:

- PC + "The wood/bark chips in this consignment are less than 2.5 cm in any two dimensions." In practice, at inspection it would be verified that this requirement is met, but in addition the size of the third dimension should not significantly exceed 2.5 cm. If long chips are observed, inspectors are likely to reject the consignment. (T. Scarr, personal communication)
- in Low Risk Season only (October 1- March 31) (and processed before the end of that period, in approved facilities): permit.

Options at the place of production

7.13 - Can the pest be reliably detected by visual inspection at the place of production?
no
Level of uncertainty: **low**
As for wood.

7.14 - Can the pest be reliably detected by testing at the place of production?
no
Level of uncertainty: **low**
As for wood

7.15 - Can infestation of the commodity be reliably prevented by treatment of the crop?
no
Level of uncertainty: **low**
As for wood.

7.16 - Can infestation of the commodity be reliably prevented by growing resistant cultivars?
no
Level of uncertainty: **low**
As for wood.

7.17 - Can infestation of the commodity be reliably prevented by growing the crop in specified conditions (e.g. protected conditions such as screened greenhouses, physical isolation, sterilized growing medium, exclusion of running water, etc.)?
no
Level of uncertainty: **low**
As for wood.

7.18 - Can infestation of the commodity be reliably prevented by harvesting only at certain times of the year, at specific crop ages or growth stages?
no
Level of uncertainty: **low**
As for wood.

7.19 - Can infestation of the commodity be reliably prevented by production in a certification scheme (i.e. official scheme for the production of healthy plants for planting)?
no
Level of uncertainty: **low**
Not relevant for forestry.

7.20 - Based on your answer to question 4.01, select the rate of spread.
high rate of spread (>10 km per year)
Level of uncertainty: **low**
Possible measure: pest-free place of production or pest free area

7.21 - The possible measure is: pest-free place of production or pest free area. Can this be reliably guaranteed?
Yes, but only for pest free area
Level of uncertainty: **low**
As for wood

Options after harvest, at pre-clearance or during transport

7.22 - Can the pest be reliably detected by a visual inspection of a consignment at the time of export, during transport/storage or at import?

yes in a systems approach
Level of uncertainty: **low**
Signs of presence of the pest in wood chips (e.g. galleries) would not be easy to observe. Sampling rates for a possible detection of such pests in wood chips have not been defined but large samples would be needed to be confident that *A. planipennis* is not present (Økland *et al.*, 2012). However, inspection of the consignment may allow to check the size of the chips (see 7.24)

7.23 - Can the pest be reliably detected by testing of the commodity (e.g. for pest plant, seeds in a consignment)?
no
Level of uncertainty: **low**
As for wood.

7.24 - Can the pest be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)?
no
Level of uncertainty: **low**
Chipping down to a certain size (with screen smaller than 2.5 cm) is considered effective against *A. planipennis* (McCullough *et al.*, 2007, USDA-APHIS, 2010). The current EU requirement for wood chips against *A. planipennis* is that the wood “has been processed into pieces of not more than 2.5 cm thickness and width” (EU, 2000), in Canada it is that the wood/bark chips in this consignment are less than 2.5 cm in any two dimensions (with additional action at inspection – see 7.10), in the USA that chips are 1 inch (2.5 cm) or less in diameter (see 7.01).

The EWG noted that in the study by McCullough *et al.*, (2007), the chips obtained with a 2.5 cm screen were substantially smaller than 2.5 cm in two dimensions (1.1 x 0.4 cm). This was also an experimental study and it is not known how wide-scale commercial production of wood chips could comply with size requirements for wood chips. The EWG concluded that there is no evidence that chips of 2.5 cm in two dimensions are completely safe.

The EWG discussed whether a possible measure could be to specify the screen size (2.5 cm) instead of the chip size. However, using similar screen size as used in the above study, it was not known whether similar small chip size would be obtained in other types of chippers and grinders. Consequently this option is not recommended.
Other treatments could be effective but their practical implementation should be defined based on further research. New Zealand regulates wood chips, sawdust and wood for a number of pests, including *Agrilus sexsignatus* (MAF, 2003). Wood pieces should be either no larger than 15 mm in length and 10 mm in cross-section, or no greater than 3 mm in cross-section if longer than 15 mm. Treatment options required for import in New Zealand are either heat treatment or fumigation as outlined below:
- heat treatment. It has been shown that heat treatment at 55°C for 120 minutes applied to wood chips does not kill all prepupae (overwintering 4th larval stage) of *A. planipennis* (McCullough *et al.*, 2007). No prepupae survived exposure of 60°C for 120 minutes. In logs, there is some uncertainty on the best duration and temperature for an completely effective treatment (see 7.24 for wood). In New Zealand heat treatment of wood chips for at least 4 hours at a minimum core temperature of 70°C is required to destroy a range of wood boring pests including *A. sexsignatus*.
- fumigation. In New Zealand, requirements for wood chips against insects are methyl bromide or sulphuryl fluoride fumigation (80 g/m^3), in separate units no larger than 2 m^3, for more than 24 continuous hours at a minimum temperature of 10°C. In Israel (Israel, 2009b), methyl-bromide fumigation is required against internal and external pests for 16 hours at 80 g/m^3 at 10-20°C or at 48g/m^3 for 16 hours at 21°C or more (see question 7.10 for this pathway). The EWG was not aware of commercial use of sulfuryl fluoride fumigation for wood chips.

- irradiation. As irradiation is considered effective to destroy wood boring insects in wood (EPPO Standard PM 10/8, EPPO (2008c)), it might also be used for wood chips, although this might be difficult to apply in practice for a large quantity of chips. It would likely be too expensive for such a low value commodity.

Given the increase in international trade of wood chips, the EWG recommended a general study on the pest risks associated with wood chips, based on literature and communication with the wood chip industry, in order to consider issues such as:
- current practices in the production, trade and use of wood chips,
- pest risks associated with wood chips,
- possible measures that could be applied for wood chips,
- gaps in knowledge for developing such measures.

7.25 - Does the pest occur only on certain parts of the plant or plant products (e.g. bark, flowers), which can be removed without reducing the value of the consignment?
no
Level of uncertainty: **low**
The pest occurs in or under the bark and in the outer sapwood. If the wood chips are made from wood debarked and with the outer sapwood removed to a depth of 2.5 cm (with additional requirements as for 7.25 for wood), it would reduce the risk that the pest occurs. However, this is probably not practical or economic.
The Panel on Phytosanitary Measures considered that this measure was not realistic due to the cost of debarking compared to the value of the chips. In addition, it will be difficult to check that the measure was correctly implemented in the exporting country.

7.26 - Can infestation of the consignment be reliably prevented by handling and packing methods?
no
Level of uncertainty: **low**
Possible measure: specific handling/packing methods
As a stand-alone measure, wood chips or wood waste could be stored in the exporting country under strict control of the NPPO for a sufficient period, i.e., 2 years for wood waste and 1 year for wood chips, since only prepupae, pupae, and callow adults would be likely to survive the chipping process and should have emerged as adults within this period of time.
In case other measures are applied (PFA, produced after removal of bark and outer sapwood), storage and transport in the period after chipping should be done in conditions preventing entry of adults. This is because the chipping process releases strong concentrations of host volatiles, and adults may be attracted to consignments of wood chip soon after chipping. This also applies to freshly-produced waste wood.

The Panel on Phytosanitary Measures considered that given the difficulty to control the application of this measure in practice, it was not an appropriate option for imported material.

Options that can be implemented after entry of consignments

7.27 - Can the pest be reliably detected during post-entry quarantine?
no
Level of uncertainty: **low**
Not applicable for wood products.

7.28 - Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the PRA area, or limited periods of entry, and can such limitations be applied in practice?
yes
Level of uncertainty: **low**
Possible measure: import of the consignment under special licence/permit and specified restrictions

The wood chips for processing could be imported to approved facilities under the control of the NPPO during periods of the year outside of the flight period of *A. planipennis*. The appropriate period will depend on the origin, destination and storage conditions. For example, Canada identifies the low risk season for

imports from regulated areas in the USA as October 1-March 31.
Imported material would need to be processed before air temperatures would allow emergence and flight of the pest. This might be possible for wood chips imported by specific plants for burning for energy production or for the production of fiberboards or paper. Chips must be covered during transport from the point of entry to the processing plant (by using covered trucks, containers and railcars). Additionally, chips should not be stored outside. This would be possible only if use can be guaranteed and verified. The specifications of the requirements (including the allowed period of import) need to be done on a case by case basis depending on the origin and the country of destination.

The Panel on Phytosanitary Measures considered that given the difficulty to control the application of this measure in practice, it was not an appropriate option for imported material. However, the Panel on Quarantine Pests for Forestry considered that it may be applicable in the case of an outbreak in the EPPO region because the NPPO will be able to control the movement and use of the wood chips.

7.29 - Are there effective measures that could be taken in the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts?
no
Level of uncertainty: **low**
As for wood.

7.30 - Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?
yes

Q.	Standalone	Systems Approach	Possible Measure	Uncertainty
7.20		X	pest free area	low

7.31 - Does each of the individual measures identified reduce the risk to an acceptable level?
yes
Level of uncertainty: **low**
The following measure reduce the risk to an acceptable level: PFA + storage and transport to prevent contamination by adults

7.34 - Estimate to what extent the measures (or combination of measures) being considered interfere with international trade.
Level of uncertainty: **low**
The measures will interfere with international trade, even if some countries already have some measures in place. However, several countries (e.g. EU, New Zealand, Israel) already require measures for wood chips for phytosanitary purposes.

7.35 - Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.
Level of uncertainty: **low**

A. planipennis would be very difficult to eradicate and contain if introduced, therefore it is essential to take measures to prevent its introduction.

7.36 - Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences?
Yes, see 3.31.

Pathway 3: Plants for planting

7.06 - Is the pathway that is being considered a commodity of plants and plant products?
yes

7.09 - If the pest is a plant, is it the commodity itself?
no (the pest is not a plant)

7.10 - Are there any existing phytosanitary measures applied on the pathway that could prevent the introduction of the pest? (if yes, specify the measures in the justification)
no
Level of uncertainty: **low**

There are already efficient measures in place in some EPPO countries (see below) but not for all of them (e.g. Eastern Europe). The following requirements were found in the EU Directive and EPPO collection of phytosanitary regulations / summaries:

EU	Plants for planting (except seeds and plants in tissue culture) of *Fraxinus*, *Juglans mandshurica*, *Ulmus davidiana*, *Ulmus parvifolia* and *Pterocarya rhoifolia* from Canada, China, Japan, Mongolia, Republic of Korea, Russia, Taiwan and USA	(a) grown throughout their life in a PFA; or (b) have, for a period of at least two years prior to export, been grown in a place of production where no signs of *Agrilus planipennis* Fairmaire have been observed during two official inspections per year carried out at appropriate times, including immediately prior to export.

Plants for planting would be subject to inspection, but *A. planipennis* is difficult to detect especially at early stages of infestation.

Plants for planting with soil:
In the EU (EU Directive 2000/29/EC - consolidated) - Annex A, section I. points 39 and 40 (EU, 2000)

- “A phytosanitary certificate would be required for "Trees and shrubs/Deciduous trees and shrubs, intended for planting, other than seeds and plants in tissue culture, originating in third countries other than European and Mediterranean countries"
- Associated phytosanitary requirements:

Annex IV, Part A, section 1, point 39: ...where appropriate, official statement that the plants:
— are clean (i.e. free from plant debris) and free from flowers and fruits,
— have been grown in nurseries,
— have been inspected at appropriate times and prior to export and found free from symptoms of harmful bacteria, viruses and virus-like organisms, and either found free from signs or symptoms of harmful nematodes, insects, mites and fungi, or have been subjected to appropriate treatment to eliminate such organisms.
Annex IV Part A Section 1 point 40:where appropriate, official statement that the plants are dormant and free from leaves.”

Bonsais
“A PC is required for "Naturally or artificially dwarfed plants intended for planting other than seeds, originating in non-European countries"
Some of the specific requirements of Annex IV, Part A, Section I, point 43 might be helpful in relation to *A. planipenis* (not all requirements of this point are listed below), especially:
(a) the plants, including those collected directly from natural habitats, shall have been grown, held and trained for at least two consecutive years prior to dispatch in officially registered nurseries, which are subject to an officially supervised control regime,
(b) the plants on the nurseries referred to in (a)
shall:
(aa) at least during the period referred to in (a):
... [2 requirements omitted]
— have been officially inspected at least six times a year at appropriate intervals for the presence of harmful organisms of concern, which are those in the Annexes to the Directive. These inspections, which shall also

be carried out on plants in the immediate vicinity of the nurseries referred to in (a), shall be carried out at least by visual examination of each row in the field or nursery and by visual examination of all parts of the plant above the growing medium, using a random sample of at least 300 plants from a given genus where the number of plants of that genus is not more than 3 000 plants, or 10 % of the plants if there are more than 3 000 plants from that genus,
— have been found free, in these inspections, from the relevant harmful organisms of concern as specified in the previous indent. Infested plants shall be removed. The remaining plants, where appropriate, shall be effectively treated, and in addition shall be held for an appropriate period and inspected to ensure freedom from such harmful organisms of concern,
[3 requirements omitted]
or
[1 requirement omitted]
(bb) ....”

UK has additional measures in place: plants for planting of *Fraxinus* spp. must come from a PFA for *Chalara fraxinea* (UK Plant Health, 2012).

In Russia and countries of the Commonwealth of Independent States, plants for planting require an import permit.

For reference, Canada and USA regulate their respective imports of ash plants for planting as follows:

Canada (CFIA, 2012b) from regulated States in the USA

- Ash nursery stock: Import Prohibited
- Ash branches <1.5 cm in diameter PC+ "The ash branches are no more than 1.5 cm in diameter and were harvested in a county where Agrilus planipennis is not known to occur based on official surveys."
- Ash logs and branches > 1.5 cm in diameter Low Risk Season only (October 1-March 31). Permit

USA (USDA-APHIS, 2012d)

- Ash plants from counties regulated for the Emerald Ash Borer (EAB): prohibited
- From counties not regulated for EAB but located within a regulated province or territory IP and PC
- From provinces or territories not regulated for EAB

Options at the place of production

7.13 - Can the pest be reliably detected by visual inspection at the place of production?
no
Level of uncertainty: **low**
The presence of the pest is not easy to detect, in particular the signs of early infestation until adults have emerged. It is likely that nursery plants would be subjected to a certain degree of inspection and surveillance, which might allow detection of some signs of presence (exit holes, galleries under the bark), although the presence of the pest is very difficult to detect without destructive sampling, and larvae do not produce signs or symptoms that are externally visible (see under 2).

7.14 - Can the pest be reliably detected by testing at the place of production?
no
Level of uncertainty: **low**
There is currently no reliable detection method to detect the insect.

7.15 - Can infestation of the commodity be reliably prevented by treatment of the crop?
No
Level of uncertainty: **low**
There is no evidence that insecticide treatments would provide 100% protection for nursery stock. A range of systemic insecticides have been used to provide protection of mature trees (for example soil drench with imidacloprid, or stem injection with emamectin benzoate or azadirachtin). Such products are likely to provide protection for nursery material but it still has to be proven. It is currently not considered as an option in nurseries in the USA and Canada.

7.16 - Can infestation of the commodity be reliably prevented by growing resistant cultivars?
no
Level of uncertainty: **low**
As for wood.

7.17 - Can infestation of the commodity be reliably prevented by growing the crop in specified conditions (e.g. protected conditions such as screened greenhouses, physical isolation, sterilized growing medium, exclusion of running water, etc.)?
Yes, only very specific conditions (officially controlled facilities, equivalent to quarantine facilities)
Level of uncertainty: **low**
Possible measure: specified growing conditions of the crop
Growing plants under insect-proof conditions (e.g. mesh houses, nets, greenhouses) during the period of adult flight is generally not considered practical but could in principle be effective. *A. planipennis* is attracted to the volatiles from ash trees and which increases the risk. Appropriate surveillance should be in place as well as forecasting for the flight period, but there is no reliable sensitive detection method. The plants should be under protected conditions throughout the period of flight of adults. In commercial production, it will be difficult to ensure the integrity of the physical protection and to detect any openings in time. These measures may be appropriate for high value commodities and very small scale production in officially controlled facilities (equivalent to quarantine facilities).

7.18 - Can infestation of the commodity be reliably prevented by harvesting only at certain times of the year, at specific crop ages or growth stages?
no
Level of uncertainty: **low**
Possible measure: specified age of plant, growth stage or time of year of harvest
Larvae or pupae can be present in the wood throughout the year. Limiting the commodity to small seedlings would prevent infestation, but it is not clear what the minimum diameter of such material should be.

7.19 - Can infestation of the commodity be reliably prevented by production in a certification scheme (i.e. official scheme for the production of healthy plants for planting)?
no
Level of uncertainty: **low**
Certification schemes are in place to address mostly plant pathogens, and are not considered to be a possible measure.

7.20 - Based on your answer to question 4.01, select the rate of spread.
high rate of spread (>10 km per year)
Level of uncertainty: **low**
Possible measure: pest free area

7.21 - The possible measure is: pest free place of production or pest free area
Can this be reliably guaranteed?
yes
Level of uncertainty: **low**
There was no agreement in the EWG on the cases in which a PFA could be established for the purpose of exporting plants for planting. Some members supported that such PFAs could be established in all cases under the conditions defined for wood products (see 7.21 for wood), and that the establishment phase would imply the application of official containment measures. Others supported that, given the high risk associated with plants for planting, PFA was only an option for countries where the pest is under eradication or containment. *The Panel on Phytosanitary Measures considered that a PFA according to the conditions defined in 7.21 for wood was relevant also for plants for planting.*

As for wood products, pest-free place of production is not a possible option.

Options after harvest, at pre-clearance or during transport

7.22 - Can the pest be reliably detected by a visual inspection of a consignment at the time of export, during transport/storage or at import?

no

Level of uncertainty: **low**

The pest is difficult to detect. Symptoms will not appear until after emergence of adults and early infestations would not be detected.

7.23 - Can the pest be reliably detected by testing of the commodity (e.g. for pest plant, seeds in a consignment)?

no

Level of uncertainty: **low**

As 7.14

7.24 - Can the pest be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)?

no

Level of uncertainty: **low**

No practical treatment is available to control all stages of the pest, especially non-feeding stages such as prepupae and pupae.

Larvae are difficult to detect, and also difficult to remove or target with specific treatments. If presenting signs of damage, plants might be removed from the consignments, but this would not be sufficient to ensure that the pest is not present in the consignment.

Fumigation, irradiation and heat treatment are possible, but have not been evaluated. They will probably affect the viability of the plants.

Chemical treatment

Systemic insecticides as injections or drenches are mentioned. They would not be effective against prepupal larvae that have completed feeding, or pupae.

Treatment with fumigants is probably not effective since the larvae are protected inside woody stems and fumigants will probably not be able to enter the larval tunnels to kill the larvae. Treatment with methyl bromide under vacuum might kill the larvae inside the woody material (T201-a-2 in USDA Treatment Manual). Research will be needed to determine the efficacy of this method. This method cannot be recommended from an environmental point of view as the use of methyl bromide should be abandoned in the future due to negative effects of this substance on the ozone layer (Montreal Protocol).

Irradiation

Insects need an absorbed dosage of 1000 Gy. Effects on plants can be seen on a dosage of more than 1 Gy; 1000 Gy will lead to negative effects on the viability of the plants. Lower dosages may be sufficient to sterilize the larvae inside the plants. Experimental research will be needed to test that hypothesis. When it works, methods will have to be developed to be able to check that the treatment has been properly performed and larvae are innocuous.

Thermal treatment

Incubation of woody plants (dormant) in hot water might kill the larvae inside the stem. Larvae are present in the woody stem of the plant and plants need probably to stay in a hot water for a relatively long time to achieve lethal temperatures inside the wood that will kill the larvae. It is, therefore, expected that temperatures and exposure time needed to kill the larvae will negatively affect the viability of the plants. Heat treatment is accepted as a Phytosanitary procedure to kill larvae of *Anoplophora glabripennis* (another longhorned beetle) in wood packaging material. In that case the internal core of the material should reach a minimum of 56°C during 30 min. [EPPO Standard PM 10/6(1) *Heat treatment of wood to control insects and wood-borne nematodes*, EPPO (2008)]. Such a treatment will likely have negative effects on the viability of the young trees and will, therefore, not be a good option.

7.25 - Does the pest occur only on certain parts of the plant or plant products (e.g. bark, flowers),

which can be removed without reducing the value of the consignment?
no
Level of uncertainty: **low**
The larvae are present under the bark of main stem and branches.

7.26 - Can infestation of the consignment be reliably prevented by handling and packing methods?
no
Level of uncertainty: **low**
Eggs could be laid on the bark and some pest stages (larvae, prepupae, pupae, callow adults) could be in the plants before packing and handling.

Options that can be implemented after entry of consignments

7.27 - Can the pest be reliably detected during post-entry quarantine?
no
Level of uncertainty: **low**
Plants for planting could be kept in post-entry quarantine in conditions favorable to the insect until the emergence of the adults. At low levels of infestation, detection is not reliable. It would require that every tree is inspected thoroughly to detect any exit holes and it is possible that they will not be detected. The pest can develop over a period including two successive overwintering periods if conditions are not favourable, and the post-entry quarantine should be long enough (2 complete growing seasons) to ensure that all adults have emerged. *A. planipennis* is known to have a 1-2 years life cycle, but this could be extended in areas with cooler summers than where it currently occurs.

7.28 - Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the PRA area, or limited periods of entry, and can such limitations be applied in practice?
no
Level of uncertainty: **low**
The end use is for planting, most of the PRA area is at risk from *A. planipennis*, and if any areas are not at risk (i.e. areas where ash cannot grow), they would likely not be importing ash plants for planting.

7.29 - Are there effective measures that could be taken in the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts?
no
Level of uncertainty: **low**
As for wood.

7.30 - Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?

Q.	Standalone	Systems Approach	Possible Measure	Uncertainty
7.17	X		specified growing conditions of the crop	low
7.20	X		pest free area	low

yes

7.31 - Does each of the individual measures identified reduce the risk to an acceptable level?
no
Level of uncertainty: **low**
- PFA
- growing under insect proof conditions (very specific conditions, officially controlled facilities, equivalent to quarantine facilities)

7.34 - Estimate to what extent the measures (or combination of measures) being considered interfere with international trade.

Level of uncertainty: **low**
The effect on trade would be limited because it is thought that the import volume of host plants for planting is limited.

7.35 - Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.
Level of uncertainty: **low**
Growing under insect proof conditions (quarantine conditions) is unlikely to be cost effective, except for high value plants such as bonsais.

A. planipennis would be very difficult to eradicate, and contain if introduced, therefore it is essential to take measures to prevent its introduction..

7.36 - Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences?
yes
see 3.31

Pathway 4: Bark

7.06 - Is the pathway that is being considered a commodity of plants and plant products?
yes

7.09 - If the pest is a plant, is it the commodity itself?
no (the pest is not a plant)

7.10 - Are there any existing phytosanitary measures applied on the pathway that could prevent the introduction of the pest? (if yes, specify the measures in the justification)
no
Level of uncertainty: **low**

There is no measure in place that would prevent introduction for the whole EPPO region. The following requirements were found in the EU Directive:
EU requirements for isolated bark of *Fraxinus* spp., *Juglans mandshurica*, *Ulmus davidiana*, *Ulmus parvifolia* and *Pterocarya rhoifolia* from Canada, China, Japan, Mongolia, Republic of Korea, Russia, Taiwan and USA: (a) originating in a PFA; or (b) processed into pieces of not more than 2.5 cm thickness and width.

For reference, Canada and USA regulate their respective imports of isolated bark (bark chips) as follows:

USA (USDA-APHIS, 2012d) for ash wood chips or bark chips:

- larger than 1 inch (2.5 cm) in diameter from a county regulated for *A. planipennis*: prohibited.
- 1 inch (2.5 cm) or less in diameter from a county regulated for *A. planipennis:* PC.
- from Canadian counties not regulated for *A. planipennis* but located within a regulated Province or Territory: accompanied by a PC with an AD stating that, “The articles in the shipment were produced or harvested in a county where the EAB does not occur, based on official surveys.”

Canada (CFIA, 2012b) for ash wood/bark chips from regulated areas of the USA:

- PC + "The wood/bark chips in this consignment are less than 2.5 cm in any two dimensions."
- in Low Risk Season only (October 1- March 31): permit.

Options at the place of production

7.13 - Can the pest be reliably detected by visual inspection at the place of production?
no
Level of uncertainty: **low**
As for wood.

7.14 - Can the pest be reliably detected by testing at the place of production
no
Level of uncertainty: **low**
As for wood.

7.15 - Can infestation of the commodity be reliably prevented by treatment of the crop?
no
Level of uncertainty: **low**
As for wood.

7.16 - Can infestation of the commodity be reliably prevented by growing resistant cultivars?
no
Level of uncertainty: **low**
As for wood.

7.17 - Can infestation of the commodity be reliably prevented by growing the crop in specified conditions (e.g. protected conditions such as screened greenhouses, physical isolation, sterilized

growing medium, exclusion of running water, etc.)?
no
Level of uncertainty: **low**
Possible measure: specified growing conditions of the crop
As for wood.

7.18 - Can infestation of the commodity be reliably prevented by harvesting only at certain times of the year, at specific crop ages or growth stages?
no
Level of uncertainty: **low**
Possible measure: specified age of plant, growth stage or time of year of harvest
The life stages that present a risk are late larvae, prepupae, pupae and callow adults. Late larvae, prepupae and pupae may be present all year round, callow adults at certain times of the year.

7.19 - Can infestation of the commodity be reliably prevented by production in a certification scheme (i.e. official scheme for the production of healthy plants for planting)?
no
Level of uncertainty: **low**
Not relevant for forestry.

7.20 - Based on your answer to question 4.01, select the rate of spread.
high rate of spread (>10 km per year)
Level of uncertainty: **low**
Possible measure: pest free area

7.21 - The possible measure is: pest-free place of production or pest free area
Can this be reliably guaranteed?
yes
Level of uncertainty: **low**
As for wood.

Options after harvest, at pre-clearance or during transport

7.22 - Can the pest be reliably detected by a visual inspection of a consignment at the time of export, during transport/storage or at import?
no
Level of uncertainty: **low**
The pest would difficult to detect in bark.

7.23 - Can the pest be reliably detected by testing of the commodity (e.g. for pest plant, seeds in a consignment)?
no
Level of uncertainty: **low**
As for wood.

7.24 - Can the pest be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)?
no
Level of uncertainty: **low**
As for wood chips.

7.25 - Does the pest occur only on certain parts of the plant or plant products (e.g. bark, flowers), which can be removed without reducing the value of the consignment?
No
Level of uncertainty: **low**
Several life stages may be present in the bark.

7.26 - Can infestation of the consignment be reliably prevented by handling and packing methods?
no
Level of uncertainty: **low**
As for wood chips.

Options that can be implemented after entry of consignments

7.27 - Can the pest be reliably detected during post-entry quarantine?
no
Level of uncertainty: **low**
As for wood chips

7.28 - Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the PRA area, or limited periods of entry, and can such limitations be applied in practice?
no
Level of uncertainty: **low**
As for wood chips. This would apply to bark for processing but not for bark to be used outdoors as mulch.

7.29 - Are there effective measures that could be taken in the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts?
no
Level of uncertainty: **low**
As for wood.

7.30 - Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?
yes

Q.	**Standalone**	**Systems Approach**	**Possible Measure**	**Uncertainty**
7.20	X		pest free area	low

7.31 - Does each of the individual measures identified reduce the risk to an acceptable level?
yes
Level of uncertainty: **low**
A PFA would reduce the risk to an acceptable level:

7.34 - Estimate to what extent the measures (or combination of measures) being considered interfere with international trade.
Level of uncertainty: **low**
The measures will interfere with international trade, if there is trade.

7.35 - Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.
Level of uncertainty: **low**
A. planipennis would be very difficult to eradicate, and contain if introduced, therefore it is essential to take measures to prevent its introduction..

7.36 - Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences?
yes
See 3.31

Appendix 3. Trade of wood from countries where A. planipennis occurs

Table 1. Exports of wood from the USA (4403990090 - HLOGS OTHR TEMP) (this includes ash, but not oak, beech, birch and poplar).

	2006	2007	2008	2009	2010	2011	01/10-2011	01/10-2012
World Total	69,883	80,520	127,760	104,241	136,227	90,950	83,169	47,857
Albania	0	0	0	0	4	0	0	0
Algeria	0	0	41	0	0	0	0	0
Belgium	1,437	582	2,012	1,537	1,838	749	720	292
Bulgaria	0	0	15	0	0	0	0	0
Croatia	46	30	91	59	0	80	80	0
Cyprus	0	0	654	87	198	0	0	0
Czech Rep	0	0	46	0	16	266	266	0
Denmark(*)	166	54	764	568	379	72	72	9
Estonia	0	17	70	359	620	470	470	16
Finland	0	0	792	524	714	406	406	154
France(*)	636	409	826	482	733	193	139	4
Germany(*)	1,756	3,638	11,038	9,239	7,990	3,154	3,019	759
Greece	15	361	2,542	2,085	1,096	82	82	0
Ireland	353	267	1,226	959	603	175	175	12
Israel(*)	0	191	656	961	1,284	783	783	173
Italy(*)	3,927	11,494	9,197	9,950	18,433	24,360	22,697	9,520
Jordan	0	19	206	299	219	63	30	0
Latvia	0	453	0	0	25	0	0	0
Lithuania	0	0	283	43	0	163	163	0
Malta	15	32	509	260	247	262	243	172
Montenegro	0	0	272	0	0	0	0	0
Morocco	0	64	199	122	52	90	90	0
Netherlands	183	485	1,001	1,051	951	926	836	126
Norway(*)	76	23	1,111	291	179	75	75	60
Poland	0	0	15	1,757	1,010	207	207	0
Portugal	620	1,565	2,229	1,822	1,302	897	897	7
Romania	0	0	174	0	0	0	0	0
Russia	0	0	96	74	16	0	0	0
Slovenia	0	0	227	263	78	214	214	0
Spain	1,553	1,685	3,372	2,135	2,055	442	442	115
Sweden	88	124	711	594	771	254	238	0
Switzerland(*)	63	445	123	0	0	0	0	0
Turkey	8	1,441	2,144	771	1,376	2,133	2,051	1,760
UK	501	1,316	11,946	9,087	9,757	1,759	1,644	625

Table 2. Exports of wood from the USA (4407950000 - LMBR, ASH)

	2007	2008	2009	2010	2011	01/10-2011	01/10-2012
World Total	87,878	71,672	63,278	113,449	132,854	110,847	140,893
Albania	10	0	5	34	23	0	15
Austria	36	34	23	0	6	6	0
Belarus	0	20	0	0	0	0	0
Belgium	862	898	296	1,047	754	593	735
Bulgaria	0	18	0	0	0	0	0
Cyprus	30	31	16	19	9	9	0
Czech Rep	0	0	0	0	0	0	6
Denmark(*)	1,298	437	170	143	525	474	451
Estonia	255	639	1,111	3,781	5,239	4,805	3,359
Finland	125	112	130	167	267	264	132
France(*)	782	330	344	477	1,070	946	683
Germany(*)	1,852	1,216	664	2,002	2,631	1,834	2,724
Greece	800	1,010	587	461	222	172	218
Ireland	2,004	863	650	393	620	559	527
Israel(*)	702	778	137	228	61	6	88
Italy(*)	5,247	3,777	3,739	5,524	9,015	7,688	7,070
Jordan	298	702	95	521	358	328	160
Lithuania	0	0	0	219	0	0	0
Malta	236	34	74	166	76	70	72
Morocco	269	69	162	366	136	117	238
Netherlands	978	861	661	1,233	739	546	986
Norway(*)	258	160	271	166	185	170	301
Poland	0	0	29	217	194	130	129
Portugal	2,530	2,070	1,019	1,398	949	713	772
Russia	0	43	114	0	94	82	97
Slovenia	0	0	0	0	26	26	0
Spain	3,185	2,097	627	1,441	687	598	831
Sweden	592	585	427	427	314	261	367
Switzerland(*)	0	0	0	89	0	0	0
Tunisia	0	0	9	0	0	0	0
Turkey	27	14	8	628	1,747	1,546	2,771
Ukraine	0	0	0	0	0	0	48
UK	7,482	6,998	5,176	5,739	7,288	5,765	7,582

Table 3. Exports of Wood in the rough, non-coniferous, and logs for pulping (440399). from Canada, for top importers for each year - Quantities in m3

	2012	2011	2010	2009	2008	2007	2006
World	376,098	252,124	262,684	246,380	176,911	188,886	293,020
Netherlands	1,099	0	687	1,210	346	3,207	227
Germany	5,027	382	1,076	839	595	755	630
Italy		195	111	1,047	767	1,148	1,537
Israel				66	80	45	0
France		36	38	61	71	30	131
Morocco	-	-	-	-	-	33	0
Turkey	-	-	20	1	0	492	0
Spain	237	0	0	0			
Poland	-	-	13	0	0	133	0
Norway	-	759	0	0	0	31	0
Czech Republic	-	4	0	0	0	40	0
Jordan	-	-	3,044	0	0	22,272	27,810
Portugal	-	-	74	0	0	0	
Belgium	-	-	22				
Austria	-	-	-	-	65	798	149
Switzerland	-	-	-	-	26	304	58
Serbia	-	-	-	-	23	0	0
Finland	-	-	-	-	40	0	0
UK	-	-	-	-	16	547	543

Includes birch, alder, cherry, ash, maple, poplar, walnut, other temperate

Table4. Exports of lumber, non-coniferous, of thickness > 6 mm (440799). from Canada, for top importers for each year - Quantities in m3

	2012	2011	2010	2009	2008	2007	2006
World	*171,974*	*171,300*	*306,376*	*160,739*	*252,841*	*408,631*	*1,002,091*
Austria	-	205	127	48	493	447	1,925
Belgium	698	7,672	111,141	213	695	1,538	3,242
Bulgaria	19	34	0	0			
Croatia	-	-	33	52	68	46	137
Cyprus	20	105	33	14	85	18	207
Czech Rep	9	32	0	3	142	106	65
Denmark	163	257	273	179	1,445	1,495	3,061
Estonia	-	87	119	103	1,254	379	0
Finland	42	315	297	204	998	835	1,413
France	114	252	630	1,104	1,455	2,461	3,622
Germany[1]	2,935	4,413	4,651	3,260	5,091	6,619	23,407
Greece	5	14	110	25	132	348	470
Ireland	286	154	310	502	1,291	2,058	1,767
Israel	82	202	188	298	926	66,600	4,769
Italy	163	606	940	943	1,292	3,020	6,191
Jordan	81	6	0	31	84	43	1,034
Lithuania	68	294	271	59	1,046	293	1,453
Malta	-	22	51	24	32	495	490
Morocco	86	115	62	0	59	156	
Netherlands	343	658	790	526	1,069	2,343	2,991
Norway	154	265	161	6	0	908	
Poland	80	228	347	480	510	573	1,124
Portugal	71	282	78	112	51	1,158	1,756
Russia	61	0	6	32	2	277	0
Slovenia	-	21	0	0	126	-	-
Spain	89	86	71	271	782	2,164	5,503
Sweden	224	306	549	373	835	1,197	3,615
Switzerland	-	-	29	27	112	69	757
Turkey	33	461	0	62	312	44	307
UK	955	1,472	2,672	2,583	5,354	11,135	15,528

Includes birch, maple alder, cherry, poplar, ash, other temperate

Table 5. Imports of fuelwood by EU countries (eurostat). No export from Mongolia, Korea Dem Rep, Japan. Years and EU countries without imports were deleted

	China						USA					
	2006	2007	2008	2009	2010	2011	2006	2007	2008	2009	2010	2011
Austria	:	:	:	:	:	:	:	:	:	4	:	:
Belgium	:	:	:	:	1	:	:	:	1	:	:	:
Cyprus	:	:	:	:	:	:	:	123	:	:	:	:
Czech Rep	:	:	:	210	:	:	:	:	28	:	:	:
Germany	:	:	13	190	:	:	:	94	:	1	28	50
Denmark	:	:	0	:	:	:	:	1	68	:	:	:
Estonia	:	:	:	:	:	:	:	:	:	:	:	:
Spain	:	:	:	:	:	:	:	:	130	:	:	0
France	:	:	15	:	:	:	:	213	:	:	:	:
UK	100	:	:	43	190	200	6.808	9.045	8.737	5.327	6.334	222
Greece	:	:	36	:	:	20	:	:	:	:	:	:
Hungary	:	:	:	:	:	:	:	:	:	:	:	17
Ireland	:	282	6.450	2	5	:	6	1.500	850	34	3	1
Italy	2.508	3.573	:	:	:	166	:	4.238	408	:	:	:
Netherlands	2.675	21	:	:	41	0	:	:	:	:	:	:
Portugal	:	:	:	:	:	2	822	812	440	1.576	:	1.519
Romania	:	78	:	:	:	:	:	:	:	:	:	:
Sweden	:	0	:	:	:	:	37	35	7	0	11	6

	Canada						Korea Rep.		Russia					
	2006	2007	2008	2009	2010	2011	2006	2008	2006	2007	2008	2009	2010	2011
Austria	:	:	:	:	1	3	:	:	43.070	269.794	2.714	212	1.854	:
Belgium	:	:	:	11	:	:	:	:	:	437	:	22.466	701	2.918
Bulgaria	183	:	:	:	:	:	:	:	:	:	:	:	:	:
Cyprus	:	:	:	:	:	:	:	:	250	:	:	:	:	:
Czech Rep	:	:	:	:	:	:	:	:	431	:	:	:	:	644
Germany	:	:	:	:	:	:	:	:	1.844	12.428	53.068	5.308	152.777	72.516
Denmark	:	:	:	:	:	:	:	:	5.864	2.851	90.547	108.923	53.696	238.499
Estonia	:	:	:	:	:	:	:	:	8.802	22.593	12.107	206	:	9.572
Finland	:	:	:	:	:	:	:	:	828.021	706.496	530.908	2.857.992	435.947	232.616
France	120	192	:	:	:	:	:	:	:	:	:	94	:	:
United Kingdom	:	:	:	:	:	:	:	:	:	195	:	:	:	:
Hungary	:	:	:	:	:	:	:	:	200	200	:	:	107	:
Ireland	:	369	1	9	8	:	:	:	:	75	:	100	:	230
Italy	4.779	5.734	:	:	:	:	240	240	672	:	218	415	1.286	1.040
Lithuania	:	:	:	:	:	:	:	:	22.494	16.816	190	1.107	2.739	1.275
Latvia	:	:	:	:	:	:	:	:	2.385	15.523	:	130	475	3.997
Netherlands	:	:	:	8	:	:	:	:	:	:	:	:	2.589	1.099
Poland	:	:	:	:	:	:	:	:	:	341	1.662	:	:	:
Sweden	:	:	:	:	:	1	:	:	696.307	286.582	486.318	1.833.249	563.213	1.083.405
Slovakia	:	:	:	:	:	:	:	:	:	:	:	:	1.171	:

Table 6. Imports of round wood (hardwood, except oak, beech, poplar, birch) (44039995) by EU countries (eurostat). No export from Mongolia, Korea Rep. Korea Dem Rep, Years and EU countries without imports were deleted

	China						Japan					USA						Canad						Russia						Taiwan					
	2006	2007	2008	2009	2010	2011	2006	2007	2009	2010	2011	2006	2007	2008	2009	2010	2011	2006	2007	2008	2009	2010	2011	2006	2007	2008	2009	2010	2011	2006	2007	2008	2009	2010	2011
AT	344	2	:	:	:	:	:	:	:	:	:	2.958	2.938	924	1.150	2.949	3.212	204	:	:	:	430	:	435	1.847	471	305	:	220	:	:	:	:	:	:
BE	8	:	4	139	15	:	:	:	:	:	:	2.143	3.001	2.367	1.352	808	32	390	585	:	4.192	1.354	473	:	:	360	:	:	:	:	:	:	:	:	1.381
BG	:	:	:	:	:	:	:	:	:	:	:	25	:	:	:	216	82	:	:	:	:	:	:	:	263	:	:	:	:	:	:	:	:	:	:
CY	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	668	:	:	:	:	:	:	:	:	:	:	:	:	:
CZ	:	:	:	9	5	93	:	:	:	:	:	804	7.202	3.937	593	3.606	1.124	380	:	:	:	:	:	392	205	419	13	:	:	:	:	:	:	:	:
DE	100	15	82	217	555	417	:	:	1.190	1.602	1.127	338.374	354.158	230.255	151.769	186.380	198.499	7.638	10.300	4.006	2.125	11.267	7.763	15.748	109.223	136.371	29.460	27.288	:	98	:	22	:	:	:
DK	114	224	:	:	7	8	0	180	:	:	:	2.982	3.814	630	:	499	393	437	424	1.755	:	:	:	210.495	:	:	:	:	5.761	:	:	:	:	:	:
EE	:	2	0	:	:	:	3.753	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	1.407.762	647.104	464.125	:	9.806	:	:	:	:	:	:	:
ES	:	:	:	12	58	:	:	:	:	:	:	73.892	42.301	39.077	10.875	38.970	40.097	1.046	765	:	1.246	:	:	:	194	:	:	:	:	:	:	:	:	:	:
FI	:	:	:	:	:	0	:	:	:	:	:	:	0	0	:	2	5	:	:	:	1	:	:	3.732.791	3.435.810	3.024.670	956.427	1.899.306	1.798.167	:	:	:	:	:	:
FR	415	1	395	7	60	0	:	:	:	1	:	36.724	35.713	36.379	21.496	26.339	19.821	2.509	3.921	664	3.276	729	908	196	:	:	:	:	:	663	711	:	:	837	:
UK	550	454	1.493	862	4.314	0	0	:	:	:	:	68.880	79.081	77.650	51.343	13.985	12.515	42.780	61.178	46.560	19.467	682	5.061	:	:	:	579	:	:	:	:	:	:	:	:
GR	:	:	:	:	:	:	:	:	:	:	:	:	:	201	221	:	:	:	:	:	:	:	:	616	:	:	:	:	:	:	:	:	:	:	:
HU	6	:	:	:	:	:	:	:	:	:	:	:	:	:	:	20	:	:	:	:	:	:	:	6.406	1.272	:	:	:	:	:	:	:	:	:	:
IE	2.647	4.173	895	450	125	0	:	:	:	2	:	31.238	30.537	13.535	10.395	1.822	3	8.190	5.393	568	351	350	421	:	:	:	:	:	:	:	:	:	:	:	:
IT	1.039	5.643	1.680	255	240	1.406	:	:	:	:	:	609.376	843.232	433.574	256.402	417.832	463.826	12.248	8.196	4.734	5.280	1.958	2.850	3.658	3.508	923	:	:	:	405	118	3	60	140	:
LT	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	23.723	18.324	:	:	:	:	:	:	:	:	:	:
LU	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	208	:	:	:	:	:	:	:	:	:	:	:
LV	:	:	:	:	:	:	:	:	:	:	:	204	4.925	1.361	:	:	:	:	:	:	:	:	:	6.446	19.306	3.715	:	:	:	:	:	:	:	:	:
MT	:	:	:	:	:	:	:	:	:	:	:	0	0	:	:	0	200	0	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
NL	1.060	173	59	104	412	:	:	:	:	:	:	3.820	1.287	1.321	457	1.062	3.257	371	:	:	:	6	10	:	:	:	:	:	:	:	:	:	:	:	:
PL	:	:	:	:	24	94	:	:	:	:	:	0	:	191	4	0	0	:	115	:	:	:	:	3.705	3.234	4.287	:	:	:	:	:	:	:	:	:
PT	1	:	:	:	:	7	:	:	:	:	:	166.821	170.952	77.352	36.337	52.068	50.130	424	816	219	:	262	:	:	:	:	:	:	:	:	:	:	:	:	:
RO	326	312	:	:	:	:	:	:	:	:	:	:	:	190	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
SE	:	:	74	:	:	232	:	:	:	:	:	0	465	27	35	185	409	0	49	:	:	173	607	1.431.805	1.480.108	1.204.458	85.580	366.697	154.310	:	:	:	:	:	:
SI	:	:	:	:	:	:	:	:	:	:	:	1.380	2.597	3.976	5.338	2.301	7.032	232	0	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
SK	:	:	:	:	:	0	:	:	:	:	:	1.131	:	0	:	:	:	:	:	:	:	:	:	906	:	:	:	:	:	:	:	:	:	:	:

Table 7. Imports of ash sawn wood (44079510) by EU countries (eurostat). No export from Mongolia, Korea Rep.. Korea Dem Rep, Japan, Years and EU countries without imports were deleted

	China			USA					Canada					Russia				
	2007	2008	2009	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
Austria	:	:	:	:	:	:	:	:	:	:	:	:	:	169	:	:	:	:
Belgium	:	:	:	:	:	:	983	1.782	:	:	:	:	:	:	:	:	:	:
Cyprus	:	:	:	:	11	:	:	:	:	:	:	:	:	:	:	:	:	:
Czech Rep	:	:	:	:	:	14	:	:	:	:	:	:	:	:	:	:	:	:
Germany	:	:	:	:	190	386	210	:	635	301	:	:	:	:	:	:	:	:
Denmark	:	:	108	:	:	:	:	98	:	:	:	67	:	:	:	:	18	:
Estonia	:	237	:	:	17.075	3.909	646	367	:	6.935	2.596	:	136	:	:	:	:	:
Spain	:	:	:	80	195	:	:	206	:	:	:	:	:	:	:	:	:	:
France	:	:	:	:	103	:	:	158	:	:	:	:	:	:	:	:	:	:
United Kingdom	:	52	:	998	727	:	3.683	10.786	195	:	:	:	254	:	:	:	:	:
Greece	:	:	:	:	228	:	:	:	:	:	:	:	:	:	:	:	:	:
Ireland	:	:	:	3.744	2.640	1.059	886	1.849	:	282	:	:	:	:	:	:	:	:
Italy	:	:	:	:	:	:	163	831	:	:	:	:	:	108	:	:	:	:
Lithuania	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	408
Latvia	68	:	:	:	:	:	:	:	:	:	:	:	:	207	422	:	301	128
Malta	:	:	:	:	:	368	439	256	:	:	:	:	:	:	:	:	:	:
Netherlands	:	:	:	:	151	14	:	:	:	:	:	:	:	:	:	:	:	:
Poland	:	:	:	:	:	:	:	4	:	:	:	:	:	:	:	:	:	:
Portugal	:	:	:	198	573	315	1.850	207	408	:	:	:	:	:	:	:	:	:
Sweden	:	:	:	:	307	294	498	:	:	:	209	734	:	:	:	:	:	:

Table 8. Imports of ash sawn wood (44079599) by EU countries (eurostat). No export from Mongolia, Korea Rep.. Korea Dem Rep, Japan, Years and EU countries without imports were deleted

	China					USA					Canada					Korea Rep		Russia				
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011	2007	2009	2007	2008	2009	2010	2011
Austria	:	:	:	:	:	113	:	200	:	468	:	:	:	:	7.351	:	:	:	:	:	:	:
Belgium	:	:	:	12	:	4.818	3.880	1.864	6.014	5.441	753	495	300	:	691	:	:	:	47	:	:	:
Cyprus	:	:	:	:	:	230	671	621	516	104	35	166	118	40	47	:	:	:	:	:	:	:
Czech Rep	:	:	:	:	:	182	117	121	:	:	:	:	:	:	95	:	:	:	:	:	:	:
Germany	:	:	557	:	:	12.724	16.627	15.326	22.507	29.346	7.028	7.662	7.007	13.514	8.773	:	:	194	521	:	220	180
Denmark	185	:	:	:	:	5.282	6.105	2.199	2.469	5.433	1.513	5.080	2.532	2.031	4.230	:	:	:	:	432	:	:
Estonia	:	:	:	:	:	8.136	19.255	22.964	48.016	68.795	432	441	4.726	6.352	13.968	:	:	:	:	:	30	:
Spain	:	:	:	:	:	28.505	29.694	13.090	17.815	12.497	4.758	2.613	1.609	571	663	:	:	:	:	:	:	:
Finland	:	:	:	:	:	5.084	2.487	2.934	3.848	3.970	399	430	785	725	956	:	:	:	:	:	:	:
France	:	521	:	:	:	2.731	4.018	7.894	9.631	16.526	345	1.903	732	1.627	1.083	:	:	:	:	:	:	:
UK	185	:	4	:	:	58.335	95.476	81.011	95.730	79.699	12.754	20.364	10.666	9.733	10.058	:	:	:	:	:	:	:
Greece	:	:	:	:	:	1.593	5.202	5.389	3.372	2.256	:	1.277	94	110	:	:	:	:	:	:	:	:
Ireland	:	:	:	60	:	3.703	3.435	5.909	2.695	3.910	800	:	:	643	145	:	:	:	:	:	:	:
Italy	2	:	:	:	:	95.812	116.214	164.005	162.337	165.028	14.308	3.747	7.729	7.858	5.838	:	40	557	513	:	:	:
Lithuania	:	:	:	:	:	:	:	:	204	20	12	10	:	:	1.281	:	:	2.769	1.803	193	205	:
Latvia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	5.106	1.158	466	:	:
Malta	:	:	:	:	:	433	2.861	2.016	2.373	1.240	20	:	:	:	:	:	:	:	:	:	:	:
Netherlands	:	:	:	:	:	9.276	11.194	10.715	11.647	10.656	1.010	2.259	856	417	:	:	:	:	:	:	:	:
Poland	:	:	:	:	:	:	1	603	5	40	279	527	155	28	153	:	:	16.599	4.980	577	:	:
Portugal	:	:	:	:	:	14.458	15.420	12.725	16.982	19.406	2.415	1.673	2.600	1.345	1.317	:	:	:	:	:	:	:
Romania	:	:	:	:	:	:	:	:	:	:	995	203	:	:	:	:	:	:	:	:	:	:
Sweden	1	:	:	:	:	764	3.143	2.524	3.383	5.150	2.491	2.161	2.818	2.819	2.614	:	:	:	:	:	:	:
Slovenia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	404	:	:	:	:

Appendix 4. Trade of wood waste and scrap wood, and hardwood wood chips from countries where *A. planipennis* occurs

Table 1. Exports of hardwood wood chips (440122) from Canada from top importers for each year (2012 data are for January-October) (quantities in metric tonnes)

	2006	2007	2008	2009	2010	2011	2012
World	256,653	263,008	213,619	159,023	221,550	219,454	358,293
Austria	-	0	0	0	0,		
Belgium	0	0	0	2	-		
Finland	0	28,500	57,709	118,307	98,563		
Germany	41,130						
Greece	0	0	2				
Israel	0	0	1	-			
Italy	112,247	7	0	22	-		
Netherlands	0	21	0	3	16	24	
Norway	0	0	0	0	66,280		
Spain	-	0	0	0	2		
Sweden	0	30,000					
Turkey	0	156,295	146,964	37,730	33.146	218,133	338,717
United Kingdom	0	253	881	2,039	0	1	

Table 2. Exports of hardwood wood chips (44012200) from USA (quantities in metric tonnes). Note: EPPO countries with no imports where deleted from the table below.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Jan - Oct 2011	Jan - Oct 2012	% Change (Qty)
World Total	3,292,371.0	2,079,407.0	1,114,023.0	643,458.0	702,861.0	624,647.0	714,398.0	903,740.0	1,164,566.0	640,002.0	526,631.0	452,028.0	375,680.0	393,588.0	5
Belgium	0.0	0.0	58.0	0.0	0.0	14.0	9.0	0.0	664.0	0.0	609.0	0.0	0.0	0.0	--
Bulgaria	2.0	6.0	17.0	0.0	0.0	14.0	636.0	0.0	813.0	813.0	111.0	813.0	813.0	1,871.0	130
Czech Republic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.0	0.0	0.0	0.0	0.0	0.0	--
Denmark(*)	0.0	0.0	50,862.0	0.0	0.0	0.0	0.0	496.0	2,088.0	0.0	0.0	0.0	0.0	0.0	--
Finland	2,237.0	0.0	0.0	465.0	524.0	541.0	0.0	0.0	44.0	0.0	0.0	0.0	0.0	0.0	--
France(*)	1,559.0	769.0	77.0	19.0	8.0	103.0	7,100.0	12,578.0	15,341.0	10,075.0	6,738.0	11,119.0	7,555.0	11,615.0	54
Germany(*)	0.0	42.0	428.0	1,040.0	90.0	340.0	3,666.0	5,360.0	3,309.0	3,470.0	7,930.0	9,641.0	7,423.0	14,470.0	95
Greece	30.0	865.0	3.0	11.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Ireland	66.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Israel(*)	10.0	3.0	22.0	0.0	6.0	465.0	491.0	2,228.0	1,319.0	2,181.0	1,674.0	2,518.0	2,442.0	2,827.0	16
Italy(*)	19,916.0	28,059.0	21,840.0	30,048.0	39,892.0	4,292.0	6,103.0	8,594.0	8,318.0	13,364.0	11,741.0	12,403.0	12,173.0	2,772.0	-77
Kazakhstan	0.0	151.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Moldova	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	473.0	0.0	0.0	0.0	0.0	0.0	--
Morocco	0.0	2.0	5.0	258.0	5.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Netherlands	0.0	0.0	0.0	10.0	5.0	1.0	164.0	893.0	5,642.0	2,745.0	2,025.0	63.0	63.0	130.0	106
Portugal	0.0	0.0	33.0	6.0	3.0	23.0	654.0	2,763.0	4,005.0	1,373.0	513.0	2,800.0	2,800.0	0.0	--
Slovenia	0.0	0.0	0.0	126.0	2,682.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Spain	970.0	1,062.0	20.0	19.0	139.0	907.0	2,808.0	7,413.0	4,016.0	4,065.0	5,423.0	4,212.0	3,524.0	4,941.0	40
Sweden	0.0	0.0	0.0	0.0	0.0	0.0	0.0	421.0	965.0	0.0	0.0	70.0	70.0	875.0	1,150
Switzerland(*)	0.0	0.0	0.0	0.0	0.0	0.0	270.0	0.0	0.0	476.0	0.0	194.0	106.0	0.0	--
Turkey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	226.0	0.0	45.0	0.0	0.0	0.0	12,184.0	--
UK	253.0	31.0	24.0	0.0	15.0	40.0	360.0	228.0	128.0	223.0	130.0	334.0	160.0	6,129.0	3,731

Table 3. Import of hardwood wood chips (44012200) into the EU. There were no imports from Mongolia and Korea Dem. Rep. Note: Years without imports and EPPO countries with no imports were deleted.

	China						Japan		USA						Canada						Korea Rep					Russia					
	2006	2007	2008	2009	2010	2011	2010	2011	2006	2007	2008	2009	2010	2011	2006	2007	2008	2009	2010	2011	2007	8	9	10	11	2006	2007	2008	2009	2010	2011
Austria	9	0	0	0	:	:	:	:	4	:	:	0	0	4	:	:	:	:	0	:	:	:	:	:	:	:	:	:	:	:	:
Belgium	:	:	3	16	:	10	:	:	:	0	:	4	:	182	:	:	:	:	:	:	:	:	:	:	0	:	:	260	:	:	:
Bulgaria	:	:	:	:	:	:	:	:	41	:	:	:	:	100	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Cyprus	:	:	:	:	:	:	:	:	:	:	1	:	:	1	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Czech Rep	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	32	:	:	:	:	:	:	:	:	:	:	:
Germany	:	305	156	219	5	3	:	:	182	678	472	567	1.223	1.580	:	411.235	:	1	:	:	:	:	:	:	:	:	:	:	:	142	:
Denmark	0	2	:	:	:	0	:	:	:	:	:	75	59	33	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	107	24.000
Estonia	:	:	:	:	:	:	:	:	:	1	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	4.477	:	:	14.984
Spain	:	:	:	:	:	:	:	:	597	912	947	766	378	885	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Finland	9	:	:	:	:	:	:	:	0	:	:	10	6	:	:	175.951	533.421	709.949	985.107	:	:	:	:	:	:	789.506	902.808	1.192.804	1.433.552	3.014.241	2.427.411
France	:	:	:	:	:	:	:	:	0	193	253	119	256	822	:	:	67	62	:	:	:	:	:	:	:	:	:	:	:	:	:
United Kingdom	:	192	:	:	350	2.211	:	:	1.889	681	430	563	573	741	152	:	449	151	162	145	:	:	:	:	:	:	:	:	:	:	:
Greece	:	:	:	:	:	:	:	:	:	:	:	:	0	12	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Hungary	48	:	:	:	:	:	:	:	231	209	91	12	19	5	5	:	:	:	1	0	:	:	:	:	:	:	0	:	:	:	:
Ireland	:	:	:	295	878	:	:	:	10	63	215	85	18	:	:	:	:	271	:	:	:	:	:	:	:	:	:	:	:	:	:
Italy	60	2	203	299	650	346	:	:	140	431	225	201	768	835	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Lithuania	:	:	0	:	:	141	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	3	:	200	100	:
Netherlands	150	17	202	31	3	3	1	:	122	106	99	191	386	661	:	:	:	:	:	2	19	19	12	3	5	:	6.014	:	:	:	:
Poland	:	:	:	:	:	:	:	:	:	0	9	:	:	0	:	:	:	:	:	:	:	:	:	:	:	:	:	0	:	:	:
Portugal	:	:	:	:	:	:	:	:	108	556	471	250	56	330	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Sweden	9	0	0	4	1	2	:	1	15	0	:	0	17	16	:	:	:	0	:	2	:	:	:	:	:	:	:	28.705	17.346	143.466	16.408
Slovenia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	647

Table 4. Import of waste wood and scrap wood (44013090 until 2008, then 44013080) into the EU. No imports from Mongolia and Korea Dem. Rep. Years and EPPO countries with no imports were deleted.

	China						Japan					USA						Canada						Korea Rep			Russia					
	2006	2007	2008	2009	2010	2011	2006	07	08	10	11	2006	2007	2008	2009	2010	2011	2006	2007	2008	2009	2010	2011	2007	2010	2011	2006	2007	2008	2009	2010	2011
Austria	:	:	:	0	:	:	:	:	:	:	:	0	:	17	0	0	0	:	:	9	:	:	4	:	:	:	4.474	1.820	:	8.540	1.079	:
Belgium	88	2	387	318	415	83	:	:	:	:	174	2344	1.477	642	1.265	60.778	116.550	1822277	2169988	758.430	290.616	126	136.646	:	:	:	57.612	:	2.587	1.296	4.705	23.283
Bulgaria	:	5	:	:	:	:	:	:	:	:	:	12	:	:	:	:	:	:	:	:	:	:	:	4	:	:	:	0	:	:	:	37
Cyprus	:	:	:	:	:	:	:	:	:	:	:	:	15	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Czech Rep	142	:	:	:	165	:	:	:	:	:	:	145	:	1	64	0	82	:	:	3	18	:	:	:	:	:	:	195	:	:	418	1.731
Germany	:	244	317	179	:	:	:	81	17	:	:	2.433	6.331	20.748	15.498	12.152	10.013	2.580	3.554	1.378	461	458	460	:	:	:	8.083	18.291	27.374	183.895	189.369	326.851
Denmark	168	552	1.241	:	:	1.740	:	:	:	:	:	338	729	980	332	849	750	255.076	526.583	77.270	0	:	:	0	0	:	173.211	273.630	108.394	48.129	120.559	255.105
Estonia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	7	:	:	:	17.633	373	4.224	19.852	2.029	3.657
Spain	:	40	1.442	:	:	0	:	:	:	:	:	837	329	120	257	762	151	:	:	:	225	3	2	:	:	:	:	:	:	:	:	:
Finland	91	:	3	9	:	:	:	:	:	1	:	41	34	0	:	3	4	:	29	:	:	:	:	:	:	:	1151208	524.147	1589711	1079223	1215059	1521877
France	0	186	71	255	53	48	:	:	12	:	:	2.663	2.125	3.339	1.556	1.037	1.696	1.621	:	377	:	34	0	:	:	:	:	:	:	:	:	:
UK	:	1.586	43	1.072	2.185	1.775	:	:	:	:	1	3.676	12.804	166.650	3.205	4.349	11.806	81.553	67.002	393.764	6.480	353	365	:	:	:	30.018	142.364	827.432	:	:	202
Greece	:	:	:	:	:	:	:	:	:	:	:	:	:	:	192	76	:	:	:	:	195	197	:	:	:	:	:	:	:	:	:	:
Hungary	:	152	:	1	13	11	:	:	:	:	:	71	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	2.573	231	2.922	18.873
Ireland	:	2.015	274	24	830	:	:	:	:	:	18	978	972	3.352	688	:	91	31.817	249.125	16.437	1.820	:	:	:	:	:	480	28.179	874	894	220	:
Italy	12.843	12.309	1.001	778	4	:	:	3	:	:	0	11.855	40.921	1.231	1.416	548	1.061	107.888	95.890	1.820	26	:	2	2	:	:	34.866	18.729	:	1.073	10.254	210
Lithuania	:	:	:	:	:	42	:	:	:	:	:	:	:	:	:	:	:	:	2	7	:	:	:	:	:	:	4.079	5.272	9.450	888	34.129	69.049
Latvia	:	:	:	:	:	:	:	:	:	:	:	:	0	:	:	:	:	0	:	:	:	:	:	:	:	:	1.241	2.021	29.899	10.075	628	1.692
Malta	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	8	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Netherlands	9	725	195	397	271	1.161	7	:	:	:	:	14	7.093	679.891	:	0	5	1704318	1375887	4400280	103.743	:	2	:	15	2	62.419	114.439	35.392	:	:	:
Poland	:	0	:	:	:	:	:	:	:	:	35	:	0	:	28	7	80.425	:	:	:	:	:	:	:	:	:	1.979	2.191	37.050	11.367	8.145	211.388
Portugal	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	143	14	12	:	15	:	:	:	:	:	:	:	:	:	:	:	:
Sweden	4	34	:	:	0	6	:	:	:	:	:	7	254	55.782	94	139	44.770	1305972	824.230	317.512	:	:	2	:	:	:	592.242	686.103	1253383	14.795	97.910	108.293
Slovenia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	0	:	5	8	0	3	2	5	:	:	:	:	:	:	:	:	210
Slovakia	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	3.726	:	:	:	:	:

Appendix 5 - Species of Ulmus and Juglans in countries of the former-USSR (other than those indicated under section 6) (From EPPO, 2000)

Current name	Natural distribution	Cultivated
Juglans californica	-	Georgia (West – Adler); Uzbekistan (Toshkent); Turkmenistan (Ashghabad)
Juglans cinerea	-	C.E.Russia, S.E.Russia; Ukraine; S.Siberia (West); Central Asia
Juglans fallax	Central Asia	-
Juglans nigra	-	C.E.Russia, S.E.Russia; Latvia; Estonia; Belarus; Moldova; Ukraine
Juglans regia	Central Asia; Tajikistan	C.E.Russia, S.E.Russia; Latvia; Lithuania; Belarus; Moldova; Ukraine; Transcaucasus
Juglans rupestris	-	Georgia (West – Adler); Ukraine
Ulmus glabra (= U. elliptica)	S.E.Russia; Ukraine (Crimea); Transcaucasus	S.E.Russia; Moldova; Ukraine; Central Asia
Ulmus laciniata	N.E.Russia, C.E.Russia, S.E. Russia, N. Far East, S. Far East (mountains); Baltic countries; Belarus; Moldova; Ukraine	-
Ulmus laevis (= U. celtidea = U. pedunculata)	N.E.Russia, C.E.Russia, S.E. Russia; Baltic countries; Belarus; Moldova; Ukraine; Transcaucasus	-
Ulmus macrocarpa	N.E. Siberia, S. Siberia (East), Transbaïkalia, S. Far East	-
Ulmus minor (= U. foliacea = U. campestris)	S.E.Russia; Moldova; Ukraine (Crimea); Transcaucasus	S. Siberia (Altay); Estonia; Latvia (Riga); Azerbaijan; Kazakhstan; Central Asia
Ulmus minor (= U. araxina)	S.E.Russia (South-East); Transcaucasus	Central Asia
Ulmus minor (= U. densa)	Central Asia	-
Ulmus minor (= U. grossheimii)	S.E.Russia (South-East – Dagestan); Azerbajjan (Nakhichevan')	-
Ulmus minor (= U. suberosa)	C.E.Russia, S.E.Russia; Baltic countries; Belarus; Moldova; Ukraine; Transcaucasus	Central Asia
Ulmus parvifolia (= U. chinensis)	-	S.E.Russia; Georgia (West – Sukhumi); Uzbekistan (Toshkent)
Ulmus pumila (= U. manshurica = U. pinnato-ramosa = U. turkestanica)	N.E. Siberia, S. Siberia (East), Transbaïkalia, N. Far East, S. Far East	C.E.Russia, S.E.Russia; Baltic countries; Belarus; Moldova; Ukraine
Ulmus pumila (= U. pinnato-ramosa)	-	C.E.Russia, S.E.Russia; Central Asia
Ulmus pumila (= U. turkestanica)	-	Central Asia
Ulmus rubra (= U. fulva)	-	C.E.Russia (Moscow); Ukraine (Kremenchug)
Ulmus scabra (= U. glabra subsp. *scabra)*	N.E.Russia, C.E.Russia, S.E. Russia; Baltic countries; Belarus; Moldova; Ukraine; Transcaucasus	Azerbaijan (Baky); Tajikistan (Dushanbe)

Appendix 6. Recent research and discussion on the efficacy of heat treatment against *Agrilus planipennis*

When contacted by the EWG about the efficacy of heat treatment (2013-01-29), **Dr Eric Allen**[2] *answered as follows:*

Clearly, there is evidence that the prepupal stage of *Agrilus planipennis* has a certain level of thermotolerance to treatment at 56°C for 30 min. The experimental data reported by authors such as McCullough *et al.* (2007), Nzokou *et al.* (2008), Meyers *et al.* (2009), Goebel *et al.* (2010), and Sobek *et al.* (2011) all provide some insight into the question; none with a definitive answer that gives clear guidance for the treatment of all wood commodities (nor a clear picture of how to interpret the data in the light of statistical confidence). Following is a summary of these studies:

Thermotolerance of *Agrilus planipennis*
Agrilus planipennis was reported in several studies to survive heat treatment of 56°C for 30 min. McCullough *et al.* (2007) reported survival of *A. planipennis* prepupae in wood chips (6.5 x 3.1 x 1.5 cm) treated at 60°C for 20 min, but not 120 min. At 55°C, 17% of the prepupae survived; no prepupae survived exposure to 60°C for 120 min; although no pupation of surviving prepupae occurred in chips exposed to 55 or 60°C. This study monitored chamber temperature. Myers *et al.* (2009) evaluated survival of *A. planipennis* larvae and prepupae in firewood. Temperature monitoring probes were inserted to 3.5 cm (maximum penetration depth of the beetle) Larvae were capable of surviving a temperatures-time combination up to 60°C for 30 min in wood, prepupae up to 55°C for 30 min, 50°C for 60 min and 60°C for 15 min. Adult emergence was observed in firewood in 45, 50, and 55°C treatments for both 30- and 60-min time intervals; no emergence occurred in any of the 60 or 65°C treatments. Nzokou *et al.* (2008) observed *A. planipennis* adults emerging from logs heated to 60°C for 30 min but not at 65°C. Goebel *et al.* (2010) reported adult emergence from firewood treated at chamber temperatures near 56°C in a small dry kiln. Haack and Petrice (IFQRG-2010) tested survival of A. planipennis, (as well as ash bark beetle, pine bark beetle and pine weevil) in a 56°C chamber for various lengths of time, measuring temperature at the core and at 1 cm below the surface. No emergence of any species tested was observed in logs treated to a core temp of 56°C. Sobek *et al.* (2011) tested *A. planipennis* survival in log bolts in an operational heat treatment chamber. They reported complete mortality of all larval instars at 56°C for 30 min. Similarly all pupae died at exposures as short as 10 min at 54°C. They also considered the mechanisms of thermotolerance in EAB. Heat shock proteins were produced when larvae were slowly warmed from room to treatment temperatures; these larvae had higher thermal tolerance. They proposed that this mechanism could result in survival above laboratory tested 56°C for 30 min. However, they argued that heat treatment schedules used under operational conditions in Canadian HT facilities far exceed the ISPM 15 standard and that even extreme thermal plasticity is unlikely to allow pest insects to survive the heat treatment process. They also considered that sub-lethal impact of treatment that could result in reduced fecundity or sterility might increase the safety margin of existing heat treatments (Sobek *et al.* 2011 citing Scott *et al.*, 1997, Huang *et al.*, 2007, and Mironidis & Savopoulou-Soultani, 2010).

When the International Forest Quarantine Research Group looked at the issue in 2010, they agreed on the following statement:

> **IFQRG evaluation of *A. planipennis*:**
> The International Forestry Quarantine Research Group (2010) reviewed the published literature on *A. planipennis* thermotolerance**.** The studies were conducted on firewood and wood chips and did not test the ISPM-15 standard and were therefore not valid for consideration in wood packaging. The group is unaware of any interceptions of EAB in wood packaging material in international movement of regulated wood. The EU has not reported any interception of EAB in any wood commodity; no US interceptions of EAB in wood packaging.

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Dr Allen chairs the International Forestry Quarantine Research Group, and is deputy coordinator of the International Union of Forest Research Organizations working group "Alien Invasive Species in International Trade," and serves on the North American Plant Protection Organization forestry panel and the International Plant Protection Convention (IPPC) technical panel for forestry quarantine.

Participants agreed that the phytosanitary measures applied under normal operating conditions to fulfil requirements of ISPM-15 continue to be appropriate to sufficiently reduce the risk of EAB.

This statement by IFQRG could equally apply to sawn wood for which heat treatment is only a part of a larger risk reduction "system" of integrated phytosanitary measures. Other components include:

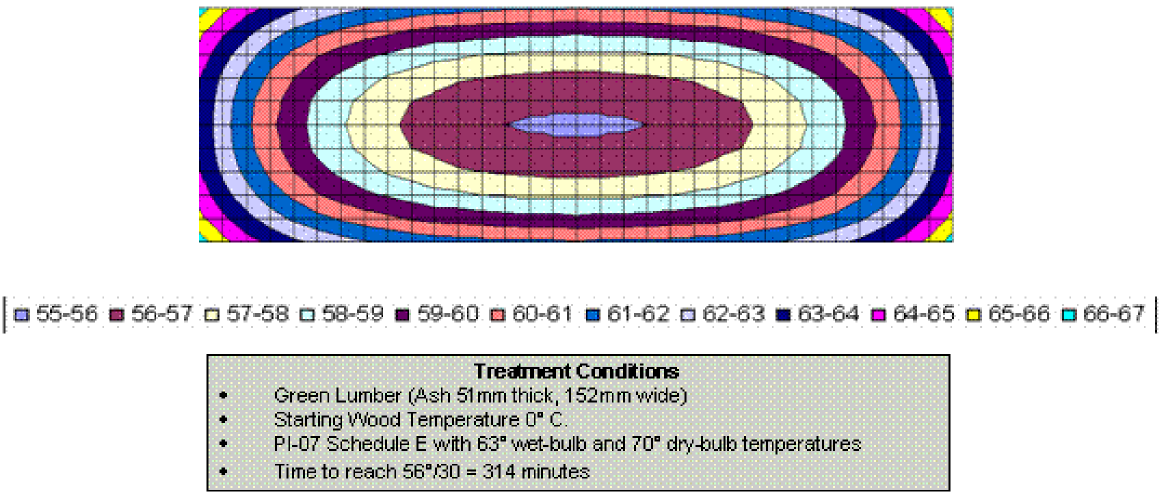
- debarking (most larvae and in larger dimension logs, most prepupae and adults removed),
- milling, most life stages removed (only a small percentage (the outer corners or boards cut from the outside of the log – and then only larger diameter logs) could be infested with EAB.
- HT and KD – following PI-07 the temperatures achieved by ash wood that is dried to 7-8% MC far exceed 56/30, likely over 70°C

Thermal penetration models – temperature gradients:
Currently most heat treatment is achieved through the use of existing moisture reduction wood kilns (where controlled application of heat is a part of the drying process) or chambers specifically designed for heat treatment. There are a number of considerations that need to be addressed in order to achieve a core temperature of 56°C for every piece of wood in a large load; e.g. wood species, variability in wood density, moisture and piece size, initial temperature, and evenness of heat distribution in the chamber. In order to compensate for these variables, temperature monitoring probes are placed strategically in sentinel pieces of wood or temperature time schedules are developed. In either case, ambient chamber temperatures are set higher than 56°C, often 70-90°C. Since the heat treatment process requires many hours for all wood pieces to reach 56°C, much of the wood, in particular the outer "skin" and corners of each wood piece is heated to temperatures higher than 56°C for times far in excess of 30 min. For organisms like *Agrilus planipennis* therefore,

> "*Heating the wood core to 56°C will result in a mass and size-dependent temperature gradient across the logs, and species dwelling in the outermost layers, such as EAB, will be exposed to considerably higher temperatures for longer periods of time than species dwelling in the core. After termination of the treatment, thermal inertia means the wood will remain at higher temperatures for some time, which gives reassurance that the current standard (as implemented in the facility we investigated) is sufficient in exterminating EAB.*" (Sobek *et al.* 2011).

This logic is in line with a modelling analysis conducted by Forintek and CFS in 2007 that demonstrated that ash wood treated under hardwood treatment schedules in the CFIA manual PI-07 received exposure to temperatures in excess of 60°C for several hours (Fig 1).

Fig 1. Temperature profile at end of heat treatment through cross-section of 51mm thick by 152mm wide ash wood



The generic schedule approach adopted by PI-07 contains sufficient safeguarding measures to ensure that all wood products treated according to the schedule will meet the phytosanitary standard, a minimum wood core temperature of 56°C for a minimum of 30 minutes. It provides a minimum standard to achieve the treatment target. Where moisture reduction is also a goal, wood is subjected to heat for much longer periods of time. For example, in a typical charge of 5/4 (32 mm thick) ash sawn wood dried to 7% MC at a Canadian hardwood mill, the wood were exposed to ambient temperatures exceeding 90°C for 232 hours (more than 9 days). The wet-bulb temperature during the same time period exceeded 73°C. In this example the phytosanitary requirement was met within the first 11 hours.

Heat treatment as a component of an integrated measures approach

Various mechanical processes that are used in the manufacture of wood products from trees including harvesting practices, wood storage, milling and post-milling processes result in the reduction of associated pests (FAO 2011). These processes transform the structure and physical properties of the wood, generally reducing the quality of the substrate for the successful survival of pest organisms that may have inhabited the living tree. Each of these steps reduces pest prevalence in the wood and can be considered independent phytosanitary measures. In keeping with international principles of integrated measures, the cumulative effect of these processes results in greater pest risk reduction than by a single measure. In this context, heat treatment is a part of a greater risk reduction exercise, not the sole opportunity for pest mitigation.

The effectiveness of these risk reduction processes is based on the understanding of the biology of the pest, how and where it lives in the bark and woody tissues of the host tree. For example, life stages of *Agrilus planipennis*: eggs, larvae, prepupae, pupae and adults live in the bark or in the cambial or sapwood tissue just underlying the bark. In merchantable log sizes the beetle life stages rarely, if ever penetrate the sapwood and are effectively removed during debarking. This single production process removes most pest risk. The next major production process, where logs are sawn into boards removes a significant portion of the outer sapwood where prepupal chambers are formed in smaller diameter logs. Finally, heat treatment of sawn wood that ensure that the wood has reached a core temperature of 56°C for 30 minutes kills virtually all *A. planipennis* life stages that may still be present. In combination these independent phytosanitary measures more effectively reduce pest risk than implementation of any one measure alone.

Set in the context of risk reduction through multiple integrated measures, it may therefore not be necessary for a single component measure, heat treatment for example, to result in near-100% mortality. Haack *et al.* (2011) indicated that biological factors also come into play suggesting that:

> "*the focus on mortality as the sole criterion for evaluating quarantine security disregards risk-based factors along the pathway, such as the likelihood of infestation, natural survival, reproductive potential and establishment potential, as well as processing parameters such as packaging and shipping practices and distribution times*"

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